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The Characteristics of Omega-3 Fatty Acids Concentrated Microcapsules from Wastewater Byproduct of Tuna Canning *(Thunnus sp.)*

Ni Wayan Suriani[1]*, Marthy Lingkan Stella Taulu[2]

[1]Department of Chemistry, Faculty of Natural Science and Mathematics, Manado State of University, Manado, 95618, North Sulawesi, Indonesia
[2]Department of Biology, Faculty of Natural Science and Mathematics, Manado State of University, Manado, 95618, North Sulawesi, Indonesia

Abstract: The study aims to determine the characteristics including water content, free fatty acids, peroxide number, Cu and Fe content and fatty acid profile including the content of SFA, MUFA, PUFA, omega-3, omega-6, omega 9, EPA and DHA omega-3 fatty acid concentrated microcapsule from liquid waste byproduct of tuna canning in Bitung, North Sulawesi. Omega-3 fatty acids concentrated microencapsulation with *spray drying* technique *with* encapsulation mixture consisting of gelatin, Na-caseinate and maltodextrin plus lecithin as an emulsifier. The results are omega-3 fatty acid concentrated microcapsule with a water content of 4.08%, free fatty acids of 5.66%, peroxide number of 7.56 (meq/Kg), iron (Cu) of 0.23 (ppm) and copper (Fe) of 1.05 (ppm) and the fatty acid profile containing SFA of 33.14%, MUFA of 30.79%, PUFA of 25.66%, omega-9 (C18: 1ω-9) of 19.97%, omega-3 such as linolenic acid (C18: 3ω-3) of 2.18%, the EPA (C20: 5ω-3) of 4.28% and DHA (C22: 6ω-3) of 19.19%. The characteristics of fish oil and wastewater omega-3 fatty acid concentrated microcapsule liquid waste are in accordance with the standards of *the International Fish Meal and Oil Manufacturers Association* (IFOMA). Urea crystallization process increases the levels of polyunsaturated fatty acids (PUFAs) such as omega-3 EPA and DHA which are used for the manufacture of omega-3 fatty acids concentrated microcapsules. The fatty acid profile of omega-3 fatty acid concentrate oil microcapsules from tuna canning wastewater byproduct is quite high, especially EPA and DHA.
Keywords: Fatty acid profile, omega-3 fatty acid concentrate, microcapsules, oil from the tuna canning wastewater.

Introduction

Fish oil is a good source of polyunsaturated fatty acids (PUFA), especially omega-3 long-chain EPA and DHA[1]. Furthermore Yuwono showed that fish oil from extraction with organic solvents from tuna eye and eye pads waste had higher levels of EPA and DHA respectively 5.1 and 26.2% for *Yellowfin* tuna species and the levels of EPA and DHA are5.9% and 24.1% for *Skipjack* species (based on the percent relative)[2]. Tuna fish oil is a good source of omega-3 polyunsaturated fatty acid (Ω-3 PUFA), especially the fatty acids of long-chain omega-3 EPA *(eicosapentaenoic acid,* C20: 5 Ω -3) and DHA *(docosahexaenoic acid,* C22: 6 Ω-3)[1].

Omega-3 long chain fatty acid is considered beneficial for growth and development throughout the life cycle and plays an important role in the prevention and treatment of coronary arteries (arteriosclerosis, hypertension, arthritis, and impaired immune response[3,4]. In addition, DHA is important in the development of the central nervous system and the eyes of the baby so it is considered as promising nutrients because of the good effect on the retina and the brain [5]. The use of oil with high omega-3fatty acids (Ω-3 FA) in food is limited due to very susceptible to oxidation. Oxidation of lipids can be reduced with the addition of antioxidants and/or with oil microencapsulation[6,7].

Fish oil is still the main source of omega-3 fatty acids, especially EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) are important for health. The positive influence of omega-3 fatty acids to health through platelet function modulation, decrease the activity of coagulation monocytes, suppress leukocyte adhesion, and lowers blood pressure so it can be used for the treatment of coronary heart disease[8]. This fatty acid is a fatty acid that is the most important in the brain, retina, and spermatozoa, and required for visual acuity, cognitive ability[9], and sperm motility[10]. In people with diabetes, omega-3 fatty acid can improve glucose tolerance[11] and to prevent and decrease insulin resistance[12]

In contrast to omega-6, which can trigger the incidence of prostate cancer, omega-3 fatty acid inhibits the progression of prostate cancer, breast cancer and other hormone-related cancer.Terry *et al.,*[13] proved that omega-3fatty acids inhibit the development of mouth cancer, including cancer of the salivary glands. Consumption of omega-3 fatty acid may slow the growth of cancer, improve the success of chemotherapy, and decrease the side effects of chemotherapy[14].

Utilization of oil with high omega-3 fatty acids in foods is limited because the oil is very susceptible to oxidation[15], and fat oxidation can be reduced by the addition of antioxidants or with microencapsulated oils[16]. For the food industry, the majority of omega-3 fatty acids are used in the form of microcapsules. Omega-3 fatty acids microcapsules are imported and not produced in Indonesia, whereas according to Baik *et al.,* industrial demand for fish oil microcapsules is increased along with the increasing public awareness of the importance of omega-3 fatty acids.[17]

Fish oil microcapsules form can expand the use of omega-3 fatty acids. In the form of microcapsules, omega-3 fatty acids exist in the protected form and can minimize the effect of oxidation on product sensory quality[18]. Microcapsules can also cover the stench in the final product[19].

The microcapsules are produced by the process of microencapsulation, i.e.coating technique of liquid droplets or solid particles. There are several microencapsulation methods of sensitive material such as omega-3 fatty acid. Spray drying is the most common method since the operational costs is 30-50 times lower than freeze drying. In the spray drying process, there is sharp increase in surface area that can improve the oxidation, if the encapsulatant is not thick or dense enough to block oxygen. Some encapsulants have emulsifying capacity and a good coating capability, Sodium caseinate is a good stabilizer for fat emulsion[20]. Encapsulant mixture of gelatin, sodium caseinate and maltodextrin were investigated by Lin *et al.,*[6]. Encapsulant use of proteins and carbohydrates has several advantages, i.e. good rehydration properties and are able to flow or clot. The use of both can simultaneously improve the stability of the microcapsules to oxidation, so it is used as encapsulant in this study.

Material and Methods

2.1. Materials and tools

The research material includes raw material liquid waste obtained from the tuna canning byproduct *(Yellowfin tuna: skipjack tuna* 60: 40%) of PT *Sinar Pure Food International* in Bitung, North Sulawesi. The chemicals used are: n-hexane (technical), distilled water, methanol, ethanol, sodium hydroxide, Na_2 EDTA, concentrated hydrochloric acid, urea (technical), Whatman filter paper No. 43, sodium caseinate, gelatin, maltodextrin, avicel 101, lecithin. Chemicals for analysis of fatty acid profile consists of methylene chloride, a solution of BF_3 *(boron trifluoride) in methanol, nitrogen and standard fatty acid (C10: 0, C12: 0, C14: 0, C16: 0, C16: 1, C18 : 0, C18:* 1ω-9; C18: 2 ω-6; C18: 3 ω-3; C20: 0, C20: 4ω-6; C20: 5ω-3 and C22: 6 ω-3

The equipment used is gas chromatography (GC -9AM Shimadzu), atomic absorption spectrophotometry (AAS), *spray dryer (Buchi mini spray dryer* B-290), a set of Soxhlet, *Rotary Vacuum Evaporator* (Buchi Rotavapor R-200), *Homogenaizer, Hot Plate,* printer jerky, analytical balance and the means of glasses.

2.2. Microencapsulation methods of omega-3 fatty acid concentrate

The making purpose of Omega-3 fatty acids concentrate microcapsules from oils which are derived from liquid waste in this research is to make the oil in the form of solids that will be added in the functional manufacture of chicken meatballs at a later stage. According to Wagner and Warthesen microencapsulation goal is stabilization of the materials, controlling the release of the packing material, separating the reactive materials from other materials, extending the usefulness of foodstuffs sensitive components, and adding certain components of foodstuffs other foodstuffs[21].

Microencapsulation is a technique of coating a core material *(core)* with a coating material (encapsulant) in the micron size. Omega-3 fatty acids concentrate microencapsulation uses*spray drying* technique *with* encapsulantmixture consisting of gelatin, Na-caseinate and maltodextrin and lecithin as an emulsifier. Procedure of making microcapsules are as follows: gelatin of 20g, Na-caseinate of 20g and maltodextrinof 20g are dissolved in water of 100ml, homogenized on a stirrer rotation speed of 2000 rpm at 40^0-50^0 C. Mix 20g of concentrated omega-3 fatty acid with 4g of emulsifier lecithin and 1 gavicel then homogenized for 5 minutes followed by spray drying at *an inlet* temperature of 120^0C and *an outlet* temperature of 70^0 C.

The observed variables in tuna canning wastewater byproduct oil and omega-3 fatty acids concentrate microcapsule includes the determination of water content with Toluene Distillation method (AOAC)[22]; levels of free fatty acids (AOAC)[22], 2000); peroxide (AOAC)[22] 2000); levels of copper (Cu) and the levels of iron (Fe) with the atomic absorption spectrophotometry method, whereas the fatty acid profile is analyzed by gas chromatography[23].

3. Results and Discussion

3.1. The Characteristics of Tuna Canning Wastewater Byproduct Fish Oil and omega-3 fatty acids concentrate microcapsule

The characteristics of tuna canning wastewater byproduct fish oil and omega-3 fatty acids concentrate microcapsule includes water content, free fatty acids, peroxide number of iron (Fe) and levels of copper (Cu) are presented in Table 1.

Table 1: The Characteristics of Tuna Canning Wastewater Byproduct Fish Oil and omega-3 fatty acids concentrate microcapsule

Quality parameters	Oil sources		
	Wastewater	**Microcapsule**	**Standard IFOMA**
Water content (%)	1,02	4,08	< 1
Free fatty acids - FFA (%)	3,99	5,66	1 - 7
Peroxide value (meq / Kg)	15,81	7,56	3 – 20
Cu (ppm)	0,14	0,23	<0,3
Fe (ppm)	0,39	1,05	0,5 – 0,7

Water content

Oil from wastewater has a moisture content of 1.22% and omega-3 fatty acids concentrated microcapsule at 4.08%. The water content still remains in the tuna canning wastewater byproduct fish oil because when the extraction there is the addition of distilled water and when evaporation at a temperature of

30°C there may still be a small portion of water that is not evaporated. Therefore, this study have a higher water content than the IFOMA standard (water content <1). In the hydrolysis reaction, fat or oil will produce free fatty acids and glycerol. Hydrolysis reaction can result in damage to the oil or fat due to the presence of water in oil or fat. This reaction will lead to hydrolysis rancidity that produces flavor and smell of rancid oil. The higher the moisture content of fish oil, the faster the hydrolysis reaction and the lower quality fish oil[24].

Free fatty acids levels

Analysis of acid number / free fatty acids is necessary to determine the level of lipid hydrolysis, i.e. how the amount of fatty acids that are not bound to glycerol. The number of high free fatty acid will accelerate the breakdown of the oil. Oil from liquid waste contains FFA content that is equal to 3.99% and omega-3 fatty acids concentrate microcapsule of 5.66%. The presence of free fatty acids in the fat / oil is usually used as an early indicator of damage to the fat / oil as hydrolysis. The existence of free fatty acids is very closely related to the water content in oil that can facilitate the hydrolysis of oil or fat.

In the hydrolysis reaction, fats and oils produce free fatty acids and hydrolysis will be accelerated due to the heating during the *pre-cooking* at a temperature of 90-100^{0}C for 60 minutes at the beginning of the canning process. Ketaren suggested that the acid number is a number that indicates the free fatty acids contained in fats / oils by water with an enzyme catalyst / heat on triglyceride ester bond will generate free fatty acids as found in the following reaction[25]:

$$\text{Triglycerides} + H_2O \underset{\text{heat}}{\overset{\text{enzyme}}{\rightleftharpoons}} \text{diglyceride} + \text{monoglyceride} + \text{free fatty acids}$$

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Peroxide Numbers

Peroxide number analysis is necessary to know the primary oxidation phenomena. The most common damage is rancidity by oxidation is often called auto-oxidation. During the reaction, auto-oxidation will form peroxides, the reaction will be accelerated due to the presence of light, the increase in temperature, oxygen, humidity and the presence of other catalysts[26].

Fish oil from waste water has 15.81 of peroxide value (meq / kg) and omega-3 fatty acids concentrate microcapsule of 7.86 (meq / kg). Fe can accelerate oxidation as a catalyst for oxidation reactions. Peroxide number in this study still meets the IFOMA standards (peroxide number of 3-20 meq / kg). This number can be used to determine the level of oxidation of fats or oils. Fat or oil may contain unsaturated fatty acids which can be oxidized and produce a peroxide compound. The existence of peroxide in fish oil is expected as a result of *precooking process.* According to Pak, heating with high temperatures cause oxidation reaction primer on oil and will produce peroxide. If the fat undergoes oxidation, the peroxide compound will increase[27].

Copper (Cu) Levels

Metal is a catalyst of the auto-oxidation process on oil, although fatty foodstuffs generally contain very small metal[28]. Analysis of copper (Cu) content is conducted because its existence is to catalyze auto-oxidation. The oil wastewater contains Cu of 0.14 (ppm) and omega-3 fatty acids concentrate microcapsule of 0.23 (ppm). The value of Cu metal content in the liquid waste oil in this study is in accordance with the IFOMA standards.

Iron (Fe) Levels

Just as the existence of Cu, metallic iron (Fe) also acts as a catalyst in the auto-oxidation reaction in fish oil. Oil from liquid waste contains Fe of 4.39 (ppm) and omega-3 fatty acids microencapsulated of 1.05 (ppm). Fe content value in this study did not meet the IFOMA standards (0.5-0.7 ppm). In fish, metals such as Fe and Cu are generally form complexes with proteins. Analysis of the metal content of iron (Fe) and copper (Cu) is conducted because the presence of both metals in fish oil are thought to contribute to the oxidation reaction. Hamilton said metal is a catalyst in the oil auto-oxidation process, although fatty foodstuffs generally contain very small metal[28].

3.2. The fatty acid profile of omega-3 fatty acids concentrated microcapsule

The fatty acid profile of fish oil from tuna canning wastewater byproduct, the omega-3 fatty acids concentrated and omega-3 fatty acids concentrated microcapsule are presented on Table 2.

Table 2: The fatty acid profile of fish oil from tuna canning wastewater byproduct, the omega-3 fatty acids concentrated and omega-3 fatty acids concentrated microcapsule

Fatty acid profile (% relative)	**Oil sources**		
	Wastewater	**Concentrate ω-3**	**Microcapsule Concentrate ω-3**
capric acid (C10:0)	0,1	1,27	0,04
Laureat acid (C12:0)	1,9	0	0,28
Mirystic acid (C14:0)	4,21	0,38	1,22
Palmitate acid (C16:0)	19,32	2,48	9,33
Stearic acid (C18:0)	6,25	0,31	19,2
Arakidat acid (C20:0)	0,51	0,59	2,67
Behenic acid (C22:0)	2,24	2,66	-
Total SFA	**33,71**	**7,68**	**33,14**
Palmitoleic acid (C16:1ω-7)	4,82	1,19	10,83
Oleic acid (C18:1ω-9)	**13,97**	**1,51**	**19,97**
Total MUFA	**18,79**	**2,71**	**30,79**
Linoleic acid (C18:2ω-6)	**1,39**	**0,83**	**-**
Linolenic acid (C18:3ω-3)	0,37	0,50	2,18
EPA(C20:5ω-3)	**4,16**	**9,87**	**4,28**
DHA(C22:6ω-3)	**21,38**	**59,68**	**19,19**
EPA + DHA	**25,54**	**69,55**	**23,47**
Total Omega-3	**25,91**	**70,05**	**25,66**
Total PUFA	**27,64**	**70,88**	**25,66**
Total Unsaturated Fatty Acid	**46,43**	**73,59**	**56,45**

Total Saturated Fatty Acid (SFA).

The analysis result of *Saturated fatty acids* (SFA) shows that oil from liquid waste, omega-3 fatty acid concentrate and omega-3 fatty acid concentrate microcapsule contain *capric acid* (C10: 0), *lauric acid* (C12: 0), *Myristic acid* (C14: 0), *palmitic acid* (C16: 0), *stearic acid* (C18: 0), *anachidic acid* (C20: 0), *behenic acid* (C22: 0). Oil from the wastewater contains the total SFA of 33.71%, while oil from omega-3 fatty acid concentrate contains a total of 7.68 SFA % and oil from the omega-3 fatty acid concentrate microcapsule contains the highest average of SFA amount of 33.14%. The saturated fatty acids (SFA) content of fish oil from wastewater and omega-3 fatty acids concentrate microcapsule is almost the same.

Total Monounsaturated Fatty Acid (MUFA).

The analysis results of *monounsaturated fatty acid* (MUFA) indicates that the oil from liquid waste, omega-3 fatty acid concentrate and the omega-3 fatty acid concentrated microcapsule contains *palmitoleic acid* (C16:1n-7) and *oleic acid* (C18: 1n-9). Oil from liquid waste contains MUFA average total of of 18.79% while oil from omega-3 fatty acid concentrate contains MUFA average total of 2.71%, and oil from solid waste contains the highest MUFA average total MUFA of 30.79%. These results show that the oil of the total solid waste contains the best MUFA when compared to the oil from wastewater and oil from fish salvage.

PUFA Total content

The analysis results of *polyunsaturated fatty acid* (PUFA) indicates that the oil from wastewater, solid waste and fish salvage contains *linoleic acid* (C18:2n-6), *linolenic acid* (C18:3n-3), EPA *(eicosapentaenoic)* and DHA *(Docosahexaenoat).* Oil from liquid waste contains PUFA total of 27.64%, the oil from omega-3 fatty acids concentrate of 70.88% and oil from the omega-3 fatty acid concentrate microcapsule of 25.66.

Fatty Acids Omega-9 Content

The analysis results of o*leic acid* (C18:1n-9) or omega-9 show that the oil from liquid waste contains the highest Omega-9 of 13.97%, while the oil from omega-3 fatty acids concentrate contains omega-9 of 1.51% and oil from the omega-3 fatty acids concentrate microcapsule containsthe lowest omega-9 of 19.97%.

The content of Omega-6 Fatty Acids

The analysis result of *linoleic acid* (C18: 2n-6) or Omega-6 shows that oil from liquid waste contains Omega-6 of 1.39%, oil from omega-3 fatty acids concentrate contains 0.83%, while oil from the omega-3 fatty acid concentrate microcapsule is not detected.

The total content of Omega-3 Fatty Acids

The analysis result shows that the oil from liquid waste, omega-3 fatty acid concentrate and the omega-3 fatty acid concentrate microcapsule contain omega-3 total which isconsisted of *linolenic acid* (C18: 3n-3), EPA and DHA. Oil from the liquid waste contains omega-3 total of 27.64%, omega-3 fatty acid concentrates contains 70.05% and omega-3 fatty acid concentrate microcapsule of 25.66%.

The content of EPA and DHA

The oil from liquid waste contains EPA of 4.16%, DHA of 21.38%, omega-3 fatty acids concentrate microcapsule contains EPA **and DHA of 4.28% and 19.19%.** Fatimah[29] reported that tuna canning byproduct oil (liquid waste) contains 25.5% SFA, 15.51% MUFA, 33.26% PUFA, 12.69% omega-9, 0.71% omega-6,32.55% Omega-3 Total, EPA 6.03%, DHA 25.41% and EPA + DHA 31.44%. Howe *et al.*[18] reported that tuna fish oil from flouring waste contains 4.8% EPA and 22.4% DHA. The raw materials which are used for flouring process are the canning solid waste and tuna *filleting,*i.e.*viscera,* red meat, fins, tail, and head. While the eye, eye pads, and the brain are part of the head of tuna fish which are rich in omega-3 fatty acids, especially DHA. Furthermore,Visentainer *et al.,*[30] mentions that the tuna oil *(Thunnusthynnus)* had higher levels of EPA and DHA which are 4.7% and 36.3%. Yuwono showed that the fish oil which is extracted with solvents from tuna eye and eye pads waste had EPA level of 5.1% and DHA level of 26.2% for the *Yellowfin* tuna variety and EPA level of 5.9% and DHA level of 24.1% for *Skipjack* tuna variety. Many factors influence the composition of fatty acids in fish oil[2]. Visentainer *et al.,* mentions that the fluctuations in the quality of fish foodi.e. phytoplankton, affect the levels of omega-3 fatty acids in fish oil[30]. Further explained that the factors that influence the fatty acid composition are the species, sex, sexual maturity, body size, fishing location, water temperature, food type and season. These factors cause variations in the composition of tuna oil than previous studies.

According to Imran and Sahgk , some of the benefits of omega-3 fatty acids are able to cure diabetes, atherosclerosis, cancer prevention, and strengthen the immune system[31]. In addition to omega-3 (EPA -

DHA), there is essential fatty acids that cannot be synthesized by the body comes from the diet by fish. So the supply of food products rich in omega-3 fatty acids is very important. Fish such as tuna, anchovies, trout and salmon are the main source of EPA and DHA[32]. Furthermore Toisuta *et al.,* [33] reported that the highest amount of saturated fatty acids (SFA) on the byproduct of tuna is 30.82% head,26.85% skin, 16.95% intestine, 26.56% liver and 21.31% *gonads* (reproductive organs), the total value of the highest saturated fatty acids at the head is 30.82%. The results of research conducted by Toisuta *et al.,* [33] also showed that the highest content amount of the monounsaturated fatty acids of tuna byproducts is oleic fatty acid (C18:1n9c) including: heads of 17.76%, skin of 15.21%, intestine of 6.97%, liver of 4.85% and *gonad* of 5.94%; while double unsaturated fatty acids *docosahexaenoic acid* (DHA = C22: 6n3) including heads of 16.41%, skin of 25.10%, intestines of 25.44%, liver of 6.91%,and gonads of 41.50%.

The profile data test of omega-3 fatty acid concentrate in Table 2 indicates that the SFA content of 33.71% decrease to 7.68%, MUFA decrease from 18.79% to 2.71%, Omega-9 decrease from 13.97% to 1.51% and Omega-6 decrease from 1.39 to 0.83%. Urea crystallization method can eliminate saturated fatty acids and multiple bond unsaturated fatty acids (MUFA). In the process of urea crystallization is an effective technique to get PUFA concentrates in the form of free fatty acids.

The technique can eliminate saturated fatty acids and monoenoat acid[34]. Saturated and unsaturated fatty acids can be separated by urea crystallization due to differences in both the alkyl chain linearity. Saturated fatty acids have a straight alkyl chain, and unsaturated fatty acids because they have double bonds grooves[35]. Yeo and Harris states that at the urea inclusion complexes, urea molecules that bind the hydrogen form channel *(tunnel)* which is parallel[36]. The urea channel structure is stable if the channel is filled by a compound *(guest compound)* with a dense arrangement. The urea channel has a diameter based on the van der Waals bonding radius that varies is between 5.5 and 5.8 A. Only appropriate molecular compounds can be a guest compound forming inclusion complexes. PUFA from 27.64% increase to 70.88%,the enrichment level of 2.56 times, the total amount of omega-3 from 25.91% increase to 70.05%,the enrichment level of 2.70 times, the EPA content of 4.16% increase to 9.87%, enrichment level of 2.37 times, DHA from 21.38% increase to 59.68%, enrichment level of 2.79 times and the amount of EPA + DHA from 25.54% increase to 69.55%, there is a degree of enrichment of 2.72 times.

The research results by Yuwono[2] showed EPA + DHA level in tuna eye and eye pad oil concentrate obtained is 83.9% with the initial EPA + DHA level of 31.3% so that the level of enrichment of 2.62 times. Estiasih *et al.,*[37] also reported the analysis result of responses to omega-3 fatty acid concentrate of tuna flouring byproducts using Central Composite Design with EPA + DHA levels between 61.16 to 82.33%. Enrichment level of EPA + DHA from the origin fish oil, i.e. EPA + DHA levels in the omega-3 fatty acid concentrate are divided by EPA + DHA levels in fish oil from tuna flouring byproduct is 2.90 to 3.93 times. The results showed levels of EPA + DHA in omega-3 concentrate from wastewater fish oil are lower than in the previous studies, but still higher than those reported by Fatimah[29].The levels of EPA + DHA in omega-3 concentrate from tuna canning byproducts (wastewater) of 50.66% at a ratio of urea: fatty acid of 3: 1, and the 24-hour long crystallization obtained EPA + DHA levels by 50.21%, this may be due to different materials and tuna fishing areas.

The results shows a higher level of enrichment than the research by Yuwono which allegedly caused the lower levels of EPA + DHA in the tuna flouring byproduct oil[2]. The low EPA and DHA levels mean the more saturated fatty acid which has preference forms higher complex so that the formation of urea inclusion complexes are more. Visentainer *et al.,* mentions that the fluctuations in the quality of fish food i.e. phytoplankton, affects the levels of omega-3 fatty acids in fish oil[30]. Further explained that the factors that influence the fatty acid composition is the species, sex, sexual maturity, body size, location of fishing, water temperature, food type, and season. Therefore, from the analysis result of fatty acid profiles concentrates containing high omega-3 EPA + DHA and Omega-3 total in oil from tuna canning liquid waste byproduct in Bitung North Sulawesi, it can be made microcapsules which will substitute into jerky minced chicken.

The profile test results of fatty acid microcapsules in Table 2 indicate that the SFA content of 34.84%, MUFA of 30.79%, Omega-9 of 19.97%, are higher than the omega-3 fatty acid concentrate, and this is probably due to the influence of the use to coating material, while PUFA of 25.66%, Omega-3 total of 25.66%, EPA of

4.28%, DHA of 19.19%, and EPA + DHA of 23.47% lower than the omega-3 concentrate, this may be due to the encapsulation process in a spray dryer. Microencapsulation process causes a decrease in EPA and DHA microcapsules which are shown by omega-3 fatty acids retention parameter, as reported by Estiasih *et al.* [38], the flouring byproduct oil microcapsules that are rich in omega-3 fatty acid and contains EPA + DHA of 36.44 mg / g, before encapsulated the content of EPA + DHA of oils rich in omega-3 is 175.48 mg / g so it decreases 4.82 times. Omega-3 fatty acid concentrate is a material that is sensitive to oxidative damage, especially light and heat, so it is effectively encapsulated by spray drying method. This is due to the contact time between the air dryer with *droplets* sprayed into the drying chamber occurs within a relatively short time, so the probability of degradation due to heat can be minimized. However, in this study the rate of flow speed of the spray dryer is used of 100ml/h with an inlet temperature of 120^0 C and an outlet temperature of 70^0 C, it is possible to occurs damage to the oil as stuffing material.

Conclusion

The characteristics of fish oil and omega-3 fatty acid concentrate microcapsule from tuna canning liquid waste still meet the standards of *the International Fish Meal and Oil Manufacturers Association* (IFOMA). Urea crystallization process increases the levels of polyunsaturated fatty acids (PUFA) such as omega-3 EPA and DHA that are used for the manufacture of omega-3 fatty acids concentrate microcapsule. The profile of omega-3 fatty acid concentrate microcapsule from tuna canning liquid waste byproduct is still quite high, especially EPA and DHA.

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