Quality of physicochemical and sensory of mushroom 
(Pleurotus ostreatus) chicken nuggets with carrageenan and konjac as hydrocolloids

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Abstract. Nuggets are mostly made of meat however reducing meat in meat product impact on characterization products. The present study was to investigate the effect of various hydrocolloids (carrageenan and konjac) on the physicochemical characteristic of chicken mushroom nuggets. Four formulations of mushroom chicken nuggets were N0 (non-hydrocolloid), N1 (sodium tripolyphosphate -STPP), N2 (konjac), and N3 (carrageenan). All nuggets were evaluated for moisture content, ash content, color, texture, pH, cooking loss, and sensory evaluation. The moisture content was less than 60 %. The cooking loss and texture of the nuggets was affected (P<0.05) additional of hydrocolloids. The N3 increased cooking loss (11.34) and hardness (1360.14 N). The sensory attributes were not influenced of the additional hydrocolloids. This current study indicated that N2 could be potential as thickener in mushroom chicken nuggets caused the pH value, cohesiveness, and chewiness of N2 were similar (P>0.05) to N1.

1. Introduction

Convenience foods impact on lifestyle at present hence frozen food product becomes a lifestyle choice. Chicken nuggets is one of popular frozen food, that is chicken product made from meat cut to shape and coated of bread flour [1]. Today's consumer preferences are healthy food. Consumptions of fiber have been important because it effects on our system body. Substitution of convenience product is one of ways to improve product being better. However, the desirable sensory of product is substantial factor. Decision of a consumer is not only healthiness food but also sensory expectation.

Mushrooms have been known as source fiber hence they have been used as meat like product. They have unique flavor and beneficial effect. They have rich in protein, high fiber, low cholesterol and rich in amino acid [2]. The nutrition of fresh oyster mushroom ware 88.75% of moisture content, 9.76% of ash, 28.85% of protein, 2.47% of fat, 48.16% of carbohydrate, and 12.87% of fiber [3]. In addition, the texture of mushrooms is similar to chicken meat. The mushrooms had been used to formulation in sausages [4], nuggets [5], patty [6], and meatballs [7]. Chicken nugget is made from meat and flours that is establish batter on emulsion system. The emulsion system will impact on quality of the nuggets. Additional thickening agent is one of methods to preserve the quality of nuggets. Sodium tripolyphosphate (STPP) is food additive that commonly used as a tenderizer [8]. However, the STPP is chemical and its additional is regulated [8]. The hydrocolloids function is food additive as a thickener in coated product like nuggets moreover It will absorb water easily and form a gel [9]. However, it is
important to understand substitute product and food additive prior to the quality of nuggets. The aim of this current study was to investigate the effect of various hydrocolloids (carrageenan and konjac flours) on the physicochemical characteristic of chicken mushroom nuggets.

2. Materials and Methods

2.1. Materials
The mushroom was purchased from BumDes Daya Maju Sambang, WestJava, Indonesia. Chicken meat, seasoning (onion, garlic, shallots, pepper powder, nutmeg powder, salt, sugar) were obtained from local market. While STPP, konjac and carrageenan were obtained from Bandung, West Java.

2.2. Preparation of nuggets
The mushroom was steamed for 15 minutes. The formulation of the nuggets is given in Table 1. All ingredients were mixed and chopped in chopper (Philips). The batter was placed on a baking pan and steamed for 30 minutes. The mixture was cooled at room temperature (±28 °C) and was cut to size 1x1x5 cm. The mixture was coating using flour, egg whites, and bread flour after that the nuggets were baked in oven at 105 °C for 10 minutes.

| Materials               | N0     | N1    | N2     | N3     |
|-------------------------|--------|-------|--------|--------|
| Oyster Mushroom         | 30.27  | 30.27 | 30.27  | 30.27  |
| Chicken meat            | 15.13  | 15.13 | 15.13  | 15.13  |
| STPP                    | -      | 0.34  | -      | -      |
| Konjac flours           | -      | -     | 0.34   | -      |
| Carrageenan flours      | -      | -     | -      | 0.34   |
| Flours                  | 15.89  | 15.89 | 15.89  | 15.89  |
| Condiment               | 27.02  | 27.02 | 27.02  | 27.02  |
| Ice water               | 4.54   | 4.54  | 4.54   | 4.54   |

2.3. The characteristics of physicochemical analysis
The moisture and ash were determined using the gravimetric method according to AOAC [10]. The protein content was determined using Dumas combustion method by DuMAster Buchi D-480. The cooking loss was assayed using method Sheard et al. [11] measured weight of cooked product and raw. The percentage of weight loss was calculated according to Equation 1:

\[ \text{% cooking loss} = \left( \frac{\text{initial mass} - \text{final mass}}{\text{initial mass}} \right) \times 100 \] (1)

The texture profile analysis was examined using texture analyzer TA-XT2 (Microsystems Ltd. Surrey, England, UK) using method of Kumar et al. [12]. All nuggets were cut into cube sized (1x1x2) cm. Setting the condition were pre-test speed 2mm/Sec, test speed 1 mm/Sec, post-test speed 10 mm/Sec, 30% strain mode, 5 seconds time and trigger force 5 g, and stainless-steel cylinder probe 5mm diameter (P35). pH value was analyzed using Kim et al. [13] with modified. Two grams of sample and 10 ml distilled water were homogenized using vortex. pH was determined using a pH meter analyzer (Mettler-Toledo). The color analysis was measured using Konica Minolta Chromameter and color score was performed as CIE Lab.
2.4. Sensory evaluation
The sensory evaluation was processed using hedonic testing. The test was conducted on 30 untrained panelists. The panelist assessed the attributes of color, flavor, texture and overall acceptability assessed through 5 levels (1 very dislike to 5 very like).

2.5. Statistical analysis
The statistical analysis was performed by ANOVA and Duncan’s multiple range test at 5% signification. All measurements were replicated in triplicate and the experiment was done twice.

3. Result and Discussion

3.1. Characteristic of chemical properties
The chemical properties of all nuggets are shown in Table 2. The moisture content of N0, N1, N2, and N3 was 49.95%, 52.00%, 50.73% and 51.96%, respectively. The moisture content was significantly different (P<0.05). The moisture content of added hydrocolloid nuggets was higher than control nugget (N0). This result is similar with previous studies. The addition of carrageenan on the chicken patty affect the increasing of moisture content [14]. The research of Gadekar et al. [15] showed that carrageenan had effect of increasing the moisture content on the goat meat product but not significantly different with control. The use of konjac were increasing 11-12% the moisture content of the reduce reduced-fat frankfurters [16,17]. The result of Ruiz-capillas et al. [18] and Triki et al. [19] research presented that the moisture content of sausage added with konjac were significant higher than control. The moisture content of added carrageenan (N3) was higher than N0 and N2, its similar with the result study of Husain and Huda-Faujan [20]. The moisture content of all nuggets in this study were in accordance with Indonesian National Standard (SNI) for chicken nugget. Base on the SNI, the moisture content of chicken nugget must less than 60% [21]. The water content determine shelf life of product which increasing of water content results microorganisms to multiply [22]. According to additional of hydrocolloid, the moisture content of N2 was the best.

The ranged of ash content for all nuggets were between 1.94 % and 2.02 % and the ash content of N0, N1, N2 and N3 were not significantly different (Table 2). This result was corresponding with SNI that the ash content of chicken nugget must less than 2.5%. The result of previous studies showed that that ash content of chicken nugget of shiitake mushroom powder was 2.37% [23]. Formerly, Husain and Huda-Faujan [20] reported that the ash content of mushroom steams and chickpea flour ranged between 2.93%-3.03%. The ash content of chicken patty and goat meat product that addition of carrageenan was not significantly different when compared to control [14,15]. The addition of konjac on sausage and reduce reduced-fat frankfurter were not affect their ash content [17,19]. Others research showed that konjac was affect the increasing of ash content of sausage and reduce reduced-fat frankfurter [16,18].

The ranged of protein contents for all nuggets were between 19.77 % and 22.11 %. The protein contents of the nuggets were N0 (20.02 %), N1 (22.11 %), N2 (20.09 %), and N3 (19.77). The use of hydrocolloids affects the decrease of the protein content but there were not significantly different. This result is consistent with previous studies. The carrageenan was effect on the had effect on the decline of protein content of the chicken patty [14]. Furthermore, the konjac also affect the decrease of protein content in sausage and reduce reduced-fat frankfurter [16,19]. However, the results of this study are not in accordance with the research of Ruiz-capillas et al. [18] and Lin et. al. [17], where the protein content of sausage and reduce reduced-fat frankfurter were increase with the addition of konjac.

The pH value of all nuggets was 6.10-6.23. Similar study were reported by Husain and Huda-Faujan [20] that pH value of mushroom nugget had range 6.50-6.60. The pH value of konjac, xanthan and shiitake powder nugget formulations was 6.13-6.22 [23]. The pH value of N1 (6.26) and N2 (6.23) were significantly higher than N0 (6.10). Furthermore, the pH value of N3 (6.23) was also higher than N0 but not significantly different. The addition of various hydrocolloids has affected the increasing of pH value on reduce reduced-fat frankfurter and sausage [16,18]. Das et al. [14] and Gadekar et al. [15] described...
that the carrageenan affected the increasing of pH value on the chicken patty and goat meat product but not significantly different when compared to control.

### Table 2. Chemical properties of various meat mushroom nuggets.

| Chemical properties | N0         | N1         | N2         | N3         |
|---------------------|------------|------------|------------|------------|
| Moisture (%)        | 49.95<sup>a</sup> | 52.00<sup>b</sup> | 50.73<sup>c</sup> | 51.96<sup>b</sup> |
| Ash (db%)           | 1.94<sup>a</sup>   | 2.02<sup>a</sup>   | 1.99<sup>a</sup>   | 1.96<sup>a</sup>   |
| pH values           | 6.10<sup>a</sup>   | 6.26<sup>c</sup>   | 6.23b<sup>c</sup>  | 6.14<sup>ab</sup>  |
| Protein (db%)       | 20.02<sup>a</sup> | 22.11<sup>a</sup> | 20.09<sup>a</sup> | 19.77<sup>a</sup> |

Values are expressed as mean ± standard deviation. Means in the same row with different letters were significantly different at p<0.05

3.2. Characteristic of physical properties

The physical properties of the nuggets are presented in Table 3. Cooking loss of N1, N2, N3 were lower than N0. The previous research Luckose et al. [24], the cooking loss of chicken nuggets is 19.61% where is higher than N0. The cooking loss is character where indicated water holding capacity (WHC). The lower cooking loss, the better WHC [25]. Meat protein formed firm stable net of restructured product like nuggets where water and denaturation of protein effected restructured product [26]. Jeong and Han [27] showed that additional fruit with high fiber reduced the cooking loss of sausages. The fiber contributes to bonding water and to keeping fat [26]. The cooking loss of N1 and N2 were not significant different. The STPP is chemical salt while konjac is hydrocolloid. This result indicated that hydrogen bond of hydrocolloid was interacted with meat along mushrooms [13].

The lightness value of the nuggets was N0 (60.84), N1 (61.43), N2 (60.13), and N3 (60.85), respectively (Table 3). The lightness value of nuggets commercial is 64.38-68.41 [28]. The nuggets commercial is made from chicken while added mushrooms can change of the color. The mushrooms have greyish white color that additional mushrooms can decrease lightness [6]. The a-value of N0, N1, and N2 were not significant different, but significantly higher than N3. The b-value was significantly lower (P<0.05) in N1, N2 and N3 than N0. The b-value of mushroom chicken nuggets is lower than chicken nuggets or commercial chicken nuggets where additional mushroom is decreases the yellowness [6]. The lightness, a value, and b value of N2 were significantly lower than control, its consistent with previous studies. The addition of konjac affect the decline of lightness, a value, and b value of sausage and reduced-fat frankfurter [16,19].

The hardness was affected by the additional of hydrocolloids. The hardness of N0, N2 and N3 were no significantly different than N1. According to Wan Rosli et al. [6], additional level of mushroom on patty decreased the hardness. The flour has function as fillers that adequate to bind and to hold water in system [25]. The additional of hydrocolloid may have caused the increased in the hardness. The hardness of chicken patty that added carrageenan was higher than control but not significantly different [14]. The carrageenan forms a rigid gel because of cross linking [29]. The additional of konjac caused the increasing of hardness on the reduced-fat frankfurter and sausage [16,18]. In this study additional of STPP was the highest of the hardness. The STPP increases ionic force that causing meat protein are more elastic [8].

The springiness of N0, N1 and N3 were not significantly different, while N3 was higher than other. It is indicated N0 had enough elasticity. The cohesiveness and the chewiness of N0 was not significant different from N2 and N3. The N1 was the best of chewiness and both of N0 and N2 were the best of springiness. The cohesiveness of N0 was not significantly different than all treatments. The cohesiveness impact on interaction of ingredients [30]. The texture properties of the nuggets in this study are similar with previous studies. The addition of konjac and carrageenan caused the increase of hardness and there were not affect the springiness, cohesiveness, and chewiness of sausage, reduced-fat frankfurter, and
chicken patty [16,18]. The additional STPP increased springiness in ham that was highly bounded in STPP because of interaction between ionic strength of STPP and interference on structure of myofibril [31]. In this study, the nuggets were solid interaction with other ingredients. The N2 had better texture profile than N0 and N3.

Table 3. Physical properties of various meat mushroom nuggets.

| Nuggets | N0       | N1       | N2       | N3       |
|---------|----------|----------|----------|----------|
| Cooking loss | 14.72<sup>a</sup> | 12.65<sup>b</sup> | 11.34<sup>c</sup> | 12.17<sup>b</sup> |
| L<sup>+</sup> | 60.84<sup>ab</sup> | 61.43<sup>b</sup> | 60.13<sup>a</sup> | 60.85<sup>ab</sup> |
| a<sup>*</sup> | 2.65<sup>a</sup> | 2.42<sup>a</sup> | 2.25<sup>a</sup> | 1.77<sup>b</sup> |
| b<sup>*</sup> | 18.43<sup>a</sup> | 16.82<sup>b</sup> | 17.09<sup>b</sup> | 15.52<sup>c</sup> |
| Hardness (N) | 1254.10<sup>a</sup> | 1616.94<sup>b</sup> | 1360.14<sup>a</sup> | 1360.14<sup>a</sup> |
| Springiness | 0.89<sup>ac</sup> | 0.86<sup>ab</sup> | 0.94<sup>c</sup> | 0.82<sup>b</sup> |
| Cohesiveness | 0.75<sup>ab</sup> | 0.75<sup>bc</sup> | 0.79<sup>a</sup> | 0.72<sup>b</sup> |
| Chewiness (N) | 827.96<sup>a</sup> | 1038.73<sup>b</sup> | 898.09<sup>ab</sup> | 808.41<sup>a</sup> |

Means in the same row with different letters were significantly different at p<0.05

3.3. Sensory evaluation

The sensory evaluation of mushroom chicken nuggets with various hydrocolloids are shown in Fig. 1. The flavor, texture, and taste of N0, N1, N2, and N3 was not significantly different. The color and overall of N1 was the highest. However, the color and overall of others treatment (N0, N2, and N3) were accepted by panelist which based on the overall was more than 3 (like). The additional hydrocolloids had positive result on sensory characteristics of the nuggets. Previously, Nayak et al. [1] and Nafiah et al. [32] disclosed that additional carrageenan was not affected preference panelist. The result of this study consistence with previous that the additional of konjac was not change sensory evaluation [19]. This result indicated that additional konjac (N2) or carragenan (N3) could be accepted as well as additional STPP (N1). In this study seem additional hydrocolloids (N2 and N3) were suitable alternative to STPP (N1) substitutes.

Figure 1. Sensory evaluation of mushroom chicken nuggets with various hydrocolloids.
4. Conclusion
The mushroom chicken nuggets expose possibilities of hydrocolloids to improve texture. The moisture content and pH value were affected by additional of hydrocolloid, whereas N2 was better than N3. Furthermore, the additional hydrocolloids were affected the cooking loss and textures. The cooking loss, lightness (L-value), and hardness of N2 were higher (P<0.05) than N0 and N3. Sensory attributes of the mushroom chicken nuggets were unaffected by additional of hydrocolloids. The study describes that konjac and carrageenan can be used to replace STPP without noticeable changes in sensory. Hence, the mushroom chicken nuggets can be made without added hydrocolloids or salt (STPP) that the sensory evaluation is not different from addition of hydrocolloids. The additional of konjac (N2) was better of physicochemical properties of mushroom chicken nuggets.

Acknowledgments
The authors are grateful to thank for Research Center for Appropriate Technology, Indonesian Institute of Sciences (LIPI) for providing access and technical support.

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