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# 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 warranty 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 warranty 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* (EA<sub>g</sub> EC)

Enteroaggregative *E. coli* (EA<sub>g</sub> 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 Gram positive 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. softenburgh*, *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 parahaemolyticus*

*V. parahaemolyticus* 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), cytotoxin 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 Diphyllbothriasis

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 *Diphyllbothrium* 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 [ $\sim 63^{\circ}$  C]; or freezing at  $-4^{\circ}$ F ( $-20^{\circ}$ C) or below for 7 days (total time); or at  $-31^{\circ}$ F ( $-35^{\circ}$ C) or below until solid, and storing at  $-31^{\circ}$ F ( $-35^{\circ}$ C) or below for 15 hours; or at  $-31^{\circ}$ F ( $-35^{\circ}$ C) or below until solid and storing at  $-4^{\circ}$ F ( $-20^{\circ}$ 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 *Byssoschlamys*, 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 ( $aw$ ) 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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