Meat Packaging

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The term ‘packaging’ refers to the technological intervention aimed at the protection of food from a variety of factors, which provokes the product detriment. Packaging is considered as one of the most interesting technological aspects and a constantly evolving issue in food production.

Keywords: packaging ; vacuum ; MAP ; meat spoilage

1. Introduction

Food security and food safety are two sides of the same coin. From one side, we have to answer to the pressing query: “How we will feed an extra two billion people by the middle of this century?” [1][2], on the other side, foodborne illness is still a current, costly threat for human health and each year, more than 9 million foodborne illnesses are caused by a major pathogen in the United States [3]. In order to face these challenges, one of the several approaches carried out is the constant improvement and updating of food packaging. Packaging is defined as the container which preserves, maintains and protects products from the environment, advertises, makes them user-friendly and easy sealable [4]. An effective food packaging technology should maintain product characteristics at the point of sale, producing less food waste and environmental impact [5].

Since ancient times, man has endeavoured to preserve the procured food, trying to avoid alterations and contaminations which could make it uneatable [6]. From 6000 BC, an empirical “primitive vacuum” was introduced, eliminating the air from holes and subsequently from containers, according to the possibility of the period. Dated back to the early 90s, other studies revealed how an increase in CO_2 concentration could extend the shelf-life of food. From those findings, the method of modifying the percentages of air constituents modernised the food preservation [6].

These considerations introduce the fundamental concept in the context of food production: shelf-life. The shelf-life of a product is, under certain conditions of storage, the time limit within the progress of individual reactive events that determine imperceptible changes in the sensory plan, still acceptable in terms of safety [7]. Nowadays, this aspect is closely related to packaging and technological intervention aimed at food preservation from multiple alteration processes [8].

Among the commercial foods, meat is one of the most perishable, and many factors can influence the shelf-life: briefly, bacterial growth, enzymatic activity and oxidation processes. Some factors are affected by package type and environment, in particular at the point of sale [9]. The meat industry is firmly interested in processing methods that provide a long shelf-life and protective packaging methods.

2. Meat Packaging Overview

2.1. Function of Packaging

Packaging fulfils several functions: the first is containment at any stage of the production cycle, storage and transport [4][10]. Another fundamental purpose of packaging is to protect meat and meat products, preserving the characteristics during storage and maintaining the quality standards required for selling. Packaging protects meat and meat products during processing, storage and distribution from mechanical, chemical and biological hazards (i.e., contamination by microorganisms and parasites, contamination by dirt and toxic substances) [11]. Packaging represents a barrier against secondary contamination of meat, although the inhibition of the initial contaminant flora cannot rely only on packaging. To reduce meat spoilage, in fact, packaging has to be associated with other treatments, which limit the growth of microorganisms, according to the so-called “hurdles technology” strategy [2]. The third remarkable function is promotion; in fact, packaging is also defined as a silent seller [11]. According to the main functions, there are three levels of packaging. The primary (or sales units) is at the inner level where the packaging material is in direct contact with the product to prevent chemical and physical contamination from the environment. It is aimed at the preservation of chemical and sensory characteristics (e.g., moisture and flavour). Secondary packaging (or pre-packaging) is a sales unit completion and provides protection from mechanical stresses during storage and transport. Tertiary packaging (outer packaging) are units that facilitate the shipment, transport and palletising. The secondary and tertiary packaging are functional for food transportation [4].

2.2. Meat Packaging Materials

2.2.1. Properties of Materials Used in Meat Packaging

For meat packaging, synthetic materials used are in the form of plastic films or foil, often combined with outer packages (i.e., cardboard boxes or other materials). Materials used for inner packaging are selected according to specific requirements: flexibility, mechanical strength, lightness, odourless, hygiene, easy recycling, resistance to hot and cold temperatures, resistance to oil and fats, good barrier properties against gases, sealing capability and price of production. The properties of a material are determined by its molecular structure, molecular weight and its chemical composition. The gas permeability allows the exchange of oxygen, carbon dioxide and water vapour between the inside and the outside of the packaging, and this is a feature of the polymer materials, either synthetic (plastics) or natural (cellulosic materials).

Barrier against gases: A film has to prevent the evaporation of product moisture and the entrance of oxygen. Oxygen negatively affects unpackaged meat during prolonged storage periods, causing colour alteration due to oxidation of the myoglobin, turning the red meat colour to dark red, grey and green, and determining the formation of volatile compounds for fats oxidation and rancidity [12][13][14]. Beyond oxygen-proof films, oxygen-permeable foils are desirable, in case of fresh ready-to-sell meat portions, for the bright red meat colour conservation. In case of fresh meat or fresh sausages, or cooked ham, the relative moisture content is high, and the packaging material should be sufficiently water-vapour-proof, to prevent weight and quality losses by evaporation and drying during storage. For prolonged storage, such as in vacuum-packaged meat, the more permeable to oxygen the film is, the less durability the product will have [15].

Barrier against light: The exposure of meat and meat products to daylight or artificial light accelerates unattractive oxidation, rancidity and colour changes. Transparent packaging films allow attractive presentation without providing sufficient light protections; for light-sensitive products or products exposed to strong light, opaque or coloured film, such as aluminium foils, are used. It is pointed out that an efficient way to improve the light-barrier property of packaging materials is to add UV stabilisers or UV absorbers into the packaging materials [16], even including transparent packaging films. Using some metallised packaging film is also affective to slow down fat photo-oxidation [17].

2.2.2. Materials for Packaging Films

Most films used for meat packaging originate from synthetic plastic materials. The most common synthetic materials used for meat packaging are: Polyethylene (PE), Polypropylene (PP), Polyvinylchloride (PVC), Polyester (PET), Polyamide (PA), Polyvinylidenchloride (PVDC) and Ethylenvinyl alcohol (EVOH) (Table 1 and Table 2) [18].

Table 1. Single-layer film application adapted from FAO [19].

Single Layer Films	Meat	Advantages	Disadvantages	Materials
Wrapping	Meat pieces, processed meat products, bone-in or boneless meat cuts or entire carcasses.	Protection from external contamination, self-adhesive "cling film"	No protection from oxygen, low water vapour permeability	PE, PA, PVC, PP
	Chilled meat portions for self-service outlets, placed in hygienic cellulose or plastic tray and tightly wrapped with single-layer plastic film.	High oxygen permeability favouring oxymyoglobin formation	Low water vapour permeability	PE or soft PVC Cellulose films less self-adhesive
Freezer storage	Meat blocks, meat cuts or smaller portions of meat or meat products.	Prevent evaporation losses, avoid freezer burn and ice formation		PA, PE

Table 2. Multi-layer film application adapted from FAO [19].

Multi-Layer Films	Oxygen Barrier	Water-Vapour Barrier	Sealant Layer	Outside Layer
PA	++	-		++

Multi-Layer Films	Oxygen Barrier	Water-Vapour Barrier	Sealant Layer	Outside Layer
PE	**-**	**++**	**++**	
Combination PA/PE	**++**	**++**		
Ionomer	**I**		**++**	
PET				**++**
PVDC	**++**			
PP				**++**

++*: highly effective,* +*: efective,* -*: non effective.*

2.3. Edible, Bio-Based and Biodegradable Materials

More attention is given to sustainability and renewable sources, in particular plant-derived products and by-products from fermentation [20]. Robertson [21] defines bio-based packaging material as derived from primarily annually renewable sources, and thus excludes paper-based materials because the renewal time is ranging from 25 to 65 years, according to the species and country. Research is conducted to achieve a more sustainable packaging industry and improve renewal sources-based material, but the commercialisation is not still widely diffused. The main problems to solve are the solid waste problem, litter problem and pollution of marine environment [22]. Edible films (thickness < 254 μm) or sheets (thickness > 254 μm) are preformed separately from food, while edible coatings are formed directly onto the surface of the food [23]. The function of protection, from loss of moisture, gases, oil and fat migration solute transport, volatile compounds migration, is maintained, as well as the favoured handling properties [14]. The aim of this type of packaging is to extend shelf-life and improve the efficiency of the material: they can not only reduce pollution, but also contribute to the nutritional value, they can be used for heterogeneous foods and in combination with inedible materials and they can be carriers of antimicrobials and antioxidant agents. Polymers generally form coherent, stand-alone films. Edible films based on polar biopolymers (polysaccharides and proteins) are generally efficient gas barriers and have moderately good mechanical properties at low relative humidity, but both properties markedly degrade at high relative humidity. In addition, proteins and polysaccharides give water-sensitive films with poor moisture barrier performance. In contrast, hydrophobic lipids are effective against moisture migration, but their mechanical properties are much inferior to those of hydrocolloid films because of their non-polymeric nature. Most of the composite films studied to date consist of a lipid layer supported by a polysaccharide or protein layer, or lipid material dispersed in a polysaccharide or protein matrix.

Biopolymers, bio-based materials, are organic material in which carbon come exclusively from biological sources. It is a polymeric material directly extracted from or indirectly produced by biomass. It does not mean that they are edible or biodegradable, but they are easily compostable, with low environmental impact, avoiding the use of energetic sources, and are now renewable. Cellulose is among biopolymers directly extracted from natural sources. Starch could be of different origin but is always made of amylose (linear polymer of glucose) and amylopectin (ramiphied polymer of glucose). Pectines are polymers of galatturonic acid, which could be partially esterified by methyl alcohol, and they can be used to produce edible coating [24]. Future bio-based materials are likely to be blends of polymers and nanoclays (so-called bionanocomposites) in order to achieve the desired barrier and mechanical properties demanded by the food industry.

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