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Physical and Organoleptic Properties of Chicken Nugget from Domestic Chicken (*Gallus domesticus*) Meat with Different Corn Flours as Filler

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Abstract The research aims to understand the physical and organoleptic properties of the Indonesian domestic chicken (*Gallus domesticus*) nugget made with different corn flours as filler. The research was done in two research steps. The first step was to observe the physical properties of the chicken nugget through a completely randomized design, where five different corn flours were used and measured six times each. The second step was to observe the organoleptic properties of the chicken nugget through two-factorials completely randomized design with five different panellists (P1, P2, P3, P4, and P5) were the first factor and different corn flours were the second factor. The corn flours used in this research were yellow-corn (J1); fluffy-corn (J2); purple-corn (J3); Provit A1-corn (J4); and Provit A2-corn (J5) flour. The measured variables include cooking loss, flavor, aroma, texture, and color of the chicken nugget. The results showed that J1 chicken nugget had the lowest cooking loss at 1.27%, while the organoleptic measurements showed that J4 chicken nugget had the best organoleptic properties. The research concluded that the usage of Provit A1-corn (J4) flour would give the best overall physical and organoleptic properties of chicken nugget made from domestic chicken meat.

Introduction

One of the popular processed chicken meat products is a chicken nugget. A chicken nugget is made from seasoned ground chicken meat, covered by flour and bread crumbs. The mixture is then half-fried and frozen to maintain its quality during storage (Permadi *et al*., 2012). Gumilar *et al*. (2011) further explained that the making of chicken nuggets required a filler which binds water yet not causing emulsification. In addition, the usage of carbohydrates as filler in chicken nuggets would reduce the production cost regarding that meat as the main ingredients are usually more expensive (Abubakar *et al*., 2011).

In Indonesia, people prefer domestic chicken meat over commercial broiler chicken meat. According to Koswara (2009), domestic chickens are more active in foraging, resulting in low-fat content and drier meat. The water content in younger broiler chicken meat is at around 71%, while on the domestic chicken meats (which is usually slaughtered at an older age) is at 60-66%. Moreover, chicken meat also contains high lactic acid, which helps improve its taste. In every 100 grams of domestic chicken meat, it contained 302 calories, 18.2 g of protein, 25 g of fat, 14 mg of calcium, 200 mg of phosphorus, 1.5 mg of iron, 810 SI of vitamin A, 0.08 mg of Vitamin B1 and 55.9 g of water (Departemen Kesehatan, 1981). The nutritional

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value of domestic chicken meat thus showed the potential to be processed for consumption.

Corn flour is one of the carbohydrates that can be used as fillers in making chicken nuggets. Corn flour has the ability to bind and hold the water during cooking (Wellyalina & Aisman, 2013). Suarni (2009) explained that the size of corn starch is large enough to resist heat and moisture. In addition, corn is one of the functional foods that are good for health. Corn has rich functional components such as dietary fibers, essential fatty acids, isoflavone, Fe minerals, β-carotene (pro-vitamin A), essential amino acids and others. The consumption of dietary fiber is known to provide immunity against various diseases such as colon cancer, cardiovascular disease, and obesity.

It is widely known that the corn varieties and concentrations would affect chicken nugget qualities. The physicochemical properties that should be considered in selecting corn varieties include Water Holding Capacity (WHC), Oil Holding Capacity (OHC), and emulsion properties of the corn. The water and oil absorption capacity give an overview of the corn's ability to bind water and oil, which would affect the final product qualities after being processed. In accordance, Wellyalina & Aisman (2013) explained that one of the factors which affect chicken nuggets qualities is the amount or concentration of the added fillers, thus it becomes necessary to understand the best corn flour concentration in making chicken nuggets.

Processing techniques also play an important role in determining chicken nuggets' qualities. According to Rhee *et al*. (2003), the main challenge in meat restructuring technology is on how these products could have both good physical and chemical qualities, even in its raw form or after being processed. Different variations of raw materials, formulations, and cooking methods would have resulted in different physical, chemical, and nutritional properties of the restructured meat products. As example, meat processing in high temperatures would cause protein denaturation, followed by coagulation, decreased solubility of the products (Permadi *et al*., 2012), and decreased beta-carotene content (Mastuti, 2008). Frying is the process of transferring heat by using oil as a medium, where the surface temperature could reach more than 100°C. The temperature in frying would also affect appearance, taste, fat absorption, storability and economic factors of the food. In general, the longer the frying time would be resulted in more oil absorption, while lower temperature would cause unwanted damage in food. Erwati (2001) added that wider surface area of the fried food resulted in more oil absorption. In this study, we determine the physical and organoleptic properties of the fried domestic chicken nuggets which used five different corn flours as filler materials.

Materials and Methods

Materials

The materials used in making the chicken nuggets in this research were 400 g of domestic chicken meat and 10% (w/w) corn flours as filler, then added with 250 g of bread flour, 2.5% (w/w) salt, 10% (w/w) garlic, and supplementary ingredients such as ice cubes, skim milk powder, cooking oil, corn oil, peppers were added accordingly to needs.

Chicken nuggets

The chicken nuggets were made by following Tanoto (1994). A total of 400 g chicken meat was grounded and then added with ice, salt, sugar, pepper, garlic, skim milk, and corn oil. The corn flour was then added as much as 40 gr (10% of meat weight) on the dough and mixed until homogenous. The dough was then molded, put into a plastic-coated aluminum, and then steamed at 70°C for 30 minutes. The nugget was then rested until it reached room temperature before kept into a refrigerator for 30 minutes. The dense dough was then cut at

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the size of 4 cm length and width, and 1 cm thick. The nugget pieces were then coated with flour batter made from 80 g of cornstarch and 100 ml of water, smeared with bread crumbs, egg washed, and smeared again with bread crumbs before fried. The frying was done in two steps consisted of initial frying and final frying. The initial frying was done at 170°C for 30 seconds, and the fried chicken nuggets were packed in plastic bags and stored in a freezer, while the final frying was done at 170°C for 4 minutes.

Methods

This research was carried out through two experimental steps. The first step was to observe the physical characteristic of domestic chicken nuggets by measuring its cooking loss through a completely randomized statistical design, consisted of five different fillers (corn flours) and repeated six times each. The corn flours used this research were yellow-corn flour (J1); fluffy-corn flour (J2); purple-corn flour (J3); Provit A1 corn flour (J4); and Provit A2 corn flour (J5). The second step was to observe the organoleptic properties of the chicken nugget, which consisted of taste, aroma, texture, and color through a two-factorial completely randomized design. The first factor was five panelists for the organoleptic test, namely: *P1 = panelist 1; P2 = panelist 2; P3 = panelist 3; P4 = panelist 4;* and *P5 = panelist 5,* and the second factor was five different corn flours (J1, J2, J3, J4, and J5). Furthermore, in the second step, a total of 25 treatment combinations were obtained (*P1J1, …, PnJn*), and each combination was done in triplicates. The collected data were analyzed by using analysis of variance (ANOVA) and further tested by Duncan's Multiple Ranged Test (DMRT). The cooking loss measurement of the chicken nugget was calculated as follows:

$$\%\ Cooking\ loss = \frac{raw\ weight - cooked\ weight}{raw\ weight}\ x\ 100$$

The organoleptic tests were carried out by five panellists consisted of scientists and postgraduate students of the Faculty of Animal Husbandry, University of Brawijaya, Malang, who are familiar with chicken nuggets. The organoleptic properties of the chicken nugget were measured in 5-point descriptive scores, with a score of 5 indicates extremely desirable properties, and the score of 1 indicates extremely undesirable properties. The more detailed organoleptic scores for each parameter were described in Table 1.

Table 1. Organoleptic properties scoring of the chicken nuggets

Parameters	Scores				
	1	2	3	4	5
Taste	Unpleasant	Not tasty	Rather tasty	Tasty	Delicious
Aroma	Aberrant	Corn dominant	Balanced	Chicken meat dominant	Chicken meat aroma
Texture	Very rough	Rough	Rather rough	Rather smooth	Smooth
Color	Aberrant	Dark brown	Light brown	Brownish-yellow	Golden yellow

Results and Discussion

The results of statistical analysis on the effect of different corn flours to the physical (cooking loss) and organoleptic properties (taste, aroma, texture, and color) of nuggets from domestic chicken meat are presented in Table 2 and 3.

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Cooking loss

The results of the statistical analysis showed that the domestic chicken nuggets filled with yellow-corn flour (J1) had the lowest cooking loss, followed by Provit A2 corn flour (J4) and Provit A1 corn flour (J5), which were 1.27%, 1.35%, and 1.44%, respectively. Moreover, the highest cooking loss occurred in the chicken nugget filled with purple-corn flour (J3) at 4.69% and followed by fluffy-corn flour (J2) at 3.06%.

Table 2. The effect of different corn flours on the cooking loss of domestic chicken nuggets

	J1 (%)	J2 (%)	J3 (%)	J4 (%)	J5 (%)
Means	1.269 ± 0.301^{a}	3.055 ± 0.148^{c}	4.690 ± 0.281^{d}	1.353 ± 0.069^{ab}	1.436 ± 0.064^{b}

Description: Different superscripts in the same column indicates significant differences (P<0.01)

Deep frying can be defined as the process of cooking foods by immersing food into the frying oil with a temperature of 150-200°C, which is well above the boiling temperature of water (Ni & Datta, 1999). Moreover, Farkas *et al.* (1996) added that during deep frying, an intensive heat transfer process occurred, and expected to produce significant internal vaporization and pressure generation as a function of the porous structure of the product. Moreover, during the deep frying, a process of oil absorption would occur in the product. Saguy & Pinthus (1995) mentioned that oil absorption occurs as moisture is removed from the food during frying and the amount of oil uptake has been shown to be directly proportional to the amount of moisture loss (Saguy & Pinthus, 1995). In this study, the chicken nugget was deep fried at 170°C two times, the initial frying was for 30 seconds and the second frying was for 4 minutes. Our previous research (Ma'ruf *et al*., 2019), showed that the Provit A2 corn-flour had higher WHC compared to yellow corn flour, this thus indicates that even though the yellow corn flour had lower WHC, the flour had higher oil absorption capacities compared to the Provit A2 corn-flour.

The cooking loss in this study is still lower compared to the commercial chicken nuggets, which are in the range of 3.37-13% (Lukman *et al*., 2009). Cooking loss is one of the parameters which reflect the water-holding capacity of processed meat. Qin (2013) stated that the lower cooking loss indicates the better water-holding capacity of the meat products. The usage of corn flours as fillers in the chicken nuggets, especially, yellow-corn, Provit A1 and Provit A2 corn flours, resulted in a low cooking loss, which showed that the chicken nugget has a good water holding capacity. On the other hand, the cooking loss is also synonymous with emulsion stability. It is an important parameter for assessing the quality of meat products. Lukman *et al.* (2009) showed that emulsion breakdown would occur with the increasing temperature, thus causing cooking loss. The physical properties of processed meat are mainly affected by the cooking loss and the water-resistance of the product during processing which can be observed on the changing of color, texture, juiciness, and tenderness. Kowale *et al*. (2008) added that the protein content in processed meat is responsible for both cooking loss and its water holding capacity.

Organoleptic Properties

Tenderness of meat products, along with flavor and color are the main organoleptic qualities that influence consumers' overall judgement (Wood *et al.*, 1995). They can be influenced by several production factors (genetics, feeding systems, etc.) and processing

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techniques (chilling, marinating, cooking). Therefore, to be able to enhance product quality, meticulous measurements of processing steps need to be conducted and optimized (Warkup, 1993). In this study, we observe the utilization of domestic chicken meat and various corn-flour to the organoleptic qualities of chicken nugget as described below.

Taste

The results showed that the taste of domestic chicken nuggets was in the range of 3.33 (rather tasty) to 5 (delicious), where a rather tasty chicken nugget was obtained in the P3J1 and P4J1 treatments, while the delicious chicken nugget was obtained in the P1J3, P1J5, P1J4, P1J2, P3J3, P3J5, P3J4, P3J2, P4J5, and P5J4. The interaction between organoleptic panelists and the use of different corn flours had a very significant effect ($P<0.01$) on the taste of the chicken nuggets. However, the DMRT analysis showed that P1J3, P1J5, P1J4, P1J2, P3J3, P3J5, P3J4, P3J2, P4J5, and P5J4 were not significantly different ($P>0.05$) from P2J3, P2J4, P4J3, and P4J4, where these treatments also resulted in a delicious chicken nugget.

It can be seen from the result that rather tasty chicken nuggets resulted from the usage of yellow-corn flour as filler, while other corn flours (fluffy-corn, purple-corn, Provit A1-corn, and Provit A2-corn flour) resulted in the delicious taste of chicken nuggets. However, panelist 1, 2, and 5 (P1, P2, and P5) stated that the usage of yellow-corn flour as filler resulted in tasty chicken nuggets. Overall, the usage of yellow-corn flour resulted in the least taste score of all measured chicken nuggets. A more detailed result of taste measurement can be seen in Table 3. The insignificant taste difference between corn flour varieties indicates that corn flour did not affect the taste of the chicken nugget. Previous research showed that the major factor which affect the taste of chicken nugget is the seasoning, such as sodium chlorides, polyphosphates and sugar (Barbanti & Pasquini, 2004). In this study, the only difference between each treatment was the different variety of corn flour, while the other ingredients such as the seasoning remained the same. The similar ingredients aside from the corn flour variety thus allegedly caused the similar taste score.

Aroma

The obtained score of the domestic chicken nuggets aroma was around 3.33 (balanced aroma between corn and chicken meat) - 5 (chicken meat aroma), where the balanced aroma was found in P2J1 and P2J3 treatments, and the chicken meat aroma was found in P1J3, P1J5, P1J4, P1J2, P2J2, P3J3, P3J5, P3J4, P3J2, P4J5, P4J4, and P5J4. Furthermore, the interaction between organoleptic panelists and the usage of different corn flours had a significant effect ($P<0.01$) on the aroma of the domestic chicken nuggets. The DMRT test showed that the chicken nugget with chicken meat aroma (P1J3, P1J5, P1J4, P1J2, P2J2, P3J3, P3J5, P3J4, P3J2, P4J5, P4J4, and P5J4) had significant differences ($P<0.05$) to P4J2, and a highly significant differences ($P<0.01$) to P2J1 and P2J3 which had balanced aroma. Subsequently, P2J4, P3J1, P1J1, P2J5, P5J1, P5J3, P5J5, and P5J2 (dominant chicken meat aroma), were also significantly different ($P<0.05$) from P4J1 and P4J3.

Table 3. Organoleptic tests on the domestic chicken nuggets with different corn flours as filler

Treatments		Flavor	Aroma	Texture	Color
P1	J1	4.00^{c}	4.00^{cd}	4.33^{bc}	4.00^{c}
	J2	5.00^{a}	5.00^{a}	4.00^{cd}	4.00^{c}
	J3	5.00^{a}	5.00^{a}	4.33^{bc}	4.00^{c}
	J4	5.00^{a}	5.00^{a}	4.00^{cd}	4.00^{c}

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Treatments		Flavor	Aroma	Texture	Color
	J5	5.00^{a}	5.00^{a}	4.33^{bc}	4.00^{c}
P2	J1	4.33^{bc}	3.33^{e}	3.33^{e}	4.33^{bc}
	J2	4.00^{c}	5.00^{a}	5.00^{a}	4.33^{bc}
	J3	4.67^{ab}	3.33^{e}	4.33^{bc}	4.67^{ab}
	J4	4.67^{ab}	3.67^{de}	3.67^{d}	4.67^{ab}
	J5	4.00^{c}	4.00^{cd}	3.67^{d}	4.67^{ab}
P3	J1	3.33^{d}	3.67^{de}	4.67^{ab}	4.00^{c}
	J2	5.00^{a}	5.00^{a}	5.00^{a}	4.00^{c}
	J3	5.00^{a}	5.00^{a}	5.00^{a}	4.00^{c}
	J4	5.00^{a}	5.00^{a}	5.00^{a}	4.00^{c}
	J5	5.00^{a}	5.00^{a}	5.00^{a}	4.00^{c}
P4	J1	3.33^{d}	4.33^{bc}	4.00^{cd}	4.33^{bc}
	J2	4.00^{c}	4.67^{ab}	4.33^{bc}	4.33^{bc}
	J3	4.67^{ab}	4.33^{bc}	4.33^{bc}	4.00^{c}
	J4	4.67^{ab}	5.00^{a}	4.33^{bc}	4.67^{ab}
	J5	5.00^{a}	5.00^{a}	5.00^{a}	4.00^{c}
P5	J1	4.00^{c}	4.00^{cd}	4.33^{bc}	5.00^{a}
	J2	4.00^{c}	4.00^{cd}	5.00^{a}	4.00^{c}
	J3	4.33^{bc}	4.00^{cd}	4.67^{ab}	4.00^{c}
	J4	5.00^{a}	5.00^{a}	5.00^{a}	5.00^{a}
	J5	4.00^{c}	4.00^{cd}	4.33^{a}	5.00^{a}

Description: Different superscripts in the same column indicates significant differences

There are many criteria that would affect consumer decisions to buy meat products, some of them were the product's appearance, taste, aroma, and texture. In general, consumers prefer high-quality and safe meat products that contain natural tastes and aromas (Aymerich *et al*., 2008). Flavor, which mainly affected by two factors, namely: taste and aroma, is considered as the most important factor that influences consumer's habits and preferences of buying meat products before the product is eaten (Sitz *et al*., 2005). In the production of domestic chicken nuggets in this study, even though most of them were dominated by the proportion of chicken meat, the role of the used corn flour also contributes both in taste and the aroma of the chicken nuggets.

In this research, it is shown that even though the highest proportion in the chicken nugget ingredients was the domestic chicken meat, corn flour also contributes to the organoleptic properties of the nugget. This was caused by the use of Provit corn flour as a filler would yield higher amylopectin in corn starch which makes it easier to gelatinized (Corn Refiners Association, 2006), then allows nutritional components, such as amino acids, amylopectin and corn fatty acids bind to the nutritional components in the solution of domestic chicken meat. Rahayu (2015) stated that Provit A corn rich in amino acids, amylopectin and β-carotene. Amylopectin affects the organoleptic properties of the corn, especially on its texture and taste. In principle, higher amylopectin content would have resulted in softer, fluffier, and tastier corn. Moreover, the composition would also influence its amylographic nature (Suarni & Widowati, 2016).

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According to Brunton *et al*., (2002) and Jayasena *et al*. (2013), Maillard reaction, lipid thermal degradation and Maillard-lipid interactions are considered to be the main reactions, which produce flavor and aroma during cooking meat products. Brunton *et al*. (2002) reported, there were approximately 500 volatile compounds identified in cooked poultry meat, the majority of which were identified in chickens. Mottram (1998) suggested that free sugar, sugar phosphate, sugar bound nucleotides, free amino acids, peptides, nucleotides, and other nitrogen components such as thiamine are considered as flavor precursors in meat. The chicken flavor is associated with the presence of free amino acids, including glutamic acid and nucleotides, such as inosine-5'-monophosphate (IMP) (Takahashi *et al*., 2012). Similar to other meats, lipids play an important role in the development of poultry meat flavor (Pérez-Alvarez & Fernández-López, 2010).

Texture

The results of the organoleptic test showed that the texture of domestic chicken nugget was ranging from 3.33 (rather rough) to 5 (smooth), where a rather rough texture was obtained in P2J1 treatment, while the smooth texture was obtained in P2J2, P3J3, P3J5, P3J4, P3J2, P4J5, P5J4, and P5J2. The interaction between organoleptic panelists and the usage of different corn flours had a highly significant effect ($P<0.01$) on the texture of chicken nuggets. Furthermore, the DMR test showed that P2J2, P3J3, P3J5, P3J4, P3J2, P4J5, P5J4, and P5J2 (smooth texture) treatment were not significantly different ($P>0.05$) from P3J1 and P5J3 treatments, but significantly different ($P<0.05$) from the treatments P1J1, P1J3, P1J5, P2J3, P4J3, P4J4, P4J2, P5J1, and P5J5 (slightly smooth texture), and highly significant different ($P<0.01$) from P2J1 treatments (rather coarse texture), P1J4, P1J2, P2J5, P2J4, and P4J1 (slightly smooth texture).

The texture is considered important in the processed meat product characteristics, such as in chicken nuggets, which would determine the level of consumer acceptance of the product. Robbins *et al*. (2003) stated that in addition to taste, tenderness and juiciness are the most important factors of texture with respect to customer satisfaction. Juiciness measures the amount of liquid stored in the product. Consumers usually prefer juicier product because of its better mouth feel. The lower moisture retention and more shrinkage in thinner meat products then explained the lower juiciness percentage compared to thicker meat (Das *et al*., 2013)

The results of this study indicate that the chicken nuggets which have a rather smooth texture are dominated by nuggets with fluffy-corn flour (J2), Provit A1-corn flour (J4) and Provit A2-corn flour (J5) as filler. This is regarding the corns used are rich in starch, especially amylopectin, which at the time of cooking undergoes an irreversible gelatinization process, then resulted in a strong water binding capacity. Suarni & Widowati (2016) stated that higher the amylopectin content resulted in softer, fluffier and tastier corn. In contrast, El-Dirani (2002) reported changes in the texture of fried chicken nuggets were caused by physiochemical changes that mainly occur in the dough and breading. It is reported that the loss of moisture, protein denaturation, and starch gelatinization are the main factors that affect the changing texture.

Color

The results of organoleptic test showed that the color of domestic chicken nuggets was ranging from 4 (brownish yellow) to 5 (golden yellow), where the brownish-yellow chicken nugget is obtained in P1J1, P1J3, P1J5, P1J4, P1J2, P3J1, P3J3, P3J5, P3J4, P3J2, P4J3, P4J5, P5J3, and P5J2, while the golden yellow chicken nugget was obtained in the P5J1, P5J5, and P5J4. The interaction between organoleptic panelists

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and the usage of different corn flours were significantly affected (P<0.05) the color of domestic chicken nuggets. The DMR test showed that P5J1, P5J5, and P5J4 (golden yellow) were not significantly different (P>0.05) from P2J3, P2J5, P2J4, and P4J4 treatments, but significantly different (P<0.01) from P1J1, P1J3, P1J5, P1J4, P1J2, P3J1, P3J3, P3J5, P3J4, P3J2, P4J3, P4J5, P5J3, and P5J2 (brownish yellow), also significantly different (P<0.05) from P2J1, P2J2, P4J1, and P4J2 treatments (brownish yellow color).

Kilincceker (2013) stated that the color attributes of fried chicken products can visually enhance the product's preferential ability as it would affect consumer preferences by increasing food attractiveness. Based on the statistical tests, there are six treatment interactions that had a golden yellow color, namely: P5J1, P5J5, P5J4, P2J3, P2J5, P2J4, and P4J4. Attractive golden yellow color characteristics of free-range chicken nuggets in this study were influenced by the decomposition process of protein contained in domestic chicken nugget dough, which interacts with carotene pigments both from the fat of the domestic chicken meat and the corn flours during frying and resulted in golden yellow color.

It can be seen that chicken nugget with Provit A1 and A2-corn flour had a golden yellow color. It is regarding that both of the corn flours contained higher β-carotene which caused the golden yellow color in the chicken nugget. Das *et al*. (2013) stated that the color properties arise from several chemical reactions during frying, including protein denaturation, starch gelatinization, and Maillard reaction from dough and breading which affect the color of the crust. In accordance to Barbut (2015), caramel content and other components in food can increase the browning by Maillard reaction. In accordance, Kilincceker (2013) reported that carotene and protein pigments caused blisters on the cooked chicken meat and gives rise to a golden yellow color.

Conclusions

The research concluded that the usage of Provit-A1 corn flour (J4) as filler gave the best overall results, both on physical properties and organoleptic properties of the chicken nuggets made from domestic chicken (*Gallus Domesticus*) meat.

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