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Guide for the selection of valorisation options of by-catches

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Produced by: AZTI. © 2018

With the collaboration of: DTU, MATIS and NUSCIENCE.

ISBN: 978-84-944022-4-1

How to cite this guide: Iñarra, B., Bald, C., Cebrián, M., Pérez-Villareal, B. & Zufía, J. (2018) Guide for the selection of valorisation options of by-catches. AZTI, Derio, España. 52 pag.

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This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement no. 633680

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INTRODUCTION

The Common Fisheries Policy of the European Commission introduced in 2013 a discard ban which states that all catches of species subjected to catch quotas and/or Minimum Conservation Reference Size (MCRS) will have to be landed and will be counted against quota.

The discard ban, or Landing Obligation (LO), is being gradually implemented, since 2015 to 2019 when all EU fisheries will be required to land all catches. Meanwhile, involved agents may explore and put into practice different strategies first, to minimize the discards and second, to find the most adequate uses for Unavoidable Unwanted Catches (UUC) subjected to the LO to prevent the impact that the discard ban may have in the harbors and local economies.

DiscardLess project aims to contribute to the gradual elimination of the discards in the European fisheries, in agreement with the reformed Common Fisheries Policy of the EU and the implementation of the LO.

LO states that only UUC above MCRS can be used for human consumption and UUC under MRCS must be landed and giving them some valuable usage or destiny. But this usage must avoid the promotion of the captures under MCRS and, at the same time, without affecting negatively the existing markets. All the other catches need to be properly managed, but their profitability must be subjected to the avoidance of incentivizing by-catches.

OBJECTIVE AND SCOPE OF THIS GUIDE

This working guide deals with how Unavoidable, Unwanted Catches (UUC) can be utilised once they have been landed. A comprehensive view and analysis of the possibilities of the multiple existing valorisation options for the fish species and their parts is given. Then, a methodology for the selection of the most suitable valorisation option that can be adapted to any specific geographical scenario is proposed.

There is a broad range of possibilities to valorise fish and fish derived compounds, however, not all the solutions are able to deal with the huge variability of the expected landings. Maintaining the discards in the food chain by the commercialization of by-catches (subjected to legislation), the production of food ingredients or the obtaining of valuable bio-molecules is consireded as the priority option.

Increasing fish consumption and global consumer trends in industrialized countries towards processed and ready to eat foods and motivations for healthier, convenient, natural and ethical products may lead to the development of many new successful products. The design of fish products must take in consideration the consumer preferences in each country.

Other options of less value can be also foreseen and evaluated such as products for industrial uses, the production of energy, composting or incineration. Landfilling UUC is the last option and cannot be considered as a valorisation option.

To facilitate the selection of the most suitable option in each scenario, first, information on the state-of-the-art of more than 30 valorisation processes has been gathered and analysed, including aspects related with the availability of infrastructures, technical complexity, product applications, potential market, economic aspects and regulatory aspects. This extensive review of most suitable uses of UUC has been performed based on bibliographic search, previous knowledge, current experiences and works performed by DiscardLess partners.

The valorisation options have been classified as: Food applications, Bio-Products (valuable compounds for food, cosmetic or other uses), Feed, Industrial uses, Energy production or Agronomic (see Table 1 in methodology).

Therefore, with the aim to be disseminated, this detailed information has been summarized in the corresponding fact sheets designed *ad hoc* and annexed into this guide. Each fact sheet contains basic information on the valorisation option and its products, also an evaluation for this specific option of the critical aspects that will influence the feasibility of its implementation.

The selection of the most suitable option may need the simultaneous evaluation of a lot of technical, market and economic parameters or factors. Collecting the data needed and the subsequent studies can be very time consuming and expensive.

For that reason, a simplified methodology for the selection of most suitable uses of UUC in different scenarios is hereby proposed and described. A four steps procedure has been described to perform a preliminary selection with a minimum quantity of information. A set of parameters have been selected an evaluated for each technological solution to produce a simple help-decision-making tool. In brief, all the selection parameters have been summarized in 6 factors grouped in 3 categories and a set of prioritization criteria to give each factor a score. A prioritization table has been constructed in which the scoring assigned to each valorisation option for each criterium has been assigned based in the information collected in the above-mentioned fact sheets.

HOW THIS METHODOLOGY CAN BE USED AND BY WHOM?

The results from this guide and the symplified methodology for the selection of valorisation options can be of the interest of:

- / Research institutions.
- / Local companies: valorisators, processors.
- / Local administration bodies to develop integrated valorisation plans for discards.
- / Policy makers to promote the implementation of selected strategies.

The simplified methodology can be applied in other geographical areas to identify the most suitable valorisation options.

SELECTION OF POTENTIAL USES

For the selection of a valorisation solution in a concrete scenario (*case study* as defined in DiscardLess) there are many parameters that must be considered. In each scenario, the combination of parameters may lead to different solutions even when the basic statements are the same. In this chapter, basic principles for a methodology for the selection of best valorisation options are described.

In a first approach, a common prioritization scheme for the valorisation of food by-products may be applied. Following the hierarchy of valorisation options for any FW or by-product established by the waste framework Directive of the European parliament (2008)[1], as shown in Figure 1, where the first option is always the prevention and the reduction of the by-product generation that in is linked with the increase of gear selectivity and the optimization of fishing strategies. The second option is to maintain the food by-product in the food chain through the commercialization of by-catches (subjected to legislation), the production of food ingredients or the obtaining of valuable bio-molecules. In third place comes the production of fishmeal and fish oil that are used for animal feed, mainly for aquaculture. This is the most common use of fish by-products, and is a straight forward option for the treatment of UUC when there is an available facility in the nearby.

1 European Parliament Council, 2008/98/EC of The European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. 2008. Brussels.

Other options of less value can be also foreseen and evaluated such as products for industrial uses, the production of energy, composting or incineration. Landfilling UUC is the last option and cannot be considered as a valorisation option.

Therefore, a first classification of the available valorisation options can be made attending to the final use or destiny of the products obtained, as shown in Table 1.

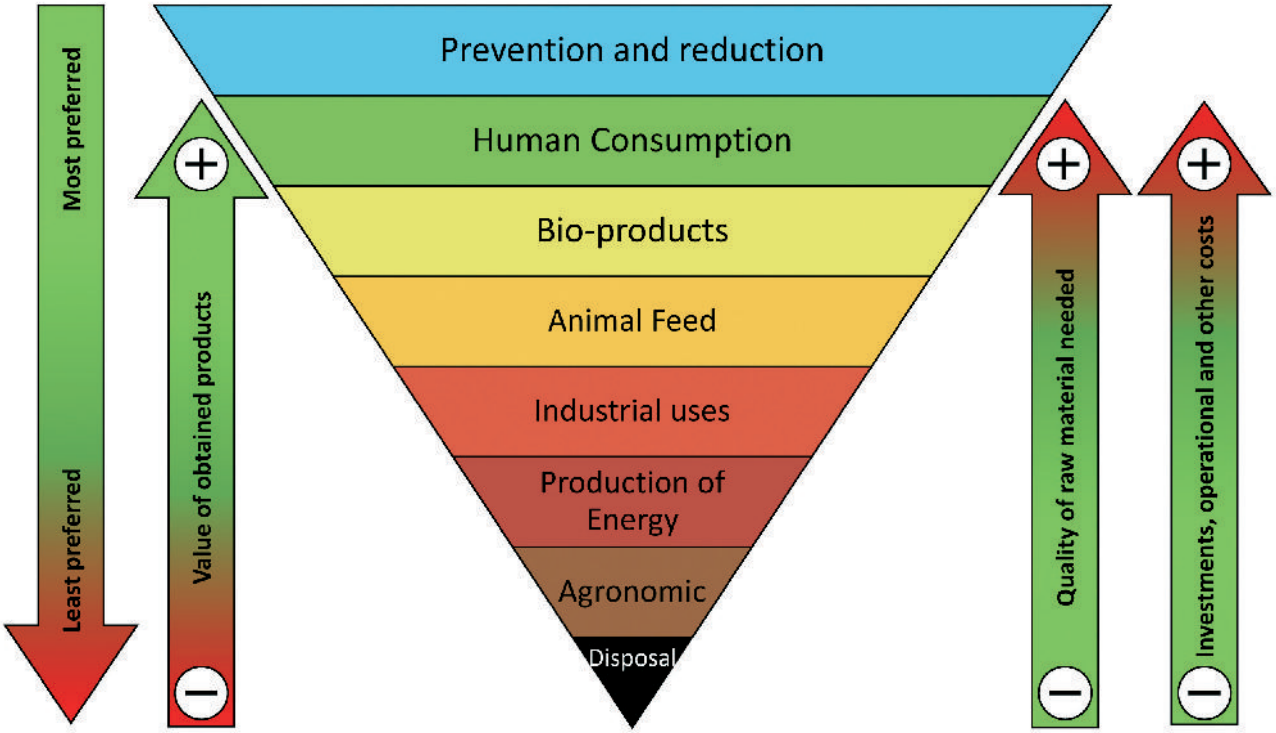


Figure 1: Standard prioritizations for the valorisation of food by-products

Table 1: Main valorisation options by categories for UUC

Category	Valorisation option
FOOD	New fish products
	Surimi
	Fish pulp / Mince
BIO-PRODUCTS	Bioactive peptides
	Chitin / Chitosan
	Chondroitin sulphate
	Collagen
	Astaxanthin
	Enzymes
	Fat-soluble vitamins
	Gelatine
	Hyaluronic acid
	Insulin
	Minerals
	Peptones
	Phospholipids
	Polyunsaturated fatty acids
	Protamine
	Sterols
	Squalene
FEED	Fishmeal
	Fish oil
	Mink feed
	Marine beef / Bait
	Direct pig feed
	Protein concentrate
	Protein hydrolysate
	Silage
	Insects growth
INDUSTRIAL USES	Leather
	Fish oil
	Minerals
	Chitin / Chitosan
	Pearl essence
ENERGY	Biogas
	Biodiesel
AGRONOMIC USES	Fertilisers
	Compost

Biorefinery processes

Biorefinery is the integrated process that sustainable transforms a biological raw material (animal or vegetal) into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat). Many of the described processed of UUC valorisation are susceptible to be obtained together in a biorefinery scheme. For instance, when producing a food product, a first biorefinery step undergo when fish meat is separated from viscera, heads and bones that can be further processed to obtain other valuable products.

The simplest biorefinery scheme is the obtaining of fishmeal and fish oil where, when using a good stick water recovery system, all the raw material treated issues marketable products. A simplified process scheme is shown in Figure 3, in brief the raw material (UUC, of fish by-products) is thermally treated and coagulated protein and oil are separated and recovered.

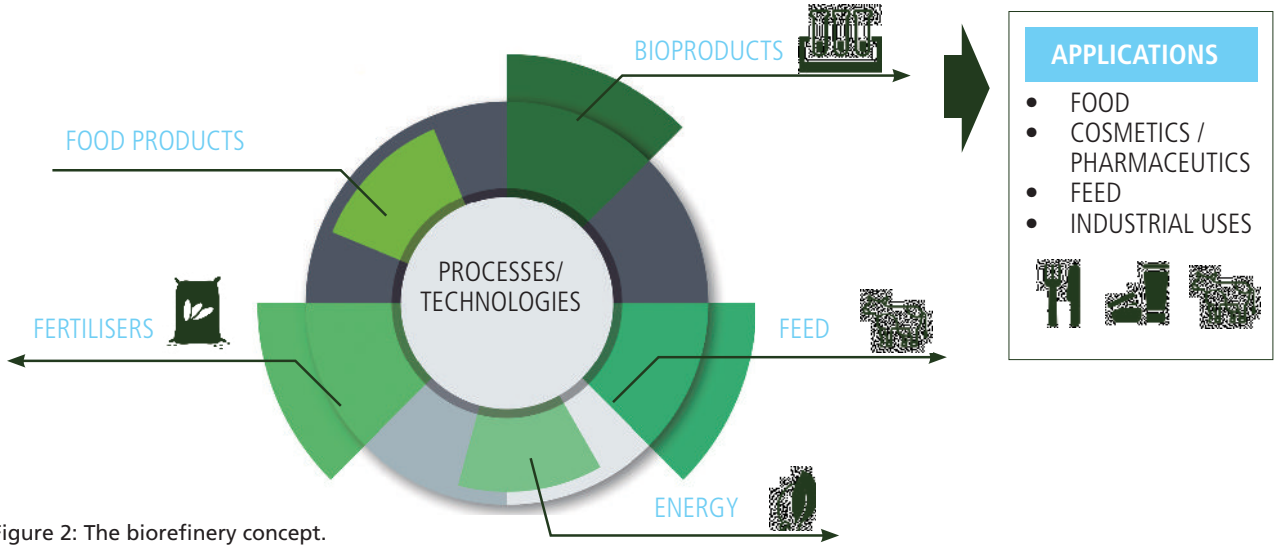


Figure 2: The biorefinery concept.

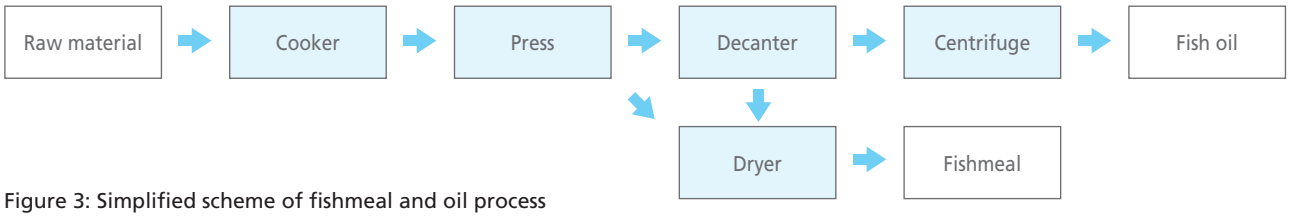


Figure 3: Simplified scheme of fishmeal and oil process

Another process that can be considered as a simple biorefinery scheme is the production of fish protein concentrate (FPC) where, on the one hand, the fish oil is extracted and recovered and, on the other hand a fish protein concentrate is produced (figure 4).

A slightly more complex scheme is the integrated obtaining of fish protein hydrolysates, shown in Figure 5. In the same process fish oil and fishbones are recovered and the later can be subsequently used to produce calcium or other mineral products.

If the hydrolysis process is very intensive, protein hydrolysate may also be further separated in two products by mean of an ultrafiltration process, obtaining pepsin and peptones as shown in Figure 6.

Another point to consider is that obtained oils can be further processed. If the quality and composition is suitable the oil can be processed to obtain PUFAs and vitamins concentrates, and if the quality is not good enough the oil can be utilised to produce biodiesel or other technical uses. Also, fish bones can be processed to obtain both mineral calcium supplements or gelatines.

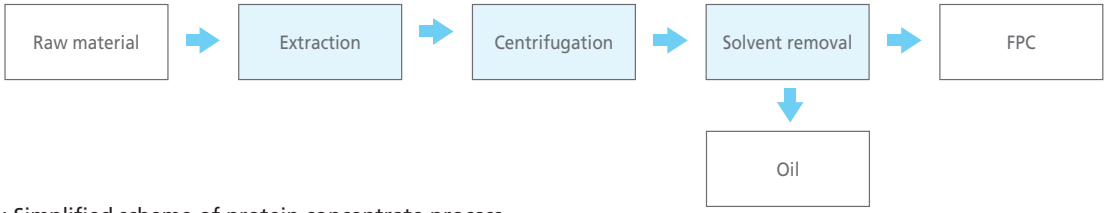


Figure 4: Simplified scheme of protein concentrate process

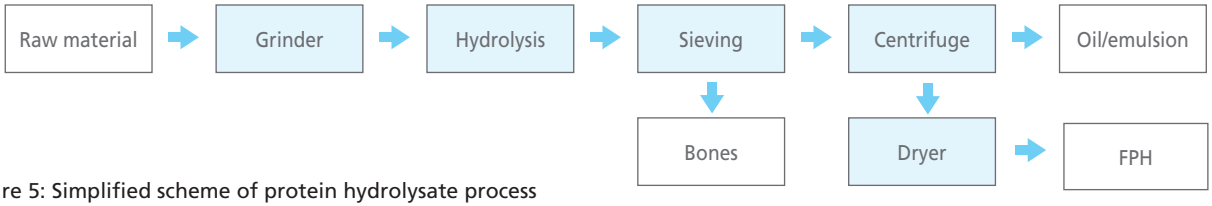


Figure 5: Simplified scheme of protein hydrolysate process

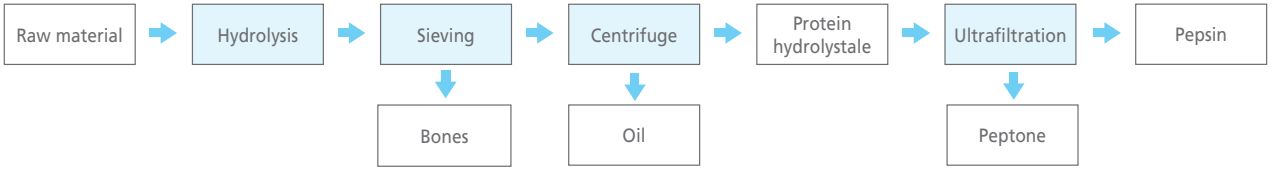


Figure 6: Simplified scheme of peptone process

SIMPLIFIED METHODOLOGICAL APPROACH

The simplified methodology for the selection of the potential uses for UUC in a specific scenario is based in a Multi-Criteria Decision Analysis (MCDA) using an Analytic Hierarchy Process (AHP) method. MCDA provides a good framework for procedures that rank alternatives, based on their assessment across selected criteria, and such methods have been widely applied in different environmental areas quite effectively in the past.

AHP was introduced as the most appropriate method because it allows partitioning the problem on smaller decision sets one at a time. The first step is to define and evaluate the criteria, which must be done case by case, adapted to the subject of the study and stated by consensus.

Principles applied for the criteria selection to evaluate the main parameters involved in the process are:

- *systemic principle*: criteria system should reflect the essential characteristic and the whole performance of the system.
- *measurability principle*: criteria should be measurable in quantitative values or qualitative criteria should be transformed into numbers.
- *comparability principle*: criteria must be comparable or normalized.

Definition of the criteria for the selection

When evaluating a concrete scenario, to be able to select the best and more feasible option, the study must deal with all the critical aspects that can have an influence in the technical or economic feasibility.

These aspects can be grouped in 3 main categories:

- Technical parameters.
- Market aspects.
- Economic aspects.

Technical parameters are those related with the technical feasibility of a solution, such as:

- Variability, dispersion of landings.
- Characteristics of landed catches.
- Maturity of the process.
- Ratio, quality and purity of product obtained.
- Availability of technology and equipment at industrial scale.
- Feasibility of modifications on board.
- Availability of storage, preservation and other facilities, equipment, logistics, etc. in port and the region.

Market aspects, are the parameters related with:

- Compliance with health, environmental and other specific regulations for each use.
- Existence of potential clients interested.
- Market demand for the product produced, nowadays availability and consumers-users acceptance.

- Enough quality and volumes of product to satisfy the demand.

Economic aspects are the factors that affect the economic feasibility of the solution such as:

- Minimum volume of raw material for sustainable production.
- Final value / price of product.
- Cost / benefit expected.
- Feasibility of making use of current infrastructures to reduce investment costs.

In many cases, it's almost impossible to collect all the information needed to evaluate all the options, and the studies are quite expensive and time consuming. Thus, for a first evaluation in the different case studies, a simplified methodology to facilitate the selection procedure is hereby presented.

For this purpose, a set of criteria for the final evaluation is proposed. Some of them must be studied case by case as they can vary from one to another Region. These are namely the "case study dependent" factors. Other criteria are considered intrinsic to the specific technological solution proposed. Thus, the criteria have been classified into three groups:

Case study dependent:

- **Available raw material** is the amount of the discards that can be processed in this way.
- The existence of **available facilities and infrastructures** in the studied Region that can be used to obtain the product is considered positive.

Technical factors:

- **Yield:** is the result of both, the proportion of fish that can enter this valorisation option and the yield of the process to produce the valuable compound or final product.
- **Technology Maturity** refers to the industrial feasibility and necessary investment cost for implementing the solution. Maturity implies generally technical feasibility (availability of the technology) and lower implementation costs.

Economic factors:

- **Production Costs** accounts for the different costs involved in the production of the product.
- **Value of the product**: market value of the product or compound.
- The **Competition** is measured by the quantities produced or the size of the competitor companies.
- The **Potential Market** is an indicator of the demand on the product to be marketed.

METHODOLOGICAL STEPS

The proposed methodology can be structured in four main steps:

1. Data gathering for each valorisation option (include new options when identified).
2. Evaluate the amount of UUC available for each option.
3. Evaluate the available facilities for each option.
4. Complete the evaluation and prioritization table to identify the most suitable options.

First step: data gathering for each valorisation option

The first logical step consists in getting available information about the existing valorisation options:

- Process related information: process description, technologies involved, process complexity, processing costs.
- Resulting products: yield, characteristics, applications, potential market, quality requirements, prices, competitors, legal requirements.
- Raw materials that can be processed in this way: fish species or their fractions, quality requirements.

The list of existing technological options is long, and the information can be very extensive. Therefore, the most important and useful information of each of a wide set of options has been summarized in form of a **valorisation option factsheet** (see Fact Sheets) to facilitate this task. An evaluation of the technical and economic factors for each option is visually presented with traffic lights and corresponds to the score given when following the evaluation criteria that will be proposed. The list is open to incorporate new options when available.

Second step: evaluate the amount of UUC available for each option

According to historic discard data, or UUC landing data, the amount of raw material available for each option must be evaluated. When using historic discard data, a careful evaluation must be performed because it is no foreseen that 100 % of discards will be landed due to selectivity gear improvement, better fishing strategies or *minimis* application.

Thus, a table that links the species composing the UUC with their possible valorisation options can be constructed as in the example in Table 2. With the estimated UUC landed, considering the species and quality, the amount of raw material for each option can also be estimated and included in a column or in another table. It must be considered that the LO does not allow to use the catches under Minimum Conservation Reference Size (MCRS) for direct food consumption.

Third step: evaluate the available facilities

In each case study, the evaluation of existing and available facilities in the studied Region must be carefully performed. The selection of an option that is already industrialized has a great advantage and can be the straightforward route for a short-term solution.

Table 2: Example of valorisation options for the distinct species of the Bay of Biscay.

Valorisation option	Blackbellied angler	European hake	Horse mackerel	Atlantic mackerel	Megrim	Angler	Blue whiting	Calculated ammount per option (t)
New fish products	X	X	X	X	X	X	X	3071
Surimi	X	X	X	X	X	X	X	3071
Fish pulp	X	X	X	X	X	X	X	3071
Bioactive peptides			X	X				2457
Polyunsaturated fatty acids	X	X	X	X	X	X	X	3071
Enzymes								0
Chondroitin sulphate								0
Fat-soluble vitamins			X	X				2457
Minerals	X	X	X	X	X	X	X	3071
Astaxantin								0
Collagen		X		X	X			1363
Gelatine		X		X	X			1363
Sterols			X					1467
Insulin	X	X	X	X	X	X	X	3071
Protamine								0
Hyaluronic acid								0
Chitin / Chitosan								0
Phospholipids			X	X				2457
Peptone	X	X	X	X	X	X	X	3071
Squalene								0
Fishmeal	X	X	X	X	X	X	X	3071
Fish oil	X	X	X	X	X	X	X	3071
Mink feed	X	X	X	X	X	X	X	3071
Marine beef / Bait	X	X	X	X	X	X	X	3071
Direct pig feed	X	X	X	X	X	X	X	3071
Protein concentrate	X	X	X	X	X	X	X	3071
Protein hydrolysate	X	X	X	X	X	X	X	3071
Silage	X	X	X	X	X	X	X	3071
Insects growth	X	X	X	X	X	X	X	3071
Leather								0
Fish oil	X	X	X	X	X	X	X	3071
Minerals	X	X	X	X	X	X	X	3071
Chitin / Chitosan								0
Pearl essence		X	X	X				2822
Biogas	X	X	X	X	X	X	X	3071
Biodiesel	X	X	X	X	X	X	X	3071
Compost	X	X	X	X	X	X	X	3071
Fertilisers	X	X	X	X	X	X	X	3071

Fourth step: complete the evaluation and prioritization table to identify the most suitable options.

For this purpose, first the quantitative values of each evaluation criterion have been normalized and classified into standard ranges to allow performing the evaluation of each option (Table 3). Following, each range was assigned a score, the more favourable the higher the score, usually 5, 3, 1 and 0 in order to highlight small differences in the next calculations in the prioritization methodology. It must be considered that some factors have a negative effect (Competing companies, Production Costs) and, therefore, become a low score when their quantitative factor is high.

A ponderation or weighting coefficient will be assigned to each prioritization criterion and each valorisation option will obtain a score (a value between zero and one) based in following equation:

$$V_{CS} = (x_1 \bullet A + x_2 \bullet B) / (5 \bullet (x_1 + x_2))$$

$$V_{tech} = (x_3 \bullet C + x_4 \bullet D) / (5 \bullet (x_3 + x_4))$$

$$V_{eco} = (x_5 \bullet E + x_6 \bullet F + x_7 \bullet G + x_8 \bullet H) / (5 \bullet (x_5 + x_6 + x_7 + x_8))$$

Where V_{CS} is the score obtained for the case study dependent criteria, V_{tech} is the score of the technical criteria and V_{tech} is the score of the economic criteria. x_1 to x_8 are the weighting coefficient values assigned to each criterion for the prioritization and A, B, C, D, E, F, G and H are the score of each criteria as defined in Table 3.

Table 3: Normalization of range values of prioritization criteria and assignment of numerical scores to each value range

			Score			
Category	**Criteria**	**Units**	**5**	**3**	**1**	**0**
Case Study dependent	**A:** Available Raw Material	t/Year	> 2000	1000-2000	500-1000	< 500
	B: Available facilities	N° Facilities	> 2	2	1	0
Technical	**C:** Yield	%	> 50	10-50	< 10	< 0.05
	D: Technology maturity	--	High	Medium	Low	Experimental
Economic	**E:** Value of the product	€/Kg	> 50	5-50	0.5-5	< 0.5
	F: Potential Market	t/year	> 1000	100-1000	5-100	< 5
	G: Production Costs	€/Kg	< 0.5	0.5-5	5-50	> 50
	H: Competing Companies	t/year	0	< 100	100-500	> 500

Weighting coefficient values, x_1 to x_8 (cells in purple Table 4), should highlight the importance of each criterion in the final decision and are usually values between 1 and 10, defined through consensus within the project team. As a recommendation:

- Key/critical factor: 10 points
- Very important factor: 7 points
- Factor with some relevance: 3 points
- Factor with small relevance: 1 points

The final score, total score or priority value (Vp) for each solution comes from the product of the case dependent, technical and economical score.

$$V_p = (y_1 \bullet V_{CS} + y_2 \bullet V_{tech} + y_3 \bullet V_{eco}) / (y_1 + y_2 + y_3)$$

Where y_1 to y_3 are the weighting coefficient values assigned to each category (in blue cells in Table 4).

Thus, the methodology allows not only the evaluation considering all the criteria at the same time but also the evaluation of each valorisation option from the technical and economical point of view separately, as well as evaluating the weight of the case study dependent criteria.

Table 4 presents the example of the prioritization analysis for a specific case study: the discards of the Bay of Biscay. It summarizes the partial scores and total score obtained for each option. The color code of the scores facilitates differentiating the best evaluated options (green) from the worst scored ones (red).

Table 4: Prioritization evaluation of Valorisation options for the Bay of Biscay case study. Case study dependent factors.

	CS dependent			Technical Parameters			Economical Parameters					
Criterion	A	B	V_{cs}	C	D	V_{tech}	E	F	G	H	V_{eco}	V_p
Weighting coefficient	10	7	10	7	3	7	10	10	7	1	3	
New fish products	5	5	1.00	5	5	1.00	3	5	3	1	0.73	0.96
Surimi	5	0	0.59	3	5	0.72	3	3	1	1	0.49	0.62
Fish pulp	5	5	1.00	3	5	0.72	1	5	5	5	0.71	0.86
Bioactive peptides	5	1	0.67	3	3	0.60	5	3	1	3	0.64	0.64
Polyunsaturated fatty acids	5	3	0.84	3	5	0.72	3	5	3	1	0.73	0.78
Enzymes	0	0	0.00	1	1	0.20	1	1	1	1	0.20	0.10
Chondroitin sulphate	0	3	0.25	1	3	0.32	5	3	1	1	0.63	0.33
Fat-soluble vitamins	5	0	0.59	1	3	0.32	3	5	1	1	0.63	0.50
Minerals	5	1	0.67	3	5	0.72	1	5	5	3	0.70	0.69
Astaxanthin	0	0	0.00	1	5	0.44	5	3	1	3	0.64	0.25
Collagen	5	3	0.84	1	5	0.44	3	3	3	1	0.59	0.66
Gelatine	5	3	0.84	1	5	0.44	3	3	3	1	0.59	0.66
Sterols	5	0	0.59	1	1	0.20	3	3	0	3	0.45	0.43
Insulin	5	0	0.59	3	1	0.48	3	1	0	0	0.29	0.50
Protamine	0	0	0.00	1	3	0.32	5	1	1	1	0.49	0.18
Hyaluronic acid	0	0	0.00	1	3	0.32	5	3	1	1	0.63	0.21
Chitin / Chitosan	0	0	0.00	1	5	0.44	5	3	3	1	0.73	0.26
Phospholipids	5	0	0.59	1	3	0.32	3	3	1	3	0.50	0.48
Peptone	5	1	0.67	3	5	0.72	1	1	3	1	0.30	0.63
Squalene	0	0	0.00	1	3	0.32	5	3	1	1	0.63	0.21
Fishmeal	5	5	1.00	5	5	1.00	1	5	5	1	0.69	0.95
Fish oil	5	5	1.00	5	5	1.00	1	5	5	1	0.69	0.95
Mink feed	5	3	0.84	5	3	0.88	1	1	5	3	0.41	0.79
Marine beef / Bait	5	1	0.67	5	3	0.88	1	1	5	3	0.41	0.71
Direct pig feed	5	1	0.67	5	3	0.88	1	3	5	3	0.56	0.73
Protein concentrate	5	3	0.84	5	5	1.00	3	5	3	3	0.74	0.88
Protein hydrolysate	5	3	0.84	5	5	1.00	3	5	3	3	0.74	0.88
Silage	5	0	0.59	5	5	1.00	1	3	5	3	0.56	0.73
Insects growth	5	0	0.59	5	1	0.76	1	3	5	5	0.57	0.65
Leather	0	3	0.25	1	5	0.44	3	1	3	5	0.47	0.35
Fish oil	5	5	1.00	5	5	1.00	0	5	5	0	0.61	0.94
Minerals	5	3	0.84	3	5	0.72	0	3	5	3	0.49	0.74
Chitin / Chitosan	0	0	0.00	3	5	0.72	1	3	3	1	0.44	0.32
Pearl essence	5	0	0.59	1	5	0.44	1	1	3	3	0.31	0.50
Biogas	5	1	0.67	1	3	0.32	1	3	3	1	0.44	0.51
Compost	5	1	0.67	3	3	0.60	0	3	5	1	0.47	0.62
Fertilisers	5	1	0.67	3	5	0.72	1	3	5	1	0.54	0.67

THE PREVIOUS EXPERIENCE OF EU DISCARDLESS PROJECT

The methodology has been previously applied in DISCARDLESS project to three different scenarios or case studies: Bay of Biscay, North Sea and Iceland. In the case of Iceland, the results have been compared with the current situation as the LO has been implemented since 1977 and used as a reference for the validation of the methodology.

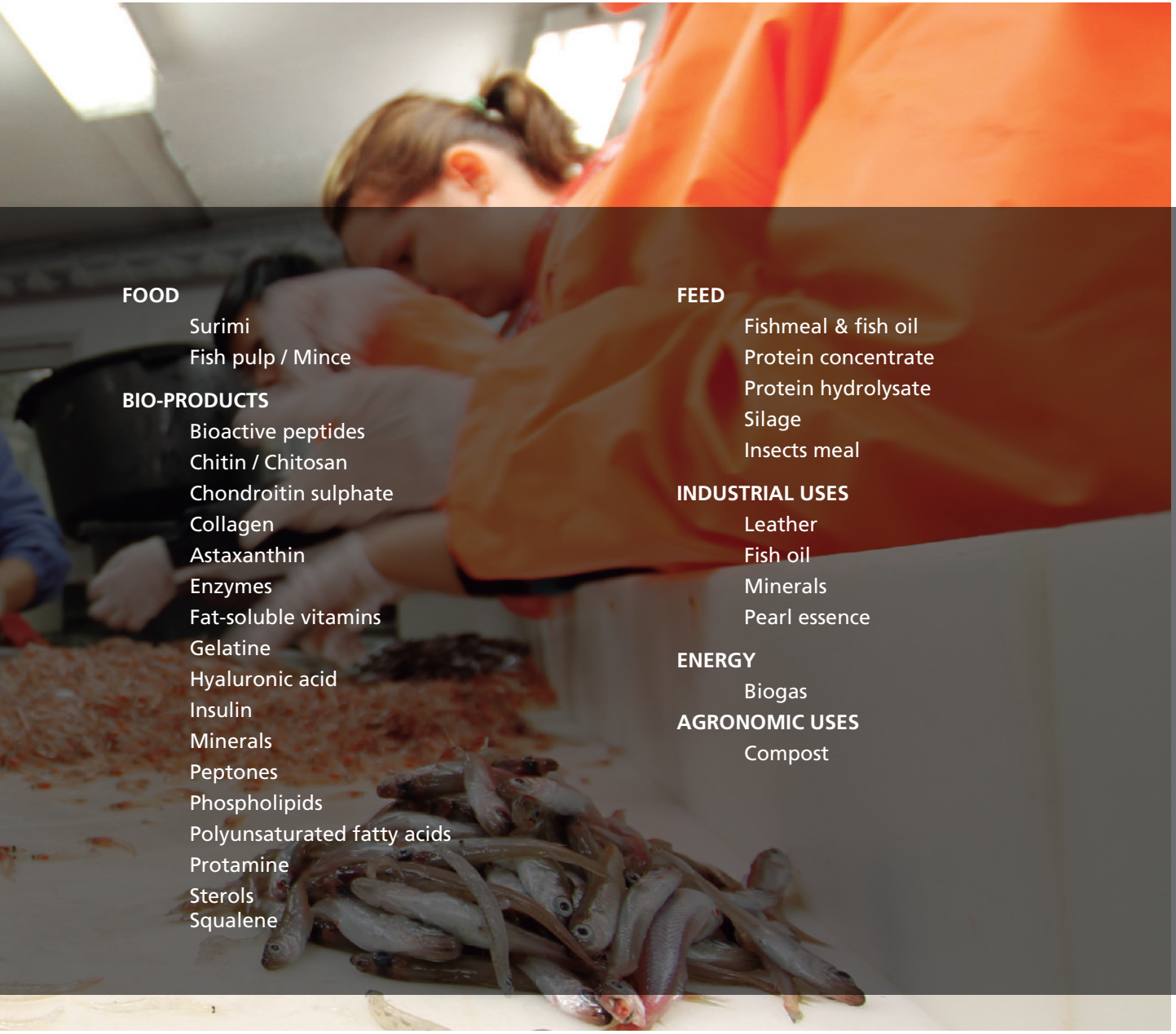
Some fish species as mackerel, horse mackerel and blue whiting are considered very important for Northwestern Cantabrian Fishery in Spain. Due to its low commercial value it is necessary to promote their commercialization and consumption by developing new seafood products or concepts. When there is a reasonable amount of UCC above MCRS, the production of new fish products is always the preferred solution.

The production of fishmeal and fish oil that are used for animal feed, mainly for aquaculture, is the most common use of fish by-products and is a straight forward option for the treatment of UUC when there is an available facility in the nearby.

There are already fishmeal facilities in Denmark than can process UUC and therefore this solution gets the better marks. Moreover, these processing facilities are located close the largest fishing harbours. However, there are other harbours with potentially big quantity of discards and long distances to current facilities, implying that UUC would have to be transported. In these scenarios, and when catches are below MRCS the production of fish protein concentrates and hydrolysates can be a reasonable option. The results agree with the current practice where most UUC are transported with the rest of the fish to one of the major ports and then rendered to fishmeal and fish oil.

In Iceland, the discards rates are very low, due to an already well implemented discard ban, healthy stocks, selective fishery and relatively good markets for catches that on other places would be considered UUC. When applying the developed methodology all the options highly scored are already being produced, which in a way confirms the methodology applied for the selection of valorisation options.

VALORISATION OPTION FACT SHEETS



FOOD

- Surimi
- Fish pulp / Mince

BIO-PRODUCTS

- Bioactive peptides
- Chitin / Chitosan
- Chondroitin sulphate
- Collagen
- Astaxanthin
- Enzymes
- Fat-soluble vitamins
- Gelatine
- Hyaluronic acid
- Insulin
- Minerals
- Peptones
- Phospholipids
- Polyunsaturated fatty acids
- Protamine
- Sterols
- Squalene

FEED

- Fishmeal & fish oil
- Protein concentrate
- Protein hydrolysate
- Silage
- Insects meal

INDUSTRIAL USES

- Leather
- Fish oil
- Minerals
- Pearl essence

ENERGY

- Biogas

AGRONOMIC USES

- Compost

SURIMI

PRODUCT DESCRIPTION:

"Surimi" stands for "minced fish muscle" in Japanese. Basically "surimi" is fish meat mechanically deboned.

Surimi is the stabilized myofibrillar protein obtained from the fish meat, that it is washed with water and mixed with several cryoprotectants. It is an intermediate food product which is further used to manufacture several products generally known as "fish replacers or analogues" and ready to eat, convenience food products.

Surimi is a product of high nutritive value, with high protein content and low in fat. It has no flavor or taste and it is colorless. It shows high emulsifying and gelling properties.

PRODUCT APPLICATIONS:

Surimi is not the final product but an intermediate one, so, the possible obtained end products vary from crab analogues, fish sausages, fish fingers, scallops, prawn, lobster tail and eel analogues and other product forms.

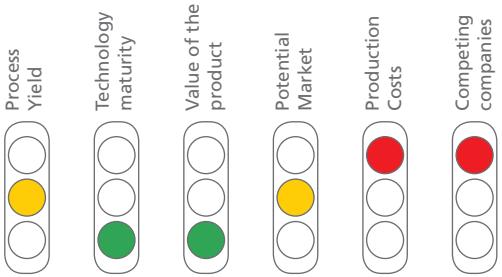
Due to its capacity to form thermo-irreversible gels, with a high resistance and hardness, it is possible to shape them with several technologies, and produce a great number of products with high commercial value, safe and easy to consume.

RAW MATERIALS:

Alaska pollock accounts for 50 % of the surimi production. In general, muscle from fish species with white meat, whose proteins have high gel forming capacity, small-sized (small bones) and underexploited species. Also squid mantle and good quality meat as by-product from filleting are used.

Freshness is determinant in surimi elaboration.

FEASIBILITY:



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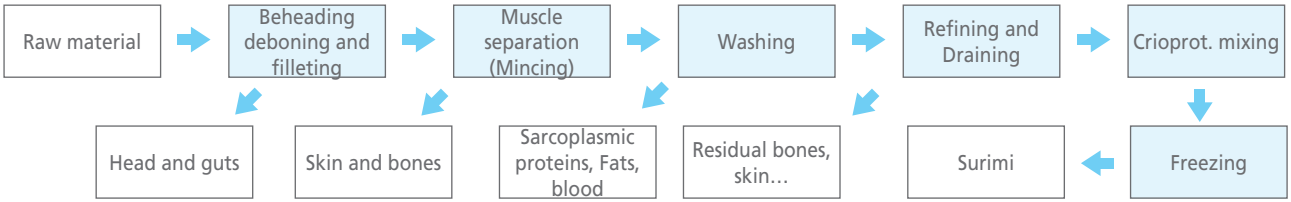

FISH MINCE

PRODUCT DESCRIPTION:

It is an intermediate product obtained from gutting, skinning and deboning the whole fish by a fish mince processor capable to separate fish meat from skin and bones.

It is mainly commercialized as frozen blocks that contains other additives as cryoprotectants or antioxidants.

It can be produced from fatty or lean fish species. However, the high fat content of the mince reduces the time of consumption of these minces due to their fast fatty acid oxidation.

Fish Mince maintains the excellent nutritional characteristics of fresh and frozen fish (protein content, amino acid profile, fatty acid profile, vitamins and minerals).

PRODUCT APPLICATIONS:

Fish mince may be used directly frozen or refrigerated by food industry to obtain restructured fish products (balls, hamburgers, sausages, sticks, snacks,...) or other food products containing fish as ingredient.

RAW MATERIALS:

A wide range of fish species can be used. The feasibility of automatization of the whole process depends on the anatomy, morphology, size and deterioration susceptibility. So is it for Atlantic mackerel, horse mackerel, hake and megrim. Blue whiting spoils very fast and must be frozen immediately after catching and processed in a short time. Angler and lack-bellied anglerfish must be hand manipulated, which increases the cost of the processing. However, the excellent sensory characteristics of their mince makes them very valuable.

FEASIBILITY:

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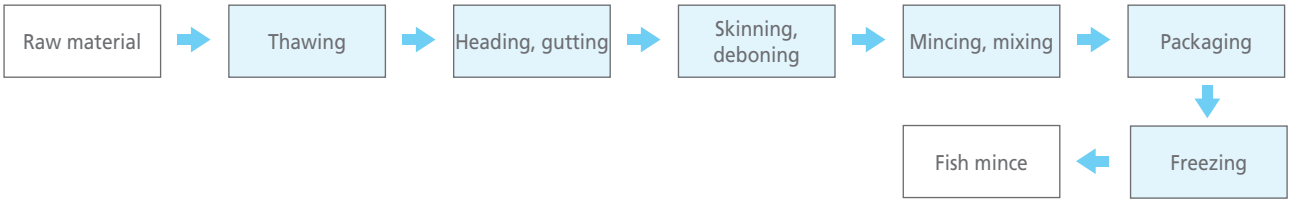


BIOACTIVE PEPTIDES

PRODUCT DESCRIPTION:

Bioactive peptides result from the hydrolysis of proteins of organic products of animal origin, also from category 3 animal by-products. Hydrolysates contain mainly free amino acids di-, tri- and oligopeptides, depending on the degree of hydrolysis. Peptides can also be released in fermentation processes and during gastrointestinal digestion. Peptides can have different biological activities beyond their nutritional value.

PRODUCT APPLICATIONS:

Marine-derived proteins and peptides have potential uses in novel products, in the food, beverage, nutraceuticals, pharmaceutical and cosmetic industries.

Reported bioactivities for marine derived peptides include antioxidant, antihypertensive, anticoagulant and calcium binding activity.

Nowadays, most of applications are in nutraceutical market, as antihypertensive capsules and pills.

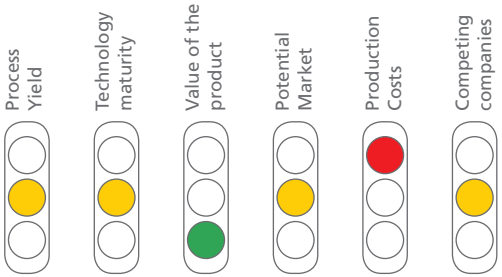
In feed, bioactive peptides with immuno-stimulating, antioxidant and/or antimicrobial properties can have interest in preventing gastrointestinal diseases.

RAW MATERIALS:

Protein rich fractions from fish processing waste and mollusks and crustaceans as well as those coming from fishery discards.

Marine organisms including fish, crustaceans and mollusks are also a rich source of non-protein derived bioactive peptides (not from hydrolysed proteins).

FEASIBILITY:



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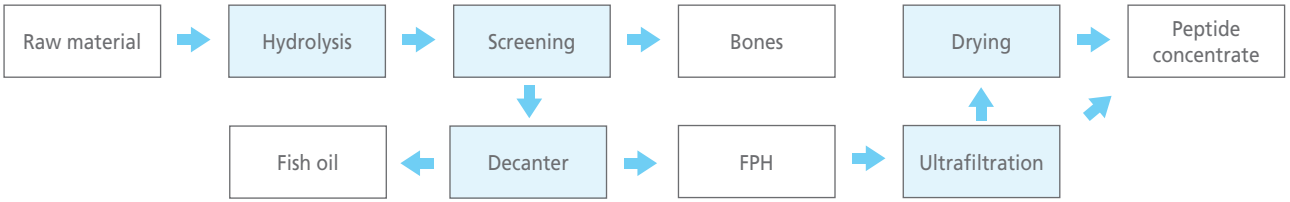
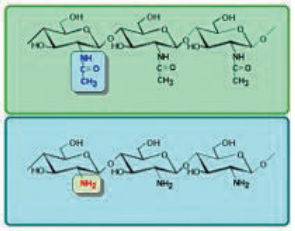


CHITOSAN

PRODUCT DESCRIPTION:

Chitosan is a biopolymer, a polysaccharide, obtained through the deproteinization, demineralization, decolouration and deacetylation of chitin, a biopolymer of N-acetyl- glucosamine, present in the exoskeleton of arthropods (very known from the crustacean shells) and in the cell wall of fungi.



Chitin

Chitosan

PRODUCT APPLICATIONS:

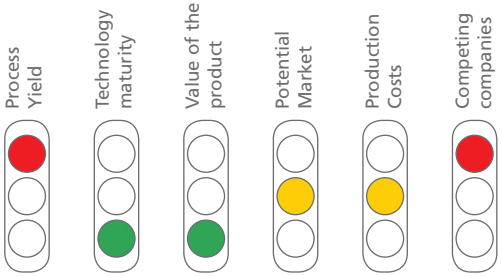
Chitosan in its different modified forms as well as different degrees of purity can be used in a very wide range of applications. It has interesting technological properties, i.e. antimicrobial, antioxidant and fat binding, due basically it is positively charged in its surface. It is used in industrial applications as food grade flocculant in water treatment and in paper manufacture; in cosmetics in foams; in food applications in edible films or in microencapsulation of ingredients; in pharmacy, in nutritional supplements as fat binder;

in aquaculture and ruminant feeding to reduce infections and improve yield; in medicine as material in histocompatible tissues and contact lenses.

RAW MATERIALS:

The raw materials from marine origin are almost exclusively crustacean shells. The crustacean shell representing around a 3 % of the total body weight. Shrimp shells have the highest chitin content, 30-40 %, followed by crab shells, 15-30 %.

FEASIBILITY:



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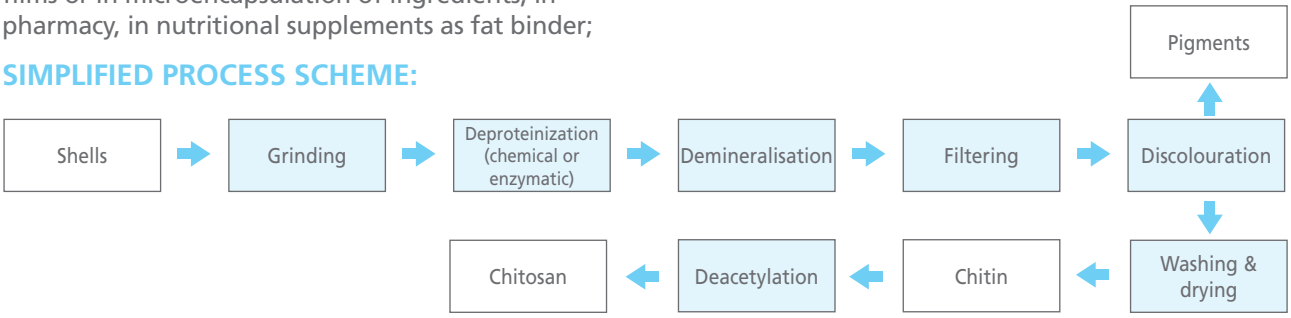


CHONDROITIN SULFATE

PRODUCT DESCRIPTION:

Chondroitin sulfate (CS) is a polymer constituted by alternating molecules of glucuronic acid and N-acetyl-galactosamine sulfated. This material is an essential component of extracellular matrix of connective tissues.

Chondroitin sulfate provides cartilage with its mechanical and elastic properties, and gives this tissue a large part of its resistance to compression. Chondroitin sulfate is usually associated with proteins constituting high molecular weight aggregates called proteoglycans.

PRODUCT APPLICATIONS:

It is used as a dietary supplement with anti-inflammatory properties, as an aid against arthritis.

In cosmetics it is present in skin and hair care products.

In pet food in supplements for connective tissue repair (dogs) and in skin care.

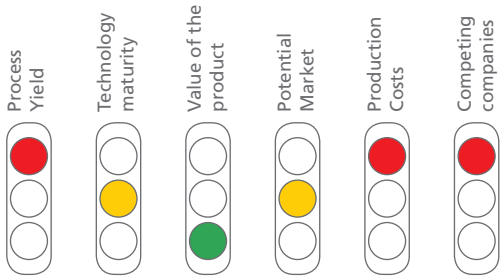
In feed is commonly used in connective tissue supporting (horses).

Together with glucosamine it is used in veterinary medicine in wound gels.

RAW MATERIALS:

It is abundant in the skeleton of cartilaginous fishes, sharks and rays, where it represents 6 to 8 % of the total body weight.

FEASIBILITY:



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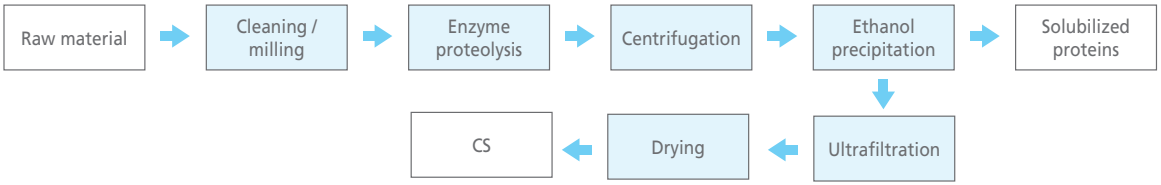
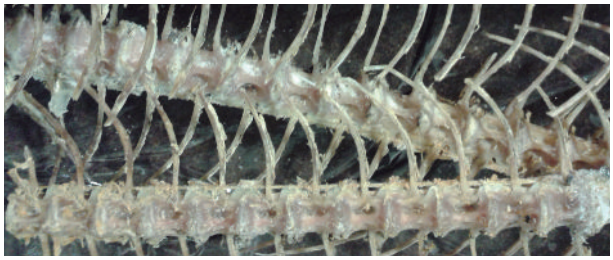


COLLAGEN



PRODUCT DESCRIPTION:

Collagen is the primary structural protein in the extracellular space in the various connective tissues in animal bodies, playing a vital role in the formation and maintenance of bones, tendons, ligaments, hair, nails and skin. Collagen can be produced from different sources, including fish bones and skins. The final form of the product is usually as dried powder.

PRODUCT APPLICATIONS:

Research has suggested that orally administrated collagen peptides reduce the effects of ageing on skin and improves joint health. Thus, collagen is used in medicines for arthritis and osteoporosis. Then it can be utilized in cream and other cosmetics for skincare.

Collagen has been widely used in cosmetic surgery, as healing aid for burn patients for reconstruction of bone and wide variety of dental and surgical purposes. The high nutritional value of collagen makes it an excellent additive in functional food and food supplements.

RAW MATERIALS:

Collagen is the most abundant type of protein in animals. Fish gelatin and collagen peptides are product of collagen hydrolysis. Collagen can be derived from various fish by-raw materials sources including skin and scales, heads, connective tissue and bones. Fish bones are 60-70 % minerals (calcium, phosphorus) and hydroxyapatite and the remaining content is 30 % collagen.

FEASIBILITY:

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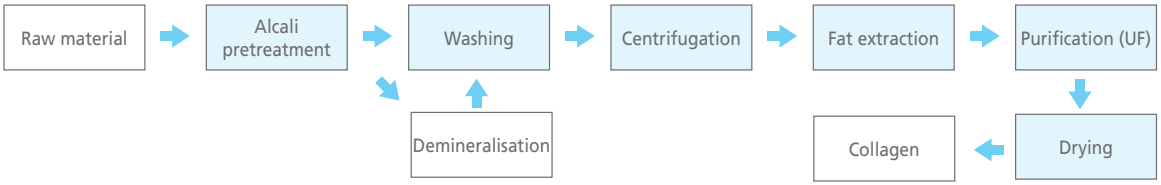
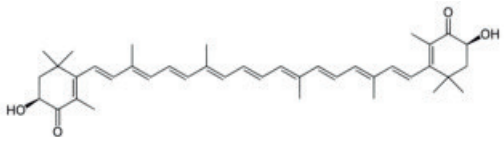


ASTAXANTHIN

PRODUCT DESCRIPTION:

Astaxanthin is a carotenoid, a xanthophyll or oxygen containing pigment. It is a colourful (red-orange), lipid-soluble pigment.

Its colour is due to the long chain of conjugated double bonds. This chain of double bonds gives astaxanthin also a strong antioxidant function.



PRODUCT APPLICATIONS:

Due its functional properties, it is mainly used in food, feed and aquafeed applications as colouring, antioxidant and as nutritional supplement. In cosmetics, it is used in skin care and anti-aging formulations.

Main claims for astaxanthin, when used as a nutritional supplement are: antioxidant, prevents diabetes, cardiovascular diseases, and neurodegenerative disorders, and also stimulates immune system. Astaxanthin products are used for commercial applications in the dosage forms as tablets, capsules, syrups, oils, soft gels, creams, biomass and granulated powders.

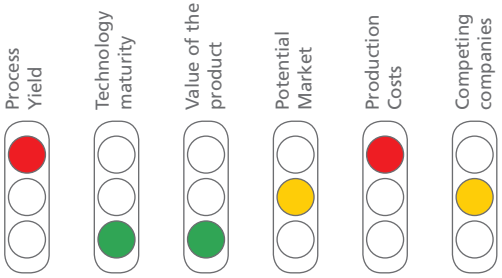
RAW MATERIALS:

Production can come from both natural and synthetic sources.

The natural sources of astaxanthin are algae, yeasts, salmon, trout, antartic krill, shrimp, crayfish and crustacean shells, as a co-product of the production of chitin and chitosan.

Examples of microorganisms containing astaxanthin are microalgae such as H*aematococcus pluvialis, Chlorella zofingiensis, Chlorococcum* and the yeast *Phaffia rhodozyma.*

FEASIBILITY:



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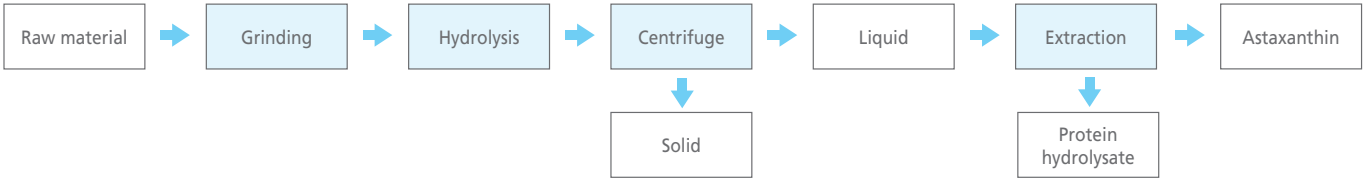
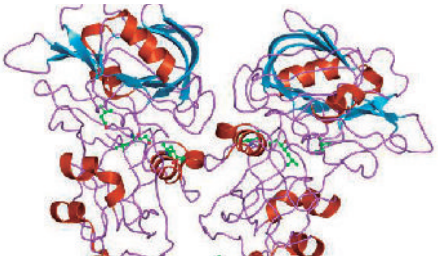


ENZYMES



PRODUCT DESCRIPTION:

Proteolytic Enzymes or proteases catalyze the degradation of peptide bounds of the proteins. Lipases are the enzymes that catalyze the hydrolysis of ester bonds in substrates, such as triacylglycerols.

Proteases derived from fish can be divided into two main classes:

- Pepsins, very resistant to autolysis at low pH and heat sensitive.
- Trypsin, stable in alkaline media and very unstable in acidic conditions (trypsin from mammals are most stable in acidic media).

PRODUCT APPLICATIONS:

There is a wider range of actual and potential applications of lipases, ranging from cleaning products to modified foods, flavor development (i.e. cheese rippening), biodiesel production, pharmaceutical processes and synthesis of structured lipids. They can be used in the purification of PUFAs from fish oil.

Proteases play a key role in a wide variety of industrial processes: in cheese making, protein hydrolysates production, in detergents, textile & leather processing, biofuel processing,

Pepsin from cold-water species such as Atlantic cod and orange roughy have been used for hydrolyzing collagen and release caviar from the roe of the same species. Cod pepsin was tested for skinning of herring and used to descale hake and haddock.

RAW MATERIALS:

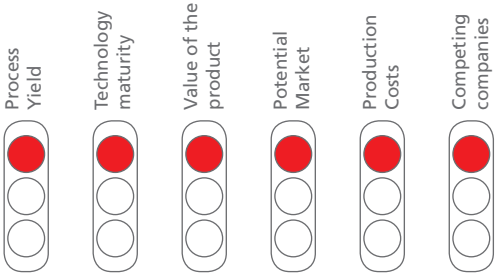
By-products from fish processing industries, especially digestive organs, are the potential sources of numerous enzymes, such as lipases and proteases.

Proteases can be obtained from fish digestive organs and viscera.

Pepsin can be obtained from the stomach of the fish.

Lipases can be obtained from fish liver and intestines.

FEASIBILITY:



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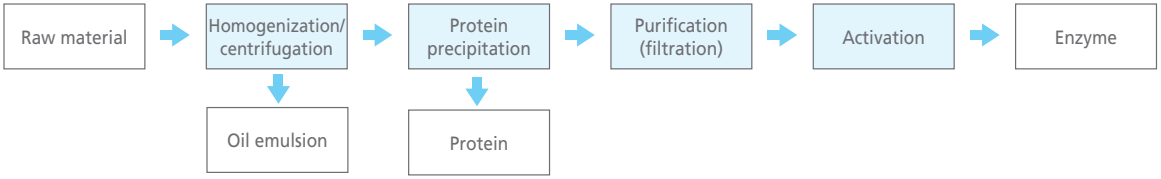


VITAMINS

PRODUCT DESCRIPTION:

Vitamin A is a group of fat-soluble substances that are found in animal products. Therefore, it is present in high concentrations in fish fatty tissues.

Vitamin D is present in fish oil. Vitamin dietary sources are eggs, fish, and dairy products. It is also synthetized in the skin through a non-enzymatic reaction activated by the sunlight.

EFSA has confirmed that clear health benefits have been established for the dietary intake of vitamin A in contributing to:

- normal cell differentiation;
- a normal function of the immune system;
- the maintenance of normal skin and mucous membranes;
- the maintenance of normal vision;
- normal iron metabolism.

While the nutrition claims for omega 3 fatty acids and vitamin D are:

- Vitamin D supports normal bones
- EPA & DHA support normal heart function.
- DHA supports the maintenance of normal vision
- DHA supports normal brain function.

PRODUCT APPLICATIONS:

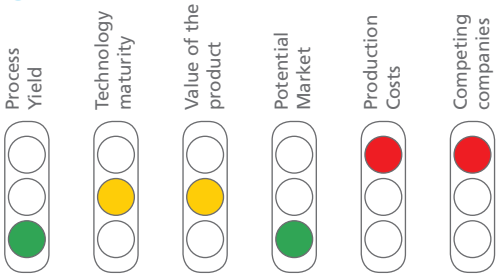
High quality fish oil rich in vitamins A and D is commercialized in dietary supplements, in fortified food products (margarine, dairy) and feed supplements.

RAW MATERIALS:

Main sources due its content and quality are cod and shark liver, low fat species that accumulate fat in the liver. By-products from farmed salmonids (salmon, trout) can be also used to produce fish oil of a quality that is well suited for human consumption.

In Norway, the species that produce the greatest concentrations of A and D are Gadus virens and Gadus pollachius. Their oils contain as much as to 5000 IU vitamin A and 500 IU vitamin D per gram.

FEASIBILITY:



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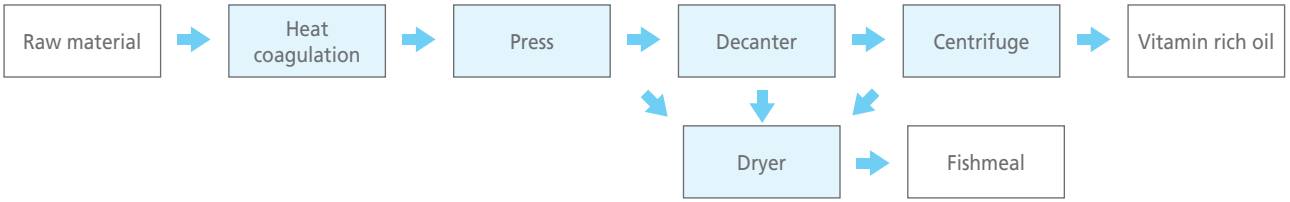


GELATINE

PRODUCT DESCRIPTION:

Gelatine is an irreversibly hydrolysed form of collagen, which produces smaller peptides with a broad molecular weight range.

Gelatine is a viscous semi-solid gel; its typical general composition includes 85-90 % protein, 2-4 % mineral salts and 8-12 % water.

There are two main types of gelatines:

- Type A: obtained from the acid hydrolysis procedure.
- Type B: obtained from the alkaline hydrolysis procedure.

PRODUCT APPLICATIONS:

Gelatine is commonly used as a gelling agent in food, pharmaceutical drugs, photography and cosmetics manufacturing.

Gelatine is found in most gummy candies, as well as other products such as marshmallows, gelatine deserts and some ice creams, dips and yogurts.

The traditional application for cold water fish gelatine is microencapsulation of heat sensitive. vitamins and other nutrients.

RAW MATERIALS:

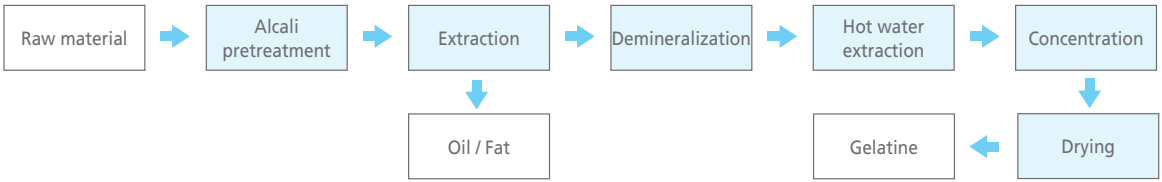
The main sources of commercial gelatine are porcine and calf skin and bones. The most common raw material for fish gelatine is fish skin (specially tuna skins), but substantial amounts are also made from fish scales. Fish bones may be used, but they contain much less collagen than skins.

Gelatin quality varies largely among different species and fractions and if warm or cold water fish are used.

Hygienic requirements are strict when gelatine is intended to be used for added value applications.

FEASIBILITY:

SIMPLIFIED PROCESS SCHEME:



HYALURONIC ACID

PRODUCT DESCRIPTION:

Hyaluronic acid (HA) is a glycosaminoglycan, a natural and linear polymer composed of repeating disaccharide units of B-1, 3-N-acetyl glucosamine and B-1, 4-glucuronic acid with a molecular weight up to 6 million Daltons. Present in skin, bones and joints, it gives elasticity to these parts of the body. It also gives shape to the eyeball and is present in the vitreous humour. Its production and function in human body decreases with age.

PRODUCT APPLICATIONS:

According to the systems used, different qualities of hyaluronic acid can be obtained, which can be used in a variety of applications.

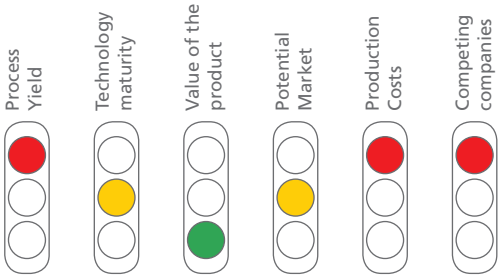
Thus, it is used in skin regenerative cosmetics and injections in cosmetic surgery or in recovery from injury of joints. It is found in dietary supplements for joint care.

It is also used in veterinary as adjunct in treatment of noninfectious synovitis and in osteoarthritis in dogs and horses.

RAW MATERIALS:

Marine sources are shark cartilage and fish eyeballs. Before the rise of bovine spongiform encephalopathy, the main source of this compound was the vitreous humour and synovial fluid of joints of cattle. Rooster combs have been the other main source of HA. All these sources must now compete with biotechnological processes that produce HA.

FEASIBILITY:



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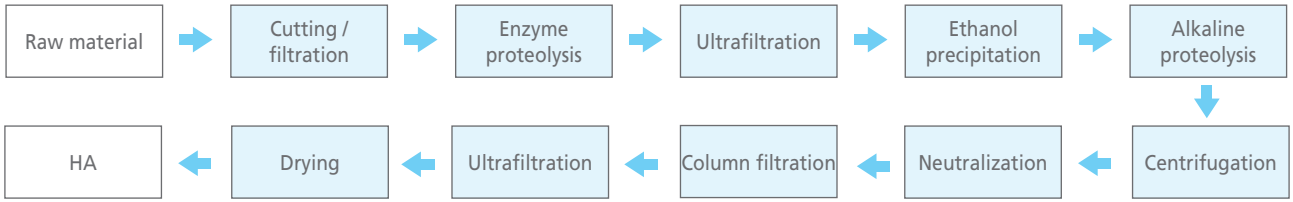
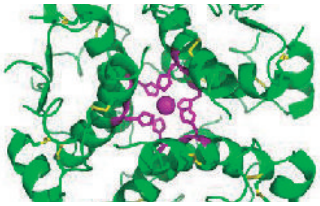


INSULIN

PRODUCT DESCRIPTION:

Insulin is a peptide hormone that plays a major role in metabolism.

It is produced by beta cells of the pancreatic islets and by the Brockmann body, an endocrine organ found in some teleost fishes.



PRODUCT APPLICATIONS:

Insulin is necessary to regulate the amount of glucose (sugar) in the blood and is required for the normal functioning of the body.

Insulin is used in medicine to control blood sugar in people with diabetes type 1 or type 2.

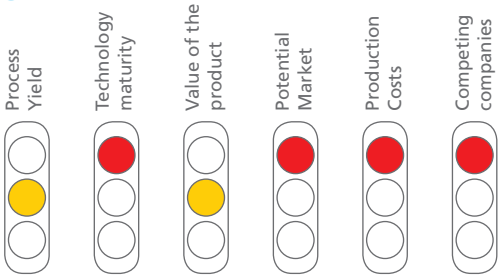
The use of fish insulin and insulin producing cells is still at developmental stage.

RAW MATERIALS:

Human insulin for medical purposes is mainly produced biotechnologically using recombinant microorganisms.

Insulin from fish islets is easily extractable. Moreover, endocrine cells are easy to harvest and fishes can regenerate the tissue after extraction. But fish insulin molecule differs from human insulin. Therefore, Brockmann body of transgenic teleost fishes is being investigated as a potential source of cells for the production of human insulin.

FEASIBILITY:



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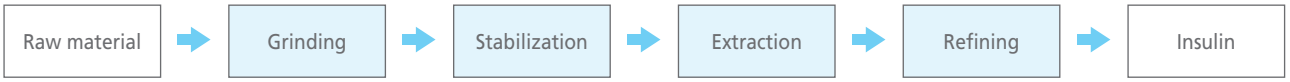
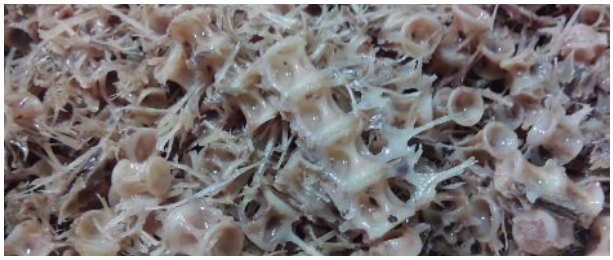


MINERALS



PRODUCT DESCRIPTION:

Product obtained from fish bones consisting in tricalcium phosphate in form of hydroxyapatite crystals, elemental calcium and phosphate and collagen. It may also contain magnesium as well as trace elements as iodine, iron, zinc and selenium.

Other products in the market are composed only of hydroxyapatite, obtained as a co-product of the production of fish collagen and gelatin.

Generally sold bulk in powder form or formulated in capsules or pills.

It can be also obtained from bivalve molluscan shells but in form of pure calcium carbonate.

PRODUCT APPLICATIONS:

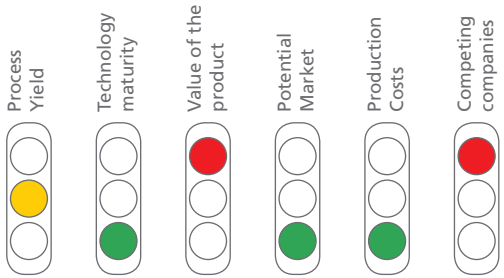
The product obtained from fish bones can be used:

- As food marine mineral supplement in nutraceutical market or as mineral- collagen complex supplement.
- As food ingredient.
- As mineral supplement in feed and pet food.
- As soil improver or mineral fertiliser.

RAW MATERIALS:

Bones constitute a significant part of the fish; approximately 10–15 % of total fish biomass is bones from the head and vertebrae. The composition of fish bones varies among different species and the type of bone being constituted mainly by 45-60 % tricalcium phosphate and 35-55 % collagen (dry matter basis).

FEASIBILITY:



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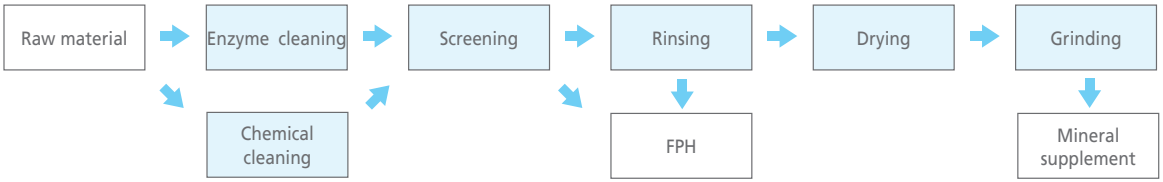
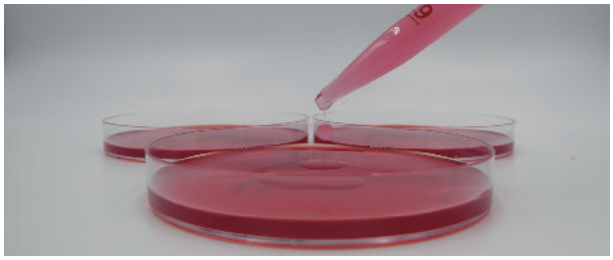


FISH PEPTONES



PRODUCT DESCRIPTION:

Peptones are a water-soluble mixture of polypeptides and amino acids which are widely used as substrate in many biological and biotechnological applications, such as in microbial biomass production. The product is a brownish yellow to brown homogenous free flowing powder, having characteristic odor of protein. The peptones available for culture media may be in the form of gels and liquids.

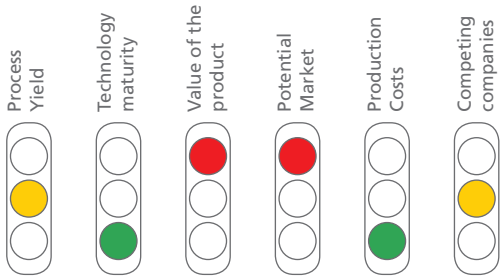
RAW MATERIALS:

Peptones are primarily obtained from the products of bovine or porcine origin, such as meat, internal organs, gelatin, and milk, but also from plants and yeasts. Fish peptone is obtained by enzymatic hydrolysis of fish flour or fish by-products.

PRODUCT APPLICATIONS:

Peptone favors the growth of a wide variety of microorganisms. In industrial fermentation media, fish peptone is suited for the growth of Lactobacillus, Escherichia, yeast etc. In diagnostic media it is particularly well suited for cultures of Staphylococcus aureus. Peptones are also used in tissue culture media as well as in vaccine stabilizers. Fish hydrolysates can be also used as a source of amino acids in plant foliar fertilisers.

FEASIBILITY:



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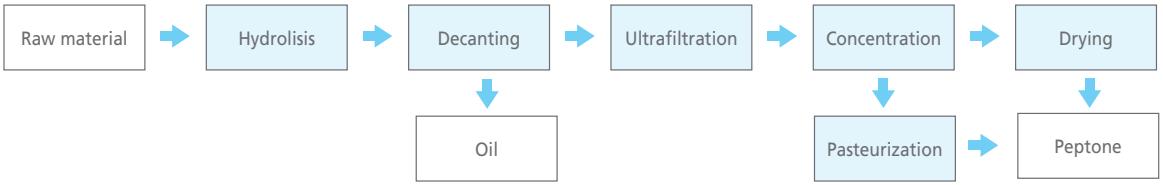
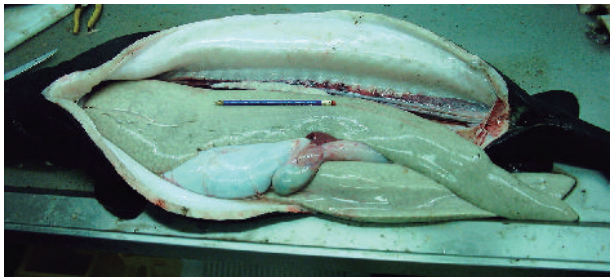


SQUALENE



PRODUCT DESCRIPTION:

Squalene is a lipid, hydrocarbon with 30-carbon, which is the biochemical precursor to the whole family of steroids.

It's an isoprenoid intermediate in the synthesis of the cholesterol, steroid hormones and vitamin D.

Squalene product is a 99.5 % pure extract of Shark Liver Oil.

PRODUCT APPLICATIONS:

Squalene is used in cosmetics, such as moisturizing creams or sunscreens and in pharmacy as immune-stimulant or coadjuvant in vaccines.

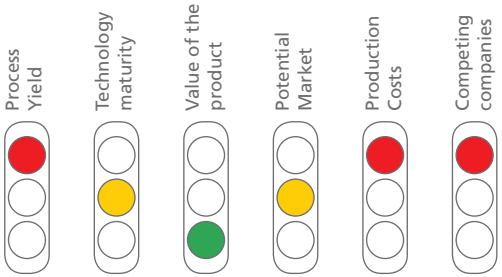
As dietary supplement it is usually commercialized as shark liver oil. It's said to act as anti-oxidant, antibiotic, anti-coagulant, anti-histaminic, digestive or immune stimulant among other effects.

RAW MATERIALS:

Squalene is taken from the livers of three species of shark: the deep sea shark (*Centrophorus squamosus*), the dogfish (*Sqaulus acanthias*), and the basking shark (*Cetorhinus maximus)*. The liver makes up about 25 % of the total shark body weight of these sharks.

Currently its use is being discarded in favor of other more sustainable sources of squalene like the olive oil.

FEASIBILITY:



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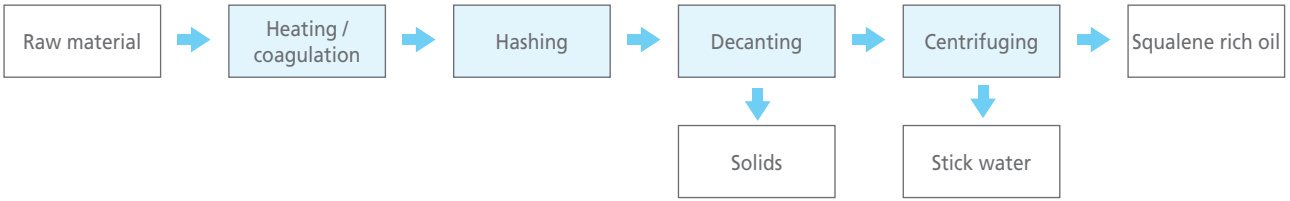

PHOSPHOLIPIDS

PRODUCT DESCRIPTION:

Phospholipids (PLs) are amphiphilic molecules with an hydrophobic tail composed by two fatty acids joined together by an hydrophilic head, a glycerol molecule with a phosphate group. PLs conform the structure of the biological membranes and liposomes.

The most predominant PLs in marine sources such as salmon, tuna, rainbow trout and mackerel, is phosphatidylcholine, whereas phosphatidylethanolamine is shown to be the second most abundant. Phosphatidylinositol, phosphatidylserine, lyso-phosphatidylcholine, and sphingomyelin are found in smaller amounts.

One main difference with vegetable PLs is that marine omega-3 phospholipids (n-3 PLs) contain long-chain n-3 PUFAs.

PRODUCT APPLICATIONS:

Nutritional use: as emulsifiers in baked goods, instant drinks, dairy products, chocolate and margarine.

Cosmetics: emollients for skin care, hair care, make-up. Mainly used as vehicles or carriers in delivery systems (liposomes).

Pharmaceutical: antibacterial, antiviral and antitumoral activities, alleviate senescence, cognitive disfunctions, inflammatory diseases. There are no specific health claims approved by EFSA.

RAW MATERIALS:

Fish roe: it is used for human consumption and is a rich source of n-3 PUFAs in PL form. Fish roe from herring, salmon, pollock, and flying fish contain between 38-75 % of their lipids as PLs.

Krill oil (KO): it is extracted from the Antartic crustacean krill. High amount of PL-bound n-3 PUFAs (around 40%), in particular EPA and DHA.

Fish (oil): cold-water oily fish like salmon, sardine, anchovy, herring, or mackerel (1–1.5 % PLs).

FEASIBILITY:

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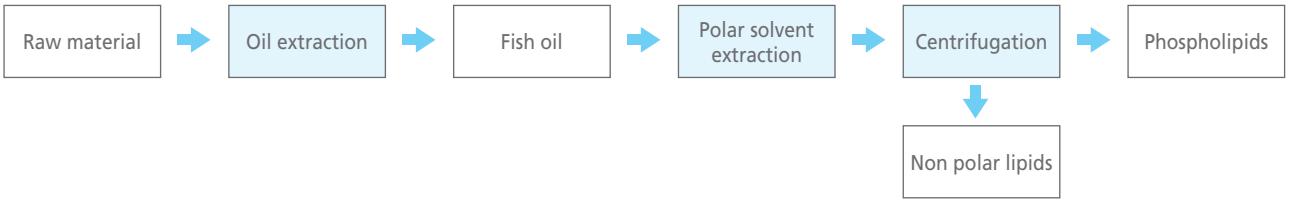
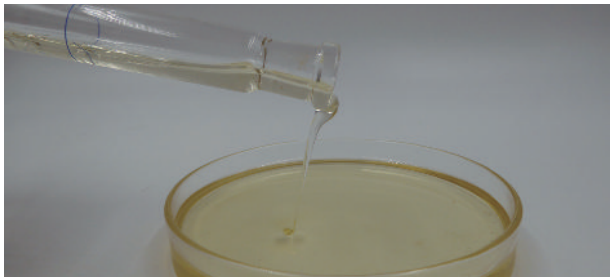


POLYUNSATURATED FATTY ACIDS



PRODUCT DESCRIPTION:

Polyunsaturated Fatty Acids (PUFAs) are fatty acids with more than one un-saturation (double bond) in their chain.

PUFAs include important compounds such as essential fatty acids.

There are two major families of PUFAs:

- Omega-3: mainly docosahexaenoic acid (DHA), and eicosapentaenoic acid (EPA) present in fish, shellfish, plants and algae, and Alpha linolenic acid (ALA) only present in plants.
- Omega-6: linoleic acid (LA), gamma linoleic acid (GLA) and arachidonic acid (AA), present in a lower amount in fish oils.

PRODUCT APPLICATIONS:

PUFAs have demonstrated effect on cardiovascular diseases prevention, normal brain and nervous tissue development, as well as anti-carcinogenic anti- inflammatory and anti-allergenic properties.

Therefore, PUFAs find their main applications in:

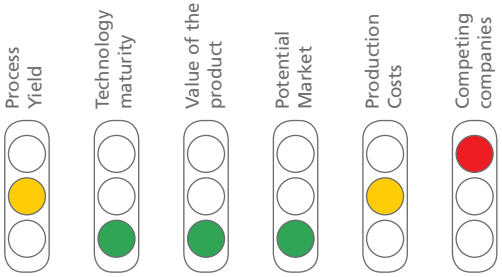
- Infant formulae
- Functional food & beverages (dairy products, non-caloric beverages, canned food, margarines, pre-cooked food, flours, snacks, sweets, eggs, meat products)
- Dietary supplements
- Feed, pet food and aquaculture feed
- Cosmetics

RAW MATERIALS:

EPA and DHA are purified from the high quality oil extracted from oily fish species and also from some crustacean species (Antartic krill).

The most common and traditional source is cold pressed oil from cod liver. Oil is extracted also from cold-water fishes from the Scombridae, Clupeidae and Salmonidae families such as salmon, mackerel, halibut, sardines, tuna, and herring.

FEASIBILITY:



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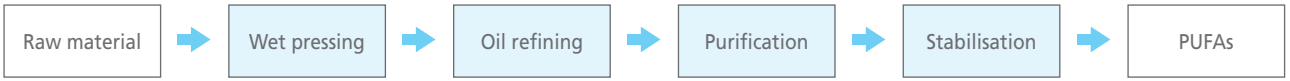


PROTAMINE / PROTAMINE SULPHATE

PRODUCT DESCRIPTION:

Protamine is a protein (Molecular weight around 4 - 5 kDa), which works to maintain and protects DNA from being damaged.

Protamine sulfate is defined by the European Pharmacopoeia monograph as consisting of the sulfates of basic peptides extracted from the sperm or roe of fish, usually species of Salmonidae and Clupeidae.

PRODUCT APPLICATIONS:

Protamine has been widely used as a natural food preservative since 1980's, because Protamine has strong antibacterial effects.

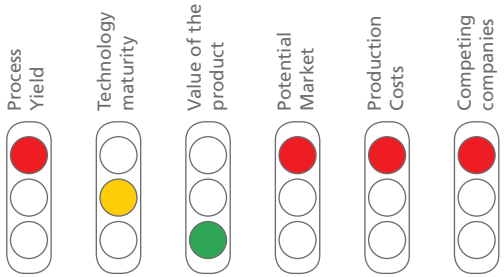
As a pharmaceutical product, Protamine works neutralizing Heparin effect, keeps continued antihyperglycemic effects together with Insulin, and also works against fat absorption in the intestine.

RAW MATERIALS:

Sperm and roe of Salmonidae (salmon, trout, chars, freshwater whitefishes, and graylings) and Clupeidae (herrings, shads, sardines, hilsa, and menhadens species).

Nowadays it is mainly produced through recombinant biotechnology.

FEASIBILITY:



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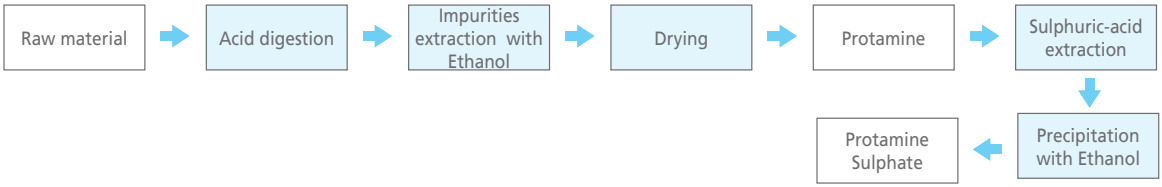


STEROLS

PRODUCT DESCRIPTION:

Sterols are steroid alcohols (complex polycyclic lipids with a hydrocarbon nucleus) found in plants and animals, and which include the mycosterols, phytosterols (derived from plants), and zoosterols (derived from animals). The principal sterol of animal fats (including marine oils) is, by far, cholesterol. Some Phytosterols (campesterol, sitosterol, stigmasterol…) can also be found in marine organisms in small quantities, as a dietary origin from phytoplankton. The major presence of phytosterols is observed in bivalves due to phytoplankton food sources. Phytosterols have received much attention in the last decade because of their cholesterol-lowering properties.

PRODUCT APPLICATIONS:

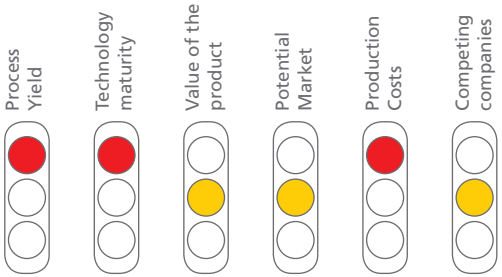
The global plant sterol esters market is segmented into food, pharmaceutical, and cosmetics industry. Food sector accounts for the highest demand for plant sterol esters, accounting for over 50 % share of the global market in terms of volume.

Phytostanol and phytosterol esters are chemically stable, fat-type materials, having comparable chemical and physical properties to edible fats and oils. They are Generally Recognized As Safe (GRAS) by the U.S. Food and Drug Administration (FDA) and approved as safe ingredients by the European Food Safety Authority.

RAW MATERIALS:

Fish and shellfish viscera are the primary sources of sterols. The presence of phytosterols in fish is quite low, so the cost of extraction would be much higher compared to other natural sources (plants,…). The major economic interest of extracting phytosterols would be in bivalves.

FEASIBILITY:



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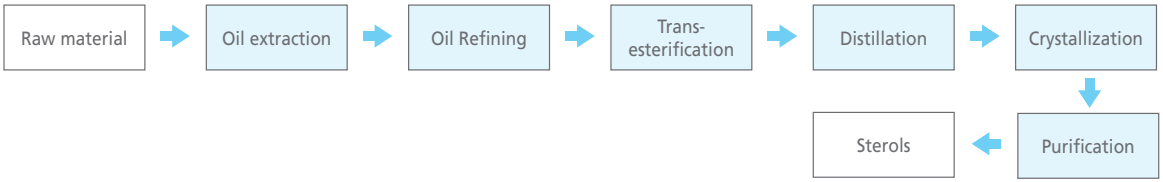


FISHMEAL AND FISH OIL

PRODUCT DESCRIPTION:

Fishmeal is a brown powder rich in protein. The colour is affected by fish species, particle size, fat and moisture content.

Standard fishmeal typically has 64-67 % crude protein with up to 12 % fat and 10-20 % ash.

Fish oil is the co-product of the fishmeal plants. It is a liquid product composed mainly by fatty acids, high in unsaturated fatty acid, with variable amounts of phospholipids, glycerol ethers and wax esters.

PRODUCT APPLICATIONS:

Fishmeal is mainly used in animal feed. Aquaculture accounts for > 60 %, pigs 25 %, and poultry 8 %.

Fish oil has different uses that can vary depending on its composition. Aquaculture destiny accounts for ~80 % and ~13 % is destined to human consumption.

Fish oil can also be used as food grade lubricant, solvent in industrial products (paints, varnishes, pesticides, ink, rubber …) and in the production of biodiesel.

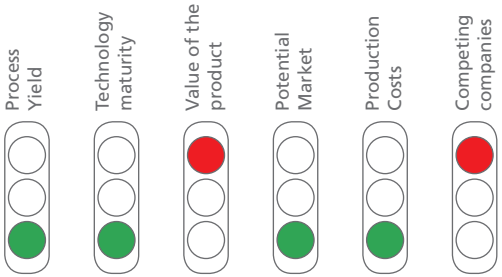
High quality oil is obtained through cold pressing and can be further refined to obtain a polyunsaturated fatty acids (PUFAs) rich product to be used in food products, supplements, cosmetics and pharmaceuticals.

RAW MATERIALS:

Fishmeal and fish oil can be obtained from any kind of discard or fish by-product, including shellfish. Fatty acid composition and quality depend on the species and freshness.

If deterioration of the raw Fish occurs, much lower quality and price of the product is obtained.

FEASIBILITY:



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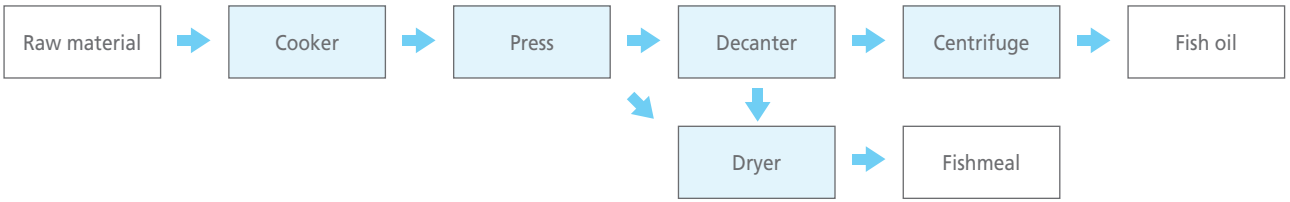


FISH PROTEIN CONCENTRATE

PRODUCT DESCRIPTION:

Fish Protein Concentrates are prepared from fish by extracting out the oil and the bones, so that the resultant product is higher in protein and lower in ash content than fishmeal and FPH. They can be classified into:

- Fish protein concentrate (FPC) : protein 65-80 % and fat/oil 1-3 %.
- Fish protein isolate (FPI): less than 1 % fat/oil and more than 90 % protein.

FPCs can fall into two categories:

- FPC type A: odour-free and tasteless product with a fat content around 0.5-1 % and protein up to 80 %.
- FPC type B: Typical oil content is around 3 % and protein content is smaller than in type A.

PRODUCT APPLICATIONS:

Main uses of the FPC are:

- As protein supplement in the food industry
- Nutritional supplement
- Animal feeding

FPC has primarily been used in specialized feeding applications with monogastric animals, such as in milk replacers or starter feeds. It is an excellent source of highly digestible amino acids, but its costs normally limit its usage. It can be used to replace other protein sources if available to a comparable price.

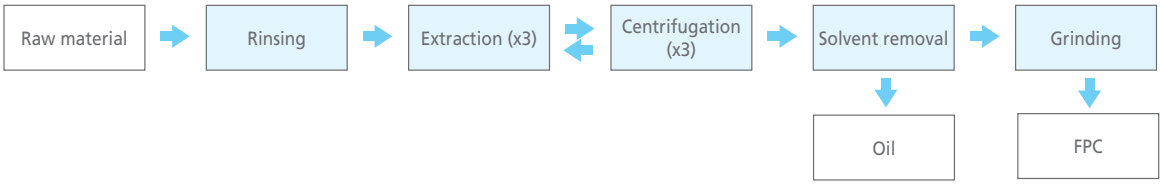
RAW MATERIALS:

All species and several fractions can be used as raw materials for FPCs (fish muscle, whole fish or fish by-products).

Raw material should be stored in refrigerated conditions or frozen in containers. Gutting improves the quality and the storage life of many fish species. In order to control hystamine production, storage conditions and product characteristics must be carefully selected.

FEASIBILITY:

SIMPLIFIED PROCESS SCHEME:



FISH PROTEIN HYDROLYSATES

PRODUCT DESCRIPTION:

Fish protein hydrolysate is the result of the enzymatic or chemical hydrolysis of the protein fraction of whole fish, fish muscle, fish by-products or process waters. FPH has interesting technological and sensory properties.

Typically, it is a powder with creamy colour and a fishy smell. It presents around 80 % protein, less than 5 % humidity and less than 11 % of fat content.

There are two main presentations:

- Soluble Fish protein hydrolysate (FPH).
- Partially hydrolysed protein (PHP).

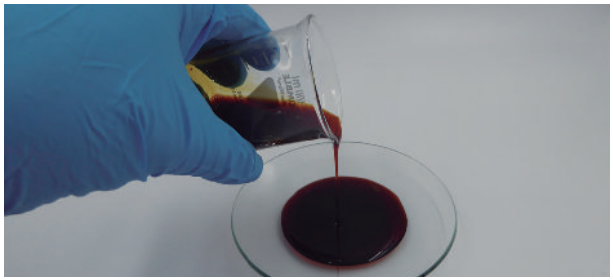
PRODUCT APPLICATIONS:

Due their good sensory and technological properties, FPH find applications in the food industry as tasting and flavoring agents in fish sauce and soups or as texturizing, foaming, jelling or emulsifying agents in bakery, ice cream, meat products and sauces. Also as salt and monosodium glutamate replacers.

There are a few nutritional supplements in the market with fish hydrolysates with health promoting properties (see bioactive peptides).

As a protein source with improved digestibility and flavor, FPH are used in nutritional supplements in feed, aquafeed and pet food.

In agriculture they are used as nitrogen source in fertilisers and in biotechnology as source of peptones in culture media (see peptones).



RAW MATERIALS:

FPH can be obtained from any kind of species, from the fish muscle, whole fish or fish by-products.

There is no need of previous transformation although previous concentration would be advisable in order to reduce transport costs. Raw material should be stored in refrigerated conditions or frozen. Hystamine production must be carefully controlled.

FEASIBILITY:

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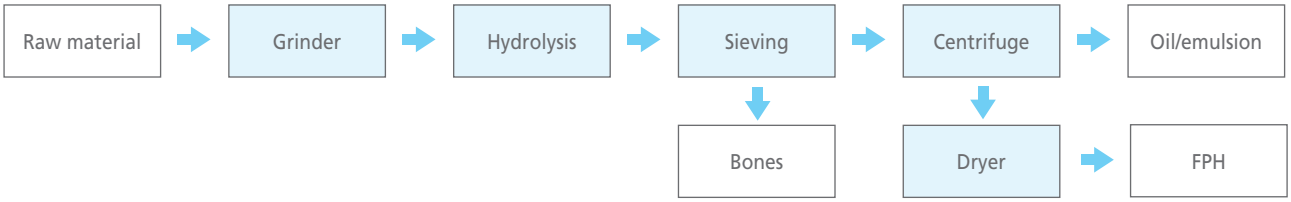
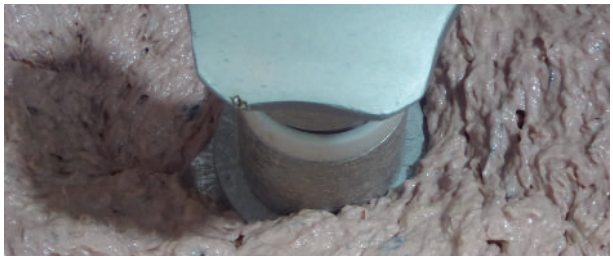


SILAGE



PRODUCT DESCRIPTION:

Fish silage can be described as a liquid product produced from the autolysis of the whole fish or part of it, including viscera, to which acids, enzymes or lactic-acid-producing bacteria may be added. Liquefaction is caused by the action of enzymes naturally present in the fish, and is accelerated by the acid which creates the right conditions for the enzymes to break down the tissues and limits the growth of spoilage bacteria. It is a simple process that can be easily scalable for use in small and large operating units previous to the separation of oil and protein hydrolysate in centralized plants.

RAW MATERIALS:

Fish silage can be made of every species of fish and every part of the fish.

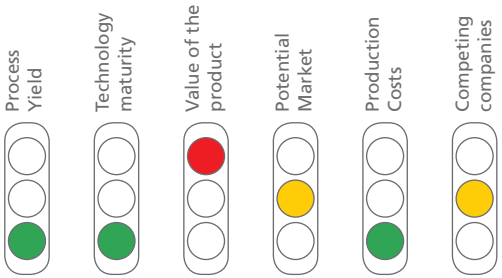
The quality of the silage depends on the freshness of the raw materials.

PRODUCT APPLICATIONS:

The products of the fish silage of category 3 by-products, oil and protein hydrolysate, are used as aquafeed for farmed species other than the species of origin. They are also used for poultry, pigs, pet food or mink feed.

The resulting oil from the silage of category 2 by-products is used in the production of biodiesel. The protein hydrolysate can be used as organic fertiliser in agriculture.

FEASIBILITY:



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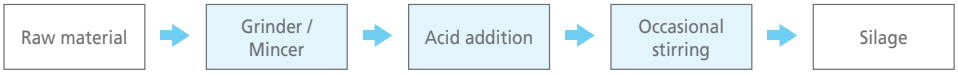


INSECT MEAL

PRODUCT DESCRIPTION:

Insect meal is a brown protein rich powder, usually made from whole, dried and grinded insects. The colour varies slightly between insect species used and the feed they are grown on.

Crude protein content varies from 40 up to 75 %. Some insect meals, for example (black soldier fly larvae, housefly maggot meal, mealworm, silkworm) contain as high as 36 % oil. Aminoacidic as well as fatty acid composition depend on the species used and the growing substrate.

PRODUCT APPLICATIONS:

Insects have been a part of human diet through the ages. Today, it is believed that insects are part of the direct diet of 2 billion people, but insect rearing for food in the western world is still at a relatively pioneering stage. Insects are authorized in the EU for human consumption under novel food regulation since January 2018.

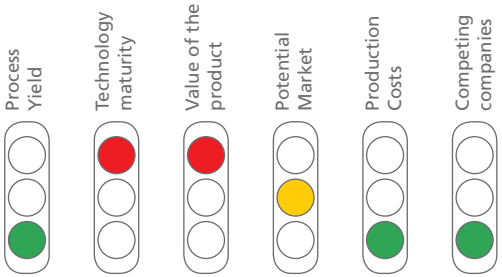
Insect meal for aquafeed is a rising industry in the western world. Since 2017 insect meal is authorized for aquaculture feeding in the UE. It provides an excellent source of protein and lipids. Chitin can also be valorized as a co-product.

Larvae rearing generates frass as a by-product that can be used as a good fertiliser.

RAW MATERIALS:

EU regulation 2017/893 authorizes the use of insect meal for aquaculture feeding and limits the number of substrates from animal origin that may be used for insect growth to specific category 3 by-products, fishmeal among others. However, fishmeal competes with insect meal as ingredient for feed.

FEASIBILITY:



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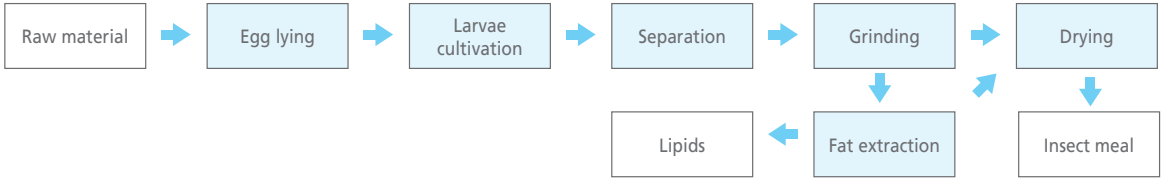


LEATHER

PRODUCT DESCRIPTION:

Fish leather is the cured and tanned skins of fish. The diversity of fish leather available is enormous due to the use of different fish species and the variety of the finishes that can be applied. The texture of the leather is dependent on the size according to the species. Collagen forms the main component in fish skin, which make it strong and flexible.

PRODUCT APPLICATIONS:

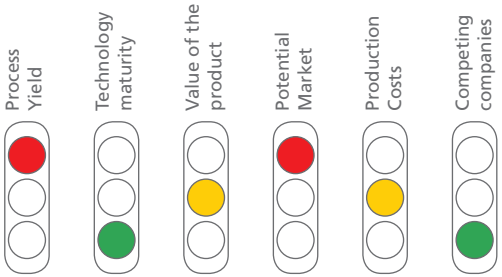
Fish leather can be used to make a wide variety of items such as jewelry, accessories including phone or iPad cases, belts, wallets, bags and in shoes.
It can also be used for a much larger variety of crafts. It is often used for bookbinding, fashion and upholstery.

RAW MATERIALS:

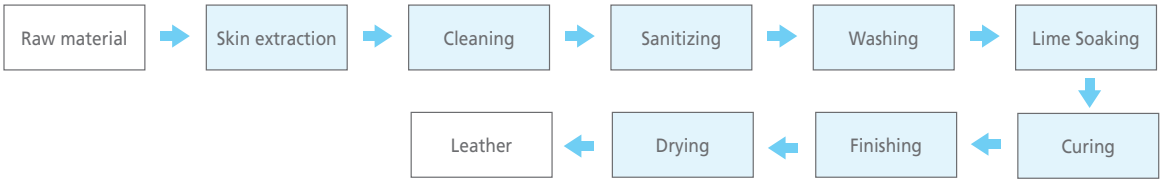
Fish leather is produced from species like Carp, Salmon, Perch, Tilapia, Cod, Sea Bass, Eel or shark.

Fish leather is remarkably strong although there are big differences between species. While salmon and tilapia are somewhat more flexible and can stretch to a degree, carp and sea bass is far thicker and more rigid. Fish leather in general is often likened to being as strong as sheep skin.

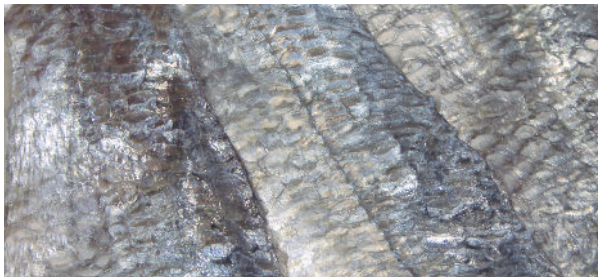
FEASIBILITY:



SIMPLIFIED PROCESS SCHEME:



PEARL ESSENCE



PRODUCT DESCRIPTION:

Guanine is an iridescent substance that is found in the epidermal layer and scales. The suspension of guanine in a solvent is called “pearl essence“. It is a substance with similar optic features to mother-of-pearl.

When it settles on the inside of hollow balls or covers the exterior of solid balls, an optical effect similar to real pearls occurs. The pearl essence is used in the manufacture of synthetic pearls, the coating of objects with iridescent finish and nail lacquers.

PRODUCT APPLICATIONS:

Manufacture of synthetic imitation pearls. Decoration items: sanitary materials, jewelers, umbrella’s grips and also in cosmetics for the manufacture of varnishes for nails and lipsticks.

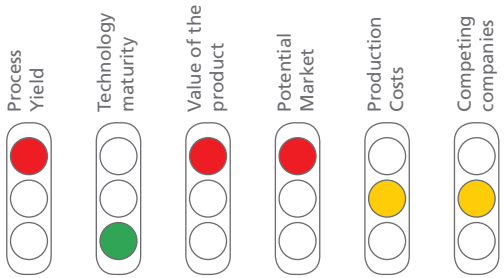
Others: paints & coating, plastics, printing inks, textiles, paper & paperboard. Globally, automotive paints and industrial machinery/maintenance coatings occupy largest market share among all pearlescent pigment applications.

RAW MATERIALS:

Fish scales from species like sardine, carp or herring. It is also present in the reflective deposits of the eyes of deep-sea fish.

Pearl essence from natural origin competes with synthetic chemical products.

FEASIBILITY:



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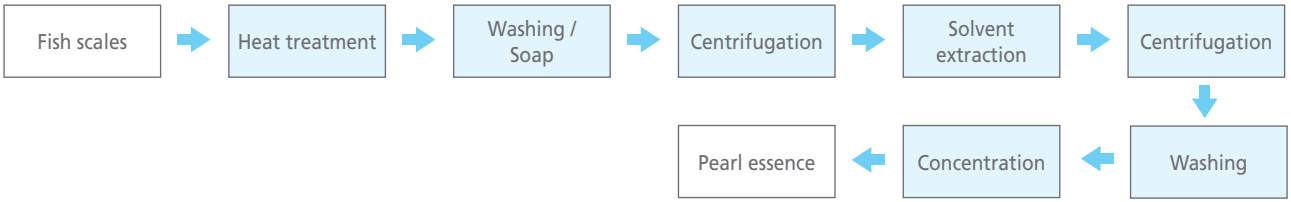


BIOGAS

PRODUCT DESCRIPTION:

Biogas is produced through the Anaerobic Digestion (AD) of organic matter produced by several microorganisms in absence of oxygen.

The products of AD are:

-Biogas: generally composed of 55-65 % methane, 35-45 % carbon dioxide, 0-3 % nitrogen, 0-1 % hydrogen, and 0-1 % hydrogen sulfide.

-Digested substrate, commonly named digestate, used as fertiliser in agriculture.

PRODUCT APPLICATIONS:

Biogas can be used for:

-Electricity production in a CHP gas engine, where the waste heat from the engine is used for heating the digester; cooking; space heating; water heating; and process heating.

-Direct combustion as a fuel in a boiler.

-Grid injection.

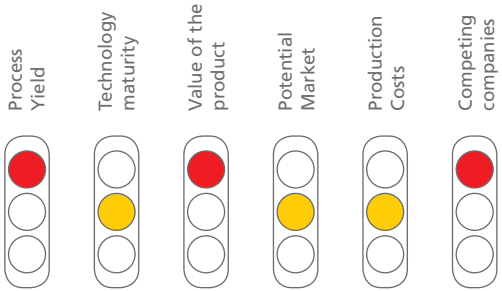
-If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells.

RAW MATERIALS:

All species and fish fractions can be used.
Fish wastes need to be pretreated by thermal hygienization (pasteurization) and must have a granulometry < 12 mm before anaerobic digestion.

Digestion of fish wastes as an unique substrate is not recommended because of the presence of inhibitory compounds and its unbalanced C/N ratio. They are usually fed in a percentage varying from 10 to 25 %.

FEASIBILITY:



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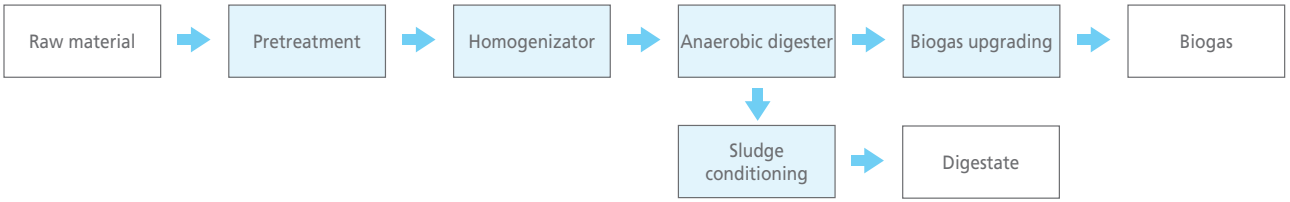


COMPOST FERTILISER

PRODUCT DESCRIPTION:

Compost can be defined as organic matter, similar to the humic substances of the soil that is stabilized through an aerobic decomposition process carried out by several microorganisms (fungi, bacteria, actinomyces...).

The general composition of compost is:

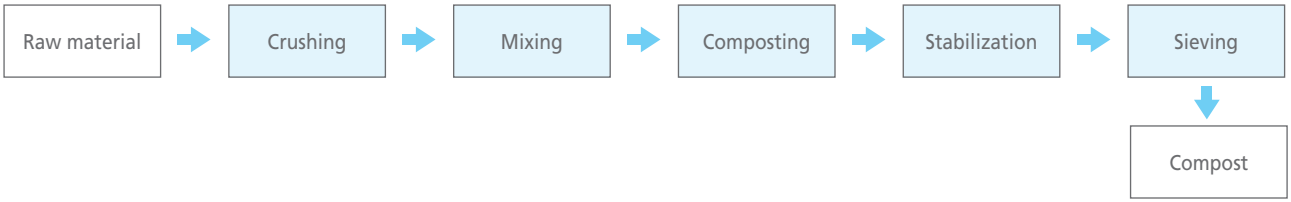
- % Humidity : 30-40 %
- C/N ratio: < 20
- % Organic Matter (OM): > 35 %
- Granulometry: 90 % particles Ø < 25 mm
- Stones and gravel Ø > 5 mm, less than 5 %
- Impurities Ø > 2mm: less than 3 %

PRODUCT APPLICATIONS:

Compost has the following main uses:

- Agricultural and residential: soil amendment, fertiliser supplement, top dressing for pasture and hay crop maintenance, fertiliser substitute, mulch for fruit trees.
- Commercial: soil amendment for turf establishment, landscape planting and beds, potting mix component, peat substitute, topsoil substitute, fertiliser supplement.

SIMPLIFIED PROCESS SCHEME:



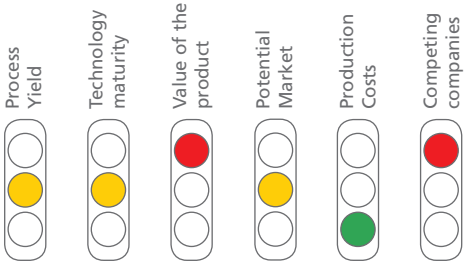
- Municipal: landfill cover materials, topsoil for road and construction work, soil amendment, mulch for landscape planting.

RAW MATERIALS:

All species and all parts of fish can be used (whole fish or fish by-products).

Fish by products need to be crushed and mixed with other substrates. Compost from fish usually consists of fish waste, saw dust, wood bark ships and is covered with leaf compost to make a compost pile.

FEASIBILITY:



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