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# Processing and Quality Characteristics of New Canned Fish Products Contained Omega-3 Fatty Acids

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# Omega-3 지방산이 함유된 새로운 어류통조림 제품의 제조 및 품질특성

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## Abstract

In this study, the composition of proximate and fatty acid composition of six kinds of fish (capelin, herring, saury, mackerel, cod and Alaska pollack) were investigated. And the proximate composition, fatty acid composition and sensory evaluation of canned paste products manufactured using these fish species were investigated. The proximate compositions of the six kinds of fish were moisture 60.1-81.9%, crude lipid 0.7-20.6%, crude protein 13.9-17.9%, ash 1.2-1.5% for muscle tissue, and moisture 27.8-32.4%, crude lipid 58.4-63.4%, crude protein 6.9-7.3% and ash 0.9-1.0% for liver. The fatty acid compositions of six kinds of fish were shown 23.60-27.17% of saturated, 43.87-49.54% of monounsaturated and 21.58-31.09% of polyunsaturated fatty acids in muscle tissue and 16.30-20.63%, 53.21-56.22% and 21.92-29.25% for liver, respectively. The proximate compositions of canned fish paste were moisture 59.9-64.9%, crude lipid 17.8-22.1%, crude protein 10.2-13.4%, ash 1.3-1.5%, carbohydrate 4.6-4.7% in canned fish paste prepared with muscle tissue and moisture 63.8-65.7%, crude lipid 20.4-22.2%, crude protein 8.2-8.3%, ash 1.1-1.2%, carbohydrate 4.5-4.6% in canned fish paste prepared with muscle and liver, together. Fatty acid compositions of canned fish paste prepared from six kinds of fish were saturated fatty acid 20.30-27.35%, monounsaturated fatty acid 45.37-48.41% and polyunsaturated fatty acid 24.24-34.33%, and 18.58-22.42%, 54.68-55.31% and 22.27-26.74% in canned fish paste products using muscle and tissue, respectively.

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From the results of sensory evaluation of canned fish paste manufactured by six kinds of fish, there were excellent sensory evaluations in all canned products and little differences in sensory characteristics between samples.

**Key words : Proximate composition, Fatty acid composition, Muscle and liver, Sensory evaluation, Canned fish paste**

## Ⅰ. Introduction

One of the main components of the human diet are lipids, their nutritional value is determined by qualitative and quantitative composition of polyunsaturated fatty acids (PUFA). PUFA of the omega-3 (n-3) and omega-6 (n-6) families with the first double bond arranged at the 3d or the 6th carbon atom relative to methyl end of the chain are considered to be the most important for human organism. The main representatives of the n-3 family are linolenic (18:3n-3), eicosapentaenoic (EPA, 20:5n-3) and docosahexaenoic (DHA, 22:6n-3) fatty acids. The linoleic (18:2n-6) and arachidonic (20:4n-6) acids are of special physiological importance in the n-6 family. Fatty acids of n-3 and n-6 families participate in formation of structure elements of cell membranes, lipoprotein complexes of the brain, spinal cord, heart, liver and other organs; the acids are precursors of a number of biologically important metabolites, namely, prostaglandins, tromboxanes, leukotrienes, lipoxins, resolvins, neuroprotectins etc. (Calder, 2009; Sangiovanni and Chew, 2005; Weylandt et al., 2012). These metabolites contribute to normalization of cell metabolism, to cholesterol exchange and cholesterol excretion from organism. Moreover, they are involved in control of blood pressure, stimulate defense mechanisms of the organism, and improve tolerance to infectious diseases, radiation effects and other harmful factors (Bernardi, 1996; Farooque, et al., 2000; Phang et al., 2011).

Polyunsaturated fatty acids are indispensable or essential for human health, because human organism does not synthesize these acids in sufficient amounts but depends only on the intake with food (Bell and Tocher, 2009; Lands, 2009), the most efficient ratio of n-6 to n-3 fatty acids in human diet being 4:1 (Harris et al., 2009). The total daily supply of n-3 fatty acids EPA and DHA into the adult organism should be no less than 1 g (Reis and Hibbeln, 2006). A reduced consumption of n-3 fatty acids or an unbalanced ratio of n-3 to the total n-6 fatty acids may result in a change of the fatty acid composition of cell membranes and hence in various failures of their functions, cardiovascular and nervous diseases, gastro-intestinal disturbances, psychic dysfunction and other disorders (Mcnamara and Carlson, 2006; Davis and Kris-Etherton, 2003; Hibbeln et al., 2006; Robert, 2006; Saldanha et al., 2009; Harris et al., 2009).

It is known that the main sources of EPA and DHA are fish and marine invertebrates. Consumption of fish, fish oil or fish-based biologically active additives reduces the risk of developing diseases of cardiovascular, nervous and other systems. However, not all freshwater and marine hydrobionts can be rich sources of EPA and DHA. A major part of hydrobionts contain oil at a rate of 0.5-5.0% of raw weight. Therefore, the seafood portions containing the recommended 1 g daily dose of EPA and DHA are rather big, about 167-563 g (Gladyshev et al., 2006, 2007, 2009;

Simon et al., 2012).

The only exception is natural preserves of saury and herring, their (respectively) 41 g and 56 g portions provide the body with the daily demanded dose of n-3 fatty acids. However, most of the valuable components of the natural fish preserves with high contents of oil are usually of no use, while only dense contents of preserves are eaten, without separated oil, so the healthy lipids of great nutritional value are lost.

In the waters of the Pacific Ocean and adjacent seas, there occur various fish species with very high oil contents. Considerable amounts of cod and Alaska pollack are caught every year, their muscle tissues contain few lipids but lipid contents of their liver reaches 50% and more, depending on the season of fishing. Due to the fact that the mass of the liver during the fishery season is 5.0-8.0%, large volumes of fish liver are formed at cod processing, allowing us to establish mass production of healthy food and help consumers to provide their organism with n-3 fatty acids.

One of the efficient methods for producing such products for mass consumption is the thermal treatment with the best conservation of all components of the raw material in hermetically sealed cans or in bags packed under vacuum (Lapis et al., 2013). The thermal processing within a closed system eliminates significantly a loss of nutrition substances compared with cooking, roasting, stewing and other methods of processing. The absence of oxygen in canned food and inactivation of enzymes excludes lipid oxidation and protein hydrolysis resulting in bitter and unpleasant after-taste at a long storage.

The aim of the present work is a comparative study of lipid composition of commercial marine fish of the Pacific and creation on their basis of healthy canned products as an important and accessible source of n-3 fatty acids for human diet.

## Ⅱ. Materials and Methods

### 1. Selection of the material and preparation of samples to be analyzed

We used for our studies test specimens of frozen capelin (*Mallotus villosus*), Pacific herring (*Clupea harengus pallasi*), Pacific saury (*Cololabis saira*), Pacific mackerel (Scomber japonicus), Pacific cod (*Gadus macrocephalus*) and Alaska pollack (*Theragra chalcogramma*) selected from commercial batches, their frozen liver and canned fish. Muscle and liver were frozen in 10.0 kg block and 5.0 kg block, respectively

The storage period of frozen samples did not exceed 1 month at -25°C. After thawing of a fish or liver block, we took samples (no less than 0.3 kg each) from different parts of the block and formed one composite sample. The combined weight of a sample was 3 kg of muscle and 1.5 kg of fish liver, respectively. When preparing an average sample of muscle, we removed head and fins, cut the fish trunk along the belly, removed all internal organs and the spinal column. Samples of fish fillets and fish liver were washed, dried and milled.

### 2. Processing of canned fish paste products

In natural canned fish paste products produced from high-fat objects, the fat rich in a high content of valuable n-3 fatty acids usually separates from the solid part of the product. As a rule, it is not eaten. To preserve the entire lipid portion of the fish object is possible in the manufacture of combined canned paste-like products, the

composition of which should be supplemented with texturizing components (dry milk powder, starch, and lecithin). The addition of oil-browned onion and carrot to the paste reduces the distinct fish and liver taste and smell and forms a product of pleasant taste and aromatic properties. This is caused by the fact that in the process of browning of vegetables induces the reaction of melanoidin formation, resulting in accumulation of aromatic substances.

Preparation of the canned combination will make it possible to efficiently use the valuable raw materials without any loss of products and to impart high consumer characteristics and a treatment-and-protective trend to fish products.

Depending on the lipid content in the objects for manufacture of the canned food, we have developed 3 compositions of fish paste, as shown in <Table 1>.

The mixture of the components prepared according to the prescription was milled on a cutter for 5-6 min. The paste mass was filled in washed and scalded metal cans (301-3), a net weight of 135 g. The cans were sealed using a vacuum seamer (805A, Japan) and then sterilized in a steam retort system (ISUZU, Seisakusho Co., Japan) for 30 min at 120°C. Fo value was measured using a wireless types of Fo value measuring device (Iblo Electronic Gmbh, Germany) by holding thermal measurement logger at the geometric center of the 301-3 can filled with fish paste. After cooling, canned food was thoroughly washed, dried, and stored.

<Table 1> Mixing ratio of the canned fish paste products (%)[1)]

| Components | Canned capelin paste | Canned herring paste | Canned saury paste | Canned mackerel paste | Canned cod paste | Canned Alaska pollack paste |
|---|---|---|---|---|---|---|
| Muscle tissue | 66.0 | 70.0 | 66.0 | 70.0 | 25.3 | 25.3 |
| Liver | - | - | - | - | 35.0 | 35.0 |
| Onion browned in oil | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| Carrot browned in oil | 10.0 | 10.0 | 10.0 | 10.0 | 11.0 | 11.0 |
| Bean paste | - | - | - | - | 15.0 | 15.0 |
| Dry milk | 2.0 | 2.0 | 2.0 | 2.0 | - | - |
| Starch | 2.0 | - | 2.0 | - | - | - |
| Lecithin | - | 3.4 | - | 3.4 | - | - |
| Sugar | 1.0 | 1.0 | 1.0 | 1.0 | - | - |
| Salt | 1.4 | 1.4 | 1.4 | 1.4 | 1.5 | 1.5 |
| Milled sweet pepper | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Milled black pepper | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Water | 5.4 | - | 5.4 | - | - | - |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

[1)]: Percentage to the total content

### 3. Determination of moisture content

To determine the mass fraction of moisture in the samples, we put 2.0 g of the chopped sample in a clean-dried weighing bottle and dried it in a laboratory drying oven at 105°C to constant weight. The first weighing was performed after 3 hours, further – in 30 min. If the difference between two weighings did not exceed 0.001 g, the attained mass was considered as constant. The weight portion of moisture (X) was calculated in percent according to the formula:

$$X = (m_1-m_2/m_1-m) \times 100$$

where $m$ is mass of the weighing bottle,

$m_1$ : mass of the weighing bottle with the sample before drying,

$m_2$ : mass of the weighing bottle with the sample after drying.

### 4. Determination of lipid content

The total lipid content was determined by gravimetry after lipid extraction according to Bligh and Dyer (1959).

### 5. Determination of crude protein content

The determination of the crude protein content was performed by automated Kjeldahl method using Kjeltec Auto Analyzer 2300 (Tecator, Sweden). We introduced a weighed sample (1.0 g) into a 200 mL flask and added 15 mL of concentrated sulfuric acid ($H_2SO_4$, with density of 1.84 kg/L) and 1 g of catalyst mixture of copper sulfate ($CuSO_4$) and potassium sulfate ($K_2SO_4$) with a ratio of 1:10 (w/w). As a control we added 15 mL of sulfuric acid and 1.0 g of catalyst into the Kjeldahl flask. Test and control flasks were inserted into the cartridge chamber of Kjeltec Auto Analyzer 2300, where the sample was burned up (mineralization) in automatic mode during 40 min to obtain a clear solution. Cooling was followed by automated neutralization of the sample. The samples were transferred to another chamber, where ammonia ($NH_3$) released in the presence of water and 40% solution of sodium hydroxide (NaOH) at a temperature rise and was then absorbed by 0.1 N solution of hydrochloric acid (HCl). The process of elimination and neutralization of the samples is monitored by special filters impregnated with indicators. The amount of $NH_3$ absorbed by HCl allows the device to calculate automatically and show on the display the nitrogen content in the weighed sample. The mass portion of the protein in the sample (%) was calculated by multiplying the obtained amount of nitrogen by the coefficient 6.25.

### 6. Determination of ash content

To determine a mass portion of ash, we placed 10.0 g of the milled sample into the crucible calcined up to a constant mass and burned the sample on an electric stove until no more smoke released. Then we placed the crucible into a muffle furnace and carried out combustion of the sample at 500°C until the particles became white. Ashing was considered as complete if the crucible mass between two calcinations and weighings did not exceed 0.0015 g. The mass fraction of mineral material (X) was calculated in percent using the formula:

$$X = (m_1-m/m_2) \times 100$$

where $m$ : the crucible mass, g;

$m_1$ : the crucible mass with the residue

after burning of the weighed sample and calcination, g;

$m_2$ : weighed sample mass, g.

### 7. Determination of carbohydrate content

Carbohydrate content was expressed as 100-(total content of moisture + crude lipid + crude protein + ash)

### 8. Determination of fatty acid composition

The fatty acid (FA) methyl esters of obtained total lipids were prepared according to Carreau and Dubacq (1978). Analysis of FA esters was conducted by gas chromatography on a Shimadzu GC-17A chromatograph (Shimadzu, Kyoto, Japan) with a flame-ionization detector, a capillary column 30 m × 0.25 mm i.d. Supelcowax 10 (Bellefonte, PA). An analysis was performed under the following conditions: column temperature 190°C, the injector and detector temperature 240°C. Helium was used as a carrier gas. The peaks of methyl esters of FA were identified by retention time of the individual FA esters through comparison of their equivalent carbon length numbers with the authentic standards (PUFA-3 mix from menhaden oil was purchased from Supelco, Bellefonte, PA) (Stransky et al., 1997).

### 9. Sensory evaluation

Sensory evaluation of canned fish paste was conducted by a panel of taste experts for fish products. The quality of the canned fish paste was determined by the descriptive method, product appearance, and their organoleptic properties via sensory perception. The product's appearance was assessed after opening the can. Before extracting the contents of the can, the experts determined the product's packing, surface, and color, its scorching toward the can's inside surface, and the presence of coagulated protein. After removing the contents of the can onto a plate, the experts checked shape regularity, structure uniformity, and degree of grinding of the paste. Evaluation of the organoleptic properties involved determining the odor, taste, and consistency of the product. Assessing the odor, the expert panel paid attention to the intensity and retention of the characteristic odor of canned fish as well as to the degree of manifestation of the food additives used. Evaluation of the canned fish paste taste included determining the intensity of the taste typical of this fish species after sterilization as well as the taste intensity of the food additives used. Fish paste consistency was determined by evaluating its density by pressing the middle part of the product with the flat side of a fork and testing for juiciness and tenderness.

### 10. Statistical analysis

A Statistica 5.5 computer package was used for data analysis. Duncan's multiple range test (Steel and Torrie, 1980) was used to check for difference between two means, at 95% significance level.

## Ⅲ. Results and Discussion

### 1. Proximate composition of raw fish

Proximate composition of the used fish raw material is presented in <Table 2>. The moisture content of muscle tissues was the highest in Alaska pollack of 81.9 g/100 g, followed by cod of 81.7 g/100 g, and capelin *M. villosus*, herring *C. harengus*, sauri *C. saira* and mackerel *S. japonicus* were 60.0-68.2 g/100 g. And the moisture content

<Table 2> Comparison in proximate composition of muscle tissue and liver of marine fishes (g/100 g)

| Components | Capelin | Herring | Saury | Mackerel | Cod | | Alaska pollack | |
|---|---|---|---|---|---|---|---|---|
| | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue | Liver | Muscle tissue | Liver |
| Moisture | 68.2±1.5e | 66.9±1.3de | 60.0±1.4c | 64.5±1.3d | 81.7±2.0f | 32.4±0.8b | 81.9±1.7f | 27.8±0.6a |
| Crude lipid | 16.4±0.4b | 17.4±0.4b | 20.6±0.6c | 16.7±0.2b | 0.7±0.0a | 58.4±1.2d | 0.8±0.0a | 63.4±1.4e |
| Crude protein | 13.8±0.2b | 14.1±0.2b | 17.9±0.3e | 17.0±0.5d | 16.1±0.3c | 7.3±0.2a | 15.9±0.4c | 6.9±0.3a |
| Ash | 1.3±0.1cd | 1.4±0.0cd | 1.2±0.1bc | 1.5±0.1d | 1.3±0.2cd | 0.9±0.1a | 1.2±0.0bc | 1.0±0.0ab |
| Carbohydrate | 0.3±0.1a | 0.2±0.1a | 0.3±0.1a | 0.3±0.0a | 0.2±0.1a | 1.0±0.1b | 0.2±0.0a | 0.9±0.1b |

Values are the means±standard deviation of three determination
Means within each line followed by the same letter are not significantly different ($P<0.05$).

of liver in cod *G. macrocephalus* and Alaska pollack *T. chalcogramma* were 32.4 g/100 g and 27.8 g/100 g, respectively. The muscle tissues of the capelin *M. villosus*, herring *C. harengus*, saury *C. saira*, and mackerel *S. japonicus* had high lipid contents, while lipid content of the cod *G. macrocephalus* and Alaska pollack *T. chalcogramma* muscles was no more than 1.0%, but their liver contained more lipids than 50.0% of the total mass. Therefore, for further study we used tissues and liver of sea fish with high lipid contents. The crude protein content of muscle tissues was the highest in the saury of 17.9 g/100 g, followed by the mackerel (17.0 g/100 g), the code (16.1 g/100 g), the Alaska pollack (15.9 g/100 g), the herring (14.1 g/100 g), and the capelin (13.8 g/100 g). And the crude protein content of liver in the cod and Alaska pollack were 7.3 g/100 g and 6.9 g/100 g, respectively. There was little difference in the amount of ash between the muscle of samples at 1.2-1.5 g/100 g and at 0.9-1.0 g/100 g for the liver of cod and Alaska pollack.

There are some reports that proximate compositions in saury were 66.9% moisture, 14.45% crude lipid, 12.53% crude protein and 1.07% ash (Oh et al., 1998) which was higher moisture content and lower crude protein than the results of this experiment, while mackerel generally had 74.4% moisture, 7.0% crude lipid, 17.5% crude protein and 1.0% ash (Lee et al., 1998) which resulted in a higher water content and a lower crude lipid than the results of this experiment and the content of moisture, crude lipid, crude protein and ash in the Alaska pollack muscle (Oh, 1994) were 80.4%, 1.4%, 15.7%, and 1.3%, respectively, so that it did not differ much from the results of this experiment.

## 2. Fatty acid composition of raw fish

We have studied the fatty acid composition of total lipids in the muscle tissue of fatty fish and in the liver of the cod *G. macrocephalus* and the Alaska pollack *T. chalcogramma* <Table 3>. Depending on the fish species, the content of saturated fatty acids in the lipids of fish muscle tissues accounted for 23.60-27.17% of total fatty acids. The share of saturated fatty acids in the liver of cod and Alaska pollack was significantly lower

<Table 3> Fatty acid composition of lipids in muscle tissue and liver of marine fish (%)[1)]

| Fatty acid | Capelin | Herring | Saury | Mackerel | Cod | Alaska pollack |
|---|---|---|---|---|---|---|
| | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue | Liver | Liver |
| 14:0 | 7.29 | 8.19 | 7.89 | 6.07 | 2.01 | 4.90 |
| 15:0-i | 0.19 | 0.26 | 0.26 | 0.13 | - | - |
| 15:0 | 0.73 | 0.38 | 0.78 | 0.48 | 0.26 | 0.53 |
| 16:0-i | - | - | - | - | 0.11 | - |
| 16:0-ai | - | 0.28 | 0.28 | - | - | 0.39 |
| 16:0 | 15.74 | 16.49 | 12.09 | 14.25 | 10.13 | 11.72 |
| 17:0-i | - | 0.15 | 0.15 | - | 0.22 | - |
| 17:0 | 0.23 | - | 0.34 | 1.18 | 0.15 | 0.84 |
| 18:0 | 2.53 | 1.42 | 1.81 | 2.55 | 3.42 | 2.25 |
| **Σsat** | **26.71** | **27.17** | **23.60** | **24.66** | **16.30** | **20.63** |
| Σ16:1 | 7.46 | 10.9 | 4.16 | 5.03 | 8.89 | 11.76 |
| 17:1 | 0.29 | 0.26 | 0.27 | 0.18 | 0.45 | - |
| Σ18:1 | 15.79 | 20.61 | 6.76 | 11.90 | 33.20 | 18.63 |
| Σ20:1 | 8.51 | 9.24 | 15.29 | 14.90 | 8.02 | 13.85 |
| Σ22:1 | 13.97 | 8.53 | 17.39 | 15.16 | 2.65 | 11.98 |
| **Σmono** | **46.02** | **49.54** | **43.87** | **47.17** | **53.21** | **56.22** |
| 16:3 n-3 | - | 0.24 | - | - | 0.12 | 0.49 |
| 16:4 n-1 | 0.12 | 0.24 | - | 0.30 | 0.17 | 0.79 |
| 18:2 n-6 | 1.40 | 0.98 | 1.48 | 1.83 | 0.68 | 1.08 |
| 18:2 n-4 | 0.13 | 0.10 | - | - | 0.31 | 0.24 |
| 18:3 n-3 | 1.47 | 0.62 | 1.28 | 2.03 | 0.32 | 0.37 |
| 18:4 n-3 | 3.15 | 1.51 | 4.92 | 0.65 | 0.88 | 1.47 |
| 18:4 n-1 | - | 0.16 | - | - | 0.13 | 0.27 |
| 18:5 n-3 | 0.20 | 0.13 | 0.19 | - | - | - |
| 20:2 n-6 | 0.11 | 0.15 | 0.21 | 0.10 | 0.26 | 0.12 |
| 20:3 n-6 | - | - | 0.14 | - | 0.23 | - |
| 20:4 n-6 | 0.56 | 0.24 | 0.33 | 0.55 | 0.92 | 0.19 |
| 20:3 n-3 | 0.10 | - | 0.17 | - | - | - |
| 20:4 n-3 | 1.68 | 0.50 | 0.94 | 1.78 | 0.44 | 0.36 |
| 20:5 n-3 | 7.02 | 8.98 | 7.19 | 7.24 | 13.25 | 10.87 |
| 21:5 n-3 | 0.33 | 0.28 | 0.29 | 0.17 | 0.51 | 0.44 |
| 22:5 n-3 | 0.90 | 0.48 | 1.04 | 1.61 | 1.43 | 0.53 |
| 22:6 n-3 | 8.42 | 6.97 | 12.91 | 10.59 | 9.60 | 4.70 |
| **Σpoly** | **25.59** | **21.58** | **31.09** | **26.85** | **29.25** | **21.92** |
| Undefined | 1.68 | 1.79 | 1.45 | 1.32 | 1.24 | 1.19 |

[1)]: Percentage to the total content

(16.30-20.63%). This acid group was dominated by palmitic acid (16:0), the amount of which was more than 50.0% of the total saturated fatty acids. Other principal saturated acids were myristic (14:0) and stearic (18:0) acids but they were much inferior to palmitic acid in the content, particularly in the lipids of cod and Alaska pollack liver.

Monounsaturated fatty acids made up more than 50.0% of the total sum of fatty acids in liver lipids of the cod *G. macrocephalus* and the Alaska

pollack *T. chalcogramma*. In lipids of fish muscle tissues, the fraction of these acids was less than a half from the total fatty acids. In the lipids of cod and Alaska pollack liver, oleic acid (18:1) dominated; palmitoleic (16:1), eicosenoic (20:1) and isomeric acids erucic (22:1 n-11) were present in smaller amounts. The same monounsaturated fatty acids were found in lipids of muscle tissue of these fish species, but their proportions were different. Oleic acid (18:1) prevailed in the muscles of the capelin *M. villosus* and the herring *C. harengus*; isomeric acid erucic (22:1 n-11) was dominant in the tissues of the saury *C. saira* and the mackerel *S. japonicus*.

The content of polyunsaturated fatty acid (PUFA) was 21.58–31.09% of the total fatty acids in lipids of fish muscle tissue, 29.25% in lipids of cod liver, and only 21.92% in Alaska pollack liver. EPA (20:5 n-3) and DHA (22:6 n-3) dominated in this group of fatty acids; they accounted for 60.33-73.91% of the total PUFA in the lipids of fish muscle tissues. The fractions of these fatty acids among PUFA varied in lipids of the Alaska pollack and cod liver from 71.03% to 78.12%.

The above results reveal that the selected objects are a rich source of PUFA, mostly EPA and DHA.

There are reported that 14:0, 16:0, 18:1 20:5 and 22:6 of the fatty acids were founded to be 1.2, 16.4, 13.4, 16.6 and 27.7 area%, respectively, in the commercial Kwamegi from pacific herring *Clupea pallasii* (Heo et al. 2012). Kim et al. (1999) found that 14:0.16:0, 20:5 and 22:6 of the fatty acids were reported to be as 7.4, 11.75, 5.13, and 10.61 area% respectively in saury, resulting in slightly different values from 7.89, 12.09, 7.19, and 12.91 area% in this experiment. Jeong et al. (1999) examined that seasonal variations in the of lipid and fatty acid compositions of 12 species of fish, reporting that 12:0, 14:0, 16:0, 18:1, 20:5 and 22:6 of fatty acids in mackerel were 3.13-4.33, 17.4-20.0, 16.9-22, 5.28-7.41, and 13.6-15.6 area%, respectively, while tested in slightly different values from 6.07, 12.09, 11.90, 7.24 and 10.59 area% in this study. In addition, Jeong et al. (1995) reported that the fatty acid compositions of 14:0, 16:0, 18:1, 20:5 and 22:6 were 5.26, 25.03, 23.12, 5.75 and 13.81 area%, respectively, in the lipid extracted from mackerel intestines. And Park et al. (2006) reported that the fatty acid composition of 16:0, 18:1, 20:5 and 22:6 in domestic mackerel taken from Busan were 18.0, 18.7, 6.8, 5.75 and 28.5 area%, which differed from the results of this experiment.

## 3. Proximate composition of canned fish paste products

Proximate composition of canned fish paste products are presented in <Table 4>.

The moisture content were 64.9% of canned capelin paste, 62.7% of canned herring paste, 60.0% of canned saury paste, 59.9% of canned mackerel paste prepared by muscle tissue, and both canned cod paste and canned Alaska pollack paste were 65.7% and 63.8%, respectively, manufactured by muscle tissue and liver.

Crude lipid content were 22.1% of canned mackerel paste followed by 20.6% of canned saury paste, 20.4% of canned herring paste and 17.8% of canned capelin paste prepared with muscle tissue. and both canned cod paste and canned Alaska pollack paste were 20.4% and 22.2% manufactured by muscle tissue and livers which was higher content than the products manufactured by muscle tissue.

<Table 4> Comparison in proximate composition of canned fish paste products (g/100 g)

| Components | Capelin | Herring | Saury | Mackerel | Cod | Alaska pollack |
|---|---|---|---|---|---|---|
| | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue and liver[1)] | Muscle tissue and liver |
| Moisture | 64.9±1.6$^{b}$ | 62.7±1.3$^{ab}$ | 60.0±1.4$^{a}$ | 59.9±0.8$^{a}$ | 65.7±1.1$^{b}$ | 63.8±1.3$^{b}$ |
| Crude lipid | 17.8±0.4$^{a}$ | 20.4±0.9$^{b}$ | 20.6±0.3$^{b}$ | 22.1±0.6$^{c}$ | 20.4±0.2$^{b}$ | 22.2±0.3$^{c}$ |
| Crude protein | 10.2±0.2$^{b}$ | 11.0±0.2$^{c}$ | 13.4±0.1$^{d}$ | 13.0±0.5$^{d}$ | 8.3±0.2$^{a}$ | 8.2±0.1$^{a}$ |
| Ash | 1.5±0.1$^{b}$ | 1.3±0.0$^{ab}$ | 1.4±0.1$^{ab}$ | 1.3±0.1$^{ab}$ | 1.1±0.2$^{a}$ | 1.2±0.1$^{ab}$ |
| Carbohydrate | 4.7±0.1$^{NS}$ | 4.6±0.3 | 4.6±0.2 | 4.7±0.2 | 4.5±0.1 | 4.6±0.2 |

Values are the means±standard deviation of three determination
Means within each line followed by the same letter are not significantly different ($P<0.05$).
NS: Not significant
[1)]: Mixing ratio of the muscle tissue and liver is showed in <Table 1>.

The crude protein content were 13.4% for canned saury paste, followed by canned mackerel paste (13.0%), canned herring paste (11.0%), canned capelin paste (10.2%) made from muscle tissue, and both canned cod paste and canned Alaska pollack paste were 8.3% and 8.2%, respectively manufactured by muscle tissue and liver. For ash and carbohydrates, there was little difference in content between products ranged from 1.1-1.5% and 4.5-4.7%, respectively.

Jung(2018) reported the proximate compositions of canned oyster porridge added with Panax ginseng sprout and canned shrimp porridge added with Panax ginseng sprout. Proximate composition were 88.0-89.3% for moisture, 1.2-1.5% for crude lipid, 0.8-1.2% for crude protein and 0.3-0.6% for ash in canned oyster porridge added with Panax ginseng sprout and 87.9-89.1% for moisture, 1.4-1.6% for crude lipid, 1.0-1.4% for crude protein and 0.4-0.5% for ash in canned oyster porridge added with Panax ginseng sprout powder and 86.7-88.3% for moisture, 1.5-1.7% for crude lipid, 0.5-0.7% for crude protein and 0.3-0.4% for ash in canned oyster porridge added with Panax ginseng sprout extract. Proximate composition were 87.5-88.0% for moisture, 1.2-1.5% for crude lipid, 2.9-3.2% for crude protein and 0.3-0.6% for ash in canned shrimp porridge added with Panax ginseng sprout and 86.8-87.1% for moisture, 1.3-1.6% for crude lipid, 2.9-3.4% for crude protein and 0.3-0.5% for ash in canned shrimp porridge added with Panax ginseng sprout powder and 86.5-87.8% for moisture, 1.6-2.1% for crude lipid, 2.9-3.4% for crude protein and 0.4-0.7% for ash in canned shrimp porridge added with Panax ginseng sprout extract.

From the results in this study, the content of moisture contained higher amount in canned oyster porridge added with fresh Panax ginseng sprout and canned shrimp porridge added with Panax ginseng sprout powder, while the amount of crude lipid, crude protein, and ash were unusually high in the canned fish paste product. It was estimated that the reason for this kind of difference was because of the difference in the additive raw material.

## 4. Fatty acid composition of canned fish paste products

The composition of fatty acids in canned fish paste products (capeline, herring, saury, mackerel, cod, and Alaska pollack) were indicated in <Table 5>.

<Table 5> Fatty acid composition of canned fish paste products (wt %)

| Fatty acid | Capelin | Herring | Saury | Mackerel | Cod | Alaska pollack |
|---|---|---|---|---|---|---|
| | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue and liver[3)] | Muscle tissue and liver |
| 4:0 | 0.18 | 0.16 | 0.15 | 0.15 | -[1)] | - |
| 6:0 | tr[2)] | tr | tr | tr | - | - |
| 10:0 | tr | tr | tr | tr | - | - |
| 12:0 | tr | tr | tr | tr | - | - |
| 14:0 | 5.13 | 6.06 | 8.62 | 3.83 | 2.92 | 1.96 |
| 15:0-i | 0.18 | 0.31 | 0.31 | 0.15 | - | - |
| 15:0 | 1.04 | 0.26 | 0.83 | 0.25 | 0.60 | 0.24 |
| 16:0-i | 2.56 | 3.24 | 1.14 | 3.04 | 1.11 | 1.15 |
| 16:0-ai | - | 0.16 | 0.26 | - | 0.45 | - |
| 16:0 | 15.14 | 12.13 | 11.51 | 12.11 | 13.10 | 9.89 |
| 17:0-i | - | 1.05 | 0.15 | - | - | 1.05 |
| 17:0 | 0.12 | - | 0.36 | 0.64 | 0.96 | 0.24 |
| 18:0 | 2.81 | 2.67 | 2.48 | - | 3.27 | 4.06 |
| $\Sigma$ sat | 27.35 | 26.19 | 25.97 | 20.30 | 22.42 | 18.58 |
| 14:1 | tr | tr | tr | tr | - | - |
| $\Sigma$ 16:1 | 6.72 | 8.00 | 4.70 | 3.04 | 6.30 | 6.45 |
| 17:1 | 0.18 | 0.16 | 0.31 | 0.10 | - | 0.43 |
| $\Sigma$ 18:1 | 24.11 | 26.76 | 16.31 | 5.59 | 25.19 | 36.44 |
| $\Sigma$ 20:1 | 5.19 | 6.48 | 5.83 | 10.40 | 10.43 | 7.83 |
| 22:1 | 1.83 | tr | tr | 0.83 | 0.10 | - |
| 22:1 n-11 | 10.32 | 5.96 | 13.16 | 13.09 | 13.30 | 2.58 |
| $\Sigma$ mono | 48.41 | 47.46 | 45.59 | 45.37 | 55.31 | 54.68 |
| 16:3n-3 | - | 0.16 | - | tr | 0.55 | 0.10 |
| 16:4n-1 | tr | 0.16 | - | 0.15 | 0.40 | 0.14 |
| 18:2 n-6 | 6.04 | 4.13 | 4.96 | 4.22 | 3.48 | 3.77 |
| 18:2 n-4 | tr | 7.21 | - | 6.72 | 0.25 | 0.29 |
| 18:3 n-3 | 1.47 | 1.31 | 1.34 | 1.91 | 0.40 | 0.29 |
| 18:4 n-3 | 3.72 | 1.05 | 2.58 | 0.34 | 1.66 | 0.86 |
| 18:4 n-1 | - | 0.10 | - | tr | 0.30 | 0.14 |
| 18:5 n-3 | 0.12 | 0.10 | 0.21 | tr | - | - |
| 20:2 n-6 | tr | 0.10 | 0.21 | 0.10 | 0.15 | 0.24 |
| 20:3 n-6 | - | - | 0.15 | tr | - | 0.24 |
| 20:4 n-6 | 0.31 | 0.16 | 0.36 | 0.29 | 0.20 | 0.91 |
| 20:3 n-3 | tr | - | 0.15 | tr | - | - |
| 20:4 n-3 | 0.98 | 0.31 | 1.03 | 0.98 | 0.40 | 0.43 |
| 20:5 n-3 | 5.49 | 6.38 | 7.59 | 6.38 | 7.10 | 8.12 |
| 21:5 n-3 | 0.79 | 0.16 | 0.31 | 0.10 | 0.50 | 0.48 |
| 22:5 n-3 | 1.16 | 0.10 | 1.08 | 0.98 | 0.60 | 1.38 |
| 22:6 n-3 | 5.74 | 4.91 | 8.47 | 10.64 | 5.24 | 9.36 |
| $\Sigma$ poly | 24.24 | 26.35 | 28.45 | 34.33 | 22.27 | 26.74 |

[1)]: Not detected, [2)]: <0.1%, [3)]: Mixing ratio of the muscle tissue and liver is showed in <Table 1>.

In canned capelin paste product, the saturated, monounsaturated and polyunsaturated fatty acid accounted for 27.35%, 48.41%, and 24.24%, respectively, the highest of which was the monounsaturated fatty acid. C16:0 was the highest in content with 15,14% in saturated fatty acids, 24.11%, 10.32%, and 6.72% for C18:1, C22:1 n-11 and C16:1 in the monounsaturated fatty acids, and 6.04%, 5.74% and 5.49% for 18:2 n-6, 22:6 n-3 and 20:5 n-3 in polyunsaturated fatty acids, respectively.

In the case of canned herring paste product, the saturated, monounsaturated and polyunsaturated fatty acids accounted for 26.19%, 47.46%, and 26.35%, respectively, among which the monunsaturated fatty acids were the most abundant. C16:0 was the highest in content with 12.13% in saturated fatty acids, and C18:1, C16:1 and C20:1 were 26.76%, 8.00% and 6.48% in the monounsaturated fatty acids, respectively, while C18:2 n-4, C20:5 n-3 and C22:6 n-3 were 7.21%, 6.38% and 4.91% in polyunsaturated fatty acids, respectively.

In canned saury paste product, the saturated, monounsaturated and polyunsaturated fatty acids accounted for 25.97%, 45.59%, and 28.45%, respectively, among which the monounsaturated fatty acids were the most abundant. There was the highest in content with 11.51% of C16:0 in saturated fatty acids, 16.31%, 13.16% and 5.83% of C18:1, C22:1 n-11 and C 20:1 in monounsaturated fatty acids, and 6.47%, 7.59% and 4.96% of C22:6 n-3, C20:5 n-3, C 18:2 n-6 in polyunsaturated fatty acids, respectively.

In the case of canned mackerel paste product, the saturated, monounsaturated and polyunsaturated fatty acids accounted for 20.30%, 45.37%, and 34.33%, respectively, among which the monounsaturated fatty acid was the most abundant. C16:0 was the highest in content with 12.11% in saturated fatty acids and C22:1 n-11, C 20:1 and C18:1 were high in content with 13.09%, 10.40% and 5.59% in monounsaturated fatty acid, while C22:6 n-3, C18:2 n-4 and C20:5 n-3 were 10.64%, 6.72% and 6.38% in polyunsaturated fatty acids, respectively.

In canned cod paste product produced by combining muscles and liver accounted for 22.42% of saturated fatty acids, 53.31% of monounsaturated fatty acids and 22.27% of polyunsaturated fatty acid, respectively, of which the highest content was monounsaturated fatty acid. C16:0 was the highest in content with 13.10% of saturated fatty acids, and C18:1, C22:1 n-11 and C 20:1 were high content with 25.19%, 13.30%, and 10.43% in monounsaturated fatty acids, respectively. C20:5 n-3, C22:6 n-3 and C18:2 n-6 were high content with 7.10%, 5.24% and 3.48% in polyunsaturated fatty acids, respectively,

In canned Alaska pollack paste product manufactured by adding muscle and liver together, the saturated, monounsaturated and polyunsaturated fatty acid accounted for 18.58%, 54.68%, and 26.74%, respectively, of which the most abundant were monounsaturated fatty acids. In saturated fatty acids, C16:0 was the highest in content with 9.89% of total fatty acids, and C18:1, C20:1 and C16:1 were 36.44%, 7.83%, and 6.45% in monounsaturated fat acids, respectively. C22:6 n-3, C20:5 n-3 and C18:2 n-6 were high content with 9.36%, 8.12% and 3.77% in polyunsaturated fatty acids, respectively.

The total amount of EPA and DHA was 11.23%, 11.29%, 16.06%, 17.02%, 12.34% and 17.48% for canned capelin paste, canned herring paste, canned saury paste, canned mackerel paste, canned cod paste and canned Alaska pollack paste, respectively.

<Table 6> Sensory evaluation of canned fish paste products

| | Capelin | Herring | Saury | Mackerel | Cod | ollack |
|---|---|---|---|---|---|---|
| | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue | Muscle tissue and liver[1)] | Muscle tissue and liver |
| Appearance | 4.5±0.3$^{NS}$ | 4.6±0.2 | 4.7±0.2 | 4.7±0.2 | 4.4±0.1 | 4.4±0.2 |
| Colour | 4.6±0.2$^{NS}$ | 4.7±0.2 | 4.7±0.2 | 4.7±0.1 | 4.5±0.2 | 4.5±0.1 |
| Odor | 4.8±0.1$^{NS}$ | 4.9±0.1 | 4.9±0.1 | 4.9±0.1 | 4.7±0.1 | 4.6±0.2 |
| Texture | 4.6±0.2$^{NS}$ | 4.7±0.1 | 4.8±0.2 | 4.8±0.1 | 4.7±0.2 | 4.7±0.2 |
| Taste | 4.7±0.2$^{NS}$ | 4.8±0.1 | 4.8±0.2 | 4.8±0.1 | 4.6±0.1 | 4.5±0.2 |

5 Scales, 1: very poor, 2: poor, 3: acceptable, 4: good, 5: very good
Values are the means±standard deviation of 15 determination
NS: not significant
1): Mixing ratio of the muscle tissue and liver is showed in <Table 1>.

### 5. Sensory evaluation of the canned fish paste products

The ready-for-use preserves were of high commercial quality, they had pleasant flavor, soft and succulent consistency. The mass of the product was homogeneous, the texture being uniform. No distinct smell of fish and a bitter taste typical of liver were registered in the preserves. Neither the fat separation from a solid part of the product nor the presence of a thin fatty layer were recorded.

The sensory evaluation of the canned fish paste was determined using a 5-point scale(1: very poor, 2: poor, 3: acceptable, 4: good, 5: very good). The results of the ball assessment of the organoleptic properties of canned fish paste are given in the <Table 6>. Tasters noted that all canned foods are characterized by high organoleptic characteristics.

## Ⅳ. Conclusion

The raw material as a source of n-3 fatty acids is a muscle tissue of high-fatty fish species *Mallotus villosus*, *Clupea harengus pallasi*, *Cololabis saira*, *Scomber japonicus,* as well as liver of *Gadus macrocephalus* and *Theragra chalcogramma.*

Conservation of valuable fish lipids is possible in producing combined canned fish paste products of a paste kind, in which no fat separation from the thick portion occurs after sterilization.

Compositions of the canned fish paste products have been developed. The canned fish paste products based on the muscle tissue of fatty fish species and the liver of cods are sources of omega-3 fatty acids and can be used in the complex of diet therapy for patients with cardiovascular disorders and in the field of preventive treatment.

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