Characteristics of Instant Mushroom Cream Soup Enriched with Catfish Oil Microcapsules

E Hastarini¹, Nabila², R J Napitupulu¹, S H Poernomo²

¹) Research Center for Marine and Fisheries Product Processing and Biotechnology, Jakarta, Indonesia
²) Fisheries College, Jakarta, Indonesia

Corresponding authors: emahastarini@gmail.com

Abstract. Fish oil generally contains long-chain unsaturated fatty acids, which are fatty acids that have double bonds, for example, Eicosa pentaenoic acid (EPA), and hexanoic acid (DHA). Catfish oil microencapsulation which is rich in omega-3 fatty acids is an attempt to maintain taste, aroma, stability, and also to transfer bioactive components from fish oil for fortification purposes in food or medicine. This study aims to determine the physical, chemical and microbiological characteristics of instant mushroom cream soup enriched with catfish oil microcapsules. The treatment of adding catfish oil microcapsules to instant mushroom cream soup was 0%, 3%, 3.3%, 3.6%. Water absorption index (IPA) values ranged from 1.34-2.46 mL/gr, the water solubility index (IKA) value was 0.04-0.06 g/mL, the results of color testing on mushroom cream soup were with notation L*80.26, a* 1.00 and b* 24.33 on the addition of microcapsules 3.60%. Enrichment of fish oil microcapsules affects the chemical quality of instant mushroom cream soup (water, protein, fat and carbohydrate content). The TPC test value in instant mushroom cream soup has a range of 7.4x10⁴ to 1.63x10⁵ col / g. Staphylococcus aureus test results <2.5x10² cabbage / g, according to SNI standards. The best physical characteristics of instant mushroom cream soup were reached by the addition of microcapsules 3.6%.

Keywords: Characteristics, cream soup, catfish oil, microcapsules

1. Introduction

Indonesia is a maritime country with diverse natural resources. One of its natural resources come from waters. Aquatic commodities that have high economic value in the export market, among others, catfish, tuna, shrimp and seaweed. Especially for catfish, this fish production in Indonesia continues to increase every year along with the demand for consumption fish both locally and export. The Ministry of Maritime Affairs and Fisheries [15] reported that catfish production in 2010 reached 147,888 tons, 2011 (229,267 tons), 2012 (347,000 tons), 2013 (410,883.20 tons), and 2014 (403,132.80 tons), with an increase on average 30.73% [15].

Catfish is not only sold as whole fish, but most catfish in Indonesia are also sold in the form of fresh or frozen filet products. The process of processing catfish usually produces by-products of around 67% of the total catfish [32]. One of the developments of these byproducts based products is fish oil. Fish oil is a component of fat in the body tissues of fish that have been extracted in the form of oil [7].

Hastarini’s [11] study showed that the fat content of body parts of catfish ranged from 2.72% to 35.32%. The head section, the flesh of the belly flap and stomach contents are potential parts used as raw material for making fish oil, namely by yielding coarse fish oil produced by 9.84%, 28.52% and 20.34% for Siam catfish, and for catfish Jambal namely 9.54%, 25.60%, and 30.05%.

Fish oil is a source of omega-3 fatty acids [26]. Dewi (1996) reported that the content of omega-3 fatty acids in lemuru (Sardinella sp.) canning fish oil can reach 29.68%, but according to Shahidi and Wanasundara (1998) high content of unsaturated fatty acids is the cause of damage to oil fish. The technique that can be attempted to maintain stability, prevent rancidity and provide added value to fish oil is microencapsulation [12].
Consumer demand for food products over the past decade tends to lead to foods that contribute to health or the provision of nutrition, prevention of disease and improve physical and mental health without ignoring the ease and practicality of presentation [20, 17]. Instant soup is an instant dry food processed product that can be made from meat, fish, vegetables, cereals or mixtures with or without the addition of permitted food additives. Instant specifications are emphasized on instant components of dry constituent ingredients [4]. The instant cream soup is generally in the form of dry soups made from meat [16], vegetables [34] or mushrooms [27]. Enrichment of instant cream soup is still focused on protein fortification. Milantisari (2005) and Sangadah (2006) reported on the use of broilers as a source of protein in instant cream soup of white oyster mushrooms and shiitake mushrooms. Then Haryasyah et al. (2009) reported on the use of silkworm pupa as a protein source for instant cream soup, so that elemental fortification or other nutritional enrichment that plays an important role in health, such as essential fatty acids [14] still very much needed to be developed. The manufacture of instant mushroom cream soup with the addition of encapsulated fish oil aims to make products have added value and highly nutritious.

The purpose of this study was to determine the quality characteristics of physically, chemically, and microbiologically of instant mushroom cream soup enriched with catfish oil microcapsules.

2. Materials and Method

2.1 Materials

The raw material used is refined catfish oil obtained from the Research Centre for Product Processing and Biotechnology, Jakarta. Maltodextrin as catfish oil coating. The ingredients for making soup consist of button mushrooms, fillers, corn oil, skim milk and spices. The chemicals used in this study were diethyl ether, sulfuric acid, sodium hydroxide, K2SO4.

2.2 Methods

Preparation of Catfish Microcapsules

The stages of making microencapsulation are divided into two important stages, namely the manufacture of emulsions with maltodextrin coatings (emulsification of fish oil) and the making of microcapsules (microencapsulation) using a spray dryer. According to Fang et al. (2003) the microencapsulation process of a liquid-shaped material into a solid form consists of two stages: 1) Involves emulsification of fat with a liquid solution of coating material to produce oil in water emulsion and 2) It involves rapid dehydration of the emulsion. The process of making emulsions can be pure catfish oil seen in Figure 1.
Figure 1. Making Emulsions (a) Homogenization with Ultraturrax (b) Oil Emulsion with Coating (c).

The coating (maltodextrin) is dissolved in distilled water slowly until a solution is formed. The ratio between coating and water is 1: 3. This process can be done with the help of a hot plate stirrer temperature of 60ºC. Catfish oil is put into maltodextrin solution by homogenizing using a homogenizer (ultraturrax) 11,000 RPM for 5 minutes. The composition of fish oil used is 50% of coating material [33]. Stable catfish oil emulsions are formed. Viscosity of catfish oil emulsion needs to be maintained low because it will affect the speed of the spray dryer in the microencapsulation process. The viscosity of the emulsion is higher, so it will be increasingly difficult to suction the device. The resulting fish oil emulsion is then dried using a spray dryer with conditions of inlet drying = 145 °C and T outlet = 110 °C, air flow rate of 73 m3 / hour and feed rate of 5.3 g / minute.

Instant Mushroom Cream Soup Enriched with Catfish Oil Microcapsules

This research was conducted by adding catfish oil microcapsules with a concentration variation of 0%; 3.00%; 3.30% and 3.60% in the formulation of instant mushroom cream soup. Composite ingredients for cream soup in the form of button mushrooms, fillers (corn starch), skim milk, corn oil and spices. After the mixing and homogenization process, drying is done using a drum dryer. The analysis includes physical testing (Water absorption index, Water Solubility Index, color), chemistry (moisture, ash, protein, fat, and carbohydrate) and microbiology (Total Plates Count (TPC) and Staphylococcus aureus).

3. Results and Discussion

3.1 Physical characteristics

Physical characteristics of instant mushroom cream soup with catfish oil microcapsules enrichment include water absorption index (IPA), water solubility index (IKA) in Table 1 and color can be seen in Table 2.

| Parameter | The concentration of addition of catfish oil microcapsules | comparison |
|-----------|----------------------------------------------------------|-------------|
| IPA (mL/g) | Control 2.46±0.01<sup>a</sup> 3.00% 1.34±0.26<sup>b</sup> 3.30% 2.20±0.26<sup>b</sup> 3.60% 2.33±0.20<sup>b</sup> 4.26* | |
| IKA (g/mL) | 0.04±0.01<sup>b</sup> 0.06±0.01<sup>a</sup> 0.06±0.01<sup>b</sup> 0.06±0.00<sup>b</sup> 0.02* | |

Description: The numbers followed by different superscript letters (a, b) on the same line show significantly different (p <0.05).

* Pramestia (2012)

Water absorption index (IPA) shows how much the ability of a food ingredient to absorb water. The greater the water absorption index value, the greater the ability of the material to absorb water if it is reconstituted. Factors that influence the rehydration power of a material are the properties of material particles or porosity and the polarity of the material and its composition. Rehydration power also depends on the availability of hydrophilic groups and macromolecular gel
formation capacity, which is gelatinized starch. The more starch is gelatinized, the greater the ability of the product to absorb water [18].

Data in Table 1 results of various analysis of water absorption index (IPA) of instant mushroom cream soup were significantly different (p < 0.05) by catfish oil microcapsules. The science value of instant mushroom cream soup ranged from 1.34 ± 0.26 mL / g to 2.46 ± 0.01 mL / g. This value is lower than the instant cream soup IPA from fish oil microencapsulation rich in omega-3 fatty acids as a fortification ingredient in instant crab cream soup which is 4.26 mL / g [21].

Instant mushroom cream soup that has a high science value is the control cream soup with an IPA value of 2.46 mL / g when instant cream soup is boiled with water, the instant control cream soup has the best appearance that resembles cream soup before being dried in the drum dryer. Duncan’s test results showed that the effect of adding catfish oil microcapsules to a concentration of 3.00% had a different effect on the control, 3.30% and 3.60%. Water absorption occurs when starch granules from maltodextrin absorb water in the presence of high temperatures in the cooking process. The cooking process with ingredients that have a low moisture content causes partial gelatinization to take place. Insufficient amount of water will cause destabilization of the amorphous portion of starch granule as a result of the penetration of water and heat into the granule [18].

Water Solubility Index (IKA) states the number of particles (grams) dissolved in certain amounts of water (milliliters). Based on Table 1, the value of Water Solubility Index (IKA) was significantly different (p < 0.05) by the addition of catfish oil microcapsules. IKA value of mushroom cream soup ranged from 0.04 ± 0.01 to 0.06 ± 0.01. Duncan’s test results showed that the effect of addition of control catfish oil microcapsules on the value of the Water Solubility Index (IKA) produced differed with concentrations of 3.00%, 3.30% and 3.60%. Increasing the amount of fat can inhibit the absorption of water during the rehydration process. Fats can envelop starch granules in foodstuffs thus blocking the absorption of water against starch molecules in instant cream soup [24].

### Table 2. Color Analysis of Instant Mushroom Cream Soup

| Constanta | Control | 3,00% | 3,30% | 3,60% |
|-----------|---------|-------|-------|-------|
| L*        | 76.67±0.58b | 80.01±0.58b | 79.82±0.58b | 80.26±0.00d |
| a*        | 2.00±0.00d  | 1.67±0.58b  | 2.00±0.00d  | 1.00±0.00b  |
| b*        | 26.00±0.00b  | 24.33±0.58a  | 23.67±0.58b  | 24.33±0.58a  |

Description: The numbers followed by different superscript letters (a, b) on the same line show significantly different (p < 0.05).

Instant mushroom cream soup was analyzed for color using a physical instrument (Minolta CR 300 Chromameter). The color notation system is characterized by three color parameters which are stated with the L *, a * and b * notations. The value L * represents brightness (range of values 0 = black and 100 = white), + a * states the color is reddish and −a * denotes a greenish color, + b * denotes yellow and −b * denotes blue.

Data in Table 2 shows that the brightness notation (* L) was significantly different (p < 0.05) by the addition of catfish oil microcapsules. The brightness level (* L) of instant mushroom cream soup ranged from 76.67 ± 0.58 to 80.26 ± 0.00. Duncan's test results showed that the effect of adding fish oil microcapsules to the control of L * notation was different with a concentration of 3.00%, 3.30% and 3.60%, whereas in a notation * the addition of microcapsules 3.60% was different from that produced by the control, 3.00% and 3.30%. The brightness level of instant mushroom cream soup with the addition of 3.60% fish oil microcapsules is the best. The mixed microcapsules have a white color so that when mixed with instant cream soup, will add white or brightness to the cream soup.
3.2 Chemical Characteristics

Chemical characteristics analyzed include water, ash, protein, fat, and carbohydrate (by difference). The test was carried out on three concentrations of instant mushroom cream soup with catfish oil microcapsules and instant control mushroom cream soup (Table 3).

| Parameter               | The concentration of microcapsules | Addition of catfish oil microcapsules | Comparison          |
|-------------------------|------------------------------------|---------------------------------------|---------------------|
| Moisture content (%)    | Control 3.00%                      | 3.16±0.15 a                           | 4.69±0.31c          |
|                         | 3.30%                              | 3.18±0.05 a                           |                     |
|                         | 3.60%                              | 3.69±0.67 b                           |                     |
| Ash content (%)         | 5.72±0.50 a                        | 5.89±0.07 a                           | 5.79±0.19 a         |
|                         | 3.30%                              | 5.80±0.57 a                           | 10.94**             |
| Protein content (%)     | 1.04±0.04 a                        | 1.35±0.22 b                           | 1.21±0.01 c         |
|                         | 3.30%                              | 1.10±0.01 b                           | 9.99**              |
| Fat content (%)         | 1.60±0.17 a                        | 3.18±0.05 c                           | 3.22±0.20 c         |
|                         | 3.30%                              | 3.34±0.11 b                           | 11.51**             |
| Carbohydrate content (%)| 85.72±0.39b                        | 86.60±0.31 d                          | 86.84±0.08 b        |
|                         | 3.00%                              | 86.87±0.32 a                          | 58.4**              |

Table 3. Chemical Characteristics of Instant Mushroom Cream Soup

Description: The numbers followed by different superscript letters (a, b, c) on the same line show significantly different (p <0.05).

* BN (1996)

**Rubilar et al. (2012)

The moisture content of instant mushroom cream soup has fulfilled the requirement interval for instant cream soup water content according to the National Standardization Agency 01-4321-1996, which ranges from 2% -7%. The value of water content in mushroom cream soup ranged from 3.16 ± 0.15 to 4.69 ± 0.31. Duncan's further test results showed that the moisture content of instant mushroom cream soup concentration of 3.00% was not different from the microcapsule addition concentration of 3.30%, while the effect on the control treatment and concentration was 3.60%. The lowest water content value from instant mushroom cream soup was 3.00% concentration treatment, which was 3.16%. This low moisture content can have a longer durability. According to Sunyoto and Futiawati (2012) materials with a water content of less than 8% can reduce the growth of microorganisms and damaging chemical reactions, such as hydrolysis and fat oxidation.

The ash content in mushroom cream soup was not significantly different (P>0.05) by the addition of catfish oil microcapsules. The ash content in mushroom cream soup ranged from 5.72 ± 0.50 to 5.89 ± 0.07. The value of ash content of addition of catfish oil microcapsules has an increase in the value of instant control mushroom cream soup. This alleged increase is due to the contribution of ash content to maltodextrin which is used as a microcapsule coating material. FAO (1995) states that the standard value of maltodextrin according to DSN (1992) is 50.5%. Ash content is a value that can indicate mineral elements or inorganic substances (Winarno, 2002). The combustion process, the organic matter is burned but the inorganic substances are not. The ash content of instant mushroom cream soup has fulfilled the interval of ash content requirements of instant cream soup according to Rubilar et al. (2012), which ranged from 10.94%. Ash content in higher instant mushroom cream soup indicates that the formula has more minerals or inorganic substances.

The results of variance analysis showed that the addition of fish oil microcapsule concentrations had a significantly different effect (p <0.05) on the protein content of instant mushroom cream soup. Duncan’s further test results showed that the protein content of instant mushroom cream soup with the addition of 3.30% microcapsule of catfish oil gave a different effect on the concentration of 3.00% microcapsules and a concentration of 3.30% gave no different effect on
the concentration of 3.60% and control. Protein content values have a range of 1.04 ±0.04 to 1.35 ± 0.22, the protein content is below the standard of BSN (1996) and cream soup Rubilar et al. (2012). The best protein value is found in instant cream supplement with microcapsule concentration of 3.00%. The process of drying cream soup with a drum dryer with high temperature (drum dryer temperature 80 °C) makes the protein denatured. High temperatures or heat will damage the bonds that make up the molecular configuration so that the molecules will expand. This results in the arrangement of the polypeptide chain of a protein molecule to change, protein denatured (Winarno, 1997). The protein content of instant mushroom cream soup decreased with the addition of fish oil microcapsules, although the levels decreased along with the level of addition (Table 3). The decrease in protein content is due to the influence of the ratio between chemical components which is affected by the addition of fish oil microcapsules, such as the increase in ash, water, and fat levels. The test results of protein content found in lemuru fish oil microcapsules were 0.24 ± 0.04% [21].

The results of the variance analysis showed that the addition of fish oil microcapsules concentration had a significant effect (p <0.05) on the fat content of instant mushroom cream soup. Fat content values have a range of 1.60 ± 0.17 to 3.34 ± 0.11. Duncan's follow-up showed that the fat content of instant control mushroom cream gave a different effect on the value of fat content with the addition of microcapsules concentration of 3.00%, 3.30%, and 3.60%. The fat content of instant cream soup is increasing along with the increase in the concentration of fish oil microcapsules. According to Pramestia (2012), in addition to the addition of fish oil microcapsules, the addition of corn oil can also increase fat levels in instant crab cream soup. Determination of carbohydrate levels by difference results in an estimate of the total amount of carbohydrates, both simple and complex carbohydrates. The results of the analysis of variance showed that the addition of fish oil microcapsule concentration had no significant effect (p> 0.05) on the carbohydrate content of instant mushroom cream soup with a range of 85.72 ± 0.39 to 86.87 ± 0.32. Based on Duncan's further test results, the carbohydrate content of instant mushroom cream soup with microcapsule concentration of 3.60% gave no different value to the carbohydrate content of mushroom cream soup 3 00% gives a different effect with a concentration of 3.30% and control. The high levels of carbohydrates in instant soup are obtained from its constituent ingredients such as corn starch (cornstarch), skim milk, button mushrooms and others [13].

3.3 Microbiological characteristics

Microbiological characteristics of instant mushroom cream soup with enrichment of catfish oil microcapsules includes the value of TPV and Staphylococcus aureus can be seen in Table 4.

| Parameter | The concentration of microcapsules | Comparison |
|-----------|-----------------------------------|------------|
| Control   | 1.63x10⁴ col / g (TPV)            |            |
| 3.00%     | 7.4x10⁴ col / g                  |            |
| 3.30%     | 1.1x10⁵ col / g                  |            |
| 3.60%     | 1.04x10⁵ col / g                 | <1x10⁶*    |
| Staphylococcus aureus | < 2.5 x 10⁵ col / g | < 2.5 x 10⁸* |
|           | 10⁵                               |            |
|           | 10²                               | < 2.5 x 10⁸* |

*SNI 7388:2009 maximum limit of microbial contamination in food

The TPC value of instant mushroom cream soup ranged from 7.4x10⁴ col / g to 1.63x10⁵ col / g. A slightly higher TPC value is likely due to contamination when processed with a drum dryer and poor packaging process. According to Rakhamawati (2012), the dangers of microorganisms are...
related to packaging materials because some materials may be contaminated with microorganisms. Storage conditions must be such that it suppresses the possibility of contamination. Some packaging or containers need to be sterilized before being used or sterilized after the container is filled. Other risks are the inclusion of toxic components from government materials into food ingredients or the transfer of odors from packaging materials to these food products.

The test of *Staphylococcus aureus* instant mushroom cream soup with the addition of microcapsules of catfish oil is known that all treatments show a value of <2x10^2 col/ gr, which has met the SNI 7388: 2009 standard maximum limit of microbial contamination in food. Staphylococcus aureus bacteria are normal human microflora bacteria. These bacteria are usually found in the upper respiratory tract and human skin. S. aureus is a food poisoning bacteria that can cause gastroenteritis due to consuming food containing one or more enterotoxins produced. The toxin produced is resistant to high temperatures, even though the bacteria die by heating but the toxin produced will not be damaged [29] and can still survive even with cooling or freezing [1].

### 4. Conclusion

1. The best physical characteristics of instant mushroom cream soup was reached by the addition of microcapsules 3.6%.
2. In instant mushroom cream soup, the best protein content was reached by the addition of microcapsules 3.0%.
3. The best microbiological characteristics of instant mushroom cream soup was reached by microcapsule addition of 7.4x10^4 col/g, resulting in TPC of *Staphylococcus aureus* <2.5 x 10^2 col/g in all formulations.

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