Optimizing Quality and Shelf-Life of Sturgeon Caviar

Termination Report

Reporting Period	September 1, 2002–September 1, 2006 with no cost extensions through 2008		
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REASON FOR TERMINATION

Objectives completed.

PROJECT OBJECTIVES

1. Characterize the sensory attributes of caviar and determine what factors influence product flavor, texture, color and other sensory attributes.
2. Determine how to optimize quality factors through diet modification, rearing conditions, and timing of harvest
3. Evaluate thermal and non-thermal processing methods to improve the shelf-life of caviar; evaluate microwave and RF processes for pasteurization.
4. Evaluate freezing methods to improve the shelf-life of caviar, and evaluate enzyme pretreatment, cryogenic and partial freezing processes for preservation.

PRINCIPAL ACCOMPLISHMENTS

This project solved technological issues facing the development of caviar from cultured white sturgeon (*Acispenser transmontanus*), an important species in California and the Inland Northwest. We assessed quality and sensory attributes of white sturgeon caviar; a number of different processing technologies including thermal processing, freezing; and the use of processing aids and additives. We also studied dietary changes on product quality and factors affecting product safety. This study should provide useful data to develop, produce, and promote American caviar. The longer term impact of the study is to assist the development of domestic and international markets for U.S. sturgeon products and provide opportunities for product diversification.

Objective 1. Characterize the sensory attributes of caviar and determine what factors influence product flavor, texture, color, and other sensory attributes.

Since there is no standardized way to grade caviar, this study looked at the sensory attributes correlated with high- and low-quality caviar. The descriptive analysis panel developed a lexicon with 33 attributes and found 16 significantly

discriminated between the 22 commercial caviars tested. This reliable sensory lexicon can be used to evaluate caviar products from a variety of sources, feed regimes, and processing conditions, and has already been used to evaluate numerous samples provided by companies throughout the Western region. From evaluation of a large number of samples, it appears that the attributes selected for the lexicon provide a wide enough range to cover differences observed among caviars sturgeon samples (imported Beluga, Sevruga, Osetra, *Astara asetra*; American Sevruga; cultivated Osetra; white sturgeon, spoonbill sturgeon, hackleback, and paddlefish).

Expert judges were asked to rate the caviar on a quality scale from zero to 100 taking into consideration all the sensory qualities such as taste, aroma, appearance, and texture. The experts included chefs, members of the caviar industry, and faculty of the Culinary Institute of America. Some of the judges had more experience with caviar than other judges, creating some disagreement about what constituted high- or low-quality. The judges rated the imported Osetra as the highest-quality and an imported Sevruga and domestic Spoonbill as the lowest quality. However, judges had different opinions on what traits constitute high-quality caviar. The results from the study indicate that caviar producers should strive for an egg that has a thicker skin and a buttery flavor and mouth-feel. The eggs should not have any bitterness, sourness, metallic flavors, grassy leaves, or high salt.

Expert ratings are good indicators of consumer likes and dislikes, but further work should be done with consumer testing. If manufacturers are looking to develop new products and are interested in how consumers will react, expert assessors will not necessarily describe the attributes that are relevant for product development. The use of new ingredients, processing techniques, and storage methods can cause conflict with experts' specifications regardless of how consumers may perceive the product.

Rheological tests can provide an instrumental assessment of product texture with correlations found between egg size and skin thickness; dissolvability, breakability, and firmness. Both the physical properties and sensory characteristics of caviar can vary by how the product is packed, and the location of the sample within a jar.

Objective 2. Determine how to optimize quality factors through diet modification, rearing conditions, and timing of harvest.

Large-scale feeding trials that evaluated antioxidants were conducted. Eggs from fish consuming a high antioxidant diet can differ in certain flavor, aroma, and texture characteristics by both instrumental and sensory tests, but these differences may not affect overall product quality or consumer acceptability or preference. For example, in one study, the breakability (tougher skins) and skin thickness of caviar from fish on the control diet were significantly greater than for eggs from fish fed an experimental diet containing antioxidants.

The fish fed the experimental diet produced eggs that were wetter in appearance and more bitter and that had a stronger aftertaste; however, there was an overlap in sensory attributes for samples between the two treatment groups. Eggs from fish raised on the experimental diet also had more viscous internal contents. The experimental eggs had a more consistent or uniform appearance in the jar compared to the control. Lastly, the experimental eggs separated in the mouth more easily and dissolved faster than the control diet eggs. These results are reproduceable between two different panels at different years for fish on similar diets. Antioxidants may have prevented the occurrence of off flavors and poor textures. Previous research suggests that the addition of antioxidants benefits the shelf life of the product and preserves the fresh flavor.

Objective 3. Evaluate thermal and non-thermal processing methods to improve the shelf-life of caviar; evaluate microwave and RF processes for pasteurization.

Dielectric and conventional thermal processing methods were developed for packed caviar in jars and plastic containers. Shelf life of caviar products could be extended by using different additives, with antimicrobial agents, particularly nisin, improving the effectiveness of thermal processing treatments by reducing both the treatment temperature needed to inactivate *Listeria monocytogenes*, the vegetative pathogen of greatest heat resistance in aquatic food products, and treatment time.

Objective 4. Evaluate freezing methods to improve the shelf-life of caviar, evaluate enzyme pretreatment, cryogenic, and partial freezing processes for preservation.

Freezing (including cryogenic technologies and super-cooling) were successfully developed. In addition, various pre-freezing treatments were evaluated as means to enhance storage stability and maintain product quality. The lack

of endogeneous transglutaminase in sturgeon roe means that treatment with various additives (e.g., polyphosphate, sulfate salts, calcium chloride) that is often effective for improving the texture of some fish roe products (e.g., ikura) through a cross-linking reaction of membrane proteins, will not be effective for sturgeon caviar. Protein composition of salmon and sturgeon roe products differ significantly.

IMPACTS

The WRAC-sponsored research has had positive impacts on the industry by providing processing and storage technologies to extend shelf life and maintain product quality and safety. Investigators have worked with individual aquaculture facilities on strategies to produce safe, high-quality caviar with an extended shelf life and have provided technical information needed to show that caviar from cultivated fish is a quality product, and as good as caviar from wild harvested fish. During the course of this study, the quality of caviar from U.S. producers has become more reliable, with consistently attainable product standards that are necessary for further market development.

Implementation of technologies developed in this project has resulted in major cost savings, potentially in the range of millions of dollars per year. For example, if caviar goes "sour" during storage, the value drops from roughly $1,000 per pound to $10 per pound.

Product quality is a critical feature for any aquatic food, and probably more important for higher value items. The demand for sturgeon caviar continues to exceed supply, and sturgeon remain subject to extreme over-exploitation throughout their natural range of distribution (Bledsoe and Rasco, 2006; Wirth et al. 2002). The quality of imported product has dropped over the past two years, despite a significant increase in price (Bledsoe and Rasco, 2006; Irwin and Marsh, 2005). Restrictions on the sale of beluga caviar will continue to provide an excellent opportunity for U.S. producers to meet market demand for caviar as foreign supplies tighten. The United States and European Union remain the largest import markets of beluga caviar selling in 2005 at retail prices of $750–1,500/100 g in high-end European retail markets and $450/100g in the U.S., substantially more than three years earlier. Prices are dramatically higher in 2006 at £229/50 g for beluga caviar, £123/50 g for sevruga and £159/50 g at retail stores in London in August. Because of trade restrictions and current high demand, there is every reason to believe that there will be a good market for sturgeon caviar (*Acipenser transmontanus*) produced in the United States.

It will be important to be able to predict how products from aquacultured sturgeon differ from wild fish and how to exploit these differences to one's advantage in the marketplace by promoting caviar with distinct attributes to specific markets. The flavor of caviar changes as it ages, with the conventional market for an aged product that has undergone a certain degree of auto-oxidation. However, there are new markets for fresher products that realistically can only be made from cultivated fish. For example, Prunier recently introduced a "48-hr" old Paris brand malosol caviar, selling in London at £141/50 g indicating that there are markets for a wide variety of caviar products.

RECOMMENDED FOLLOW-UP ACTIVITIES

Additional work should be conducted to assist sturgeon growers and processors to develop products for particular markets based upon sensory characteristics that can result from differences in fish diet, harvest technology, processing method, and storage conditions and time. Research is needed to assist growers to determine when fish are mature and when the optimal time is to harvest eggs for greatest yield and quality. The nutritional needs of these fish are still not well understood; also not well understood is how the diet could be modified to improve the flavor, texture and mouthfeel of the caviar, control fat content and color, and to shorten depuration periods needed to control for off-flavor development. Studies on husbandry or processing practices that could improve texture and flavor should be continued. Texture changes are often more important than flavor in assessing caviar quality, and how texture is affected by product source (water, temperature, age), fish diet, and processing and storage conditions should receive more attention. Experiments focused on reducing the membrane fragility of sturgeon eggs should examine agents other than enzymes. Studies on the safety and lowest effective levels of treatments necessary for controlling texture and microbial spoilage should be evaluated, as well as continued work on technologies and practices that could maintain product quality and safety.

PUBLICATIONS

Shin, J. H., Kang, D. H., and Rasco, B. 2006. Effect of water phase salt content on the growth of *Listeria monocytogenes* in refrigerated sturgeon caviar. In preparation.

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Al-Holy, M., Ruiter, J., Lin, M., Kang, D.H., and Rasco, B. 2004. Inactivation of Listeria innocua in nisin treated salmon (*Oncorhynchus keta*) and sturgeon (*Acipenser transmontanus*) caviar treated by radio frequency (RF). J. Food Protection. 67(9): 1848-8154.

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Bledsoe, G.E., Bledsoe, C.D. and Rasco, B.A. 2003. Caviar and Fish Roe Products. Critical Reviews in Food Science and Nutrition. 43(2):233-271.

PAPERS PRESENTED

Shin, J.H., Lin, M., and Rasco, B. 2006. Effect of water phase salt and storage temperature on the growth of *Listeria monocytogenes* in sturgeon (*Acipenser transmontanus*) caviar. Institute of Food Technologists Annual Meeting. June 24-28, 2006. Orlando, FL.

Al-Holy, M.A., Ruiter, J., Lin, M., Kang, D.H., Rasco, B.A. 2004. Inactivation of *Listeria innocua* in salmon (*Onchorhynchus keta*) and sturgeon (*Acipenser transmontanus*) caviar using radio frequency (RF) pasteurization with nisin. Aquaculture 2004. World Aquaculture Society. March 1-5,2004. Honolulu HI.

Al-Holy, M.A., Lin, M., Kang, D.H., Rasco, B.A. 2004. Combined effect of nisin with chemical antimicrobials or moderate heat on the destruction of *Listeria monocytogenes* in sturgeon (*Acipenser transmontanus*) caviar. Aquaculture 2004. World Aquaculture Society. March 1-5, 2004. Honolulu HI.

Al-Holy, M, Wang, Y, Tang, J. and Rasco, BA. 2002. Dielectric properties of salmon (*Oncorhynchus keta*) and sturgeon (*Acipenser transmontanus*) caviar at 27 MHz and 915 MHz as a function of temperature. Institute of Food Technologists Annual Meeting (international). Anaheim, CA. June 14-19, 2002.

Bledsoe, GE, Rasco, BA and Bledsoe, CE. 2002. Caviar and fish roe products. Pacific Fisheries Technologists Annual Meeting (international). Reno, NV. Feb. 27-29, 2002.

SUPPORT

YEAR	WRAC-USDA FUNDS	OTHER SUPPORT					TOTAL SUPPORT
		University	Industry	Other Federal	Other	Total	
2002	57,000	17,400	56,000	19,200		92,600	$149,600
2003	57,000	17,400	51,500	25,000		93,900	$150,900
2004	57,000	9,000	56,500	19,250		84,750	$141,750
2005	57,000	5,000	56,500	12,500		74,000	$131,000
TOTAL	228,000	48,800	220,500	75,950		345,250	$573,250