Agro-Waste Research and Augmentation (AWRA): Carbonization of Coconut (*Cocos nucifera*) Husks as Raw Materials for Charcoal Briquettes

Abstract: This study used experimental approach in coming up with substitute material for charcoal briquettes as alternative fuel. An agricultural waste, Coconut (*Cocos nucifera*) Husks was utilized and compared with known charcoal variety, wood charcoal and coconut shell charcoal in the study. It was found out that coconut husk charcoal briquettes had the shortest duration recorded under the boiling ability test, allowing water to reach boiling point at the shortest amount of time and the longest burning ability, the rate that the charcoal turned to ash after ignition. There were significant differences noted in terms of burning time and boiling ability between the coconut husk charcoal briquettes, coconut shell charcoal, and wood charcoal. This study showed the potential of agricultural waste for bioconversion, to be specific carbonization as material for charcoal briquettes. It is looking into reusing agricultural waste and turning it for potential income source for the farmers. It could lessen the demand for hard wood charcoals thus minimizing the threat for deforestation. Carbonization can create smokeless fuel which could lessen the damage to the ozone layer further contributing the prevention of global warming. Further studies and a more in-depth investigation of alternative sources and reusing agricultural waste is recommended.

Keywords*:* biodegradable, alternative fuel, smokeless, environmental impact

I. Introduction

Agricultural waste management has recently received attention among researchers who are interested in understanding its nature and sustainability (Foley et al., 2011). In the past, agricultural waste management researchers focused on the facet of this management variable in areas of understanding the concept (Obi, Ugwuishiwu, & Nwakaire, 2016), generation (Girotto, Alibardi, & Cossu, 2015), production (Chandra, Takeuchi, & Hasegawa, 2012), food bioconversion (Uçkun Kiran, Trzcinski, Ng, & Liu, 2014), utilization (Väisänen, Haapala, Lappalainen, & Tomppo, 2016), biodegradation (Emadian, Onay, & Demirel, 2017), valorization (Tuck, Pérez, Horváth, Sheldon, & Poliakoff, 2012), and profitability (Mel, Yong, Avicenna, Ihsan, & Setyobudi, 2015).

Globally, humans generate 998 million tons of agro-waste annually which makes up 15% of the total waste generation (André, Pauss, & Ribeiro, 2018). The Philippines, in particular, is generating agricultural waste of 0.078 kg/cap/day or

780,000 tons of agro-waste in a year (Agamuthu, 2009). The country is looking into zero waste initiative (Sapuay, 2016) that could lessen the production thus doing less damage to the environment. In Region 8, rice, corn and cassava are the top three crops produced. It posted a 1.11% growth in rice production from 984,017 to 994,972 metric tons or a 98% sufficiency index. Likewise, cassava production increased by 3.95% from 78,805.43 to 81,918.12 metric tons (Department of Agriculture - Regional Field Unit VIII, 2015).

With all of the information given, it bounces back to the question, why there are so much agro-waste generated? Are there necessary steps taken to solve it? Is there a way to convert agro-waste into something useful? Is bioconversion even possible?

The questions presented motivated the researcher to focus on agricultural waste, Coconut (*Cocos nucifera*) Husks carbonization as material for charcoal briquettes. There is a need to look into the acceptability of these materials and how it would fare with the traditional charcoal, hence the conduct of this study.

II. Objectives

This study opted to carbonize agricultural waste from the utilization of Coconut (*Cocos nucifera*) Husks as biomass converted to charcoal briquettes.

1. Find out the potential of agricultural waste from the utilization of Coconut (*Cocos nucifera*) Husks as alternative materials for charcoal briquettes in terms of its burning time and boiling ability;
2. Compare the quality of agricultural waste from the utilization of Coconut (*Cocos nucifera*) Husks as alternative materials for charcoal briquettes in terms of its burning time and boiling ability; and
3. Find out if the alternative material for charcoal briquettes and commercial charcoals, coconut shell and wood, has the best qualities in terms of its burning time and boiling ability.

III. Methodology

This study utilized a controlled experimental design, specifically quasi-experimental design, of which isolation, augmentation, control, as well as data analysis are conducted under laboratory conditions (Fraenkel & Wallen, 2006).

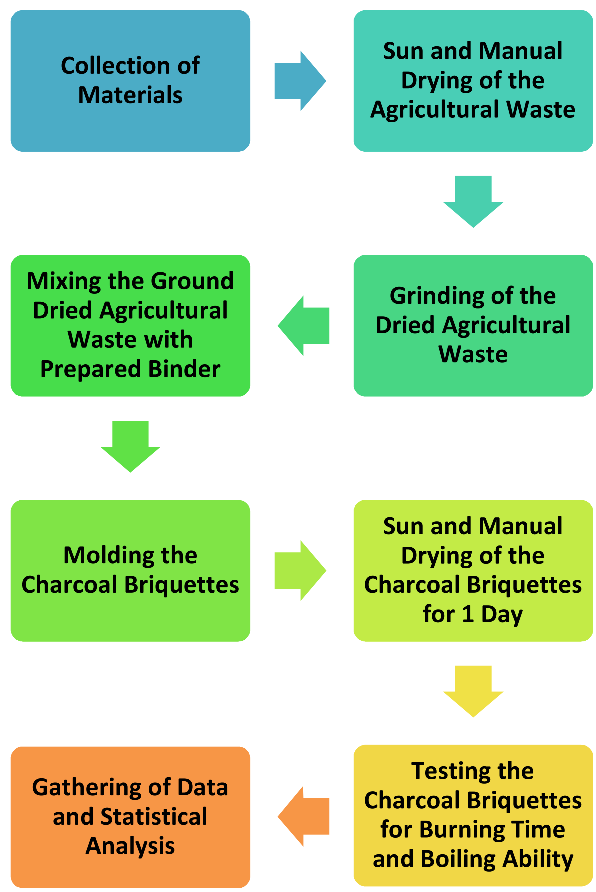

Figure 1: Process Flowchart

For gauging the effectiveness of the charcoal briquettes, burning time and boiling ability tests were conducted. Testing the burning time simply means from the ignition of the briquette samples as well as the control and measuring the duration or how long will it sustain the flame until it completely turns to ash. Likewise, measuring boiling ability means subjecting each proportion to boiling a 100 ml of water, measuring the time for the water to reach its boiling point.

Table 1. Composition of Experimental and Control Groups

Material (in grams)	Experimental	Control	
	Charcoal Briquette	Coconut Shell Charcoal	Wood Charcoal
Coconut Husk	195	0	0
Biomass Binder	5	0	0
Coconut Shell	0	200	0
Wood	0	0	200

The variation in time for the two tests were subjected to statistical analysis, both descriptive and inferential statistics, with the aid of Microsoft Excel Data Analysis and SPSS.

IV. Results and Discussion

The technology generated in the study centers around the utilization of agricultural waste, bioconversion in the form of carbonization and tackling the issues on agricultural waste management, threats of deforestation and alternative fuel sources. This study is brainchild of the Agro-Waste Research and Augmentation (AWRA) Phase 1 study with the same aim of farmer empowerment and agricultural innovation. It is looking into reusing agricultural waste and turning it for potential income source for the farmers. It could lessen the demand for hard wood charcoals thus minimizing the threat for deforestation. Carbonization can create smokeless fuel which could lessen the damage to the ozone layer further contributing the prevention of global warming.

a. Burning Time Test

Table showed the result of the burning time test which highlighted that the proportion with the longest duration of burning time or the duration it takes to turn the charcoal to ash is that of the charcoal briquettes with 48 minutes, 39.33 seconds.

Table 2. Burning Time Test for Each Charcoal Proportions

Charcoal	Time Trials (MM:SS)			Average (MM:SS)
	1	2	3	
Coconut Husk Briquette	47:58.6	48:30.8	49:28.6	**48:39.33**
Coconut Shell	38.54.1	40:16.8	39:57.2	39:42.70
Wood	41.37.8	43:59.8	44:38.1	43:25.23

Likewise, it can be gleamed that coconut shell had the shortest burning time duration with 39 minutes and 42.70 seconds. This means that the coconut shell charcoal quickly turned to ash. While the wood charcoal was fairly in the middle with 43 minutes and 25.23 seconds.

b. Boiling Ability Test

Table showed the result of the boiling ability test between the alternative charcoal briquette, coconut shell charcoal and wood charcoal in three trials.

Likewise, it can be noted coconut husk charcoal briquettes posted the lowest time for water to reach the boiling point, specifically, 5 minutes and 23.43 seconds. This means that the coconut husk charcoal briquettes can generate a higher temperature compared to the other two proportions.

Table 3. Boiling Ability Test for Each Charcoal Proportions

Charcoal	Time Trials (MM:SS)			Average (MM:SS)
	1	2	3	
Coconut Husk Briquette	5:52.80	5:01.80	5:15.70	**5:23.43**
Coconut Shell	6:07.60	6:01.40	6:07.10	6:05.37
Wood	6:13.70	6:01.50	6:10.90	6:08.70

Wood charcoal posted the lowest boiling ability, 6 minutes and 8.70 seconds, thus it takes longer for water to reach its boiling point when exposed to wood charcoal.

c. Difference in Burning Time and Boiling Ability

Upon subjecting the results of both test to statistical analysis, it was found that there were significant differences in the burning time and boiling ability of the alternative charcoal briquette to coconut shell and wood charcoals.

5. Conclusion and Recommendation

It was found out that coconut husk charcoal briquettes had the shortest duration recorded under the boiling ability test, allowing water to reach boiling point at the shortest amount of time though it was noted that among three alternatives, it did not burned out easily to ash. Significant differences were noted in terms of burning time and boiling ability.

This study showed the potential of agricultural waste for bioconversion, to be specific carbonization as material for charcoal briquettes. It is looking into reusing agricultural waste and turning it for potential income source for the farmers. It could lessen the demand for hard wood charcoals thus minimizing the threat for deforestation. Carbonization can create smokeless fuel which could lessen the damage to the ozone layer further contributing the prevention of global warming.

The study could be comprehensive by recalibration of proportion for charcoal briquettes to determine the perfect consistency for maximum effect. Further studies and a more in-depth investigation of alternative sources and reusing agricultural waste is recommended

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