High pressure processing to enhance food safety and extend shelf-life

The global adoption of High Pressure Processing (HPP) in the food industry is on a significant upswing with increased ownership from food manufacturers and the growth and expansion of the HPP service providers.

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Avure's AV-X, the world's first scalable HPP machine.

This growth is driven by food safety, extended shelf-life to reach new markets and the increased efforts by food manufacturers to meet customers' demands for natural, preservative-free foods.

This has driven food manufacturers to either develop new formulations such as baby foods, refrigerated soups, etc and/or to modify existing formulations for the refrigerated segments. Although the expansion of food categories into HPP is extensive, the RTE meat and raw protein segments continue to be the major product category using HPP, primarily food safety and quality extension.

The RTE meat and poultry industry has experienced several recalls of products because of contamination with Listeria monocytogenes, salmonella, E. coli O157:H7 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, environment, or breakdown in quality assurance and HACCP programs. Additionally, newer, stricter rules on pathogens reduction in raw products including those for the pet food industry have increased the use of HPP as a post lethality treatment to increase food safety.

RTE meat and poultry

The USDA Food Safety and Inspection Services' (FSIS) 2003 interim rule for the control of L. monocytogenes in RTE meat and poultry products was issued to enhance the safety of meat products. It required processors to implement one of three risk-based alternatives 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 pasteurisation could not be used with most products due to adverse organoleptic effects.

Additionally, the use of chemical preservatives is counter to customer demands.

The adoption of a viable intervention method to meet microbiological safety standards without comprising the sensorial quality and customer demands has been afforded by High Pressure Processing (HPP).

Results of several HPP validation studies done by Avure Technologies and other published reports clearly showed that HPP will provide the food safety for these at-risk products (Figs. 1 and 2) without affecting their quality as well as meeting customers' need for preservative-free products.

Avure Technologies submitted the results of a comprehensive validation study to FSIS that led to the acceptance of HPP and a letter of

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no objection from FSIS, as a post

Fig. 1. Fate of inoculated pathogens in sliced roast beef with and without HPP (5930 bars; 180 seconds) during storage at 4°C (average, n = 3). <10 CFU/g (confirmed as negative/25g with enrichment procedure) is plotted as 0.

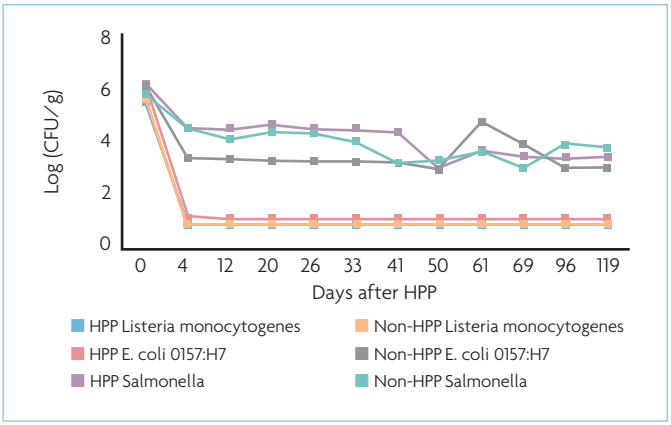
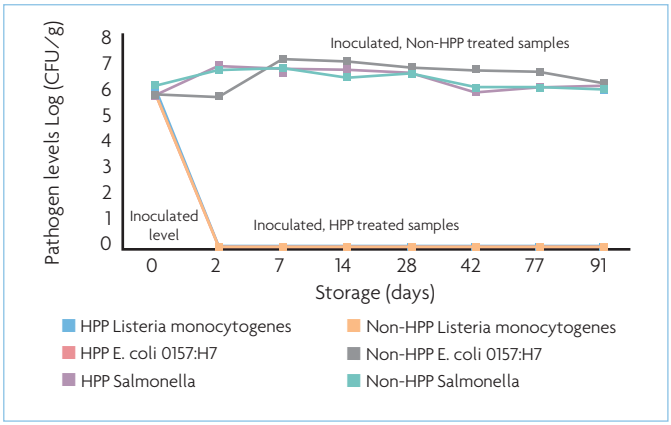


Fig. 2. Fate of inoculated pathogens in cooked chicken sausages with and without HPP (5930 bars; 180 seconds) during storage at 4°C (average, n = 3). <10 CFU/g (confirmed as negative/25g with enrichment procedure) is plotted as 0.



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lethality treatment for the control of L. monocytogenes in RTE meat plants.

Extension of quality and shelf life

An important economic benefit of using HPP for controlling food borne pathogens is the concurrent inactivation of spoilage micro-organisms. 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 higher quality products that maintain 'recently produced' organoleptic characteristics throughout the shelf life. Non-HPP products tend to lose sensory attributes such as taste, colour, and texture as shelf life nears its end.

The decline in product quality over time 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. HPP roast beef showed remarkable organoleptic properties after 100 days in storage compared to the same product without HPP.

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 (Fig. 3).

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.

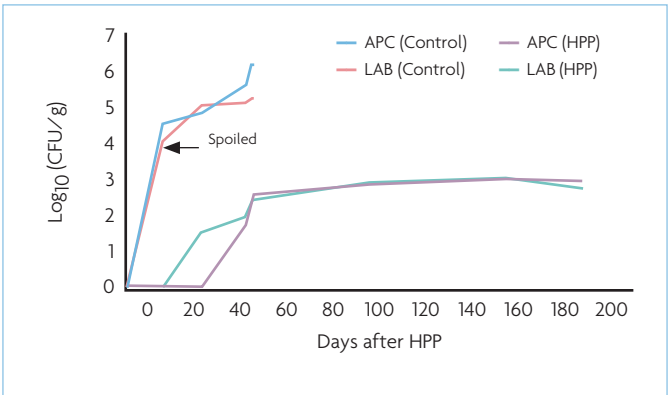

Fig. 3. Extension of shelf-life of Black Forest Ham treated at 86,000 psi for three minutes vs. non-HPP samples.

A very important element for the microbiological and product quality extension is the use of high quality package material that has very good barrier properties such as those for oxygen, moisture and UV.

Packages with good oxygen barrier (low OTR) are essential for controlling the growth of spoilage microflora that survived the HPP process, particularly certain strains of lactic acid bacteria as well as preventing oxidation. EVOH based packages tend to offer good protection and are the most commonly used materials for HPP meat products.

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 have to deal with tougher food safety regulations all while protecting their brand.

Traditional heat treatment methods to inactivate micro-organisms are the only viable options for certain RTE meat and poultry products due to the adverse effects on sensory attributes. HPP inactivates micro-organisms 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 to 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 micro-organisms is increasing in the meat processing industry. The unique behaviour of raw protein and hydrocolloids can be maximised to enhance the quality of meats and meat products such as for tenderising, marinating, and improved binding characteristics.

The high demand for tender meat, particularly beef, by consumers is an ever-present challenge for the industry due to the difficulty in controlling tenderisation.

The use of HPP to tenderise meats has the potential to revolutionise the red meat industry since tenderisation effects are highly variable between meat carcases.

By understanding the biochemical mechanisms of muscle breakdown, processors can utilise HPP to 'turn on' and promote endogenous enzyme systems that tenderise muscle protein. HPP can increase the activities of certain enzyme systems such as those of the calpain family resulting in an increase in tenderisation. Similarly, the activity of added proteases such as papain can be enhanced by HPP.

During HPP, raw protein unfolds exposing no 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 with hamburger meat that is free of food borne 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

The implementation of HPP technology in the meat processing industry serves an important role in providing safer, higher quality, and higher value products to the consumers. It is increasingly used to eliminate or reduce chemical additives for more natural and organic products.

By taking advantage of the unique behaviour 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 or no chemical additives. ■

References are available from the author on request