Surimi from Freshwater Fish with Cryoprotectant Sucrose, Sorbitol, and Sodium Tripolyphosphate

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Abstract. Research has been conducted to produce surimi from freshwater fish (tilapia and snakehead fish). In general, this study aims to determine the process of making surimi from freshwater fish so that the concept of fishery product diversification can be applied. The specific purpose is to study the manufacture of surimi from freshwater fish and to investigate the addition of cryoprotectants consisting of sucrose, sorbitol and sodium tripolyphosphate (STPP) with different concentrations on the quality of frozen surimi. A factorial randomized block design consisting of two factors was used. The first factor was the type of fish, namely tilapia and snakehead fish. The second factor was a combination of cryoprotectants which consists of four levels namely K1 = (2% sucrose, 2% sorbitol, and 0.1% STPP), K2 = (3% sucrose, 3% sorbitol, and STPP 0.2%), K3 = (4% sucrose, 4% sorbitol, and 0.3% STPP), K4 = (5% sucrose, 5% sorbitol, and 0.4% STPP). Parameters analyzed were yield, moisture content, ash content, protein content, pH, water holding capacity (WHC) and folding test. The results showed that surimi from snakehead fish species had high yield, moisture content, protein content, and folding test, but had a low WHC value. The best surimi was obtained from snakehead fish which was added cryoprotectant combination of 5% sucrose, 5% sorbitol, and 0.4% STPP. The surimi has a moisture content of 78.91%, protein content of 19.84%, pH 6.38, WHC 2.08%, and folding test of 3.66 (not cracked after the first folding).

1. Introduction
Surimi is deboned fish meat that has been subjected to leaching and dewatering processes to remove sarcoplasmic proteins and concentrate myofibrillar proteins [1]. In production of surimi, fresh fish is skinned, deboned, and washed. Cleaned fish flesh is then minced, washed in iced water, dewatered by filtration and pressing, blended with cryoprotectant (such as sucrose, sorbitol, and STPP), wrapped, and stored in freezer.

Cryoprotectant protect surimi from protein dehydration, so as to prevent protein freeze-denaturation of myofibrillar proteins during frozen storage, hence preserving the gel-forming ability of surimi. Sucrose, sorbitol, and sodium tripolyphosphate (STPP) are food additives often used with different concentrations in the production of surimi [2],[3].

This study used freshwater fish, tilapia (Oreochromis niloticus) and snakehead fish (Channa striatus). In Aceh, these two types of fish are not common cultivated and underutilized. In harvest
season, fish are abundant, however fish price and fish utilization are low. Therefore, to increase the use of fish that is rarely used, it is necessary to make a diversification of freshwater fish into processed products that are economically valuable such as surimi. The production of surimi employs underutilized fish, result in product diversification of freshwater fish, and generate value-added product.

The purpose of this research is to study the process of making freshwater fish surimi, so that the concept of product diversification by utilizing raw materials for fishery products can be applied. In addition, this study also aims to understand the function of cryoprotectant addition which consists of sucrose, sorbitol and sodium tripolyphosphate (STPP) with different concentrations so that it can produce high quality frozen surimi.

2. Method
Fresh tilapia (Oreochromis niloticus) and snakehead fish (Channa striatus) were obtained from local fish farms. They were deboned directly after gutting and washing with water. Fish flesh that has been weighed and added ice were minced by using chopper. Fish meat that has been minced was washed 5 times using ice water with a ratio of fish and water 1: 5. During the last washing, salt (NaCl) was added as much as 0.30% of the weight of the minced fish. Then the washed minced fish was wrapped using a filter cloth and pressed by using a hydraulic press with a pressure of 50 kg/cm² for 5 minutes. Minced fish then mixed with combination of cryoprotectants i.e, K1 = 2% sucrose, 2% sorbitol, and 0.1% STPP, K2 = 3% sucrose, 3% sorbitol, and 0.2% STPP, K3 = 4% sucrose, 4% sorbitol, 0.3% STPP, K4 = 5% sucrose, 5% sorbitol, and 0.4% STPP. Each surimi sample was subdivided into 2-kg blocks, packed into low density polyethylene bags and freeze until the internal temperature reached – 22 °C, then stored at –20 °C until analysis. The surimi was analyzed for yield, moisture, ash and protein contents, folding test (folding test), measurement of pH (degree of acidity), and water holding capacity (WHC).

Data were collected and analyzed using the completely randomized block design. Analysis of variance was performed on SPSS version 17.0 for Windows.

3. Results and Discussion
3.1 Yield
Surimi yield of tilapia and snakehead fish ranged from 24.76% - 35.23% with an average of 27.73%. The effect of fish species on surimi yield can be seen in Figure 1.

![Figure 1. Surimi yield based on fish species.](image)

Tilapia surimi (N1) had lower yield compared to snakehead fish surimi (N2). The yield of tilapia surimi was 26.15%, lower than the yield of snakehead surimi which was 29.31%. This is presumably because the water and protein contents of snakehead fish surimi were higher than the moisture content of tilapia surimi (Figures 2 and 3).
3.2 Moisture Content

Water is an important component in food ingredients because water can affect the appearance, texture, and taste of food [4]. Water contents of tilapia and snakehead fish surimi ranged from 74.69 to 81.82% with an average of 78.54%. Study showed that the moisture content obtained from some surimi had met the quality requirements of SNI frozen surimi. According to [5], the moisture content of fish surimi is between 80-82%.

Based on analysis of variance, the fish species had a very significant effect (P≤0.01) on the water content of surimi, while the combination of cryoprotectant and interaction between fish species and cryoprotectant combination had no significant effect (P> 0.05) on the moisture content of surimi. The effect of fish species on water content of surimi can be seen in Figure 2.

Figure 2 shows that tilapia surimi (N1) has lower moisture content than snakehead surimi (N2). The moisture content of tilapia surimi was 77.13% while that of snakehead surimi was 79.94%. This is presumably because the water content of each type of fish is affected by habitat and species of fish. Tilapia has water content of 77.8% whereas snakehead fish has a water content of 89%.

3.3 Ash Content

According to [6], ash content reflects the amount of non-flammable minerals contained in volatile substances. Surimi ash content produced from tilapia and snakehead fish ranged from 0.33% - 0.73% with an average of 0.60%.

Based on the analysis of variance, fish species, the combination of cryoprotectant and their interaction had no significant effect (P> 0.05) on the ash content of surimi.

3.4 Protein Content

Protein contents in foodstuffs generally determined the quality of the foodstuff [7]. Protein levels of tilapia and snakehead fish surimi ranged from 8.75 to 26.26% with an average of 16.26%. Fish species had a very significant effect (P≤0.01) on protein content of surimi produced. Whereas the cryoprotectant combinations, and the interaction between fish species and cryoprotectant combinations had no significant effect (P> 0.05) on protein content of surimi produced. Figure 3 shows the effect of fish species on protein content of surimi.
Figure 3 shows that the protein content of tilapia surimi lower than that of snakehead fish surimi. Tilapia surimi had protein content of 13.27% while snakehead surimi had 19.26%. This is presumably because fish protein contents vary based on the fish species. Tilapia had protein content of 20.08% while snakehead fish had protein content of 25.2%. In the surimi process production, not all proteins are desirable. The important protein in surimi production is the miofibril protein, therefore some water soluble protein will be wasted during the washing process. Sarcoplasmic protein is one of the unwanted water soluble proteins which can inhibit gel formation of surimi.

3.5 pH
The pH is one factors that influence surimi gel formation. The pH of surimi produced in this study ranged from 4.44 to 6.70 with an average of 5.27. Based on the analysis of variance, fish species, combination of cryoprotectant and their interaction on the pH of surimi were significant. The effect of fish species, combination of cryoprotectant and interaction between species of fish with cryoprotectant combinations can be seen in Figure 4.

Based on Figure 4, the pH of tilapia surimi tended not to increase, while the pH of snakehead fish surimi increased along with the increase of cryoprotectant concentration. This is presumably because the concentration of cryoprotectant can increase the pH, so that it can produce a chewy texture. This can be seen in the snakehead fish surimi which had a high folding test compared to tilapia surimi. According to [8], the characteristics of a good quality surimi have a pH of 6.5 - 7.0. If the pH value of a product is lower than 6.0, the fish gel will not be formed.
3.6 Water Holding Capacity

Water holding capacity (WHC) is the ability of meat protein to bind water both from the meat itself and from outside. WHC is an important factor in gel formation [9] and is closely related to free water released. The results of surimi WHC analysis from tilapia and snakehead fish ranged from 0.40% - 8.477% with an average of 3.71%. Analysis of variance showed that the fish species and the combination of cryoprotectant had significant effect (P≤0.05) on the WHC value, while the interaction between fish species with cryoprotectant combinations had no significant effect (P> 0.05) on the WHC. The effect of fish species on WHC of surimi can be seen in Figure 5.

![Figure 5. The effect of fish species on surimi water holding capacity.](image)

Based on analysis of variance, surimi water holding capacity of tilapia higher than that of snakehead fish, with WHC of 4.84% and 2.59%, respectively. This is might due to the lower water content of tilapia surimi. Similarly, snakehead fish have a low WHC due to the higher protein and water contents of the surimi. The effect of cryoprotectant combination on WHC of surimi can be seen in Figure 6.

![Figure 6. The effect of cryoprotectant combination on water holding capacity (WHC) of surimi.](image)

Figure 6 shows that all surimi containing cryoprotectant combination had the same WHC except for K3 (4% sucrose, 4% sorbitol, and 0.3% STPP). This findings contrary to the results of [10] which showed that a cryoprotectant combination of 4% sucrose, 4% sorbitol, and 0.3% STPP produced the best surimi with WHC of 64.66%. In the process of making surimi, cryoprotectant serves to improve the ability of water as a binding energy, preventing the exchange of water molecules from proteins so that it can stabilize the proteins. If the proteins damaged, the ability to bind water will be reduced and thus cause the WHC to decrease.
3.7 Folding Test
Folding test aims to determine the level of surimi elasticity subjectively. Folding test of tilapia and snakehead fish surimi ranged from 1-5 (cracked when pressed with the finger to not crack after two folds) with an average of 2.25. Based on analysis of variance, fish species had a very significant effect (P≤0.01) on surimi folding test. While the interaction between combination of cryoprotectant and fish species had no significant effect (P> 0.05) on the surimi folding test. Surimi folding test showed that tilapia surimi had lower folding test of 1.5 (cracked when pressed with the finger to crack immediately after the first folding) compared to that of snakehead fish surimi which had value of 3 (gradually cracked after the first fold). The effect of fish species on surimi folding test can be seen in Figure 7.

The strength applied during surimi folding test depends on the protein contained in the fish. According to [5], fish gel products that have high gel strength will produce a higher folding test and bite test, with a range from 4-5 (AA grade) for folding test and 7-10 for bite test. The higher the folding test, the better the quality of the surimi gel will be.

4. Conclusions
Surimi from the snakehead fish had high moisture and protein content, also had high folding test, but had low WHC. The higher the cryoprotectant concentration, the higher the pH. However, combination of cryoprotectant concentration added gives the same WHC value except for K3 (4% sucrose, 4% sorbitol, 0.3% STPP) which had the lowest WHC. The best treatment was obtained from surimi using snakeheadfish with cryoprotectant combination of 5% sucrose, 5% sorbitol, and 0.4% sodium tripolyphosphate (N2K4). The surimi had moisture content of 78.91%, protein content of 19.84%, pH 6.38, WHC 2.08, and a folding test of 3.66 (did not crack after the first folding).

5. Acknowledgment
We thank Syiah Kuala University, Banda Aceh, Indonesia and Ministry of Technology, Research and Higher Education of the Republic of Indonesia for providing the financial support.

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