PRODUCTION AND EVALUATION OF COCONUT (*Cocos nucifera*) LEAF MIDRIB (RACHIS) CHARCOAL

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ABSTRACT: *This study was conducted to produce and evaluate a coconut leaf midrib charcoal as an alternative fuel for cooking, heating and grilling. Specifically, it was aimed to produce a bio-fuel from coconut leaf midrib that is environment friendly and economically feasible. Moreover, it aimed to determine the volume of ash residue, boiling rate, heating value, burning efficiency and burning rate of the coconut leaf midrib charcoal then compare it to coconut shell charcoal and verify its benefit-cost ratio. Coconut leaf midrib charcoal obtained higher values in its heating value and boiling rate when compared to coconut shell charcoal.*

Keywords: Coconut Leaf Midrib Charcoal, Boiling Rate, Heating Value, Burning Efficiency, Charcoal Burning Rate

1. INTRODUCTION

In today's millennium, energy scarcity is slowly getting higher and it is a serious matter that we, the humankind, who are the number one consumers of energy, must find a solution. It may sound so impossible to find a definite answer to this kind of problem instantly, but researchers nowadays are patiently finding an alternative way of getting energy aside from fossil fuels. One example of this is the renewable source of energy that comes from the natural environment of the earth, which promises an infinite but cheap, and clean energy source [4,5-7]. The problem with this kind of energy source is that human technology is not yet capable (so far) to harness its full capacity of giving us the energy that we need. That is why humans are still finding a better alternative way of getting energy from the environment. One of which is cutting down of trees, to make fuels for domestic purposes, one concrete example is the wood charcoal [19-26]. Wood charcoal is known to be a great fuel for human's daily activities, both for heating and for cooking. It is an amorphous form of carbon made by the distinctive distillation of almost any carbonaceous material. Because of its low sulfur content, it is used to replace coke in the processing of some types of iron. Wood charcoal is also used for making black gun powder for carbonizing steel, in the production of calcium carbide, sodium cyanide, and carbon tetrachloride, and for making arc electrodes [6]. It was then very useful and beneficial to humans, until it became a reason for this worldwide problem that humans are now facing, the Global Warming. One of the causes of existence of the global warming is that the humankind kept on cutting trees for whatsoever purposes that we have in mind [1,7-10]. Now, the government issues laws that limit/inhibit people from slashing trees. With this, the wood charcoal industries diminish or lower its production number along the years that have passed. On the other hand, man has discovered that a coconut shell is also good as a material for charcoal making. Many farmers are suffering from a low income from coconut shell charcoal [13]. With this kind of problem from our coconut farmers, the researcher decided to produce and evaluate a charcoal made from the neglected coconut leaf midrib. The discarded plant material is naturally rich in carbon, which, like wood chunks can be used in making a homemade charcoal. Making a charcoal out of it may reduce the dependence on fossil fuels in heating, cooking and grilling and will make another additional livelihood to coconut farmers and some humans who will find it profitable

Objectives of the Study

This study was conducted to produce and evaluate a coconut leaf midrib charcoal as an alternative fuel for cooking, heating and grilling.

Specifically, its aim is to:

1. Produce a bio-fuel from coconut leaf midrib that is environment friendly and economically feasible.
2. Determine the volume of ash residue, boiling rate, heating value, burning efficiency and charcoal burning rate of the coconut leaf midrib charcoal then compare it to coconut shell charcoal; and
3. Determine its benefit-cost ratio.

2. MATERIALS AND METHODS

The raw materials collected and prepared was the coconut leaf midrib that is already fallen from the coconut tree. The leaves were then air dried for 14 days. Pre-tests were made to ensure that the coconut leaf midrib had the possibility to be a charcoal. After which, the coconut leaf midrib were ready to undergo charcoal making/carbonization process. The charcoal made were then tested and evaluated according to all the data that were needed.

3. RESULTS AND DISCUSSIONS

Ash Residue Content

Ash residue is the total weight of the particles which remains on fire. When the fuel was totally burnt, there were residues left [10]. These remains were the ashes. These were collected and weighed in order to determine its volume. Table 2 represents the data gathered for the volume of ash residue. As the result shows, the average ash residue for coconut leaf midrib charcoal was 21.7 g while the coconut shell charcoal had a volume of ash residue of only 10.53 g. As a result, coconut shell charcoal has a lesser volume of ash remains compared to coconut leaf midrib charcoal of about 11.17 g.

Table 2: Volume of Ash Residue of Coconut Leaf Midrib Charcoal

Treatments	Percentage (%)
1	23.2
2	20.2

Average	**21.7**
Coconut Shell Charcoal	10.3

Table 3 shows the two-sample t-test for the volume of ash residue of coconut leaf midrib charcoal performed in Minitab. It can be observed that the calculated *p*-value is equal to 0.123 which is greater than the significance level ($0.123 > \alpha = 0.05$). This means that the treatments (Different Charcoal Kilns) have no significant effects on the volume of ash residue of the coconut leaf midrib charcoal.

Table 3: Two-sample t-test for T1 vs T2 (Volume of Ash Residue)

Treatment	Estimate for difference	5% CI for difference	P – Value
T1	3.00	(2.90, 3.10)	0.123
T2			

Burning Efficiency

Coconut leaf midrib charcoal's burning efficiency determines how much amount of charcoal was burnt. As the result of this study in Table 4, the highest burning efficiency among the treatments was T2 with only 3.6% difference of the result of T1. The average value of the two treatments is 78.3% which results to 11.4% difference of the coconut shell charcoal's burning efficiency. This implies that the coconut shell charcoal is much better in terms of burning efficiency. The lesser the ash residue only means that more fuel were burned compare to coconut leaf midrib charcoal. But as the result showed, the coconut leaf midrib charcoal can compete to the performance of the coconut shell charcoal.

Table 4: Burning Efficiency of Coconut Leaf Midrib Charcoal

Treatment	Charcoal Burning
1	76.8
2	79.2
Average	**78.3**
Coconut Shell Charcoal	89.7

Table 5: Two-sample t-test for T1 vs. T2 (Burning Efficiency)

Treatment	Estimate for	5% CI for	P –
T1	-3.00	(-2.90, -3.10)	0.123
T2			

It can be observed in Table 5, it shows the two-sample t-test for the burning efficiency of coconut leaf midrib charcoal performed in Minitab. That the calculated *p*-value is equal to 0.123 which is greater than the significance level ($0.123 > \alpha = 0.05$). This means that the treatments (Different Charcoal Kilns) have no significant effects on the burning efficiency of the coconut leaf midrib charcoal.

Figure 1. Coconut Leaf Midrib Charcoal

Heating Value

The results show that the heating value of the coconut leaf midrib charcoal was 1.3 kJ/kg higher than the heating value of the coconut shell charcoal. Table 6 shows that the charcoal's heating value was 1.3 kJ/kg higher than the heating value of the coconut shell charcoal. The computed heating value of coconut leaf midrib charcoal in each treatment were T1 = 591.6, and T2 = 597.7 kJ/kg respectively. Coconut shell charcoal has a heating value of 593.3 kJ/kg. This implies that the coconut leaf midrib charcoal performs well in terms of its heating value just like that of the coconut shell charcoal. As based on the study conducted, this is because of the different initial temperatures of the water as indicated in Table 6.

Table 6: Heating Value of Coconut Leaf Midrib Charcoal

Treatments	Heating Value
1	591.6
2	597.7
Average	**594.6**
Coconut Shell Charcoal	593.3

There is no significant difference in the heating value among the treatments (Different Charcoal Kilns) of the coconut leaf midrib charcoal, as shown in Table 7, for the result of two-sample t-test for heating value of coconut leaf midrib charcoal performed in Minitab, the calculated *p*-value is equal to 0.377 which is greater than the significance level ($0.377 > \alpha = 0.05$).

Table 7: Two-sample t-test for T1 vs T2 (Heating Value)

Treatment	Estimate for difference	5% CI for difference	P – Value
T1	-6.13	(-6.55, -5.72)	0.377
T2			

Boiling Rate

The coconut leaf midrib charcoal's boiling rate determines the amount of water that the charcoal able to boil within a span of time. Results show that the average boiling rate of the two treatments has a higher value compared to coconut shell charcoal, in Table 8, there's a difference of 18.2 g/min in their boiling rate, it is because of the composition of the material and its burning capability compared to the coconut shell charcoal. The computed boiling rate of coconut leaf midrib in each treatment were T1 = 27.8 and T2 = 28.2 g/min, respectively. While the coconut shell charcoal has a boiling rate of only 9.6 g/min. This implies that using coconut leaf midrib charcoal to boil the water will boil the water faster than using coconut shell charcoal. As based on the study conducted, the coconut leaf midrib charcoal has a higher boiling rate compared to coconut shell charcoal because the coconut leaf midrib charcoal burns faster than the coconut leaf midrib charcoal.

Table 8: Boiling Rate of Coconut Leaf Midrib Charcoal

Treatment	Boiling Rate (g/min)
1	27.8
2	28.2
Average	**27.8**

Coconut Shell Charcoal	9.6

Table 9 it shows the two-sample t-test for the boiling rate of coconut leaf midrib charcoal performed in Minitab. It was observed that the calculated *p*-value is equal to 0.968 which is greater than the significance level ($0.968 > \alpha = 0.05$). This means that the treatments (Different Charcoal Kilns) have no significant effects on the boiling rate of the coconut leaf midrib charcoal.

Table 9: Two-sample t-test for T1 vs T2 (Boiling rate)

Treatment	Estimate for difference	5% CI for difference	P – Value
T1 **T2**	-0.13	(-0.34, 0.07)	0.968

Charcoal Burning Rate

Charcoal burning rate is the ratio of the weight of the fuel consumed in kg per unit time in hour. The time to boil the water is the total time consumed which started from the fire setting until the 200 grams of water was boiled. Table 10 represents the data gathered on the charcoal burning rate of each treatment in coconut leaf midrib charcoal and coconut shell charcoal. Based on the data gathered, the computed charcoal burning rate of coconut leaf midrib charcoal are as follows: T1 = 0.133 kg/hr, T2 = 0.144 kg/hr and the coconut shell charcoal has 0.053 kg/hr. The average time to boil a 200 g of water for each treatment in coconut leaf midrib charcoal are 7.2 min and 7.1 min, and 20.88 min for the coconut shell charcoal. As a result, coconut shell charcoal showed lesser value of the charcoal burning rate and takes longer time to burn compared to the treatments of coconut leaf midrib charcoal, thus, making the coconut shell charcoal longer to burn. This is maybe because of the reason that the coconut leaf midrib charcoal is not as compact as coconut shell charcoal, thus making the coconut leaf midrib charcoal faster to be burnt. And if we take a look on the data in Table 8, it shows that coconut leaf midrib charcoal boils water faster than the coconut shell charcoal, for it also burns faster than the compared charcoal due to its compactness and combustibility.

Table 10: Charcoal Burning Rate of Coconut Leaf Midrib Charcoal

Treatments	Charcoal Burning Rate (kg/hr)
1	0.133
2	0.144
Average	**0.138**
Coconut Shell Charcoal	0.053

Furthermore, Table 11 shows that the treatments (Different Charcoal Kilns) have no significant effects on the charcoal burning rate of the coconut leaf midrib charcoal, for the calculated *p*-value is equal to 0.684 which is greater than the significance level ($0.0684 > \alpha = 0.05$).

Table 11: Two-sample t-test for T1 vs T2 (Charcoal Burning Rate)

Treatment	Estimate for difference	5% CI for difference	P – Value
T1 **T2**	-0.0070	(-0.0081, -0.0059)	0.684

Benefit Cost Ratio

Based on Table 12, the computed benefit-cost ratio for coconut leaf midrib charcoal was 1.44. This means that for every peso spent in this venture, it is estimated that it will earn 1.44 pesos. It's very obvious that coconut leaf midrib charcoal has a great benefit to offer to the households as a cheap alternative source of cooking fuel.

Table 12: Cost analysis of coconut leaf midrib charcoal using BCR.

ITEM	PRICE /YEAR (Php)
Investment Cost	
Coconut Leaf Midrib	720.00
Transportation of CLM Charcoal	1,800.00
Drum Kiln	1,500.00
Cellophane (packaging)	100.00
Total Investment Cost	**4,120.00**
Fixed Cost	
Depreciation (2 years)	750.00
Total Fixed Cost	**750.00**
Variable Cost	
Labor cost (300.00 pesos per day)	43,200.00
Total Variable Cost	**43,200.00**
Total Operating Cost	**48,070.00**
Returns	
Production of CLM charcoal/week (60 kg/week)	
Price of coconut leaf midrib charcoal (8 pesos/kg)	**69,120.00**
Benefit-Cost Ratio	**1.44**

RESULT OF STATISTICAL TOOL USED

According to statistical tool used, which is the two-sample t-test, it shows that the treatments (T1 = Tin Can Kiln, T2 = Earth Kiln) of this study have no significant effects on all the parameters used which are the ash residue of the coconut leaf midrib charcoal, burning efficiency, heating value, boiling rate, and charcoal burning rate of the produced charcoal, this was because the parameters were the fuel properties of the coconut leaf midrib charcoal, it cannot be affected by how the charcoal was made by using different methods of creating it with the use of different kilns. It is its unique property that when made by utilizing different kilns, it will always show the same result.

4. CONCLUSION

Based on the results, the researcher concludes that using coconut leaf midrib charcoal is economical because of its abundant availability or in other words, it can easily be found within the locality. It can also help the government in dealing with waste usage instead of causing harm to the environment and to us human beings.

Furthermore, though coconut shell charcoal is already available and more efficient, we cannot deny the fact that due to the growing population of the country, the availability of this material will reach to its scarcity and coming with such a

charcoal is costly and it needs more work to make this kind of energy, and with that, the introduction of using an alternative will start. And the coconut leaf midrib charcoal will be its good alternative.

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