

# **The Effects of High Hydrostatic Pressure on Meats**

Errol V. Raghubeer

Avure Technologies Inc.  
Kent, WA 98032

September, 2007

## **Introduction**

High hydrostatic pressure is an innovative technology that has become an integral part of the meat processing industry. The technology could not have come at a better time for an industry that was experiencing an alarmingly high rate of food safety related recalls and facing stiffer regulations to control the incidence of listeriosis in ready-to-eat (RTE) meat and poultry products. Amid the requirements for safer products, there is a growing demand for minimally processed, more natural products that do not contain chemical preservatives. High pressure processing (HPP) met the requirements for delivering a safer, more natural product to the consumer without the need for chemical preservatives. Not only has the industry been able to meet these demands, it is also able to offer products that have extended quality with longer shelf-life. This allows companies to extend their product lines into larger geographical markets. Apart from these benefits, meat processors are able to use HPP to improve the quality and value of their products. The use of HPP for the tenderization of muscle protein and marinating mechanisms is becoming an important tool for the industry. The remarkable success that was enjoyed by other segments of the food industry from the implementation of HPP is now being exploited by the meat industry.

## **A Safer Product**

The RTE meat and poultry industry has experienced several recalls of products because of contamination with *Listeria monocytogenes* and other pathogens. A significant number of illnesses and deaths have been associated with some of these recalls. The sources of the contamination could be raw materials, environmental contamination, or breakdown in quality assurance and HACCP programs. However, the need for a post lethality treatment and better control of pathogens in processing plants was very evident. The USDA Food safety and Inspection Services' (FSIS) 2003 interim rule for the control of *L. monocytogenes* in RTE meat and poultry products (9 CFR 430.) was issued to enhance the safety of meat products. It required processors to implement one of three risk-based alternatives (1, 2, or 3) that define their production process. This ruling required companies to share plant information and data with the FSIS. This regulation caused much panic among processors to find a process or combination of processes to meet these regulations and maintain their customer base. Traditional

methods such as heat pasteurization could not be used with most products due to adverse organoleptic effects. Results of studies done by Avure technologies, Kent WA USA (Figure 1) and other published reports clearly showed that HPP will provide the food safety of these at-risk products without affecting their quality (Morales, *et al* Journal of Food Protection, Vol. 69, No. 10, 2006, pp 2539–2543; Hayman, *et al* Journal of Food Protection, Vol. 67, No. , 2004, pp 1709–1718).

In 2003 the FSIS issued a letter-of-no-objection (LNO) for the use of HPP as an effective post-packaged intervention method in controlling *L. monocytogenes* in RTE meat and poultry products for US companies. Similar process approval for the implementation of HPP to control *Listeria monocytogenes* are in place by other agencies. Health Canada recently issued a similar LNO for the control of *L. monocytogenes* in cured and uncured RTE pork products. HPP is now commonly used by many US and Canadian processors to meet the FSIS Alternative 1 category. Companies such as Hormel Foods, Perdue Farms, Tyson Foods, Santa Maria Foods, Fresherized Foods, among others have implemented HPP technology to meet their strict food safety programs and government regulations to deliver safer, higher quality products to the market.

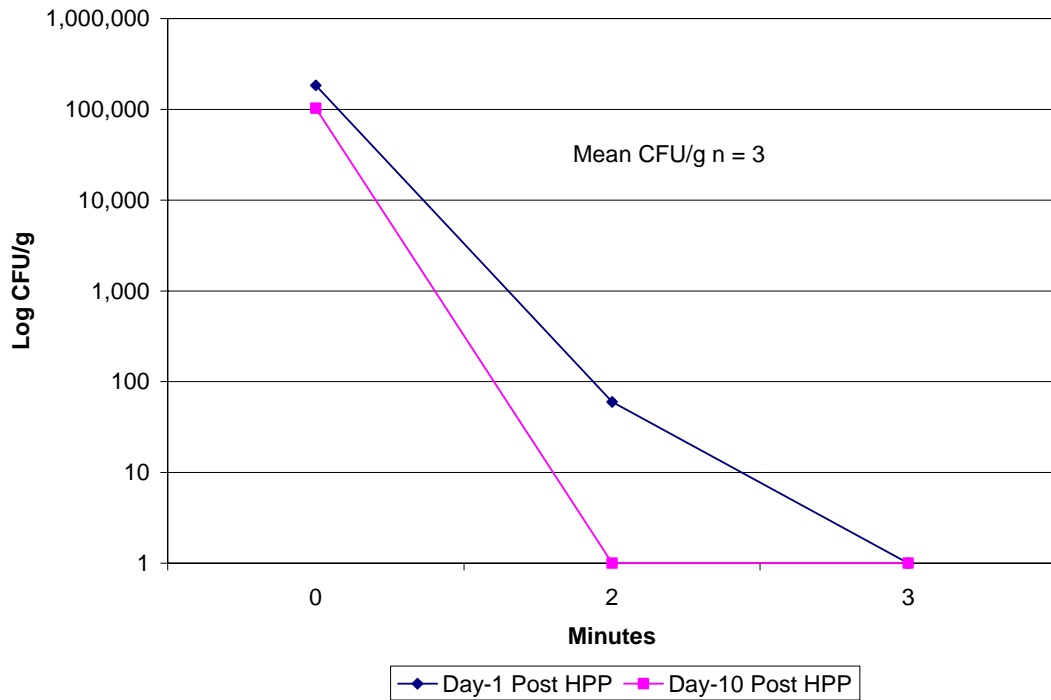


Figure 1. The reduction of *Listeria monocytogenes* in low water activity ( $A_w$ ) prosciutto by high pressure processing for treatment times of 2 and 3 minutes. At 2 minutes, there was > 3-log reduction whereas for the 3 minute treatment time there was a 5-log reduction of the inoculated *L. monocytogenes* strains. The survivors at the 2 minute treatment died off within the 10 days of storage.

## Extension of Quality and Shelf-life

An important economic benefit of using HPP for controlling foodborne pathogens is the concurrent destruction of spoilage microorganisms. This results in more than doubling of the shelf-life and an extension of the quality of the treated products. This significant “side effect” had been a major driver for the implementation of HPP because of the huge return on investment. Processors not only have the means of getting longer microbiological shelf-life, but are able to reduce or eliminate chemical preservatives and offer their customers the high quality products that maintain “recently produced” organoleptic characteristics throughout the shelf-life. Non-HPP products tend to lose sensory attributes such as taste, color, texture as shelf-life nears its end. Figure 2 shows the maintenance of high quality through shelf-life (upper red) and the decline in quality as shelf-life nears for non-HPP samples. These rankings in this chart were provided by customers during the evaluation of HPP technology on products with normal levels of preservatives and HPP products without chemical additives.

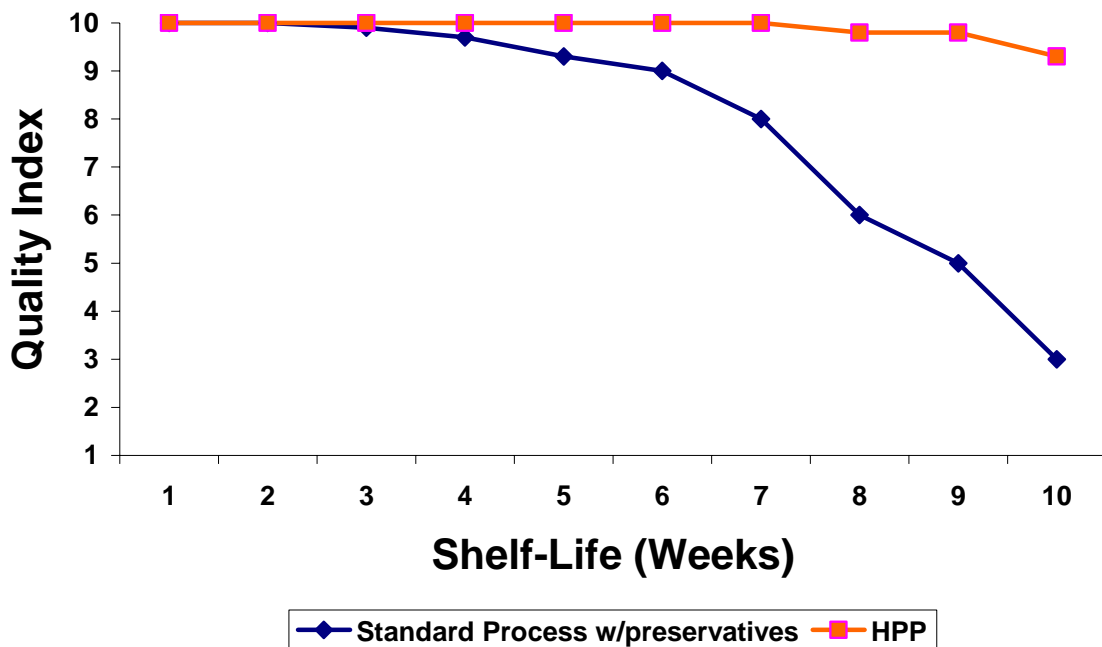


Figure 2. High pressure RTE meat and poultry products maintained good quality attributes (upper red line) throughout shelf-life whereas, non-HPP products (lower blue line) tend to lose sensory properties as the end of shelf-life nears. The above chart shows average rankings from evaluators of HPP products without preservatives compared to standard products with preservatives.

This decline in product quality can result in economic loss due to distressed products or more importantly, loss of customers who may be turned off from a product with poor quality near the end of shelf-life. Figure 3 shows the remarkable organoleptic properties of HPP roast beef on the right after 100 days in storage compared to the same product without HPP on the left. The non-HPP products showed visible signs of spoilage after 40 days of storage whereas HPP had fresh tasting characteristics after 125 days. The quantitative microbial indicators of spoilage such as the levels of aerobic bacteria (APC), coliform bacteria, lactic acid bacteria, and fungi were high in the non-HPP product compared to the significantly low levels and absence of some strains in the HPP product. Many processors using HPP technology are able to increase their geographical market with the confidence that their products will maintain their high quality during the extended shelf-life.

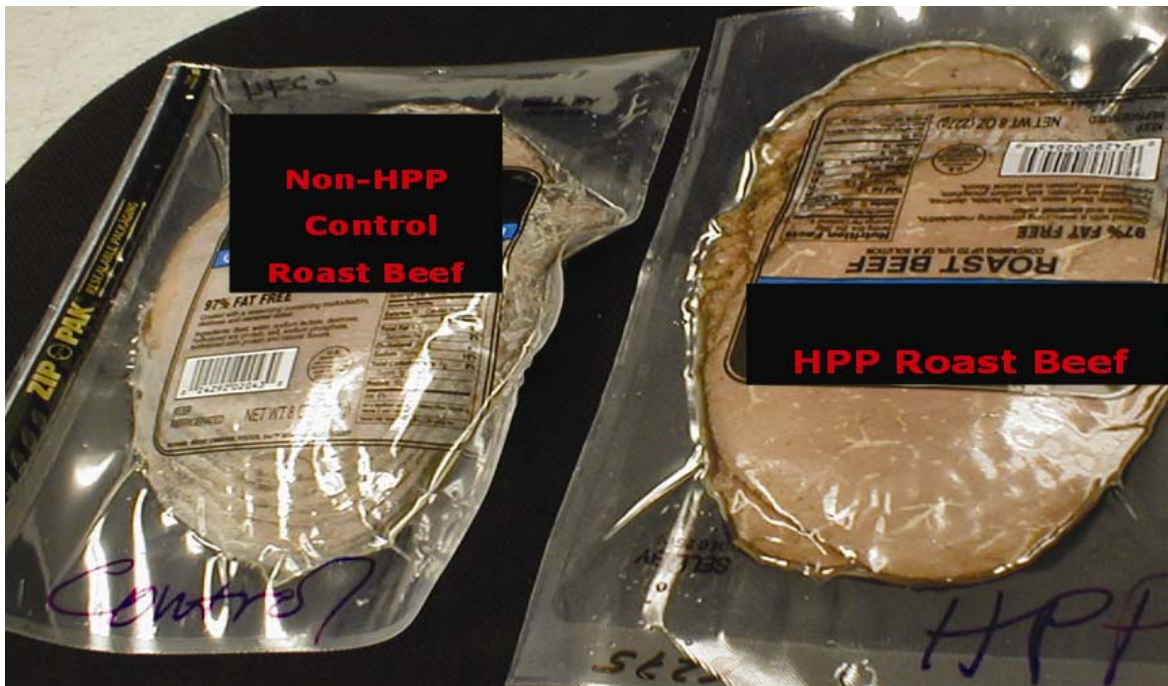


Figure 3. High pressure processed roast beef (right) after 100 days maintained exceptional color, texture and taste for more than 100 days of storage following treatment. The non-HPP product (left) showed signs of spoilage within 40 days of storage.

## **A Better Product**

There is a high and rapidly increasing demand by consumers for minimally processed RTE meat products without chemical additives. Processors are struggling to meet this demand and at the same time having to deal with tougher food safety regulations all while protecting their brand. Traditional heat treatment methods to inactivate microorganisms are only viable options for certain RTE meat and poultry products due to the adverse effects on sensory attributes. HPP inactivates microorganisms in these products naturally without changes in nutritional components and organoleptic properties. Many processors have implemented the technology to reduce or completely eliminate chemical and other preservatives and meet the strict pathogen regulations. This gives processors the means of meeting the current demands of customers and providing products for the rapidly increasing natural and organic markets.

The use of HPP technology for benefits other than destroying microorganisms is increasing in the meat processing industry. The unique behavior of raw protein and hydrocolloids can be maximized to enhance the quality of meats and meat products such as for tenderizing, marinating, and improved binding characteristics. The high demand for tender meat, particular beef, by consumers is an ever-present challenge for the industry due to the difficulty in controlling tenderization. The use of HPP to tenderize meats has the potential to revolutionize the red meat industry since tenderization effects are highly variable between meat carcasses. By understanding the biochemical mechanisms of muscle breakdown, processors can utilize HPP to “turn on” and promote endogenous enzyme systems that tenderize muscle protein. HPP can increase the activities of certain enzyme systems such as those of the calpain family resulting in an increase in tenderization. Similarly, the activity of added proteases such as papain can be enhanced by HPP.

During HPP, raw protein unfolds exposing non-covalent interactions which facilitates the hydration of protein. This mechanism is being increasingly used to marinate muscle protein giving processors a more rapid and viable alternative to traditional vacuum tumbling and injection procedures. The hydration of raw protein is a tremendous benefit to processors since it improves yield and moistness of meat products. For formulated products such as meat sausages, hot dogs, and deli meats, the increased water-binding capacity and improved emulsion

properties of raw proteins and hydrocolloids will reduce liquid purge during shelf-life and improve the mouth-feel and quality of the finished products.

The beef industry faces the constant challenge of providing consumers hamburger meat that is free of foodborne pathogens. Although HPP has shown to have some negative effects on raw hamburger meat, the prospect of using HPP to treat the raw materials such as beef trims prior to grinding and formulating is very promising. HPP has been shown to effectively eliminate pathogens such as *Escherichia coli* O157:H7, Salmonella, Campylobacter and Listeria in beef trims.

### **A Bright Future for the Meat Processing Industry**

High pressure processing is no longer regarded as a novel technology. It has proven very successful in other segments of the food industry. Seafood processors are increasingly using it to inactivate bacterial pathogens and viruses in shellfish and improve processing operations. Processors of crustaceans are using HPP to shuck lobster and crab. This not only provides them with increased processing efficiencies and product yield but opens new markets for raw lobster and crab meat. This success is now being experienced by the meat industry. The implementation of the technology in the meat processing industry serves an important role in providing safer, higher quality, and higher value products consumers. It is increasingly used to eliminate or reduce chemical additives for more natural and organic products. By taking advantage of the unique behavior of raw proteins and other commonly used raw materials, processors can formulate RTE meat and poultry products with better sensory characteristics and with less dependence on chemical additives.