The characteristics of cookies from sorghum flour and almond flour with variations in the type of fat

by Nur Aini

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B Sustriawan, N Aini*, R Setyawati, R Hania, R T Sandi and R Irfan

Department of Food Technology, Jenderal Soedirman University, Purwokerto, Indonesia

Corresponding author: nur.aini@unsoed.ac.id

Abstract. The substitution of wheat flour with almond flour and addition of vegetables fat can influence the final properties of cookies, enhance the taste, and eliminate skim milk use which produce lactose-free cookies. This study aims to determine the effect of different ratio of sorghum flour to almond flour and addition of various type of fat to the physical and chemical properties of cookies. This research used a factorial randomized block template (RBD) with study factors ratio of sorghum flour to almond flour (1:1, 2:1, and 3:1) and the form of fat added (margarine, VCO, and a mixture of margarine and VCO (1:1 w / w)). The findings showed that the ratio of sorghum flour and almond flour had a major effect on the ash, fat, dissolved protein, and reducing sugar content. Type of fat had a major impact on the ash, fat, and reducing sugar content. The best treatment in this study showed in a ratio of sorghum flour and almond flour of 1:1 using margarine with water content 3.08%, ash content 0.82%, fat content 36.65%, dissolved protein content of 1.27%, decreasing sugar content of 0.56%, and loaf volume of 92.04%.

1. Introduction

Sorghum is an important cereal crop to fulfil the carbohydrate needs, it is in the top five cereal crops after wheat, rice, corn and barley. Sorghum has great potential to be developed in Indonesia as a local food ingredient since it has a large area of adaptation [1]. However, although its nutritional content is equivalent to rice, sorghum has not been widely consumed by Indonesians. It contains 332 cal/100 g of calories, 11% protein, 3.3% fat, and 73% carbohydrates.

The use of sorghum in the form of flour is more profitable because it is more practical and easier to process flour into various snack products such as cookies. Cookies made from sorghum flour can be used an alternative for people who cannot consume gluten since sorghum flour does not contain gluten [2]. Besides the advantages of sorghum flour, there are anti-nutritional compounds, namely tannins that can affect the taste of sorghum flour cookies. Tannins are polyphenolic compounds that can cause a slightly bitter taste [3]. This makes processed sorghum products less popular. To solve this issue, almond flour can be added to improve the taste of the cookies.

Almonds have a savory taste due to their high vegetable fat. In addition, almonds contain 21.15% protein. Thus, almonds can act as a protein source in cookies instead of skim milk, so that cookies can be lactose-free and can be consumed by people with lactose-intolerance [4]. Furthermore, the addition of fat in making cookies can also affect the taste and texture [5]. Fat is widely used in the manufacture of bakery products with the aim of helping to soften the final product. There are basically various types of fat that can be added to cookies, for example, margarine and virgin coconut oil (VCO). Margarine is

a food ingredient that contains 80% fat, made by mixing vegetable fats and oils with other additives [6]. Additionally, virgin coconut oil (VCO) is oil produced from fresh coconut fruit. VCO can be beneficial for the health of the body since it contains a lot of medium chain fatty acid (MCFA) [7].

This study aims to: 1) find out the effect of the ratio of sorghum flour and almond flour on the physical and chemical properties of the resulting gluten and lactose free cookies; 2) find out the effect of variations in the type of fat added on the physical and chemical properties of the resulting gluten and lactose free cookies; and 3) find out the best treatment on ratio of sorghum flour and almond flour as well as the type of fat added in making gluten and lactose free cookies.

2. Experimental details

2.1. Ingredients

Numbu sorghum from Bandung, almond flour (PT Khas Jaya Nusantara), margarine, virgin coconut oil (VCO), refined sugar, egg yolk, and baking powder were used as the ingredients to make cookies. Distilled water, BSA solution, Lowry B reagent solution, Lowry A reagent solution, hexane solvent, anhydrous glucose, Nelson reagent solution, and arsenomolybdate reagent solution were also used for study.

2.2. Sorghum flour production

The process of making sorghum flour referred to Abdelghafor et al. [8] with modifications. The sorghum seeds that had been polished were soaked in water for 24 hours and then drained. The soaked sorghum seeds were then dried using a cabinet dryer at 60°C for 28 hours until the moisture content reached 10-12%, which was indicated by the dry and brittle texture of the sorghum seeds. The sorghum seeds were then ground using a flour mill and sieved using an 80-mesh sieve. The sifted sorghum flour was then weighed and packaged using the primary PP plastic bag packaging.

2.3. Cookies production

The cookies production procedures referred to Bolarinwa et al. [9] with modifications with following ingredients: 49.72% flour, 16.60% granulated sugar, 22.87% fat, 9.94% egg yolk, 0.49% baking powder, and 0.38% salt. The procedures were mixing 50 grams of sorghum flour and almond flour according to each treatment and other ingredients such as granulated sugar, fat based on each treatment (margarine, VCO, and a mixture of margarine and VCO). In addition, other ingredients such as egg yolks, salt, and baking powder were also prepared in an amount based on a predetermined formulation. Furthermore, sugar, fat, salt, baking powder and egg yolk were mixed for 7 minutes using a mixer. The mixture was then mixed with flour prepared according to the treatment. The dough was then stirred until it was homogeneous and molded using a circle cookie mold. The cookie dough was baked in an oven at 150°C for 20 minutes. The last stage, cookies were prepared for analysis.

2.4. Experimental design

This study was conducted experimentally using a factorial randomized block design (RBD) with three replications. The treatment factor studied was the ratio of sorghum flour and almond flour, consisting of three levels including 1: 1; 2:1 and 3:1; as well as the variation factor for the type of fat added, consisting of three levels: margarine, VCO, and a mixture of margarine and VCO (1: 1 w/w).

2.5.Analysis of samples

The variables observed included moisture content [10], ash content [10], dissolved protein content fat content [10], reducing sugar content [10], and leaf volume of cookies [11]. Data from chemical and physical analysis of cookies were analyzed by analysis of variance (ANOVA). If there is a significant effect ($p < 0.05$), it will be followed by the Duncan Multiple Range Test (DMRT) at the 5% level. The best treatment was determined by the effectiveness index method based on the physical and chemical properties of the cookies.

3. Results and discussion

3.1. Characteristics of the product

3.1.1. Moisture content. There was no major effect on the moisture content of the cookies on the ratio of sorghum flour and almond flour, differences in the type of fat, and the relationship between them. The average value of cookies' moisture content for each procedure ranged from 2.52% to 3.46% based on Figure 1. The water moisture produced in this study was higher than in the research conducted by Siqueira et al. [12], which found that sorghum flour and canna flour cookies with a moisture content of 2.44% were the products made. This can be caused by the use of different raw materials resulting in different moisture content. In addition, the moisture content in cookies can be affected by the temperature and duration of baking of the cookie dough. The longer the baking time and the higher the temperature used, the lower the moisture content of the cookies. It is because the heat transmitted through the oven or similar evaporates the water in the cookie dough [9].

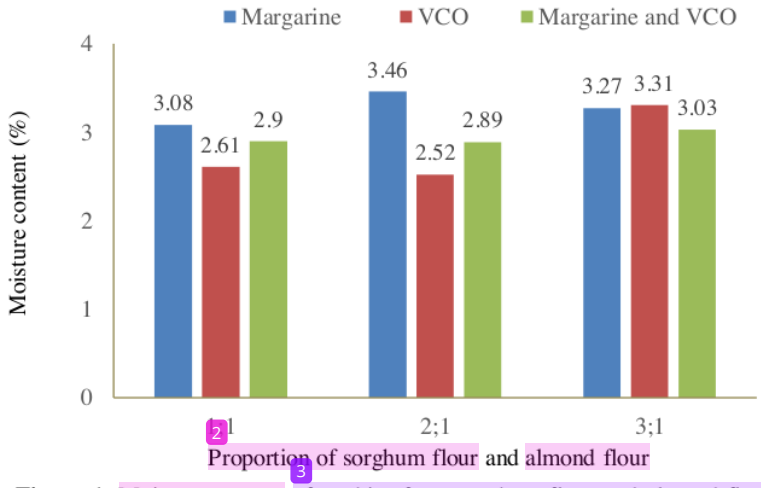

Figure 1. Moisture content of cookies from sorghum flour and almond flour with variation of fat

3.1.2. Ash content. Ratio of sorghum flour and almond flour and variations in the type of fat had a significant effect on the ash content of cookies, but the interaction between them had no significant effect. The highest ash content of cookies was found in proportion of sorghum flour : almond flour 1:1 (0.54%) and it was lower if the ratio of almond flour was getting smaller (Figure 2). Based on Siqueira et al. [12], almond flour has an ash content of 2.85%. Meanwhile, according to Teixeira et al. [13] sorghum flour has an ash content of 2.29%. Thus, differences in ash content in the materials used affect the ash content of the resulting cookies. More importantly, the polishing process of sorghum seeds can also reduce the ash content of sorghum since the polishing process of sorghum seeds will erode part of the seed coat [14]. Consequently, the ash content of polished sorghum is lower than the ash content of unpolished sorghum.

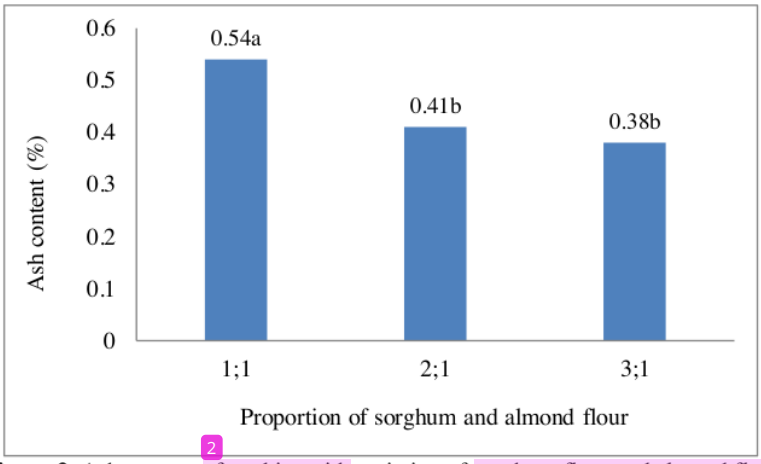

Figure 2. Ash content of cookies with variation of sorghum flour and almond flour

Cookies with the addition of margarine had the highest ash content (0.67%), followed by cookies with the addition of a mixture of margarine and VCO (0.40%) and cookies with the addition of VCO (0.26%) (Figure 3). The ash content of a food ingredient can be affected by mineral content of food ingredient. Margarine has a mineral content that is relatively greater than VCO because in general there is a vitamin and mineral fortification process in margarine processing to increase its nutritional value [15]. Meanwhile, VCO processing is generally carried out by separating the cream in coconut milk, which is then heated to produce oil [7].

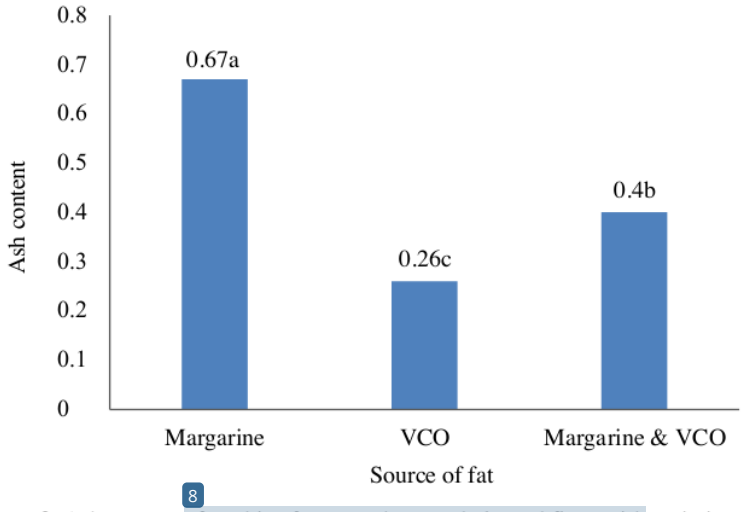

Figure 3. Ash content of cookies from sorghum and almond flour with variation of fat

In a study conducted by Barlina [16], sago cookies added with margarine have an ash content ranging from 1.46% to 1.62%, while sago cookies added with VCO have an ash content ranging from 1.23% - 1.41%. Here, it can be seen that cookies added with margarine have a greater ash content than cookies added with VCO.

3.1.3. Fat content. Ratio of sorghum flour and almond flour and variations in the type of fat had a very significant effect on the fat content of cookies, but the interaction between them had no significant effect. The greater the ratio of almond flour, the higher the fat content (Figure 4). This is because almond flour has a higher fat content (54.62%) than sorghum flour (3,65%) [17,18]. The results of fat content in this study did not differ much from a research conducted by Jia et al. [19] regarding cookies made from brown rice flour and almond flour, the g fat content was 32.99%. This indicates that a high ratio of almond flour will produce cookies with a high fat content.

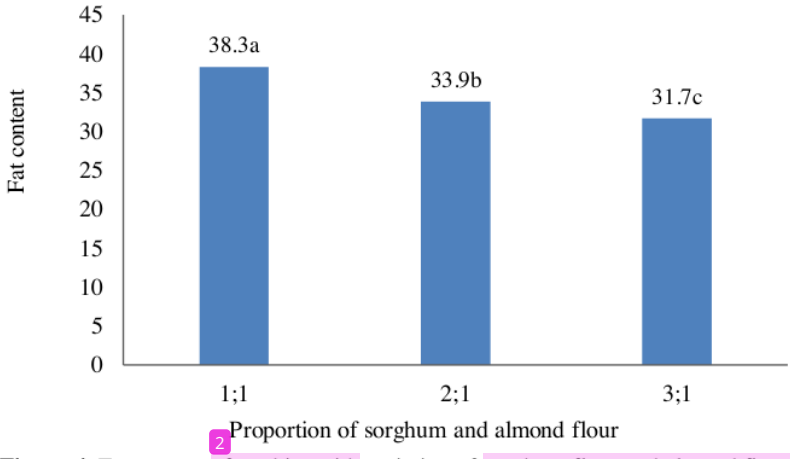

Figure 4. Fat content of cookies with variation of sorghum flour and almond flour

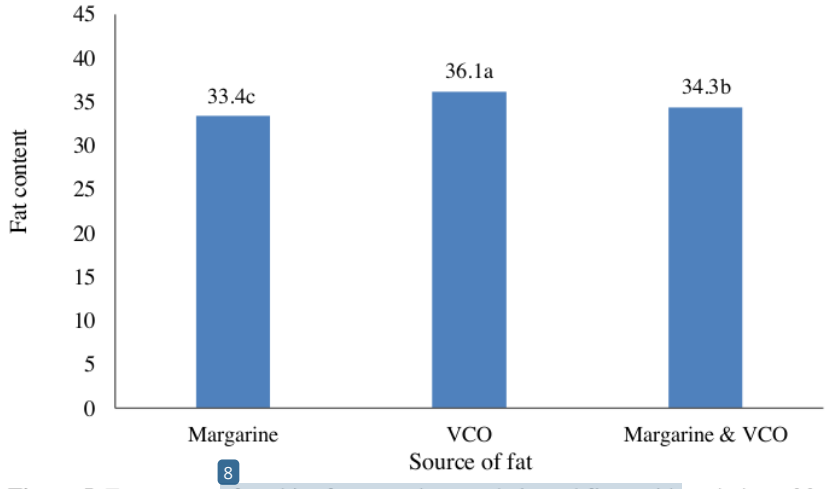

Figure 5. Fat content of cookies from sorghum and almond flour with variation of fat

Figure 5 shows that there are differences in the fat content of cookies with the addition of margarine, VCO, and a mixture of margarine and VCO. The highest to the lowest fat content of cookies were 36.14%, 34.34% and 33.40%, respectively. Cookies with the addition of VCO have a higher fat content than cookies with the addition of margarine with a reason that VCO contains 92% fat in the form of medium chain fatty acids and short chain fatty acids [20], while margarine has a lower fat content than VCO, which is 81.6 % [6]. The high fat content in VCO can be caused by VCO processing in which there is no addition of other ingredients so that pure coconut oil is obtained, while commercial products

such as margarine are enriched with other ingredients such as vitamins, minerals, dyes, and so on so that they have a lower fat content than VCO [16].

3.1.4. Soluble protein. Ratio of sorghum flour and almond flour had a very significant effect on the soluble protein content of cookies, but the variation in the type of fat and the interaction between them had no significant effect. The highest soluble protein content (1.25%) was found in proportion of sorghum flour : almond flour 1:1, and the soluble protein content was lower with the smaller the ratio of almond flour (Figure 6). This is due to the different soluble protein content in sorghum and almond flour which affects the soluble protein content of the cookies produced. Sorghum flour has a protein content of 10.11%) [21], while almond flour has a greater protein content than sorghum flour, which is 26.50% [12].

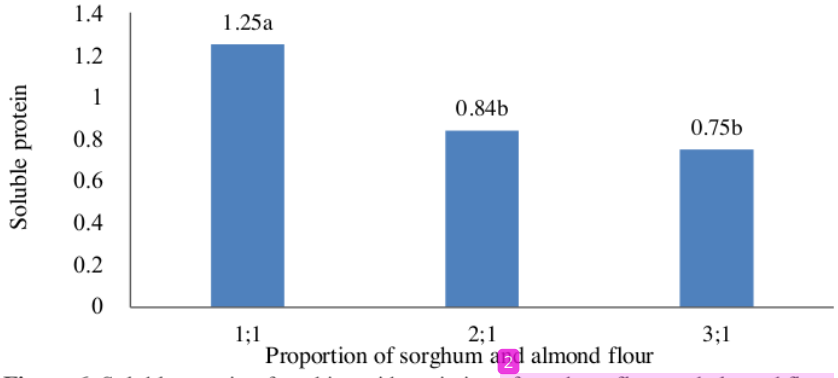

Figure 6. Soluble protein of cookies with variation of sorghum flour and almond flour

The soluble protein of cookies in this study was lower than the protein content in Bolarinwa et al. [9] regarding the manufacture of biscuits from rice flour, in which the soluble protein content obtained was around 1.36% -1.70%. The difference in soluble protein content can be due to the use of different flour and the addition of yeast and fermentation to the flour for 12-60 hours which can increase the soluble protein content in the corn rice flour. The soaking process in sorghum seeds can also reduce the soluble protein content in the resulting flour because the protein bonds can be released so that the protein components will dissolve in water

3.1.5. Reducing sugar. Ratio of sorghum flour and almond flour and variations in the type of fat had a significant effect on the reducing sugar content of cookies. However, the interaction between treatments was not significant. The highest reducing sugar content was found in proportion sorghum flour : almond flour 1:1 (0.55%), and it decreased with the higher the ratio of sorghum flour (Figure 7). The reducing sugar content in the resulting cookies can be affected by the reducing sugar content in the ingredients used. In a study by Ulfi et al. [22] regarding the characteristics of modified sorghum flour, sorghum flour with control treatment had a reducing sugar content of 0.302%. Vargas-Solórzano et al. [23] affirmed that sorghum flour made by wet method on various varieties has carbohydrate content in the range of 79.39% - 79.80%. Moreover, reducing sugar content in almonds is relatively small (0.05 - 0.13%) in the form of glucose and fructose and almond flour has a carbohydrate content of 11.82% [24].

Additionally, the reducing sugar content of cookies can be influenced by the starch in sorghum and almonds which can change into reducing sugar content due to high temperature treatment, during the drying process in making flour and during baking process of the dough in the oven.

Cookies with a mixture of margarine and VCO had the highest reducing sugar (0.50%), followed by cookies with margarine (0.38%), and the lowest reducing sugar content was cookies with VCO (0.29%). The higher fat in margarine and VCO will increase the amount of fat solids in cookies which can reduce carbohydrate levels so that the reducing sugar content can also decrease. The reducing sugar content in

cookies can affect the Maillard reaction which can affect the brown color of cookies. Relatively low reducing sugar content can cause a low intensity of browning in cookies [25].

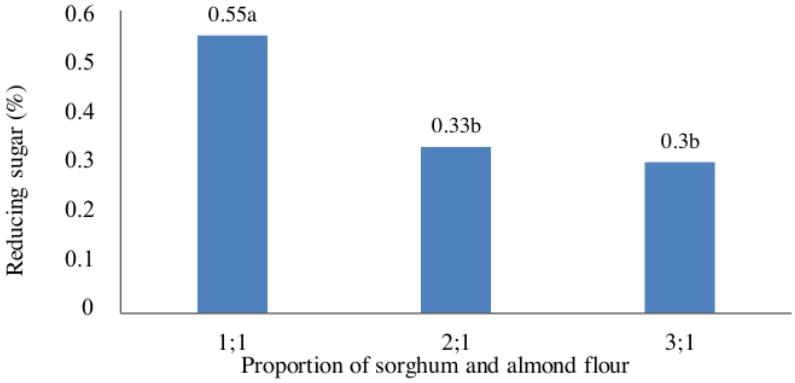

Figure 7. Reducing sugar of cookies with variation of sorghum flour and almond

3.1.6. Loaf volume. Ratio of sorghum flour and almond flour, variations in the type of fat, and the interaction between them had no significant effect on the loaf volume of cookies. The average loaf volume of cookies ranged from 51.25% to 101.40% in which cookies with a ratio of sorghum flour and almond flour of 3 : 1 and with the addition of VCO had the smallest loaf volume. Meanwhile, cookies with a ratio of sorghum flour and almond flour of 2: 1 and with the addition of margarine and VCO had the largest loaf volume. In addition, sorghum flour does not contain gluten like wheat flour [26]. The added fat in cookies has the ability to trap air during the mixing process of the ingredients. Consequently, the air bubbles trapped in the dough will increase loaf volume of cookies [27].

Besides the use of flour and fat, the addition of additives like baking powder can also influence the loaf volume of cookies. Meeting liquids from other ingredients and hot temperatures during the baking process in the oven, baking powder can cause the formation of CO_2 gas in the dough, in which air cavities are formed [28]; these air cavities can increase loaf volume of cookies.

In a study conducted by Lee and Jin [29], cookies made from brown rice flour also have a small loaf volume of 0.20%-0.4. This is because both studies use non-wheat flour without the addition of baking powder. Meanwhile, in this study, there was the addition of baking powder so that the loaf volume of cookies produced tended to be large.

3.1.7. Determination of the best treatment. Based on the calculation of the effectiveness index test, it can be seen that the best treatment in this study was ratio of sorghum flour and almond flour of 1:1 and with the addition of margarine. These cookies contain moisture content of 3.08%, ash content of 0.82%, fat content of 36.65%, dissolved protein content of 1.27%, reducing sugar content of 0.56%, and loaf volume of 92.04%.

Cookies with a ratio of sorghum flour and almond flour of 1:1 produced the cookies with the highest dissolved protein content than cookies with a ratio of 2:1 and 3:1; in the calculation of the effectiveness index test, dissolved protein content had the highest weight among other parameters. Last but not least, the use of margarine produces cookies with lower fat content than cookies that use VCO and a mixture of margarine and VCO.

4. Conclusion

Increasing the VCO concentration from 15% to 25% in the cheese analogue production increases the fat and water content while at the same time reducing the sensory properties. The addition of various emulsifier types does not significantly influence the physicochemical variables and sensory properties of the cheese analogue. The best cheese analogue was produced with treatment A3B2: 25% VCO and

Tween 80. This treatment produced a yield value of 59.93% bb, fat content of 49.96% db and dissolved protein content of 11.51% db with the following sensory properties: colour value of 3.84 (yellowish white), aroma value of 4.07 (slightly typical of cheese), taste value of 5.48 (slightly salty), texture value of 2.55 (not hard) and the favourite value is 4.38 (rather preferable).

Acknowledgements
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