Different raw material for fishmeal and fish oil production – Sources, regulations, quality criteria, and research needs

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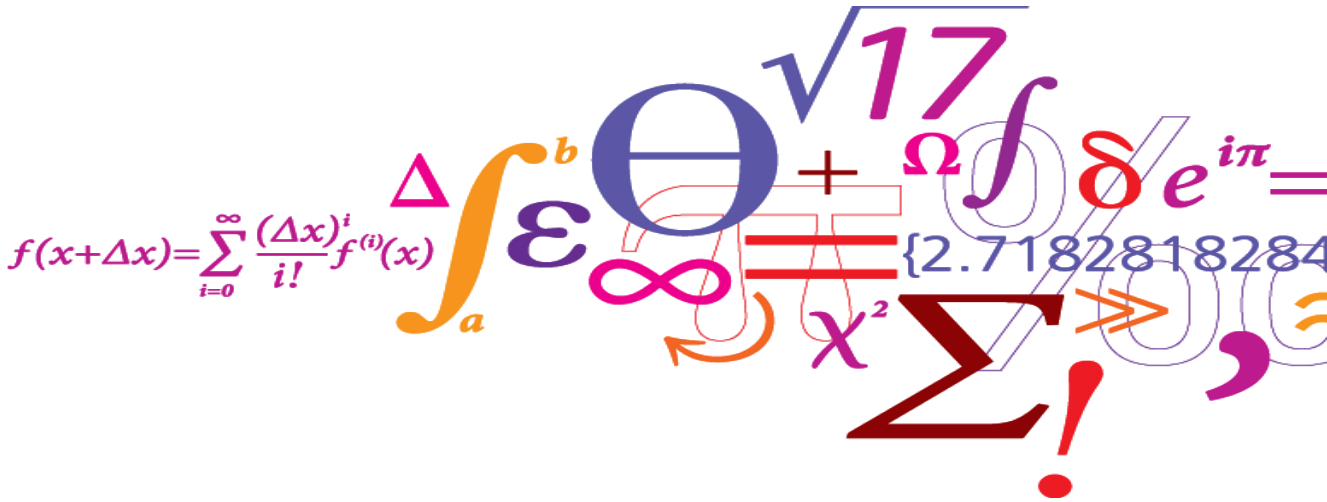

Research Group for Bioactives – Analysis and Application
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Agenda

- Sources of raw material (species, whole fish, by-products)
- Quality criteria for raw material
  - Freshness (e.g. TVN), biogenic amines, dioxins.
- Relevant regulations for raw material
- Research needs

Sources of Raw Material

- Sources of raw material for fishmeal and oil production:
  - (a) Fish caught for the sole purpose of fishmeal production (e.g. Peru, Norway, Denmark, South Africa, and U.S.A.).
  - (b) By-catches.
  - (c) Fish off cuts and offal/trimmings from the consumption industry incl. aquaculture (By-products).

Foto: Line Reeh

Sources of Raw Material

Table 1. Main fish species used for fishmeal and fish oil production by the top producing countries.

Countries	Species
Chile	anchovy, horse mackerel
China	various species
Denmark	pout, sand eel, sprat
European Union	pout, capelin, sand eel, and mackerel
Iceland and Norway	capelin, herring, blue whiting
Japan	sardine, pilchard, mackerel
Peru	anchovy
South Africa	pilchard
Thailand	various species
USA	menhaden, pollock

Source: Miles and Chapman (2006)

Sources of Raw Material

Table 2. Landings of small pelagic fish, and fish meal and fish oil production (in tons, average 2001-2006) by the Nordic countries.

Countries	Species	Landings[1]	Fishmeal[2]	Fish oil[2]
Norway	Capelin Norway pout Blue whiting Sandeels European sprat Total	229,000 15,000 720,000 92,000 5,000 1,061,000	203,000	47,500
Iceland	Capelin Blue whiting Atlantic herring Total	665,000 359,000 238,000 1,262,000	221,000	74,000
Denmark	Atlantic herring Norway pout Blue whiting Sandeels European sprat Total	135,500 36,000 65,000 387,500 257,500 881,500	327,000	106,000
Faroe Islands	Capelin Norway pout Blue whiting Sandeels Total	36,500 1,500 254,500 7,000 299,500	43,500	11,000

Source: [1]FAO 2008, [2]IFFO 2006

Sources of Raw Material

Table 3. Proximate composition of whole fish.

Fish	Protein %	Fat %	Ash %	Water %
Capelin	14	6-15	2	73-78
Blue whiting	15	2-5	2	79
Sand eel	18	7	2	73
Norway pout	16	2-3	4	73-77
Sprat	15	18	3	70-73
NS herring	17	10-17	2	60-80
NVG herring	17	4-10	2	60-80
Mackerel	18	16-31	1-2	60-74

North Sea herring (NS herring); Norwegian Spring Spawning herring (NVG herring).

Source: FAO 2018, Nifes 2018; PELAGIA 2018

Sources of Raw Material
By-products

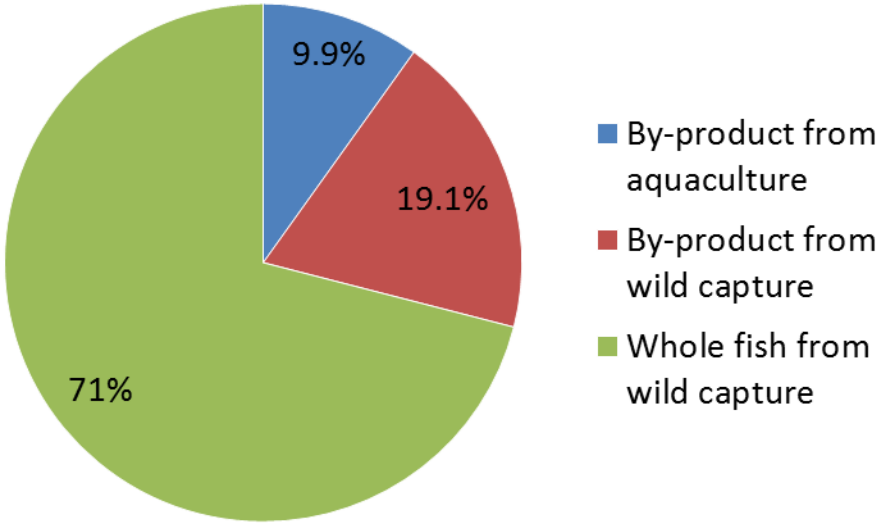


Figure 1. Share of different sources of raw material used for the production of fishmeal (Jackson and Newton, 2016)

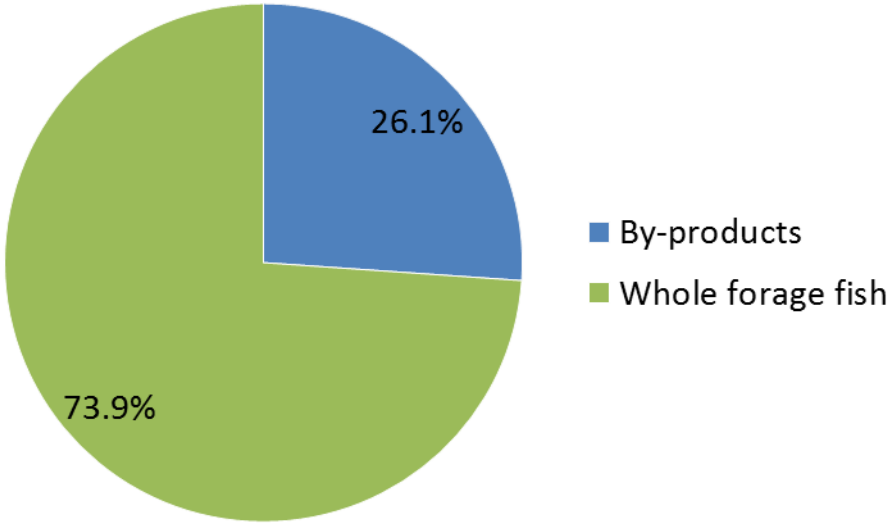


Figure 2. Source of raw material used for the production of fish oil in percentage (Jackson and Newton, 2016)

- It is estimated that globally there are an additional 11.7 million tonnes of by-product produced in processing plants that are not collected for the production of marine ingredients (Jackson and Newton, 2016).
- Asia (excluding China), at 4.6 million tonnes, is the area with the largest potential for the utilisation of by-product.
- In Europe it is estimated that there are an additional 0.6 million tonnes that could be used.

Sources of Raw Material
By-products

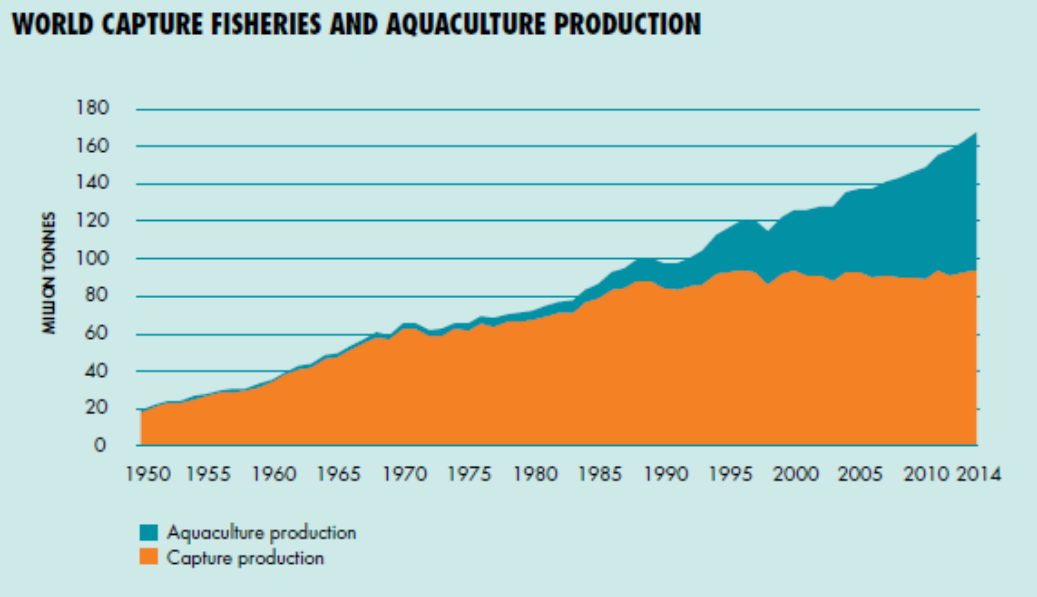


Figure 3. World wild catch fisheries and aquaculture production (FAO, 2016)

- The world fishery production is expected to be 17% higher by 2023 mainly due to the growth in aquaculture fish production (OECD/FAO, 2014).
- The aquaculture growth rate is expected to grow by 2.5% per annum. The increased production of aquaculture will ensure a growing potential supply of raw material for the production of fishmeal and fish oil.
- Fishmeal production is estimated to grow by 25-30% over the next 10 years as a result of increased by-product availability whereas fish oil production is estimated to increase by only around 5-10% over the same period (Jackson and Newton, 2016).

Table 4. Source of raw material for production of the fishmeal and fish oil (EWOS) utilized in fish feed production by three key feed manufacturers – BioMar, Skretting and EWOS, 2015.

	Biomar		Skretting	EWOS (FM and FO)
Species	**Volume MT**	**Share %**	**Share %**	**Share %**
Whole forage fish				
Blue whiting	35,149	22	33	12.8
Anchoveta	33,625	21	14	28.2
Sardine	24,862	16		7.2
Capelin	18,005	11	Icelandic 8 Barents Sea 3	6.8
Krill	10,114	6		
Lesser sand eel	8,380	5	7	
Sprat	2,661	2	European 11 Baltic 3	4.4
Herring – Icelandic summer spawning		2		
Herring – Norwegian spring spawning		1		
Menhaden	1,996	1		3.3
Other	1,939	1		5.0
Norway pout	1,824	1	2	
Jack mackerel	1,731	1		
Other marine - krill				0.08
Total marine	**159,459**	**87%**	**83%**	**67.7%**
Trimmings				
Herring - Norwegian spring spawning			7	16.3
Herring - Icelandic summer spawning			1	
Capelin			Barents Sea 1	1.1
Unidentified/various			8	3.5
White fish offal				7.8
Hake				1.0
Atlantic mackerel				2.5
Total Trimmings	**19,174**	**12%**	**17%**	**32.2%**
Certification				
IFFO RS approved fisheries		**92%**	**96%**	**93%**

Sources: SEAFISH 2016

Quality Criteria

- Freshness of the fish raw material is the major factor affecting the quality of the produced fishmeal and fish oil, which will impact the product nutritional value and obtained prices.

- **Total volatile basic nitrogen (TVB-N)**
  - TVB-N expresses the combined total amount of nitrogen in the bases (ammonia, trimethylamine, dimethylamine) formed during spoilage of fish, and is a commonly used estimate of spoilage.
  - TVB-N can be measured easily and quickly using relatively simple apparatus and, for this reason, the TVB-N value is often used as a rejection limit in regulations and commercial specifications.
  - TVB-N content in raw material of acceptable quality/freshness should be below 60 mg TVB-N/100 g of whole fish for human consumption.

Quality Criteria

- **<u>Limitations</u>**
  - TVB-N is a spoilage parameter developed and defined for ice stored gutted fish and fish filets.
  - It has not been investigated for the determination of the 'freshness' of whole fish used as raw material intended to be used for production of fish oil for human consumption.
  - the criterion of 60 mg TVB-N/100 g for whole fish is not based on scientific evidence (EFSA 2010).
- The European Food Safety Authority recommends sensory assessment for the evaluation of the freshness of raw material for fish oil production for human consumption (EFSA 2010).

Quality Criteria

Biogenic amines

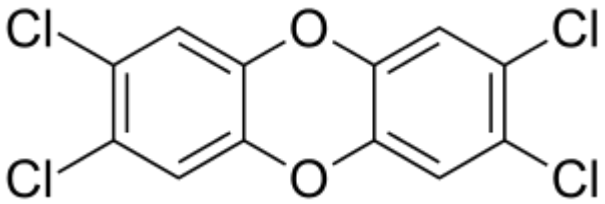
- Biogenic amines present in fish are almost totally the result of the action of exogenous enzymes released by the various microorganisms associated with the seafood products (Frank et al., 1981).
- Biogenic amines are produced during enzymatic hydrolysis of amino acids, which starts right after death, and can be indicative of the extent of the enzymatic degradation of the protein in the raw material before processing.
- While biogenic amines are natural occurring compounds, which play a rule in many critical functions in the human body, the consumption of seafood with high concentrations of such compounds may constitute a safety issue for the consumer.
- Levels of histamine above 500–1000 mg/kg are considered potentially dangerous to human health (Brink et al., 1990).
- The EU established maximal limits on levels of histamine from fishery products.

Quality Criteria

- **Biogenic amines**
- The presence of biogenic amines is one of the main factors that affect the quality of fishmeal.
- Biogenic amines are heat-stable and, thereby, do not volatilize or evaporate during drying.
- They are also water-soluble, and thus they can be separated from the presscake during drying and concentrated in the soluble fraction (stickwater).
- This means that "whole" meals, in which the condensed solubles are added back to the presscake during the drying process, will contain relatively higher levels of biogenic amines than meals that contain only the presscake.
- The recommended quantity of biogenic amines for a high quality fishmeal, should be less than 1000 ppm for histamine, and the total sum of all four of the main biogenic amines (cadaverine, putrescine, tyramine and histamine) should be less than 2000 ppm (Pike and Hardy, 1997).

Quality Criteria

- **<u>Dioxins and dioxin-like PCBs</u>**
- Environmental pollutants derived both from natural, but mostly, anthropogenic activities.
- Formed locally, they have a global environmental distribution, and accumulate in the food chain, mainly in the fatty tissue of animals.
- Dioxins are currently largely removed during oil refining processes.
- Fishmeal is also analysed for dioxins and if required can also be purified for dioxins using an extraction process.
- This ensures the production of fishmeal and oil with levels of dioxins and dioxin-like PCBs that comply with EU regulations.



Structure of one of the dioxin compounds: 2,3,7,8-tetraklordibenzo-p-dioxin (TCDD)

Regulations and guidelines

Production of fish oil intended for human consumption must comply with the Food Hygiene Regulations set by the European Commission (EC). Relevant regulations: EC 852/2004, EC 854/2004, EC 853/2004 as amended by EC 1020/2008, and EC 2074/2005 as amended by EC 1022/2008.

- **Regulations for raw material and fish oil produced for human consumption:**

- **General requirements for raw material**
  - Come from establishments, including vessels, registered or approved pursuant to the Hygiene Regulations.
  - Derive from fishery products which are fit for human consumption and are handled throughout the food chain as such.

Regulations and guidelines

- **<u>Specific requirements for raw material:</u>**
  - The raw material must be chilled as soon as possible after the catch. When chilling is not possible on board the vessel the raw material must undergo chilling as soon as possible after landing and be stored at a temperature approaching that of melting ice.
  - However, by way of derogation the food business operator may refrain from chilling the fishery products, when whole fishery products are used directly in the preparation of fish oil for human consumption, and the raw material is processed within 36 hours after the catch, provided that the freshness criterion laid down are met.
  - The freshness criterion is based on the total volatile basic nitrogen (TVB-N), which shall not exceed 60 mg of nitrogen/100 g of whole fishery products used directly for the preparation of fish oil for human consumption. However, where the raw material is still fit for human consumption the competent authority may set limits at a higher level for certain species.

Regulations and guidelines

- **Dioxins**
- Raw materials containing contaminants in concentrations exceeding the recommended maximum limits and action limits must be avoided.

Table 5. Combined maximum dioxin and dioxin-like PCB levels and action limits in seafood for human consumption (incl. fish oil).

Maximum levels[1]	Sum	Dioxins & Furans	Dioxin-like PCBs
Fish	8 pg/g	4 pg/g	4 pg/g
Marine oil, incl. fish body oil and liver oil	10 pg/g	2 pg/g	8 pg/g
Action limits[2]			
Fish and fish products	6 pg/g	3 pg/g	3 pg/g
Marine oil incl. fish oil	7.5 pg/g	1.5 pg/g	6 pg/g

[1] EC Regulation 199/2006; [2] EC Recommendation 2006/88/EC

Table 6. Combined maximum dioxin and dioxin-like PCB levels in farmed animal and fish feed.

Maximum levels[1]	Sum	Dioxins & Furans	Dioxin-like PCBs
Fish, other aquatic animals, their products and by-products, except:	4.5 pg/g	1.25 pg/g	3.25 pg/g
-Fish oil	24 pg/g	6 pg/g	18 pg/g
- fish protein hydrolysates (>20%fat)	11 pg/g	2.25 pg/g	8.75 pg/g
Compound feeding stuffs for fish	7 pg/g	2.25 pg/g	4.75 pg/g

EC Directive 2006/13/EC

Challenges and Research Needs

- **Knowledge Gaps and Research Needs**
  - Establish the relationship between freshness of raw fish and the properties (including the level of lipid oxidation) and yield of the obtained refined fish oil.
  - Determine whether TVB-N is a suitable spoilage parameter for whole/ungutted fish used as raw material for production of fish oil intended for human consumption and if it relates to lipid oxidation. If this is the case, scientific research should be carried out to establish the foundation of setting TVB-N limits for whole fish.
  - Develop sensory methods such as Quality Index Method (QIM) schemes for fish species intended as raw material for fish oil production (EFSA 2010).
  - Better understanding of effect of raw material freshness/quality on animal growth performance.
- **Challenges**
  - How to further increase high-quality fishmeal and oil production from by-products.
  - How to optimize collection of trimmings (by-products) from smaller processing plants.
  - By-products from aquaculture yield poorer quality oil (lower content of omega-3 PUFA).

Thank you for your attention!

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