

Antioxidant Activity, Organoleptic Quality 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 substituting wheat flour with corn flour on antioxidant activity and organoleptic of dangke nuggets with different storage durations. This study used a completely randomized design (CRD) factorial pattern with three replications and three treatments. The first factor was 0%, 5%, and 10% corn flour; the second was 0, 14, and 28 days of storage in the freezer. Antioxidant measurement using the DPPH method and organoleptic includes testing color, aroma, taste, texture, and preference of dangke nuggets. The results showed no correlation between the treatment level of corn flour addition and the storage duration, which had no significant effect ($P > 0.05$) on the antioxidant content of dangke nuggets. For organoleptic parameters in terms of color, aroma, taste, texture, and liking, there was no correlation between the treatment level of corn flour addition and storage duration, which had no significant effect ($P > 0.05$). From this study, it can be concluded that the treatment of a 5% corn flour addition level in the formulation can increase antioxidant activity and organoleptic quality in terms of the aroma and texture of nuggets, and the addition of 10% corn flour also improves the quality of color and liking of nuggets. Meanwhile, the more extended storage, the more antioxidant and organoleptic quality of dangke nuggets will decrease.

1 Introduction

Dangke are food products made from milk [1]. of buffalos or cows with a manufacturing process that is still done traditionally and comes from Enrekang regency of South Sulawesi and plays a role as one of the livelihoods of the local community that needs to be preserved and developed to provide welfare for the community. Cheese is a top-rated dairy product today, with a diverse variety in the market [2]. Dangke are often nicknamed Enrekang unique cheese because of their soft texture, resembling cheese in general [3].

The knowledge of making dangke is passed down from generation to generation from their parents. Since then, the process of making dangke has been traditional. The material used initially was from buffalo milk and then mixed with squeezed passe leaves, but the

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buffalo population is decreasing, and *passe wood* is challenging to obtain. Therefore, cow's milk and papaya sap are used to make *dangke*. In terms of the shape or model, it remains as before, which is cone-shaped because it uses coconut shells as a mold [3].

Dangke has oval-shaped characteristics, a compact and chewy texture, a strong milk aroma, and a savory taste [4]. *Dangke* can be yellowish-white in color [5]. The short shelf life of *Dangke* cheese is classified as very perishable; this causes the market reach of this product to be limited [6]. The shelf life of *dangke* is relatively short because of the high water content, which is around 49.3-62.4% [7], so it is classified as soft cheese, which has elastic properties [5]. Besides, *dangke* has a protein content of 23.8%, fat 14.8%, and ash 2.1% [8].

Regarding the processing, *dangke* is categorized as fresh cheese without maceration. Fresh cheese is a product that has a pH close to neutral, high water content, and water activity that allows the growth of pathogens and spoilage microorganisms that can reduce its shelf life [9].

Over time, *Dangke* has had various innovative products that can overcome the problem of *Dangke*'s relatively short shelf life at room temperature. One of the innovations carried out to increase the shelf life, taste, and interest of the public in *Dangke* products is processing them into *Dangke* nugget products.

Nugget is processed meat made from the first ground until smooth, added with flavorings and other additives, coated with adhesive material, and then fried [10]. Other ingredients that can be made into nuggets include vegetables, tofu, and tempe [11]. As a source of food security, animal protein is needed by humanity to increase health, especially body resistance, and to increase immunity against disease [12].

Another ingredient that can be made into nuggets is *Dangke*. *Dangke*'s short shelf life and perishability cause the product's market reach to be limited [6]. *Dangke* nugget processing is an effort to increase the shelf life and expand marketing and consumers to various regions in Indonesia to contribute to providing animal-source food with high nutritional value [8] and diversifying milk-based food.

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 chewiness of the product [13]. Another filler that can be used in making nuggets is corn flour. Corn flour is perfect for emulsion products because it can bind water and hold the water during cooking; besides that, corn flour also has paste properties that are not thick, not sticky, have viscosity, can form a chewy gel, and are stable at high heating temperatures [14].

White sticky corn contains 97%-100% amylopectin and has a low amylose content. Products with high amylopectin content and low amylose can trigger the *puffing* process so that the resulting product becomes crisp, light, and crunchy [15].

Corn flour has the advantage of containing carotenoids such as β -carotene, α -carotene, and fucoxanthin, which are natural antioxidants that can reduce free radicals. Free radicals can cause carcinogenic cell damage. Corn also has a relatively large size of corn starch granules, showing excellent resistance to heat and water treatment [16]. These compounds provide several health functions for the body. In general, carotenoids are antioxidants that protect the body from free radicals. The many health functions of carotenoids mean that they are also used as nutraceutical products. Carotenoids with potential anticancer activity are widely found in fruits and vegetables [17].

Antioxidants are compounds that can inhibit free radicals to prevent the onset of diseases associated with free radicals [18]. Many synthetic antioxidant products are on the market, even though synthetic antioxidants hurt human health. Therefore, it is necessary to utilize natural sources of antioxidants derived from various types of plants, such as fruits, vegetables, and spices [18].

White sticky corn contains 97%-100% amylopectin, while white sticky corn that has been made into corn flour contains 7.75% moisture content, 2.64% ash content, 18.67% protein

content, 11.61% fat content, 4.29% crude fiber content, 3.62% amylose, 61.28% starch, and 16.04% water absorption [15].

The application of corn flour is one of the local food utilization that is readily available, so it is used as an option that needs to be developed. In this study, using sticky corn flour is expected to provide good results and quality on antioxidant activity and organoleptic of dangke nuggets and be able to produce processed products based on functional food.

2 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), B3 (28 days).

1.1 Preparation of corn flour

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

1.2 Preparation of Dangke nuggets

The procedure for making dangke nuggets refers to the modified method by Arham [19]: weighing the ingredients to be used. Dangke, egg yolk, ice cubes, and salt were put into a food processor and ground for 2 minutes (until mixed). Other ingredients such as wheat flour, corn flour, onions, pepper, and flavoring were added and ground again until all ingredients were mixed. The prepared dough was put into a baking tray and steamed for 30 minutes. The cooked dough was 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 therapies stored in the freezer for 14 and 28 days and antioxidant testing was carried out. Nuggets stored in a refrigerator were ready to be fried in hot oil until they produced a golden yellow color and then drained; organoleptic testing was carried out.

3 Measured variable

The variables measured were the antioxidant activity and organoleptic quality of dangke nuggets with the addition of corn flour.

3.1 Antioxidant activity

Antioxidant testing was carried out based on Prasetyo et al. [20]; DPPH powder weighed as much as 0.007 g, dissolved with 50 mL of ethanol, and vortexed until dissolved. The DPPH solution was taken to 1 mL, then added ethanol to 5 mL and allowed to stand for 30 minutes. Crushed nugget samples were then homogenized. The sample was weighed, 1 gram was put in a measuring cup, 0.0019 DPPH was added, and 50 ml of 100% methanol and vortex until the sample was dissolved. Centrifuged at 3,000 rpm for 15 minutes and then filtered. Incubated for 30 minutes at room temperature, then read the absorbance using a spectrophotometer with a wavelength of 517 nm. Samples were made as many as 3 with three repetitions. Antioxidant levels can be measured using the following formula:

$$\text{Antioxidant level} = \frac{\text{Control absorbance} - \text{Sample absorbance}}{\text{Control absorbance}} 100\% \quad (1)$$

3.2 Organoleptic quality

Organoleptic tests are based on the human sense organs acting as panelists. The panelists used were semi-trained, totaling 30 people. Panelists are students who have undergone training and have been used in several studies at the Laboratory of Milk Processing Biotechnology, Faculty of Animal Husbandry, Hasanuddin University. They are aged between 18 and 25 years, sensitive to taste, not color blind, and not hungry. The panelists assessed the aspects of color (1. Very dark yellow, 2. Slightly dark yellow, 3. Yellow, 4. Slightly bright yellow, 5. Bright yellow, 6. Very bright yellow), aroma (1. Very does not smell like milk, 2. Doesn't smell like milk, 3. Slightly smells like milk, 4. Has a milky smell, 5. Strongly smells like milk, 6. Very much smells like milk), taste (1. Not very tasty, 2. Not very tasty, 3. Slightly savory, 4. Savory, 5. Very tasty, 6. Very very tasty), texture (1. Very not smooth, 2. Not smooth, 3. Somewhat smooth, 4. Smooth, 5. Very smooth, 6. Very very smooth).

4 Results and Discussion

4.1 Antioxidant Activity of Dangke Nuggets

The variance analysis showed that the flour addition level had a very significant effect ($P < 0.01$), indicating an influence of the flour addition treatment level on the dangke nuggets' antioxidant content. Further test results show that 0% corn flour differs from 5% and 10%, and vice versa (Table 1). The difference in antioxidant content in nuggets can be caused by differences in the type and level of flour added to the dough, but each flour used has antioxidant content. Wheat flour is made from wheat, which contains carotenoids, tocopherol, and flavonoid compounds that act as antioxidants [21]. Corn flour contains carotenoids, fiber, and natural antioxidants that can reduce free radicals [16]. Combining corn and wheat flour can increase the antioxidant content of nuggets.

The results of variance analysis showed that the long storage treatment for dangke nuggets had no significant effect ($P > 0.05$), which means that there was no effect of prolonged storage treatment on the antioxidant content of dangke nuggets. The longer the storage of nuggets, the lower the antioxidant content. A decrease in antioxidant content can occur because antioxidants are susceptible to oxidation by several factors, such as light and oxygen, causing a reduction in the percentage value of antioxidant activity during storage [22]. The analysis of variance for the two factors showed no interaction between the flour addition level and the nuggets' storage time, which had no significant effect ($P > 0.05$) on the antioxidant content of

dangke nuggets. The treatment with the highest antioxidant content of dangke nuggets was obtained with a 5% addition of corn flour.

Table 1. The average antioxidant value of dangle nuggets with corn flour (*Zea mays L.*) addition with different storage durations.

Addition Level (%)	Storage Duration (Days)			Average
	0	14	28	
0	50.93±0.75	47.23±0.22	47.74±0.30	48.63±1.78 ^a
5	58.53±0.55	57.06±5.43	57.01±0.45	57.53±2.83 ^b
10	41.38±0.46	39.92±0.88	42.30±0.18	41.20±1.15 ^c
Average	50.28±7.46 ^a	48.07±7.94 ^b	49.02±6.44 ^{ab}	

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

4.2 Organoleptic Quality of Dangke Nuggets

Table 2 shows the effect of storage time on the organoleptic properties of Dangke Nugget, which uses corn flour as a binding agent. This addition as a binding agent uses levels 0 (without addition as a control), 5, and 10%.

4.2.1 Colour

The average value of the flour addition level to the nugget color organoleptic was the highest in the treatment of 10% corn flour addition with a value of 4.20, and the lowest is in the addition of 0% corn flour with a value of 3.73, which means the nugget criteria are slightly bright yellow. The results of the analysis of variance for the treatment of flour addition level to the color of nuggets showed results that had a significant effect (P<0.05), which means that there was an effect of the corn flour addition level in the making of dangke nuggets on the color aspect. Making nuggets through the steaming process produces changes in the color of the nuggets. According to [23], browning reactions occur due to the Maillard reaction, which is a reaction between carbohydrates, significantly reducing sugars and amino acids in the presence of heating. This reaction produces a yellow-to-brown color, highly desirable in food processing. According to Winarno [24], the color of nuggets most preferred by consumers is golden yellow.

The average value of the nugget storage duration treatment on the color organoleptic was the highest in 0 days with a value of 4.13, and the lowest is in the 14-day treatment with a value of 3.88, which means the nugget criteria are slightly bright yellow. The results of the analysis of variance for the treatment of storage duration on nugget color showed no significant effect (P>0.05). According to Sumonsiri and Sheryl [25], color intensity is more stable when stored in a refrigerator than at room temperature.

The results of the analysis of variance for the interaction between the treatment of corn flour addition level and storage duration on the color organoleptic of dangke nuggets were found to have no significant effect (P>0.05), which means that there is no interaction between the factors of corn flour addition level and storage duration of nuggets.

Table 2. Average organoleptic value and preference for dangke nuggets with the addition of corn flour.

Sample	Addition Level (%)	Storage Duration (Days)			Average
		0	14	28	
Colour	0	4.13±1.25	3.57±1.35	3.57±1.35	3.73±1.34 ^a
	5	4.00±1.07	3.90±1.12	4.10±1.15	4.00±1.09 ^{ab}
	10	4.27±0.69	4.17±0.74	4.17±1.05	4.20±0.83 ^b
	Avarage	4.13±1.00	3.88±1.12	3.92±1.22	
Flavour	0	3.00±0.87	3.27±1.04	3.23±0.85	3.17±0.92
	5	3.27±1.08	3.33±0.80	3.27±1.01	3.29±0.96
	10	2.90±0.66	3.07±0.69	3.03±0.71	3.00±0.68
	Avarage	3.06±0.89	3.22±0.85	3.18±0.86	
Taste	0	4.63±0.99	4.53±1.04	4.50±1.00	4.56±1.00 ^a
	5	4.40±0.96	4.37±0.99	4.17±1.05	4.31±1.00 ^{ab}
	10	4.13±0.76	4.10±0.80	3.93±0.93	4.06±0.81 ^b
	Avarage	4.39±0.93	4.33±0.96	4.20±0.99	
Texture	0	4.43±0.67	4.40±0.77	4.10±1.09	4.31±8.70 ^a
	6	5.00±0.91	4.77±0.77	4.87±0.97	4.88±0.88 ^b
	g	4.70±0.87	4.53±0.81	4.60±0.81	4.61±0.84 ^c
	Avarage	4.71±0.85	4.57±0.79	4.52±1.00	
Preference	0	4.00±0.94	3.40±0.72	3.13±0.73	3.51±0.87 ^a
	5	4.10±0.99	3.70±0.70	3.67±0.80	3.82±0.85 ^b
	10	4.67±1.02	3.87±0.73	3.63±0.66	4.06±0.92 ^c
	Avarage	4.26±1.02 ^a	3.66±0.73 ^b	3.48±0.76 ^b	

4.2.2 Aroma

The results of the average value of the treatment of flour level addition to the organoleptic aroma were the highest in the treatment of 5% with a value of 3.29 and the lowest in the addition of 10% corn flour with a value of 3.00, which means that the criteria for nuggets aroma are somewhat milky. The results of the analysis of variance for the treatment of flour addition levels on the aroma of nuggets showed no significant effect ($P>0.05$). According to Rezki et al. [26], using various types of flour with different concentrations does not affect the aroma of nuggets. This can be caused by the concentration of flour used, which is still very low (maximum 3%), so it only contributes a little to the aroma of the nuggets produced.

The average value of the treatment of nugget storage duration on the highest aroma organoleptic is 14 days with a value of 3.22, and the lowest is in the 0-day treatment with a value of 3.06, which means the criteria are somewhat milky aroma. The results of the analysis of variance for the treatment of storage duration on the aroma of nuggets showed no significant effect ($P>0.05$).

The results of the analysis of variance for the interaction between the treatment level of corn flour addition and storage duration on the organoleptic aroma of dangke nuggets were found to have no significant effect ($P>0.05$), which means that there is no interaction between the factors of corn flour addition level and storage duration of nuggets.

4.2.3Taste

The results of the average value of the flour addition level to the nugget’s organoleptic taste were obtained the highest in the treatment of 0% addition of flour with a value of 4.56, which

means the criteria for nuggets with a very savory taste and the lowest in the addition of 10% corn flour with a value of 4.06 which means the requirements for nuggets with a savory taste. The results of the analysis of variance for the treatment of flour level addition to the taste of nuggets showed a very significant effect ($P < 0.01$), which means that there is an effect of the corn flour addition level in the making of dangke nuggets on the taste of nuggets. This is because there are differences in the use of flour, and the percentage of flour used is different so that it can affect the taste of nuggets. According to Winarno [27], the taste is usually influenced by several things, such as chemical compounds, temperature, the combination of food with additives, and the length of the cooking process; the taste is more influenced by the formation of ingredients than the food processing.

The results of the average value for storage duration treatment on the nuggets organoleptic taste is the highest at 0 days with a value of 4.39 and the lowest at 28 days with a value of 4.20, which means the criteria for nuggets with a savory taste. The results of the analysis of variance for the storage duration treatment on the taste of nuggets showed no significant effect ($P > 0.05$).

The results of the analysis of variance for the interaction between the treatment level of corn flour addition and storage duration on the organoleptic taste of dangke nuggets were found to have no significant effect ($P > 0.05$), which means that there is no interaction between the factors of corn flour addition level and storage duration of nuggets.

4.2.4 Texture

The results of the average value for the treatment of flour addition levels on the organoleptic texture of nuggets were obtained the highest in the treatment of 5% flour addition with a value of 4.88, which means the criteria for nuggets with a beautiful texture and the lowest in the addition of 0% corn flour with a value of 4.31 which means the requirements for nuggets with a fine texture. The results of the analysis of variance for the treatment of flour addition level to the texture of the nuggets showed a very significant effect ($P < 0.01$), which means that there is an effect of the corn flour addition level in the making of dangke nuggets on the texture of the nuggets. This is due to the difference in flour and flour use presentation levels. The most preferred criteria by the panelists were those that used a combination of wheat flour and corn flour. According to Balitbantan [28], white corn flour has a fluffy or chewy texture and has high water absorption compared to other corn types. Adding wheat flour to crab nuggets produces a slightly stiff texture.

The results of the average value for storage duration treatment on the nugget's organoleptic texture was the highest in 0 days with a value of 4.71 and the lowest in the 28-day with a value of 4.52, which means the criteria for nuggets with a very smooth texture. The results of the analysis of variance for the treatment of storage duration on the texture of nuggets showed no significant effect ($P > 0.05$).

The results of the analysis of variance for the interaction between the corn flour addition level and storage duration on the dangke nuggets organoleptic texture were found to have no significant effect ($P > 0.05$), which means that there is no interaction between the factors of corn flour addition level and storage duration of nuggets.

4.2.5 Preference

The results of the average value of the flour addition level to the organoleptic preference of nuggets were obtained the highest in the treatment of 10% addition of flour with a value of 4.06 and the lowest in the addition of 0% corn flour with a value of 3.51, which means the criteria for nuggets preference was in Like criteria. The results of the analysis of variance for

the flour addition level treatment to the liking of nuggets showed results that were very significantly influenced ($P < 0.01$), which means that there is an effect of the corn flour addition level in the dangke nuggets making on the level of nugget preference. Overall, the results obtained by the panelists had a response of Like to the nuggets both with and without corn flour. The results obtained are the same as the results of the organoleptic test conducted by [16]; the level of liking for corn flour in native chicken nuggets received a like response from the panelists.

The results of the average value of the storage duration treatment on the liking organoleptic was the highest in 0 days with a value of 4.26 and the criteria of like and the lowest in the 28-day t with a value of 3.48 and the criteria was somewhat like. The results of the analysis of variance for the treatment of storage duration and the texture of the nuggets showed a very significant effect ($P < 0.01$), which means that there is an effect of the dangke nuggets' storage duration on the level of nugget liking. The longer the storage duration of nuggets, the more the response of panelists from Like to Somewhat Like decreased.

The results of the analysis of variance for the interaction between the treatment of the corn flour addition level and the storage duration on the Liking organoleptic of dangke nuggets were found to have no significant effect ($P > 0.05$), which means that there is no interaction between the factors of the corn flour addition level and the nuggets storage duration.

5 Conclusion

The treatment of a 5% corn flour addition level in the formulation can increase antioxidant activity and organoleptic quality in terms of aroma and texture of nuggets, and the addition of 10% corn flour also improves the quality of color and liking of nuggets. Meanwhile, the longer the storage duration, the lower the antioxidant and organoleptic quality of dangke nuggets.

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