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Soluble protein content, crude fiber, and hardness in Dangke nugget using red rice flour as filler in different steaming periods

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Soluble protein content, crude fiber, and hardness in Dangke nugget using red rice flour as filler in different steaming periods

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Abstract : Processing dangke into nuggets requires a filler to help bind water and reduce production costs. Besides containing starch, which binds water, red rice flour also has antioxidant activity and fiber beneficial for health. This research aimed to determine the level of red rice flour as filler and the optimum steaming period for dangke nugget based on soluble protein, crude fiber, and its hardness. This research applied a completely randomized design with a two-factor factorial pattern. The first factor was the level of red rice flour substituting dangke in (0%, 10%, and 20%) formulations, and the second factor was the steaming periods (20 and 30 minutes). The results showed that the increased level of usage of red rice flour by up to 20% significantly ($P < 0.01$) increased the hardness, and slightly increased the soluble protein content and crude fiber of dangke nuggets. The increase in steaming period significantly ($P < 0.01$) increased the soluble protein content, and slightly increased the hardness of the product texture. There was no significant effect in the interaction between two treatments. Red rice flour at 20% can be used as filler to partially substitute dangke in nugget formulation with a steaming period of 30 minutes.

1. Introduction

Dangke is a fresh cheese product made by people in Enrekang district, South Sulawesi. Papaya sap is used as milk coagulant in dangke production, while the milk is heated over medium heat to reach the optimal temperature for the papain enzyme in papaya sap to work. Apart from the use of papaya sap, dangke production also uses coconut shells as molds and banana leaves for packaging [1]. Dangke has high nutritional values in which cow milk dangke has 23.8% protein content, 14.8% fat, 55.0% water, and 2.1% ash, while buffalo milk dangke has 21.3% protein content, 15.9% fat, 52.7% water, and 2.7% ash [2]. The marketing issue of dangke outside the production area is its short shelf life at room temperature due to its relatively high moisture content. This causes dangke consumers to be limited to the Enrekang area and its surroundings although it is preferred in sensory and has high nutritional values. Processing dangke into nuggets can be an effort to increase its shelf life so that the marketing and consumers can expand to other areas in Indonesia. This can contribute to the provision of food sources of animal protein with high nutritional values for the people of Indonesia.

According to SNI (2002) nuggets, in this case chicken nuggets, are processed chicken products that are shaped, cooked and frozen, made from a mixture of ground chicken coated with or without the addition of other food ingredients and permitted food additives [3]. In its development, nuggets can also be made from ingredients other than chicken, including fish [4], shrimp [5], tempe [6], tofu [7],



and others. Filler is often added to nugget formulation and is usually made from starch that is rich in carbohydrates because it has strong water-binding properties that can improve the quality of nuggets and reduce production costs. Several types of local Indonesian flour have been used, including tapioca flour in fish nuggets [8], cassava flour in gizzard nuggets [9], suweg flour in chicken nuggets [10], combination of tapioca and sago flour in tempeh nuggets [11], and so on. The use of red rice flour as filler in producing nuggets has not been widely reported.

In addition to the commonly known white rice, there are also other rice varieties that have color pigments, including red rice (*Oryza sativa*). The chemical composition of red rice from Indonesia includes 8.95% moisture, 3.68% protein, 0.39% fat, 1.15% ash, and 2.52% fiber [12]. Besides having nutritional value, red rice also contains high fiber that makes it beneficial for health. Consuming fiber can prevent colon and rectal diseases [13]. The color in red rice is produced by anthocyanin pigments found on the outer skin. Consuming red rice reduces the risk of type 2 diabetes, heart disease, and cancer. This protective effect is related to the presence of bioactive compounds such as antioxidants, polyphenols, vitamins, and crude fiber in the outer layer of red rice [14]. Rice flour contains about 80% starch which can undergo gelatinization and has the ability to bind water during the heating process so that it can be used as an ingredient in food processing [15]. The water-binding capacity is essential in nugget processing.

Steaming is a heating method used in nugget processing. During steaming, various changes occur in the components of the ingredients mainly due to the degree of heat treatment used and the rate of water evaporation from the ingredients. The effect of steaming period can affect the quality of the resulting product. Subsequently, it is important to determine the steaming period of dangke nugget processing and the usage level of red rice flour as filler in dangke nugget formulation.

2. Materials and method

2.1. Material

Dangke nuggets were made using the following main ingredients; dangke, from a producer in Cendana sub-district, Enrekang district, red rice and wheat flour with medium protein content purchased at a supermarket in Makassar, egg yolks and ice cubes. Additional ingredients included salt, powdered garlic, and ground pepper. Egg whites, breadcrumbs and flour were used as the coating material. The composition of main ingredients in the control treatment formulation was dangke (70%), wheat flour (10%), red rice flour (0%), egg yolks (10%), and ice cubes (10%), while the additives were salt (1.5%), garlic powder, (1%), and ground pepper (0.5%). The use of red rice flour in the formulation then substituted dangke according to the treatment of usage level of red rice flour.

Parameter measurements used in this research were lowry reagent, folin reagent, Bovine Serum Albumine (BSA), and distilled water for soluble protein content. The fiber content determined by using H₂SO₄, NaOH, K₂SO₄, and 95% alcohol. These were purchased at a chemical store in Makassar city.

2.2. Method

2.2.1. Red rice flour production. The stages of making red rice flour included washing the rice under running water to clean it from dirt, soaking it for 12 hours, sun drying it for 24 hours, pounding it using a pestle, and sifting the yield with an 80 mesh sieve to produce a fine textured red rice flour.

2.2.2. Dangke nugget production. The ingredients, consisting of dangke, wheat flour, red rice flour, egg yolk, and ice cubes, were ground in a food processor for 2 minutes. Next, the powdered garlic and ground pepper were added to the mixture and ground for 2 minutes. The dough was poured into the pan, then steamed for 20 and 30 minutes. The cooked dough was cut into 4 x 4 cm² squares, dipped in egg white, then covered with bread flour and panir flour. The nuggets were stored in the refrigerator at 5°C until the parameter measurements were made.

2.2.3. Parameter measurements. Soluble protein content was calculated based on the method of Lowry et al [16], while crude fiber content was measured with AOAC method [17]. The hardness of the dangke nugget texture was measured using CD-Shear Force tool according to Abustam's measurement procedure [18]. The nugget sample was cut 2 cm in length and 0.635 cm in radius, then the sample was inserted into the CD-Shear Force hole. The nugget sample was cut perpendicular to the wind direction, and the amount of pressure signified on the instrument was recorded. Texture hardness was measured using the following formula:

$$A = A1 / L$$

A = Hardness of dangke nugget (Kg/Cm²)

A1 = Applied pressure (Kg)

L = Cross-sectional area of the sample {3.14 x (0.635 cm)²}

2.2.4. Statistical analysis

The treatments were arranged in a Completely Randomized Factorial Design with two factors: steaming times (20 and 30 min.) and red rice flour levels (0, 10, and 20%). Each treatment was repeated three times. Data measured for solubility proteins with crude fiber content, and texture hardness of dangke nuggets were interpreted with analysis of variance (ANOVA). The statistical significance of treatment at 5% level was followed by the Duncan's Multiple Range Test (DMRT). The data processing utilized SPSS -16.0 software.

3. Results and discussions

The results of measurement of dangke nugget's characteristics at various levels of red rice flour addition are presented in table 1. The results of the variance analysis showed that the treatment of red rice flour addition level had no significant effects on soluble protein and crude fiber, but it had a significant effect on the texture hardness ($P < 0.01$).

Table 1. Soluble protein content, crude fiber, and hardness of dangke nugget based on the effect of of red rice flour levels

Red rice flour levels (%)	Soluble protein (%)	Crude fiber (%)	Hardness (kg/cm ²)
0	30.78±12.18	0.37±0.14	0.14 ^a ±0.02
10	33.93±11.41	0.33±0.04	0.19 ^{ab} ±0.05
20	38.77±11.22	0.42±0.04	0.24 ^b ±0.07

^{ab}Different notations in the same column show significant differences ($P < 0.01$)

The measurement results of dangke nugget's characteristics at 20 and 30 minute steaming periods are presented in table 2. The results of the variance analysis highlighted that the treatment of steaming period had a significant effect ($P < 0.01$) on soluble protein content, yet it had no significant effects on the crude fiber content and texture hardness.

Table 2. Levels of soluble protein content, crude fiber, and hardness of dangke nugget based on the effect of steaming period

Steaming period (min.)	Soluble protein (%)	Crude fiber (%)	Hardness (kg/cm ²)
20	26.26 ^a ±5.73	0.39±0.09	0.17±0.04
30	42.72 ^b ±9.60	0.36±0.08	0.21±0.08

Different letter (ab) notations in the same column show significant differences ($P < 0.01$)

The results of the variance analysis indicated that the interaction between the treatment levels of rice flour addition and steaming period had no significant effects on the levels of soluble protein content, crude fiber, and texture hardness of the produced nuggets.

3.1. Soluble protein content

Table 1 shows that the protein content of dangke nuggets was at the lowest in the treatment without the addition of red rice flour, while the highest protein content was in the addition of 20% red rice flour although it was not statistically significant. There was an increase in soluble protein content along with the increasing level of red rice flour addition although the protein content of red rice was lower than that of dangke. The protein content of red rice was approximately 6.93% w/w [19], while the protein content of cow milk dangke was approximately 23.8%. The increase in protein content presumably occurred because red rice flour protein was slightly more soluble than casein and dangke whey proteins which had been denatured during the dangke-making process. Denaturation decreased the solubility of proteins compared to native proteins and caused aggregation which was difficult to be reversed after cooling [20].

The increase in steaming period from 20 to 30 minutes ($P < 0.01$) can significantly increase the soluble protein content of dangke nuggets (table 2). This is presumably due to an increase in temperature as the steaming period increases causing more protein bonds to be hydrolyzed so that it is easier to dissolve during cooking. Indriyani et al (2013) reported that the protein content of red rice flour tends to increase as the drying time of red rice grain in making flour increases [21]. Pelegrine (2010) explain that temperature is one factor that influences the protein solubility [22]. It is further explained that at pH 6, protein solubility increases at temperatures between 50 and 70°C.

3.2. Crude fiber content

Foods with high fiber content have a positive effect on health as fiber consumption can increase fecal volume, reduce intestinal transit time, cholesterol and glycemic levels, capture substances that are harmful to humans (mutagenic and carcinogenic agents), and stimulate the proliferation of intestinal flora [23]. The fiber content of dangke nuggets using red rice flour was 20% higher than those without adding red rice flour (table 1). This indicates that the partial substitution of dangke with red rice flour in nugget formulation can increase the product's fiber content. Islam et al (2012) reported an increase in fiber content of biscuits as the level of wheat flour substituted with red rice flour increased [24]. The increase in fiber content is related to the high fiber content of red rice that is around 5.27g/100g [25].

There is a tendency that increasing the steaming period from 20 to 30 minutes can reduce the fiber content of dangke nuggets although it is not statistically significant (table 2). This may be caused by the change in insoluble food fiber to dissolve with increasing temperature during steaming. The increase in temperature can break the weak bonds between the polysaccharide chains and split the glycoside bonds of the polysaccharide food fibers; as a result, the insoluble food fiber becomes dissolved [26]. Caprita et al (2011) found that the water extract viscosity value of wheat and barley increased when heated at 100°C in which the increase in viscosity value indicated the conversion of insoluble food fiber to soluble dietary fiber [27].

3.3. Hardness

Hardness is an important parameter in assessing the texture quality of nuggets. The texture hardness of dangke nuggets using red rice flour at a level of 20% was significantly ($P < 0.01$) higher than those without using red rice flour. This result implies the ability to bind water and protein (dangke) was stronger than amylose starch and amylopectin from carbohydrates (red rice flour). Abo-Zaid E M and Saleh F M (2020) revealed that replacing skim milk and wheat flour with taro flour as a binder caused the texture hardness of chicken nugget to increase [28]. Reported Hariati et al (2018) that replacing wheat flour with red rice flour decreased the level of panelists' acceptance of the resulted steamed sponge texture, where the higher the usage level of red rice flour, the more decreased the level of panelists' preference for the texture [29]. The amylose and amylopectin content of carbohydrate flour determines the binding strength of water. When heated, amylopectin undergoes an irreversible gelatinization process which results in a strong water binding ability. Muthia et al (2010) stated that the type of flour with high amylopectin content produced softer duck sausages [30]. Red rice flour has

a moderate amylose content, around 11.27% to 20.46% [31]. The amylopectin content of rice flour is lower than that of glutinous, tapioca, and wheat flour, while the viscosity value of rice flour is lower than that of glutinous and tapioca flour [32].

The hardness of dangke nuggets tended to increase as the steaming period increased; however, it did not have a significant effect statistically (table 2). The increase in steaming period caused more water to evaporate from the ingredients so that the texture of the product became denser. Heating in high temperatures for a long time resulted in denatured protein; hence, the water content was more easily evaporated. The heating effects on protein denaturation covered the secondary and tertiary structures of the unfolded protein causing hydrophobic groups to interact and reduce the ability to bind water [33]. Alyani et al (2016) reported that the increase in boiling time of milkfish from 20, 30, to 40 minutes caused the moisture content of pindang fish to decrease and differed significantly between each treatment [34]. The increase in hardness of dangke nuggets due to the increased steaming period may also be associated with the increased level of amylose in red rice flour due to heating. According to Funnema (1985), heat can break the α -1,6 glycosidic bonds, so that the amylopectin structure changes to amylose causing its amount to increase [35]. Rice with high amylose content produces rice with a hard texture [36].

4. Conclusion

The increased level of red rice flour up to 20% as filler to substitute dangke can increase the hardness of its texture, and there is a tendency of increased soluble protein content and crude fiber of dangke nuggets. The increased dough steaming period to 30 minutes can increase the soluble protein content, and there is a tendency of increased hardness of the dangke nugget texture. The 20% red rice flour usage level and 30 minutes of dough steaming period is a combination of treatments that can produce the best quality dangke nuggets.

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