The effect of tapioca flour and milk powder on the quality of analog mushroom processed from surimi

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Abstract. Surimi is a myofibril protein concentrate that can be processed into various innovative analog products. Innovation surimi research into analog mushroom products was formulated with tapioca flour (12% & 15%) and milk powder (2.5% & 5%) has been done. The surimi that was formulated using both ingredients and other material was molded and steamed to become a surimi jelly in mushroom shape. Observations of analog mushroom were made on proximate analysis, pH, texture profile, colour, and sensory evaluation. The results showed that the more tapioca concentrations added, will affect of the decrease of ash and protein content, texture profile value (springiness, cohesiveness), and sensory value (appearance, texture and taste), but increase of hardness, brightness (L* value) and yellowness (+b*) of analog mushrooms. While the addition of concentration milk powder has an effect increasing of fat content, brightness (L* value) and texture profile value (gumminess & chewingness). Mushroom analogs treated with 12% tapioca flour and 5% milk powder produce analog mushroom that have physical (lightness, L* value), texture profile value (hardness, springiness, cohesiveness, gumminess and chewingness) and sensory properties (texture and taste) better compared to other treatments

1. Introduction

Surimi is a myofibril protein concentrate that can be processed into various innovative analog products with shapes and colors according to the imitated product. This is based on the ability of myofibril protein to form good protein gels, therefore surimi can be used to make high-quality and value-added seafood products [1]. The gel-forming ability was based on myofibril protein, which can form a strong elastic gel with the addition of salt and heat treatment [2]. In general, surimi-based products were processed by mixing surimi with salt and other additives, then moulding, colouring, and heating to form a final product with the desired texture and attractive colour [3].

Surimi jelly products can be made in various interesting shapes and colors, such as carrageenan/agar jelly. Carrageenan jelly was processed by formulating carrageenan and konjac and KCl, was then moulding and cooled. This technology can be adopted for processing surimi and fish jelly products in order to obtain various products in the form of mushroom, carrot slices, broccoli, quail eggs, etc. Surimi jelly products can be applied to the contents of soup, steam boat, or tom yam as a ready-to-eat food product that is low in fat and cholesterol.
The innovation of surimi into surimi jelly product with various forms such as mushroom and carrot slices with attractive colors and shapes has been studied. The product was formulated using 4% konjac and 0.5% carrageenan and 0.8% KCl into surimi and then colored according to the product was made. The resulting products have chemical, physical and sensory properties that are preferred by panelists [4]. However, surimi which was formulated using konjac is constrained by the price of konjac which is quite expensive and the availability of konjac which is quite difficult at the district level.

Meanwhile, in the surimi-based product industry, tapioca is a flour that was widely used, because it was cheap and easy to obtain, the ability to bind water is high, and is able to form a good gel [3]. The addition of tapioca flour to surimi based products can improve the texture, because tapioca flour has a high level of elasticity, but cannot cook quickly at low temperatures [5]. The use of tapioca in surimi-based products can modify the texture, improve gel stability during freezing, and reduce production costs [6]. In addition, tapioca flour contains high amylopectin which has a branched structure, when heated it forms a double helix structure and forms a flexible and cohesive gel [7]. Meanwhile, the addition of tapioca flour can increase the strength of surimi based products, due to the formation of a 3-dimensional network structure during the gelatinization process [8].

In this study, analogous mushroom will be formulated from surimi with tapioca flour. The amount of flour added was determined based on the product to be processed with the characteristics of the final product based on texture, color, taste, frozen storage and the economic value and price of the product [9]. Beside this, there is a correlation between the amount of tapioca flour added and the quality of the surimi based product [3]. Meanwhile, the type and concentration of tapioca flour that was added can affect the properties of the resulting gel product due to the gelatinization process that occurs during heating [10]. In the processing of fish meatballs, the addition of tapioca flour can range from 15-20% [11, 12]. Whereas for kamaboko which requires a more elastic texture, the addition of tapioca ranged from 8 to 12% resulting in sensory and physical properties of kamaboko that are not significantly different [13]. In general, according Suzuki (1981) the kamaboko producers add starch by 5%-20% to strengthen ashi gel and long-lasting kamaboko gel [14].

To obtain the white color of analog mushroom products, the processor of carrageenan jelly products, using claudy flour. Claudy four is a by-product of palm oil, which was used to obtain egg white color [4]. However, claudy flour is also difficult to obtain in the district level. In this study, to obtain the white color of analog mushroom products, powdered milk which is easily obtained was used. Powdered milk was widely used by fish paste processors in Palembang to obtain a white color with concentration of between 5-10%. This study aims to study the use of tapioca flour and powdered milk as fillers to determine the chemical properties, color, texture and sensory of the resulting analog mushroom [15].

2. Material and Methods

2.1 Material

The material used in this research is surimi obtained from PT Rizky Food Sukabumi, West Java, Indonesia. Meanwhile, other ingredients used are tapioca flour, salt, fresh egg white, full cream milk powder (made by Nestle), mushroom flavor, carrageenan and monosodium glutamate (MSG) and ice water. While the tool used were a food processor, mushroom molding made of silicon rubber material, stove and steaming and a set of tool for chemical analysis.

2.2 Research methods

The variables used in this study were the concentration of tapioca flour 12% (A1) and 15% (A2) and the concentration of powdered milk 2.5% (B1) and 5% (B2) with the formulations used as shown in Table 1.
Tabel 1. Analog mushroom formulation in various treatments.

| Material         | Formulation |
|------------------|-------------|
|                  | A1 B1 | A1 B2 | A2B1 | A2B2 |
| Surimi           | 500 g | 500 g | 500 g | 500 g |
| Milk Powder      | 2.5%  | 5%    | 2.50% | 5%   |
| Tapioca Starch   | 12%   | 12%   | 15%   | 15%  |
| Salt             | 2.50% | 2.50% | 2.50% | 2.50%|
| Mono Sodium Glutamat | 0.4 % | 0.4 % | 0.4 % | 0.4 %|
| Carrageenan      | 0.50% | 0.50% | 0.50% | 0.50%|
| Egg White        | 5%    | 5%    | 5%    | 5%   |
| Mushroom flavour | 2%    | 2%    | 2%    | 2%   |
| Ice Water        | 20%   | 20%   | 20%   | 20%  |

Note :
A1B1 : Tapioca flour 12%, Milk powder 2.5%
A1B2 : Tapioca flour 12%, Milk powder 5%
A2B1 : Tapioca flour 15%, Milk powder 2.5
A2B2 : Tapioca flour 15%, Milk powder 5%

2.3. Analog Mushroom Processing Procedure

The processing of analog mushroom based on previous research [4] by stirring surimi with salt using a food processor (Panasonic brand) for 2 minutes. Then adding ice water and carrageenan and stirring for about 3 minutes until the carrageenan mixed homogeneously. Next, add egg white, milk, mushroom flavor, MSG and tapioca flour and stir for 5 minutes until a homogeneous dough was obtained. The dough then was molded using a mold in the form of a mushroom, by filling the dough into the mold while pressing it until it is solid (Figure 1a). The dough was then steamed with the mold for 10 minutes until the denatured protein and starch gelatinize and form a gel. The molding was then removed from the steamer and the dough was released from the mold, and an analog mushroom was obtained (Figure 1b). The analog mushroom was then steamed again for 10 minutes until cooked. The cooked mushroom was soaked in a 0.5% salt solution and then frozen. The flow diagram of the analog mushroom processing can be seen in Figure 2.
2.4. Observation

Observation of the quality properties of analog mushroom was carried out on proximate analysis was done against to (1) Moisture content: Samples were dried in the oven at 105°C for 18 hour according SNI 01-2354.2-2006. (2) Ash content: Sample was burned at 550 ± 5°C overnight according SNI 01-2354.1-2006. (3) Protein content: protein content determination were based on analysis of the total nitrogen content in the samples, using Kjeldahl method. (SN1 01-2354.3-2006, BSN 2006) and (4) Fat Content: The fat content determined by solvent extraction methods using Soxhlet (SNI 01-2354.3-2006, BSN 2006), and pH analysis: measurement of pH using digital pH meter (Thermo Fisher Scientific Orion). (SNI 698911-2004, BSN 2004) [16].
Texture profile measurements were carried out using the TAXT texture analyzer. (Stable Microsystems, Godalming, Surrey, Inggris). The instrument was equipped with a TA-50 probe (cylinder 50 mm in diameter). Mushroom cylindrical specimens were pressed longitudinally for two cycles. The test conditions were a pre-test speed of 2 mm/s, a pretest speed of 1 mm/s, a post-test speed of 2 mm/s, a time between two cycles of 5 seconds, and a compression rate of 35% of the initial height. Data were obtained based on the output of EXTRAD Dimension Software in the Texture Analyzer operational application. For the uniaxial test, the data obtained is the peak force-deformation when the sample breaks which is expressed in Newtons (N) which is the force required to deform (firmness) the sample. In the TPA test results obtained values that describe the texture profile of the material in the form of hardness (hardness), adhesiveness (stickiness), springiness (elasticity) and chewiness obtained from the Texture Profile Analysis (TPA) curve.

Color of samples was measured using the L*ab Monochromator Minolta. The result of color was stated by the value of L* value which indicates the brightness or darkness. L* 100 value for white and L* = 0 for black, + a* for reddish color, -a* for greenish color, + b* for yellowish color and -b* for greenish color [17].

Sensory test was observed for the level of preference using the hedonic test scale 1-5 (SNI 01-2346-2006) [16] using 25 semi-trained panelists from the Research Center For Marine and Fisheries Product Processing and Biotechnology. The experiment was carried out with 3 replications. Statistical analysis was performed using a completely randomized design (CRD) with the SPSS 16 program.

3. Results and discussion

3.1. Proximate analysis and pH value

The results of the analysis of the proximate surimi was used as raw material had a moisture content of 79.14 ± 0.87%, an ash content of 2.74 ± 0.01%, a protein content of 16.23 ± 1.22%, a fat content of 1.19 ± 0.09% and pH 6.60 ± 0.02. While the results of the proximate analysis of analog mushroom can be seen in Table 2. The results of statistical analysis showed that the treatment of tapioca flour and powdered milk concentrations had a significant effect (p <0.05) on the ash content, protein content and fat content of the analog mushroom product.

The moisture content of analog mushroom in this study ranged from 69.76 - 70.9% (Table 2). In this study, the use of 12% and 15% tapioca flour and the addition of 2.5% and 5% milk did not affect the moisture content of the analog mushroom product. This water content is lower when compared to the moisture content of analog mushroom processed using 4% konjac and 0.8% KCL, which is 83.05% [4]. The high water content of analog mushroom processed from konjac is due to the fact that konjac has a very large ability to absorb water, namely 138-200% [18], so the product is more watery. This low water content causes the resulting analog mushroom to be slightly less juicy.

The results of the analysis of ash content in various treatments ranged from 2.29 to 2.65%. Analog mushroom treated with 12% tapioca flour had a higher ash content and significantly different (p <0.05) from analog mushroom treated with 15% tapioca flour. Conversely, the addition of 5% powdered milk produced analog mushroom which had lower ash content than analog mushroom treated with 2.5% powdered milk. The decrease ash content of analog mushroom treated with 15% tapioca is thought to have originated from the surimi used. In this study, the surimi used had an ash content of 2.74 ± 0.01%, while the ash content of tapioca flour was generally not more than 0.5% [19], so that the addition of tapioca flour concentration resulted in a decrease in the ash content of the resulting analog mushroom. The results of this study are in line with yellow fin nuggets, where the ash content of the nuggets decreases with increasing concentrations of tapioca flour were used [20].
Table 2. Analysis proximate & pH of analog mushroom which processing at various treatments.

| Treatments | Water content (%) | Ash content (%) | Protein content (%) | Fat content (%) | pH       |
|------------|-------------------|-----------------|---------------------|----------------|----------|
| A1B1       | 70.0 ± 0.31a      | 2.65 ± 0.17ac   | 11.33 ± 0.58a       | 0.89 ±0.05a    | 6.99 ± 0.03a |
| A1B2       | 70.1 ± 0.29a      | 2.42 ± 0.21a    | 10.12 ± 0.83a       | 1.21 ± 0.00b   | 7.04±0.01a |
| A2B1       | 70.42 ± .75a      | 2.38 ± 0.08bd   | 9.95 ± 0.73b        | 0.87 ± 0.07a   | 7.09 ± 0.02a |
| A2B2       | 69.76 ±0.36a      | 2.29 ± 0.07b    | 9.61 ± 0.58b        | 1.21 ± 0.04b   | 7.01 ± 0.01a |

Note:
A1B1 : Tapioca flour 12%, Milk powder 2.5%
A1B2 : Tapioca flour 12%, Milk powder 5%
A2B1 : Tapioca flour 15%, Milk powder 2.5
A2B2 : Tapioca flour 15%, Milk powder 5

The results of analog mushroom protein analysis in various treatments ranged from 9.51 – 11.33%, this protein content was slightly higher than the analog mushroom research which was processed using 4% konjac and 0.8% KCl namely 8.03% [4]. The results of statistical analysis showed that the treatment given had a significant effect (p <0.05) on the protein content of the product. The addition of tapioca starch concentration caused a decrease in the protein content of the resulting analog mushroom. The protein content of surimi used in this study was 16.23 ± 1, 22%, and protein content of tapioca flour according Sediaooetomo (2004) per 100 g of sample was 0.59%, fat 3.39% and carbohydrates 6, 99% [20]. While the powdered milk used in this study was full cream powder milk with a protein content of 22. 22% per 100 g and 29.62% fat [21], or in 5 grams containing 1.11% protein or 2.5 g of protein 0.55%. Therefore, the more tapioca flour that was added caused a decrease in the levels of the resulting analog mushroom protein. While, the addition of milk had an effect on decreasing the protein content of the resulting mushroom products, but the decrease was not significantly different.

The results of fat analysis on analog mushroom ranged from 0.87 to 1.21%. The results of statistical analysis showed that the treatment given only affected the fat content of analog mushroom treated with 5% powdered milk. While, surimi which was used as a raw material has a fat content of only 1.19 ± 0.99 and tapioca flour which was used as a filler contains quite low fat, which is 0.59% and the powdered milk used contains 29.62 / 100 gr or 1.48%, every 5 grams of milk added. Therefore the use of powdered milk with a higher concentration will produce analogous mushroom with a higher fat content as well. Fat content in the product will gives a savory taste to the product, also has an affects on the texture, aroma of the analog mushroom [22, 23].

Observation of the pH value shows that the mushroom analog product has a pH value ranging from 6.99 ± 0.03 to 7.09 ± 0.02 which is neutral. The results of statistical analysis showed that the treatment given had no significant effect (p> 0.05) on the pH of the resulting analog mushroom. Surimi used as raw material is neutral with a pH of 6. 60, as well as fillers used such as tapioca flour and powdered milk are also neutral. The pH of the product is closely related to gel formation, in white-fleshed fish the gel will form well at pH 7.0-7.2, whereas if the pH is above 7 it will produce a weak gel, while pH above 7.6 surimi will not form. gel at all [24]. At neutral pH, analogous mushroom will be obtained with high gel strength. The strength of fish gel can be related to the solubility of myofibril protein. Myofibril protein is more soluble at neutral pH conditions or 6.5-7 than at acidic conditions. The pH value which is close to neutral pH causes the solubility of protein to be high and the actomyosin becomes more stable, so that it is expected to produce products that have high gel strength [25].

3.2 Color Analysis
The results of the surimi analysis used have a brightness level with a value of L * = 59, 56 and a reddish color + a * = 0.83 and a yellowish value of + b * = 16, 01. which shows that the surimi was
used in this study has a creamy white color which tends to be yellowish in color. The brightness test results data on the analog mushroom with the concentration treatment of tapioca flour and powdered milk can be seen in Table 3. Based on the results of statistical analysis, it shows that the treatment given has a significant effect (p <0.05) on the lightness and yellowish color of the resulting analog mushroom products.

Table 3. The results of the analysis of the colour using the L*ab monochromator.

| Treatment       | L* (lightness) | +a* (redness) | +b* (yellowness) |
|-----------------|----------------|---------------|------------------|
| A1B1            | 70.93 ± 0.23^a| 0.54 ± 0.13^a| 13.28 ± 0.78^a  |
| A1B2            | 73.74 ± 0.70^b| 0.35 ± 0.06^a| 13.38 ± 0.52^a  |
| A2B1            | 72.42 ± 0.53^ab| 0.40 ± 0.06^a| 13.65 ± 0.14^ab |
| A2B2            | 73.66 ± 1.10^b| 0.37 ± 0.01^a| 13.79 ± 0.42^b  |

Note: A1B1 : Tapioca flour 12%, Milk powder 2.5%
A1B2 : Tapioca flour 12%, Milk powder 5%
A2B1 : Tapioca flour 15%, Milk powder 2.5%
A2B2 : Tapioca flour 15%, Milk powder 5%

Analog mushrooms treated with 15% tapioca flour produced products with better brightness and significantly different (p <0.05) when compared to analog mushroom treated with 12% tapioca flour. Likewise, the addition of powdered milk had an effect on increasing the brightness (L* value) of the resulting analog mushroom, but the lightness level was not significantly different from the analog mushroom treated with 15% tapioca and 5% powdered milk. This is due to the whiteness of the tapioca flour is whiter than the surimi was used. The results of research from various samples of tapioca flour circulating in the market ranged from 95.22-100% [26]. While in this study, the surimi used had a brightness level of L* 59.56 and a value of + a* (redness) = 0.83 and a value of + b* (yellowish) = 16.01, which indicates that the surimi was used is creamy white which tends to be yellowish in color. Therefore, the more tapioca flour was used, the lighter the analog mushroom will be significant, which is indicated by the increasing L* value. Likewise, the addition of 5% milk produced a better lightness level, although for products formulated with 15% tapioca, the increase in brightness was not significantly different (p> 0.05).

The addition of tapioca flour and powdered milk, had no significant effect (p> 0.05) on the degree of redness in the analog mushroom products. Conversely, the more tapioca and powdered milk was used have an effect on the increasing yellowish color of the analog mushroom products. The more tapioca flour, the color of the mushroom product more yellowish. Generally, starch has a much greater proportion of amylopectin when compared to amylose. The amylose content in most starch sources usually ranges from 20-30% and amylopectin 70-80% [7]. Flour with high amylose content will form a creamy white gel, while flour containing high amylopectin will form a transparent gel [27]. In this study surimi was used had a fairly high degree of yellowness, namely + b* = 16.01. Thus the more starch was used, the resulting product more transparent, but it was covered by the yellowish color of the surimi used. So the higher tapioca concentration given the clearer the yellowish color of the analogue mushroom produced.

This addition of milk has an effect on increasing brightness (L* value), but cannot mask the yellowish color of the surimi as raw material. The degree of yellowness (+ b*) of analog mushroom products ranged from 13.28 – 13.79, which decreased slightly when compared to the degree of yellowness of the surimi (16, 01). In this study the milk used is full cream powder milk, which has a yellowish color caused by the presence of fat and beta carotene [28], that has an effect on increasing the yellowish color of the mushroom product. In general, products with high lightness levels and low levels of reddish and yellowish colors are preferred by consumers [29]. Based on this, the product with the formulation of 12% tapioca flour and 5% powdered milk produced the analog mushroom with the
best degree of whiteness with high brightness (L * value), with the lowest reddish and yellowish color levels.

3.3 Texture Profile

The results of the study on the elasticity properties ranged from 0.91-0.94 mm (Table 4). Analog mushrooms are categorized chewy if they are able to withstand external pressure and return to their original shape. It can be seen that the more tapioca was used, the lower the elasticity of the analog mushroom was significantly (p <0.05). Meanwhile, the addition of milk had no effect on the elasticity of the analog mushroom. Actually, the addition of tapioca was expected to improve the texture of the resulting analog mushroom. However, the increasing concentration of tapioca which was added actually has an effect on decreasing the elasticity of the resulting product. This is because the higher the added tapioca starch will require a lot of water for the gelatinization process [30, 2]. Meanwhile, protein molecules at a temperature of less than 50°C will form a 3-dimensional network like a net through the cross-linking of actomyosin proteins where water is trapped in it [2]. The starch-protein system (tapioca - surimi) is different from the water-starch system, because myofibrilair protein will undergo a gel setting first when heated at a temperature of 40-50 °C [8]. This causes the availability of water during starch gelatinization at temperatures above 70°C to be limited, even though the starch grains expand, tapioca flour cannot expand as well as in the water-starch system [31]. Incomplete gelatinization of starch will cause the gel that is formed to be stiff and hard so that it will affect the decrease in the elasticity of analog mushrooms treated with 15% tapioca [3].

Observatin on the cohesiveness of the surimi product is formed due to the attraction between the actin and myosin protein molecules which bind each other to form a compact mass [24]. The addition of salt causes myofibril protein to be easily extracted, than actin and myosin binds easily to form an actomyosin complex, that plays a role in compact gel formation [2]. The results showed that the analog mushrooms treated with 12% tapioca produced a product with higher cohesiveness, if compared to analog mushroom treated with 15% tapioca. The mushroom that was processed with a concentration of 12% tapioca contain more protein than analog mushoom was processed using 15% tapioca. This protein is a myofibril protein derived from surimi that was used. Myofibril protein both actin and myosin plays an important role in the functional properties of proteins such as the gel formation process [24], which causes the gel that was formed in the resulting analog mushroom to be stronger and more compact.

Table 4. Result profil texture analysis of analog mushroom at various treatments.

| Treatment | Hardness (kg) | Elasticity (mm) | Cohesiveness | Gumminess | Chewingness (g/sec) |
|-----------|---------------|-----------------|--------------|-----------|--------------------|
| A1B1      | 1.940 <sup>a</sup> | 0.94<sup>a</sup> | 0.77<sup>a</sup> | 1.507<sup>a</sup> | 1.418<sup>a</sup> |
| A1B2      | 2.284<sup>c</sup> | 0.94<sup>a</sup> | 0.77<sup>a</sup> | 1.775<sup>b</sup> | 1.673<sup>b</sup> |
| A2B1      | 2.225<sup>b</sup> | 0.91<sup>b</sup> | 0.72<sup>b</sup> | 1.469<sup>a</sup> | 1.346<sup>a</sup> |
| A2B2      | 2.173<sup>b</sup> | 0.92<sup>b</sup> | 0.74<sup>b</sup> | 1.622<sup>b</sup> | 1.490<sup>a</sup> |

Note: A1B1: Tapioca flour 12%, Milk powder 2.5% A1B2: Tapioca flour 15%, Milk powder 2.5 % A2B1: Tapioca flour 15, Milk powder 5% A2B2: Tapioca flour 15, Milk powder 5

The addition of salt to surimi causes myofibril protein to be dissolved simultaneously and will form a gumminess texture. Salt will cause molecular ionic bonds between sodium ions (Na +) and protein carboxyl groups (COOH) and Cl - ions with amino acids (CH (NH2) -COOH) which are soluble in the water and produce sticky texture [24]. Soluble myosin combines with actin filaments to produce actomyosin macromolecules and a gumminess paste is formed [25]. The results showed that
the treatment of tapioca flour had no effect on the gummines of the analogue mushroom. Meanwhile, the addition of milk had an effect on the increase in the gummines of the resulting analog mushrooms. This can be related to the addition of milk protein which will increase the molecular ionic bonds of sodium ions with carboxyl groups and Cl ions with amino acids so that the resulting texture of the analog mushroom is stickier [24].

Chewingness is the rate at which a material is subjected to load, then returns to its original state after the burdensome force is removed. In general, the elasticity of fish protein gel is influenced by temperature, heating at a temperature of 50-60°C produces the best textural properties [32]. The results of statistical analysis showed that only analog mushroom treated with 12% tapioca flour and 5% powdered milk produced the best elasticity level, which was significantly different from analog mushrooms treated with other formulations. The resilience of surimi-based products can be attributed to the water-holding capacity. Water binding capacity is an important factor in the formation of flexible / elastic fish protein gels. The interaction between protein and water will affect the texture, juiciness and color, and taste of the surimi processed products [33]. Water binding capacity is influenced by myofibril protein concentration, temperature, the presence of other food components such as fat and salt. In this study, analog mushroom processed with 12% tapioca starch and 5% powdered milk contain protein and fat which can support water-holding capacity so as to produce a product that is more chewy than other formulations.

3.4. Sensory evaluation
The sensory evaluation of mushroom analog was carried out on appearance, odor, taste, texture and overall using the hedonic quality test with a range of 1-5. The results of the sensory analysis can be seen in Figure 3. Panelists gave appearance scores ranging from 3.71- 3.88 which means between neutral and like. The more tapioca flour that was given, the panelist’s assessment give a lower value of the appearance. This can be attributed to the appearance of the product which is less smooth surface. Panelists gave the highest average appearance value for processed products with a concentration of 12% tapioca and 2.5% powdered milk. Analog mushroom products that were processed using these formulations produce products that are clearer and have a smoother surface. This is due to the lower concentration of tapioca and milk powder, so the dough is easily dissolved homogeneously with the amount of water added. The more homogeneous dough when it is printed in molding then heated will cause water molecules to be bound by hydrogen bonds to the hydroxyl amylose and amylopectin groups which cause the development and solubility of starch granules and form products with a smoother surface [34]. Meanwhile the homogeneous dough when heated will gelatinize perfectly and complete gelatinization will produce a more transparent product as a result of the breakdown of the crystalline structure in the starch molecule [27].

![Appearance and Odor Scores](image-url)
Figure 3. Result of sensory evaluation of analog mushroom at various treatments.

Analog mushroom that were formulated with a concentration of 12% tapioca and 2.5% powdered milk have a clearer white appearance. The higher the concentration of tapioca flour and powdered milk used as filler tends to decrease the appearance of the analogous mushroom product. The more tapioca flour and powdered milk were added to produce a product that is less glossy, and the surface is less smooth, causing a decrease in the panelist's assessment of the appearance of analogous mushroom.

Observation of the odor showed that the panelists gave odor values ranging from 3.06-3.55, namely between neutral to like. The volatile compounds contained in the ingredients have an influence on the aroma characteristics of a product. According to Fellow (1992) surimi contains volatile fatty acids and free essential amino acids which are also volatile so that if these components are mixed during processing it will give a savory and fragrant aroma. Furthermore, it was said that the savory aroma that was smelled due to changes in the structure of fat, protein, and carbohydrates during the processing process, will have a strong savory aroma and a slightly fishy aroma. The results showed that the panelists preferred products processed using 15% tapioca flour compared to with 12% tapioca flour. This may be due to the concentration of 12% tapioca, the amount of surimi was used more and when heated produces analogous mushroom products that odor a little fishy. Panelists prefer analogous mushrooms that are processed with 15% tapioca concentration. This is presumably because the heating process will cause the breakdown of hydrogen bond due to rising temperatures and changes in reducing sugar isomers in tapioca which cause a sweet odor, which can mask the slightly fishy smell of surimi. Panelists prefer mushrooms products processed with tapioca at a concentration of 15% and powdered milk 2.5% compared to products processed with other treatments.

In the surimi-based product industry, texture is one of the most important sensory properties whose formation was influenced not only by the functional properties of protein but also by the added starch. The assessment of the texture showed that the panelists gave varying scores ranging from 2.88-3.94 or between slightly disliked, neutral to like. Panelists gave the lowest value for analog mushroom treated with 15% tapioca and 5% powdered milk. This is because the resulting texture is hard and less elastic. While the highest value was obtained from analog mushroom processed using 12% tapioca flour and 5% powdered milk. Products processed with the formulation of 12% tapioca flour and 5% powdered milk produce analog mushroom products that are hard but have chewy and elastic properties. The addition of 10% flour will cause inhibition of the formation of fish protein gel when heated will form a stiff gel, with a less elastic texture. In the surimi industry, the flour was used in the range of 4-12%, however the elasticity of the gel will decrease if the flour used is greater than 8%. Meanwhile, in the protein-starch system the formation of kamaboko gel occurs at a temperature of 40-50°C and absorbs a lot of water, while the starch gelatinization process will occur at temperatures above the gelatinization temperature, namely 70-80°C. At this temperature, part of the water mass has been used for the formation of kamaboko gel, so that the gelatinization that occurs becomes lack of water, so that the swelling of the starch granules is imperfect and the tapioca gel structure formed
becomes very stiff. Therefore, analog mushrooms treated with a concentration of 15% tapioca and 5% milk resulted in a stiff and less elastic product which was less favored by the panelists.

Taste is one important factor in determining panelist acceptance of a product. The taste of analog mushroom that appears is influenced by several factors due to heating, the addition of spices and other fillers to produce a distinctive taste. Panelists gave taste values ranging from 3.41 – 3.88 which means neutral to like. The results of statistical analysis show that the treatment given affects the value of the taste. Panelists tend to give decreasing value as the tapioca flour with high concentration. The highest level of preference for the panelists was obtained from analog mushroom processed from 12% tapioca flour and 5% powdered milk. This is due to the fact that in addition to the higher proportion of surimi and the addition of full cream milk powder which is rich in fat, it will produce a tastier and more savory taste of analog mushroom. Fat in full cream milk comes from fatty acids such as butyrate, palmitic, oleic, and myristic. The presence of these fatty acids in food gives a delicious taste effect and the texture of the food becomes soft and savory [28].

4. Conclusion

From the results of this study, it can be concluded that the addition of tapioca flour concentration has an effect on decreasing the ash and protein content, texture profile (chewiness and cohesiveness), and sensory properties (appearance, texture and taste), but increases the properties of brightness, yellowish color and hardness of the resulting analog mushroom products. Meanwhile, the addition of powdered milk concentration has an effect on increasing the fat content, color (lightness & yellowishness) and texture profile (hardness, stickiness and flexibility of the product). Analog mushroom was processed with 12% tapioca flour and 5% powdered milk formulation to produce products that have bright properties, texture profiles (hardness, chewiness, cohesiveness, stickiness and flexibility) and sensory properties (texture and taste) that are better than other treatments.

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