

Marination of Beef for Enhancement

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Marination is a technique used to improve the tenderness, juiciness and flavor of cooked beef. Typically, marinated beef is bathed in a solution or sauce containing ingredients known to increase tenderness and juiciness, and enrich flavor. This often slow process involves the passive transport of marinade into meat products by absorption or osmosis. To decrease the marination times and increase uniformity of marinade distribution in beef products, specialized equipment can be used to inject the marinade deep into the beef cut. This process is often called “deep basting”, “injection marination” or “enhancement”. The marinating of beef products is not a new technology and has a well documented history. However, the techniques, equipment and terminology continue to be refined and updated to improve quality and consumer satisfaction.

In regard to meat products, enhanced is a term used to describe an improvement in quality. Today, the process of adding non-meat ingredients to fresh meat to improve eating quality is defined as ‘enhancement.’ The 2004 National Meat Case Study found that 16% of whole-muscle beef cuts in U.S. retail cases are enhanced.

Ingredients

The ingredients used in enhanced beef products typically consist of water, salt and alkaline phosphates. The water is used to dissolve the non-meat ingredients and contributes to the tenderness and juiciness of the meat product. The addition of water also increases yield, which is important to processors because of economic advantages that offset production costs. Salt is added at low levels to improve flavor and to increase the uniformity of solution distribution inside the beef product. Alkaline phosphates interact with beef proteins and increase their ability to hold moisture inside the products during cooking, which increases the juiciness of the cooked beef.

Natural flavorings, such as rosemary spice extract, are also often incorporated into beef enhancement solutions. Natural flavorings are added because of their strong antioxidative properties rather than their flavoring attributes. These antioxidants increase the shelf-life of products by protecting beef against oxidation - causing beef lean to change from red to brown in color - during retail display. Sodium and potassium lactate also can be found in enhanced beef products. Both ingredients are known for their antimicrobial properties and extend shelf-life by inhibiting the growth of spoilage bacteria. Because salt is already present in most solutions, potassium lactate is often preferred to reduce sodium and avoid off-flavor development resulting from sodium lactate use. Finally, natural tenderizers (ficin, bromelin, and papain) originating from tropical plants (fig, pineapple, and papaya) can be incorporated into enhancement solutions to improve meat tenderness.

Use Levels

Ingredient use levels and the amount of solution delivered into the products vary, and are often proprietary. Because the solution is added to the product, the level or amount at which it is added will affect ingredient levels in the final product. For this reason, care must be given to formulate solutions that provide a desired amount of each ingredient in the beef at a given injection level. Injection levels in beef are expressed in percentages, which reflect the percentage increase in weight after solution injection. Injection levels among beef products typically range from 8 to 12%. Research has shown that injection levels ranging from 7.5 to 15% did not change panelists opinions on the tenderness and juiciness of enhanced beef strip steaks. However, the panelists did think enhanced steaks were more tender and juicy than steaks that were not enhanced or injected with water only. This indicates panelists were able to detect the difference and ranked these additional treatments lower in tenderness and juiciness than those enhanced with a solution containing salt, alkaline phosphate, and sodium lactate. This data also indicates meat quality is enhanced in these types of products because of the ingredients used – not the addition of water only.

The level of each ingredient in the solution is often expressed as the percentage of the ingredient in the meat product after injection. Salt is generally formulated to deliver 0.2% to 0.4% in the final product. Alkaline phosphate levels typically represent 0.25% to 0.45% of the final product weight. Phosphate levels are regulated by the government and cannot exceed 0.5% in the final product according

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to the United States Department of Agriculture (USDA). A natural flavoring like rosemary extract is generally used at levels of 0.05% to 0.2% in the final product, depending on its source. Sodium and potassium levels are typically recommended at 2.5%-3.0%. These levels will vary by product and by injection level, so it is best to read the package label to determine the ingredients used and the level of enhancement.

Calcium Chloride

Numerous researchers have successfully documented improved meat tenderness and decreased variation in meat tenderness resulting from marination with solutions containing calcium chloride (CaCl₂). It has been documented that a CaCl₂ solution injected at 5% (level of ingredient in the product after injection) consistently improves meat tenderness scores over non-marinated control steaks. Researchers also have shown that CaCl₂ can be used in commercial beef operations at current production speeds, is acceptable to consumers when served in a restaurant setting and can command premium prices from consumers who purchase meat in a retail setting. Nonetheless, the use of calcium chloride marination, despite being extensively investigated, has not been adopted by the meat industry.

Packaging

Enhancement of traditional retail cuts requires additional equipment, storage space and labor. This increases cost of production, but also provides opportunity for process control and innovation. These opportunities have allowed processors to incorporate new packaging systems in enhanced production systems designed to provide consumers with the products they desire with an extended case-life. These packaging systems are known as case-ready modified-atmosphere systems because the atmosphere inside the package has been modified and shipped ready to be placed into the retail case. A variety of modified atmosphere packaging systems are being used by the meat industry differing in levels of oxygen, carbon dioxide, carbon monoxide and/or nitrogen.

Safety

Meat processors have safely produced deep marinated products for years. In May 2005, USDA-Food Safety Inspection Service (FSIS) published notice that establishments who produce mechanically tenderized beef products must reassess their safety plans because recent outbreaks indicate that E. coli O157:H7 is a hazard reasonably likely to occur in these products. Needle tenderization and multi-needle injection are not the same process, but similarities shared by these processes warrant consideration. Researchers are currently working with the meat industry and USDA-FSIS to assess the safety of deep marination in a commercial setting and explore potential interventions to maintain the safety of these products. These on-going projects are based on USDA-FSIS suggestions that processors of these products may want to “consider implementing purchase specifications that require that incoming product has been treated to eliminate or reduce E. coli O157:H7 to an undetectable

level” and that processors “might also consider applying an allowed antimicrobial agent to the surface of the product prior to processing or tenderization.”

References:

- 2004 National Meat Case Study: Today's Retail Meat Case, Evolving Trends Across the Country. Accessed at: <http://www.beefretail.org/uDocs/consumertrendsbrochure512.pdf> on June 20, 2005.
- Brooks, J.C., Belew, J.B., Griffin, D.B., Gwartney, B.L., Hale, D.S., Henning, W.R., Johnson, D.D., Morgan, J.B., Parrish, F.C. Jr. and Reagan, J.O. 2000. National beef tenderness survey-1998. *J. Anim. Sci.* 78 (7):1852-1860.
- Carr, M.A., Crocket, K.L., Ramsey, C.B. and Miller, M.F. 2004. Consumer acceptance of calcium chloride-marinated top loin steaks. *J. Anim. Sci.* 82:1471-1474.
- Dikeman, M.E., Hunt, M.C., Addist, P.B., Schoenbeck, H.J., Pullen, M., Katsanidis, E. and Yancey, E.J. 2003. Effects of postexsanguination vascular infusion of cattle with a solution of saccharides, sodium chloride, and phosphates or with calcium chloride on quality and sensory traits of steaks and ground beef. *J. Anim. Sci.* 81:156-166.
- Hoover, L.C., Cook, K.D., Miller, M.F., Huffman, K.L., Wu, C.K., Lansdell, J.L. and Ramsey, C.B. 1995. Restaurant consumer acceptance of beef loin strip steaks tenderized with calcium chloride. *J. Anim. Sci.* 73:3633-3638.
- Hunt, M.C., Schoenbeck, J.J. Yancey, E.J., Dikeman, M.E., Loughin, T. M. and Addis, P.B. 2003. Effects of postexsanguination vascular infusion of carcasses with calcium chloride or a solution of saccharides, sodium chloride, and phosphates on beef display-color stability. *J. Anim. Sci.* 81:669-675.
- Jerez, N.C., Calkins, C.R. and Velazco, J. 2003. Prerigor injection using glycolytic inhibitors in low-quality beef muscles. *J. Anim. Sci.* 81:997-1003.
- Kerth, C.R., Miller, M.F. and Ramsey, C.B. 1995. Improvement of beef tenderness and quality traits with calcium chloride injection in beef loins 48 hours postmortem. *J. Anim. Sci.* 73:750-756.
- Miller, M.F., Huffman, K.L., Gilbert, S.Y., Hamman, L.L. and Ramsey, C.B. 1995. Retail Consumer acceptance of beef tenderized with calcium chloride. *J. Anim. Sci.* 73:2308-2314.
- Milligan, S.D., Miller, M.F., Oats, C.N. and Ramsey, C.B. 1997. Calcium chloride injection and degree of doneness effects on the sensory characteristics of beef inside round roasts. *J. Anim. Sci.* 75:668-672.
- Ostoja, H. and Cierach, M. 2003. Effect of calcium ions on the solubility of muscular collagen and tenderness of beef meat. *Nahrung.* 47:388-390.
- Smith, G.C., Carpenter, Z.L., Cross, H.R., Murphey, C.E., Abraham, H.C., Savell, J.W., Davis, G.W., Berry, B.W. and Parrish, F.C., Jr. 1984. Relationship of USDA marbling groups to palatability of cooked beef. *J. Food Qual.* 7:289-308.
- Vote, D.J., Platter, W.J., Tatum, J.D., Schmidt, G.R., Belk, K.E., Smith, G.C., and Speer, N.C. 2000. Injection of beef strip loins with solutions containing sodium tripolyphosphate, sodium lactate, and sodium chloride to enhance palatability. *J. Anim. Sci.* 78 (4):952-957.
- Wheeler, T.L., Koohmaraie, M., Lansdell, J.L., Siragusa, G.R. and Miller, M.F. 1993. Effects of postmortem injection time, injection level, and concentration of calcium chloride on beef quality traits. *J. Anim. Sci.* 71:2965-2974.

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