A Simple Candlenut Shell Carbonization Tool

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Abstract. In order to produce charcoals from the candlenut shell, a tool is need such as candlenut carbonization tool using a vertical multi chambers (CCT-VMC). The tool is indicated some weaknesses; the oxygen kept flowing into the chambers when cooling process are carried out, so oxidation occurred in the last phase of producing charcoal. This was due to some holes on the tools are not being able to close perfectly. The aims of the research are to produce a carbonization tool that are able to reduce the oxidation when cooling process being performed by reducing the openings on the tool and to determine the tool’s capacity. The tool was designed by utilizing Autodesk Inventor 2018 software. The result shows that the tool has two vertical chambers that provide space for adequate air supply when performing a burning process. The main components are a half metal drum, a chamber barrier, and a cover. It is also found that the tool needs 9.5 hour to process 24 kg of candlenut which consist of 2 hours for burning process and 7.5 hours for cooling process.

Keywords: candlenut seeds, biomass, carbonization tool, vertical multi-chambers

1. Introduction
South Aceh, a district of Aceh Province, riches for natural resources, however Candlenut seeds, derived from Aleurites moluccana plants, are one of important commodities from the place. Candlenut (Aleurites moluccana) is one type of industrial plant from the family of Euphorbiaceae [1-3]. Candlenut seed and candlenut shell were shown in Figure 1. The seeds were taken by breaking the shells as the solid waste from the candlenut fruit [4]. Candlenut shell is one of biomass waste which is a renewable energy source [5-7]. However, today the biomass waste can be converted as charcoals and briquettes. The briquette has been used for individual and industrial purposes as alternative energy whereas the charcoal for industrial purposes such as cosmetics, purifying agent [6], and many others. Since the need of the such charcoal has increase as the increase in industrial need, charcoal become a promising business.

Figure 1. Candlenut and its shell
Charcoal is a carbon rich product that result from the thermal treatment of natural organic feedstock in an oxygen-limited environment [8]. The charcoal is produced by slow heating biomass waste called carbonization [6]. Carbonization is a crucial step because of its porous structural forming [9] which define the amount of porosity on the charcoal. However, to produce the best quality of charcoal, it is crucial to fulfil the standard values of several physical and chemical characteristics such density, porosity, water content, carbon content and so forth.

To produce the charcoal, a good tool is required to obtain best quality of it. Some tools have been produced, but they need other sources as the energy to burn the shells such palm shell pyrolysis drum reactor [10]. Moreover, some tools allow oxygen enter carbonization chambers while cooling process is taking place. It causes the decrease in the quality of the charcoal. From previous study regarding to the effectivity of the candlenut carbonization tool using a vertical multi chamber (CCT-VMC) on the quantity and quality of the charcoal [11]. It is indicated that there were some weaknesses of the tool; the oxygen kept flowing into the chambers when cooling process are carried out, so oxidation occurred in the last phase of producing charcoal. This was due to some holes on the tools are not being able to close perfectly, especially the holes where the carbonization chamber barriers are placed. Figure 2 is showing the CCT-VMC design.

![Figure 2. Candlenut shell Carbonization tool using a vertical multi chambers (CCT-VMC)](image)

The carbonization chamber barriers (CCB) are being placed from the side of the drum. Those are pushed to slide into the chamber. The hole on the side wall of drum remains imperfectly closed, especially the one downside of the CBB which hardly closed using sticky mud. Thus, a new method and tool are needed to develop in order to attain a good quality of charcoal. In addition, the research is also aimed to define the Simple Candlenut Carbonization Tool’s time consumed for a carbonization process by performing some experiments.

2. Method
2.1 Design
Considering minimizing the oxidation process when the cooling process taking place, a simple candlenut carbonization tool is designed containing holes as less as possible and providing an easy operational process of carbonization. If some of the holes cannot be dismissed, then some features may develop in order to stop the air kept flowing to the carbonization chambers. However, some features of the candlenut carbonization tool using a vertical multi chambers are still utilized. They are human operational power, fully uses the energy from the candlenut itself in carrying out carbonization process, low material and manufacturing process cost. Therefore, the tool is expected to be afforded by the user in terms of cost and produces a better quality of charcoal.

By utilizing Autodesk Inventor 2018, simple candlenut carbonization tool is designed using 2 vertical carbonization chambers, carbonization chamber I and II, which aims to provide space for adequate air
supply when performing a burning process. It will attain a perfect candlenut burnt that generates enough heat to facilitate carbonization chamber II having carbonized. The carbonization chambers were shown in Figure 3.

![Figure 3. A simple candlenut carbonization tool](image)

The tool mentioned above requires 3 main components, namely drum as the main frame to constrain the outside and inside environment and also as a base for initial burning, carbonization chamber barrier and a cover to shield the top part of the tool. Figure 4 below shows the detail of the 3 main components.

![Figure 4. Three main components of a simple candlenut carbonization tool](image)

### 2.2 Tools and Material

A Simple Candlenut Shell Carbonization Tool required some material to be manufactured and tools to be used in manufacturing process. The materials are half of 200 liters metal drum, L-Shape angle bar, 2 mm thick iron plate, 1 mm thick aluminum plate, and Ø 10 mm iron bar. The tool is designed by utilizing Autodesk Inventor 2018 software that allowed designer experiencing a real-looked of the product designed. Welding, grinding, and drilling machines and others appropriate tools such as hammers and scales are used in performing manufacturing process.

### 2.3 Tool Experiments

The experiments are performed to determine time consuming in a carbonization process using a Simple Candlenut Shell Carbonization Tool. In order to gain enough data, the experiments are done in three times. Every carbonization chambers filled with 12 kg of candlenut shell that will be carbonized. Tool’s time consuming is defined by measures the temperature during the carbonization process which consist of burning and cooling process.

In burning process, temperature will be increased as time increased whereas in cooling process conversely. Burning process time is measured from the initial burnt in carbonization chamber I until the burning stage completed, which was indicated by the little amount of and bluish smoke [9]. Cooling process is starting when the burning process and completing when the temperature inside and outside
carbonization chamber are similar. Temperature inside and outside carbonization chamber are measured using thermocouple. The measured temperatures will be used to determine time processing of the tool.

2.4 Flowchart of Manufacturing and Designing Tool

The following is a flow diagram in designing and manufacturing of a simple candlenut shell carbonization tool as shown in Figure 5.

![Flowchart of tool design and manufacture](image)

3. Results and Discussion

3.1 A Simple Candlenut Shell Carbonization Tool

The final design of the simple carbonization Tool is shown in Figure 3 and 4. The tool has been designed with lesser holes than the previous tool, the tool with vertical multiple chambers. There are two ways to eliminate the high oxidation which was by taking out the slide mechanism and an attached reservoir beneath the tool.

Manufacturing process of the tool followed the design shown in Figure 3 and 4. Through all the process of manufacturing, all main parts of the tool and the complete one shown in Figure 6 respectively.
Simple Cundlenut Shell Carbonization Tool  
Drum  
CCB  
Cover

Main components of Simple Cundlenut Shell Carbonization Tool

Figure 6. Manufacturing outcome which is A Simple Candlenut Shell Carbonization Tool.

3.2 Results of the Experiment

The temperature data in burning and cooling stage were attained in all carbonization chambers (CC) every 30 minutes using thermocouple. The data are shown in Table 1 and Table 2.

Table 1. Temperature of candlenut shell in burning process

| Time (Minutes) | Experiment I |       |       | Experiment II |       |       | Experiment III |       |       |
|----------------|--------------|-------|-------|---------------|-------|-------|----------------|-------|-------|
|                | Temperature (°C) | Avg. | Avg.  | Temperature (°C) | Avg.  | Avg.  | Temperature (°C) | Avg.  | Avg.  |
| 0              | 32            | 32    | 32    | 32            | 32    | 32    | 32             | 32    | 32    |
| 30             | 263           | 145   | 204   | 301           | 169   | 235   | 253            | 123   | 188   |
| 60             | 411           | 304   | 357.5 | 356           | 243   | 299.5 | 399            | 323   | 361   |
| 90             | 435           | 354   | 394.5 | 429           | 274   | 351.5 | 435            | 352   | 393.5 |
| 120            | 323           | 220   | 271.5 | 312           | 209   | 260.5 | 323            | 221   | 272   |

Table 2. Temperature of candlenut shell in cooling process’s

| Time (Minutes) | Experiment I |       |       | Experiment II |       |       | Experiment III |       |       |
|----------------|--------------|-------|-------|---------------|-------|-------|----------------|-------|-------|
|                | Temperature (°C) | Avg. | Avg.  | Temperature (°C) | Avg.  | Avg.  | Temperature (°C) | Avg.  | Avg.  |
| 0              | 90            | 84    | 87    | 92            | 90    | 91    | 98             | 99    | 98.5  |
| 0.5            | 65            | 56    | 60.5  | 77            | 71    | 74    | 83             | 87    | 85    |
| 1              | 55            | 47    | 51    | 62            | 60    | 61    | 66             | 82    | 74    |
| 1.5            | 49            | 45    | 47    | 58            | 53    | 55.5  | 61             | 75    | 68    |
| 2              | 46            | 43    | 44.5  | 54            | 50    | 52    | 53             | 63    | 58    |
| 2.5            | 44            | 43    | 43.5  | 50            | 46    | 48    | 53             | 63    | 58    |
| 3              | 43            | 42    | 42.5  | 47            | 45    | 46    | 51             | 58    | 54.5  |
| 3.5            | 40            | 40    | 40    | 43            | 41    | 42    | 47             | 53    | 50    |
| 4              | 39            | 40    | 39.5  | 40            | 39    | 39.5  | 44             | 48    | 46    |
| 4.5            | 39            | 40    | 39.5  | 39            | 39    | 39    | 39             | 46    | 42.5  |
| 5              | 38            | 39    | 38.5  | 38            | 39    | 38.5  | 38             | 39    | 38.5  |
| 5.5            | 38            | 37    | 37.5  | 38            | 37    | 37.5  | 38             | 36    | 37    |
| 6              | 36            | 34    | 35    | 36            | 34    | 35    | 36             | 34    | 35    |
| 6.5            | 34            | 34    | 34    | 34            | 33    | 33.5  | 34             | 33    | 33.5  |
| 7              | 33            | 32    | 32.5  | 33            | 32    | 32.5  | 33             | 32    | 32.5  |
| 7.5            | 32            | 32    | 32    | 32            | 32    | 32    | 32             | 32    | 32    |
| 8              | 32            | 32    | 32    | 32            | 32    | 32    | 32             | 32    | 32    |
Table 1 shows that the burning process was completed at the average temperature of 268 °C which indicated by little amount of smoke produced. From the three experiments, it can be concluded that it took 2 hours for the candlenut shell to be burnt completely. Table 2 revealed that cooling process consuming much more time compared to burning process. All experiments confirmed that inside temperature of carbonization chamber was similar to ambient temperature, 32°C, at 7.5 hours after cooling process proceeded. Therefore, the hole carbonization process of 12 kg candlenut shell using Simple Candlenut Carbonization Tool was consumed 9.5 hours which consist of 2 hours for burning process and 7.5 hours for cooling process.

A comparison was made to see the performance of the tools, between Candlenut Carbonization Tool Using a Vertical Multi Chambers (Tool 1) and Simple Candlenut Carbonization Tool (Tool 2), by comparing the processing time and the number of repetitions of the carbonization process in one day. Table 3 displays that Tool 1 is better than Tool 2 in term of processing capacity.

Table 3. The measurement of the capacity of Simple Candlenut Shell Carbonization Tool

| Description                        | Tool 1          | Tool 2          |
|------------------------------------|-----------------|-----------------|
| Σ one time processed candlenut shell (kg) | 24.00           | 24.00           |
| Single Processsed Time (hour)      | 7.75            | 9.5             |
| Σ Carbonization Process in one day (time) | 3.10            | 2.52            |
| The amount of candlenut shell that can be processed in one day (kg) | 74.32           | 60.48           |

3.3 Discussion
The results confirmed that candlenut shell can be carbonized using its own energy by utilizing a simple candlenut carbonization tool. Table 3 confirmed that Tool 1 performed better than Tool 2 in term of capacity due to less processing time. In term quality of the charcoal that has been produced still remain in question. Therefore, some researches are needed to be performed to provide some more detail information regarding the quality of the charcoal that produced by those tools. The detail information will define which tool performed better in general.

4. Conclusion
A simple candlenut carbonization tool which consist of two vertical chambers can carbonize candlenut shell without any additional energy except energy that derived from candlenut shell itself. The process of carbonization consists of 2 stages, which are burning stage and cooling stage. The tool has lesser holes compared to the previous one. It is done in order to minimize the possibility of oxidation involved in cooling stage. Tool’s experiments which consist of 12 kg candlenut shell in every carbonization chamber revealed the real time consumption of carbonization process. Burning stage consumed less time than cooling stage. Burning stage completed in only 2 hours and cooling stage was taking 7.5 hours to be finished. It is can be concluded that the total carbonization process time of 24 kg candlenut shell using Simple Candlenut Shell Carbonization Tool is 9.5 hours with 60.48 kg in total process capacity in one day. However, Candlenut Carbonization Tool Using a Vertical Multi Chambers can carbonize 74.32 kg in one day. Therefore, Candlenut Carbonization Tool Using a Vertical Multi Chambers is better than Simple Candlenut Shell Carbonization Tool in term of processing capacity.

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