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Overview of biological hazards associated with the consumption of the meat products

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Abstract

The consumption of meat products is an important source of protein for humans world-wide. This consumption is increasing around the world, so do concerns and challenges to meat hygiene and safety. The biological hazards associated with the consumption of meat products include pathogenic bacteria, viral pathogens (viruses and prions) and parasites. The occurrence of the microbial hazards in the meat products is unavoidable because the microorganisms are present on animals and in their environment. The major goal of the industry, of the public health and the regulatory authorities is to control the pathogenic microorganisms and improve the meat product safety. The objective of this review is to describe the microbial hazards which are associated with the consumption of raw and meat products. The scientific information presented here should be useful in the management of the meat products safety and in the control strategies at processor, distributor, packer, retailer and consumer.

Keywords: Raw meat, Meat products, Biological hazards

1. Introduction

Meat is an excellent concentrated nutrients source: protein with high digestibility score, essential amino acids, fatty acids, vitamins and minerals, previously considered essential to optimal human growth and development [1]. Raw meat represents the main ingredient for most meat products [2]. The meat products are acquiring a prominent position over the last years due to their high nutritional value and the important source of animal proteins for human and distinct flavour [3-6]. According to the processing technology applied, the meat products consist of uncooked processed meat products, cooked uncured meat and meat products, raw cured products, cooked cured products, commercially sterile meat products, low and intermediate a_w (water activity) products [7].

The majority of illness originates from raw meat rather than processed meat products [7]. Raw meat are liable to harbour various microorganisms during the pre-slaughter husbandry practices, handling during slaughtering, evisceration and processing, processing, distribution and storage, preservation methods, type of packaging and handling, as well as by consumption habits [1, 3-5]. The processed meat products no have longer the appearance or perishability of fresh products due to their formulation and treatment which provide a range of preservation system [7]. The stability and safety of processed meat products relies on the interaction of their microflora with the nutrients and preservations factors (processing, storage temperatures, a_w, *p*H, chemical agents and packaging. The thermal processing destroys a fraction of the initial microflora, inhibits or inactivates another part and allows growth of the remainder [7].

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The metabolic activity of growing spoilage microbial fraction results in loss of quality and shortening of shelf-life with economic losses, while the growth of pathogens may cause safety problems [4, 7-9]. Knowledge about the meat products' microflora is needed for effective management of the meat products' safety and in the control strategies at processor, distributor, packer and retailer and the consumer's safety. The present study is planned out to describe the microbial hazards which are associated with the consumption of raw and meat products.

2.Hazard associated with meat products

The hazards that compromise the safety of meat products are of physical, chemical or biological nature [4]. The biological hazards usually originate from raw meat and from salt; spices and other ingredients and natural casings include pathogenic bacteria, viruses, prions and parasites [4, 7, 10]. The initial microflora of the carcass surface is a significant sources of raw and meat products contamination [7, 9]. Although the muscles of healthy animals do not contain microorganisms (or contain very few microorganisms), the carcass surfaces are exposed to varying degrees of contamination during of the long chain of slaughtering, transport and storage [4, 9, 11-13]. The hygiene conditions of abattoir and its surrounding environment are important factors contributing in the microbial contamination of the meat [11]. The abattoir environment, the transport and the storage conditions not only contaminate the meat, but also enhance the growth of various types of spoilage and pathogenic microorganisms [11]. The growth of microorganisms depends on the hygiene practices, the automation level, the decontamination technologies used and the cleaning practices [9]. Other potential sources of microbial raw and processed meat contamination include the processing environment, storage environment, equipments, utensils and workers contributing through cross-contamination [4, 9, 11, 12, 14, 15]. The spatial distribution of microbial contaminants on meat and processed meat has been hypothesized to be not homogeneous [3]. In fact, some operations such as manipulation, slicing and transferring in packages can alter the initial microflora of meat and provide additional contamination in the handling points [9]. Raw meat used in the manufacture of meat products requires a higher microbiological quality if processing technologies are used as these have a limited ability to reduce level of pathogens in the product [7].To keep the microbial load of raw meat, the food safety requirements should be followed strictly in accordance with HACCP (Hazard analysis critical control point) [11]. Modern techniques, such as: time/temperature integrators, combination preservation system and cleaning and disinfections techniques are widely used to minimize the impact on meat product safety and reduction the microbiological risks to both producers and consumers [7, 16].

3.Spoilage microorganisms

Meat is a food that can be spoiled extremely quickly. There are many groups of microorganisms which are potentially contributing to meat spoilage [7, 17]. They belong to microbial genera of both Gram-negative and Gram-positive bacteria, such as: *Pseudomonas* spp., *Enterobacteriaceae* spp., *Acinetobacter* spp., *Aeromonas* spp., *Alcaligenes* spp., *Moraxella* spp., *Flavobacterium* spp., *Staphylococcus* spp., *Micrococcus* spp., *Serratia* spp., lactic acid bacteria, *Clostridium* spp., *Bacillus* spp., coliforms, yeasts and molds also [4, 5, 7, 17-20]. The spoilage microorganisms are commercially significant in meat products when their numbers reach around 10^7/g resulting in sensory changes limiting acceptability and self-life [7]. Species of *Pseudomonas, Acinetobacter, Alcaligenes* and *Moraxella* are particularly involved in the spoilage of unpreserved meat products stored at chill temperatures (4÷10°C) [7, 17, 21]. *Enterobacteriaceae* species are frequently present on refrigerated meat product [5]. *Enterobacteriacea* and *Pseudomonas* were more prevalent on modified atmosphere packed meat (especially on pork) [5]. The lactic acid bacteria, *Enterococci*, *Micrococci* and yeasts are predominately found in raw, salted-cured products such as corned beef, uncooked hams and bacon due to their resistance to curing salts [5, 7]. The spoilage bacteria are generally harmless, but they spoil the food product and it becomes sensory undesirable for the customer to purchase [18]. The spoilage process consists of lipids' oxidation, proteins' degradation and the loss of other valuable molecules [5].

The breakdown of fats, complex proteins, peptones, polypeptides and carbohydrates of meat results in the development of off-odours, off-flavour, change of colour, slim formation, gas production, and *p*H's change [5, 7, 18, 19, 22, 23]. The favourable *p*H's value for the growth of spoilage bacteria for meat is in the range of 5.5÷7.0. Slime's formation, structural components' degradation, off-odours and appearance change were found in meat as a result of microbial growth within this *p*H range [5]. The pre-slaughter of livestock and post-slaughter handling of meat play an important role regarding of meat quality [5].The muscles' glycogen content is reduced when animal is exposed to pre-slaughter stress which changes the *p*H of the meat, to higher or lower levels, depending on the production level of lactic acid [5]. Higher levels of *p*H (6.4÷6.8) result in DFD (Dark, Firm and Dry) meat, while the lower levels of *p*H than normal ultimate value of 6.2 lead to PSE (Pale, Soft and Exudative) meat providing a favourable medium for the growth of microorganisms [5]. The raw meat, the initial microflora, the alterations during processing, the added ingredients, and the storage temperature, time, and gas atmosphere, among other factors, define the rate and extent of meat products spoilage [24].

4.Pathogens bacteria

Meat is the main sources of foodborne diseases in humans [25, 26]. The principal pathogens which can be transmitted through meat include: *Bacillus cereus*, *Campylobacter* spp., *Clostridium perfringens*, *Clostridium botulinum*, *Escherichia coli*, *Lysteria monocytogenes*, *Salmonella* spp., *Staphylococcus aureus, Yersinia enterocolitica, Aeromonas*, *Brucella*, *Clostridium difficile*, *Enterobacter* and *Shigella* [4, 25-31]. *B. cereus* can pose a serious hazard to the meat industry, since a mild heat treatment cannot guarantee its complete inactivation [32]. This microorganism causes intoxication or toxi-infection after spores' germination and multiplication in meat foods [4, 33]. Most cases of infection with *Campylobacter jejuni* and *Campylobacter coli* are attributed to handling and consumption of raw poultry products, with cross-contamination being very important [4, 30]. *C. botulinum* and *C. perfringens* may become problematic when the meat product is temperature abused and allows growth of this pathogen. Spores of *Clostridium perfringens* become activated by heat treatment and upon time–temperature abuse they germinate, multiply and produce enterotoxin, which is released during sporulation in the intestine, leading to illness. Spores of *Clostridium botulinum*, after activation and germination, grow in anaerobic or micro-aerobic conditions and produce deadly neurotoxins in the meat food [4]. Potential sources of *Clostridium* include beef, pork and poultry products [4, 34]. *Escherichia coli* are harmless inhabitants of the humans' gastrointestinal tract and other warm-blooded animals [4]. From the gastrointestinal tract, it contaminates the animals, the soil and water, and consequently the meat products [4]. *Escherichia* species are of the most concern in undercooked poultry meat products, especially non-intact meat products, such as beef [4, 31]. The infection with *L. monocytogenes* is usually associated with ready-to-eat pork or poultry-meat products, or reheated meat products, partially cooked pork products and poultry foods contaminated after processing [4, 30]. *The Listeria*'s growth occurs during prolonged storage even at refrigeration temperatures [4]. This pathogen is sensitive to normal cooking but it may contaminate the meat products after heating, when exposed to the environment during cutting, slicing and repackaging [4]. *Listeria* is ubiquitous in the environment and may be found in many animals, in floors, walls, drains, condensed and standing water, and food residues on equipment in meat processing environments [4]. Meat and poultry products are considered major sources of *Salmonella* [4]. The infection with *Salmonella* is associated with the consumption of processed pork or poultry-meat products (ready-to-eat or to be reheated) and partially cooked pork products [30, 31]. Meat may be contaminated with *Salmonella* throughout the slaughtering, dressing and boning process, starting with the carcass during knife incision for hide removal [4]. *S. aureus* has a huge impact on animals' health and welfare and causes major economic losses in livestock's production [35]. It may become a problem in processed meat products, especially ready-to-eat pork products, where it is introduced usually by humans [4, 30]. If meat product is temperature abused, this pathogen is able to produce heat-resistant enterotoxins [4]. *Y. enterocolitica* can

be transmitted with foods contaminated through water, including partially cooked, reheated pork products or improper cooling products [4, 30]. *Shigella* can be introduced by humans in ready-to-eat meat products [4]. The pathogen control efforts should include: good production practices on the farm, slaughtering only of healthy animals, processing of carcasses under hygienic conditions, use of decontamination intervention strategies to reduce microbial levels on carcasses and fresh meat, processing (time/temperature, smoking and/or cooking), drying, fermentation, acidification, use of antimicrobials (salt, nitrate, nitrite, sugar), maintenance of the cold chain during distribution, and proper storage and preparation by food service and consumers [36].

5.Viral pathogens (viruses, prions)

The viruses including Norovirus, hepatitis A, enteroviruses and others cause the highest number of mild foodborne gastroenteritis cases [4, 37]. The viruses are unable to grow in foods and are generally sensitive to cooking [4]. The heat represents the most efficient treatment to inactivate of the viruses [37]. Temperatures ≥ 90 °C are effective in inactivating the most heat resistant enteric viruses [37]. Transmission of the viruses is mostly associated with poor hygiene, inadequate cooking or cross-contamination before products' consumption [4]. Their control in ready-to-eat meat products should be through proper hygienic practices of food service workers [4]. Transmissible spongiform encephalopathy or prion diseases are major animal health problems in the 1990s [4]. These are rare fatal neurodegenerative diseases of animals and humans [38]. The preventive controls consist of control of the risk materials: brain, eyes, spinal cord, small intestines, during slaughter of all cattle or those exceeding 30 months of age; increasing process controls for material obtained with advanced meat recovery systems and banning use in food products of mechanically separated meat [4].

6.Parasites

The parasites that can be transmitted through pork include *Taenia solium*, *Trichinella spiralis*, *Sarcocystis suihominis* and *Toxoplasma gondii*, resulting in helminthiasis (taeniasis, trichinosis, sarcocystosis and toxoplasmosis) [4, 39, 40]. Beef can be the source of *T. saginata* cysticercus, *Sarcocystis hominis*, *G. Duodenalis* and *C. parvum*. Poultry can transmit *Cryptosporidium* and *Toxoplasma gondii* [4]. *Trichinella* may also be transmitted through game meat. Inactivation of parasites is achieved through proper cooking, freezing, salting, chemical treatments and ionizing radiation of meat and meat products [4].

7.Conclusions

Raw meat and meat products are liable to harbour various microorganisms (bacteria, viral pathogens, parasites) during of the long chain of slaughtering, transport and storage, processing environment, storage environment, equipments, utensils and workers. The management of meat products safety risks should be based on good production practices on the farm, slaughtering only of healthy animals, processing of carcasses under hygienic conditions, using of decontamination strategies to reduce microbial levels on carcasses and fresh meat, processing, drying, fermentation, using of antimicrobials, maintenance of the cold chain during distribution, and proper storage and preparation by food service and consumers.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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