



Characteristics of Fish Protein Concentrate (FPC) of Marine Fish

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Authors' contributions

This work was carried out in collaboration among all authors. Author J designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AMR and TY managed the analyses of the study. Author SZR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this review article is to study the types of marine fish that can be processed into FPCs, methods for FPCs production, and the characteristics of marine fish FPCs known from various research in Indonesia. Based on a review of various articles and other literature, it can be concluded that the types of marine fish that can be processed into FPC are tuna, mackerel, anchovies, snapper, and rainbow runner. The method of FPCs production that can be used are reduction, whole meal, dry reduction and solvent extraction. The characteristics of the FPCs from various studies depend on the type of fish and the method of FPCs production.

Keywords: Reduction; solvent; tuna fish; FPC.

1. INTRODUCTION

Indonesia is the largest archipelagic country with 17,504 islands stretching from Sabang to

Merauke and surrounded by the ocean. It is not surprising that 75% of Indonesia's territory is the ocean, namely an area of 3.25 million kilometers² of territorial sea and 2.55 million

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kilometers² of the Exclusive Economic Zone. Indonesia also has the second-longest coastline after Canada with a length of 104 thousand kilometers [1]. With the vast area of the sea, Indonesia's natural resources, especially in the sea and coast, should have great potential. It is estimated that the potential of capture fisheries and aquaculture resources reaches US\$ 15.1 billion per year and US\$ 46.7 billion per year [2].

The production of marine fish sold at fish auction place in the 2017–2019 period has increased. It can be seen in 2017, production reached 657,691 tons, jumped in 2018 to 807,788 tons, and 2019 reached 816,945 tons. The main commodities of captured marine fish in 2017 were skipjack tuna which reached 467,548 tons, tuna reached 471,009 tons, tuna reached 293,333 tons, shrimp reached 400,073, and others reached 4,792,251 tons. Meanwhile, the production value of skipjack of US \$ 737,826.15, tuna of US \$ 721,057.38, prawns US \$ 739,922.25, and others US \$ 1,537,137.82 (Central Statistics Agency, 2020).

Export activities in 2020 reached the US \$ 2.407 billion with the production volume amount to 596,165,081 kilos. Major commodities such as shrimp reached the US\$ 466.24 million (37.56%), tuna-mackerel tuna-skipjack reached the US \$ 176.63 million (14.23%), squid-cuttlefish-octopus US \$ 131.94 million (10.63%), blue crab-crab reached the US \$ 105.32 million (8.48%), and seaweed reached the US \$ 53.75 million (4.33%) [3].

Indonesian people in the 2015–2019 period experienced increases. In 2015 the increase was 1397, in 2016 it reached 1462, in 2017 it was 1594, in 2018 it rose to 1723, and in 2019 it reached 1852 (Ministry of Marine Affairs and Fisheries statistics). This shows that the Indonesian people are aware of the importance of eating fish and this can be a potential for the development of processed fishery products such as the production of fish protein concentrate from marine fish.

Fish protein concentrate is a processed product in the form of flour produced by removing fat, minerals, carbohydrates, and water using organic solvents by pressing, drying, or extracting to produce a high protein concentrate of at least 50-

70% and is used to add protein to foodstuffs. Low protein [4]. The manufacture of FPC is adjusted to the properties of the protein and the solubility of the components to be removed or minimized.

Protein concentrates are divided into three types, namely type A with a minimum protein content of 67.7%, maximum fat 0.75%, odorless, tasteless, and colorless. Type B with <3% fat content and smells of fish when added to foodstuffs. Then type C, for example, common fish meal, is in a hygienic condition with a fat content of >10% and still smells like fish [5]. To produce FPC with the best quality, it is necessary to pay attention to factors such as fish species, extraction method and time, procedures, and raw materials (Riewpassa 2014). Determination of FPC quality was carried out based on FAO [6] requirements which included protein content, fat content, odor value, and whiteness degree.

Generally, all fish meat can be used as raw material for making protein concentrates, including marine fish. Marine fish are used as raw materials due to the diverse types of fish, high demand among the community, high protein content, and no need to use all parts of the fish so that by-products are possible. However, the types of fish with high economics are not evenly distributed, and there are not many processed fish products for fish meal. Therefore, this review article aims to examine the types of marine fish that can be processed into FPC, methods of making FPC, and characteristics of marine fish FPC taken from various researches in Indonesia.

2. TYPES OF MARINE FISH TO BE PROCESSED INTO FPC

Here are the types of marine fish that have the potential to be processed into FPCs.

2.1 Red Snapper

Red snapper is one of the commodities of high-quality marine fisheries. In capture fisheries, the most commonly caught types of red snapper are *Lutjanus malabaricus*, *L.johni*, *L. sanguineus*, and *L. sebae* [7]. The classification of red snapper is as follows [8]:

Phylum: Chordata
Class: Pisces
Order: Percomorphi
Family: Lutjanidae
Genus: Lutjanus
Species: *Latjanus sabae*



Fig. 1. *Latjanus sabae*
Source: fish IDER

Latjanus sabae has a very tall body with a fairly large preoperculum notch, has 10 soft rays on the anal fin, 11 spines, and 15–16 soft rays on the dorsal fin. Adult *L. sabae* has a dark red color while the juvenile is pink with dark red bands, the fins are darker in color. *L. sabae* in juvenile size is sold as an ornamental fish. Red snapper has fast growth, tolerant of turbidity and salinity, low cannibalism, and resistant to disease [9]. *Latjanus sabae* has a maximum length of 116 cm with an average length of 60 cm, a maximum weight of 32.7 kg, and a maximum age of 40 years [10].

Latjanus sabae has a wide habitat that can be found in tropical and subtropical waters at a temperature of 22.9–28.5 ° C, a depth of about 5–180 m with habitat for coral reefs and sandy substrates. In juveniles less than 20 cm in size, they are generally found in murky waters such as near the coast, mangroves, offshore reefs, or shallow coastal bays. Red snapper will pass their way to deep water as an adult and will return to shallow water during winter [10]. *L. sabae* is a carnivore with the main diet of small fish, shrimp, squid, crabs, stomatopods, cephalopods, and benthic crustaceans [9].

L. sabae adults form groups of medium size, or live solitary (Scott 2007). The first gonad maturity of males and females is estimated at 9 years of age, the size at which 50% of the population matures at 61–63 cm FL. The size of adult males is larger than that of females due to slower growth in adult females. *L. sabae* will form groups when mass spawning and spawning occurs between October and April [11].

Production of red snapper in Indonesian waters in the 2015–2018 period fluctuated, namely in

2015 it reached 239,673 tons, decreased slightly in 2016 to 232,112 tons, in 2017 increased to 505,434 tons, and decreased again in 2018 to 348,620 tons [12]. The capture generally uses handlines, traps, and deep pull nets. This fish is marketed fresh, salted dry, and frozen [10].

2.2 Anchovies

Anchovy is the cheapest source of protein and calcium, and is easily found in all corners of Indonesia. Processed anchovy products, both fresh and dried, have the highest protein and calcium content and all parts of the body can be consumed so that there is no waste from processing anchovies. 100 grams of fresh anchovies contains 77 kcal of energy, 16 g of protein, 1 g of fat, 500 mg of calcium, 500 mg of phosphorus, 1 mg of iron, and 47 mg of vitamin A and 0.1 mg of vitamin B [13].

The classification of anchovy is as follows [14]:

Phylum: Chordata
Class: Pisces
Order: Malacopterygii
Family: Clupeidae
Genus: *Stolephorus*
Species: *Stolephorus sp.*



Fig. 2. *Stolephorus sp.*
Source: *cerita pesisir*

Anchovies have a fusiform or compressed body and a silvery-white lateral line. Anchovies have forked caudal fins that do not join the anal fins, abdominal spines on the pectoral and ventral fins, and loose, small, and thin scales. The color is slightly reddish or transparent. Anchovies are as small as 6–9 cm, but *S. commersoni* and *S. indicu* can grow to 17.5 cm [15].

Anchovies are included as pelagic fish that live in coastal and estuarine waters with a salinity between 10–15‰ and a temperature of 26–29° C. Anchovies are omnivores because they have pointed teeth, a stomach, and a shorter intestine than their body length. They consume fish larvae, bivalve and gastropod larvae, copepods,

ostracods, annelids, pteropods, and diatoms. Anchovies that live in groups can reach hundreds to thousands of individuals per group, but large anchovies live solitary [14].

Anchovy migration is influenced by seasonal changes in the waters and occurs every year for a certain period of time. Spawning coincides with seasonal changes from the northwest season to the southeast monsoon in April-May or December-January with the peak spawning time not always the same every year [14]. Anchovy production in 2015-2018 fluctuated, namely in 2015 it reached 221,073 tons, decreased in 2016 to 217,398 tons, then increased in 2017 to 294,006 tons, and decreased again in 2018 to 170,842 tons [12].

2.3 Rainbow Runner

Rainbow Runner is a pelagic fish that is popular among people because of its delicious taste and affordable price. Rainbow Runner is a fast-swimming fish that has the local name dares fish, sea salmon, or rainbow fast runner fish [16]. The classification of Rainbow Runner is as follows:

Phylum: Chordata
 Class: Pisces
 Order: Actynoprygii
 Family: Perciformes
 Genus: *Carangidae*
 Species: *Elagatis bipinnulata*

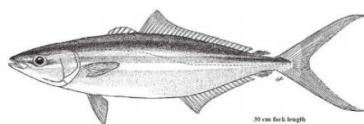


Fig. 3. *Elagatis bipinnulata*
 Source: Carpenter dan Niem (1999)

The Rainbow Runner have an elliptical body shape, tapered head and snout, smallmouth, short pectoral fins, light blue lateral lines, bluish-green body on the back but white on the belly, and dark fins with yellow color, have thick midlaterek bands (Jalanidhitah [17] in Urbasa 2014), There are finlets on the dorsal and anal fins, toothed villiform jaws with teeth on the jaw and tongue, and forked caudal fins (Ministry of Marine Affairs and Fisheries [18]). Rainbow Runner grows to a maximum length of 107-180 cm with an average of 90 cm and a maximum weight of 46.2 kg and can live up to 6 years (fishbase).

Rainbow Runner is coral pelagic fish that live in rocky coastal waters but can also be found in the high seas with a depth of about 150–200 m, generally 2–10 m, with temperatures 22.8-28.8° C [19]. The distribution area of Rainbow Runner is throughout the coastal waters and reefs of Indonesia, the Bay of Bengal, Gulf of Siam, South China Sea, Philippines Australia [20], Liguria Sea, West and East Indian Ocean, Western Central Pacific, Atlantic [21]. Rainbow Runner is a carnivorous (predator) fish that eats other fish, squid, fish larvae or eggs, isopods, amphipods, megalops, shrimp, and seaweed (Yesaki 1967).

Rainbow Runner generally lives solitary but will temporarily form groups. The average size of the Rainbow Runner caught is 30–50 cm using muro-ami, trolling line, gill nets, and purse seine [20]. The production of Rainbow Runner fish in Indonesia in 2015–2018 fluctuated, namely in 2015 - 2017 it decreased from 14,134 tonnes, 11,396 tonnes, to 5,294 tonnes and increased in 2018 to 7,503 tonnes (Ministry of Marine Affairs and Fisheries [18]). Rainbow Runner fish is generally marketed as fresh, salted, dried, and frozen for sashimi [19].

2.4 Mackerel

Mackerel is a high economic fish and is important due to the increasing demand from the domestic and world community. Mackerel fish contains high-quality protein and vitamins that support growth and endurance. The classification of mackerel fish is as follows (Sheedy, 2006):

Phylum: Chordata
 Class: Actunopterygi
 Ordo: Perciformes
 Family: Scombridae
 Genus: *Scomberomorus*
 Species: *Scomberomorus commerson*



Fig. 4. *Scomberomorus commerson*
 Source: greeners.co

The mackerel fish has an elongated body shape, solid flesh, smooth skin, and has no scales except on the lateral line. The mouth is wide, the jaw is strong and solid, and there are small teeth on the roof of the mouth. The back is grayish blue with silver scales on the belly and brim, with many thin vertical wavy bands. There are two dorsal fins and a finlet behind it, and forked caudal fins. It has a maximum length of 240 cm with a maximum weight of 70 kg. The average length is 120 cm, and at the maturity of the first gonad, it grows to 85 cm long (phasebase).

Mackerel is a pelagic fish that live in coral reefs, lagoons, the edge of the continental shelf, and shallow coastal waters at a depth of 10–70 m, temperature 22.8–29°C, low salinity, and high turbidity [22]. The distribution of pelagic fish is quite wide covering the Western Pacific, Australia, Indonesia, Fiji, Japan, China, Indonesia, the Mediterranean Sea, and St. Helena, this can be due to its migrator nature [22 and 23]. Mackerel is a carnivorous fish whose main diet is anchovies, squid, shrimp, clupeids, and carangids [22].

Adult mackerel lives solitary, but juvenile and young fish form small groups [24]. The production of mackerel fish in Indonesia in 2015–2018 is fluctuating, in 2015 was 424,890 tonnes, decreased in 2016 and 2017 to 423,880 tonnes and 325,561 tonnes, but increased again in 2018 to 507,626 tonnes [12]. Mackerel are caught using gill net, bubu, mid-water trawl, and trolling. This fish is marketed as fresh, dried, salted, processed products such as meatballs, pempek, crackers, smoked fish, and canned fish [22].

2.5 Tuna Fish

Tuna is one of the main export commodities due to a large number of interests, both domestically and in the world, hence it has a high economical value. Tuna is included in the Scrombidae family among several types of fish such as yellowfin tuna, bigeye, southern bluefin tuna, albacore, and dogtooth tuna. The classification of tuna is as follows [8]:

Phylum: Chordata
Class: Teleostei
Ordo: Perciformes
Family: Scombridae
Genus: Thunnus
Species: *Thunnus alalunga*



Fig. 5. *Thunnus alalunga*
Source: united fisheries

Albacore tuna has a torpedo body with a tapered head and slippery body. Tail fins are forked with dorsal, anal, ventral, pectoral fins that have arches to reduce friction during rapid swimming, and forked tail fins. It is silver in a color that is gradually faded to the abdomen [25]. The smallest tuna is albacore with a maximum length of 140 cm and an average length of 100 cm, the length at the first gonad maturity is 85-90 cm, a maximum weight of 60.3 kg, maximum age recorded is 9 years. Albacore tuna is included as epipelagic and mesopelagic fish that live up to a depth of 600 m with a temperature of 8.8–21.2. Albacore tuna are carnivores that prey on small fish, crustaceans, mullets, and squid [26].

Tuna fish are migratory hence the wide distribution in tropical and subtropical oceans includes Indonesia, Australia, the Mediterranean Sea, and the Western Pacific [26]. Tuna production in Indonesia in the period of 2015–2018 increased annually to 250,485 tons, 271,856 tons, 293,233 tons, and 409,024 tons. Tuna is captured using fishing rods, albacore tuna are captured mostly offshore because albacore loves soft water that is blue and neutral temperatures. Tuna is marketed as fresh, smoked, baked, and fried [26].

3. PRODUCTION METHOD OF FISH PROTEIN CONCENTRATE

The production principle of fish protein concentrate is the removal of water content and fat content in fish meat tissue, in order to obtain high quality protein concentrate. In the process of making FPC, there are two stages of processing (Widyaningsih, 1986), namely:

- a. Production stage of fishmeal concentrate (fish meal normally produced in hygienic conditions) without removing odor and fat content
- b. The extraction stage of the fishmeal concentrate (common fishmeal normally produced under hygienic conditions) made using solvents.

There are several ways or methods of making fish protein concentrate that are commonly used, namely the reduction, the "whole meal", the dry reduction and the solvent extraction methods. (Widyarningsih, 1986).

3.1 Reduction Method

This method has been done commercially for a long time. The steps consist of cooking, pressing, and drying, which is sometimes followed by processing the oil from the pressed liquor.

Cooking is a decisive step in the processing of fish protein concentrate. The way of cooking must be right to coagulate all ingredients, otherwise, the process will be difficult. Without total coagulation, it will result in a "press cake" with high water and fat content, and the separation of oil from the liquid will be more difficult. To facilitate the coagulation process during cooking, it is sometimes necessary to add a coagulant (Widyarningsih, 1986).

In the pressing process, the moisture content of the material must be taken into account, because if there is too much water the result will be like slurry. The result of pressing is a "press cake" and liquor containing water, dissolved solids, and oil.

The "press cake" obtained should be crushed/grounded first to facilitate drying. Drying is done using a mechanical dryer. The resulting fish protein concentrate contains 8-10 percent of water content but the fat content is still quite high.

3.2 The Whole Meal Method

The principle of processing the whole meal is the same as the reduction method, the difference lies in the use of pressed liquor. In the method of reducing the pressed liquor is not utilized, while in the "wholemeal" method the liquor which still contains 20 percent of solid material is utilized by concentrating.

Liquor obtained from pressing contains water, dissolved solids, oils, and water-soluble B vitamins. The liquor is separated from the oil and then concentrated to produce a thick liquid called "glue water". The "glue water" is then reconcentrated until the solid content reaches 50 percent, excess oil and sludge are also

separated, resulting in "fish soluble". (Widyarningsih, 1986).

The "fish soluble" is then mixed into the "press cake" after being blended and dried to produce a "wholemeal". To achieve the highest efficiency, the condensation of steam for heating must be prevented from passing through the product that is being heated. This prevention is done by indirect heating. The steam is passed by the room between the outdoor wall and the room where the product is being heated. The tool for heating/cooking with indirect space is called an "indirect cooker". Likewise, for the separation of oil and glue water, the heating is carried out by means of steam pipes that pass through concentrated "glue water", without the steam coming into contact with the heated product.

By the "wholemeal" processing method, the utilization of raw materials reaches 100 percent, the resulting fish protein concentrate is of good quality, even though it uses much more fuel.

3.3 Solvent Extraction Method

"Solvent extraction" is aimed at separating oil from fish protein concentrate of fishmeal produced by wet or dry reduction. The solvent used is volatile and can easily dissolve oil. Extraction is carried out by mixing fishmeal-type FPC into the solvent until all the fat is extracted, then passing it in a clean solvent to get the maximum oil content in the solvent before distilled.

The percentage of fat obtained this way is 1-2 percent. The resulting fish protein concentrate is light in color and odorless because the smell of the solvent has been removed first by dry steam. The resulting fish protein concentrate will not undergo a rancidity process, while the protein content is quite high, reaching 80 percent. The solvents commonly used are trichloroethylene or carbon tetrachloride.

Moorjani et al (1968), performed FPC extraction using ethanol, isopropanol, and acetone, it turned out that isopropanol was the most efficient because the amount of residual fat contained was less than 1 percent. The color, smell, and stain of the solvent indicate that the three solvents give a light color and are free from fishy odors, but the acetone leaves a characteristic stain.

3.4 Wet Extraction Method

Raw material in the form of wet fresh fish is mixed with one type of fat solvent which has a high boiling point and dissolves in water. This mixture is indirectly heated with steam. Some of the solvents will evaporate with water vapor, then condense. This condensed solvent is then returned to the processing process. After the raw material reaches a water content of approximately 10 percent, drying is stopped. The solvent and oil are separated by a distillation process. The type of solvent used is trichloroethylene.

The general stages of the FPC extraction method are as follows:

1. The fresh fish are brought to the fisheries product technology and food chemistry laboratory.
2. Fish are weeded to separate the entrails, bones, flesh, skin and head.
3. Next, the fish meats are washed and the size reduced by a blender.
4. The fish are ready for extraction.

The extraction process refers to the method of Nurjanah [27] in Karnila [28], with a few modifications. This experiment was carried out in the following manner:

1. Soaking the minced meat in the refrigerator (temperature $\pm 4^{\circ}\text{C}$) using solvents for 12, 18, 24 hours.
2. Samples are weighed 300 g and put into an Erlenmeyer tube with a ratio of 1: 3 (w/v) for 12, 18 and 24 hours.
3. After the extraction is complete, it is continued with the separation of the liquid and sediment using centrifugation (speed 10,000 rpm, time 15 minutes, temperature 4°C).
4. The precipitate obtained is then dried using an oven at a temperature of 60°C for ± 24 hours (until dry).
5. The proximate analysis is done observing ash content, fat content, water content, protein content, and carbohydrates.
6. Lastly, the dissolved protein and water absorption are tested.

In addition to the FPC method for fish meat, there is also an extraction method for FPC on fish eggs based on the method of Sikorski and Nazck (1981) which is modified as follows:

1. The crushed fish eggs are extracted by defatting method using IPA and ethanol solvents with the ratio of crushed fish eggs to the solvent is 1: 3 (w/v) to remove fat and water.
2. The extraction is carried out within 1, 2 and 3 hours, then filtered using filter paper.
3. The filtered precipitate is dried using a cabinet dry at a temperature of $45 \pm 2^{\circ}\text{C}$ for 4 hours.
4. Dried materials are powdered using a dishmill and sieved with a 60 mesh sieve.

4. CHARACTERISTICS OF FPC MARINE FISH

Research conducted by Yusuf et al. [29] on protein concentrates of flying fish eggs with isopropyl alcohol solvent for 3 hours extraction resulted in flying fish EFPC with a protein content of 33%, and 2% fat. Low protein value is due to repeated extraction and influenced by decreased fat and water content during extraction and drying, lower fat content than mragal EFPC by 8.8% in Chalamaiah et al. [30] and tuna and red snapper EFPC respectively 2.83% and 3.75% in Wiharja et al. [31].

Based on FAO [6] regarding the classification of FPC types, flying FPCs are included in type B FPCs. The characteristics of flying FPCs are based on the following:

Table 1. Best Flying Fish EFPC Functional Properties Characteristics Results

Functional Properties	Value
Emulsion capacity (ml/g)	22.4
Bulk density (g/ml)	0.81
Foam capacity (ml)	2.43
Water Absorption (ml/g)	5.81
Oil Absorption (ml/g)	1.68
Foam Stability (10 minute)	0.38

Source: Yusuf et al. [29]

The results showed that the value of flying EFPC emulsion capacity is higher than carp and greasy grouper which are 6.5 mL/g and 5.5 mL/g respectively. In Rao and Barramundi studies it has a value of 12 mL/g but lower than common snakehead with a value of 56 mL/g, this showed that the power to absorb water and oil in a balanced manner is better in common snakehead fish. Bulk density value in flying EFPC is higher than mragal common snakehead of 0.77 g/mL in Chalamaiah et al. (2012) and

greasy grouper of 0.75 g/mL but lower than common carp 0.83 g/mL, this showed the material of rich greasy grouper is bulkier than flying fish.

The foam capacity and foam stability of flying FPC are lower than carp which are 26 mL and 12 respectively, and greasy grouper 56 mL and 12 in Rao's study (2014). The water absorption capacity of flying EFPC is higher than that of common carp FPC which is 1.78 mL/ g, greasy grouper of 1.99 g/mL in Rao's research (2014), and tuna 5.38 g/mL, but lower than red snapper of 6. 25 g/mL in the study of Wiharja et al. [31] and FPC carp, this shows the water absorption capacity of carp, greasy grouper, and tuna FPC are better than flying fish and red snapper. The absorption capacity of flying EFPC oil was lower than EFPC tuna 1.77 g/g, red snapper 1.89 g/g in the research of Wiharja et al. [31] but higher than mas of 0.83 g/g and greasy grouper of 1.01 in the research of Galla et al. [32].

Research conducted by Rieuwpassa et al. 2014 regarding the protein concentrate of skipjack fish eggs with isopropyl alcohol solvent for 3 hours of extraction, the deffating process resulted in skipjack EFPC with 71.79% protein content, 2.78% fat, and the odor value close to neutral and good whiteness. Skipjack EFPC has 7 essential amino acids and 5 non-essential amino acids, as well as 2 semi-essential amino acids with a total of 849.79 g/g protein.

Based on FAO [6] regarding the classification of FPC types, the skipjack EFPC is included in the type B FPC. The characteristics of the skipjack EFPC are based on the following functional characteristics:

Table 2. Best skipjack FPC Functional Properties Characteristics Results

Functional Properties	Value
Water Absorption (ml/g)	1.57±0.01
Oil Absorption (ml/g)	1.82±0.01
Emulsion capacity (ml/g)	81.65±0.24
Bulk density (g/ml)	0.51±0.00
Foam capacity (%)	1.90±0.21
Foam Stability (10 minute)	0.22±1.06

Source: Rieuwpassa et al. [2013]

The results showed that the water absorption level of skipjack tuna EFPC is lower than the EFPC of tuna and red snapper which have a value of 5.38 g/mL and 6.25 g/mL in the study of Wiharja et al. [31], it shows that skipjack EFPC's

absorb water better than tuna and red snapper. The oil absorption capacity of skipjack tuna has a higher value than tuna which is 1.77 g/g, lower than red snapper of 1.89 g/g in the study of Wiharja et al. [31] and hake fish 4.67 g/g in the study of Pires et al. [33], this shows that hake fish has better oil absorption ability than skipjack.

The bulk density value of skipjack EFPC was lower than mragal EFPC at 0.77 g/mL in the study of Chamalaiah et al. 2011. Functionally, the resulting EFPC has the ability to absorb oil and water, emulsion capacity, quality bulk density to be used as additives, substitutions, and binders for applications of high protein-based products.

Research conducted by Rieuwpassa at al. 2018 regarding the physico-chemical characteristics of rainbow runner fish (*Elagatis bipinnulatus*) Protein Concentrate with 90% ethanol solvent for 3 hours of extraction.

Table 3. Best Rainbow Runner FPC Functional Properties Characteristics Results

Chemical Parameters	Total
Protein (%)	77.34
Fat (%)	1.22
Water (%)	9.34
Ash (%)	3.38
Physical Parameters	-
Smell	2.56 (<i>weak smell of fish</i>)
Whiteness (%)	54.52
Bulk density (g/ml)	1.04
Water Absorption (g/ml)	0.53
Oil Absorption (g/g)	2.10

Source: Rieuwpassa at al. [2018]

From the following table, it can be seen that the FPC of rainbow runner fish produced high levels of protein at 77.34%, low fat at 1.22%, 2.56% odor, and 54.52% whiteness. FPC of rainbow runner fish has a bulk density or the ratio of the weight of material to the space placed of 1.04 g/ml. For water absorption or the ability to hold water both from outside and inside foodstuffs [5] in Rainbow runner fish is 0.53 g/ml. The FPC of Rainbow runner fish is composed of 15 types of amino acids, of which 8 are essential amino acids, and 7 are non-essential amino acids.

Research conducted by Laili et al. 2021 regarding Characteristics of Cunang Fish (*Muraenesox talabon*) Protein Concentrate Using

Ethanol Solvent at Different Times using the Nurjannah [27] Method in Karnila [28] which has been slightly modified, cunang fish is immersed in ethanol with a ratio of 1; 3, then extracted in the refrigerator with the solvent immersion time difference of 12, 18, 21 hours.

Table 4. Best Cunang FPC Functional Properties Characteristics Results

Nutrient Content	Presentation (%)		
	12 (P1)	18 (P2)	24 (P3)
Protein (%bk)	71.66 ± 3.12	75.18 ± 2.87	78.73 ± 8.11
Fat (%bk)	3.99 ± 0.13	3.50 ± 0.17	3.20 ± 0.11
Ash (%bk)	5.86 ± 0.61	4.31 ± 0.57	6.19 ± 1.61
Water (%bb)	8.42 ± 2.07	8.35 ± 1.19	7.47 ± 1.56

Source: Laili et al. [34]

From the following table, it can be seen that the Cunang fish FPC using Ethanol solvent at different times produces different protein levels, with the highest protein content being in the FPC of cunang fish extracted for 24 hours, namely 78.73%, the lowest fat is extracted in 24 hours with fat content 3.20%, and the lowest water content is 24 hours extraction of 7.47%. The water and fat content in the 24-hour extraction was lower, because the dissolving time affected the fat and water content, but had no significant effect on the protein. While the water absorption at all the three times had no significant effect, namely having the absorption capacity of 1 ml of water.

5. FISH PROTEIN CONCENTRATE DEVELOPMENT

To develop FPCs (Fish Protein Concentrate) in the future, which has high acceptability by the community, a new type of Marine Beef or meat texture fish protein concentrate has been developed (Royan, 2010) as a product of FPC development.

Marine beef has a specialty in the form of functional properties of the protein that does not disappear, and the content of high nutritional value, so that it can be processed into a variety of meat products ranging from sausages, meatballs, hamburgers, and other processed meats. Because it has been through the process of dehydration, marine beef has excellent coagulation, emulsion, and gel formation, so it

can be an ingredient for processed beef substitute products. According to Sasamoto [35], Marine beef is a product that has the form of granules/powder, with a moisture content of about 8% that tastes like beef, made through the process of soaking fish meat that has been separated from bones and spines, which are then dried.

In the production of Marine Beef, there is no need for special raw materials, but the fat content and freshness level become things to note, because the lower the fat content, and the fresher the raw materials, the better the quality of marine beef produced. rainbow runner fish protein concentrate becomes one of the ingredients that can be used for the manufacture of marine beef because the fat content is quite low which is 1.22%. Where 1.22% is included in FPC grade B according to FAO [6] with a fat content of less than 3%. The FPC content of Rainbow runner fish is good with a fairly high protein of 77.34%, and low fat of 1.22%, to produce good quality marine beef. Aside from its content, Rainbow runner fish is chosen because this fish has not been widely utilized, so it is expected to increase the production value and consumption of Rainbow runner fish.

6. CONCLUSION

Based on the results of various articles and other literature, we can conclude that the types of sea fish that can be processed into FPCs are tuna, mackerel, anchovies, snapper, and rainbow runner. FPC creation method can be done by methods such as reduction, "wholemeal", dry reduction, and extraction with solvents. Characteristics of FPC obtained from various research conducted is highly dependent on the type of fish and the making method of FPCs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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