Introduction

Meat is a highly perishable food commodity because it provides a suitable substrate for a wide variety of micro-organisms (bacteria, yeasts, and mould). Moreover, since nutrients and moisture are present in sufficient quantity, pH is close to neutral, and the redox potential at the surface is higher than at the core, meat is a good culture medium. Compounds such as glucose, glycogen and amino acids are readily available for use and can sustain the growth of indigenous flora up to $10^9$ cells per cm$^2$ [1-2]. In whole muscle meat, microbial growth occurs on the surface because edible tissues of healthy animals are either sterile or contain very low microbial populations [3]. In ground meat, micro-organisms are introduced into the mass and grow, but are confined and do not spread as easily as in a liquid matrix.

Meat carcasses get contaminated by organisms from the hide/skin of the animal, gut content, workers’ hands, and the slaughter environment at a level of up to $10^8$ bacteria/cm$^2$ after dressing [2]. In meat, the initial microflora is mainly mesophilic and the prevailing micro-organisms will vary with storage conditions (Table 1). Under refrigeration temperature, a psychrotrophic microflora develops and micro-organisms grow in number. Under aerobic conditions, *Pseudomonas* spp. prevail and constitute 50 to 90% of the overall microbial population because of a better growth rate than the other micro-organisms. *Enterobacteriaceae* prevail under poor refrigeration (10°C) conditions and spoil the meat [2, 4-5]. When the pH is higher than 5.5, the growth of *Enterobacteriaceae, Brochothrix thermosphacta* and the psychrotrophic pathogen *Yersinia enterocolitica* is favoured, such as in fat tissue and in meat from animals that were stressed before they were slaughtered. In the latter case, post-mortem production of lactic acid is reduced, because the glycogen reserve is depleted [2, 6].

Many pathogenic micro-organisms (i.e., essentially bacteria) can be found and can grow on meat and meat products. In North America, roughly one-third of the food-borne outbreaks has been linked to the consumption of contaminated meats. The pathogenic strains that present the greatest risk with respect to meat- and poultry-borne diseases are *Salmonella* spp., *Campylobacter* spp., verotoxigenic *Escherichia coli*, *Listeria*
Intrinsic factors (occurring naturally in food; e.g., nature of constituents, pH and buffering capacity, redox potential, etc.) and extrinsic factors (applied to food systems; e.g., temperature, preservatives, modified atmosphere, etc.) influence microbial growth to various extents. The use of these extrinsic factors in meat processing, especially in combination, has increased, in some instances, meat shelf life from a few days to a few months. The use of multiple antimicrobial systems is referred to as the “hurdle technology.” Heat was soon recognized as an effective means of improving shelf life. Meat and fish preserved better when they are cooked, because the microbial population is reduced through the killing effect of heat. Other means used in meat preservation include cold temperature, modified atmosphere packaging, and chemical preservatives (e.g., nitrite).

1. Historical use of meat fermentation

Fermentation has been used as a form of food preservation since biblical times. It is now known that the antimicrobial activity of the fermenting microflora is responsible for this effect, which includes the production of inhibitory substances, such as organic acids, CO₂ gas, and antimicrobial peptides (i.e., bacteriocins; [8-9]). Hence, undesirable micro-organisms are controlled by creating an environment that is unfavourable to their survival. The ultimate efficacy of microbial control and quality in fermented meat hinges on a combination of antimicrobial hurdles (e.g., low pH, low aw, salt and nitrite concentration, etc).

Before the development of specialised equipments to control the fermentation environment, climatic conditions were important for proper fermentation and drying in order to secure the production of safe and palatable products. Although fermented meat has been produced in many countries around the world, the mountainous regions of Spain and Italy were particularly well suited because of their low relative humidity. In Hungary, winter provided the proper conditions for meat fermentation and drying [10].

Proper fermentation conditions are critical for lactic acid bacteria (LAB) to prevail over the pseudomonads and the Enterobacteriaceae population, and to reduce the pH by the formation of lactic acid from glucose in the meat or added to it. The first attempts to improve the development of the desirable LAB population consisted in the inoculation, up to 5%, of the fresh batter with a previous one that had led to a product of desirable quality, a process known as “back-slopping”. However, a sound food-fermentation industry cannot rely on such an opportunistic process. The studies on meat microbiology and the development of commercial starter cultures, in the beginning of the 1900s, secured a sustainable industry by assuring product quality and process reliability [10].

After fermentation, the product can be dried to different degrees, or not, as it is the case in spreadable German products such as Teewurst, Braunschweig and Mettwurst. Smoking and, to a lesser extent, cooking (e.g., summer sausage) are used as adjunct treatments to enhance organoleptic properties, shelf life and safety [10]. However, North American regulations stipulate that for a meat product to be shelf stable, it must comply with one of the following conditions: a) a pH equal or smaller than 4.6, or b) an aw equal or smaller than 0.85, or c) a combination of pH equal or smaller than 5.3, aw equal or