Chapter
Meat Borne Diseases

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Abstract

Red and white meat is a perfect, high-quality protein that comprises all of the nine essential amino acids (EAAs) that cannot be synthesized endogenously. Meat is the normal source of this vitamin, as well as other types of vitamins. Meat affords a range of significant vitamins and minerals that the human body needs, many of which are more bioavailable and easily absorbed than the nutrients found in plant sources. The nutrients in meat support the immune system, participate in the formation of muscle tissue, red blood cells (RBCs), and hormones, and warrant accurate functioning of the nervous system. These nutrients also affect the human senses of smell and taste, benefit our thyroids, and support antioxidant production. The main sources of pathogens in meat and meat products are; the animal itself; human handlers; equipment's in contact, environmental sources, and water used in the preparation. Meat Borne Diseases, since ancient times, played a central role in public health. This chapter is divided into nine parts, part one to part eight deals with the most important pathogens that have been associated with meat borne diseases (MBDs), these include, Meat Borne Prionic Diseases; Viral Diseases; Bacterial Diseases; Protozoal Diseases; Parasitic Diseases; Fungal Diseases; Mycotoxins; Rickettsial Diseases; while the nine-part deal with the methods of meat preservation and storage.

Keywords: meat, diseases, preservation

1. Introduction

Meat is the flesh of certain animal species that are used as food by humans. The main tissue is the skeletal muscle and its associated tissues, also the edible offal which includes organs and non-skeletal muscle tissues are considered meat. It is derived from avian, mammalian, reptilian, amphibian, and aquatic species commonly harvested for human consumption [1, 2].

Meat can be generally categorized as red or white depending on the concentration of myoglobin in muscle fiber. Meat is mainly composed of water, protein, and fats, followed by minerals, vitamins, carbohydrates, and other bioactive components [3]. From the nutritional point of view, meat's significance is derived from its high-quality protein, containing all essential amino acids, and its highly bioavailable minerals and vitamins. Meat is affluent in Vitamin B12 and iron which are not easily available in botanical foods [4]. Meat has played a vital role in human development and is a vital constituent of a well-balanced diet. It ranks among one of the most important, nourishing, and preferred food items available to the masses, which aids in fulfilling most of their body necessities. Meat fat and its fatty acid profile is a point to worry, concerning its consumption, but its moderate custom is always advised by physicians and nutritionists, to lead a healthy life. The fat content of animal carcasses ranges between 8 and 20%. The average proportion
of meat protein is about 23% that fluctuates from a lower to a higher value according to the type of meat source [5]. Generally Meat is a perfect, high-quality protein comprise all of the nine essential amino acids (EAAs) that cannot be synthesized endogenously (lysine, isoleucine, methionine, leucine, valine, tryptophan, threonine, phenylalanine, and histidine) cannot be synthesized endogenously, the human body needs to consume to build and rebuild every cell in the body, as well as for optimal health [6]. Meats Vitamin B12 plays a key role in normal metabolism, preserving brain and nervous system function, and high energy levels. Meat is the normal source of this vitamin, as well as other types of vitamins. Meat affords a range of significant vitamins and minerals that the human body needs, many of which are more bioavailable and easily absorbed than the nutrients found in plant sources. The nutrients in meat support the immune system, participate in the formation of muscle tissue, red blood cells (RBCs), and hormones, and warrant accurate functioning of the nervous system. These nutrients also affect the human senses of smell and taste, benefit our thyroids, and support antioxidant production [7, 8]. Muscular tissue in live healthy animals is virtually free any contaminant microorganisms. However, following animal slaughtering and carcass preparation, muscular tissue is being subjected to various microorganisms [9, 10].

Depending on different sanitary conditions prevailed upon meat preparation meat might be subjected to different pathogens which might be transmitted to humans (Meat Borne Diseases) [11]. These include disease causative agent like; Prion, Viral, Bacterial, Mycotic, and Parasitic Diseases [12]. The main sources of pathogens in meat and meat products are; the animal itself; human handlers; equipment’s in contact, environmental sources or water used in preparation [13]. Therefore, strict hygienic precautions must me prevailed during meat handling and preparations. Meat and its products have been engaged in many diseases or outbreaks in human consumers which necessity awareness and educational knowledge about causative agents and control hygienic measures. This chapter will cover the most important pathogens that have been associated with meat borne diseases (MBDs).

2. Meat borne prionic diseases

These are a group of diseases caused by Prion, which are very significant in the field of public health, whether human public health or veterinary public health, that is commonly known as group of diseases Spongiform Encephalopathy [14]. The most important prionic disease transmitted from cattle to human through cattle meat is the Bovine Spongiform Encephalopathy (BSE) (Mad - Cow Disease) [15]. The diseases that was discovered for the first time in Britain in November of 1986, and it had infected cows, sheep, cats, and monkeys [16].

2.1 The causative agent

The incubation period is usually very long, ranging between (2–8) years [17]. Prion in infected cattle were found in brain tissues, and in the spinal cord, bone marrow, spleen, lymph nodes, tonsils, in addition to the intestine. Prion is infectious proteins that were previously called slow viruses (Slow Viruses), but they are similar to a virus in that they contain a protein and live and multiply inside the cell, taking into account that prions differ from viruses in that they do not have DNA in their composition or it may exist, but in small quantities. Prion, which causes mad cow disease, is characterized by It’s a superior ability to resist heat, disinfectants, and UV rays and high ability to resist freezing, drying, and cooking temperatures [18].
2.1.1 Occurrence of diseases

It occurs as a result of cows eating diets containing animal protein remains, including meat and bone meal, which carry the pathogens. The occurrence of the disease started since 1970, where expansion began in Britain by using the carcasses of sick and dead animals to produce feed additives such as meat and bone meal. The preventive measures that have to be taken to facing the transmission of the disease to humans is to excluding and burning all animals that are proven to have the disease beside forbidding the use of mammalian meat and bones in feeding farm animals. At the same time all necessary health measures should be taken in red meat slaughterhouses, and emphasize the removal of animal waste and other wastes immediately after completion of the slaughtering and processing [19].

3. Meat borne viral diseases

Several viruses can cause foodborne illness, including meat and meat products. The most significant viruses transmitted to humans via foods comprise noroviruses, rotaviruses, adenoviruses, sap viruses, and astroviruses [20].

3.1 Hepatitis

Hepatitis A is caused by an infection with the hepatitis A virus (HAV). This type is most commonly transmitted by consuming water or food including meat and meat products contaminated by feces from a person infected with hepatitis A [21].

Hepatitis B caused by an infection with the hepatitis B virus (HBV). This type is transmitted through contact with infectious body fluids, such as blood, semen, and vaginal secretions, containing the (HBV). Injection drug use, having sex with an infected partner or sharing razors with an infected person increase the risk of getting hepatitis B [22].

Hepatitis C is caused by an infection with the hepatitis C virus (HCV). This type is transmitted through direct contact with infected body fluids, typically through injection drug use and sexual contact [23]. HCV is among the most common blood-borne viral infections in some countries, like USA.

Hepatitis D (delta hepatitis) It is an infection with the hepatitis D virus (HDV). HDV is contracted through direct contact with infected blood [24]. The hepatitis D virus cannot multiply without the presence of hepatitis B. It is a rare form of hepatitis that only occurs in conjunction with hepatitis B infection.

Hepatitis E caused by infection through the hepatitis E virus (HEV). Hepatitis E is mainly found in areas with poor sanitation and typically results from ingesting fecal matter that contaminates the water supply [25]. Cases of hepatitis E have been indicated in the Middle East, Asia, Africa, and Central America.

3.1.1 Noroviruses

The infection occurs through oral ingestion from contaminated food including meat and meat products, as well as water. The transmission also occurs through aerosols creating during vomiting and fomites. However, the primary route of transmission is person-to-person transmission through the fecal–oral and vomit–oral routes, and indirectly through food (ready to eat including leafy vegetables and herbs, berries, and foods handled after cooking), water, and the environment.

The European Union summary report on trends and sources of zoonoses, zoonotic agents, and food-borne outbreaks in 2016, mentioned that food is implicated
in up to 24% of global outbreaks. Crustaceans, shellfish, mollusks, and their products beside vegetables and juices are the foods most often implicated in European norovirus outbreaks in 2016 [26].

3.1.2 Rotaviruses

The virus affects mainly infants and young children. Rotaviruses cause enteric disease with symptoms characterized by fever, vomiting, diarrhea, and abdominal discomfort [27].

3.1.3 Group a rotaviruses

Group A rotaviruses are the most important agents of severe diarrhea in infants and young children and are prevalent worldwide. It is the major pathogens in humans and animals. Ten serotypes of human group A rotaviruses are defined by neutralization of one (VP7) of the two outer capsid proteins [28].

3.1.4 The non-group a virus

The non-group A viruses are divided into groups B, C, D, E, F, and G based on distinct group antigens. Of the non-group A rotavirus, only groups B and C have been detected in humans; they are not an important cause of disease in infants and young children [29].

4. Meat borne bacterial diseases

Because of the great health risks Red meats and white meat come from warm-blooded animals and, as such, their microbial flora is heterogeneous, consisting of mesophilic and psychrotrophic bacteria. These bacteria include pathogenic species from the animal and birds themselves, as well as from the environment, together with bacterial species introduced during slaughter and processing of raw products [9]. Most of these diseases are zoonotic diseases, which are transmitted to human beings, either directly or indirectly, and hence the meat and its products play an important role in transmitting these pathogens. Meat borne diseases are classified into meat borne infection and meat borne intoxication [30].

4.1 Meat borne infections

Meat borne infections are caused by the entrance of pathogenic bacteria contaminating meat and meat products into the body, and the reaction of the body tissues to their presence [12]. Meat borne infections tend to have long incubation periods and are usually characterized by fever. Bacterial meat borne infections include the following important pathogens.

4.1.1 Campylobacteriosis

The incubation period ranges between 2 and 11 days with an average of 3–5 days. *C. jejuni* and *C. coli* causes illness characterized by fever; abdominal pain (abdominal pain is associated with backache and possible mortality); foul-smelling and watery diarrhea, which runs for 3–4 days, (diarrhea may sometimes contain blood and mucus in feces); vomiting; nausea; and abdominal complaints [31].
4.1.2 Escherichia coli foodborne infection

*E. coli* is a common member of the normal flora of the large intestine [32]. Six pathotypes of *E. coli* are now recognized.

4.1.2.1 Enterohemorrhagic E coli (EHEC)

Enterohemorrhagic *E. coli* (EHEC) causes haemorrhagic colitis or haemolytic-uremic syndrome (HUS) [33].

4.1.2.2 Enteroinvasive E coli (EIEC) causes a Shigella-like dysentery

EIEC strains cause illness that is characterized by watery diarrhea in most patients. Besides, there is a fever, nausea, and abdominal cramps [34].

4.1.2.3 Enteropathogenic E coli (EPEC)

Enteropathogenic *E. coli* (EPEC) is a cause of childhood diarrhea [35]. The World Health Organization (WHO) estimated that every year 600 million (almost 1 in 10 people) fall in sick and nearly 420,000 deaths occurs worldwide as a result of contaminated food consumption [36].

4.1.2.4 Enterotoxigenic E coli (ETEC)

Enterotoxigenic *E. coli* (ETEC) is a cause of traveler’s diarrhea. ETEC are a pathogenic variant or pathovar of *E. coli* defined by production of diarrheagenic heat-labile (LT) and heat-stable (ST) enterotoxins [37].

4.1.2.5 Enteroaggregative E coli (EAgg EC)

Enteroaggregative *E. coli* (EAgg EC) is primarily associated with persistent diarrhea in children in developing countries. Polluted food appears to be the main source of EAEC infection and has been associated in numerous foodborne outbreaks of diarrhea [38].

4.1.2.6 Enteroadherent E coli (EAEC)

Enteroadherent *E. coli* (EAEC) is a cause of childhood diarrhea and traveler’s diarrhea in Mexico and North Africa.

4.1.3 Listeria monocytogenes

*Listeria monocytogenes* is the only known species in the *Listeria* genus that concern for human health. It is G+ive bacteria, that is pathogenic to both humans and animals [39, 40].

4.1.4 Salmonella species

Some of the important salmonella species involved in food poisoning include; *S. typhimurium*, *S. infantis*, *S. dublin*, *S. enteritidis*, *S. softenburg*, *S. montevideo*, *S. virchow*, and *S. Newport* [41]. Factors associated with Salmonella meat poisoning outbreaks include; consumption of inadequately cooked or thawed meat or poultry, cross-contamination of meat and meat products from infected food handlers.
besides the possible presence of rats, cockroaches, flies, in the food environment that acts as vectors of the disease [42, 43].

4.1.5 Shigellosis (bacillary dysentery)

All strains of shigella possess potent exotoxins which are carbohydrate-lipid protein complexes [44]. Any type of food including meat and meat products can transmit the shigella pathogens to cause disease in humans. Flies can spread Shigella germs when they get into contact with infected stool and then contaminate different types of food and drinking water. The illness begins 1 to 4 days after ingestion of bacteria and may last 4 to 7 days [45].

4.1.6 Vibriosis

4.1.6.1 Vibrio parahemolyticus

*V. parahemolyticus* is a pathogenic bacterium, whose natural habitat is the sea. Human infections occur solely from seafood creatures such as oysters, shrimps, crabs, lobsters, clams, and related shellfish.

4.1.6.2 Vibrio vulnificus

*V. vulnificus* causes severe foodborne infection. *V. vulnificus* infections can cause fever, nausea, myalgia, and abdominal cramps, 24–48 hours after eating contaminated food.

4.1.6.3 Vibrio cholera

Cholera is an infection of crowded poor class communities and it tends to persist in such areas. Human is the only natural host of the cholera [46]. The spread of infection is from person-to-person, through contaminated water or foods. Shrimps and vegetables are the most frequent carriers. Cholera is typically categorized by the sudden onset of uncomplicated vomiting, which is seen frequently, but very rapid dehydration and hypovolemic shock, as well as copious watery diarrhea. The frequent watery stools may be accompanied by small parts of the mucosa being liberated from the intestines [47].

4.1.7 Yersinia enterocolitica

*Y. enterocolitica* has been isolated from different types of food, such as beef, lamb, seafood, pork, milk, vegetables, and vacuum-packed meat [48]. Symptoms develop some days following ingestion of contaminated foods. It includes headache, fever, abdominal pain, diarrhea, and pharyngitis. Children appear to be more susceptible than adults [49].

4.1.8 Brucellosis

Brucellosis is a foodborne and professional zoonotic disease, caused by the bacterial genus Brucella. This infection has an extremely emerging and significant reemerging potentials in several countries [50].

Brucellosis is a cosmopolitan bacterial zoonotic disease (caused by Brucella spp.) that affects humans and various species of the wild and domestic animals,
principally food-producing animals, including cattle, buffaloes, camels, sheep, goats, pigs, and reindeer [51, 52].

Human brucellosis is a severely debilitating and disabling life-threatening disease. It is recognized by the clinical problems such as, the contribution of the interior organs, peripheral arthritis, bronchopneumonia, epididymitis, orchitis, hepatic abscesses, sacroiliitis, osteomyelitis, spondylitis, meningitis, encephalitis, cardiovascular complications, and prostatitis [53].

The transmission occurs through ingestion of polluted milk or meat and from mothers to breastfed babies. The transmission of Brucella also happens through mucous membranes or skin wounds, following direct contact with urine, vaginal discharges, blood, tissues, placenta, aborted fetuses, and through inhalation of airborne agents in an atmosphere [54].

4.2 Meat borne intoxications

These are diseases caused by the consumption of meat, meat products, and other types of foods containing the following toxicants.

4.2.1 Bio toxicants

Poisonous animals and Plants, which are found in tissues of certain animals and plants [55].

4.2.1.1 Toxic fishes

Types of intoxications associated with fish include ciguatera poisoning, tetraodon poisoning, and scombroid toxicity [56]. They include puffers, triggerfish, and parrotfish.

4.2.1.2 Mollusca

Mollusca involved are oysters, mussels, and clams, which feed on dinoflagellates and planktons containing alkaloids making them toxic.

4.2.1.3 Poisonous mammals

Mammals are not commonly inherently poisonous, but secondary toxicity may affect many of them. The toxin may be of various types e.g. heavy metals, pesticides, toxic plants, therapeutics, fungal or bacterial toxins. Most human poisoning involves secondarily transfected toxins [57].

4.2.2 Metabolic products (toxins)

Metabolic products (toxins), which formed and excreted by microbes (Bacteria, Fungi, and Algae), while they multiply in the gastrointestinal tract (GIT) of human or in food [58].

4.2.3 Poisonous substances

Poisonous substances, which may be purposely or accidentally added to food during processing, production, transportation, or storage [59]. In general, the foodborne intoxications have short incubation Periods, from minutes to hours, and
are characterized by a lack of fever. Food-borne intoxications can be classified into the following categories; Bacterial, Fungal and Chemical intoxications.

This is a type of meat-borne intoxication arising from ingestion of meat, meat products, and other types of food containing poisonous chemicals, such as heavy metals; Pesticides; insecticides; Herbicides; Fungicides. Chemicals also include Preservatives (Nitrites; antibiotics - penicillin, tetracycline, and chloramphenicol or Radionuclides (cesium, strontium, radium, barium, lanthanum) [60–62].

4.3 Bacterial meat borne intoxications

4.3.1 Bacillus cereus meat borne intoxication

Food poisoning caused by B. cereus is an acute intoxication that occurs when this bacterium produces toxins [63]. B. cereus is considered a comparatively common cause of gastroenteritis globally. There are two types of gastrointestinal disorders caused by this bacterium [64].

4.3.1.1 Emetic toxin (ETE)

The emetic syndrome, due to ETE, is an intoxication that is caused by a single highly heat-, proteolysis-, acid- and alkali-resistant toxin, that is pre-formed when ingested, leading to a rapid onset of the syndrome [65].

4.3.1.2 Hemolysin BL (Hbl)

Bacillus cereus produces emetic toxin and several enterotoxins including non-hemolytic enterotoxin (Nhe), hemolysin BL (Hbl), cytolysin K (CytK), hemolysin II (HlyII), enterotoxin FM (EntFM), and enterotoxin T (bc-D-ENT).

4.3.1.3 Non-haemolytic enterotoxin (Nhe)

Is a pore forming toxin consisting of two lytic elements NheA and NheB, and a protein NheC with unknown function encoded by nheA, nheB, and nheC, respectively [66].

4.3.1.4 Cytotoxin K (CytK)

4.3.1.4.1 Emetic disorder

Characterized by vomiting, abdominal cramps, nausea, and occasionally diarrhea that occur 1–6 hrs after consumption of contaminated meat or other types of food.

4.3.1.4.2 Diarrhea disorder

Characterized by abdominal cramps, watery stool (copious diarrhea), tenesmus rarely vomiting. These symptoms beginning 8 to 16 hrs after ingestion of contaminated food.

4.3.2 Clostridium perfringens meat borne intoxication

Clostridium meat borne intoxication is caused by the ingestion of food containing large numbers of vegetative cells of enterotoxigenic C. perfringens type A and some type C and D strains. C. perfringens multiply in the intestine and sporulate releasing C. perfringens enterotoxin (CPE).
4.3.3 Clostridium botulinum meat borne intoxication

The danger of botulism has been the deciding factor in the formulation of food processing techniques, especially canned meat [67].

4.3.4 Staphylococcus aureus meat borne intoxication

Caused by the consumption of food including meat and meat products polluted with staphylococcal enterotoxins produced by confident strains of Staph. aureus while growing in different types of food [68]. These enterotoxins are pH stable (insensitive to pH changes); as well as resistant to most proteolysis enzymes (pepsin, renin, trypsin, and chymotrypsin) [69].

5. Meat borne protozoal diseases

5.1 Toxoplasma gondii

Human toxoplasmosis occurs from eating inadequately cooked meat, particularly mutton (lamb meat), pork, and venison (deer meat), or from drinking unpasteurized milk contaminated with Toxoplasma gondii. However, cooking meat (internal temperature about 70°C or 160°F) or freezing to around (−18°C or 0°F) should be able to destroy the protozoa [70]. Eating food that was contaminated by knives, utensils, cutting boards, or other foods that had contact with raw, contaminated meat or shellfish is other possible way too [71].

5.2 Sarcocystosis

Humans become infected when they eat undercooked meat comprising these Sarcocystis. Bradyzoites are released from ruptured cysts in the small intestine and enter the lamina propria of the intestinal epithelium. There, they distinguish into macro- and microgametocytes. The Union of male and female gametes results in the creation of oocysts. Oocysts sporulate in the intestinal epithelium and are shed from the host in feces [72].

5.3 Cryptosporidiosis

This protozoal diarrheal disease caused by Cryptosporidium. Both the protozoa and the disease are generally known as “Crypto.” [73]. The probable hazards from meat borne cryptosporidiosis come from ingesting raw and uncooked foods, particularly meat and meat products. The foodborne transmission has been stated following the consumption of certain foods, such as uncooked meat products, raw sausage, offal, chicken salad, and milk. as well as the significance of disease confirmed by some researchers [74–76].

6. Meat borne parasitic diseases

6.1 Taeniasis

Eating raw or undercooked contaminated beef or pork is the primary risk factor for acquiring taeniasis. So, one way to prevent taeniasis is to cook meat at safe temperatures [77].
6.2 Trichinellosis/trichinosis

It occurs when a human eating raw or undercooked meat from animals infected with the protozoa Trichinella. Meat that comprises infective Trichinella larvae; the acid in the stomach dissolves the hard covering of the cyst around the larvae and releases the worms [78].

6.3 Diphyllobothriasis

Humans got infections by eating raw or undercooked fish. Examples of fish include salmon, trout, perch, walleyed pike, and other species of freshwater fish. Some fish such as salmon live in both fresh and saltwater and can harbor Diphyllobothrium larvae. Lightly salted, smoked, or pickled fish also may contain infectious organisms [79]. However, Cooking fish sufficiently, to an internal temperature of at least 145°F (~63°C); or freezing at −4°F (~20°C) or below for 7 days (total time); or at −31°F (~−35°C) or below until solid, and storing at −31°F (~−35°C) or below for 15 hours; or at −31°F (~−35°C) or below until solid and storing at −4°F (~−20°C) or below for 24 hours [13].

6.4 Anisakiasis

Anisakiasis, or herring worm disease, is a parasitic disease caused by nematodes (worms) that attach to the wall of the esophagus, stomach, or intestine. Humans are accidentally infected when hosts are consumed either as raw or inadequately cooked or treated fish/shellfish meals. Therefore, the infection has been directly linked to eating habits [80].

6.5 Capillariasis

When humans ingest raw or undercooked infected fish, larvae may migrate to the intestine and mature into adult worms [13, 81].

6.6 Opisthorchiasis

Liver flukes infect the liver, gallbladder, and bile duct in humans. While most infected persons do not show any symptoms, infections that last a long time can result in acute symptoms and critical disease. Chronic infection may lead to cholangiocarcinoma, a cancer of the bile ducts [13, 82].

6.7 Heterophyiasis

Heterophyiasis is caused by trematode parasites happening in regions where brackish water fish is ingested raw or under inadequately cooked circumstances [83].

6.8 Clinostomiasis (yellow grub disease)

This parasite has a complex life cycle, usually taking mollusks and fishes as intermediate (middle) hosts and birds as final (definitive) hosts. Humans may become the definitive host by ingesting raw or undercooked fish meat infected with the metacercarial stage of this type of parasite [84, 85].
7. Meat borne fungal diseases

Fungi are very common in food because it being ubiquitous. It can spoil large amounts of food and produce hazardous toxins that threaten human health. However, yeasts and mold can grow in a large diversity of food including meat and meat products, which provide a favorable place for their growth [86]. The most significant pathogenic fungi have been isolated from a wide range of foods include the following.

7.1 Aspergilli

Aspergillus contains some species with strains that are the most dangerous, with Aspergillus fumigatus causing the most serious diseases [87].

7.2 Fusarium

Well-known Fusarium mycotoxins are fumonisins, deoxynivalenol, zearalenone, and trichothecenes [88].

7.3 Mucor

Mucor contaminated food constitutes a limited potential health hazard concerning healthy consumers. No specific mycotoxin has been isolated and characterized in Mucor. The results of bioassays did indicate that toxins are present in extracts from certain Mucor species [89].

8. Mycotoxins

8.1 Aflatoxins (AFs)

The name AFs has been subsequent from the combination of “A” for the Aspergillus genus and “f” for the species flavus. AFs are greatly toxic, teratogenic, mutagenic, and carcinogenic compounds, produced as secondary metabolites by fungi belonging to numerous Aspergillus species, chiefly A. flavus and A. parasiticus. Presently, 20 diverse categories of AFs have been recognized, wherein the main ones comprise AFB1, B2, G1, G2, and M1. Fungal species belonging to A. flavus naturally produce AFB1 and AFB2, while A. parasiticus can produce AFG1 and AFG2 in addition to AFB1 and AFB2 [90].

8.2 Fumonisins

It is the secondary metabolites of the Fusarium fungi mostly from Fusarium verticillioides and Fusarium proliferatum on pollute maize and milled maize portions or other processed products [88].

8.3 Ochratoxin a (OTA)

It is produced by Penicillium verrucosum in moderate environments and Aspergillus ochraceus and the rare Aspergillus carbonarius in warm and tropical countries that can pollute crops previous to yield and or more normally through storing [91].
8.4 Patulin (PAT)

Created by fungal species of the genera, *Aspergillus*, *Penicillium*, and *Byssochlamys*, and the most significant Patulin (PAT) producer is *Penicillium* [92].

8.5 Zearalenone (ZEA)

Non-steroidal estrogenic mycotoxin formed by a diversity of *Fusarium* fungi in comfortable and warm countries. ZEA presents a similar structure to estrogen and therefore competes with 17-estradiol in binding to the estrogen receptor. So, it can cause important differences in generative structures and fertility loss in humans and animals [93].

9. Meat borne rickettsial diseases

9.1 Query fever (Q-fever)

Persons get sick by inhalation dust that has been polluted by infected animal milk, urine, feces, and birth products that contain *Coxiella burnetii*. Individuals may get ill with Q fever by consuming contaminated, unpasteurized milk, and dairy products. Infrequently, Q fever has been spread through blood transfusion, from a pregnant woman to her foetus, or through sex [43, 94].

10. Meat preservation and storage

Meat preservation helps to control spoilage by hindering the growth of microbes, it delays spoilage; also reducing enzymatic activity, and avoiding the oxidation of fatty acids that stimulate rancidity, resulting in extends the life of the product; improves product quality. Several factors are affecting the period of meat storage. The physical state of meat acting a role in the number of microbes that can grow on meat, for example, grinding meat increases the surface capacity, releases moisture and nutrients from the muscle fibers, and distributes exterior germs throughout the meat. Chemical properties of meat, such as pH and moisture content, affect the capability of microbes to grow on meat. Usual protecting tissues, such as skin or fat, can prevent microbial pollution, dryness, or other disadvantageous fluctuations. Wrapping meats with paper or protecting plastic films avoids unnecessary moisture loss and microbial pollution. There are several methods for meat preservations [95].

10.1 Chilling/refrigeration

Temperature is the most significant factor in manipulating bacterial growth. Pathogenic bacteria do not grow well in temperatures under 3°C (38°F). So, meat should be stored at temperatures that are as cold as possible. Chilled packing is the most public method of meat preservation. The typical chilled packing life for fresh meats is 5 to 7 days.

10.2 Freezing

Freezer storage is an excellent technique of meat preservation. It is significant to covering frozen meats carefully in wrapping that limits air contact with the meat to avoid moisture loss during packing.
10.3 Meat curing

The commonly used technique of preserving meat before the days of chilling. It is done for communicating specific color and flavor development, as well as the preservative outcome. The main constituents comprise common salt (sodium chloride), sodium nitrate, sodium nitrite, and sugar.

10.4 Meat smoking

Smoking and curing of meat are consistent. Smoke generation is accompanied by the creation of several organic compounds (aldehydes, ketones, organic acids, phenols, etc.) and their concentration products. Phenols act as bacteriostatic; formaldehyde as a bactericidal compound, also informing typical smoky flavor.

10.5 Canning

Canning includes sealing meat in a container and then heating it to destroy all microbes capable of meat and meat products spoilage. Under normal circumstances, canned products can safely be stored at room temperature for an unspecified period.

10.6 Drying

Oldest known technique of meat preservation. Drying removes moisture from meat products, lowers the water activity ($a_w$) significantly so that microbes cannot grow. Freeze-dried meats, dry sausages, and jerky products are all examples of dried meats capable of being stored at room temperature without fast spoilage.

10.7 Irradiation

Irradiation, or radiation, is a pasteurization technique achieved by exposing the meat to amounts of radiation. Irradiated fresh meat products still need cooling and wrapper to prevent spoilage, but the chilled storage life of these products is highly lengthy.

10.8 Fermentation

One early form of food preservation used in meat production is fermentation. Fermentation comprises the addition of confirmed safe bacteria to meat. These fermenting bacteria produce acid as they grow, lowering the pH of the meat and preventing the growth of several pathogenic microbes.

10.9 Vacuum packaging

Oxygen is essential for various bacteria to grow. For this purpose, most meats are vacuum-packaged, which extends the storage life undercooled circumstances to about 100 days. Besides, vacuum packaging reduces the oxidation of unsaturated fatty acids and slows the development of rancid meat.

11. Conclusion

In summary, the main sources of pathogens in meat and meat products are; the animal itself; human handlers; equipment’s in contact, environmental sources or
water used in preparation. Meat and its products have been engaged in many diseases or outbreaks in human consumers which necessity awareness and educational knowledge about causative agents and control hygienic measures. Therefore, strict hygienic precautions must me prevailed during meat handling and preparations.

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References

[1] Boler, D.D. and Woerner, D.R. (2017): What is meat? A perspective from the American Meat Science Association, Animal Frontiers, Volume 7, Issue 4, October 2017, Pages 8-11, https://doi.org/10.2527/af.2017.0436.

[2] O’Connor LE, Gifford CL, Woerner DR, Sharp JL, Belk KE, Campbell WW. Dietary Meat Categories and Descriptions in Chronic Disease Research Are Substantively Different within and between Experimental and Observational Studies: A Systematic Review and Landscape Analysis [published correction appears in Adv Nutr. 2020 Jan 1;11(1):180]. Adv Nutr. 2020;11(1):41-51. doi:10.1093/advances/nmz072.

[3] Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., Picard, B. and Bugeon, J. (2016): How Muscle Structure and Composition Influence Meat and Flesh Quality. The Scientific World Journal, vol. 2016, Article ID 3182746, 14 pages, 2016. https://doi.org/10.1155/2016/3182746.

[4] Obeid R, Heil SG, Verhoeven MMA, van den Heuvel EGHM, de Groot LCPGM, Eussen SJPM. Vitamin B12 Intake from Animal Foods, Biomarkers, and Health Aspects. Front Nutr. 2019; 6:93. Published 2019 Jun 28. doi:10.3389/fnut.2019.00093.

[5] Gómez, I., Janardhanan, R., Ibañez, F.C. and Beriain, M.J. (2020): The Effects of Processing and Preservation Technologies on Meat Quality: Sensory and Nutritional Aspects.

[6] Tessari P, Lante A, Mosca G. (2016): Essential amino acids: master regulators of nutrition and environmental footprint? Sci Rep. 2016; 6:26074. Published 2016 May 25. doi:10.1038/srep26074.

[7] Fayet, F., Flood, V., Petocz, P., & Samman, S. (2013). Avoidance of meat and poultry decreases intakes of omega-3 fatty acids, vitamin B12, selenium and zinc in young women. Journal of Human Nutrition and Dietetics, 27, 135-142. doi:10.1111/jhn.12092.

[8] Theobald, H.E. (2005): Dietary calcium and health. Nutrition Bulletin, first published: 17 August 2005 https://doi.org/10.1111/j.1467-3010.2005.00514.x.

[9] Rouger A, Tresse O, Zagorec M. (2017): Bacterial Contaminants of Poultry Meat: Sources, Species, and Dynamics. Microorganisms. 2017;5(3):50. Published 2017 Aug 25. doi:10.3390/microorganisms5030050.

[10] Zhao, X., Ren, W., Siegel, P.B., Li, J., Wang, Y., Yin, H., Zhang, Y., Lai, S., Shu, G. and Zhu, Q. (2018) Meat quality characteristics of chickens as influenced by housing system, sex, and genetic line interactions, Italian Journal of Animal Science, 17(2), 462-468, DOI: 10.1080/1828051X.2017.1363639.

[11] Abebe, E., Gugsa, G., Ahmed, M. (2020): Review on Major Food-Borne Zoonotic Bacterial Pathogens’, Journal of Tropical Medicine, vol. 2020, Article ID 4674235, 19 pages, 2020. https://doi.org/10.1155/2020/4674235.

[12] Bintsis T. (2017): Foodborne pathogens. AIMS Microbiol. 2017;3(3):529-563. Published 2017 Jun 29. doi:10.3934/microbiol.2017.3.529.

[13] CDC (Centers for Disease Control and Prevention) (2020): Diseases & Conditions A-Z Index . https://www.cdc.gov/diseasesconditions/az/a.html.

[14] Belay, E.D. and Schonberger, L.B. (2005): THE PUBLIC HEALTH IMPACT OF PRION DISEASES. Annu. Rev. Public Health 2005. 26:191-212. doi: 10.1146/annurev.publhealth.26.021304.144536.
[15] Glatzel M, Stoeck K, Seeger H, Lührs T, Aguzzi A. Human Prion Diseases: Molecular and Clinical Aspects. Arch Neurol. 2005;62(4):545-552. doi:10.1001/archneur.62.4.545.

[16] Aldy, J.E. and Viscusi, W.K. (2012): Risk Regulation Lessons from Mad Cows. Foundations and Trends in Microeconomics, Vol. 8, No. 4 (2012) 231-313. DOI: 10.1561/0700000046.

[17] Espinosa, J.C., Morales, M., Herva, M.E. and Torres, j.m. (2006): Transmission of bovine spongiform encephalopathy. FUTURE VIROLOGYVOL. 1, NO. 3. https://doi.org/10.2217/17460794.1.3.393.

[18] Imran, M., Mahmood, S. An overview of human prion diseases. Virol J 8, 559 (2011). https://doi.org/10.1186/1743-422X-8-559.

[19] CDC (Centers for Disease Control and Prevention) (2018): Prevention Measures against BSE Spread.

[20] O’Shea H, Blacklaws BA, Collins PJ, McKillen J, Fitzgerald R. Viruses Associated with Foodborne Infections. Reference Module in Life Sciences. 2019; B978-0-12-809633-8.90273-5. doi:10.1016/B978-0-12-809633-8.90273-5.

[21] Sánchez, G.( 2015): Processing Strategies to Inactivate Hepatitis A Virus in Food Products: A Critical Review. ComprehensiveReviewsinFood Science and FoodSafety , Vol.14. Doi: 10.1111/1541-4337.12154.

[22] Kwon SY. and Lee CH. (2011): Epidemiology and prevention of hepatitis B virus infection. Korean J Hepatol. 2011;17(2):87-95. doi:10.3350/kjhep.2011.17.2.87.

[23] Manns, M.P., Buti, M., Gane, E.D., Pawlotsky, J.M., Razavi, H., Terrault, N. and Younossi, Z. (2017): Hepatitis C virus infection. NATURE REVIEWS | DISEASE PRIMERS VOLUME 3 |

[24] Rizzetto M. (2015): Hepatitis D Virus: Introduction and Epidemiology. Cold Spring Harb Perspect Med. 2015;5(7): a021576. Published 2015 Jul 1. doi:10.1101/cshperspect.a021576.

[25] Kamar N, Dalton HR, Abravanel F, Izopet J. Hepatitis E virus infection. Clin Microbiol Rev. 2014;27(1):116-138. doi:10.1128/CMR.00057-13.

[26] Petrović T. and D’Agostino M. (2016): Viral Contamination of Food. Antimicrobial Food Packaging. 2016:65-79. doi:10.1016/B978-0-12-800723-5.00005-X.

[27] Crawford SE, Ramani S, Tate JE, et al. Rotavirus infection. Nat Rev Dis Primers. 2017; 3:17083. Published 2017 Nov 9. doi:10.1038/nrdp.2017.83.

[28] Shrestha, S., Thakali, O., Raya, S. et al. Acute gastroenteritis associated with Rotavirus A among children less than 5 years of age in Nepal. BMC Infect Dis 19, 456 (2019). https://doi.org/10.1186/s12879-019-4092-2.

[29] Sun, X., Wang, L., Qi, J., Li, D., Wang, M., Cong, X., Peng, R., Chai, W., Zhang, Q., Wang,H., Wen, H., Gao, G.F., Tan ,M. and Duan, Z. (2018): Human Group C Rotavirus VP8’s Recognize Type A Histo-Blood Group Antigens as Ligands. Journal of Virology May 2018, 92 (11) e00442–e00418; DOI: 10.1128/JVI.00442-18.

[30] Tesson, V., Federighi, M., Cummins, E., Mota, J.O., Guillou, S. and Boué, G. (2020): A Systematic Review of Beef Meat Quantitative Microbial Risk Assessment Models. Int. J. Environ. Res. Public Health 2020, 17, 688; doi:10.3390/ijerph17030688.

[31] Almashhadany, D.A.(2021): Isolation, biotyping and antimicrobial susceptibility of Campylobacter isolates
from raw milk in Erbil city, Kurdistan Region, Iraq. Italian Journal of Food Safety (under publishing).

[32] Alaboudi, A.R., Alsawaf, S.D. and Almashhadany, D.A. (1991): Food Hygiene. Mosul University. College of Veterinary Medicine, Mosul, Iraq.

[33] Moxley, R.A., Bargar, T.W., Kachman, S.D., Baker, D.R. and Francis, D.H. (2020): Intimate Attachment of *Escherichia coli* O157:H7 to Urinary Bladder Epithelium in the Gnotobiotic Piglet Model. Microorganisms 2020, 8, 263; doi:10.3390/microorganisms8020263.

[34] Hendriks, A.C.A., Reubsaet, F.A.G., Kooistra-Smid, A.M.D.M. et al. Genome-wide association studies of *Shigella* spp. and Enteroinvasive *Escherichia coli* isolates demonstrate an absence of genetic markers for prediction of disease severity. BMC Genomics 21, 138 (2020). https://doi.org/10.1186/s12864-020-6555-7.

[35] Lim, M.A., Kim, J.Y., Acharya, D., Bajgain, B.B., Park, J.H., Yoo, S.J. and Lee, K.(2020): A Diarrhoeagenic Enteropathogenic *Escherichia coli* (EPEC) Infection Outbreak That Occurred among Elementary School Children in Gyeongsangbuk-Do Province of South Korea Was Associated with Consumption of Water-Contaminated Food Items. International journal of environmental research and public health, 17(9), 3149. https://doi.org/10.3390/ijerph17093149

[36] WHO (World Health Organizaiton) (2019): Food Safety. Available online: https://www.who.int/news-room/fact-sheets/detail/food-safety (accessed on 4 June 2019).

[37] Fleckenstein, J.M. and Kuhlmann, F.M. (2019): Enterotoxigenic *Escherichia coli* Infections. Curr Infect Dis Rep 21, 9 (2019). https://doi.org/10.1007/s11908-019-0665-x

[38] Okhuysen, P. C. and DuPont, H. L. (2010). Enteroaggregative *Escherichia coli* (EAEC): A Cause of Acute and Persistent Diarrhea of Worldwide Importance. The Journal of Infectious Diseases, 202(4), 503-505. doi:10.1086/654895.

[39] Almashhadany, D.A., Abdul-Rahman Shater, A.R., Ba-Salamah, H.A. and Abd Algalil, F.M. (2018): Prevalence of *Listeria monocytogenes* in Human in Dhamar Governorate/ Yemen. Journal of Medical and Pharmaceutical Sciences Issue (1), Volume (2). DOI: 10.26389/AJSRP.F181217.

[40] Ranasinghe, R.A.S.S., Satharasinghe, D.A., Tang, J.Y.H., Rukayadi, Y., Radu, K.R., New, C.Y., Son, R. and Premarathne, J.M.K.K. (2021): Persistence of *Listeria monocytogenes* in food commodities: foodborne pathogenesis, virulence factors, and implications for public health. Food Research 5 (1) (2021) 1-16. DOI: https://doi.org/10.26656/fr.20175(1).199.

[41] Almashhadany, D. A. and Osman, A. A. (2019). Isolation, Serotyping, and Antibiogram of Salmonella Isolates from Raw Milk Sold at Retail Vending in Erbil City, Iraq. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies, 76(2), 116-122.

[42] Heredia, N. and García, S. (2018): Animals as sources of food-borne pathogens: A review. Anim Nutr. 2018;4(3):250-255. doi:10.1016/j.aninu.2018.04.006.

[43] PHAC (Public Health Agency of Canada) (2020): A-Z infectious diseases - Canada.ca. Infectious diseases. https://www.canada.ca/en/public-health/services/infectious-diseases.html.

[44] Ranjbar, R.and Farahani, A. (2019): *Shigella*: Antibiotic-Resistance Mechanisms And New Horizons For
[45] Al-Dahmoshi, H.O.M., Al-Khafaji, N.S.K., Al-Allak, M.H., Salman, W.K. and Alabbasi, A.H. (2020): A review on shigellosis: Pathogenesis and antibiotic resistance. Drug Invention Today | Vol 14 • Issue 5 • 2020.

[46] Nelson EJ, Harris JB, Morris JG Jr, Calderwood SB, Camilli A. (2009): Cholera transmission: the host, pathogen and bacteriophage dynamic. Nat Rev Microbiol. 2009;7(10):693-702. doi:10.1038/nrmicro2204.

[47] Dinede G, Abagero A, Tolosa T. (2020): Cholera outbreak in Addis Ababa, Ethiopia: A case-control study. PLoS One. 2020;15(7): e0235440. Published 2020 Jul 2. doi: 10.1371/journal.pone.0235440

[48] Gupta, V., Gulati, P., Bhagat, N., Dhar, M. S., & Virdi, J. S. (2014). Detection of Yersinia enterocolitica in food: an overview. European Journal of Clinical Microbiology & Infectious Diseases, 34(4), 641-650. doi:10.1007/s10096-014-2276-7.

[49] Chlebicz, A. and Slizewska, K. (2018): Campylobacteriosis, Salmonellosis, Yersiniosis, and Listerosis as Zoonotic Foodborne Diseases: A Review. Int. J. Environ. Res. Public Health 2018, 15, 863; doi:10.3390/ijerph15050863.

[50] Almashhadany, D.A. (2019): The significance of milk ring test for identifying Brucella antibodies in cows and buffaloes’ raw milk at Erbil governorate, Kurdistan region, Iraq. Iraqi Journal of Veterinary Sciences, Vol. 33, No. 2, 2019 (395-400). DOI: 10.33899/ijvs.2019.163085.

[51] Almashhadany, D.A. (2009): Serological Study on Brucellosis in Sheep and Goats in Thamar Province, Yemen. Egypt. J of Appl. Sci., 24 (3): 28-38.

[52] Almashhadany, D.A. (2018): Zoonotic Diseases / Part Two / Bacterial Zoonoses 1- Brucellosis. LAP LAMBERT Academic Publishing (October 12, 2018) ISBN-10: 3659823023.

[53] Almashhadany, D. A. (2014): Prevalence of Brucellosis in Human and Camels in Thamar Province / Yemen. J. Saudi Soc. For Agric. Sci , Vol 13(1a): 108-132.

[54] Almashhadany, D.A. (2018): The Utility of MRT to Screen Brucellosis among Ewe and Nanny Goats Milk in Erbil Governorate / Kurdistan Region / Iraq. IJBAPAS, September, 2018, 7(9): 1786-1802. https://doi.org/10.31032/IJBAPAS/2018/7.4551.

[55] Hashimi, M.H., Hashimi, R. and Ryan, Q. (2020): Toxic Effects of Pesticides on Humans, Plants, Animals, Pollinators and Beneficial Organisms. APRJ, 5(4): 37-47, 2020; Article no. APRJ.59338. DOI: 10.9734/APRJ/2020/v5i430114.

[56] Silva, C.C.P., Zannin, M., Rodrigues, D.S., Santos, C.R., Correa, I.A. and Junior, V.H. (2010): Clinical and Epidemiological Study of 27 Poisonings Caused by Ingesting Puffer Fish (Tetrodontidae) in the States of Santa Catarina and Bahia, Brazil. Rev. Inst. Med. trop. S. Paulo, 52(1):51-55, January–February, 2010. doi: 10.1590/S0036-46552010000100010.

[57] Wells, K., Butterworth, A. and Richards, N. (2020): A review of secondary pentobarbital poisoning in scavenging wildlife, companion animals and captive carnivores. J Vet Forensic Sci, jvfs.net, January 2020, Vol. 1, No. 1.

[58] Petersen L.E., Kellermann M.Y., Schupp P.J. (2020): Secondary Metabolites of Marine Microbes: From Natural Products Chemistry to
Chemical Ecology. In: Jungblut S., Liebich V., Bode-Dalby M. (eds) YOUMARES 9 - The Oceans: Our Research, Our Future. Springer, Cham. https://doi.org/10.1007/978-3-030-20389-4_8.

Abdulmumeen, H.A. Risikat, A.N. and Sururah, A.R. (2012): Food: Its preservatives, additives and applications. International Journal of Chemical and Biochemical Sciences, 1(2012): 36-47. DOI: 10.13140/2.1.1623.5208.

Almashhadany D.A. (2020): Monitoring of antibiotic residues among sheep meats at Erbil city and thermal processing effect on their remnants. Iraqi Journal of Veterinary Sciences, Vol. 34, No. 2, 2020 (217-222) 217. DOI: 10.33899/ijvs.2019.125814.1161.

CDC (Centers for Disease Control and Prevention) (2017): National Center for Emerging and Zoonotic Infectious Diseases (2017): How Food Gets Contaminated - The Food Production Chain.

Watari, T., Tachibana, T., Okada, A., Nishikawa, K., Otsuki, K., Nagai, N., Abe, H., Nakano, Y., Takagi, S. and Amano, Y. (2020): A review of food poisoning caused by local food in Japan. J Gen Fam Med. 2020; 00:1-9. DOI: 10.1002/jgf2.384.

Jessberger, N., Dietrich, R., Granum, P.E. and Märtlbauer, E. (2020): The Bacillus cereus Food Infection as Multifactorial Process. Toxins 2020, 12, 701; doi:10.3390/toxins12110701.

Gharib AA, El-Hamid MIA, El-Aziz NKA, Yonan EY, Allam MO (2020). Bacillus cereus: Pathogenicity, viability and adaptation. Adv. Anim. Vet. Sci. 8(s1): 34-40. DOI | http://dx.doi.org/10.17582/journal.aavs/2020/8.s1.34.40.

Tewari A, Abdullah S. Bacillus cereus food poisoning: international and Indian perspective. J Food Sci Technol. 2015 May;52(5):2500-11. doi: 10.1007/s13197-014-1344-4. Epub 2014 Apr 13. PMID: 25892750; PMCID: PMC4397285.

Zeighami, H., Nejad-dost, G., Parsadadian, A., Daneshamouz, S. and Haghi, F. (2020): Frequency of hemolysin Bl and non-hemolytic enterotoxin complex genes of Bacillus cereus in raw and cooked meat samples in Zanjan, Iran. Toxicology Reports 7 (2020) 89-92. https://doi.org/10.1016/j.toxrep.2019.12.006.

Gaware, V.M., Kotade, K.B., Dolas, R.T., Dhamak,K.B., Somawanshi, S.B. and Nikam, V.K. (2011): Botulism Foodborne Disease: A Review. J Chem. Pharm. Res., 2011, 3(1):84-92.

Kadariya J, Smith TC, Thapaliya D. (2014): Staphylococcus aureus and staphylococcal food-borne disease: an ongoing challenge in public health. Biomed Res Int. 2014; 2014:827965. doi:10.1155/2014/827965

Abril, A.G., Villa, T.G., Barros-Velázquez, J., Cañas,B., Sánchez-Pérez, A., Calo-Mata, P. and Carrera, M. (2020): Staphylococcus aureus Exotoxins and Their Detection in the Dairy Industry and Mastitis. Toxins 2020, 12, 537; doi:10.3390/toxins12090537.

Almashhadany, D.A. (2020): ELISA-based monitoring of Toxoplasma gondii among retail sheep meat in Erbil Governorate, Kurdistan region, Iraq. Malaysian Journal of Microbiology, Vol 16(3) 2020, pp. 229-234. DOI: http://dx.doi.org/10.21608/mjm.190571.

Almashhadany, D.A. (2020): Survey of Toxoplasma gondii antibodies in retail red meat samples in Erbil governorate, Kurdistan Region, Iraq. SVU-IJVS, 3 (2): 51-59. DOI: 10.21608/svu.2020.31892.1057.
[72] Fayer R, Esposito, D.H. and Dubey, J.P. (2015): Human Infections with Sarcocystis Species. Clinical Microbiology Reviews Feb 2015, 28 (2) 295-311; DOI: 10.1128/CMR.00113-14.

[73] Ahmed, S.A. and Karanis, P. (2020): Cryptosporidium and Cryptosporidiosis: The Perspective from the Gulf Countries. Int. J. Environ. Res. Public Health 2020, 17, 6824; doi:10.3390/ijerph17186824.

[74] Baxby, D. and Hart, C.A. (1986): The incidence of cryptosporidiosis: a two-year prospective survey in a children’s hospital. J. Hyg., Carnb. (1986), 96, 107-111.

[75] Feng Y. and Xiao L. (2017): Molecular Epidemiology of Cryptosporidiosis in China. Front Microbiol. 2017; 8:1701. Published 2017 Sep 6. doi:10.3389/fmicb.2017.01701.

[76] Hunter, P.R. and Nichols, G. (2002): Epidemiology and Clinical Features of Cryptosporidium Infection in Immunocompromised Patients. CLINICAL MICROBIOLOGY REVIEWS, 0893-8512/02/$04.000 DOI: 10.1128/CMR.15.1.145-154.2002. Jan. 2002, p. 145-154.

[77] Gebrie, M. and Engdaw, T.A. (2015): Review on Taeniasis and Its Zoonotic Importance. European Journal of Applied Sciences 7 (4): 182-191, 2015. DOI: 10.5829/idosi.ejas.2015.7.4.96169.

[78] Bruschi, F. and Murrell, K.D. (2002): New aspects of human trichinellosis: the impact of new Trichinella species. Postgrad Med J. 2002;78(915):15-22. doi:10.1136/ pmj.78.915.15.

[79] Dick, T. A. (2007). Diphyllobothriasis: The Diphyllobothrium latum Human Infection Conundrum and Reconciliation with a Worldwide Zoonosis. Food-Borne Parasitic Zoonoses, 151-184. doi:10.1007/978-0-387-71358-8_4.

[80] Aibinu, I.E., Smooker, P.M. and Lopata, A.L. (2019): Anisakis Nematodes in Fish and Shellfish- from infection to allergies. International Journal for Parasitology: Parasites and Wildlife, Volume 9, August 2019, Pages 384-393. https://doi.org/10.1016/j.ijppaw.2019.04.007.

[81] Fuehrer, HP., Igel, P. and Auer, H. (2011): Capillaria hepatica in man—an overview of hepatic capillariosis and spurious infections. Parasitol Res 109, 969-979 (2011). https://doi.org/10.1007/s00436-011-2494-1.

[82] Murell, K.D. and Pozio, E. (2017): The Liver Flukes: Clonorchis sinensis, Opisthorchis spp, and Metorchis spp. In: J.B. Rose and B. Jiménez-Cisneros, (eds) Global Water Pathogen Project. http://www.waterpathogens.org (Robertson, L (eds) Part 4 Helminths). http://www.waterpathogens.org/book/liver-flukes

[83] Chai, J.Y. and Jung, B.K. (2017): Fishborne zoonotic heterophyid infections: An update. Food and Waterborne Parasitology, Volumes 8-9, 2017, Pages 33-63. https://doi.org/10.1016/j.fawpar.2017.09.001.

[84] Li, F., Liu, X.H., Ge, H.L., Xie, C.Y., Cai, R.Y., Hu, Z.C., Zhang, Y.G. and Wang, Z.J. (2018): The discovery of Clinostomum complanatum metacercariae in farmed Chinese sucker, Myxocyprinus asiaticus. Aquaculture, Volume 495, 1 2018, Pages 273-280. https://doi.org/10.1016/j.aquaculture.2018.05.052.

[85] Menconi, V., Manfrin, C., Pastorino, P., Mugetti, D., Cortinovis, L., Pizzul, E., Pallavicini, A. and Prearo, M. (2020): First Report of Clinostomum complanatum (Trematoda: Digenea) in European Perch (Perca fluviatilis) from
an Italian Subalpine Lake: A Risk for Public Health?. Int. J. Environ. Res. Public Health 2020, 17, 1389; doi:10.3390/ijerph17041389.

[86] Alshannaq A. and Yu JH. (2017): Occurrence, Toxicity, and Analysis of Major Mycotoxins in Food. Int J Environ Res Public Health. 2017;14(6):632. Published 2017 Jun 13. doi:10.3390/ijerph14060632.

[87] Paterson RRM. (2019): Editorial for the Special Issue: Human Pathogenic Filamentous Fungi from Food/Water and Mycotoxins from Water. Microorganisms 2019, 7(1), 21; https://doi.org/10.3390/microorganisms7010021.

[88] Munkvold G.P. (2017): Fusarium Species and Their Associated Mycotoxins. In: Moretti A., Susca A. (eds) Mycotoxigenic Fungi. Methods in Molecular Biology, vol 1542. Humana Press, New York, NY. https://doi.org/10.1007/978-1-4939-6707-0_4.

[89] Benedict K, Chiller TM. and Mody RK. (2016): Invasive Fungal Infections Acquired from Contaminated Food or Nutritional Supplements: A Review of the Literature. Foodborne Pathog Dis. 2016;13(7):343-349. doi:10.1089/fpd.2015.2108.

[90] Kumar P, Mahato DK, Kamle M, Mohanta TK, Kang SG. (2017): Aflatoxins: A Global Concern for Food Safety, Human Health and Their Management. Front Microbiol. 2017; 7:2170. Published 2017 Jan 17. doi:10.3389/fmicb.2016.02170.

[91] Bui-Klimke TR. and Wu F. (2015): Ochratoxin A and human health risk: a review of the evidence. Crit Rev Food Sci Nutr. 2015;55(13):1860-1869. doi:10.1080/10408398.2012.724480.

[92] Erdoğan, A., Ghimire, D., Gürses, M., Çetin, B., Baran, A. (2018): Patulin Contamination in Fruit Juices and Its Control Measures. European Journal of Science and Technology No. 14, pp. 39-48, December 2018. DOI: 10.31590/ejosat.434750.

[93] Hueza IM, Raspantini PC, Raspantini LE, Latorre AO, Górniak SL. (2014): Zearalenone, an estrogenic mycotoxin, is an immunotoxic compound. Toxins (Basel). 2014;6(3):1080-1095. Published 2014 Mar 13. doi:10.3390/toxins6031080.

[94] Porter DL, Levine BL, Kalos M, Bagg A, June CH. Chimeric antigen receptor-modified T cells in chronic lymphoid leukemia. N Engl J Med. 2011 Aug 25;365(8):725-33. doi: 10.1056/NEJMoa1103849. Epub 2011 Aug 10. Erratum in: N Engl J Med. 2016 Mar 10;374(10):998. PMID: 21830940; PMCID: PMC3387277.

[95] Cenci-Goga, B.T., Iulietto, M.F., Sechi, P., Borgogni, E., Karama, M. and Grispoldi, L. (2020): New Trends in Meat Packaging. Microbiol. Res. 2020, 11, 56-67; doi:10.3390/microbiolres11020010.