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The effects of wheat, tapioca, corn, and red rice flour on TBA value and color sensory quality and the aroma of dangke nuggets

F Baharuddin, W Hatta and M I Said

Faculty of Animal Science, Hasanuddin University, Jl. Perintis
Kemerdekaan KM 10 Makassar 90245, Indonesia.

Email: wahnihatta@yahoo.com

Abstract. Dangke nuggets are innovative products of processed dangke, a type of fresh cheese from the Province of South Sulawesi, Indonesia. The anthocyanin content in red rice provides added value to its use as a filler nugget, but it reduces the quality of the color and aroma of the products. One solution is to combine red rice with other filler ingredients that have been commonly used in nugget formulations. This study aimed to examine the effects of the types and levels of flour combined with red rice flour on the TBA value and the organoleptic quality of the color and aroma of dangke nuggets. The types of flour that were combined with red rice flour included wheat flour, tapioca, and corn at the levels of 10%, 20%, and 30% respectively to substitute red rice flour. At the 30% level, the nugget formulation used only the flour tested without combination with red rice flour. The results showed that nuggets with corn flour had the highest TBA value, yellow color brightness, and milk aroma, in contrast to nuggets made from wheat flour. The increase in the level of substitution of red rice flour with other flour tended to cause the TBA value to decrease and the aroma of dangke nugget milk to become stronger, while the brightness of the yellow color was not affected. Tapioca flour and corn flour either alone or in combination with red rice flour can be used as a filler for dangke nuggets.

1. Introduction

Dangke is traditional fresh cheese originating from South Sulawesi Province, Indonesia. Dangke has a high nutritional value so that it is good for consumption. The nutritional composition of dangke includes 23.8% protein, 14.8% fat, 2.1% ash, and 55.0% water [1]. The high water content causes the shelflife of dangke to be relatively short; therefore, it needs to be processed into products that are more resistant to storage. One of the processed forms of dangke is nuggets which are made by grinding dangke with other ingredients to form a dough which is then molded into rectangular pieces and coated with flour. Nuggets can be consumed after they undergo deep frying process. The objectives of making dangke nuggets are to extend their shelflife and to carry out diversification of dangke processed products as an effort to increase the consumption of animal protein by the Indonesian society.

In the process of making nuggets, fillers are needed to increase the viscosity of the dough and reduce production costs. Filler nuggets are generally ingredients that contain high carbohydrates, such as wheat flour, tapioca flour, and corn flour. These types of flour have different characteristics, especially in gel formation. Tapioca flour can form a soft or less firm gel, while corn flour forms a very firm opaque gel.



Wheat flour has gluten protein which can give the product its preferred characteristics. These three types of ingredients are commonly used as fillers in making nuggets.

The frying process causes the dangke nuggets to undergo oxidation, which reduces their shelflife. Oxidation reactions in food products can be slowed down by providing ingredients that have antioxidant activities. Increasing the antioxidant activities of dangke nuggets can be conducted by using fillers or binders that have high antioxidant activities, including red rice flour. Red rice is potential as a filler in making nuggets because it contains carbohydrates and protein, and it is also healthy ingredient as it contains anthocyanins and beta carotene. Using red rice flour as a filler for dangke nuggets can reduce the TBA value for 14 days of storage [2]; however, this tends to reduce the sensory quality of the product [3]. Based on this, this study examined the use of several types of flour (wheat flour, tapioca, and corn) commonly used in making nuggets to be combined with red rice flour as a filler in the dangke nugget formulation and studied their effects on the quality of dangke nuggets.

2. Material and method

2.1. Research material

The ingredients used in this study included dangke (purchased at a dangke producer in Enrekang), red rice flour (purchased at an online shop in East Jakarta), wheat flour, tapioca flour, corn flour, ice cubes, egg yolk, salt, garlic, and ground pepper. Other materials included food plastic, aluminum foil, distilled water, HCl, and TBA (Thiobarbituric-acid) powder.

2.2. Research design

This study used a completely randomized design (CRD) with a two-factor factorial pattern and was repeated three times. Factor A was the type of filler flour (combined with red rice flour), as follows: A1 = Wheat Flour, A2 = Tapioca Flour, and A3 = Corn Flour. Factor B is the level of addition of filler flour (substituting red rice flour), as follows: B1 = 10%, B2 = 20%, and B3 = 30%.

2.3. Dangke nuggets manufacture

Dangke, ice cubes, eggs, and salt were ground in a food processor for 2 minutes until they were thoroughly mixed. The filler flour (according to treatment), red rice flour, garlic and pepper were added and ground for 2 minutes. The dough was poured into a baking sheet and steamed for 20 minutes. After it was chilly, the cooked dough was cut into rectangular shapes, and they were dipped in a wheat flour solution, covered with panir flour, and stored in the refrigerator.

2.4. Measurement of TBA (Thiobarbituric-Acid) Value

The determination of the TBA number was carried out according to the method of Tarladgis et al. [4]. The ingredients were weighed as much as 10 g, placed in a waring blender, and added with 50 ml of distilled water and homogenized for 2 minutes. The sample was transferred to a distillation flask and added with 47.5 mL of distilled water. After that, as much as 2.5 ml of 4 M HCl was added until the pH reached 1.5. The distillation was carried out on high temperature until 50 ml of distillate was obtained. The distillate was then piped into a closed test tube and added with 5 ml of TBA reagent. The tube was closed and mixed until the content was homogeneous and heated for 35 minutes in boiling water. Blanko were made using 5 ml distilled water and 5 ml reagents based on the determination of the sample. The test tube was cooled, and the absorbance was measured at a wavelength of 528 nm with the blanko solution as the zero point. The TBA number was expressed in mg malonaldehyde per kg of sample.

2.5. Sensory Quality Testing

The sensory qualities tested included color and aroma. The test was carried out by 40 semi-trained panelists from the students of the Faculty of Animal Science, Hasanuddin University. Before they were tested, the dangke nuggets were first fried in boiling oil (150°C). The scales and descriptions for each sensory parameter are presented in Table 1.

Table 1. Description and sensory scales of the colors and aromas of the dangke nuggets.

Scale	Color	Aroma
1	Very dark yellow	Totally non-milky aroma
2	Dark yellow	Non-milky aroma
3	Moderately dark yellow	Moderately non-milky aroma
4	Moderately bright yellow	Moderately milky aroma
5	Bright yellow	Milky aroma
6	Very bright yellow	Totally milky aroma

2.6. Statistic analysis

The data obtained were analyzed based on a completely randomized design (CRD) with a two-factor factorial pattern with three replications. The treatment that had a real effect was followed by Duncan's continued test [5]. The data processing was conducted using SPSS Statistics 16.0 software.

3. Results and discussions

3.1. TBA value (Thiobarbituric acid)

Flour is a food product that contains unsaturated fatty acids; as a result, it is susceptible to oxidation reactions, while dangke, like milk, contains saturated fatty acids, and this makes it relatively more resistant to oxidation reactions. However, Dangke nuggets have undergone a frying process that triggers an oxidation reaction. The results of the study showing that the average TBA value of dangke nuggets (after 7 days of storage in the refrigerator) using different levels and types of filler flour can be seen in table 2.

Table 2. Average TBA value (mg MD/kg) of dangke nuggets with different types and levels of filler flour.

Types of flour	Levels of flour (%)			Average
	10	20	30	
Wheat	0.044±0.004	0.028±0.001	0.027±0.001	0.033±0.008 ^a
Tapioca	0.051±0.001	0.036±0.002	0.024±0.003	0.037±0.011 ^b
Corn	0.036±0.003	0.036±0.002	0.055±0.003	0.042±0.010 ^c
Average	0.044±0.007 ^a	0.033±0.004 ^b	0.035±0.015 ^b	

^{abc}Different superscripts in the same row and column showed very significant differences ($P < 0.01$).

The treatment of flour had a very significant effect ($P < 0.01$) on the TBA value of dangke nuggets. The Duncan test results in table 2 showed that the highest TBA value of dangke nugget was in the use of corn flour, followed by tapioca, and the lowest was in the use of wheat flour. This is probably because each type of flour has different antioxidant activities. Antioxidants are able to slow down or prevent oxidation where free radicals tend to react with antioxidants than with other molecules [6]. The substitution of wheat flour with cassava flour in the bread formulation caused the antioxidant activity of bread to decrease with the increasing levels of cassava flour [7]. Wheat flour has better antioxidant activities than cassava flour. Maize has the highest antioxidant activities among all common cereals such as rice, wheat and oats [8]. Different results were obtained in this study, where the use of corn flour produced the highest TBA value of dangke nuggets compared to other types of flour. This may be due to the antagonistic effect between the components of corn and red rice which were also reported to have high antioxidant activities.

The treatment level of the addition of flour had a very significant effect ($P < 0.01$) on the TBA value of dangke nuggets. The Duncan test results in table 2 showed that the highest TBA value was found in dangke nuggets with a flour level of 10%, while the lowest value was found in dangke nuggets with flour levels of 20% and 30%. This indicates that the decrease in the level of red rice flour in the formulation causes the TBA value of the dangke nugget to decrease. The results obtained were different from studies that reported a high capacity of red rice flour to inhibit oxidation reactions in food, especially by the anthocyanin component. Red rice contain flavonoid compounds, including anthocyanins [9]. Pigmented rice, including red rice, is potential as a source of antioxidants, and bioactive compounds that act as antioxidants are called anthocyanins [10]. An increase in the antioxidant activities of composite flour wheat-purple rice with the increasing levels of purple rice flour in the formulation [11]. The lower inhibition ability of the oxidation reaction of red rice flour in this study may be due to the formation of free radicals which are still in the initiation stage, so that flour that had a high fat content showed a greater TBA value. The fat content of red rice flour was higher (1.26%) than that of corn starch (0.87%) and of tapioca starch (0.19%) [12]. In this study, the measurement of the TBA value was carried out in 7 days of storage in the refrigerator, even though the fats of dangke nuggets such as milk were partly composed of saturated fatty acids which are less peroxidated than unsaturated fatty acids [13].

Analysis of variance showed that there were highly significant interactions ($P < 0.01$) between the types and levels of flour on the TBA value of dangke nuggets. The form of the interactions between the types and levels of flour at the TBA value of dangke nuggets is presented in Figure 1.

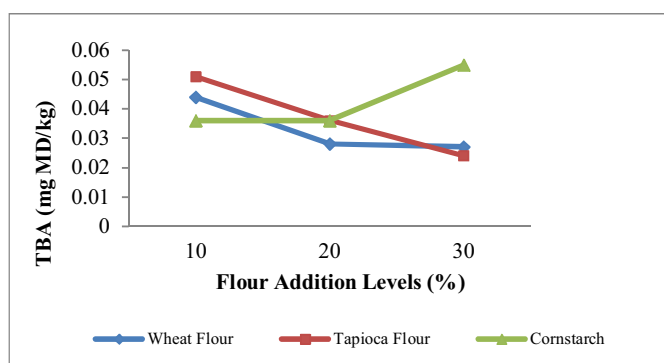


Figure 1. Interactions of types and levels of flour treatments on TBA value of dangke nuggets.

Figure 1 shows that the TBA value decreased with the increasing levels of tapioca and wheat flour, where the TBA value was lower for wheat flour compared to tapioca flour. Different results can be seen in the use of corn flour, an increase in the level of substitution of red rice flour with corn flour caused an increase in the TBA value of dangke nuggets. The results obtained indicate the presence of bioactive compounds in wheat flour and tapioca flour that could slow down the rate of oxidation reaction, while the use of corn flour showed that there were components that triggered the rate of oxidation reaction.

3.2. Color

The sensory test results of the mean dangke nugget color scales with different types and levels of flour can be seen in table 3.

Table 3. Mean of dangke nugget color sensory scales in the treatments of different types and levels of flour.

Flour Types	Flour Levels (%)			Average
	10	20	30	
Wheat	2.05±1.21	2.45±1.01	2.52±1.85	2.34±1.41 ^a
Tapioca	4.12±0.96	3.60±1.08	3.48±1.28	3.73±1.14 ^b
Corn	5.13±1.24	5.18±0.84	5.35±1.16	5.22±1.09 ^c
Average	3.77±1.71	3.74±1.48	3.78±1.87	

Different superscripts (abc) in the same column showed very significant differences ($P < 0.01$). Color scale: 1= very dark yellow to 6= very bright yellow.

The treatment of flour had a very significant effect ($P < 0.01$) on the color of dangke nuggets. The Duncan test results in Table 3 showed that the use of different types of flour produced different brightness levels of the yellow nuggets of dangke. The addition of wheat flour produced dark yellow dangke nuggets and tapioca flour produced slightly dark yellow dangke nuggets, while the addition of corn flour produced bright yellow dangke nuggets. The increase in the brightness of the yellow color with the addition of corn flour can be related to the presence of carotenoid pigments in corn. Increasing the concentration of adding corn flour can increase the carotenoid levels of the banana-corn-sago composite flour [14]. Flakes that use a higher proportion of cornmeal have colors that consumers prefer [15]. The brightness level of the yellow nugget dangke is higher with tapioca flour than with wheat flour. This may be related to the higher protein content of wheat flour so that the browning due to the Maillard reaction during heat processing was greater in nuggets with wheat flour than tapioca flour. The protein content of duck meat sausage was higher using wheat flour than tapioca flour [16].

3.3. Aroma

Aroma spread by food is a strong attraction and able to stimulate the sense of smell so that it arouses appetites. The sensory test results of the mean dangke nugget aroma scales with different levels and types of flour can be seen in table 4.

Table 4. Average sensory scales of dangke nugget on treatments of different types and levels of flour.

Flour Types	Flour Levels (%)			Average
	10	20	30	
Wheat	2.88±0.99	3.18±1.13	3.65±1.49	3.23±1.25 ^a
Tapioca	3.08±1.04	3.58±1.17	3.42±1.46	3.36±1.24 ^{ab}
Corn	3.60±1.19	3.55±1.37	3.72±1.32	3.63±1.29 ^b
Average	3.18±1.11 ^a	3.43±1.23 ^{ab}	3.60±1.42 ^b	

Different superscripts (abc) in the same row and column showed significant differences ($P < 0.05$). Aroma scale: 1 = Totally non-milky aroma to 6 = Totally milky aroma

The treatment of flour had a significant effect ($P < 0.05$) on the aroma of dangke nuggets. In Table 4, it can be seen that the dangke nuggets using corn flour had the highest aroma scale of 3.63 while the dangke nuggets using wheat flour had the lowest aroma scale of 3.23. The higher the aroma scale, the closer the aroma of the dangke nuggets to the aroma of milk. This may be due to the presence of volatile compounds in corn flour that resemble components in cow milk. High levels of protein and corn fat may also cause it to smell closer to that of milk. The flavor of corn milk and cow milk yogurt did not differ

after 14 days of storage in the refrigerator [17]. The same result was reported by [18] stating that the cheese aroma from sweet corn extract resembles cheese from cow milk. The result showed that with the use of wheat flour, dangke nuggets with the lowest milk aroma scale could be produced. Increasing the level of wheat flour in the formulation of corn-wheat flour composite reduced the sensory score of balady bread as well as its flavor and aroma [19]. He also stated that this was probably due to the high fiber content of wheat flour, which affected the color and aroma of the product.

The flour level treatment had a significant influence ($P < 0.05$) on the aroma of dangke nugget milk. In Table 3, it can be seen that an increase in the level of the addition of flour to substitute red rice flour could increase the milk aroma of dangke nuggets. At the level of 10% flour, dangke nuggets had the lowest aroma scale, in which the aroma was slightly less milky, while at the 30% level it had the highest aroma scale whose aroma was close to slightly milky. The results obtained imply that the aroma of red rice flour can mask the milky aroma of the dangke nuggets. The same result was reported by [20] stating that the biscuit flavor score decreased with the increasing level of substitution of wheat flour with purple rice flour in the flour formulation. In general, rice contains 2-acetyl-1-pyrroline components which contribute to the characteristics of cereal aroma [21]. Besides, rice also contains a hexanal component which contributes to a musty odor where its level increases due to the storage and fat oxidation reactions [22].

4. Conclusion

The use of wheat flour, tapioca, and corn as fillers (combined with red rice flour) produced different TBA values, and different sensory of color and aroma of the dangke nuggets. Increasing the level of flour (substituting red rice flour) can reduce the TBA value and increase the intensity of the milk aroma of dangke nuggets.

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