ISBN 979-98165-1-3

Proceedings

IMFS 2003

INTERNATIONAL SEMINAR ON
MARINE AND FISHERIES
15-16 December 2003
Jakarta Convention Center

Ministry of Marine Affairs and Fishery
Agency for Marine and Fisheries Research

International Marine and Fisheries Seminar Proceedings
Jakarta, December 15 – 16th 2003

EDITORS

Address : The Agency for Marine and Fisheries Research
Ministry of Marine Affairs and Fisheries
Jl. MT. Haryono Kav 52 – 53 Jakarta 12770
Phone. (021) 79180303 Fax. (021) 79191202
E-Mail: budigis@cbn.net.id

Cited : B. Sulistyo, E.S. Heruwati, A. Sudradjat, I.G.S. Mertha, A. Heri Purnomo. 2004. Proceeding of International Seminar on Marine and Fisheries. December 15 – 16th 2003. Marine and Fisheries Research Project. Jakarta. 493 p

Published by : The Agency for Marine and Fisheries Research

TABLE OF CONTENT

SECTION 2 : CAPTURE FISHERIES

SECTION 3 : MARINE FISHERIES PRODUCT

PROSPECTIVE USES OF FISH OIL IN INDONESIA

Hari Eko Irianto* and Giyatmi**

ABSTRACT

Fish oil in Indonesia has not been utilized optimally, yet. The fish oil is obtained from canned fish and fish meal industries. Research Center for Marine and Fishery Product Processing and Socio-economic, Jakarta has conducted studies to improve fish oil quality and to utilize into several products. Alkali refining method has been applied to improve fish oil quality. In order to increase the omega-3 fatty acids in fish oil, urea inclusion method is employed to produce concentrate of omega-3 fatty acids. Acidolysis with lipase as bio-catalysts is used to obtain triglycerides rich in omega-3 fatty acids. Microencapsulation technique of fish oil has been developed to improve fish oil stability and to widen fish oil use. Fish oil has also been used to increase omega-3 fatty acid status of canned fish medium, mayonnaise, fish spread and fish sausage. Fish oil has also been proposed to be used in the production of other products for food, pharmaceutical, feed, cosmetic and other non-food purposes.

INTRODUCTION

Fish oil has attracted many scientists, particularly nutritionists, to reveal its benefits to health. Many studies have confirmed that fish oil rich in omega-3 fatty acids have beneficial influence on the vascular system. Other studies have shown that omega-3 fatty acids play an important role in the development of the central nervous system and vision from the moment of conception (Andersen, 1995). Two main omega-3 fatty acids showing beneficial effects to human are eicosapentanoic acid (EPA) and docosahexanoic acid (DHA). EPA can reduce hearth disease risk. While, DHA contributes to brain and vision developments. The awareness of the beneficial effects of omega-3 fatty acids on health as well as growth and development of children in Indonesia should be anticipated.

Omega-3 fatty acid can be consumed directly from fish and processed fish products and indirectly from products enriched with fish oil or processed from fish oil. Undoubtedly Indonesia has ability to supply omega-3 fatty acids at least for local demand. As a maritime country, fishery resources of Indonesia are very rich and even statistics showed that those resources have not been explored optimally. That fact indicates that Indonesia is still capable to fulfill the fish demand by optimizing exploration. However, the fish consumption level of Indonesian is still below the target. To increase the consumption level, Indonesian government campaigns to encourage Indonesian to eat more fish. Omega-3 fatty acids can also be consumed without directly eating fish, particularly for those who do not like fish. Therefore, products containing omega-3 fatty acids should be developed to satisfy that consumer group. Actually, fish oil can be utilized not only for food purposes, but also for the production of feed, pharmaceutical, cosmetics and other non food products.

Fish oil can be categorized into two types, i.e. body oil and liver oil. Body oil is processed from the body of fish and normally known as the source of omega-3 fatty acids. Liver oil is produced from the liver of fish, such as cod and shark livers. The liver oil can be used as the source of squalene and vitamin A.

FISH OIL PRODUCTION

A study conducted by Irianto (1994) noted that fish oil in Indonesia is produced as by-products of fish meal and canned fish processing.

In fish meal processing, fish oil is separated from the liquid phase obtained after pressing. Heating or cooking in fish

* Researcher at Research Center for Marine and Fishery Product Processing and Socio-Economic, Indonesia
** Food Technology Department, Agricultural Faculty, Sahid University, Indonesia

meal processing is used to coagulate or denaturate fish protein to facilitate mechanical separation of liquid from solid. Under these conditions, fat cells are also ruptured, releasing the oil into the liquid phase (Bimbo, 1990). The efficient liberation of water and oil by cooking and pressing is an important aspect in producing high quality fish meal (Beraquet *et al*, 1984). Both traditional and conventional fish meal processors produce fishoil.

Raw materials used to produce fish meal are whole fish and fish waste. The whole fish can be single species and mixed species. Single fish species is such as oil sardine (*Sardinella lemuru*) which is used for main raw material in fish meal production in Muncar (East Java) and Pengambengan (Bali). Oil sardine used in fish meal production is normally low quality grade except during the peak season. Fish canning factories can not absorb all highly fresh fish, thus some of them go to fish meal processors. By-catch fish can be classified as mixed species which can be used for fish meal production. Fish waste which is used for fish meal production is mostly from fish canning activities. In addition, the waste from fish fillet producers is also processed into fish meal. Due to variation of raw material quality, the fish oil obtained from fish meal processing varies in quality. Factories using whole fish and fish waste as raw materials do not separate the oil in terms of the raw material used.

Fish canning process releases fish oil during pre-cooking treatment. Heating during pre-cooking induced the release of some liquid containing water, oil and protein. Pre-cooking is normally carried out by steaming the fish for approximately 20 minutes. Indeed, one of the purposes of the pre-cooking step during fish canning is to release body lipids if the fish are excessively oily or if the oil has a very strong flavour (Warne, 1988). It is known that when the fish flesh is heated, a significant proportion of water is released from the protein. The amount varies, approximately 17.5% for tuna, 19-34% for sardine, depending on the endogenous fat content (Van Den Broek, 1965). The fish oil is separated from the liquid through centrifugation or leaving for sometimes. Raw material used for fish canning processing is oil sardine, skipjack and tuna which are normally prime quality fish.

Fish oil can also be obtained from "pindang" (boiled salted fish) processing. During boiling the fish in brine, fish oil is released and floating on the surface of boiling brine. However, the colour of the fish oil is very dark which is probably due to severe oxidation attack. Salt in the brine is normally containing some metals which can act as prooxidant accelerating oxidation. The oil from pindang processing has not been utilized, but thrown away.

EXPLORATION OF RAW MATERIALS

To explore the prospective fish species used for raw material in fish oil production, 10 fish are analyzed their proximate composition (Table 1). Those fish are yellowstripe trevalley, short-bodied mackerel, scad, bigeye scad, oil sardine, hairtail, slender leatherskin, fringescale sardine, barracuda and ray (Suparno *et al*, 1997).

Oil sardine which is currently used as main raw material for fish processing industries in Muncar and Pengambengan has the highest fat content meaning to be the most potential fish to use as raw material. However, the fat content of oil sardine is significantly affected by the season through the year as shown in Figure 1. The highest fat content occurred during the peak season of oil sardine, i.e. September – December. Setiabudy (1990) found that the omega-3 fatty acids content of oil sardine is 25.2%.

FISH OIL QUALITY

Result of chemical and physical analyses of fish oil collected from fish meal and canned fish factories in Muncar and Pengambengan can be seen in Table 2. In general, the Indonesian fish oil varies chemically and physically. The quality of fish oil obtained from canning process is better compared to the one collected from fish meal processing. The significant physical difference between both oils is their colour, i.e. yellowish orange – dark brown for fish oil from fish meal factories and yellow for fish oil from fish canning. The fish oil collected from canned fish process had a lower FFA value than the oil separated from fish meal production.

Table 1. Proximate composition of 10 Indonesian fish species

Fish Species	Moisture Content (%)	Ash Content (%)	Protein Content (%)	Fat Content (%)
Yellowstripe trevalley	77.76	1.38	18.99	1.17
Short-bodied mackerel	77.28	1.80	19.17	0.78
Scad	76.33	1.71	18.94	1.35
Bigeye scad	76.19	1.69	20.93	1.39
Oil sardine	62.36	1.39	14.54	21.29
Hairtail	79.42	1.43	17.24	1.03
Slender leatherskin	76.96	1.48	20.26	0.13
Fringescale sardine	76.43	2.24	20.43	1.40
Barracuda	77.27	1.54	18.48	0.28
Ray	78.20	1.36	18.70	0.93

Source: Suparno *et al* (1997)

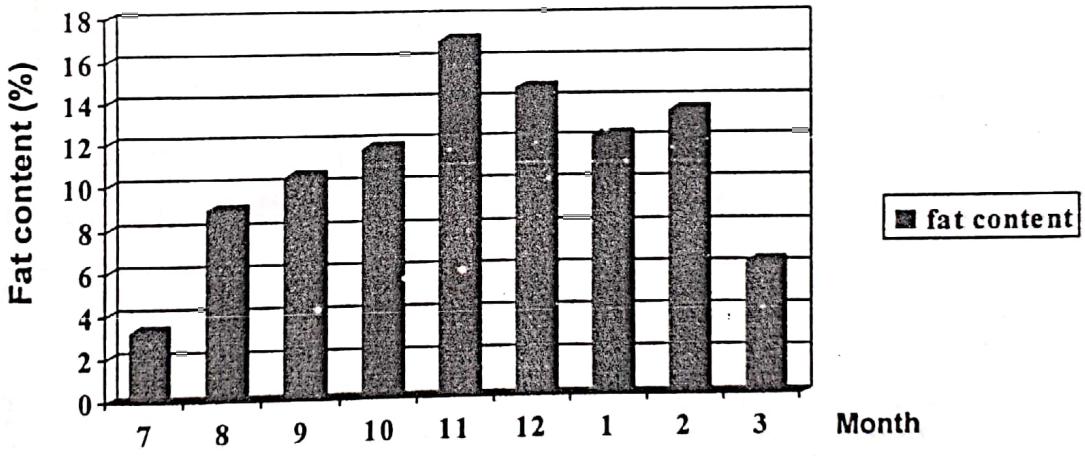

Figure 1. Fat content changes in oil sardine from month to mcnth (Suparno *et al* (1997)

Table 2. Fish oil quality from fish meal and canned fish factories

Product Description	Fish Oil From Canning Process	Fish Oil From Fish Meal Processing
Free Fatty Acids (as % oleic acid)	0.06 – 1.15	0.08 – 55.69
Refractive Index	1.4780 – 1.4790	1.4750 – 1.4800
Absorbance at 490 nm	0.22 – 0.48	1.34 – 2.56
Colour	yellow	Yellowish orange – dark brown

Source: Irianto (1992)

FISH OIL REFINING

Low quality fish oil, particularly from fish meal processing, can be improved through refining process. One of refining methods which can be applied is alkali refining process as outlined in Figure 2.
Refining process through neutralization using NaOH significantly reduces the free fatty acid content of fish oil (Table 3).The process also improves the colour of fish oil to be brighter.

Antioxidant should be added to the oil as early as possible to avoid oxidation, since heating is applied through the process, especially during degumming, neutralization and bleaching. In fact the alkali refining method is very effective for improving fish oil quality (Irianto, *et al* , 1995).

PRODUCTION OF OMEGA-3 FATTY ACID CONCENTRATE

Concentrate of omega-3 fatty acids can be processed through combination of techniques, such as saponification, solvent extraction, urea inclusion, molecular distillation, fractionation distillation, liquid chromatography and supercritical fluid carbon dioxide. Yunizal (1998) develop a process for the production of omega-3 fatty acid concentrate by comparing two methods, i.e. winterization (with and without solvent) and urea inclusion.
Table 4 shows omega-3 fatty acid content of the concentrate, in which urea inclusion method produces the concentrate with the most significant increase of omega-3 fatty acid content, particularly DHA. The basic process of urea inclusion method can be seen in Figure 3.

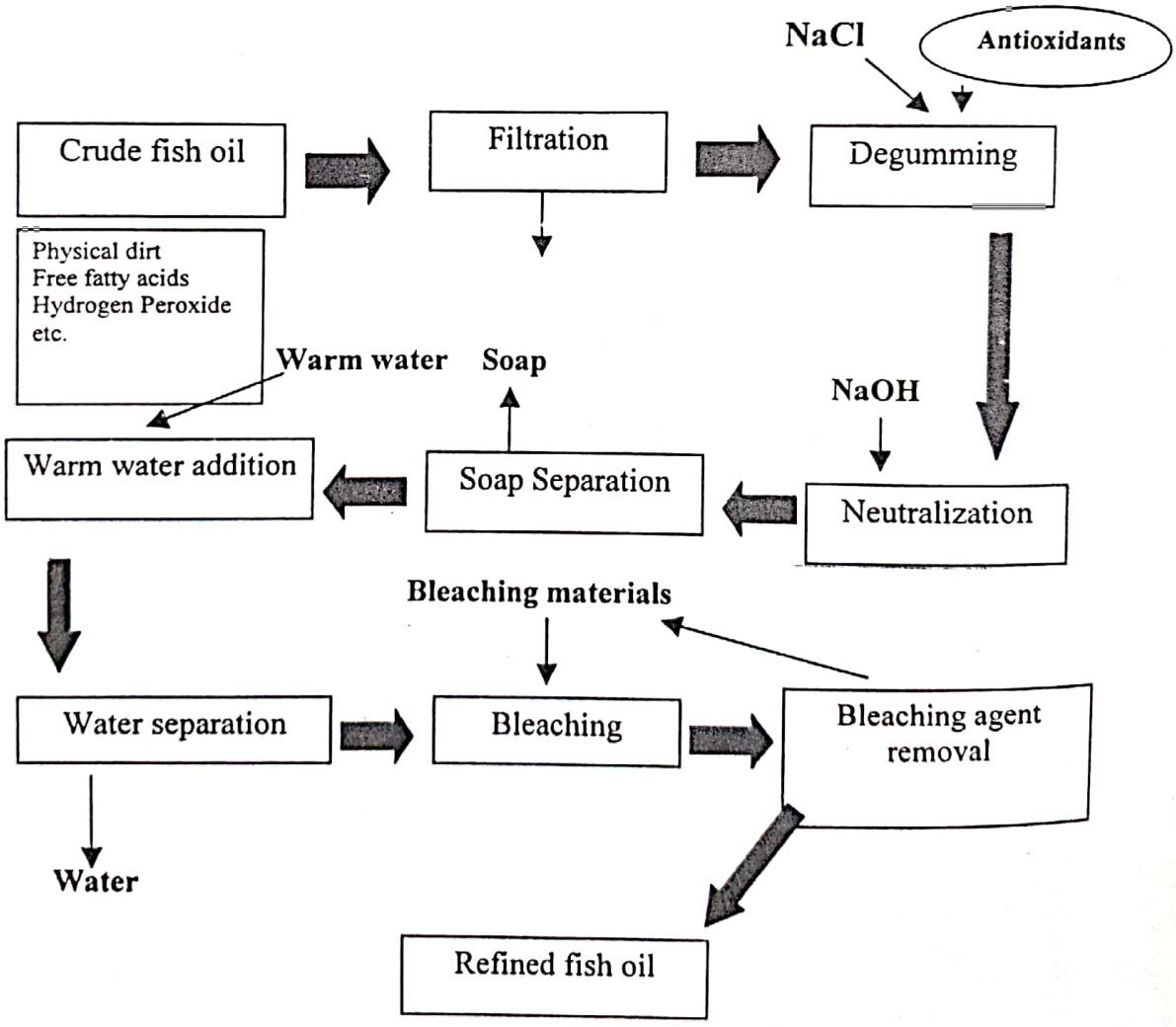

Figure 2. Alkali refining method for fish oil

Table 3. Quality changes of fish oil due to alkali refining process

Analysis Parameter	Crude Fish Oil	Refined Fish Oil
Free fatty Acid (% oleic acids)	3.20	0.27
Peroxide value (meq/kg)	11.76	6.00
Absorbance value at 490 nm	3.32	0.105

Source: Irianto, *et al* (1995)

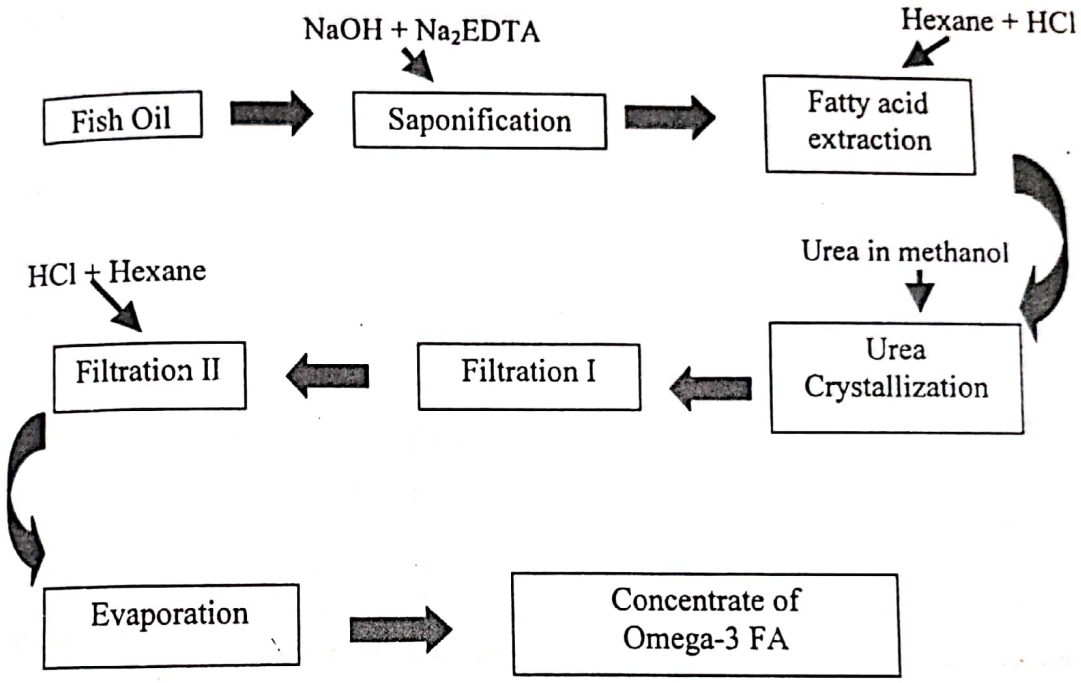

Figure 3. Flow chart of the processing method of omega-3 fatty acid concentrate

Table 4. Omega-3 fatty acid content of the concentrate of omega-3 fatty acids

Quality Specification	Winterization Without Solvent		Winterization With Solvent		Urea Inclusion	
	Fish oil from canning	Fish oil from fish meal	Fish oil from canning	Fish oil from fish meal	Fish oil from canning	Fish oil from fish meal
Omega-3 FA (%)	34.8	33.5	44.3	41.3	78.3	79.1
EPA (%)	17.7	16.7	22.9	25.1	14.0	27.1
DHA (%)	15.9	13.9	19.9	14.7	59.8	46.2

Source: Yunizal (1998)

PRODUCTION OF TRIGLYCERIDES RICH IN OMEGA-3 FATTY ACIDS

Fatty acids are more stable in triglyceride forms compared in free fatty acid forms. However, triglycerides are constructed by various fatty acids. Therefore, if consumption of glycerides rich in omega-3 fatty acids is demanded, modification of fatty acid composition should be carried out. One of the method for the production of triglycerides rich in omega-3 fatty acids is through acidolysis using enzymes as bio-catalyst.

Elisabeth (1997) used four microbial lipases for incorporating EPA and DHA into triglycerides of tuna oil. Those enzymes are *Rizomucor miehei* lipase, *Candida Antarctica* lipase, *Chromobacterium viscosum* lipase and *Pseudomonas* sp lipase. C. *antarctica* lipase is found as the most prospective enzyme to use in acidolysis process for the production of triglycerides rich in omega-3 fatty acids

MICROENCAPSULATION OF FISH OIL

Microencapsulation is a technique to improve the stability of fish oil and to expand the fish oil utilization. The technique has been applied in vitamine production. Yunizal *et al* (1998) develop a method to microencapsulate fish oil (Figure 5). The technique is actually simple, in which fish oil is firstly emulsified with encapsulant and antioxidant. The mixture is then spray dried. Encapsulants which can probably be used are gelatin, caseinate, maltodextrin, arabic gum, soybean protein isolate, whey protein isolate, and acacia gum (Lin et al, 1995; Kim and `Morr, 1996; Dian et al, 1996).

Yunizal *et al* (1998) used soybean protein isolate and arabic gum as encapsulating material with the fish oil and encapsulant ratio of 1:1. Recovery and efficiency levels of the process are 19.28% and 68.78% respectively. Meanwhile microcapsule diameter is 0.334 mm. The product can be used in infant formula, baby food, soup, fruit/health bar, bread and biscuit.

OTHER USES OF FISH OIL

Some studies to explore the prospective utilization of fish oil have been carried out by Research Center for Marine and Fishery Product Processing and Socio-economic, Jakarta. The products which have been studied their possibilities to be

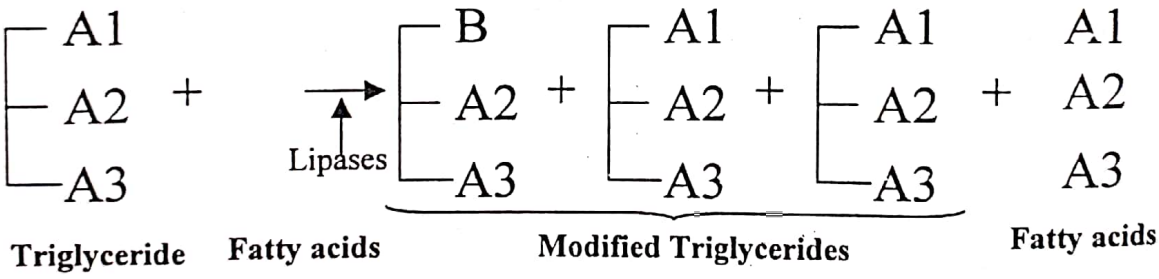

Figure 4. Acidolysis of triglycerides with lipases as a bio-catalyst

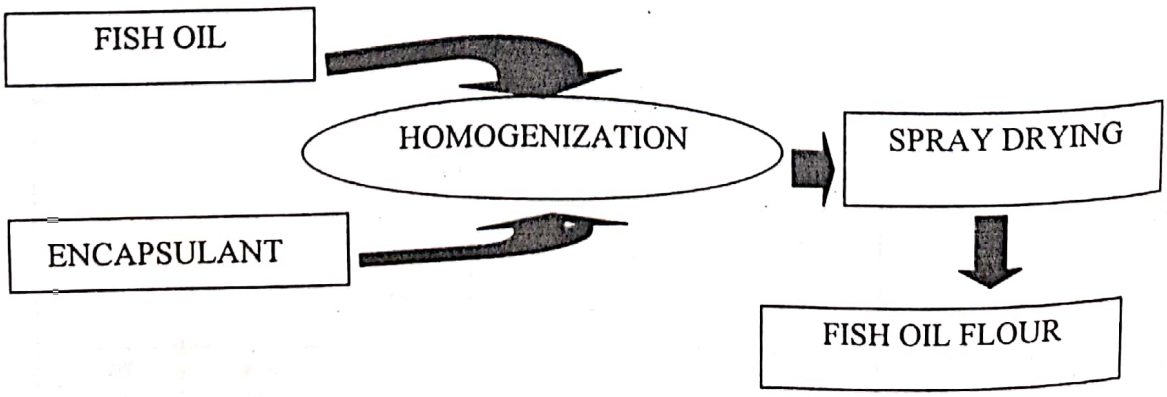

Figure 5. Processing method of microencapsulated fish oil

incorporated with fish oil are canned fish medium (Irianto, 2000, Irianto *et al*, 1997), sausage (Irianto *et al*, 1996) , mayonnaise (Irianto *et al*, 1996) and fish spread (Irianto *et al*, 1997). Fish oil levels which can be added into tomato sauce and vegetable oil medium are 18% and 60% respectively. In addition, the levels of fish oil which can be put into sausage, mayonnaise and fish spread are 7, 15 and 60%.

Other prospective utilization of fish oil is as follows:

FOODS: margarine, table spread, shortening, pastry fat, frying oil, biscuit filling, salad oil, and emulsifier

FEEDS: fish/shrimp and poultry feeds

COSMETICS: hand lotion

OTHERS: fatty acids and derivates, soap/detergent, tanning fat, protective coating, lubricants, plastics, pesticide/fungicide, polyurethane foam

DEVELOPMENT OF FISH OIL INDUSTRY

So far, fish oil in Indonesia is a by-product of other fish processing activities. To obtain good quality fish oil, the fish oil should be processed from good quality raw material. The first alternative of the development of fish oil industry proposes that fish oil extraction and refining activities

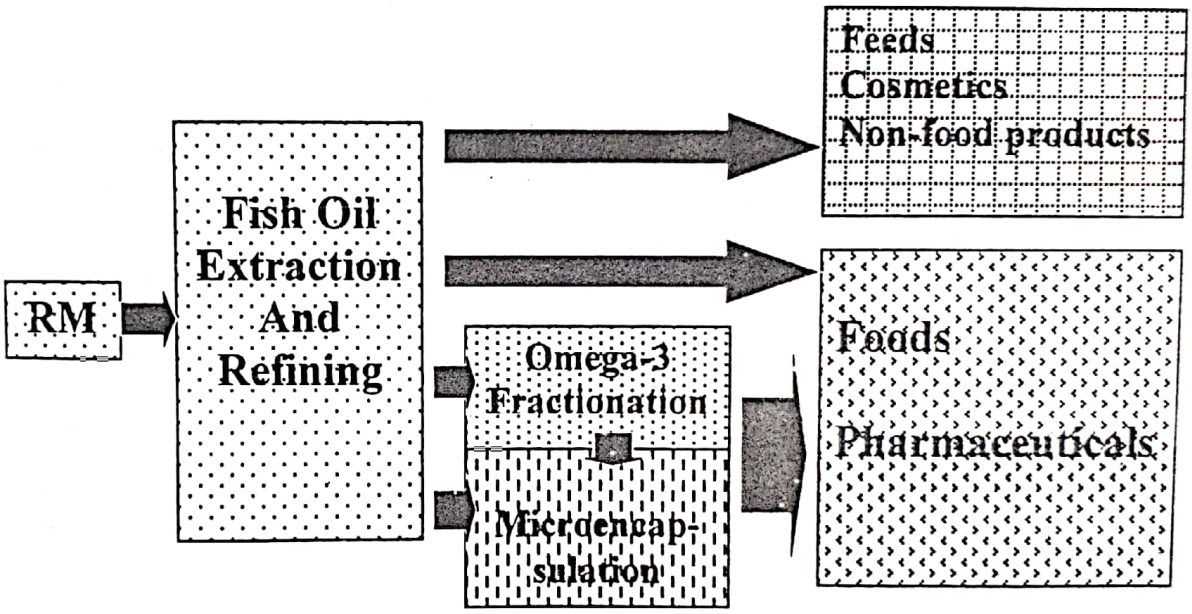

Figure 6. The first alternative of the development of fish oil industry

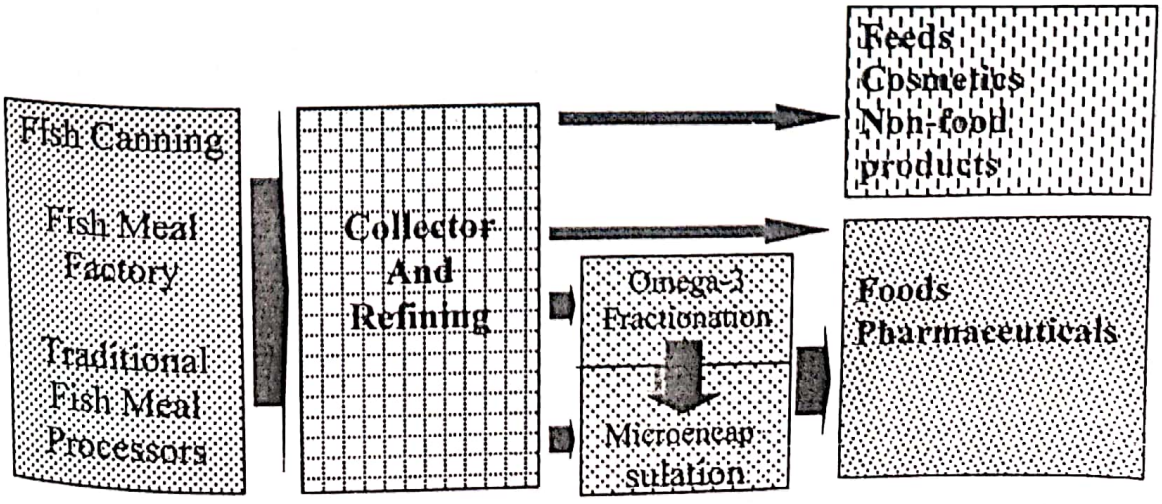

Figure 7. The second alternative of the development of fish oil industry

should be carried out in one place, in order to reduce deterioration risks due to oxidation (Figure 6). Refining should be performed as soon as possible after extraction. Antioxidants are added during refining process to inhibit oxidation attack during storage and further processes prior to be utilized for food, pharmaceutical, cosmetics and non-food products. This alternative is suitable for the development of new industry, but the development based on the existing condition can use the second alternative (Figure 7).

In the second alternative, the fish oil produced by conventional and traditional industries are suggested to be sold to a fish oil collector. The collector is proposed to do refining activity. The refined oil undergoes the same pattern as received by the first alternative.

CONCLUSIONS

Fish oil in Indonesia has non received a proper attention and regarded as waste. The quality of fish oil varies due to differences in raw material used and processing industries producing fish oil. The fish oil quality can be improved through alkali refining. Refined fish oil can be used for the production of various prospective products, such as food, pharmaceutical, cosmetics, feed and other non-human consumption products.

REFERENCES

Anderson, S. 1995. Microencapsulated marine omega-3 fatty acids for use in the food industry. *Food Tech Europ* Dec 1994/Jan 1995: 104-106

Beraquet, NJ, J Mann and A Aitken. 1984. Heat processing of herring: I. Release of water and oil. J Food Tech 19: 437-446

Bimbo, AP. 1990. Production of fish oil. *In* Fish oil in nutrition. Stansby (ed) Van Nostrand Reinhold. New York. P.141-180

Dian, NLHM, N.Sudin and MSA Yusoff. 1996. Characteristics of microencapsulated palm –based oil as affected by type of wall material. *J Sci Food Agric 70*:422-426

Elisabeth, J. 1997. Studi incorporasi enzimatik eicosapentanoic acid dan docosahexanoic acid pada trigliserida minyak ikan tuna dan crude palm oil (CPO) *Ringkasan Disertasi.* Program Pasca Sarjana-IPB. Bogor

Irianto, HE. 1992. Fish oil: refining, stability and its use in canned fish for the Indonesian market. *PhD Dissertation.* Massey University. New Zealand. 401p

Irianto, HE, YN Fawzya, Sugiyono, I Muljanah, R Peranginangin, N Retnowati, Murdinah, D Yus, B Gunawan and RS Laksana. 1996. Penelitian pengolahan dan pengkayaan produk pangan dengan sumber gizi hasil perikanan. Puslitbang Perikanan. Jakarta. 85p

Irianto, HE, YN Fawzya, Sugiyono, I Muljanah, U Rahayu, D Yus, Carkipan. and Maryadi. 1997. Penelitian pengkayaan produk pangan dengan sumber gizi hasil perikanan. Puslitbang Perikanan. Jakarta. 84p

Irianto, H E. 1995. Production and quality of Indonesian fish oil: case study in Muncar (East Java) and Bali. *In* FAO Fisheries Report No. 514 Supplement (FIIU/R514 Suppl.). Food and Agricultural Organization- of the United Nations. Rome p.243-250

Irianto, HE, YN Fawzya, Sugiyono and S Nolita. 2000. Development of tomato sauce enriched with fish oil for canned sardine medium. *In* Proceedings of the JSPS-DGHE International symposium on fisheries science in tropical area. Carman et al (eds.) . TUF International JSPS Project, Tokyo University of Fisheries. Tokyo. P.474-478

Kim, YD, CV Morr and TW Schens. 1996. Microencapsulation properties of gum arabic and several food proteins: spray dried orange oil emulsion particles. *J Agric Food Chem 44:* 1314-1320

Lin, CC, SY Lin and LS Hwang. 1995. Microencapsulation of squid oil with hydrophilic macromolecules for oxidative and thermal stabilization. *J.Food Scie 60* (1) 36-39

Setiabudi, E. 1990. Pengaruh waktu penyimpanan dan jenis filter

pada jumlah omega-3 dalam minyak limbah hasil pengalengan dan penepungan ikan lemuru. *Master thesis*. Bogor Agricultural University. Bogor

Suparno, HE Irianto and JT Murtini. 1997. Development of fishery products rich in omega-3 fatty acids. Paper presented at the final seminar STD-3 project: Improved utilization of low value fish species in Iloilo Cityu, Philippines, 23-24 September 1997. 14p

Van den Broek, CJH. 1965. Fish canning. *In* Fish as foods Vol. IV part 2. Borgstrom (ed). Academic Press. New York. p.127-205

Warne, D. 1988. Manual on fish canning. FAO Fish Tech.Pap. 285. Food and Agricultural Organization of the United Nations. Rome

Yunizal. 1998. Konsentrat omega-3 dari minyak ikan lemuru. Leaflet. Instalasi Penelitian Perikanan Laut Slipi. Jakarta

Yunizal, JT Murtini, Tazwir and S Wibowo. 1998. Penelitian asam lemak omega-3 minyak ikan lemuru. *In* Intisari penelitian perikanan laut 1997/1998. Balai Penelitian Perikanan Laut. Jakarta p. 60-62