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Physicochemical Properties of Dangke Nuggets with the Addition of Corn Flour (*Zea Mays L.*)

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ABSTRACT

This study aimed to analyze the effect of dangke nuggets with the addition of corn flour on the physicochemical properties of dangke nuggets. This study used a completely randomized design (CRD) factorial pattern with three replications and three treatments. The first factor was corn flour addition level of 0%, 5%, and 10%, and the second factor was storage time of 0, 14, and 28 days in the freezer. Physicochemical testing included the Cooking Loss test, nugget breakability, water content, protein content, and fiber content. The results showed a correlation between the corn flour addition level and the storage time, which had a significant effect ($P<0.01$) on the Cooking Loss, water content, protein content, and fiber content of dangke nuggets. At the same time, there was no correlation between the corn flour addition level and the storage time for shear force, which had no significant effect ($P>0.05$). Based on the study, it can be concluded that the addition of 5% corn flour to the formulation can increase protein content. In comparison, adding 10% corn flour provides the best quality in terms of cooking loss, nugget-breaking power, and water content and increases the fiber content of the nugget. The longer the storage, the lower the water content and protein content, reducing the quality of cooking loss and nugget-breaking power.

Keywords: Dangke, nuggets, corn flour, physicochemical properties

INTRODUCTION

Dangke nuggets are one of the innovations of dangke products. The short shelf life and easy damage of dangke cause the product's market reach to be limited [1]. Processing dangke nuggets is one of the efforts to increase shelf life and expand marketing and consumers to various regions in Indonesia to provide animal-based food with high nutritional value [2].

Nuggets are very popular in our society, especially for children. Over time, nuggets have many variations with different brands. Besides being made from meat, other ingredients can also be made into nuggets, such as vegetables, tofu, and tempeh [3]. Another material that can be

made into nuggets is dangke. The short shelf life of Dangke cheese is classified as very perishable [1]. The efforts to increase storage time and expand marketing and consumers to various regions in Indonesia can contribute to providing animal-source food with high nutritional value [2].

The steaming process can cause the release of liquid in the meat, affecting the deliciousness and nutritional value of the nuggets, so it is necessary to add binders or fillers [4]. The selection of binders and fillers must have good water absorption, taste, attractive color, and affordability [5]. One of the fillers commonly used in making nuggets is wheat flour because wheat flour contains protein in the form of gluten, which can play a role in helping to form the texture and elasticity of the product.

Wheat flour consumption in Indonesia continues to increase yearly, and the raw material for making wheat flour is generally imported. One effort to reduce dependence on imported raw materials is to use flour from local food ingredients to produce a food product [6]. One of the local foods that can be used is white glutinous corn flour. White glutinous corn has a soft or chewy texture and a high water absorption capacity compared to other types of corn [6]. Corn flour is perfect for emulsion products because it can bind and hold the water during cooking. Corn flour also has paste properties that are not sticky, have viscosity, can form a chewy gel, and are stable at high heating temperatures [7].

Corn flour filler attracts water in the dough and forms a chewy texture. The mechanism of the filler is to bind the water in the material so that there is no free water that emulsifies with fat or non-free water because free water can cause the dough to become inelastic [8]. The type of corn used to make corn flour is waxy corn with a fluffy or chewy texture, which absorbs water more than other kinds of corn. Waxy corn is widely cultivated, especially in eastern Indonesia, and Sulawesi is the center of waxy corn production [9]. Waxy corn that has been made into corn flour contains 7.75% water, 2.64% ash, 18.67% protein, 11.61% fat, 4.29% crude fiber, 3.62% amylose, 61.28% starch, and 16.04% water absorption [10].

Cooking Loss is the weight lost during cooking; the higher the cooking temperature and the longer the cooking time, the greater the loss of liquid content in the meat until it reaches a constant level [11]. Shear force (DPD) is a test to determine the meat's toughness level. The lower the shear force value of the nugget, the more tender it is, and vice versa; the higher the shear force value of the nugget, the more challenging it is [12].

Water content is the amount contained in the material expressed in percent. Water content in food is one of the determinants of the freshness and durability of a food ingredient. Based on SNI 01-6683-202, the maximum water content of nuggets is 60%. The water content dramatically affects the quality of the nuggets produced. The higher the amount of water content in a product, the faster the product is damaged, and vice versa; the lower the product's water content, the longer the product's life will be under standard storage conditions [13].

The protein content of food is generally used to measure its quality. Protein levels are influenced by the ingredients used during the nugget-making process. Still, during food processing, there can be a decrease or damage to nutrients that occurs gradually both during and after processing. The minimum protein content of nuggets is 12% (SNI 01-6683-202) [14].

Previous researchers, Hatta et al. [2], have researched “Soluble Protein Content, Crude Fiber, and Hardness in Dangke Nugget Using Red Rice Flour as Filler in Different Steaming Periods.” This research aimed to determine the level of red rice flour as filler and the optimum steaming period for dangke nuggets based on soluble protein, crude fiber, and hardness. It can

be concluded that red rice flour at 20% can be used as filler to partially substitute between two formulations with a steaming period of 30 minutes. Fauzanin et al. research [15] has examined "The effect of replacing some wheat flour with corn flour on the production of chicken meat nuggets." This study aims to determine the effect of corn flour as a partial replacement of wheat flour on chicken nuggets and determine the optimum level of corn flour used to achieve optimal production. It can be concluded that the level of corn flour substitution is best obtained at P1 treatment (10% substitution),

Based on the content of corn flour, it is used as a filler in making dangke nuggets. Its addition is expected to improve the quality of cooking losses, nugget-breaking power, water content, protein, and fiber content of the nuggets.

MATERIALS AND METHODS

The tools used in this research were scales (Haston), a food processor (Philips), pots, pans, gas stoves, baking sheets, stirrers, knives, plates, blenders, freezers, stopwatches, test tubes, rack tubes, spectrometers, micropipettes, and water baths.

The materials used in this research were dangke from Enrekang Regency, soft corn obtained from traditional markets, wheat flour, ice cubes, eggs, salt, garlic, pepper, flavorings, breadcrumbs, food plastic, labels, and cooking oil. This research used a Completely Randomized Design (CRD) with a 3 x 3 factorial pattern with three replications each. Factor A is the substitution of wheat flour with corn flour in dangke nuggets A1 (70% Dangke + 10% wheat flour + 0% corn flour), A2 (70% Dangke + 5% wheat flour + 5% corn flour), A3 (70% Dangke + 0% wheat flour + 10% corn flour). Factor B is the long storage treatment for dangke nuggets in the freezer, B1 (0 days), B2 (14 days), and B3 (28 days).

Preparation of Corn Flour

The procedure for making corn flour refers to the modified method of Suarni [16] preparing waxy corn samples, which are shaken and then soaked for 8 hours. The corn is dried and ground using a machine until smooth, followed by a sieving process to produce corn flour with the desired fineness. Then, the flour is dried again to reduce the water content. The dried corn flour was put into plastic and tested for antioxidant content.

Preparation of Cupcake Nuggets

The procedure for making dangke nuggets refers to the modified method of Hatta et al. [17] weighing the ingredients used. Dangke, egg yolk, ice cubes, and salt are put into a food processor and ground for 2 minutes (until mixed), then add other ingredients such as wheat flour, corn flour, onions, pepper, and flavoring and grind again until all ingredients are mixed. The prepared dough is put into a baking tray and steamed for 30 minutes. The cooked dough is then cooled and cut into square pieces. Pieces of dangke nuggets were coated with a solution of wheat flour and coated with bread crumbs and then put into plastic, and then stored in a freezer for 15-30 minutes for the 0-day storage treatment so that the bread crumbs were more attached to the nuggets and for other treatments stored in the freezer for 14 and 28 days and antioxidant testing

was carried out. Nuggets stored in a refrigerator are ready to be fried in hot oil until they produce a golden yellow color and then drained, and organoleptic testing is carried out.

Measured Variable

Cooking Loss

The nugget Cooking Loss test is measured by weighing the sample before and after steaming at a temperature of 80^0 C [18]. The formula for finding Cooking Loss is:

Cooking Loss (CL) is calculated using the formula:

$$CL = \frac{B1-B2}{B1} \times 100\%$$

Description:

CL = Cooking Loss Value %

B2 = weight loss

B1 = sample weight

Shear Force of Nuggets

The sample was cut to a length of ± 2 cm, and several cuts were made. The cored sample was then placed in the hole of the CD-Shear Force tool. The degree of softness is indicated by the force (kg/cm3) required to cut the sample.

$$DPD\ (Kg/Cm^2) = \frac{A}{L}$$

Description:

DPD = Dangke Breakability Value $(Kg/Cm)^2$

A = Tensile Load (Kg)

L = Cross-Sectional Area of Sample $\pi . R^2 = 3.14 \times 0.0635^2 = 1.27\ cm^2$

π = 3.14

R = The radius of the sample hole (0.635 Cm)

Water Content

Determination of water content was carried out by first drying the porcelain cup for about 1 hour in an oven at 135°C and then cooling it in a desiccator for 15 minutes, weighting the sample less than 1 gram, and putting it in a porcelain cup and then put it in an oven at 135°C to dry for 8 hours and cooled in a desiccator for 30 minutes, then weighed. Water content can be calculated using the following formula:

$$\text{Water content (\%)} = \frac{(\text{w.Petri dish+ w.sample})-(\text{w. Petri dish+w. Sample after})\ \text{X}\ ))))\text{afteroven})}{\text{Net Weight}}\ 100\ \%$$

Protein Content

Testing of protein content is done by grinding the sample using a suitable tool or grinder, weighing the sample 0.2-0.5 grams, and putting the sample into the Khjedhal tube. Then, several catalysts (Selenium mix) and 6 ml H2 SO4 were added, and homogenization was done. Samples that have been homogenized are then digested for ± 1.5 hours until they are clean and yellow. After completion of the digestion, cool until the sample is icy. Samples were analyzed using the Foss tool (KJELTEC).

$$(\%)\ N = \frac{(\text{ml HCL} - \text{ml Blank X Normality HCL x } 14{,}007 \text{ x } 100)}{\text{mg sample}} \text{x } 100\ \%$$

(%) Total protein = % N x 6,25%

Fibre Content

Crude fiber analysis was carried out by weighing 0.5-1 g of sample (x g), putting it into a 600 ml glass cup, adding 50 ml of 0.3 N H_2SO_4, and then heating it on an electric heater for 30 minutes. Next, 25 ml of 1.5 N NaOH was added, and continued to cook for 30 minutes. The liquid was dried in a desiccator at 105-110°C for one hour and put into a bunchner funnel. Filtering was done in a suction flask connected to a vacuum pump [19].

Fibre content can be calculated using the following formula:

$$\text{Fibre content } (\%) = \frac{B - c - c}{x} \text{x } 100\ \%$$

Description:

x = sample weight

a = filter paper weight

b = weight of filter paper + sample after oven

c = weight of filter paper + sample after cultivation.

RESULTS AND DISCUSSIONS

Cooking Loss

The results of variance analysis for the treatment of the corn flour addition level showed a very significant effect (P <0.01), which means that there is an effect of the addition level treatment on the average value of cooking loss of dangke nuggets. According to Saleh *et al*. [11], the higher the cooking temperature is, the longer it takes to cook.

Table 1. The Mean Value of Cooking Loss Value of Dangke Nuggets with Adding Corn Flour (*Zea mays L.*) with Different Storage Times

Addition Level (%)	Storage Time (Days)			Average
	0	14	28	
0	9.97±0.60	9.46±0.50	10.10±0.36	9.84±0.34[a]
5	4.96±0.05	5.03±0.57	5.46±0.05	5.15±0.24[b]
10	4.30±0.17	5.03±0.05	4.93±0.11	4.75±0.36[c]
Average	6.41±2.68[a]	6.51±2.21[a]	6.83±2.46[b]	

Notes: Different superscripts in the same row indicate significantly different treatments (P<0.05).

The results of variance analysis for the treatment of storage time of dangke nuggets showed a very significant effect (P<0.01), which means that storage time treatment affects the average value of dangke nuggets. The results of the BNT further test (Table 1) of the 28-day storage treatment differed from all storage treatments, while the 0-day storage treatment was not different from 14 days. According to Risnajati [20], the longer the storage time, the greater the meat cooking loss.

The analysis of the variance of the two factors showed an interaction between flour addition level and the storage time of nuggets, which had a very significant effect (P<0.01) on the cooking loss value of dangke nuggets. The interaction between the two factors showed that the addition treatment was interrelated with the storage time.

The results of the LSD further test (Table 1) treatment of flour addition level showed a difference in the average value of cooking loss of nuggets. Likewise, the storage time showed a difference in the average value of the nugget content of the treatment. Based on the table, the corn flour addition level of 0% differs from 5% and 10% and vice versa. The storage time of 28 days is different from all storage time treatments, while the storage time of 0 days is not different from 14 days. The average cooking loss obtained ranged between 4.30% and 10.10%, which means it is still within the normal range. According to Soeparno [21], the cooking loss value of meat generally ranges between 1.5% and 54.5%. It can be concluded that the average value of cooking loss is best at adding 10% corn flour with a storage period of 0 days because, at that level, it has the lowest average cooking loss value compared to other treatments. According to Basri [22], meat with a low cooking loss rate is of good quality because the possibility of releasing meat nutrients during cooking is also low. Awal *et al*. [8] mentioned that corn flour filler attracts water in the dough and forms a chewy texture. White glutinous corn has a soft or chewy texture and a high water absorption capacity compared to other corn types [6]. The lower the water binding capacity value of a food product, the higher the cooking loss value, indicating lower quality, and vice versa [23].

Shear Force of Nuggets

The results of variance analysis for the treatment of corn flour addition level showed a very significant effect (P<0.01), which means that there is an effect of the addition level treatment on the average value of dangke nuggets shear force. Corn flour has a paste that is not thick, not sticky, has viscosity, can form a chewy gel, and is stable at high heating temperatures [8]. Waxy corn contains 97% amylopectin and 3.62% amylose [10]. Amylopectin affects the gelatinization process, which can increase tenderness [24] [25]; Amylopectin causes sticky products, while amylose gives hard properties to products. The smaller the amylose content and the higher the amylopectin content, the chewier the product will be.

Table 2. The Mean Shear Force Value of Dangke Nuggets with Adding Corn Flour (*Zea mays L.*) with Different Storage Times

Addition Level (%)	Storage Time (Days)			Average
	0	14	28	
0	0.20±0.00	0.30±0.00	0.38±0.20	0.29±0.77[a]
5	0.21±0.00	0.33±0.00	0.40±0.10	0.31±0.82[b]
10	0.20±0.00	0.31±0.11	0.36±0.10	0.29±0.70[a]
Average	0.20±0.00[a]	0.31±0.10[b]	0.38±0.21[c]	

Notes: Different superscripts in the same row indicate significantly different treatments (P<0.05).

The variance analysis results for dangke nuggets' storage time showed a significant effect (P<0.01), meaning that storage time treatment affects the average value of dangke nuggets. The

lower the shear force value of the nugget [12], the more tender it is, and vice versa; the higher the shear force value of the nugget, the more challenging it is. So, it can be concluded that the average value of nugget breakability is best at the corn flour addition level of 0% and 10% with 0 0-day storage period.

Analysis of the variance of the two factors showed no interaction between flour addition level and the storage time of nuggets, which had no significant effect (P>0.05) on the shear force value of nuggets. The absence of interaction between the two factors indicates that the addition level treatment is unrelated to the storage time.

Water Content

The results of variance analysis for the treatment of corn flour addition level showed a very significant effect (P<0.01), which means that the treatment of flour addition level affects the water content of dangke nuggets. High water content in nuggets can cause the product to be easily damaged, so it can be concluded that the 10% addition level has the best water content value among other treatments. The higher the amount of water content in a product, the faster the product is damaged [13], and vice versa. Based on SNI 01-6683-202, the maximum water content of nuggets is 60%. The water content dramatically affects the quality of the nuggets produced.

Table 3. The Mean Value of Water Content of Dangke Nuggets with the Addition of Corn Flour (*Zea mays L.*) with Different Storage Times

Addition Level (%)	Storage Time (Days)			Average
	0	14	28	
0	53.22±0.10	53.39±0.21	50.55±0.53	52.39±1.40^{b}
5	49.29±0.59	47.76±0.22	45.85±0.15	47.63±1.52^{a}
10	51.02±0.05	47.55±0.09	44.04±0.09	47.54±3.02^{a}
Average	51.18±1.73^{c}	49.57±2.87^{b}	46.82±2.92^{a}	

Notes: Different superscripts in the same row indicate significantly different treatments (P<0.05).

The results of variance for the treatment of storage time of dangke nuggets showed a very significant effect (P<0.01), which means that there is an effect of storage time treatment on the water content of dangke nuggets. Water content should increase during storage, but it can decrease under certain conditions [26]. This can occur due to unstable temperature and humidity during storage, thus causing the transfer of water vapor from the material to the environment, and, ultimately, the water content of the material decreases [27].

Analysis of variance results of the two factors showed an interaction between flour addition level and the storage time of nuggets, which had a very significant effect (P<0.01) on the water content of dangke nuggets. The interaction between the two factors showed that the addition level was interrelated with the storage time. To determine the differences in each treatment, an LSD test was conducted.

The results of the LSD further test (Table 3) treatment of flour addition level showed a difference in nugget water content. Likewise, the storage time showed a difference in the nugget water content. Based on the table, the corn flour addition level of 0% differs from all treatments,

while the flour addition level of 5% is not different from 10%. As for the storage time, 0 days varies from 14 to 28 days.

Protein Content

The results of variance for the treatment of corn flour addition level showed a very significant effect (P<0.01), which means that there is an effect of the flour addition level on the protein content of dangke nuggets. Protein content is influenced by the ingredients used during the nugget-making process [16].

Table 4. The Mean Value of Protein Content of Dangke Nuggets with the Addition of Corn Flour (*Zea mays L.*) with Different Storage Times

Addition Level (%)	Storage Time (Days)			Average
	0	14	28	
0	11.75±0.23	9.43±0.00	9.34±0.38	10.17±1.20[a]
5	12.30±0.16	11.89±0.10	10.77±0.06	11.65±0.69[b]
10	10.78±0.10	10.15±0.13	9.73±0.20	10.22±0.47[a]
Average	11.61±0.68[a]	10.49±1.09[b]	9.95±0.67[c]	

Notes: Different superscripts in the same row indicate significantly different treatments (P<0.05).

Average values based on the treatment of storage time on the t protein content of dangke nuggets were obtained the highest in the treatment of 0 days storage with a value of 11.61% and the lowest protein content in 28 days storage with a value of 9.95%. This shows a decrease in protein content and nuggets' storage time. Protein levels tend to decrease due to the longer storage time, which is thought to be due to the activity of proteolytic bacteria that can digest protein [28]. Proteolytic bacteria can grow optimally at room temperature [29]. However, they can still grow and develop as storage time increases at refrigerator temperatures so that they can cause protein degradation. The results of variance for the treatment of storage time of dangke nuggets showed a very significant effect (P<0.01), which means that there is an effect of the storage time treatment on the protein content of dangke nuggets.

The analysis of the variance of the two factors showed an interaction between flour addition level and the storage time of nuggets, which had a very significant effect (P<0.01) on the protein content of dangke nuggets. The interaction between the two factors showed that the addition level treatment was interrelated with the storage time. To determine the differences in each treatment, an LSD test was conducted.

The results of the LSD further test (Table 4) treatment of flour addition level showed a difference in nugget protein content. Likewise, the storage time showed a difference in the protein content of the nuggets from the treatment. Based on the table, the 5% corn flour addition level differs from all treatments, while the 0% level of flour addition is not different from 10%. As for the storage time, 0 days is different from 14 days and 28 days.

Fibre Content

The results of the average value based on the treatment of corn flour addition level to the fiber content of dangke nuggets were obtained the highest in the treatment of 10% addition of

corn flour with a value of 0.32% and the lowest fiber content at the addition level of 0% with a value of 0.25%. The results of variance analysis for the treatment of corn flour addition level showed a very significant effect (P<0.01), which means that there is an effect of the flour addition level treatment on the fiber content of dangke nuggets. Corn flour has advantages, including higher fiber content than wheat flour [22].

Table 5. The Mean Value of Fiber Content of Dangke Nuggets with the Addition of Corn Flour (*Zea mays L.*) with Different Storage Times

Addition Level (%)	Storage Time (Days)			Average
	0	14	28	
0	0.22±0.00	0.27±0.00	0.25±0.00	0.25±0.02[a]
5	0.26±0.01	0.21±0.00	0.34±0.00	0.27±0.05[b]
10	0.29±0.01	0.36±0.00	0.32±0.00	0.32±0.21[c]
Average	0.25±0.28[a]	0.28±0.06[b]	0.31±0.04[c]	

Notes: Different superscripts in the same row indicate significantly different treatments (P<0.05).

The results of the average value based on the treatment of storage time on the fiber content of dangke nuggets were obtained the highest in the treatment of 28 days storage with a value of 0.31% and the lowest fiber content in 0 days storage with a value of 0.25%. The variance analysis results for the treatment of dangke nuggets storage time showed a very significant effect (P<0.01), meaning that storage time treatment affects the dangke nuggets fiber content. The more extended storage affects the reduction of crude fiber [30]. However, the results obtained in this study showed that the more extended storage increased crude fiber. The longer storage may increase crude fiber content due to respiration energy that causes water to escape [31]. Still, fiber, such as protopectin, is water-insoluble, so it is possible that fiber content does not decrease as water content decreases. The higher the crude fiber of a food product, the lower the water content [32]; in other words, water and fiber content are inversely correlated.

Analysis of the variance of the two factors showed an interaction between flour addition level and the storage time of nuggets, which had a very significant effect (P<0.01) on the fiber content of dangke nuggets. The interaction between the two factors showed that the addition level treatment was interrelated with the storage time. To determine the differences in each treatment, an LSD test was conducted.

The results of the LSD further test (Table 5) treatment of flour addition level showed a difference in nugget fiber content. Likewise, the storage time showed a difference in the fiber content of the nuggets. The 0% corn flour addition level differs from the 5% and 10% levels of flour addition. Meanwhile, 0 days' storage time differed from 14 days and 28 days of storage.

CONCLUSIONS

Based on the study's results, it can be concluded that adding 5% corn flour to the formulation can increase protein content. In comparison, adding 10% corn flour provides the best quality in terms of cooking loss, nugget-breaking power, and water content and increases the

fiber content of the nugget. The longer the storage, the lower the water content and protein content, reducing the quality of cooking loss and nugget-breaking power.

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