5.5 Hydrolysates

A plant using the Biomega patented process for a capacity of 10 000 tonnes per year has an approximate investment of US$4 million, including Westfalia separators and the line for drying the solids separate from the soluble protein. The production cost is quite dependent on the raw materials used; nevertheless the present price of hydrolysate is around US$1 400 per tonne for the pet food market.

6. MARKETS

6.1 Introduction

The protein market is very dynamic, with new resources and developments based on existing ones regularly appearing and replacing the traditional ingredients. Besides the normal functional properties sought by food manufacturers, consumers have a voice regarding other issues, such as GMO free (genetically modified organism), allergens and others. Protein suppliers' R&D departments should take care to keep or improve the competitive edge of their products, to avoid being replaced and to answer current public concerns.

Protein manufacturers that use salmon by-products as raw material have a relative handicap compared to protein suppliers that use raw materials specially designed to cope with the protein market specification, which might be the case with soybeans and other pulses. The salmon farmer always aims to satisfy the salmon meat consumer, and when these aims coincide, as for example in the flesh texture, the result is positive because it is also a required characteristic of the protein; but when the farmer is adding extra colour to reach the Coho Japanese market for example, the final pink protein may have no use in bakery products.

Health and consumer awareness factors play an important part in the protein market. Milk is positioned on top, with only lactose intolerance as a consumer concern, but if the protein is separated from the sugar, this hurdle disappears. Soybeans are affected by the GMO issue, and it will depend on the development of public opinion, both in the United States of America and in Europe, as to whether or not they will retain their marketability with increased prices for the GMO free protein or if their overall acceptance will be affected by the inability, real or nominal, to guarantee identity preservation (IP). Although foot-and-mouth disease, plus the mad cow syndrome bovine spongiform encephalopathy (BSE), have affected the beef protein market, it seems that both situations are under control, and consumers are recovering their confidence in the industry, but it is unlikely that it will reach the same status that it had before the crisis.

Fish proteins have a good healthy image, but there are some concerns regarding over-fishing and because the market for human consumption is heavily affected by aquaculture, which buys most of the fishmeal of marine origin – either the traditional fishmeal from pelagic species and by-catch or the fishmeal from by-products of other farmed species – the depletion of natural stocks may affect the position of fish proteins. The positive health claim for fish consumption, for a long time only associated with the omega-3 fatty acids, has expanded to include other ingredients, such as proteins and other components. So this may drive the direct consumption of fish protein additives, which will compete with the indirect use of converting them into another species protein as a feed additive.

Health functionality, or the capacity of an ingredient to have an impact on health by controlling illness, improving natural defences, controlling weight, improving rapid bodybuilding, etc. is a powerful market driver that has been studied and promoted by protein ingredient suppliers. A food processor who is already using a protein with a food technology purpose, such as binding and emulsifying, may welcome an additive that also has a health claim and use it to replace the original one. This implies that the protein manufacturer must develop these marketing tools. There is, however, one concern, mainly affecting the United States of America market with the decline of the Atkins diet to reduce weight, which is low in carbohydrates and rich in proteins. Proteins derived from salmon by-products could be used in novel applications, typically as nutraceuticals or to replace functional – from the food technology perspective – protein ingredients, already in the market and with properties that could be duplicated by salmon proteins. The growing salmon industry ensures that this ingredient is not going to be lacking in the future, but on the contrary is more likely to be in oversupply with the corresponding cost reduction. On the other hand, if by-product processors do not tightly control their supply, there might be some problems with the consistency of specifications for the proteins produced, affecting their image in the market.

6.2 Protein ingredients

Soy concentrates and isolates

The concentrates obtained from soybean grits containing about 70 percent protein have a market of around 70 000 tonnes in Europe and 80 000 tonnes in the United States of America. Soy isolates obtained from the same source, but having 90 percent protein, have a market of about 30 000 tonnes in Europe and 90 000 tonnes in the United States of America.

The United States of America is a big consumer of soy proteins, because it has a tradition of soybean production, and there are important health claims even supported by the FDA, such as the reduction in heart diseases. Research has been conducted to reduce the taste and flavour of soy proteins, making them suitable for applications where bland organoleptic properties are required, and new products have appeared, such as soy cereals, coffees and milk products. Functional properties, such as emulsification and water and fat absorption, have made soybean proteins quite useful for the meat and bakery industries.

Soy proteins are very competitive in price. Isolates with about 90 percent protein are in the range of US$4.50 to US$5.50 per kg, and concentrates from US$3 to US$4 per kg in the United States of America, while the prices in Europe are somewhat lower.

Whey protein

Whey is the liquid obtained after cheese or casein production, and it contains soluble proteins plus lactose, minerals and a minimum amount of fat. The separation of these components results in whey protein concentrates with a maximum of 80 percent protein, or whey protein isolate with 90 percent protein. Cheese factories used to discard the whey, or use it as animal feed, but first because of environmental considerations, and then because the development of functional and nutritional applications new food uses have been found for it.

The traditional effect of high temperature on whey proteins, modifying their properties and reducing their applications, has been studied by some suppliers who are now offering thermal

stable whey proteins. Hydrolysis has been another way to develop value, by providing pharmaceutical uses.

Cheese production continues to grow, so whey processing is guaranteed, independent of casein production, which in the case of Europe is very sensitive to subsidies that will probably see a reduction in the near future, making casein availability follow the trend.

When products have a neutral taste, which has led to the development of quite different functional applications; in some cases its solubility is used in beverages, where its wide pH tolerance allows it to be mixed with fruit components. In the case of meat products, its ability to gel and fix water to the protein matrix, is used to replace or extend the higher costing beef or pork protein. Its high digestibility, over 95 percent, and well-balanced AA score allows it to be used in nutritional products, such as sports beverages, hospital diets and infant formulas.

Prices are directly related to the protein content. In 2004 the price ratio between whey powder and concentrated whey with 60 to 80 percent protein, and isolated whey protein with more than 90 percent protein, was about one to four to eight, respectively, depending on the protein modifications and final uses. The European market for all the whey proteins is above 1 million tonnes per year, while the United States of America market is about two-thirds the European market in value.

Gelatine

Gelatine is obtained from bovine or swine bones and hides. Animal-borne diseases and religious considerations have directed research to find other sources of gelatine, making fish skins and bones an interesting alternative. Coldwater fish, however, has a disadvantage regarding the gel melting temperature, which is too low for jelly manufacturing, and some work has been done to obtain a higher value, with the addition of Kappa carrageenan, for this type of application (Smidsrod and Haug, 2006).

Because it has low protein nutritional value, unless combined with other proteins, because of its lack of tryptophane, an essential AA, its value lies mostly in its functional properties in different products: jellies, marshmallows, soft gel capsules and gummy products. It is also used for its water binding and texture smoothing capacity in the meat and dairy industries.

The market for traditional protein continues its upward trend in spite of BSE and higher production costs because of its functional properties, which are difficult to substitute. The world gelatine market of about 200 000 tonnes is led by Europe with consumption around 100 000 tonnes followed by the United States of America with 40 000 tonnes.

6.3 Main markets for each protein

According to their functional properties, price and availability, the different proteins find various applications within the food industry.

Table 10: Protein distribution in different applications

Application/Protein	Soy concentrate (%)	Soy isolates (%)	Whey (%)	Gelatine (%)
Dairy			40	6
Meat products	45	55	8	9
Bakery			12	
Functional foods		15	25	19
Confection/Ice cream			8	56
Feeds/Pet food	40	10		
Other	15	20	7	10

Source: Frost and Sullivan (2005a, 2005b)

6.4 Applications

There are some specific applications that could be used directly to increase the value of salmon by-products without involving any complex chemical process and just keeping the good food quality.

Hamburger patties

Because this product has a special appeal for children, it has been used in Chile, in the School Lunch Program, to increase fish product consumption, which is very low – 5 to 7 kg per capita, per year of edible parts – in spite of the huge quantities available. The programme aims to deliver 2 million rations every day, covering almost 60 percent of the school population. If salmon hamburgers are given only one day per month, the total consumption would be 1 000 tonnes over a 10-month period. The price paid for similar fish products is about US$1 800 per tonne, with a reasonable margin for the processors.

Pet foods

The total market for pet foods in Europe and the United States of America is about US$21 billion, of which US$3 billion corresponds to moist cat foods either in cans or pouches. Dog food is another venue, but because of the traditional link between cats and fish, the analysis is done only with this pet.

Market segmentation shows a matrix with four corners: premium and standard quality with private or brand labels. In this group, the segment with the lowest price is standard quality with private label, which is the easiest market to penetrate compared to the large companies with well-positioned brands. In this case the market is about US$280 million and the price in the supermarket is around US$6.80 per kg; when taking away taxes, retailer and distributor margins, and transport cost, in this case from Chile, the FOB price drops to US$1.90, giving a reasonable profit to the manufacturer.

Silage

This is a traditional use of by-products in Scotland and Norway, where special care is taken with freshness of the raw material and overall quality. The Total Volatile Nitrogen should be below 3 percent, the total peroxide level below 20 meq and the pH below 4.0. In this case the receiving companies, such as Scanbio, pay around US$100 per tonne to US$110 per tonne for the silage. This figure is fine for the processing cost, but probably too low for the by-product itself when there are other more profitable alternatives.

Salmon meal

Another traditional use of salmon by-products is for salmon meal as feed where silage has not been introduced in the industry, usually because farmers are reluctant to introduce a liquid protein. Considering the fact that they are used to dry feed, farmers would use the salmon meal in a flour or other powdered form. In Chile there are two processing companies covering more than 90 percent of the production. The salmon meal price is rather difficult to assess because it depends on the available raw materials from pelagic fisheries and soybean meal production. Nevertheless, it is close to the the pelagic fishmeal price, which is US$100 higher per tonne, because salmon meal cannot be used as salmon feed according to the regulations. The trend here is rather complex because pelagic captures are stable, and aquaculture is increasing in a sustainable way year after year, so the price should go higher and higher, unless a competitive protein for aquaculture feeds appears in the market.

6.5 Regulations

The use of salmon by-products requires, first, a definition of the term and the concept of by-products. The salmon industry, because it produces food, initially thought that clean fish heads, cuts and trimmings were waste, something to be disposed of, and they were treated as such, falling into the EU European Animal By-Product Regulation (ABPR) for the case of Europe, where it is defined as “any substance or object ... which the holder discards, intends to discard or is required to discard”.

This regulation classifies the by-products from processing plants in category 3, allowing them to be used as raw materials for pet foods, biogas, fishmeal, compost, silage, other animal feeds, incineration and category 3 processing plants. These processing facilities have specific hygienic regulations, requiring among other restrictions, that the by-products from food processing plants do not mix with lower grade by-products.

However, if the by-product coming from a food processing factory has not been contaminated or otherwise made unsuitable for human consumption, the definition of “waste” depends entirely on the holder, and the material could still be handled as food if the proper safety conditions are followed. This is also in agreement with the concept of waste prevention or minimization, avoiding treatment at the end of the processing line.

The regulations are in general not specific for fish protein products, thus the restrictions for other similar products should be considered before the dedicated regulations appear. If the fillets coming from the same fish are suitable for human consumption, the question to be answered about the by-products is if they might contain higher levels of dangerous contaminants because of the way they are deposited in the different body parts, such as antibiotics for example, or because during the process they might migrate from the bones or other parts to the protein, as could be the case of phosphorous.

The following table gives EEC Regulation No. 466/2001, specifying the maximum amounts of heavy metals for fish flesh (normal moisture content).

Table 11: **Maximum amounts of heavy metals for fish flesh**

Contaminant	mg/kg max	Analytical refrence
Lead	0.20	Directive 2001/22/CE
Cadmium	0.05	Directive 2001/22/CE
Mercury	0.50	Directive 2001/22/CE
3-MCPD*	0.02	Directive 2001/22/CE

* 3-monochloropropane-1,2-diol, included here because it applies to soy sauce and occurs in its hydrolysis process.

EEC Regulation No 2375/2001 specifies the maximum amounts of polychlorinated biphenyls (PCBs) and dioxins according to their toxicity index or WHO-TEF (toxic equivalent factors, 1997) as 4 picogram per gram of fresh weight. This limit should be considered carefully because of the different accumulation in each part of the fish body, and the variable presence in seawater, depending on the proximity to industrial areas or currents coming from them.

Residuals from veterinary drugs are another important issue. Although the industry is trying to move from remediation to prevention, using vaccines, there is always the risk of some antibiotic or its metabolites being present. The applicable EEC regulation is No. 2377/90/EEC, which gives the Maximum Residual Limits in a positive way; that is if it is not on the list it is not permitted.

Table 12: Maximum Residual Limits

Drug	MRL, ppb
Oxytetracycline	100
Oxolinic acid	100
Flumequine	600
Sulfonamides	100
Trimethoprim	50
Florfenicol	1 000
Erythromycin	200
Enrofloxacin	100
Amoxicillin	50
Emamectin	100

Source: Regulation No 2377/90/EEC

The only drugs that are occasionally used in salmon farming are the first three from the list above and are tightly controlled by the industry and the regulatory agencies.

All other drugs, such as hormones and beta-agonists, do not have maximum residual limits allowed and should not be present in any amount in the final product.

6.6 Animal welfare

Besides vegetarian diets and animal-borne diseases, one topic that is moving consumers towards dairy and vegetable proteins is animal welfare, which in the case of salmon farming refers mainly to the harvest methods. There are systems that are considered to be more or less painful or where the slaughtering is more or less humane. If the salmon by-product industry is able to demonstrate that the harvesting methods utilized are the best in terms of animal welfare, it would be prepared to handle any concern that might affect its competitiveness with other protein sources.

6.7 Conclusions

All the above indicates that if the technology used to separate the protein from salmon by-products yields a product with long peptide chains it could be used in meat applications: burgers and sausages, replacing soy concentrates and isolates. If fish flavour cannot be eliminated, the end use would be restricted to fish related products: fish fingers, frozen fish fillets and fish home replacement meals. During the introductory period and before unique properties can be developed in these new proteins, the price should be less than the corresponding soy isolates and concentrates.

If the hydrolysis renders a soluble tasteless protein, the functional and sports foods or drinks application would be the most interesting target, because the dairy market is rather complex, unless some health promoting property could be found or developed with the by-products. The positive consumer response to dairy products means that the replacement of another member of the family (whey) by a protein whose origin must be declared on the label would be difficult.

Salmon skins might be a good source of gelatine, and research might produce interesting properties to replace the traditional source, taking into account the willingness to find a replacement after the BSE crisis and the religious restraints for porcine gelatine.

The comparison between the protein availability, 27 000 tonnes, and the markets for these sample proteins – or proteins most likely to be replaced if the functionality could be developed in the proteins separated from the by-products – shows that there is a reasonable size for introduction and competition if the final technology is cost-effective enough.