USE OF HIGH PRESSURE PROCESSING ON MEAT PRODUCTS: COMMERCIAL DEVELOPMENTS AND RESEARCH TRENDS IN FOOD SCIENCE

POTTIER L.[1], TONELLO C.[2], RAKOTONDRAMAVO A.[1], GUYON C.[1], de LAMBALLERIE M.[1]
[1]UMR GEPEA, ONIRIS, CS 82225, 44322 Nantes cedex 3 France
[2]Hiperbaric, condado de Treviño 6, 09001 Burgos, Spain
laurence.pottier@oniris-nantes.fr

Abstract:
High pressure processing (HPP) is an innovative food preservation technique alternative to thermal treatment, which currently experiences strong industrial development in particular in the meat industry. Indeed HPP inactivates main part of vegetative spoilage and pathogen flora, allowing the increase of the food product shelf-life stored at refrigerated temperature. Moreover HPP preserves product sensorial quality up to the end of its shelf life and product nutritional value. HPP induces some food constitutes modifications, particularly proteins. Indeed those modifications can lead to chemical preservative/salt reduction or removal and clean label meat products.

Key words: high pressure processing, commercial developments, protein, clean label, meat products

I- INTRODUCTION: HIGH PRESSURE PROCESSING CURRENT COMMERCIAL DEVELOPMENTS

The effect of High Pressure Processing (HPP) on microorganisms and food constituents has been known since the end of the 19th century. However, the industrial development of HPP in the food industry dates back to the 1980s and led in 1990 in Japan to the first product marketed by HPP. Faced with the growing consumer demand for healthier and less processed products, manufacturers adjust their production while maintaining the sanitary quality and shelf life of their products. In this context, thermal preservation of food is limited by the changes in texture, color, flavor and nutritional value: HPP can be a response for manufacturers. In the early 2000's, HPP manufacturers started developing better equipment (horizontal design, bigger volume) to respond to the food industry demands. At the end of 2016, 385 machines (representing a global volume of about 95,000 L) were in production and one third of the global volume capacity of high pressure equipment was processing meat [1].
The extended shelf life of ready-to-eat meat products without any added food preservatives is an important characteristic for consumer acceptance. Nevertheless, HPP can affect some sensory characteristics of meat products. The physicochemical changes of treated meat products can promote the modification of their oxidation status and their technological properties (mainly texture) [2]. Recent research aims to maximize the advantages of HPP while limiting the negative effects [3,4]: we will focus here in recent advances in the knowledge of the effect of HPP on meat oxidation, digestibility and texture.

II- HIGH PRESSURE AND MEAT OXIDATION

HPP can induce modifications of components, such as lipids and proteins, and favor their oxidation by promoting the formation of radicals. 400 MPa seems to be critical for the initiation of lipid oxidation, which was probably related to the no hemic iron in the meat, rather than the hemic compounds [2].
HPP of meat can promote oxidation reactions, and it is very important to control the balance between pro- and anti-oxidants to prevent this phenomenon. Therefore, many authors have been interested in evaluating the extent of oxidation in pressurized meat to understand the underlying mechanisms or pathways. In particular, the fate of proteins such as myoglobin and hemoglobin under HPP has been investigated because these proteins act as prooxidants in raw meat. HPP of meat favors oxidation and promotes radical formation during subsequent heat treatments. Several studies concluded that treatment at pressures above 350 MPa has a prooxidant effect for all types of meat [2].
In addition, the extent of lipid oxidation depends on the treatment duration, the temperature of the HPP, and mainly on the type of meat or meat product [2]. Thus, beef samples seem to oxidize less than samples of other types of meat and contain, for example, five times fewer volatile compounds than chicken meat [5]. Furthermore, the initial packaging of the treated sample has a significant impact on the meat's oxidation during the HPP. Indeed, vacuum packaging, which is most frequently used for HP treatment, reduces the impact of the pressure on the oxidation process [2].

III- HIGH PRESSURE AND PROTEIN DIGESTIBILITY

It is well-known that high pressure treatment induces changes in protein conformation but the consequences in terms of digestibility constitute a new field of research. Recent papers focus on protein digestibility after pressurization using *in vitro* digestion. A recent study on raw bovine meat treated by high pressure (600 MPa) concludes that this product presents appearance and texture similar to cooked meat and besides the study of digested meat after HPP reveals better digestibility (few peptides of high molecular weight) and higher free amino-N release than untreated meat [6].

IV- TEXTURE MODIFICATIONS AND CLEAN LABEL PRODUCTS

Many studies on HPP focus on modification of organoleptic characteristics of the product and especially texture. Two aspects are studied: the first one associates high pressure treatment with reduction of food additives, fat and salt while preserving texture of traditional meat products [7-10]; the second one aims to develop novel/innovative texture and then novel food development [11].

The potential of high pressure to manufacture food products with reducing use of additives and salt is also a recent field of study. It is based on the fact that high pressure reduces the need for preservatives and modifies functional food properties, for instance water holding capacity of meat products allowing salt and additives reduction while maintaining products functionality. For example, several studies focus on the use of salt replacer such as KCl combined with HPP in order to reduce salt in meat products [10]. The use of high pressure to reduce phosphate content in meat products is also studied with promising results suggesting a synergistic effect between high pressure, texture and water holding capacity in case of reduced-phosphates meat products [7, 12,13]. Moreover, the development of clean label products is also studied by means of natural antimicrobials and antioxidants [14]. For example, rosemary extract reduces lipid oxidation in the same proportion as sodium ascorbate in pressurized pork batters [4]. The use of such natural additives in high pressure treated product is often associated with active packaging, for example an active packaging based on rosemary is efficient to prevent lipids oxidation in chicken processed by high pressure [15,16].

1. Tonello-Samson C (2017) High Pressure Processing Commercial Developments: Global Market, Equipment and Applications in the Meat Industry. European Symposium on Food Safety, 29-31 March 2017, Brussels, Belgium.
2. Guyon C, Meynier A, de Lamballerie, M (2016) Protein and lipid oxidation in meat: A review with emphasis on high-pressure treatments. Trends in Food Science and Technology 50: 131-143.
3. Souza CM, Boler DD, Clark DL, Kutzler LW, Holmer SF, Summerfield JW, Cannon JE, Smit NR, McKeith FK, Killefer J (2011) The effects of high pressure processing on pork quality, palatability, and further processed products. Meat Science 87(4): 419-427.
4. Villamonte G, Pottier L, de Lamballerie M (2017) Influence of high-pressure processing on the oxidative processes in pork batters: efficacy of rosemary extract and sodium ascorbate. European Food Research and Technology. DOI 10.1007/s00217-017-2865-7 (under press).
5. Schindler S, Krings U, Berger R G, Orlien V (2010) Aroma development in high pressure treated beef and chicken meat compared to raw and heat treated. Meat Science, 86: 317-323.
6. Kaur L, Astruc T, Vénien A, Loison O, Cui J, Irastorza M, Boland M: High pressure processing of meat: effects on ultrastructure and protein digestibility. Food & Function 2016, 7:2389-2397.
7. Villamonte G, Simonin H, Duranton F, Chéret R, de Lamballerie M: Functionality of pork meat protein: impact of sodium chloride and phosphates under high pressure processing. Innovative Food Science and Emerging Technologies 2013, 18: 15-23.
8. Yang HJ, Han MY, Bai Y, Han YQ, Xu XL, Zhou GH: High pressure processing alters water distribution enabling the production of reduced-fat and reduced-salt pork sausages. Meat Science 2015, 102:69-78.
9. Yang HJ, Khan MA, Han MY, Yu XB, Bai XJ, Xu XL, Zhou GH: Optimization of textural properties of reduced-fat and reduced-salt emulsion-type sausages treated with high pressure using a response surface methodology. Innovative Food Science and Emerging Technologies 2016, 33:162-169.
10. Tamm A, Bolumar T, Bajovic B, Toepfl S: Salt (NaCl) reduction in cooked ham by combined approach of high pressure treatment and the salt replacer KCl. Innovative Food Science and Emerging Technologies 2016, 36: 294-302.
11. Pingen S, Sudhaus N, Becker A, Krischek C, Klein G: High pressure as an alternative processing step for ham production. Meat Science 2016, 118: 22-27.
12. O'Flynn C, Cruz-Romero M, Troy D, Mullen AM, Kerry JP: The application of high-pressure in the reduction of salt levels in reduced-phosphate breakfast sausages. Meat Science 2014, 96: 1266-1274.
13. Speroni F, Szerman N, Vaudagna SR: High hydrostatic pressure processing of beef patties: effects of pressure level and sodium tripolyphosphate and sodium chloride concentrations on thermal and aggregative properties of proteins. Innovative Food Science and Emerging Technologies 2014, 23: 10-17.
14. Hygreeva S, Pandey MC: Novel approaches in improving the quality and safety aspects of processed meat products through high pressure processing technology - A review. Trends in Food Science & Technology 2016, 54: 175-185.
15. Bolumar T, Andersen ML, Orlien V: Antioxidant active packaging for chicken meat processed by high pressure treatment. Food Chemistry 2011, 129: 1406-1412.
16. Bolumar T, LaPeña D, Skibsted LH, Orlien V: Rosemary and oxygen scavenger in active packaging for prevention of high-pressure induced lipid oxidation in pork patties. Food Packaging and Shelf Life 2016, 7: 26-33.