Textural and sensory properties of little tuna fish balls 
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(Euthynnus affinis) arrowroot flour substitutions (Maranta arundinacea Linn.) added with sodium tripolyphosphate

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Abstract. Physical properties (water holding capacity, cohesiveness, chewiness, springiness) and sensory characteristics (cohesiveness, chewiness, springiness and overall) of little tuna fish balls that substituted with arrowroot flour and added with sodium tripolyphosphate (STPP) were investigated. Substituted little tuna fish ball was added with 0%; 0.1%; 0.2%; 0.3% of sodium tripolyphosphate. Results of this study showed that the addition of sodium tripolyphosphate increased water holding capacity, cohesiveness, chewiness, and springiness parameters with respect to better textural properties of substituted little tuna fish balls (p<0.05). Sensory evaluation test showed that overall, substituted little tuna fish balls with 0.1% addition of STPP were the most favored by panelists. Water holding capacity, cohesiveness, chewiness, and springiness parameters of substituted little tuna fish balls added with 0.1% of STPP were increase up to 4.7%, 9.1%, 8.6%, and 2.0%, respectively. The multiple comparison tests showed that color, odor, flavor parameter of substituted little tuna fish balls added with sodium tripolyphosphate were relatively the same level.

1. Introduction
Little tuna fish is one of the marine catches with a high production amount in Indonesia. Little tuna has a high protein content of 26.2% per 100 g and rich in omega-3 fatty acids [1]. However, the utilization and food processing of little tuna as the main ingredient in food products is still limited. Little tuna fish are usually marketed in the local fish market and most people prefer to consume little tuna fish in the original form, such as fried fish, steamed fish, etc. Little tuna fish has good potential as a major ingredient in a food product and it can diversify little tuna fish into various processed products such as fish balls, nuggets, and shredded fish to increase the consumption number of little tuna. In this study, little tuna fish was used as the main ingredient for fish balls production. Presence study reported that arrowroot flour can be used as a filler for fish balls and was used to substitute tapioca flour because arrowroot flour has a high starch content of 98.10% with the carbohydrate content of 85.2% [2]. Dietary fiber in food product could affect health and able to cure many chronic diseases. Harmayani et al [3] reported that arrowroot flour contained 13.7% of dietary fiber (8.7% insoluble dietary fiber and 5.0% soluble dietary fiber). The good quality parameter of fish balls is influenced by appearance, textual properties and taste, and nutritional value [4]. Surimi has advantages, which can be processed into various products such as kamaboko, fish balls, and nuggets [5]. Surimi has been
used as the main material for little tuna fish balls production and aims to provide good results for its textural characteristic. The utilization of surimi as a major ingredient in the fish product, e.g. fish balls, can provide benefits that are a good gel formation [6].

Surimi is minced fish meat or fish paste that has been washed from sarcoplasmic proteins, lipids, and other fish waste so that it is called a wet concentrate protein [5]. In this study also used sodium tripolyphosphate (STPP) as a gelling agent. STPP is commonly used in the restructured meat product. STPP has the ability to increase the water holding capacity. Glorieux et al state that STPP affects ionic strength by forming polyelectrolytes in water, causing electrostatic repulsion between the meat proteins, which allows more space for binding water and hence, increased WHC [7]. On the other hand, the maximum amount of the application of STPP in a food product which was described by Codex Alimentarius Abried Version is 0.3% of the weight of used meat in processed meat product [8]. Due to the textural characteristic of surimi and gelling formation by STPP in the processed meat product, the textural and sensory characteristics of little tuna fish balls with arrowroot flour substitution with STPP addition were investigated to study consumer acceptance to little tuna fish balls product.

2. Materials and Methods

2.1. Materials

Little tuna was used as the main ingredient for the production process of little tuna fish balls. Little tuna was obtained from the local fish market, Solo (Indonesia). Arrowroot flour as supporting material was obtained from CV. Kusuka Ubiku, Yogyakarta (Indonesia). STPP food grade was kindly provided by a local shop in Surakarta (Indonesia). The other supporting ingredients such as tapioca flour, salt, sugar, egg, and pepper were purchased from Pasar Gede Solo (Indonesia).

2.2. Surimi production

The little tuna surimi processing method was previously described by the Center for Testing the Application of Fisheries [9]. The little tuna fish were cleaned and filleted to obtain only the white meat. The fish was minced and added with ice block to keep the temperature of the minced fish not more than 22°C. The minced fish were mixed, stirred and washed twice with cold water (at 5-10°C) with fish meat and water ratio was 1:4 (v/w). At the second washing step, 0.3% of salt was added into the mixture and then stirred. After that, the washed minced fish meat was pressed with a hand press technique in order to reduce the remaining water. The minced fish meat was added with 2% of sugar. After that, the surimi was stored at -20°C until fish balls processing time.

2.3. Fish ball production

The little tuna fish balls were prepared from surimi and other ingredients (garlic, salt, sugar, and pepper), eggs, tapioca flour, and arrowroot flour. Surimi and other ingredients were weighed according to the specified composition before processing carried out and then, these mixtures were mixed the fish balls dough until well mixed and form a thick dough. STPP were added into the fish balls dough and shaped manually into balls with a diameter of the fish balls up to 2 cm. The uncooked fish balls were boiled in boiling water at a temperature of 100°C. In this study, the arrowroot flour substitutions ratio was 22.5% of total surimi weigh. The concentration of STPP which was added to the fish balls dough was 0%; 0.1%; 0.2% and 0.3%. The percentage of STPP concentration on the fish balls dough was obtained from a preliminary study.

2.4. Analytical methods of little tuna fish balls

The physical, chemical and sensory properties of little tuna fish balls were determined. Textural properties (cohesiveness, chewiness, and springiness) were performed using the Texture Profile Analyzer [10] and water holding capacity (WHC) method described by Muchtadi [11]. Chemical properties i.e. water content was performed using the thermogravmetry method and ash content was analyzed using oven method [12]. All experiments were performed in triplicate. Determination of
sensory evaluation was investigated using scoring and multiple comparison tests [13,14]. In this study, twenty five semi-trained sensory panels have been used to evaluate the sensory characteristics of little tuna fish balls. The panelists should be passed a preliminary screening program, and then the panelist was selected and trained to discriminate differences and communicate their reactions on sensory characteristics of little tuna fish balls.

3. Results and Discussion
3.1. Chemical and Physical Properties of Fish balls

Little tuna surimi as the raw material was investigated before being processed into fish balls. Little tuna surimi contains 73.75% water content, the ash content of 1.02% and 23.27% protein content. The results of the cemical properties of little tuna fish balls showed in Table 1. The highest water content and ash content of little tuna fish balls were achieved by the addition of 0.3% STPP, which was 66.60%. At higher STPP concentration, the water content of little tuna fish balls was an increase. Effect of STPP addition in little tuna fish balls could increase the ability of proteins to absorb the water. Phosphate groups in STPP could bond with NaCl increased the solubility of the protein. This fact was in line with Aulawi and Retty [15] that the addition of STPP can increase the water content and water holding capacity of meat balls. The water content of little tuna fish balls with the addition of STPP has been in accordance with the water content in fish balls product which reported in SNI 01-3819-1995, which was a maximum of 70% (wet basis). The ash content of fish balls shows that the increasing concentration of the STPP addition, the ash content of fish balls tends to increase. Dewanti said this because STPP can bind nutrients which were dissolved in salt solutions such as vitamins, minerals, and proteins so that it can increase the ash content of fish balls [16].

| STPP (%) | Water Content (%) | Ash (%) | WHC (%) | Cohesiveness (%) | Chewiness (%) | Springiness (%) |
|----------|-------------------|---------|---------|------------------|---------------|-----------------|
| 0.0      | 63.53a            | 2.59a   | 61.74a  | 0.44a            | 4197.47a       | 8.51a           |
| 0.1      | 64.20b            | 2.66b   | 64.66b  | 0.48b            | 4556.49ab      | 8.68ab          |
| 0.2      | 65.43b            | 2.77c   | 68.63c  | 0.48b            | 5128.79ab      | 8.76ab          |
| 0.3      | 66.60c            | 2.88d   | 72.50d  | 0.49b            | 5836.66b       | 8.83b           |

*Notation different letters in the same column indicate significant difference at a significance level of 5%*

The textural properties showed in Table 1. The water holding capacity (WHC) of little tuna fish balls was increased significantly different (p<0.05) by the addition of STPP. Water holding capacity of little tuna fish balls will increase as the concentration of STPP increases. Long et al [17] reported that STPP is one of phosphate salt which could improve the water holding capacity, stabilize pH and reduce weight loss when meat products were cooked. Water holding capacity is the ability of protein gels to maintain water. Water holding capacity was strongly influenced by water content, protein and salt use. The higher protein content also could increase the WHC value [18]. Salt gives a large effect on ionic strength and it is able to extract myosin from the structure of meat myofibril. Salt can increase the swelling of the protein structure but does not dissolve protein much [19]. Cohesiveness level of little tuna fish balls with STPP addition is higher than that of the little tuna fish balls without STPP addition. In this study, the addition of STPP could increase significantly (p<0.05) the cohesiveness of little tuna fish balls with STPP addition. Increasing of STPP concentration addition There was no significant difference (p>0.05) cohesiveness value of little tuna fish balls with different concentration of STPP addition. Yuanita reported that the increasing of STPP concentration on tilapia fish balls can
increase cohesiveness properties of tilapia fish balls [20]. In addition, the compact texture was also influenced by the type of flour which was used as a filler, especially those starch content [21].

The previous study reported that STPP which was added as a gelling agent could increase the hardness and cohesiveness properties of meatball [22]. The higher the STPP concentration which was added to little tuna fish balls affected and increased the water holding capacity, hence little tuna fish balls have a chewy texture and more stable [23]. Bonded water in fish balls structure affects the texture of fish balls to become chewy and was not easily destroyed [23]. Elasticity properties of little tuna fish balls were increased with the addition of STPP. STPP has the ability to extract meat protein which could give affect to increase the water holding capacity. Increasing the water holding capacity is caused by the binding power of the water. The elasticity of the fish ball produced was related to the strength of the gel formed during the heating process [24].

An increasing the water content could affect springiness, cohesiveness and hardness properties of little tuna fish balls [25]. Pandisurya reported that the elasticity properties of the fish ball are related to the ability of starch molecules to form gels or elastic three-dimensional networks [26]. The texture of little tuna fish balls with the addition of STPP was also influenced by the use of surimi as raw materials. At the second washing process on surimi processing could eliminate sarcoplasmic protein which can inhibit gel formation and dissolve myofibril protein to form sol actomyosin so it could increase the strength of the gel.

### 3.2 Sensory Properties of Fish ball

Little tuna fish balls were assessed for sensory attributes using an acceptance test (Figure 1) and the differentiation test after production (Figure 2). Based on the acceptance test for cohesiveness, chewiness and springiness parameters, panelists most like little tuna fish balls with the addition of 0.3% STPP. The results of the acceptance test are consistent with the results of the STPP addition of the tuna fish balls test found in Figure 2 which was presented that fish balls with the addition of 0.3% STPP have a stronger cohesiveness than little tuna fish balls without the addition of arrowroot flour and STPP (reference).

![Figure 1](image-url) **Figure 1.** Sensory properties (scoring method) of little tuna fish balls with 0% (●), 0.1% (■), 0.2% (▲), or 0.3% (●) STPP concentration.
Figure 2. Intensity differentiation's score of sensory properties of little tuna fish balls arrowroot flour substitutions with 0% (♦), 0.1% (■), 0.2% (▲), or 0.3% (●) of STPP addition compared to little tuna fish balls without addition of arrowroot flour and STPP (as reference)

Based on the results of the acceptance test and differentiation test, the result showed that the addition of STPP, the cohesiveness of little tuna fish balls was increased. STPP addition could increase texture due to the incorporation of polymer chains, so as to form a continuous mesh that could catch water in it and form a strong, compact and rigid structure [20]. According to [27], the springiness of little tuna fish balls was influenced by water holding capacity. A high water holding capacity indicates that the protein contained in a product was also high, so fish ball becomes more elastic [27]. The overall score of little tuna fish balls with the addition of 0%; 0.1%; 0.2% and 0.3% STPP showed in Figure 1. In general, these results showed the good acceptance of the little tuna fish balls. Overall, little tuna fish balls with 0.1% addition were favored by panelists.

4. Conclusions
Water content, ash content, water holding capacity, and texture (cohesiveness, chewiness, springiness) of little tuna fish balls arrowroot substitution were increased with the addition of STPP. Based on the acceptance test and differentiation test of little tuna fishball substitution with arrowroot flour and of 0.1% addition of STPP was most preferred by panelists.

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