Salmon by-products

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Processing waste from aquaculture products is largely an untapped ingredient resource for the aqua feed industry. Oils and proteins recovered from the offal would partially offset the future gap in demand and supply of marine oils and proteins. This article reviews the opportunities for oil and hydrolysate manufactured from the processing waste of farmed salmon.

It has been estimated that by 2010 the aqua feed industry will consume 50% of the world's fishmeal and 80% of the fish oil production (Barlow, 2003). This estimate assumes that such large amounts of fishmeal and fish oil would still be available to the aqua feed industry on a cost-effective basis. The industry is facing competition from other animal feed sectors which are developing a renewed taste for fish ingredients to improve animal health and human nutrition. For example, recent research has shown that feeding small quantities of fish oil significantly improves fertility in pigs, poultry and even cows. Already supermarkets are stocking "designer" *Omega-3* supplemented milk and eggs which depend on fish oil. The newly updated US NRC Nutrients Requirements for Dogs and Cats, has recommended adding *Omega-3* fatty acids from fish oil for the first time. If manufactures of animal and pet foods start using more fish meal and oil, the supplies will become increasingly scarce and even more expensive.

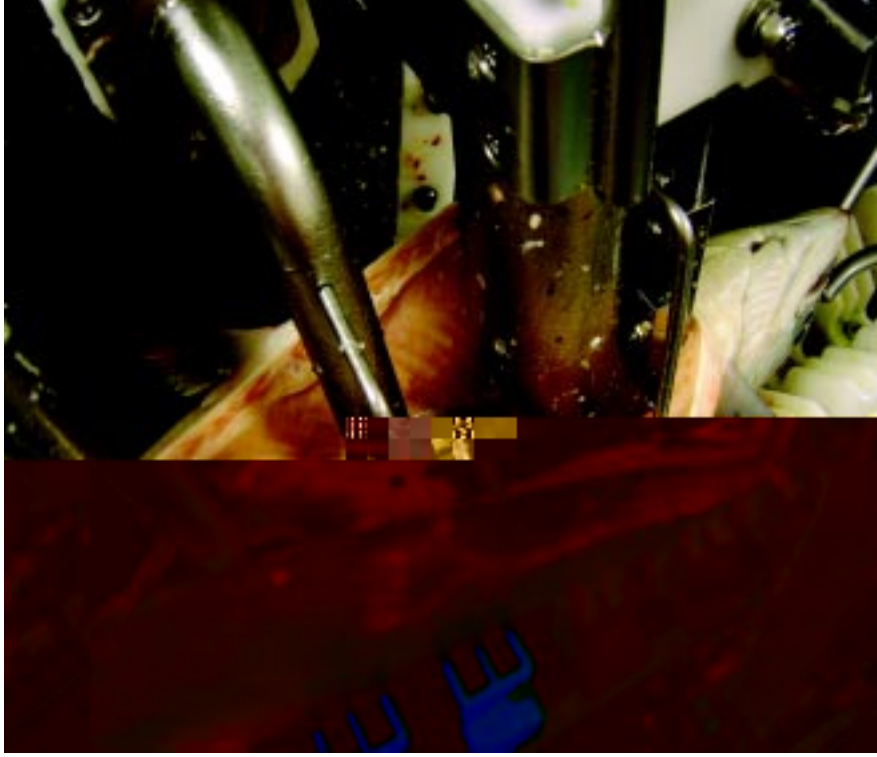
Mr. Ian Wright graduated with a degree in biology 25 years ago and has since worked in commercial nutrition. He started his career as a sales representative for a UK multinational agricultural merchant and by 28 was sales director of a regional feed manufacturer. In 1987 he became sales director of an agricultural biotechnology company. Ian was recently appointed sales director of Rossyew Ltd, which specializes in salmon oil and hydrolysate production.

There is not an infinite amount of fish in the sea and we need to manage our fish by-products better than in the past. This should involve greater utilization of fish by-products and the production of specialty fish ingredients that at low levels of inclusion will disguise and balance vegetable and animal proteins and oils. One option is to produce more fish hydrolysate, which has several functional advantages over fish meal. The remote and geographically dispersed nature of many fisheries and the very high capital cost of fishmeal plants make smaller scale fish hydrolysate production an intriguing proposition. The technology also provides opportunities to utilize protein wastes generated from fish and shellfish processing industries. The processing yield of fish converted into fillets may be as low as 35%, but the by-products (composed of viscera, skin and bones) are sufficiently high in protein, oil and other nutrients to make them a significant resource.

Global salmon farming yields about 1 million metric tons of fish and assuming a conservative processing yield of 75%, nearly 250,000 MT of waste is available for conversion into useful products such as salmon hydrolysate and oil. Since salmon is processed entirely for human consumption, very high standards of freshness and hygienic quality are followed. This can be used to advantage by the byproducts manufacturer to produce high quality byproducts.

Manufacturing of Salmon Byproducts

The Rossyew company, uses Scottish salmon by-products to produce salmon hydrolysate and salmon oil. We ensure that the processing wastes are stabilized within 4 hours of slaughter. Rapid stabilization and processing prevents spoilage and maximizes palatability. Furthermore, it sources only fully traceable food grade salmon by-products to ensure low levels of organic pollutants such as dioxins in the byproducts.



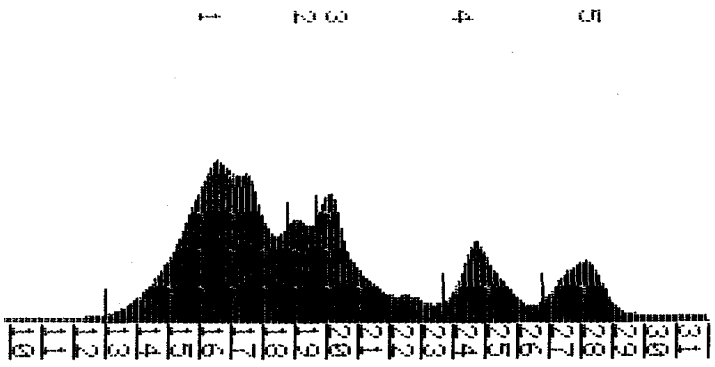
Processing of salmon for human consumption ensures very high standards of freshness and food safety even for the byproducts.

The typical process of manufacturing salmon byproducts involves maceration of viscera or bony by-products and then enzymatically digesting the protein into a liquid soup. During the next stage bones are removed and the fish oil is separated by centrifugation. The final stage is concentration of the hydrolysate by either spray drying to produce a powder, or low temperature vacuum evaporation to produce a thick liquid. Yields of hydrolysate and oil vary with the type of fish processed. In Atlantic salmon, every metric ton of the byproduct yields about 200 kg each of orange coloured salmon oil and condensed salmon hydrolysate.

Salmon Hydrolysate

Fish hydrolysate, is a product distinct from fish meal and fish solubles, and has unique attractant applications. During the hydrolysis process, large protein molecules are enzymatically broken down to a range of smaller peptides and amino acids. These molecules have varying degrees of solubility so when added to aquaculture feeds, diffuse out of the feed at different rates giving a "phased release effect" (Figure 1). Superficially hydrolysates and fish solubles appear similar, but as the name suggests the latter contain mostly soluble amino acids that are prone to rapid leaching. Some researchers (Guillaume 1997) believe that such free amino acids are not effectively assimilated by shrimps. Furthermore, fish solubles contain only the "soluble" portion of the fish's protein, while fish hydrolysates reflect the complete amino acid profile of the protein (Table 1). This may also be why Lawrence (2003) recently reported poor fish soluble attractant results with the Pacific white shrimp, *Litopenaeus vannamei*.

It is notable that modern hydrolysate concentration technology involves lower temperature vacuum evaporation process (60C) compared with fish meal and solubles production (Figure 2). Lower temperatures may retain more of the beneficial

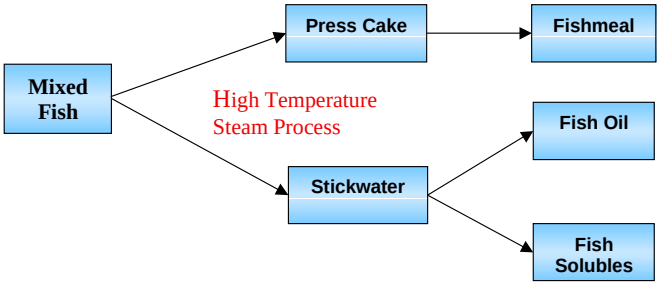


Peak 1 – MW 4012 Daltons
Peak 2 – MW 1483
Peak 3 – MW 950
Peak 4 – MW 151
Peak 5 – MW 38

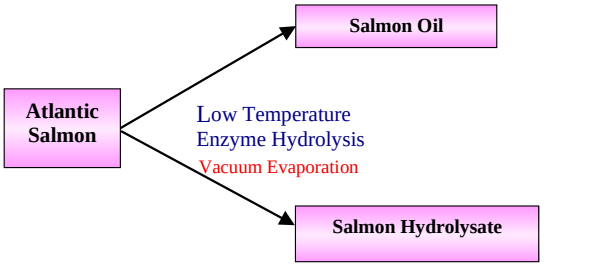
***Fig 1**. Molecular weight (MW, expressed in Daltons) of peptides in Rossyew Scottish salmon hydrolysate (Loughborough University, UK)*

***Fig 2**. Manufacturing of fish byproducts compared*

(a) Conventional fishmeal, fish oil and fish soluble manufacturing



(b) Modern fish hydrolysate and fish oil process



(Full peptide/amino acid spectrum)

functional and health properties of the fish protein (Haard 2001; Bechtel 2003).

Salmon hydrolysate can be coated either to the outside, or added to the inside of feed pellets to improve palatability. In trials shrimp feed palatability has been shown to be greatly enhanced with the hydrolysate application in both low and high

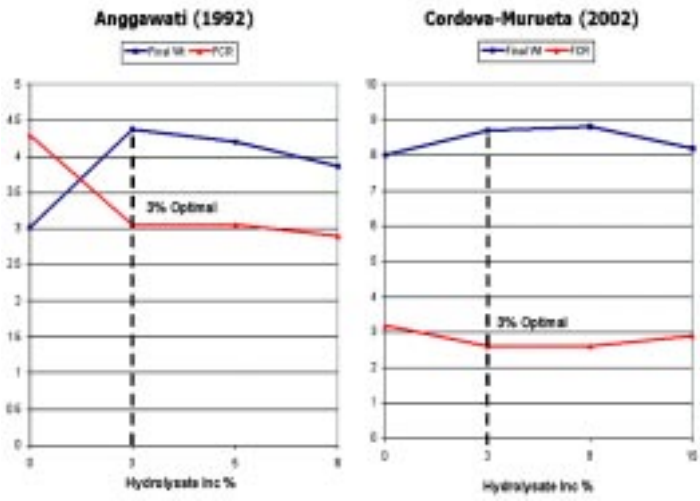


Fig 3. *Results of feeding penaeid shrimp with fish hydrolysate*

fish meal feed formulations. Research has shown that excessive levels of fish hydrolysate, however, may impair performance. The optimum inclusion rate of fish hydrolysates on shrimp growth can be clearly seen in the feeding experiments of Aggawati (1992) with *Penaeus monodon* and Cordova-Murueta (2002) with *Litopenaeus vannamei*. They both found that 3% dried fish hydrolysate (equivalent to 6% evaporated liquid hydrolysate), produced the highest growth rates and the best feed conversion (Figure 3). Commercial experience has confirmed these growth observations along with improved shrimp carcass quality and beneficial immune effects (Negret 2003).

Salmon Oil

The Scottish salmon oil produced using the latest production technology attracts a premium over standard fish oils because the processing method produces oil with low odor and very low pollutant levels. Low levels of organic pollutants such as dioxins have been achieved by careful sourcing of fully traceable human grade salmon by-products and Rossyew has developed in house "salmon oil micro-filtration" to minimize even the small traces of pollutants. The oil is rich in mono- and polyunsaturated fatty acids (Table 2). Since it is derived from salmon, it retains its carotenoid pigments (20 ppm) and astaxanthin (levels variable), which are natural oil antioxidants.

Cross Species Feeding

To avoid the potential risk of disease transmission, the European Community has banned the feeding of the same fish species back to itself (*intra-species* ban). However, salmon products make an ideal protein source for shrimp. Likewise shrimp head hydrolysate is an ideal protein ingredient in salmon feed. So, there is yet more scope for two way byproduct utilization between the salmon and shrimp which will benefit both industries.

References

Available from the author upon request.

Table 1. *Typical composition of Menhaden fish solubles and salmon hydrolysate (as is)*

Composition, % As is	Menhaden solubles	Salmon hydrolysate
Moisture	53	55
Crude protein	30	30
Crude fat	8	5
Ash	7.6	3.5
Amino acids		
Alanine	2.1	1.8
Arginine	1.5	1.9
Aspartic acid	1.8	2.8
Cystine	0.1	0.2
Glutamic acid	2.9	4.2
Glycine	3.0	1.8
Histidine	0.7	0.5
Isoleucine	0.6	1.2
Leucine	1.4	2.3
Lysine	1.7	2.3
Methionine	0.5	0.9
Phenylanine	0.7	1.1
Proline	1.6	1.4
Serine	0.9	1.8
Taurine	1.0	0.1
Threonine	0.7	1.1
Tryptophan	0.1	0.4
Tyrosine	0.4	1.0
Valine	1.0	1.5

Table 2. *Fatty acid composition of salmon oil*

Fatty acid	% of Total Fatty Acids
Total saturates	20.5
Total monounsaturates	46.5
18:2n6 (Linoleic acid)	4.0
20:4n6 (Arachidonic acid)	2.0
18:3n3 (Linolenic acid)	2.0
20:5n3 (EPA)	7.0
22:6n3 (DHA)	13.0

Fish hydrolysate suppliers

Fish hydrolysate manufacturers are few and far between. Soprochece, based in France, is producing powdered fish hydrolysates and fish oils for animal feeds. In Alaska, a company by the name *of* Round Gold produces hydrolysate from Pacific salmon by products. The Scotland-based Rossyew Ltd is a new company producing liquid salmon hydrolysate and salmon oil from Atlantic salmon employing state-of-the-art technology.