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Responsibility

Pilot system recovers protein, lipids from fish byproducts

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West Virginia University system capable of flow rates up to 300 liters per hour

West Virginia University's recovery system shows a decanter-centrifuge on the left and two bioreactors on the right. The continuous homogenizer is not shown.

Fish-filleting operations generate significant amounts of byproducts such as frames, heads, guts, and the like. In the United States, most of these byproducts are sent to landfills, and only limited amounts are rendered for animal feeds due to the high polyunsaturation of fish lipids with a propensity to develop rancid off odors. Aquaculture production has quadrupled during the past two decades, yet the industrial methods to recover fillets from fish have not changed, and therefore, the amount of byproducts has increased correspondingly.

Filleting yields

Commercial filleting of 100 kg of rainbow trout or tilapia typically yields 30 to 40 kg of fillets and 60 to 70 kg of byproducts. The trout and tilapia byproducts contain over 20 kg of fish meat, as well as valuable omega-3 fatty acids that are beneficial to human cardiovascular health.

Recovery and subsequent use of the fish meat and lipids in the development of human food products or other value-added applications could produce additional revenue for a processor. The reduced amount of byproducts would also help alleviate the ever-increasing environmental issues associated with fish processing.

Recovery technology

Isoelectric solubilization/precipitation has long been used in the dairy industry and the manufacture of soy protein isolates/concentrates. For example, precipitation of the milk protein casein at its isoelectric point yields curds, which is a fundamental step in cheese making.

Isoelectric solubilization/precipitation has also been recently applied to isolate myofibrillar and sarcoplasmic muscle proteins from various fish species. When applied to fish byproduct, this technique offers high yield; separation of lipids and bones, skin, and other insolubles; and a feasible continuous mode of operation that enables water reuse.

Solubilization/precipitation

Five basic steps in isoelectric solubilization/precipitation are required to recover functional muscle proteins from fish processing byproducts:

1. Homogenization of byproducts with water to increase surface area for subsequent solubilization reaction.
2. Solubilization of fish muscle proteins at basic or acidic pH due to electrostatic repulsion between the proteins and electrostatic interaction between water dipoles and charged protein molecules.
3. Separation of protein solution from fish lipids and insolubles.
4. Precipitation of fish muscle proteins at their isoelectric point (pH = 5.5).
5. Separation of the precipitated proteins from the water to allow water reuse.

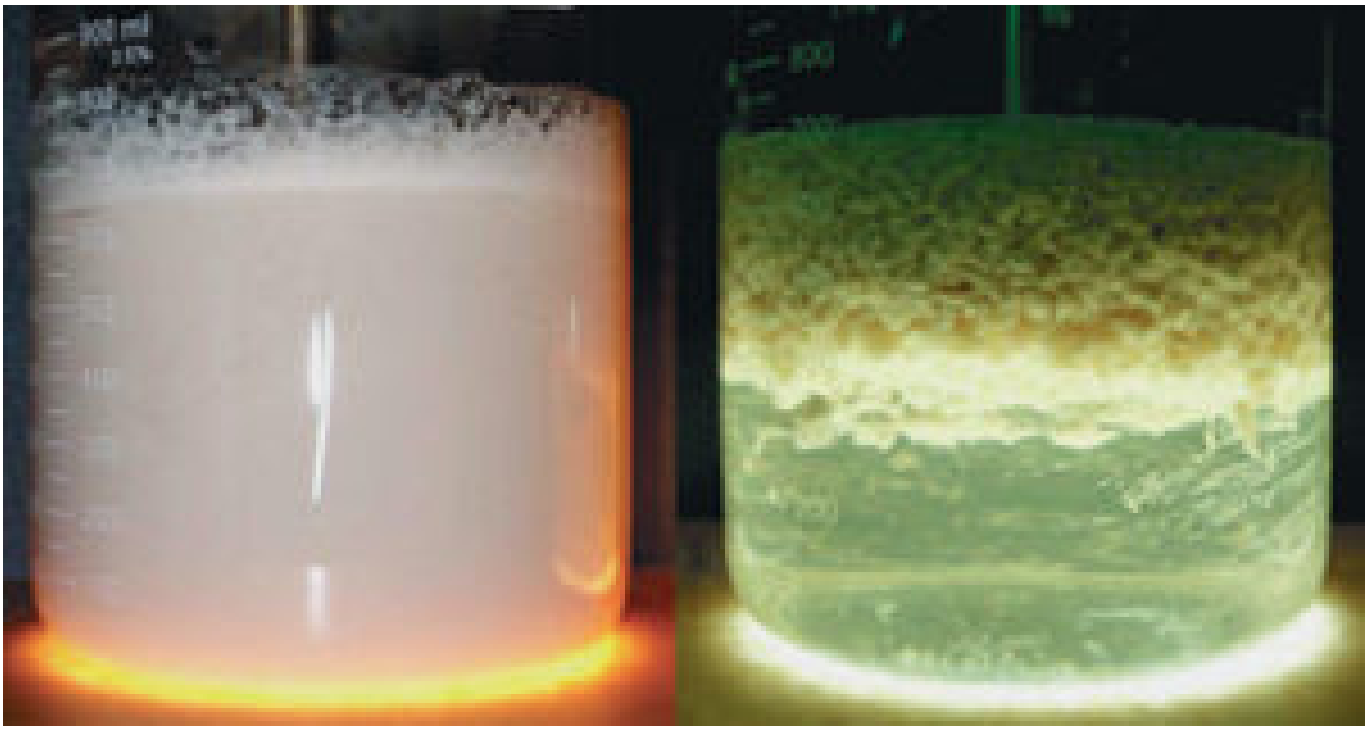
Steps 2 and 4 are carried our in bioreactors that allow continuous pH adjustment and variable flow rate of the solution through the system. Decanter-centrifuges handle the separation steps 3 and 5. Homogenization is carried out in a continuous homogenizer capable of supplying a sufficient volume of fish homogenate to maintain flow in steps 2 to 5. It is critical to match flow rate between all steps.

Pilot recovery system

A pilot protein and lipid recovery system constructed at West Virginia University in Morgantown, West Virginia, USA, is capable of flow rates up to 300 liters per hour, allowing processing of about 43 kg byproducts per hour on a continuous basis. The system could be easily scaled up by replacing the pilot-scale bioreactors and decanter-centrifuges with commercial-scale counterparts.

The researchers at West Virginia University have also designed a commercial bioreactor recovery system capable of processing over 11 metric tons (MT) fish byproducts per day. The modular system could be expanded with more bioreactor modules to suit particular processing needs.

Continuous pH adjustment at the pilot scale is relatively simple. However, protein separation following the adjustment



Protein flocculation can enhance separation of the fish muscle proteins in the decanter-centrifuge. On the left are fish muscle proteins without flocculant. On the right are muscle proteins following a 10-minute reaction with
a commercial flocculant.

of pH to 5.5 to precipitate functional muscle proteins is slow due to the small protein size. The decanter-centrifuges used in fish processing typically apply fixed gravitational force under 4,000 x *g*. Protein particle sizes can be increased by flocculants commonly used in the food industry and in the treatment of drinking water. Therefore, the protein separation in an industrial decanter-centrifuge could be more efficient.

Flocculants with different ionic charge characteristics and molecular weights were tested at different concentrations. Protein separation was evaluated by measuring optical density of the supernatant. An anionic flocculant with high molecular weight at 65 ppm resulted in excellent protein separation after a 10-minute reaction. The optical density of the supernatant was comparable to that of clear water.

This flocculant can be injected into the bioreactor during pH adjustment, resulting in increased protein size and more efficient separation during subsequent centrifugation in a decanter-centrifuge. The effluent water from the decanter-centrifuge can be reused in the homogenization step.

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