Effect of time and temperature sorghum germination on the fineness and color of sorghum sprout flour

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Abstract. Sorghum is a local product that is quite prospective in providing local carbohydrate sources. Processing sorghum seeds into sorghum flour is one alternative to replace the consumption of wheat flour which continues to increase. However, sorghum flour used in composite flour will provide dry, sandy and crumb properties that are hard so fast, so that other processes need to be done to improve its characteristics. Soaking and germination can reduce antinutrient compounds and can also increase nutritional value. The purpose of this study was to obtain the time and temperature of germination and the interaction between the two to produce good sorghum sprout flour. The research method used was an experimental method using Factorial Randomized Group Design (RGD). The first factor is the germination temperature (A) with 2 levels, namely $A_1 = 25 \, ^\circ C$ and $A_2 = 35 \, ^\circ C$. The second factor is the time of germination (B) with 3 levels, namely $B_1 = 12$ hours, $B_2 = 24$ hours and $B_3 = 36$ hours. Combinations carried out there are 6, each combination is repeated 3 times. Germination with variations in the time and temperature of germination did not show a significant effect on the physical characteristics of sorghum sprout flour. The best rendement and color values were found in the germination treatment at 25C at 36 hours ie 98.02% and 72.36% while the best fineness modulus was found in the germination treatment at 35 °C for 36 hours ie 2.43.

Keywords: sorghum sprout flour, germination, fineness, color

1. Introduction
Indonesia's demand for wheat commodities is relative high. It is because of the consumption of wheat-based flour continuously increasing along with the increase of food industry production. Sorghum is an alternative food commodity that has considerable potential to be developed in Indonesia. As a food, the nutritional content of shorgum is very competitive with rice and corn [1]. Sorghum has the same nutrition content with wheat as a raw material for wheat flour [2]. Sorghum seeds contain good nutrients as food ingredients. Sorghum seeds contain fat (3.65%), crude fiber (2.74%), ash (2.24%), protein (10.11%), and carbohydrates (80.42%) [3]. The development of sorghum is prospective enough to provide local source of carbohydrates [4].

Sorghum flour use in composite flour will give a dry, sandy and crumb features that are quickly hardens so it needs to be modified to improve the characteristics [5]. Germination can cause changes in nutritional content and functional characteristics due to aerobic respiration and biochemical metabolism [6]. Germination can be influenced by several factors such as the condition of germinated
seeds and environmental factors such as temperatures that can affect the nutritional content of germinated sorghum seeds [7]. Each plant genetically requires different temperatures for optimum growth and depends on species and plant varieties [8].

The physical characteristics of flour can affect the characteristics of the products that produced. The physical characteristics of flour which are most important in determining the quality of flour are the level of fineness of the flour and the level of color of the flour. Fineness modulus is an index used to express the smoothness of bulk solids such as flour. The level of fineness modulus is generally divided into coarse, medium and fine, where the finer the material, the smaller of fineness modulus [9]. While color is one of the factors that can determine the quality of a product. Mixing process and good processing can be seen from uniform and even colors [10]. The purpose of this study was to obtain the time and temperature of germination and the interaction between the two to produce good sorghum sprout flour.

2. Materials and methods

2.1. Materials

The main material used in this study was sorghum seeds of Numbu variety from Ujung Berung, Bandung, which had previously been germinated with a certain time and temperature. The equipment used is Disc Mill, shaker sieve, Digital Shiver Shaker, Spectrophotometer and analytic balance.

2.2. Sampel preparation

Sorghum seeds washed with water until cleaned, then drained. The dried sorghum seeds were placed on a wet flannel cloth and then closed. Then the sorghum seeds were stored in a dark room in temperature of 25 °C and 35 °C at for 12, 24 and 36 hours. Sorghum sprout seeds drying with sun drying method for one day, then analyzed the moisture content of the seeds. If the moisture content of sorghum seeds was below 14%, then it would be followed by decortication and make sorghum sprout seeds into the flour. Decortication sorghum seeds used a manual decorticating device using mortar and pestle and sorghum sprout flour made by using Disc Mill.

2.3. Analysis of physical characteristics of sorghum flour

2.3.1. Rendement. Calculate the amount of rendement flour based on the percentage of weight of the material produced on the initial weight of used material by using equation (1):

\[
Rendement (\%) = \frac{B_2}{B_1} \times 100\% \tag{1}
\]

where:  
\( B_1 \) = initial weight (g)  
\( B_2 \) = weight of the material produced (g)

2.3.2. Fineness modulus. A 100 grams of sorghum flour were sifted using 35, 60, 100 and 120 mesh sieves. Mesh showed the number of holes per inch on the same line. Sifting using a mechanical vibrator. The sieve with the largest hole size was placed at the top, and the smallest in the lowest place. Sifting was carried out for 10 minutes with amplitude 60. The weighing of flour was held in each of its fractions (each mesh). Calculation of fineness modulus is as follows:

Determine the material fraction retained:

\[
X_i = \frac{W_{\text{material retained}}}{W_{\text{total}}} \times 100\% \tag{2}
\]
Determine the fineness modulus:

$$FM = \frac{\sum (\text{cumulative percentage retained on specified sieves})}{100}$$ (3)

where: $X_i = \%$ materials left

$W_{\text{total}} = \%$ cumulative materials retained

2.3.3. Color. Activate the computer and spectrophotometer by pressing the on/off button at the bottom right of the tool. Open the Magic NX Spectra program. Select the bar instrument menu. Select connect to connect the spectrophotometric tool with the program. Each time you use a tool to be calibrated by selecting calibration in the instrument menu bar, do zero calibration and white calibration according to the program's instructions. Measurements were made by placing samples in available sample containers and then measuring them on a scale of values L, a and b. The L value represents the brightness parameter which had values from 0 (black) to 100 (white) the value of a indicates the reflected light which produced a mixture of chromatic colors red and green with a + (positive) values from 0–100 for red and a- (negative) from 0 - (-80) for green. Notation b denotes a chromatic color mixed with blue and yellow with a value of b + (positive) from 0–70 for yellow and a value of b- (negative) from 0 - (-70) for blue. Next would be calculated the white degree value with the white degree standard used, namely BASO₄ through the following equation:

$$\text{Color} (X) = 100 - \sqrt{(100 - L)^2 + (a^2 + b^2)}$$ (4)

$$\text{Color} (%) = \frac{X}{110.8} \times 100$$ (5)

2.4. Statistic analysis

The research method used was an experimental method using Factorial Randomized Group Design (RGD) using SPSS 16 tools. The first factor was the germination temperature (A) with 2 levels, namely $A_1 = 25 \, ^{\circ}C$ and $A_2 = 35 \, ^{\circ}C$. The second factor was the time of germination (B) with 3 levels, namely $B_1 = 12$ hours, $B_2 = 24$ hours and $B_3 = 36$ hours. There were 6 combinations that were carried out, each combination was repeated 3 times, so the number of combinations was 18 experimental units.

3. Result and discussion

3.1. Rendement

Rendement is one of the parameters that quite important to know the economic value of a product. A high rendement value product would cause the economic value of the product to be high too [11]. Rendemen showed the product obtained by comparing the initial weight of the material with the final weight expressed in percent so that we could know the weight of the material lost during the processing [12].

| Temperature (A) | Time (B)       |       |       |       |
|----------------|----------------|-------|-------|-------|
|                | 12 hours       | 24 hours | 36 hours |
| 25 °C          | 91.72 ± 11.72 a | 92.40 ± 7.37 a | 98.02 ± 0.67 a |
| A              | A              | A     |       |
| 35 °C          | 95.99 ± 2.71 a  | 89.58 ± 3.22 a | 87.32 ± 7.04 a |
| A              | A              | A     | B     |

* The same alphabet in one column and row shows the value is not statistically significantly different at $p \leq 0.05$ using the Duncan methods.
Based on data table 1 Duncan values obtained showed that not all rendement value of sorghum flour were significantly different in each combination of treatments. The rendement value of sorghum sprout flour tend to increase along with the length of germination time, but if the germination temperature was increased the rendement value of sorghum sprout flour would decrease with the length of germination time. The highest rendement value of sorghum flour was found in the treatment with germination at 25 °C for 36 hours, 98.02%, while the lowest rendement value of sorghum sprout flour was found in the treatment with germination at 35 °C for 36 hours, 87.32%. The rendement value could be influenced by several factors including the weight of the material used. The weight the material used could cause higher rendement value [13]. However, the weight would decrease during cleaning and soaking. The decrease in mass was due to the quality of the seeds. The less-good seeds would float and be wasted in the process of water immersion and removal.

The moisture content of the product could affect the rendement value because of drying process. Drying process with low temperature caused the water content of materials could be evaporated less, so the rendement value produced was high and drying process with higher temperature could cause the water to be evaporated more so that it could decrease the rendement value of flour [14]. Drying of sorghum seeds with variations of temperature and time of germination was carried out using sun drying was dried for one day. Drying with sun drying method could be caused by several factors, such as wind speed, air temperature and humidity [15]. Drying using sun drying method tend to be unstable because the temperature of the environment would always changing [16].

Soaked and germination treatments could affect the moisture content of the seeds. It was because during the germination process there was water absorption, metabolism of decomposition of food reserve material, transport of decomposition material from endospem to the active part of the embryo, assimilation, respiration and growth [17]. Water absorption was the initial step for seed germination. Water in the seed cells served to activate germination enzymes, such as the α-amylase enzyme. Water was important in composing protoplasm and as a metabolic reaction medium [18].

The starch content of a material could affect the high and low rendement of a product [19]. This was because during the germination process there was hydrolysis of carbohydrates, proteins and fats into simple molecules so that they were easily digested, provide energy and become a substrate at the beginning of the growth and development stage [20]. Based on research conducted by [21] showed that along with the length of the germination process on sorghum seeds could reduce starch levels in ingredients. This decrease was due to the activity of microorganisms during immersion which made changes to the starch component. Temperature could also affect the product's nutrient content. Temperature had an important role in the process of germination because the temperature could affect various chemical reactions that occur during the germination process of seeds such as activating enzymes that play a role in the germination process, including amylase, lipase and proteinase [8].

3.2. Fineness modulus.

Fineness modulus was the level of fineness of flour from a production process. Fineness modulus could be used to show uniformity of grinding results or distribution of fine and coarse fractions in the grinding process. The smaller the fineness modulus value states the finer the size of the flour granules [10].

| Temperature (A) | 12 hours | 24 hours | 36 hours |
|----------------|----------|----------|----------|
| 25 °C          | 2.52 ± 0.18 a | 2.57 ± 0.09 a | 2.49 ± 0.11 a |
| 35 °C          | 2.52 ± 0.04 a | 2.51 ± 0.07 a | 2.43 ± 0.11 a |

*a The same alphabet in one column and row shows the value is not statistically significantly different at p ≤ 0.05 using the Duncan methods.*
Based on data table 2, Duncan values obtained showed that all the fineness modulus value of sorghum flour fineness was not significantly different in each combination of treatments. The highest fineness modulus was found in the germination treatment with a temperature of 25 °C for 24 hours, which is 2.57 while the lowest modulus of fineness was found in the treatment with germination at 35 °C for 36 hours ie 2.43. The fineness modulus tend to decrease with the length of germination time. However, germination at 24-hour in 25 °C the fineness modulus a change. The fineness modulus could be influenced by several factors including the composition of pericarp, embrio, and corneous endosperm where the more the amount the more rough and not uniform the texture was produced. Perikarp and embrio had a hard texture and are difficult to mash so that they could affect the fineness modulus of the sorghum flour particles [12].

The germination process could affect the fineness modulus of flour. The process of germination took place in the absorption of water needed for seed metabolism. Ambition of water caused swelling of cells in seeds that could cause seed skin to soften so that it could facilitate the roots to grow past the seed coat [22]. In addition, the drying process could also affect the fineness modulus of a product. During the drying process, the slower the air drying speed, the drying process would be longer so that the water vapor in the material could be released more and would produce fine flour, this was due to the higher drying temperature used then the evaporated water from the material would be higher so flour will be produced which had a higher fineness modulus value [9].

Decortication process could also affect the fineness modulus value. The longer decortication process, the more pericarp and embrio would produce flour with a finer and more uniform texture. The more the percentage of flour particle size was finer, the lower the fineness modulus value [12]. The fineness modulus value showed the uniformity of the results of grinding or the distribution of coarse and fine fractions of ingredients. Flour had a medium fineness modulus value had scale between 2.1–4.1 [23]. So that the sorghum sprout flour produced with various variations in temperature and time of germination was included in the flour category with medium smoothness.

3.3. Color

The color of a product gave an impression in the assessment of the product and as a parameter for the appearance of the product [11].

| Temperature (A) | Time (B) | 12 hours | 24 hours | 36 hours |
|----------------|----------|----------|----------|----------|
| 25 °C          |          | 71.44 ± 1.05 a | 71.39 ± 0.51 a | 72.36 ± 1.55 a |
|                | A        | A        | A        | A        |
| 35 °C          | 71.53 ± 1.01 a | 70.87 ± 0.14 a | 71.06 ± 0.06 a |  |
|                | A        | A        | A        | A        |

* The same alphabet in one column and row shows the value is not statistically significantly different at p ≤ 0.05 using the Duncan methods.

Based on data table 3, Duncan values obtained showed that all color values of sorghum flour were not significantly different in each combination of treatments. The highest color value was found in the germination treatment with a temperature of 25 °C for 36 hours which was 72.36% while the lowest color value was found in the treatment with germination at 35 °C for 24 hours ie 70.87%. The color value of sorghum sprout flour tend to decrease at 24-hour germination at 25 °C and 35 °C, then it would rise again at 36 hours germination time.

[24] states that white sorghum had ivory white (cream) and yellowish white endosperms so that the longer decortication process, the less pericarp would give a dull white ivory color. Perikarp contained pigments such as tannins or phenol components and starch granules which determine the color of sorghum seeds, such as white to old brown sapodilla (Hermawan, 2014). Based on research conducted by [21] showed that immersion and germination could reduce tannin levels along with the length of
germination time. In addition germination could reduce the content of phenolic components by 40% [25]. Decortication could affect the color of flour by products that produced, because with the shorter time of ignition, the less pericarp and testa of sorghum seeds were scattered, thus affecting the color of sorghum flour produced [26]. [12] states that the longer the decortication process showed the higher color value of sorghum flour that produced. This study uses a manual decorticating device, which is crushed using mortar and pestle, so that the process of decorticating destruction of sorghum seed is not well controlled, such as using an decorticating device. Therefore the white color of sorghum flour produced is still below the white color of commercial wheat flour, which is equal 86.5% [27]. This is shown that the color of sorghum flour is more brown compared to commercial flour.

4. Conclusion
Germination with variations in the time and temperature of germination did not show a significant effect on the physical characteristics of sorghum sprout flour. The best rendement and color values were found in the germination treatment at 25 °C at 36 hours ie 98.02% and 72.36% while the best modulus of fineness was found in the germination treatment at 35 °C for 36 hours i.e. 2.43.

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