The effect of boiler size of distillation to the concentration of bioethanol and yield from fermentation of sweet sorghum juice

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Abstract. Bioethanol from sorghum juice can be obtained by the fermentation process involving microorganisms. The distillation process is then carried out to increase the bioethanol concentration. The purpose of this study was to determine optimal of the boiler size from a distillation device based on the concentration of bioethanol final and yield. The bioethanol production research method consists of three stages, namely preparation of raw materials covers cleaning and pressing sorghum stem to get sweet sorghum juice, removal of phenolic compounds by the adsorption method using activated charcoal. Furthermore, the fermentation of sorghum juice is carried out in a batch system. The last stage, the main process of this research is the distillation process at column temperature 70°C, with variations in the size of boiler A (diameter 7.5; height 29 cm), B (diameter 10 cm; height 20.5 cm), C (diameter 13; height 10 cm). The bioethanol concentration parameters were analyzed using Gas chromatography. The yield calculation is based on the comparison of the volume of bioethanol distillate with the volume of sweet sorghum juice. The results of the optimum bioethanol production research on boiler size C, with final bioethanol concentration (distillate) 75%, final volume of pure bioethanol 16.5 ml, and yield 6.6%.

1. Introduction
Bioethanol is a biochemical fluid from the process of glucose fermentation using the help of microorganisms and to increase the concentration of bioethanol, followed by the process of distillation. There are various types of plants that can be used as a source of bioethanol raw materials, one of which is the most potential developed in Indonesia is a sweet sorghum plant.

Sweet Sorghum plant is a multipurpose plant, ranging from seeds, leaves, stems, and roots all parts of sorghum useful, namely as a source of food, livestock feed and raw materials of various industries. Specifically, on the stem sorghum can be obtained juice used as a source of bioethanol, the content of sugar Brix stem ranging from 7.67-12.67%, on average, 10.02% [1]. Cultivation of sweet sorghum (Sorghum bicolor L Moench) is generally done to obtain Juice as raw material of ethanol as well as liquid sugar [2,3]. Sorghum stem extracts that form juice can be fermented and distilled to be used as ethanol. The ethanol can be used to fuel the motorbike with a mixture of as much as 20 percent without revamping its motor system [4]. Through the process of fermentation, juice sorghum can produce bioethanol. The fermentation batch system is widely applied in the bioethanol industry.
because it can produce high levels of bioethanol, but its weakness, which requires a long overall operation time [5].

The distillation process is performed to increase the concentration of bioethanol using the distillation apparatus. The problem faced at this stage is that it is not easy to increase the purity of bioethanol up to 85-95%; it requires high-performance distillation tools, which can cost high. To overcome this, a thorough study is required to modify bioethanol-based sweet sorghum distillation tools. According to the study of Ninik A et al. (2013), about the design of terraced distillation tools that the more number of columns and the number of shavings will result in higher levels and amounts of alcohol [6].

The research is aimed at increasing the purity of bioethanol sourced from the sweet sorghum juice. Data to improve the performance of distillation tools based on variations boiler size will be studied influence in increasing the concentration of bioethanol and bioethanol yield.

2. Methods

2.1. Materials and tools

The main ingredient used is the stem of the sweet sorghum with the varieties of Super 1. The supporting ingredients are yeast (Saccharomyces cerevisiae), active charcoal, alcohol 95%, cotton, and aquades. The main tool used is a unit of distillation equipment with different boiler sizes. The supporting tools used are beaker glass, measuring cup, Erlenmeyer, thermometer, electric stove, pump, press machine, fermentor, hand refractometer, and place for bioethanol shelter.

2.2. Experimental

2.2.1. Preparation of raw materials. Sorghum stems obtained from the experimental Garden of Bontobili Balisereal Gowa. Preparation of raw materials begins with cleaning the sweet sorghum stems freshly harvested. Furthermore, the sorghum rods are squeezed using a pressing tool to get the juice of sweet sorghum stem. Analysis of the concentrated juice of the sweet sorghum using a hand refractometer.

2.2.2. Fermentations. Yeast (Saccharomyces cerevisiae) for inoculation, is grown in an Erlenmeyer 250 ml containing sweet juice sorghum with a sugar rate of 18% Brix. After incubation for 48 hours at room temperature, Saccharomyces cerevisiae is inoculated into the culture media to begin fermentation.

The fermentation process is carried out by taking juice sorghum sweet 750 ml inserted into the fermentor bottle with a volume of 1 liter and pasteurized at a temperature of 75 °C for 30 minutes then cooled. Next, add an Inoculum of 75 ml to the fermentor bottle aseptically, pH Medium 5.0. The fermentation process is discontinued after 30 days. Analysis of the concentration sugar of juice sweet sorghum and bioethanol levels using a hand refractometer.

2.2.3. Distillation process. The distillation process is done by inserting a solution of fermentation (crude) as much as 250 ml into the boiler, then install the fractionation column and condenser then run the water pump. At this stage, heating is held at a column temperature of 70 °C to vaporize bioethanol from crude. Variation of the size of the boiler used is the boiler A (diameter 7.5; height 29 cm), boiler B (diameter 10 cm; height 29 cm), and boiler C (diameter 13; height 10 cm). The upper result of the distillation process is analyzed of its bioethanol levels using the GC, which is hereinafter referred to as the final bioethanol concentration.

3. Results and Discussion

3.1. Effect of boiler size against final bioethanol concentration
Distillation is carried out to purify Bioethanol, the purification process begins with heating crude at 70°C at a pressure of 1 Atm. Bioethanol turns the phase into vapor and passes through the column, and subsequent vapors are condensed into bioethanol fluid with a higher concentration of crude.

During the distillation process, the vapor leading to the condenser and has condensed into a liquid at the top of the column, a portion of the liquid is returned to the column as reflux, and the remainder is pulled as distillate [7].

![Image](image_url)

**Figure 1.** Influence of boiler size based on bioethanol concentration and distillate volume

The results of fermented sweet sorghum juice (crude) with Brix bioethanol concentration of 22%. High distillate concentrations were obtained at 78%, concentrations resulting from the distillation process using type A boilers, but the lowest distillate volume charge of was 15 ml. Based on the concentration bioethanol of the distillate and the volume distillate, it is estimated that the final pure bioethanol volume is approximately 4.68 ml. Whereas for the high distillate volume of 22 ml obtained from a type C boiler with a bioethanol concentration of 75%, so the final pure bioethanol volume is estimated at around 16.5 ml. For type B boilers, it can produce 21 ml distillate volume, and distillate concentration 75% with estimated final pure bioethanol volume 15.75 ml.

### 3.2. Influence of boiler diameter size on bioethanol yield

The volume of distillate bioethanol is the volume of bioethanol per 250 ml of sweet sorghum juice, which is fermented and then distilled. Calculation of bioethanol yield is based on the volume of final pure bioethanol compared with the volume of distilled sweet sorghum juice.

| Type of boiler | Diameter of boiler (cm) | Yield (%) |
|---------------|-------------------------|-----------|
| A             | 7.5                     | 4.68      |
| B             | 10                      | 6.30      |
| C             | 13                      | 6.60      |
Table 1 shows a boiler diameter 13 cm C type yielding the greatest yield (6.60%), but the yield value of a diameter 10 cm type boiler B approaches the value of a type C boiler yield (6.30%). The yield of type A boilers with a value of 4.68% provide fewer yield than boiler type B and C. It is explained that the more surface area of the boiler, then the yield percentage will also increase.

4. Conclusion
The results of bioethanol distillation research from optimal sweet sorghum juice fermentation on boiler C size, with a final bioethanol concentration (distillate) 75%, final volume of pure bioethanol 16.5 ml, and yield 6.6%.

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