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Novel approaches in improving the quality and safety aspects of processed meat products through high pressure processing technology - A review

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ABSTRACT

Background: In recent years, there has been growing consumer demand for the minimally processed and chemical additives free Ready-To-Eat (RTE) healthier meat products. On the other hand processed and RTE meat products have been notified as the primary cause for food borne outbreaks in different countries that commonly associated with emerging pathogens such as *Salmonella*, *Listeria monocytogenes* and *Escherichia coli* species.

Scope and approach: High pressure processing (HPP) has been renewed as a best non-thermal intervention for extending the shelf-life and safety of RTE meat products without altering the sensory and nutritional properties. Meat products are complex medium with different physical and chemical compositions that influence the lethality of the microorganisms during HPP. Using high pressure levels (above 600 MPa) for complete sterility of meat products may not be economically feasible more over it may negatively affect the product quality characteristics. The present review aimed to explore the recent research investigations addressed the multi hurdle approaches to increase the effectiveness of HPP at lower processing levels in order to reduce the processing costs and to improve the safety and quality of processed meat products.

Key findings and conclusions: The combination of natural antimicrobials (plant bioactive compounds and bacteriocins) and antioxidants (plant phenolic compounds) as additional hurdles through different mechanisms (active and intelligent packaging) during HPP can definitely be an effective and innovative intervention in ensuring the complete safety of processed meat products. Moreover, the development of low salt meat products with optimum quality attributes can be highly possible through HPP technology.

1. Introduction

The consequence of globalization with the changes in consumer lifestyle, food patterns and expanding knowledge about the relationship between food and health has brought tremendous transformations in processed food industry within the past few years (Siro, Kapolna, Kapolna, & Lugasi, 2008; Sorenson et al., 2011). Among the foods, meat is one of the important food commodities that provide better and essential nutrition to the humans for years. The presence of high quality proteins, essential amino acids, B-vitamins and dietary fat recognized meat as one of the nutrient dense food (Biesalski, 2005; Decker & Park, 2010; Zhang, Xiao, Samaraweera, Lee, & Ahn, 2010). The highly perishable nature of meat and meat products requires appropriate preservation/processing techniques within minimum time periods in order to arrest it from the microbial and other possible spoilage mechanisms (Hygreeva, Pandey, & Radhakrishna, 2014). Since, the science of food has started to explore the facts about the wellness of being related to consumption of food patterns; especially processed food, the consumers became more concern over the health enhancing properties, convenience, shelf-life properties and safety while selection of processed food from the shelves (Bruhn, 2007; Rubio, Jofré, Aymerich, Guàrdia, & Garriga, 2014; Sentandreu & Sentandreu, 2011). Hence, the increasing consumer demands for the fresh like, nutritious and convenience products triggered both the academic and industrial research towards the invention and application of newer processing technologies called as non-thermal

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processing/mild processing/hurdle techniques (McArdle, Marcos, Kerry, & Mullen, 2011; Raouche, Mauricio-Iglesias, Peyron, Guillard, & Gontard, 2011; Trespalacios & Pla, 2007).

Shelf-life extension of meat products is a complex phenomenon that majorly depends on the successive control of oxidation and microbial spoilage processes under room and refrigerated storage conditions (Fung, 2010; Karabagias, Badeka, & Kontominas, 2011). The detrimental effect of high temperature processing on the nutritional and sensory properties and the possible health risks associated with synthetic antioxidants and antimicrobials present in meat products has opened new doors in food research for the development of minimally processed/hurdle processed foods/natural antioxidants and antimicrobials added food products (Campus, 2010; Lahucky, Nuernberg, Kovac, Bucko, & Nuernberg, 2010). From the past few years, both the research organizations and social media have been actively working to promote the consumer awareness about the newer food processing technologies and associated benefits related to their health and convenience aspects. In this regard, some recent reports have acquired positive responses from the consumer level, and the consumers too could realize and ready to accept the foods that are being processed by novel processing techniques (Sorenson et al., 2011). Consequently, ensuring the quality and safety of Ready To Eat (RTE) meat products while meeting the consumer demands for minimally treated, chemical additives free is been a great challenge to the meat industry (Bover-Cid, Belletti, Garriga, & Aymerich, 2012). In such products, the risk of emerging pathogen *Listeria monocytogenes* is primarily concerned due to that, the organism can able to grow in extreme conditions (low temperature, low pH and low water activity) (Juck, Neetoo, Beswick, & Chen, 2012). Recent research reports have indicated that *Listeria monocytogenes* has been recorded with high notification rates in occurrence of *listeriosis* in some countries including United States, Finland, Denmark and Spain with highest rates reported in Finland (Hereu, Dalgaard, Garriga, Aymerich, & Bover-Cid, 2014). In this regard, RTE meat products are being reported to be the primary source for the occurrence of this organism in Europe. Even though, high heat treatment eliminates *L. monocytogenes* in RTE meat products, surplus chances are there for recontamination during handling, slicing and repacking operations (Lowder, Waite- Cusic, & DeWitt, 2014; Hereu, Bover-Cid, Garriga, & Aymerich, 2012a).

High pressure processing (HPP) or high hydrostatic pressure processing (HHPP) is a novel non thermal preservation/processing technique. It is being used to extend the shelf life quality of fresh and processed food products without altering/minimal impact on the sensory and nutritional properties (Marcos, Aymerich, Garriga, & Arnau, 2013). As the HPP technique works under the isostatic condition, it involves in uniform distribution of pressure throughout food material with irrespective of size and shape. Due to uniform pressure distribution, the shape and dimensions of the food material remains same in the container/packet (de Alba, Bravo, & Medina, 2012; Han et al., 2011). Probably, high pressure (HP) research on meat and meat products is been progressing with promising results and renewed as one of the best non thermal processing techniques to improve the technological and microbial quality of meat and meat products. (Simonin, Duranton, & de Lamballerie, 2012, Fig. 1). After the first reports of Hite (1899) on effect of HPP on food preservation model systems, it leads to the use of high pressure treatment as non thermal processing technology. HPP was tested with various food products to extend their shelf life at ambient and refrigerated storage conditions. The research works of Macfarlane (1973) and Macfarlane and Morton (1978) revealed the important aspect related to the improvement in meat tenderness with HP treatments and moreover continued research studies of Cheftel and Culioli (1997); Cheah and Ledward (1996) indicated the changes associated with several quality characteristics of meat products (Jung, Ghoul, & de Lamballerie-Anton, 2003). Nowadays with the advances in food engineering the commercial setups of high pressure processing units could reach the pressure levels up to 1000 MPa and being used for pasteurization and commercial sterilization of different food products (Rendueles et al., 2011). Currently research scientists and meat technologists are showing considerable interest in application of high pressure processing as non thermal preservation and decontamination/pasteurization/sterilization technology for extending the shelf life and safety of commercial processed RTE meat products (cooked and cured) (Scheinberg, Svoboda, & Cutter, 2014). The high level risks associated with the processed meat products is the recontamination of spoilage and other emerging pathogens during handling, packing and slicing. (Sun & Holley, 2010). Recent studies have shown that treatment of meat products at around 400–600 MPa could be viable alternative intervention to thermal processing that could ensure the microbial safety of packed RTE meat products (Fulladosa, Serra, Gou, & Arnau, 2009). On the other hand food safety regulatory agencies such as United States Food and Drug Administration (USFDA), Food Safety and Inspection Service (FSIS) have been permitted the HPP as an acceptable method for elimination of *L. monocytogenes* in processed meat products (de Alba et al., 2012).

In HPP applied pressure, temperature and time are the critical factors that determine the lethality of microorganisms in particular food matrix (Bajovic, Bloumar, & Heinz, 2012). The nature of the food product such as low water activity, high fat, high protein and high solute concentration have been identified as important factors that can increase the barotolerance of microorganism and reduce the extent of bacterial inactivation and further leads to recovery of sublethally damaged cells during storage period (Rendueles et al., 2011; Szerman et al., 2011). Recent research investigations explored novel hurdle strategies to improve the process lethality rates with combination of high pressure with potent hurdles (Ananou et al., 2010). The hurdles such as; *Incorporation of natural antimicrobials and antioxidants either direct addition/through active packaging; use of high temperatures; low temperatures and modified atmosphere packaging.* Application of novel multi hurdle strategies during HPP of meat products may bring down the processing costs and moreover it allows using of moderate pressure levels in order to maintain the better quality characteristics in terms of texture and appearance.

Sodium chloride/salt is a most essential and functional ingredient in meat products that gives desired flavor, taste, color and texture (Ruusunen & Puolanne, 2005). It also importantly contributes for water holding capacity (WHC) and fat binding capacities which are believed to be important technological quality aspects that they further determine the cook loss and final composition of the product. (Weiss, Gibis, Schuh, & Salminen, 2010). Processed meat products are one of the promising sources for high levels of dietary sodium due to its functional properties as well as preservative effects (Grossi, Søltoft-Jensen, Knudsen, Christensen, & Orlien, 2012). The increasing consumer awareness about the intake of sodium chloride and associated health risks related to hypertension and other possible degenerative diseases has led to the development of low salt meat products with possible potential strategies (Desmond, 2006). The most extensively used strategies to reduce the sodium levels in meat products are replacing with other salts and substitutes like potassium chloride, sodium lactate, potassium lactate etc,. (Fulladosa et al., 2009; Fulladosa, Sala, Gou, Garriga, & Arnau, 2012). In the mean time, incorporation of these substitutes may negatively affect the sensory and other quality characteristics. Most recent studies have evaluated the favorable effects of HP treatment during the development of low salt meat