Technicalities

Reducing Fisheries and Aquaculture Environmental Footprints by Maximizing Value of Fish By-products

by Isabel Cuenca and Deepika Dave

Ocean resources support an increasing demand for food, energy, and nutrients through fisheries and aquaculture. While many negative factors such as bycatches, spoilage, and diseases may impact the environment, nearly half of the total available production is lost after the processing operations and discarded as by-products. They end up in low value products or dumped at sea/landfilled, which can further increase the environmental footprints.

Atlantic salmon is the leader in marine species farmed in the world, holding ninth place in all economic species, produced mainly in Norway, Chile, United Kingdom, and Canada. The market demand of products, such as salmon fillets and slices, generates up to 45-50% of processing discards, representing a high amount from the 2.2 million, 138,000, and 14,000 tons of Atlantic salmon produced in the world, Canada, and Newfoundland and Labrador, respectively, according to Fisheries and Oceans Canada. The industry recovers value by transforming these discards in products such as animal feed and fertilizer, while a portion goes to landfills, representing a challenge for waste management and impacting the environment. The salmon waste resources can be used as means to generate various value-added nutraceutical products such as fish oil, proteins, amino acids, biodiesel, marine calcium, and omega-3 fatty acids. Nevertheless, their high perishability results in quality loss, limiting their potential. Oxidative degradation is the main reaction leading to quality loss, especially in fatty fish such as salmon, even during frozen conditions.

The main aim of our research was to reduce oxidative degradation of salmon by-products for the maximization of their economic value. The specific objectives were: (1) the evaluation of processing methods on salmon by-products, hypothesizing a significant alteration of the internal microstructure of molecular compounds due to the degree of tissue disruption during processing, (2) the evaluation of the effect of sub-organs along with reactive substances such as hemoglobin, salts, acids and enzymes, hypothesizing a

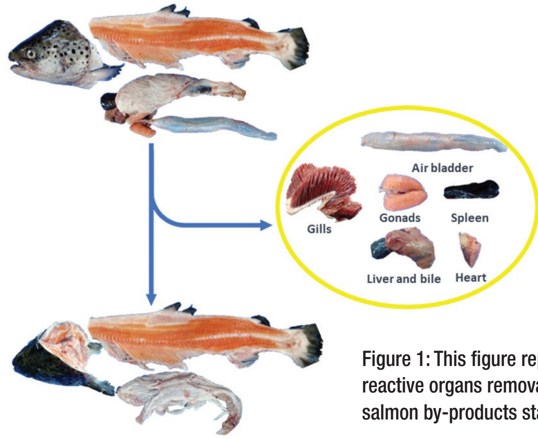

Figure 1: This figure represents reactive organs removal towards salmon by-products stabilization.

significant catalysis of degradative reactions promoted from the presence of those compounds, and (3) the evaluation of the antioxidant effect of rosemary phenolic compounds (commercial antioxidant) specifically designed for highly polyunsaturated fish oil, added through external (low tissue disruption) and homogeneous (high tissue disruption) methods.

In the first study, salmon heads, frames, and viscera were segmented in sub-organs and those with high content of reactive substances, potential promoters of lipid oxidation, and with low impact in oil yield were determined as reactive organs and removed from by-products. Consequently, gills were removed from heads, while liver, heart, kidney, spleen, bile, gonads, and bladders were removed from viscera (Figure 1). Frames were handled straightforward considering absence of significant reactive organs. All samples were ground in a meat grinder, vacuum packed, and stored at 10°C for seven days. Parallelly, whole salmon heads, frames, and viscera (with reactive organs) were processed using a meat tumbler (low tissue disruption) and meat grinder (high tissue disruption). All samples were then vacuum packed and stored at 10°C for seven days. After the storage, the oil was extracted enzymatically and analyzed for peroxide value, anisidine value, total oxidation, and free fatty acids. In this study, reactive organs, and the high processing method (high tissue disruption) statistically affected lipid oxidation in by-products, especially in viscera.

A second study was performed to evaluate the oxidative deterioration of salmon by-products during frozen storage, including the antioxidant. During this study, reactive organs were removed, and tumbling method was considered as a control, while grinding method was included as a homogeneous method in the antioxidant addition. Tumbled samples without antioxidant were separated as a control. Samples were vacuum packed and stored at -18°C for 90 days. Peroxide value, anisidine value, total oxidation, free fatty acids, and fatty acid profile were analyzed every 30 days. Similarly, during frozen storage, the high processing (grinding method) statistically affected lipid oxidation, while the use of an antioxidant showed a low and high impact when added to tumbled and ground by-products, respectively. Viscera reported the highest oxidation resulting from a high release of free fatty acids catalyzed by the digestive enzymes. These results showed low processing superficial method and reactive organ removal as a potential approach for the stabilization of salmon processing discards during storage, towards the maximization of value from fish by-products.

In conclusion, the wide recognition of potential bio-compounds present in by-products have resulted in extensive research to increase profitability while reducing environmental impacts. Nevertheless, for the realistic capitalization of these compounds, by-products should be processed as fast as possible before the degradation process starts, which in many cases it is not possible where by-products are processed in a far-away facility. The research on fish by-product stabilization during storage is at very early stages. Therefore, stabilization technology is required. The present research steps forward towards the storage and stabilization of salmon by-products to produce value-added products, increase profitability, and reduce environmental footprints of fisheries and aquaculture.

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