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Oil quality of by- products of marine fish during processing methods

Abstract

By- products that are not regarded as ordinary saleable products (fillet, round, eviscerated or beheaded fish), but which can be recirculated after treatment. Normally oil is produced from by-products of marine fatty fish species such as cod, anchovy, capelin, sardine, salmon, tuna, mackerel, Norway pout, Atlantic herring, sand eel etc. It is possible to extract oil by different process such as wet reduction, hydrolysis, silage, dry rendering and acid - alkali aid. Fish roe has high concentrations of lipids. Hydrolysis was better than wet rendering method as there was a chance for lipid oxidation in the wet rendering method. High quantity and quality of phospholipids were generated from the lipid fraction in the dry rendering process. To ensure high quality of produced products, it is important to process by-products immediately after production. It is also needed to increase the utilization of marine by- products by increasing knowledge on the chemical composition and stability of the by- products.

Keywords: by- products, salmon, process, fish oil, quality

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Introduction

By- products which are not ordinary saleable products and can be recirculated by treatment[1,2] stated that fillet cuts, backbone, head, liver, gonad, viscera, roe and other guts are all by- products. By-products can make up to 75% of the fish.

Normally oil is produced from by- products of marine fatty fish species such as cod, anchovy, capelin, sardine, salmon, tuna, mackerel, Norway pout, Atlantic herring, sand eel etc. Two- thirds of the whole-body weight as by- products normally is generated from the cod production.

The data of Falch et. al.[3] showed from four Gadidae species (cod, saithe, haddock and tusk) which are caught in Barents sea, that the viscera made up 12 – 15%, the head 15 – 20%, the backbone and trimmings (cut-offs) made up 18 – 30% of the whole body weight as by- products. In Table 1, it has showen the following fish species which are used for by- products and oil production normally.

Table 1 Marine Fish species which are used normally for by- products and oil production.[4]

Species	Country
Salmon	Norway, Denmark, Canada, USA
Cod	Norway, Denmark, Canada
Anchovy	Peru, Chile, South Africa, Namibia, Mexico, Morocco
Jack (horse) mackerel	Peru, Chile, China, Vanuatu
Capelin	Norway, Iceland, Russian Federation
Menhaden	USA: Atlantic and Gulf of Mexico
Blue whiting	Norway, UK; Russian Federation, Ireland
Sand eel	Denmark, Norway, Faroe Islands
Norway pout	Denmark, Norway, Faroe Islands
Sprat	Denmark, Russian Federation

FAO[4] estimated that by- products from world fisheries can reach to about 20 million tons per year. In 2000, about 2,32,000 metric tons by-products were derived from the Norwegian cod production, in which 1,07,000 tons were utilised and 1,25,000 tons were discarded.

RUBIN,[5] found that only 36,000 tons by- products were utilized which was about 15.5 % of the total. Approximately 2,29,000 tons of by-products were obtained from the Norwegian herring and mackerel production in 2012 and 34,000 tons of by- products were obtained from different marine fish species in 2013.[6]

There is much potential and productivity of the by- products of the marine fish. Fish by- products contain essential lipid, fatty acids and protein fractions. Polyunsaturated fatty acids (PUFA) like Eicosapentaenoic acid (EPA, C20:5 n-3) and Docosahexaenoic acid (DHA, C22:6n-3) are important elements of marine lipid and these essential polyunsaturated fatty acids are mainly found in the marine fish species. The omega-3 fatty acids have many benefits on human health especially for cardiovascular diseases, hypertension, autoimmune and inflammatory diseases.

The objective of the study was to review the different by- products from marine fish and processes which are used to produce oil, their effects on the oil quality and stability.

Methods

Raw materials:

I. By- products such as head, viscera, cut-off, bone, skin (Figure 1) and fish that are discarded from production and unsuitable for human consumption, and the by- catch from the edible fisheries.

II. By- products from the fish species such as anchovy, capelin, cod, sardine, salmon, tuna, mackerel, Norway pout, Atlantic herring, sand eel etc.

Salmon by- products | Herring by- products

Figure 1 By- products from salmon and herring.[4]

Different processes: The processes used to produce oil production can vary based on the type of raw materials used. The methods are

used to produce oil production from fish by- products were followed according to the established principles and techniques.[7]

Wet reduction process: The wet reduction process is widely operated in the processing industries worldwide. The process was a continuous process and by- products are processed through three principal operations such as cooking, pressing and separation of the oil. Moisture level was reduced to lower than 10% in the pressed cake.

Hydrolysis: Hydrolysis process was operated by reactions of proteolytic enzymes which source were from the fish themselves (autolysis) or from other sources. The enzymes can be from animal, vegetable or microbial sources. The enzymes assisted to breakdown the protein into smaller units (peptides) in the process.

Silage production: Silage production is a low- cost hydrolysis process. At first mincing of the fish was performed and an acid was aided for the preservation. Formic, propionic, sulphuric and phosphoric acids mainly used in the process. The enzymes of the fish gut helped to convert the fish protein into small soluble units and the acid helped to increase their activity. 3–4% acid was added to control the pH level under 4. Strong mineral acids were neutralized before completing the final product.

Dry rendering: Dry rendering process is similar to the wet reduction process. The process is normally used for catfish by- products. The raw material was cooked to remove water and produce dry cake. Then the dry cake was pressed to remove oil. The lipid fraction contained a high level of phospholipids in the process.

Acid alkali aided process: The process was performed by using an alkali or acid. Kristinsson and Necla[8] outlined an Acid-alkali aided process which can be operated to produce fish protein isolate and fish oil. An alkali or acid is used to digest the muscle protein in this method. Oily fish is normally used in this process.

Results

Quality and stability of oil from raw materials: The quality of oil was varied on the raw material fraction and freshness. Sorting, storage and handling of raw materials are the main factors for the quality of oil.[9]

Fish roe contains high concentrations of lipid.[10] 5% - 20% crude lipid is found in salmon roe. The muscles of fatty fish (i.e., salmon, herring, mackerel) and the liver of cod fish are good sources of marine lipid (Figure 2).

Figure 2 An example of marine fish liver and muscle oil capsules.[19]

Quality and stability of oil from different methods: Wet rendering: The quality of oil can vary in the process due to the operation's smoothness as processing need to start immediately after landing the fish.[11]

The process was hard for the sensitive marine lipid as these lipids were degraded and oxidized fast. Besides, the protein fractions were influenced and changed sometimes in the process.[12]

Hydrolysis: It is possible to produce high yield of separated oil and pure and non- oxidized oil in the hydrolysis process.

Low cooking temperature (50 - 60%) can boost the production superior quality of oil. To hydrolyse an oily fish, it must be needed to recover the oil phase without denaturing the protein. Liaset et. al.[13] found that about 80% lipid are extracted from raw materials by enzymatic hydrolysis. On contrary, Ockerman[14] observed that the traditional extraction of fish liver oil can generate about 70% lipid from the direct steaming, 80% from percolation, 50% from treatment of liver by CaCl2 or 80% from cold extraction. The hydrolysis process yielded a higher amount and quality of oil compared with the traditional oil extraction process.

Silage: The silage was heated to separate oil. The rest was evaporated–dry matter 40-50%, protein 30-35%. The composition of the silage can vary according to the raw materials used. Silage from white fish offal can generate low oil quantity. Fish silage at correct acidity and room temperature is stable for 2 years. But, the protein becomes more soluble and the amount of free fatty acids increase during the storage. To get an acceptable quality of oil, it is necessary to process the silage quickly.

Dry rendering process: In the dry rendering process, high quantity and quality of phospholipids were generated from the lipid fraction. The phospholipids were not hydrated and it was dissolved in the lipid. It also can be obtained PL fraction by hydrating the oil which is called degumming.

Discussion

To run a by- product processing industry, it is important to ensure the sustainable supply of raw materials.[15]

To ensure the quality of the raw material, it is important that the raw material is checked properly and characterised based on its chemical composition and its enzymatic activity. In the EU-project,[16] five different cod species at three different fishing grounds and three different seasons were examined and the chemical composition, proteolytic activity and stability of their by- products were characterized. Proteolytic activity and quality parameters were investigated in the experiment. Median proteolytic activity in viscera, cut-off and liver sample at pH 3 were highest when temperatures were 35°C, 35°C and 50°C respectively. On the contrary, proteolytic activity in viscera, cut- off and liver at pH 7 were highest when temperatures were 50°C, 65°C and 65°C respectively. They also observed that the proteolytic activity in viscera was induced by the fish species where the proteolytic activity in cut- off was induced by the fishing ground.

To get a stable by-product fraction, it is important to minimize the enzymatic degradation.[18] Fatty fish contain high amounts of poly-unsaturated fatty acids which are easily oxidized. The by- products from fatty fish are also prone to microbial contamination. Improper application of the biosecurity measures such as dirty farm equipment's, handling of fish, zoonotic disease can also introduce microbes in the by- products and the processing industry. Thorkelsson et. al.[15] recommended to follow hygienic handling of the raw materials, to separate and treat the easily degradable parts from the more stable fractions. Falch et. al.[17] reported that it is very important to process by-products immediately after landing the fish to obtain a good quality of finished product.

Silage production is helpful to farmers when they face logistic and economical problems to handle the fish waste and supply them to fish processing industries. Silage can be produced in large or small containers either on vessel or on- shore. Dry rendering process was easier than wet rendering as a wet rendering was a continuous process.

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Hydrolysis was better than wet rendering method as there was a chance for lipid oxidation in the wet rendering method. It should be taken in consideration for proper heat treatment, enzymes, time and temperature for hydrolysis.

Conclusion

More investigations are needed in this field to obtain more stable and good quality of finished products from the by- products. We need to utilize more of the produced by- products by increasing knowledge on the chemical composition and stability of the by- products with respect to fish species, seasons and fishing grounds. Strong regulations and logistics should be followed during the whole channel of the marine by-products oil production.[18]

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Conflicts of Interests

Author declares there are no conflicts of interests.

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