Current (2021) status of surimi industry in Indonesia and possible solutions: A review

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Abstract. The surimi industry in Indonesia, especially located on the North Coast Java, has an important role in boosting both regional and national economy. In the last 5 years, the surimi industry has been affected by the policy of prohibiting the use of destructive seine and trawl nets, known locally as cantrang. Most of the surimi industry in Indonesia use bycatches and discards of cantrang as raw material. On the other hand, the policy drives the opportunity to use the aquaculture fishes and non cantrang catches as a raw materials substitution of the surimi. Many laboratory scale observations have shown that aquaculture and small pelagic fish can be used as the raw material for surimi. However, the information around using several species of fish (multi-species) as raw material of surimi is not well provided. Therefore, the purpose of this study was to generate the recommendations regarding the use of multi-species fish as an alternative raw material for the surimi industry to replace the bycatches of cantrang. The information will allow industry both small and medium size to have a better option that suits their need to be able to fulfill the market demand.

1. Introduction

The surimi industry is one of the fisheries processing industries that have great opportunities to be built and developed in Indonesia. World surimi production reached 820,000 MT in 2017, of which 58.5% of the surimi was produced from tropical fish by several countries in Asia (Thailand, Vietnam, India, China, Indonesia, Malaysia, Pakistan and Myanmar) [1]. There are 16 surimi industries in Indonesia, all of which are located in the northern part of the island of Java; Indramayu, Tegal, Pekalongan, Kendal, Rembang, Tuban, Lamongan, Sidoarjo, Pasuruan, and Probolinggo [1]. Thus, the industry plays a significant role in the economy regionally and nationally.

The surimi industries in Indonesia have been experiencing a major problem in the last 5 years. The raw material has been well away as a consequence of the Ministry of Marine Affairs and Fisheries issued regulation No. 2/PERMEN-KP/2015 that prohibited the use of destructive seine and trawl nets, known locally as cantrang. Several surimi industries have started to collapse, correspondingly to the scarcity of raw materials and the increase in fish prices. Surimi industries in Indonesia used pelagic fish that bycatch of cantrang as raw materials such as threadfin bream (68%), goatfish (13%), croaker
(10%), big eye snapper (8%), and other species (1%) [2]. In 2016, it was noted that 6 out of the 16 medium-large scale surimi companies were closed and the rest only produced when the raw materials were still available [3].

The scarcity of raw materials resulted in a decline of surimi exports. Exports volume of surimi in 2014 reached more than 30,000, but it decreased to only 9% of volume in 2017 [3]. However, from January to August 2020, Indonesia has exported 14,043 tons of surimi, this figure is higher than exports in 2017 [1]. Even though the export figure has slowly shown an increasing trend, various efforts need to be made to support the sustainability of the surimi industry in Indonesia. Because of the circumstances mentioned, a new strategy to maintain the existence of the industry needs to be done.

One of possible strategies to strengthen the sustainability of the surimi industry is to use or formulated surimi from varieties of raw materials. This review discusses the current status of the surimi industry in Indonesia in 2021 and several possible solutions. The major problem of the industry is identified, the results of prior research are assessed, and new technology of surimi is considered.

2. Surimi Industry in Indonesia

Surimi is fish meat transformations obtained from mechanical deboned and refined fish myofibrillar proteins. Basically, surimi is a wet concentrate of high-quality myofibrillar proteins from minced fish flesh. Surimi is produced through various processes including heading, gutting, filleting, deboning, washing, dewatering, refining, mixing with cryoprotectants, and freezing [4], [5]. Alaska pollock is the most valuable species for high quality surimi, because of their desirable odor, good gelation properties, good cooking tolerance and white color [6]. Surimi industries in Southeast Asia have used the largest tropical fish resources such as big eye snapper, threadfin bream, lizard fish, ribbon fish, and croaker. They represented 60% of the global surimi production [4].

In Indonesia, surimi industries have been using demersal fish as raw materials for surimi such as kuniran (Upeneus spp), swanggi/big eye (Priacanthus spp), kurisi (Nemipterus spp), beloso (Saurida spp), kapasan (Gerres spp), coklatan (Nemipterus japonicus) and gulamah (Pseudociena amoyensis), which are the main fish caught on cantrang fishing gear [1]. In addition, these species are also commonly found in by-catch fish from shrimp catching vessels which are dumped back into the sea [7]. These fish are cheap, abundant in availability and suitable for raw materials of the surimi industry because they produce surimi with high gel strength [3].

| Table 1. Production, export and domestic market of surimi [8]. |
|--------------------|----------------|----------------|
|                    | 2018           | 2019           | 2020           |
| Total production   | 2,099.2        | 2,652.6        | 2,832.5        |
| Growth (%)         | -              | 26.4           | 6.8            |
| Domestic market    | 508.4          | 725.4          | 794.5          |
| Growth (%)         | -              | 42.7           | 9.5            |
| Export market      | 950.8          | 1,174.3        | 865.9          |
| Growth (%)         | -              | 23.5           | -26.3          |
| Others             | 639.9          | 752.9          | 1,172.0        |

3. Raw material procurement: The main problem

The global fish stock is continuously changing due to environmental conditions and/or overfishing, the global economic situation and also to the government regulation. The main problem of the surimi industry in Indonesia is the decreasing stock of raw materials. It was caused by the over exploitation or overfishing and government regulation. Capture fisheries in Java Island and some parts of Western Indonesia have been overfishing and need to get serious attention, while in Central and Eastern Indonesia that still has abundant fishery resources it is necessary to manage so as not to experience
similar things such as illegal, unreported and unregulated fishing activities (IUU fishing) [9]. In Indonesia, IUU fishing usually coincides to cause over-exploitation. It resulted in economic losses of up to 20 billion dollars annually [10]. Excessive growth in exploitation will cause problems such as: overfishing, stock depletion and environmental degradation [11].

Implementing of regulation No. 2/PERMEN-KP/2015 concerning the prohibition of trawl fishing equipment caused the availability of raw materials for the surimi industry, which has been derived from the production of cantrang fishing gear has decreased drastically. It caused the scarcity of raw materials for the surimi industry [3]. The raw materials that have been used for the surimi industry are affected specifically by the buyers, who usually also give a certain standard of the yielded surimi for their needs. Driven by that fact, the industry at most of the time hesitate to change the raw material from the ones they have been used to different species that are available. In addition, the price of raw material for surimi such as kuniran (Upeneus spp), swanggi/big eye (Priacanthus spp), kurisi (Nemipterus spp), beloso (Saurida spp), kapasan (Gerres spp), coklatan (Nemipterus japonicus) and gulamah (Pseudociena amoyensis) are affordable compare to aquaculture fish. However, owing to over-exploitation of some economic fish species and enforcement of restricted fishing regulations, finding new sources of material is inevitable.

According to the facts, the surimi industry should continuously change and develop the surimi using the new technology and/or alternative fish species [4]. The surimi industry should try to find the alternative fish species that are suitable for making surimi.Unfortunately, the surimi industry is not ready to use other species of fish as an alternative of raw materials. They lack information about the characteristics of alternative raw materials such as gel strength, folding power, and colour to be used for surimi production. Thus, it is desirable to open communication.

4. Possible solutions to address the issue

In order to solve the problem, several possible solutions have been identified. The aquaculture fish are rarely used in the industry, because the yielded surimi typically has lower gel strength compared to the usual raw material. However, recent technology has been used to improve the characteristics of surimi using several species of fish.

4.1. The use of alternative raw materials

Alternative fish species as raw materials for surimi should be cheap, abundant and continuous availability and have good gelation properties. The surimi gel properties are affected by the species of fish used to develop the gel, their chemical compositions and the activity of endogenous proteolytic and transglutaminase enzymes in fish muscle [12].

4.1.1 Aquacultured fish. Some aquacultured fish have characteristics that fulfill the requirements to be used as raw materials in the processing of surimi. The freshwater fish such as red tilapia (Oreochromis niloticus), have thick flesh, white colour, neutral odor, compact and spines that are easily separated from the bones. The supply and availability of aquacultured fish is relatively stable and tends to increase from year to year.

Table 2. Production of aquacultures fish (in tonnes) [8].

| Commodity     | 2015   | 2016   | 2017   | 2018   | 2019   |
|---------------|--------|--------|--------|--------|--------|
| Catfish       | 719.619,02 | 764.796,83 | 1.125.526,35 | 1.027.032,54 | 981.623,40 |
| Common carp   | 461.546,31 | 497.208,31 | 320.940,89 | 534.075,29 | 535.932,92 |
| Tilapia       | 1.084.280,62 | 1.114.156,31 | 1.288.735,03 | 1.169.144,54 | 1.337.831,69 |
| Pangasius     | 339.069,33 | 392.918,17 | 319.967,23 | 373.257,53 | 384.310,48 |
| Giant gourami | 121.544,79 | 137.888,69 | 234.904,36 | 179.424,53 | 187.950,73 |
The functional properties of surimi from aquacultured fish such as *Tilapia mossambicha*, *Osteochilus niloticus*, *Trichogaster pectro*, *Helostoma* sp and *Puntius javanicus* were quite well. *P. javanicus* produced surimi with the good quality, and their properties almost similar to surimi produced from demersal fish [7]. Catfish (*Clarias gariepinus*) has a high protein content and high myofibrillar protein content relative to sarcoplasmic protein, low fat content, high concentrations of glutamine and lysine, and transglutaminase activity that was higher than the protease activity. These properties support the surimi gel formation, thus, catfish is a potential alternative raw material for surimi production [12].

Gel forming ability of common carp, grass carp, and silver carp surimi was inferior to that of alaska pollock surimi, but by setting the processing at appropriate gel-forming conditions, these freshwater fishes can be utilized as raw materials for surimi [13].

### 4.1.2 Captured fish
Captured fish are a potential source of raw materials for the surimi industry. The production of several captured fish are quite high and spread in almost all regions of Indonesia.

#### Table 3
Captured fish which have potential source of raw material for surimi (in tonnes) [8].

| Commodity          | 2015         | 2016         | 2017         | 2018         | 2019 |
|--------------------|--------------|--------------|--------------|--------------|------|
| Layang (*Decapterus*) | 424,890.43   | 423,880.00   | 325,561.72   | 507,626.52   | NA   |
| Belanak (*Moolgarda seheli*) | 68,136.71    | 70,615.00    | 119,531.75   | 84,203.01   | NA   |
| Baronang (*Siganus*) | 47,930.57    | 52,180.00    | 115,937.14   | 97,615.49   | NA   |
| Kuniran (*Upeneus Sp*) | 28,919.72    | 26,280.00    | 29,631.54    | 51,411.57   | NA   |
| Kembung (*Indian mackerel*) | 411,603.48   | 361,737.00   | 443,882.58   | 360,676.96  | NA   |

#### 4.2 Application of technology in surimi process
Application of new technologies in the surimi process have allowed new resources to be used as raw material. In the United States and Canada, surimi production has been using pacific whiting from the west coast by applying the protease inhibitors. Fatty acid fish such as jack mackerel is possible to be processed as materials for surimi with decanter technology and new washing techniques. A pH-shift technology resulted in good quality surimi from giant squid [4].

Microbial transglutaminase (MTGase) has been applied to improve the quality of surimi. Concentration of MTGase, time and temperature were optimised to improve the mechanical properties of silver carp surimi. Quantitative interpretation of the relationship between the operational conditions of the setting during the surimi production was provided by empirical models [14]. MTGase significantly improved the gel strength, WHC, and protein binding, but did not affect the whiteness and pH of surimi from milkfish [15], and chub mackerel [16].

Fiber fortification up to 6g/100g improved texture and colour although some decline occurred with 8g/100g of fiber. Dynamic rheology correlated with texture and showed large increase in gel elasticity, indicating enhanced thermal gelation of surimi. Differential scanning calorimetry showed that fiber fortification did not interfere with thermal transitions of surimi myosin and actin. Long-chain fiber probably traps water physically, which is stabilized by chemical bonding with protein within the surimi gel matrix. Based on the present study, it is suggested that the fiber-protein interaction is mediated by water and is physicochemical in nature [17]. Dietary fibre improved the hardness, elasticity and WHC of surimi from Atlantic (*Scomber scombrus*) and chub Mackerel (*Scomber japonicus*) [16].

Egg white protein (EWP) is a common additive in surimi preparation steps in order to modify the textural properties of the resulting gel. The intended function of this additive is as an enzyme inhibitor to inhibit the “modori” stage (gel-softening phenomenon) during the thermal gelation process to make the products more elastic [18]. Application EWP has improved the surimi properties. EWP improve the gel strength, whiteness, and folding test surimi from pangasius [19], [20] and kurisi
improved the gel strength surimi from belanak and tilapia [22], improved the gel strength surimi from common carp [19].

Soy protein isolate can interact directly with meat proteins, which occupy the interstitial spaces in a gel matrix, water holding properties. Soy protein isolate has been found to have a protective effect against proteolysis [23]. Soy protein improved the gel strength, whiteness, and folding test of surimi from pangasius [20] and Kurisi (Nemipterus virgatus) [21].

The other technology could be applied to improve surimi quality such as carrageenan, Ca-laktat and washing technique. Carrageenan improved the gel strength, whiteness, and folding test of surimi from Kurisi (Nemipterus virgatus) [21] and Pangasius [24]. Ca Laktat improved the gel strength of surimi from pangasius [24]. Tree washing treatment improved the gel strength, pH, whiteness of surimi from baronang (Siganus) [25] and surimi from pangasius [26].

Table 4. Application of technology to improve quality of surimi.

| Application of technology | Commodity          | Result                                                                 | Ref  |
|--------------------------|--------------------|------------------------------------------------------------------------|------|
| MTGase                   | Atlantic (Scomber scombrus) and Chub Mackerel (Scomber japonicus) | MTGase improved the cohesiveness, pH, WHC, and protein binding.      | [16] |
| Dietary Fibre            | Atlantic (Scomber scombrus) and Chub Mackerel (Scomber japonicus) | Dietary fibre improved the hardness, elasticity and WHC.              | [16] |
| Egg white protein (EWP)  | Pangasius          | EWP improved the gel strength, whiteness, and folding test.            | [20] |
|                          | Belanak (Moolgarda seheli) | EWP improved the gel strength.                                         | [19] |
|                          | Tilapia            | EWP improved the folding test.                                         | [22] |
|                          | Common carp        | EWP improved the gel strength.                                         | [19] |
|                          | Kurisi (Nemipterus virgatus) | EWP improved the gel strength, whiteness, and folding test.      | [21] |
| Soy protein              | Pangasius          | Soy protein improved the gel strength, whiteness, and folding test.    | [20] |
|                          | Kurisi (Nemipterus virgatus) | Soy protein improved the gel strength, whiteness, and folding test. | [21] |
| Carrageenan              | Kurisi (Nemipterus virgatus) | Carrageenan improved the gel strength, whiteness, and folding test. | [21] |
|                          | Pangasius          | Carrageenan improved the gel strength, and whiteness.                  | [24] |
| Ca Laktat                | Pangasius          | Ca Laktat improved the gel strength.                                   | [24] |
| Washing                  | Pangasius          | Washing 3 times improved the whiteness.                                | [26] |
|                          | Baronang (Siganus) | Washing 3 times improved the gel strength, pH, and whiteness.          | [25] |

5. Conclusions
The surimi industry in Indonesia should hand in hand with research institutions to conduct research to use alternative raw materials and applied new technology for surimi. A combination of fish can be
used as an alternative raw material to produce high quality of surimi that can penetrate both international and domestic markets. Some new technologies can also be applied to improve the surimi quality. All those potential solutions are worth conducting to anticipate the scarcity of raw materials caused by over-exploitations and restricted fishing regulations by the government.

References

[1] Wasik Z 2020 Pengolahan Surimi: Status Terkini, Peluang dan Tantangannya (Jakarta: BBRP2BK)
[2] Siriraksophon S, Pangsorn S and Laong-manee P 2009 Southeast Asian Fish Dev. Center, Vol. 7(2): 1-8
[3] Hikmayani Y, Aprilliani T and Adi TR 2017 Buletin Ilmiah “MARINA” Sosial Ekonomi Kelautan dan Perikanan. 3 39
[4] Park JW 2014 Surimi and Surimi Seafood (Boca Raton: CRC Press)
[5] Sanchez AM, Navarro C, Perez-Alvarez JA, Kuri V 2009 Food. Sci. Food. Safe. 8 359
[6] Velazquez G, Miranda-Luna P, Lopez-Echevarria G, Vazquez M, Torres JA and Ramirez JA 2008 J. Text. Stud. 39 296
[7] Suryaningrum, TD, Ikasari D and Syamdidi 2020 Sifat Fungsional Surimi dari Berbagai Jenis Ikan Demersal dan Ikan Air Tawar. (Jakarta: In press)
[8] Ministry of Marine Affairs and Fisheries 2021 BKIPM Statistic (Jakarta)
[9] Andriyono S 2018 Inter. J. Life. Sci. Earth. Sci. 1 39
[10] Yunanto A, Halimatussdiah A and Zakaria NA 2018 IOP Conf. Series: Earth. Environ. Sci. 241 1
[11] Malik J, Fahrudin A, Bengen DG and Taryono 2019. J. Ilmu. Teknol. Kel. Tropis. 11 427
[12] Zuraida I, Raharjo S, Hastuti P and Indradi R 2017 Pakistan J Nutr. 16 928
[13] Luo YK, Kuwahara R, Kaneniwa M, Murata Y and Yokoyama M 2001 J. Food. Sci. 66 548
[14] Ramirez JA, Santos IA, Morales OG, Morrissey MT and Vazquez M 2000 Cienc. Tecnol. Aliment. 3 21
[15] Yuliana I, Mahendradatta M and Laga A 2020 IOP Conf. Series: Earth. Environ. Sci. 564 1
[16] Cardoso C, Mendes R, Vaz-Pires P and Nunes M L 2009 J. Sci. Food. Agri. 89 1648
[17] Debusca A, Tahergorabi R, Beamer SK, Matak KE and Jaczynski J 2014 Food. Chem. 148 70
[18] Jafarpour A, Hajiduon HA and Rezaie M 2012 J. Food. Process. Technol. 3 1
[19] Purwadi SD, Darmanto YS and Wijayanti I 2014 J. Pengolahan dan Bioteknologi Hasil Perikanan. 3 52
[20] Wicaksana FC, Agustini TW and Rianingsih L 2014 J. Pengol Biotek Hasil Perikanan. 3 1
[21] Darmanto YS and Riyadi PH 2014 J. Pengolahan dan Bioteknologi Hasil Perikanan. 3 89
[22] Radityo CT, Darmanto YS and Romadhon 2014 J. Pengolahan dan Bioteknologi Hasil Perikanan. 3 9
[23] Hasanpour F, Hoseini E, Motalebi AA and Darvish F 2012 Iranian. J. Fish. Sci. 11 518
[24] Suryaningrum TD, Ikasari D and Syamdidi 2009 J. Pascapanen dan Bioteknologi Kelautan dan Perikanan. 4 31
[25] Wawasto A, Santoso J and Nurilmala M 2018 JPHPI. 21 367
[26] Wiradimadja MMD, Pratama RI and Rizal A 2017 J. Perikanan dan Kelautan. 8 140