Preservation Technologies of Meat

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Preservation of foods modifies their composition. These changes are reflected in organoleptic characteristics and nutritional value. Knowing these changes helps to anticipate the consumer's response. In the particular case of meat different preservation methods are applied. Among the novel preservation methods highlight smart packaging technologies and use of natural antioxidants. These preservation techniques leads to physicochemical changes in meat which favorable impact the sensory and nutritional attributes of meat derivatives. This entry describes the effects of preservation technologies on sensory and nutritional quality of meat products.

Thermal processing Packaging High Pressure Processing Food additives Antioxidants Meat

1. Introduction

The changes produced in meat due to the application of different processing techniques, preservation methods, and technologies can be basically of two types: physical and chemical. Physical changes are modifications in the structure of the tissues that affect the sensory characteristics of the product such as volume, appearance, color, texture, aroma, and taste. Different effects in meat can be cited; reduced surface moisture due to dehydration, increased moisture and fat retention due to protein denaturation, and enhanced functional properties of proteins due to incorporated additives .

The chemical changes in meat are due to the molecular interactions that occur when thermal treatment is applied, food additives are added, or when storage is prolonged. When the chemical structures of the substances responsible for organoleptic characteristics or nutritional value are affected, for instance denaturation, hydrolysis, and gelation suffered by proteins due to the actions of boiling water and prolonged heating times , the consequences influence the consumer acceptance and affect balanced diet. Technologies which ensure food safety and meet the demands of the consumers without compromising the nutritional value of traditional meat products, are required.

Consumers demand preservative-free, minimally processed meat products with a longer shelf life. Nowadays the use of natural additives instead of synthetic additives is being widely accepted . In addition to this, research on more ecofriendly packaging materials, which improves the shelf life of meat, is gaining momentum. The development of new meat products with improved nutritional profiles has increased over the last decade. For this

purpose, there are two main strategies: obtaining healthier fresh meat and post-mortem processing of meat products . These strategies could affect the quality of meat products and their nutritional value.

2. Preservation

2.1. Physical Methods

2.1.1. Thermal Processing

The effects of cooking technique in meat sensory and nutritional quality are varied. However, thermal processing also has an objective in the preservation. Pasteurization or sterilization of meat at high temperatures helps to attain a better shelf life, improved palatability and enhanced flavor. The time temperature combinations of thermal processing of meat is generally decided based on the required log reduction of the specific target microorganism, expected shelf life, and the physicochemical properties of meat [1]. The main target microorganism in thermally processed RTE (Ready To Eat) food generally is *Clostridium botulinum.* The target organism in processed meat is *Listeria monocytogenes* since it grows at refrigerated conditions [2]. Cooking, sous vide cooking, canning, retort pouch processing, pasteurization are all different kinds of preservation techniques, which use high temperature to process and preserve meat.

Meat texture varies depending on the internal temperature applied during the processing and on the intrinsic characteristics of meat. The tenderness of meat increases at higher temperatures due to the denaturation of protein, solubilization of collagen, and formation of gelatin [3].

Thermal processing inactivates endogenous proteolytic enzymes and prevents development of off-flavors due to proteolysis. Heat sensitive vitamins are lost during prolonged heating at higher temperatures, but a comparable increase in the shelf life, flavor, and palatability is associated with heat treated foods. Oxidation of sulfhydryl group to disulfide group imparts the cooked flavor to meat. The color of meat changes when meat is subjected to high temperatures since myoglobin gets oxidized, which increases redness and reduces lightness of meat, relating it to the doneness of meat [4]. The consumer preference of the meat varies subjectively but the change in color is accepted as a preferred aspect of cooked meat.

Thermal processing reduces the oxidative stability of meat, which is detrimental to both nutritional and sensory quality of meat, but incorporation of antioxidants into meat has been proven to be a solution for the same [5][6]. Heat treatment has been found to concentrate the micronutrients like zinc, magnesium, iron, phosphorous in meat; however, some amount of these micronutrients are lost to thermal leaching [7].

2.1.2. Packaging

Packaging options for meat and meat products are air permeable packaging, vacuum packaging, modified atmosphere packaging, active packaging, smart packaging, and edible coatings [8]. Table 1 summarizes different examples of packaging used in meat and meat products and their effects on sensory characteristics.

Table 1. Effects of different types of packaging on the sensory characteristics of meat products.

Treatment	Meat Product	Effects
Air-permeable packaging, vacuum packaging and modified atmosphere packaging	High pH and normal pH beef [9] Lamb slices [10] Beef steaks [11] Beef fillets [12] Lamb steaks [13] Beef and pork steaks [14] Bison tenderloin steaks [15]	Vacuum packaging inhibits lipid oxidation, thus preventing unpleasant odors and flavors. Packaged in a modified atmosphere with semi-permeable internal vacuum film leads to an attractive bright red color. Packaging in CO_2 improves color and the stability of meat color compared to vacuum package.
Active packaging	Pork patties [16] Beef steaks [17] Beef [18][19]	Active packaging does not affect the tenderness of the meat. Desirable bright red color. Incorporation of essential oils in the active packaging leads to unpleasant flavors and aromas.
Edible films and coatings	Beef [20] Pork meat [21] Minced beef [22] Ready to eat (RTE) meat products [23] Pork meat hamburgers [24] Ground-beef patties [25]	The stability of the red color is improved. Lipid oxidation is inhibited, thus preventing unpleasant odor and flavor.
Combination	Pre-cooked convenience-style foods: battered sausages, bacon slices, and meat and potato pies [26]	Optical oxygen sensors in combined vacuum and modified atmosphere packaged and the use of ethanol emitters: ethanol flavor and aroma were not perceived by panelists in two of the three products assessed.

2.1.3. High Pressure Processing (HPP)

High pressure is applied for preservation purposes. Response of vegetative pathogenic and spoilage microorganisms to HPP depends on process parameters such as pressure, temperature, processing time, and on product parameters such as pH, water activity, salt content, and the presence of other antimicrobials. Inactivation of more than four log units of common vegetative pathogenic and spoilage microorganisms can be attained by HPP at 400–600 MPa with short processing times of 3–7 min at room temperature .

Ham samples treated by HPP showed increased hardness and syneresis during storage . Ham samples HPP treated at 600 MPa for 5 min showed 2 *log* and 3 *log* reductions of *L. monocytogenes* on the surface and interior respectively. Treatment at 600 MPa for 5 min in completely dry-cured ham reached the food safety objective for *L. monocytogenes,* without significantly affecting the physicochemical characteristics of dry-cured ham [27].

2.2. Chemical and Biochemical Methods

2.2.1. Food Additives

The main additives used in the production of meat derivatives are antioxidants, binders, antimicrobials, curing agents, and curing accelerators.

Synthetic antioxidants approved for use in meat products are butylhydroxyanisole (BHA), butylhydroxytoluene (BHT), propyl gallate, terbutylhydroquinone (TBHQ), and tocopherols. These antioxidants delay or inhibit the oxidation of meat and meat products, and therefore avoid the appearance of unpleasant odors and flavors.

Binder additives are added to the meat to maintain a uniform dispersion of fat throughout the product and to prevent water loss during the different stages of processing, heating, storage, and cooling. The binder additives used in meat and meat products are phosphates, starches, xanthan gum, guar gum, sodium alginate, carrageenan, carboxymethylcellulose, etc. It is worth highlighting the functions of phosphates in meat products, which are to increase the water retention capacity and increase the stabilization of the emulsion. Phosphates also have other functions such as stabilizing color, inhibiting lipid oxidation, and promoting protein dispersion [27]

The synthetic additives used as antimicrobials in meat products are organic acids such as acetic, lactic, propionic, sorbic, benzoic, and citric acids, and sulfites. Sulfites exhibit antimicrobial activity against decomposing microorganisms; however, sulfites cause health problems such as allergic reactions in sensitive people. Organic acids have activity against a wide variety of pathogenic and disrupting microorganisms [28]. Sorbic acid is used in meat products for its inhibitory activity against yeasts and molds. However, it does not affect lactic acid bacteria, which makes it a useful preservative in fermented meat products [29].

Nitrates and nitrites are the most widely used curing agent in meat products. Nitrites provide the red color and flavor of cured meat, and have antioxidant and antimicrobial properties. The reduction of nitrites and nitrates to nitric oxide is important for the color of cured meat. Nitrosyl myoglobin, which is the dominant pigment in cured meat products, is formed from the interaction of nitric oxide with the *heme* group of myoglobin [30]. Curing accelerators such as sodium ascorbate, sodium erythorbate, ascorbic acid, or erythorbic acid are added to meat to speed up the curing process, as they reduce nitrites to nitric oxide. Nitrites react with amines and amino acids leading to the formation of N-nitrosamines, which are chemical agents with potential carcinogenic, mutagenic and teratogenic activities. For this reason, alternatives are being sought to reduce or eliminate the addition of nitrites in meat products and reduce health risks [31].

2.2.2. Natural Antioxidant Ingredients

Natural antioxidant ingredients can be used as food additives in meat and meat products for their technological properties. Table 2 summarizes the effect of the addition of natural antioxidants in the formulation of meat and meat products on their sensory characteristics. The antimicrobial and antioxidant activities of some plant extracts and/or their essential oils are mainly due to the presence of some major bioactive compounds, including phenolic acids, terpenes, aldehydes, and flavonoids [32]. It should be highlighted that natural antioxidants can also be incorporated into packaging systems.

Table 2. Effects of the addition of some natural ingredients on the sensory characteristics of meat products.

Natural Ingredients		Meat Product	Effects
Essential oils: thyme, oregano, pimento, clove, citron, lemon verbena, lemon, balm, cypress leaf		Lamb meat [33] Raw chicken [34] Meatballs [35] Beef patties [36]	Extracts like clove or cinnamon increase of *L**, *a** and *b** values during storage. Concentrations of essential oils of oregano and thyme greater than 1% led to strong odor and unpleasant taste. Clove extract increased the *a** values.
Plant extracts: grape seed, green tea, pomegranate peel/rind, acerola, pine bark, bearberry, cinnamon bark, rosemary, garlic, oregano, sansho, ginger, sage.	Grape seed extract (GSE) and wine pomace	Low sulfite beef patties [37] Beef enriched with *n*-3 and CLA [38][39] Pork meatballs [40] Chicken nuggets [41]	GSE showed less color changes during the storage. GSE can darken a meat product. No modification of the sensory attributes except for the color.
	Green tea extract	Low sulphite beef patties [37] Pork meatballs [42]	No effects on odor, taste and texture. Degradation of red color is delayed. No modification of the sensory attributes except for the color.
	Rosemary extract	Turkey meat [42] Pork burgers [43]	No effects on sensory characteristics.
	Oregano extract	Sheep burgers [44]	No effects on sensory characteristics.
	Garlic	Low-salt sausages [45]	No effects on aroma, flavor and overall appearance.

Natural Ingredients		Meat Product	Effects
	Other fruit extracts: blueberries, raspberry pomace, pomegranate peel and pomegranate juice	Pork burgers and cooked pork ham [46] Beef burgers [47] Chicken patties	Sensory quality was not negatively altered.
	Citrus fiber	Bologne sausage [48]	No effect on color or texture properties. When citrus fiber is combined with rosemary essential oil, the sensory parameters improved.
Spices		Rabbit burgers [49] Indian sheep meat product [50]	Turmeric powder leads to higher yellow values. Cumin and cardamom led to high overall acceptability score.

3. Conclusions

Numerous techniques have been developed to obtain healthier meat and meat products. However, the modification of the sensory quality should be considered when preservation technologies are applied. Combinations of different technologies are necessary to achieve the best sensory quality in products with improved nutritional profile. In the development of new meat products, a comprehensive approach, including evaluation of sensory characteristics and nutritional value is necessary. Thus, this work describes the different alternatives for preservation techniques, with their advantages and disadvantages, highlighting techniques that improve the sensory characteristics and give rise to products with improved nutritional profile and consumer appeal. Preservation techniques of natural origin stand out as they prolong the shelf life of meat products without negatively affecting the sensory features.

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