Physicochemical characteristics of pempek premix flour made from mackerel fish (*Scomberomorus commersoni*) surimi powder

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**Abstract.** Pempek is known as one of the signature dishes from Palembang, South Sumatera, that is made of a mixture of fish and tapioca flour. Pempek is made through a long process such that the production time-consuming. Pempek premix flour (PPF) is made from a mixture of surimi powder, tapioca starch, and wheat flour, which can be used to make pempek instantly. This study aimed to determine the profile of PPF products based on physicochemical characteristics. This research was divided into two stages. The first stage was the process of making surimi powder from mackerel fish. The second stage was the process of making PPF and physicochemical analysis. The physicochemical characterization of PPF was conducted to obtain information on proximate content, yield, color (L*,+a,+b values), whiteness, gel strength, water absorption capacity (WAC), and microscopic structure. The result showed that PPF contained 12.18% of moisture, 18.3% of protein, 65.55% of carbohydrate, 2.27% of fat, and 1.69% of ash. The results of physical characterization showed that PPF has 97.8 lightness value (L), white color (a=2.7 and b=14.1), 85.8% whiteness value, 885.8 g cm gel strength, and 1.25 ml/g WAC. Microstructure results showed that the PPF had a solid texture appearance with different particle sizes.

1. Introduction

Indonesia is an archipelago country with high fisheries potential. This is indicated by the total national fisheries production, which increases every year. Based on data from the Central Statistics Agency, there was an increase in fisheries production from 2011 to 2016, and in 2017 the total national fishery production reached 23.26 million tons, which was divided into capture fisheries reached 6.04 million tons, and culture fisheries reached 17.22 million tons [1]. Mackerel fish (*Scomberomorus commersoni*) belong to a large pelagic fish group.

Mackerel fish has been widely used in various processed products as a form of diversification fishery products. One effort to diversify mackerel is by processing it into surimi powder. Surimi is mashed meat, which is a protein resulting from mechanical bone separation, and removal of fat components, blood, enzymes, and sarcoplasmic proteins with cold water washing treatment and added antidenaturation material in the freezing process (cryoprotectant) as a stabilizer [2,3,4]. Surimi making is now constantly developing, one of which is the manufacture of dry surimi. Dry surimi is a surimi product that has been largely removed from water content and is generally in the form of powder or flour [5].

Dry surimi products can be used as an ingredient in making instant pempek. Pempek is a traditional food from Palembang North Sumatra [6], made from ground fish meat and tapioca flour [7]. Pempek
contains 18% protein [7] and can be used as a food source of animal protein because it is made from fish meat. There are several stages in making pempek, such as preparation of fish meat, grinding fish meat, mixing ingredients, dough formation, and cooking [8,9]. From that stage, pempek is made through quite a long process and quite time-consuming. In this modern era, society demands everything that is fast and practical in making food, because people can pay much time for their preparation. Therefore people need an instant product that saves time in the process of making pempek.

Pempek premix flour is made from a mixture of surimi powder, tapioca, and wheat flour, which can be used to make pempek instantly. Some researchers have developed premix flour products with the addition of fish meal based on surimi technology. For example, research by Tawali et al (2018) on premix flour formulations for making Otak-otak [10]. This study aimed to determine the profile of pempek premix flour products based on physicochemical characteristics.

2. Materials and Methods
Mackerel fish were purchased from bacan local market in Makassar, Indonesia. The fish was kept on ice at fish: ice ratio of 1:1 (w/w) and transported within one hour to the Laboratory of the Department of Food and Science Technology, Hasanuddin University. Wheat flour, tapioca flour, salt, and garlic were purchased from Giant Supermarket. All processes of making Surimi powder, pempek flour premix, and analysis were conducted at the Product Processing and Development Laboratory, Food Science and Technology Study Program, Hassanuddin University over the period of September 2019 to January 2020.

2.1. Sample Preparation
The surimi preparation procedure was performed according to the method of Seighalani et al. (2017) and Wawasto et al. (2018) with slight modification [11,5]. Fish are washed, weeded, and separated between bones and meat manually. The fish meat was ground using a meat grinder to get minced fish meat. The mince was washed with cold water (10 °C) [12] in the stainless steel bowl at a mince: water ratio of 1 : 3 (w/v). The mixture was manually stirred for 5 min and leave for 10 min; the water was removed by tilting the bowl and squeezing manually. The washing and dewatering process was repeated three times. In the third washing, NaCl was added 0.3% (w/w). After the third washing, the mince was filtered using a nylon screen. Then add 1.5% salt seasoning and 6.67% garlic then mix well.

Surimi samples were dried using the oven drying method following Huda et al. (2012) [13]. The raw surimi samples were placed into 30X30 cm aluminum trays and dried using blower oven at the temperature of 65 °C. During the drying process, the sample was turned over and mixed every hour to ensure even heat distribution throughout the sample. The surimi sample was dried until its moisture content reach less than 10%. The dried sample was milled into powder using a disc mill with 100 mesh sieve. Then surimi flour is mixed with additional ingredients used in making pempek. The ratio between surimi powder, wheat, and tapioca flour is 20%, 40%, and 40%.

2.2. Proximate Composition Analysis
The proximate composition was determined, according to AOAC (2005) methods [14]. Moisture content was determined using the air oven method, and crude protein content was determined using the Kjeldahl method. Fat content was measured with the Soxhlet method, and ash content was determined using the dry ashing method. Carbohydrate content was calculated by difference.

2.3. Percentage of yield
The surimi yield is calculated by comparing the weight of the surimi with the weight of the crushed meat. Mashed meat is weighed as initial weight (a). Then the meat is crushed, washed, and squeezed and then weighed as final weight (c). Then surimi yield is calculated by the equation:

\[ \text{yield} = \frac{a}{c} \times 100\% \] (1)
2.4. Gel Strength
The determination of the gel strength was accomplished according to the method described by Liu et al. (2013) using a texture analyzer [15]. The 2.5 cm long sample was placed under a ¼ inch diameter probe with a measurement speed of 10 mm/sec. Then placed the sample with the cylindrical probe. The strength of the surimi gel was expressed in g/cm², which was the strength of the gel (curve height) (g force), expanding the surface of the contact area of the probes (cm²). The pressure was done once. The measurement results would be printed on graph paper and could be seen high when the sample is completely broken. Gel strength was indicated by the first peak where there was a decrease. Each analysis of gel strength was carried out using two test samples. To calculate 'Gel Strength' insert a column in the spreadsheet and multiply the breaking force by the distance to rupture (cm).

2.5 Whiteness
The color analysis was determined, according to Desbuscaet et al. (2013) method using Chromameter [16]. The color reading included lightness (L), redness (a), and yellowness (b). The equipment was standardized with a white color standard. Then the sample is placed in a tube with the lens covered and the reflectance values (L *, a *, and b *) read on the measuring device.

\[
\text{Whiteness} = 100 - \sqrt{(100 - L^*)^2 + a^* + b^*}
\]

2.6 Water Absorption Capacity
Water absorption capacity was analyzed according to the method of Valdez-Niebla et al. (1993) and Ju and Mittal (1995) [17,18]. One gram of flour mixture is added 10 ml of distilled water, then vortex for 2 minutes. Then it is left for 15 minutes and centrifuged 3000 rpm for 25 minutes. The supernatant is separated, then the sample is weighed. The difference between the weight of the sample after absorbing water and the dry sample per 100 g indicates the amount of water absorbed by the flour.

\[
WAC \% = \frac{\text{bound water (ml)}}{\text{dry sample weight (g)}} \times 100\%
\]

2.7 Microstructure
Microstructure analysis using Scanning Electron Microscope (SEM) with magnification 2000 times. The sample is first dried in a freeze dryer. After the sample preparation is complete, the sample is attached to the metal that has been coated with carbon glue to be coated using gold or metal in a vacuum tube producing a microwave device (magnetron sputtering device) equipped with a vacuum pump. In the vacuum process, a gold metal jump occurs towards the sample so that it coats the gold. The vacuum process takes about 20 minutes. Samples that have been coated are placed at the sample location in an electron microscope, and with the occurrence of electron shots toward the sample, it will be recorded into the monitor, and image capture is taken [19].

3. Result

| Treatment      | Weight before (kg) | Weight after (kg) | Yield (%) |
|----------------|--------------------|------------------|-----------|
| Minced meat    | 10                 | 6.7              | 67        |
| Wash cycle I   | 10                 | 6.2              | 62        |
| Wash cycle II  | 10                 | 5.5              | 55        |
| Wash cycle III | 10                 | 4.5              | 45        |
| Drying         | 10                 | 1                | 10        |
**Tabel 2.** Proximate analysis results.

| Parameter      | Content (%) |
|----------------|-------------|
| Moisture content | 12.18       |
| Protein        | 18.3        |
| Lipid          | 2.27        |
| Carbohydrate   | 65.55       |
| Ash content    | 1.69        |

**Tabel 3.** Physical analysis results of pempek premix flour.

| Physical analysis         | Result |
|---------------------------|--------|
| Gel strength (g.cm)       | 885.8  |
| Whiteness (%)             | 85.8   |
| Water absorption capacity (mL/g) | 1.25   |

**Figure 1.** Scanning electron microscopy results of microstructure from pempek premix flour.

4. **Discussion**

4.1. **Yield**

Surimi yield value is influenced by the process of making surimi, especially the process of washing and drying. The yield of minced mackerel fish after manual deboning was 67%, more than half the overall weight of the fish. This weight is higher compared to Hamzah (2014), who found a yield of minced flesh from Cobia fish was 46.94% [20]. The different weights of minced flesh may be due to larger bone size, less bone, and fat content [20]. According to Santana et al. (2012), differences in yield of surimi can be caused by differences in the proportion of meat and differences in fat content in fish [21].

Table 1 presents the effect of processing on the yield of surimi from minced mackerel flesh. The yield of surimi was 45% after the third wash cycle. The yield of surimi in this study was still higher compared to the yield of surimi black mouth croaker (Atrobucca nibe) from the results of the Hosseini-Shekarabi et al. (2014) which is 36.56% [22]. These results showed that yields of surimi from the minced fish meat decreased with the increased number of wash cycles [22]. According to Tanuja et al. (2014), during the washing process, many dissolved meat components such as impurities compounds, fat, blood, water-soluble protein (sarcoplasm), also dissolved with washing water [23].

The final yield of surimi flour is 10%. A study by Ramadhan et al. (2014) found that the yield of dry surimi produced using the freeze-drying method has a lower yield of 6.41% [12]. The decrease in yield from wet to dry surimi is caused by the drying process at 65°C. Dry surimi yields are affected by moisture content. Loss of large amounts of water will result in shrinking yields. The difference in yield
of dried surimi produced can be influenced by several factors, including the drying method, temperature and fish species used [5].

4.2. Proximate Analysis

Table 2 shows the proximate composition of pempek premix flour. Carbohydrate is the main component in pempek premix flour, followed by protein, water content, fat, and ash content. Premix pempek flour contains 65.55% carbohydrate. The high carbohydrate content is due to the use of ingredients such as wheat flour and tapioca flour, which contributes the most to the carbohydrate content. The protein content of pempek premix flour in this study was 18.3%. The high protein content in pempek premix flour due to the high protein content in raw mackerel fish. The addition of surimi flour contributes to the high protein content of pempek premix flour. Spanish mackerel (Scomberomorus commerson) is classified as large pelagic marine water fish, which has 19.23% protein content [24], and mackerel fish also has a high enough nutritional protein that is 21.4 gr/100 gr fish [25]. In addition, a study by Kolanus [26] found that surimi flour by oven drying method has a high protein level that is 85.46%. Water content in pempek premix flour products is 12.18%. This result has followed the water content regulation standard based on SNI 24 for the type of flour product, which is a maximum of 14%. Water content is an important component that can determine the stability and durability of food products. The lower the water content, the slower the growth of microbes so that food can last longer [26].

4.3. Gel strength, whiteness, and water absorption capacity

Gel strength, whiteness, and water absorption capacity (WAC) of pempek premix flour are shown in Tabel 3. The gel strength of pempek premix flour is 885.8 g.cm. The gel strength of pempek premix flour is affected by the content of amylose and amylopectin in flour and myofibril protein in surimi flour. The amylose structure in starch granules allows the formation of hydrogen bonds between the glucose molecules it makes, and during heating, it is able to form a three-dimensional tissue that traps water to produce a strong gel [28]. Myofibril protein plays a major role in the formation of gel functional properties in meat [29]. Hassan et al. (2017) state that salt soluble proteins, especially myosin and actomyosin, are proteins that play a role in the formation of surimi gels [30]. The interaction between starch in flour and protein gel in fish surimi occurs through the process of developing starch granules in protein gel during the cooking process. The swelling of a starch granule causes strong pressure on the protein matrix accompanied by the withdrawal of water around the protein matrix, resulting in a stronger gel [31].

According to Hidayat et al. (2009), the characteristic of flour water absorption is one of the factors that determine the ability of the dough to expand [32]. The results of water absorption capacity from pempek premix flour are 1.25 ml/g. Some components, such as protein and starch, also determine water absorption. In pempek premix flour there is a protein content from surimi flour and starch from wheat flour and tapioca flour. Proteins can bind water molecules with strong hydrogen bonds; this ability is due to hydrophilic proteins. Kouakou (2013) also reported that polar amino acid residues from proteins have an affinity for water molecules so that they can easily absorb water from products that have high protein content [33]. In flour, there is a protein compound called gluten. The protein is not soluble in water but binds to water to form gluten [34]. The starch content found in tapioca flour and wheat flour also affects the water absorption capacity. According to Hidayat et al (2007), the amylose component is related to water absorption and perfection of the gelatinization process, while the amylopectin component will largely determine the ability of product development power [35].

The brightness value (L) of premix flour is 97.8, while the value of redness / greenness (a) is 2.7 and yellowness/blueness (b) is 14.1. Pempek premix flour has a white degree value of 85.85%. The higher the white degree value means the the product is getting closer to the standard (white). The brightness of pempek flour is influenced by the color of the ingredients used. The comparison of the use of wheat flour and tapioca flour, which is more than surimi flour, affects the color of the premix flour so that the flour is predominantly white. Wheat flour and tapioca generally have higher whiteness than surimi flour. The whiteness of flour, which is 82.17% [36] and a study by Malle (2019), reported that mackerel fish...
surimi flour using the oven drying method had 72.49% white degree [37]. Surimi flour in this study was yellow in color. It was caused by the drying process at 65°C for 8 hours. According to Huda et al. (2012), the use of high temperatures during oven drying can increase the Maillard reaction [13]. The Maillard reaction can contribute to the decrease in the brightness level of surimi flour so that the white degree of surimi flour is lower than the white degree of composite flour.

4.4. Microstructure
The microstructure observation of pempek premix flour with 2000 times magnification, as shown in Figure 1. In this study, the determination of microstructure to see the quality of mixing between surimi flour and composite flour. Microstructure observation showed that overall the pempek premix flour had a solid texture appearance with different particle sizes, but there are also flour grains that are less integrated with one another, this is alleged because the mixing process is done manually suspected as a cause of lack of granules. The study of food microstructure is needed to understand the food component and the relationship between food microstructure and other important food properties that determine the quality of the food [38].

5. Conclusion
The results of this study showed that carbohydrate is the main component in pempek premix flour, followed by protein, water content, fat, and ash content. The results of the physical analysis showed that premix pempek flour has a gel strength of 885.8 g.cm, a whiteness degree of 85.8%, and water absorption 1.25 ml /g. Microstructure observation showed a solid texture appearance with different particle sizes.

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