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Nipah (*Nypa fruticans*): can it be a renewable alternative energy source?

S Eddy[1*], A A Setiawan[1], Zaharaini[2], B Utomo[3], and M Oktavia[3]

[1]Departement of Environmental Science, Faculty of Natural Sciences and Technology, Universitas PGRI Palembang. Jl. Jend. A. Yani No. 9/10 Ulu, Palembang 30251, South Sumatra, Indonesia.
[2]Departement of Physics, Faculty of Natural Sciences and Technology, Universitas PGRI Palembang. Jl. Jend. A. Yani No. 9/10 Ulu, Palembang 30251, South Sumatra, Indonesia.
[3]Departement of Geography Education, Faculty of Teacher Training and Education, Universitas PGRI Palembang. Jl. Jend. A. Yani No. 9/10 Ulu, Palembang 30251, South Sumatra, Indonesia.

*Corresponding author: syaifuleddy@gmail.com

Abstract. Nipah (*Nypa fruticans*) grows naturally in the mainland zone in mangrove forests, but it can invade all disturbed mangrove forest zones as happened in the Air Telang Protected Forest (ATPF). Nipah has not been widely used by the community and industry to make certain products. This study aims to examine the potential of the nipah fruit shell and fiber in producing renewable energy. The method used in this research is an experimental method by making charcoal briquettes from the shell and fiber of nipah fruit to be tested based on the Indonesian National Standard (SNI). Nipah fruit samples were taken from ATPF and then treated into briquettes in the laboratory. The results of the charcoal briquettes test showed that the moisture content, ash content, density and compressive strength met the SNI requirements, but the calorific value was still below the SNI requirements. These results indicate that charcoal briquettes from nipah fruit have the potential to be used as a renewable energy source through a more appropriate treatment for increasing the heating value.

1. Introduction

The world's energy needs are increasing along with the increasing population growth and industrial progress that utilizes the main energy sources from fossil energy. Massive use of fossil energy will cause an energy crisis [1]. It also has an impact on increasing greenhouse gas emissions which are the main causes of global warming [2]. In addition, exposure to gas emissions resulting from the use of fossil energy can cause around 65% of deaths [3].

Renewable energy sources are a solution to reduce dependence on fossil energy and at the same time to overcome the limitations of energy sources. One of the renewable energy sources is energy from biomass[4]. Biomass can be used as a source of energy in various ways, one of which is converting it into charcoal briquettes through the carbonization process [5]. Biomass that has the potential to be used as an energy source is one that contains a lot of lignocellulose, such as nipah (*Nypa fruticans*) which contains cellulose and hemicellulose, respectively, about 28.9-45.6% and 21.8-45.6% [6]. Nipah parts that can be used as charcoal briquettes are trees, fruit bunches and fruit shells [7].

Nipah is classified in the Arecaceae family which lives with other plants in brackish water swamps [8]. It thrives in lowland forests and is associated with other mangrove plants, such as those in the Air Telang Protected Forest (ATPF) located in Banyuasin Regency, South Sumatra Province, Indonesia [9]. The existence of mangrove forests such as ATPF is very important in providing habitat for organisms in the vicinity [10-15].

ATPF is one of the coastal protected forests that has been degraded due to anthropogenic activities [16-18] which produces far greater carbon emissions than carbon sequestration [17, 18]. One of the characteristics of degraded mangrove forests is the occurrence of nipah invasion in various zones, such as in ATPF. Nipah invasion in ATPF causes it to thrive in tidal zones and land, such as in open areas, secondary forests and ponds; which results in disruption of the function of the mangrove forest ecosystem [19].

The parts of the nipah plant that are commonly used by the community are the leaves which can be made for roofs and cigarette wrappers and the sap which is made into alcohol [20], and the fiber is made as raw material for particle board [21]. Several research results show the potential for nipah fruit shell and fiber that can be used as charcoal briquettes as an alternative energy source [22-27]. However, there has been no research that combines a mixture of nipah fruit shell and fiber for making charcoal briquettes. This study aims to analyze the quality of charcoal briquettes made from nipah fruit shell and fiber by comparing them with the quality of charcoal briquettes according to SNI (Indonesian National Standard). The results of this study are expected to be a recommendation to optimize the benefits of nipah fruit as a renewable alternative energy source.

2. Methods

This study used a field survey method at ATPF to identify the location of nipah plants and an experimental method to test the quality of charcoal briquettes.

2.1. Field sampling area

Nipah fruit samples were taken in the ATPF area located on the east coast of Sumatra Island, Banyuasin Regency, South Sumatra Province, Indonesia (Figure 1). Nipah is the dominant plant and invades degraded areas in ATPF, such as open areas, ponds and secondary forests.

2.2. Charcoal briquette formulation and quality testing

A survey was conducted at ATPF to identify locations with a lot of nipah palm trees, followed by the collection of nipah palm fruit bunches and selection of nipah fruit to be used, namely ripe fruit (Figure 2). The experimental method begins with the manufacture of charcoal briquettes at the Physics Laboratory of the Faculty of Science and Technology, Universitas PGRI Palembang (Figure 3).

The process of making charcoal briquettes begins by separating the nipah fruit from the bunch and selecting the ripe fruit, then washing it and drying it in the sun. The nipah fruit is then separated between the fibers and the shell from the fruit flesh. The fiber and shell of the nipah fruit are carbonized separately by burning in a closed drum without air until they become charcoal. Then the charcoal is pulverized and sieved using a 60 mesh sieve. Charcoal made from the fibers and shells of nipah fruit is mixed with the following variations in comparison (treatment): TI = Shell : Fiber = 0 : 50 gr = (0:1); T2 = Shell : Fiber = 12.5 : 37.5 gr = (1:3); T3 = Shell : Fiber = 25 : 25 gr = (1:1); T4 = Shell : Fiber = 37.5 : 12.5 gr = (3:1); and T5 = Shell : Fiber = 50 : 0 gr = (1:0).

Each mixture was made 3 replications. Each replication was added an adhesive made from 10 gr of tapioca dissolved in 40 ml of boiling water and stirred until thickened. The mixture is put into a mold made of pipe with a diameter of 5.52 cm and a height of 3.05 cm, then pressed with a hydraulic press. The charcoal briquettes are removed from the mold, then dried using an oven.

The quality of the produced charcoal briquettes was tested for moisture content, ash content, density, compressive strength and calorific value with reference to the Indonesian National Standard (SNI 01-6235-2000). The data obtained were analyzed by analysis of variance (F test), and continued with the Least Significant Difference (LSD) test at a level of 5% to determine the difference in the average results of each treatment.

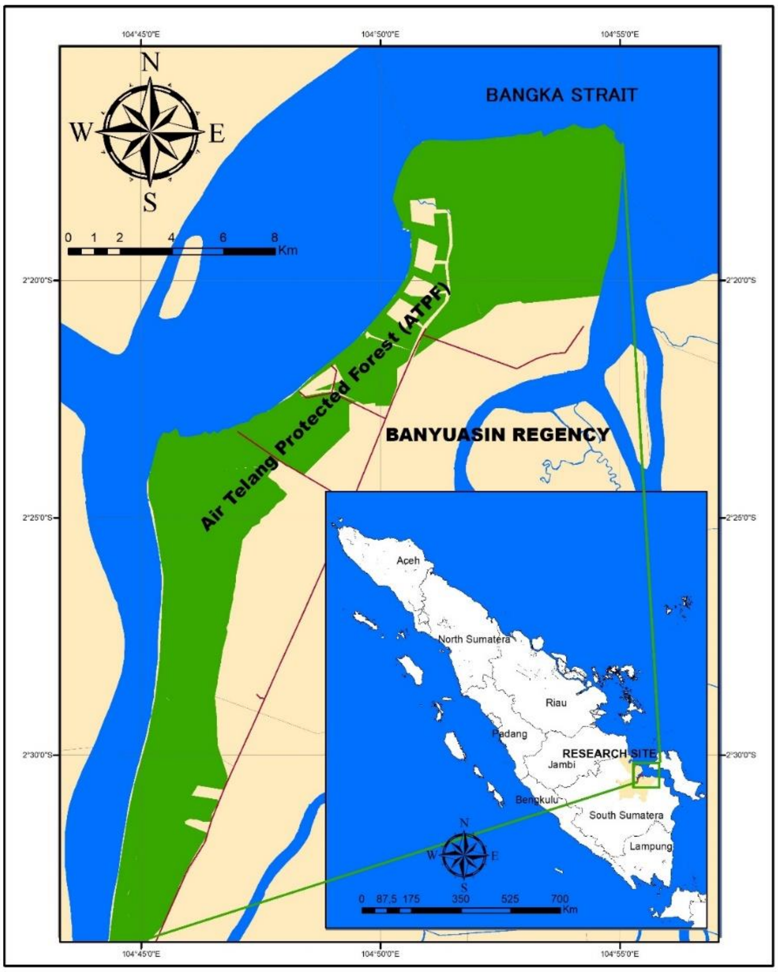

Figure 1. Location of nipah fruit sampling in Air Telang Protected Forest (ATPF).

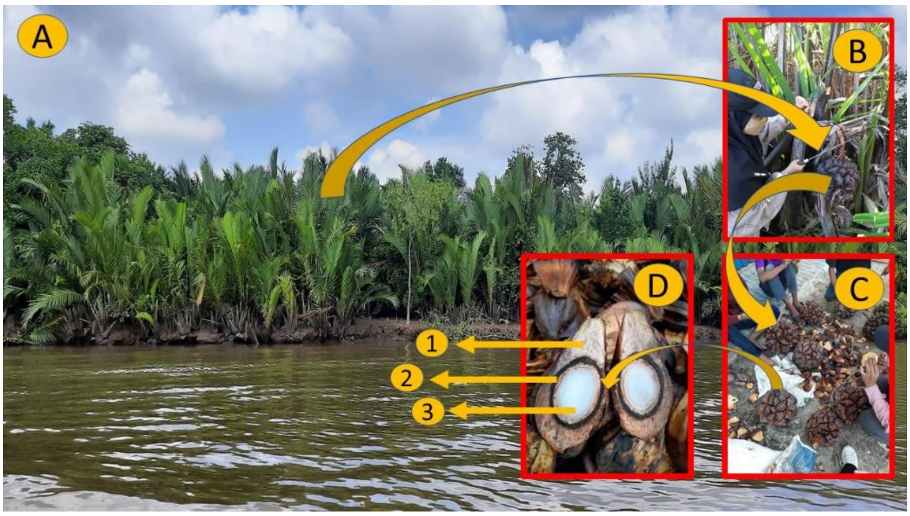

Figure 2. The process of sampling nipah fruit at ATPF. A. One of the nipah fruit sampling locations, B. Nipah fruit bunch collection, C. Selection of ripe nipah fruit, D. Nipah fruit that has been cut ((1) nipah fruit fiber, (2) nipah fruit shell, (3) Nipah fruit flesh).

Figure 3. The process of making charcoal briquettes from nipah fruit fiber and shell. A. Fruit cutting, B. Separation of fruit flesh from fibers and shells, C. Carbonization of fibers and shells, D. Refining of carbonized charcoal, E. sifting of charcoal, F. Mixing charcoal with adhesives, G. Molding of briquettes, H. Products molded charcoal briquettes.

3. Results and discussion

3.1. Nipah invasion and its benefits in ATPF

Anthropogenic activities have driven deforestation and degradation in ATPF. One indicator of the disturbance of the mangrove forest ecosystem due to anthropogenicity is the occurrence of nipah invasion in various zones. Nipah invasion in ATPF has occurred massively, where it is able to grow in tidal zones and land [19] (Figure 4). Nipah also dominates in primary forest and secondary forest in ATPF [9]. Nipah is able to invade all zones in mangrove forests and is even able to grow outside its natural habitat because it has high seed productivity and effective and adaptive seed distribution so as to suppress the growth of mangroves and other coastal species [28-30].

The use of nipah plants by the community, especially in ATPF is still traditional and not optimal. Nipah usually they use the tree, leaves and fruit. Nipah trees are used to make buildings, bridges and firewood; the leaves are used to make roofs; and the fruit to eat. However, the utilization of other parts of the nipah fruit, such as the fiber and shell has not been carried out.

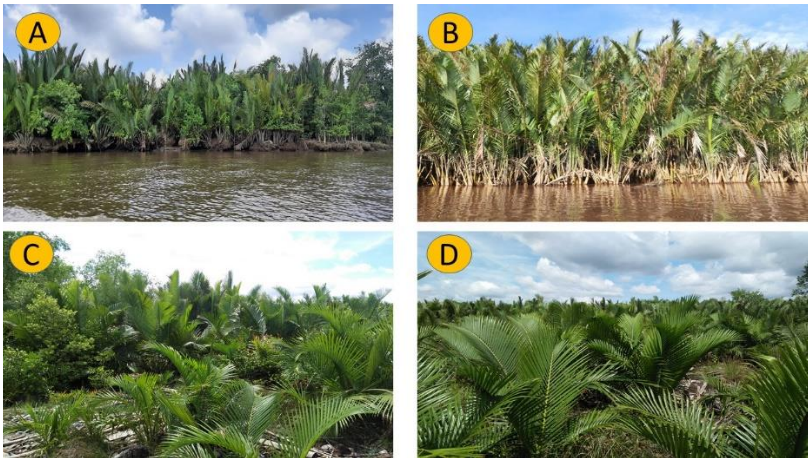

Figure 4. Nipah invasion in ATPF. Nipah invasion in the tidal zone (A and B); Nipah invasion in the mainland zone (C and D).

3.2. Quality of nipah fruit charcoal briquettes

This research has produced charcoal briquettes that we formulated from nipah fruit fibers and shells in various types based on the ratio of the amounts of the two (Figure 5). The quality of the charcoal briquettes produced is good and almost all the parameters measured have met SNI, only the calorific value is still below SNI (Table 1). The texture of the briquette charcoal produced looks still less compact (Figure 5), this is presumably because the hydraulic press used for molding charcoal briquettes is still manual (by hand) so that the pressure applied during molding is not optimal.

The value of the moisture content of charcoal briquettes for all treatments meets SNI, which is a maximum of 8%. The value of the moisture content in each treatment showed a trend of higher values if the palm fiber content was increased. The fiber of nipah fruit contains relatively higher water content due to its physical properties that easily absorb water. According to research of Vuspayani that the raw material for charcoal briquettes is one of the factors that affect the moisture content in addition to being influenced by the type of adhesive and the testing method used [31].

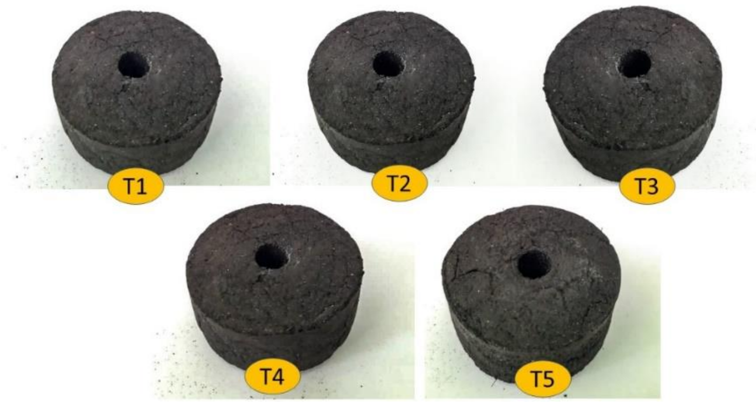

Figure 5. Charcoal briquettes produced from nipah fruit shells and fibers with a ratio of the amount between shell and fiber: 0:1 (T1), 1:3 (T2), 1:1 (T3), 3:1 (T4), and 1:0 (T5).

Table 1. $LSD_{0.05}$ test results for the average value of the quality parameters of nipah fruit briquette charcoal in each treatment. The treatments for each test parameter followed by the same letter of the alphabet were declared to have no significant effect.

Treatments	**Moisture content**		**Ash content**		**Calorific value**		**Density**		**Compressive strength**	
	(%)		**(%)**		**(Kcal/Kg)**		**(gr/cm^3)**		**(Kg/cm^2)**	
T1	6.63	a	0.7427	a	3,423.33	b	0.56	a	83.67	a
T2	6.61	a	0.7427	a	3,308.33	a	0.56	a	205.38	b
T3	6.27	b	0.7417	b	3,444.00	b	0.56	a	251.02	b
T4	4.23	c	0.7417	b	3,548.67	b	0.57	a	121.71	ab
T5	3.80	d	0.7413	c	3,859.00	c	0.57	a	174.95	ab
SNI	**Max. 8**		**Max. 8**		**Min. 5,000**		**0.5-0.6**		**Min. 50**	

The value of ash content of charcoal briquettes for all treatments meets SNI, which is a maximum of 8%. The value of ash content in all treatments showed a decreasing trend if the fiber content of nipah fruit was decreased and the shell content was increased. Nipah fruit fiber contains a lot of ash which is the remaining part of the combustion process. Ash contains silica components where it can affect the decrease in the calorific value of charcoal briquettes [31].

The calorific value of charcoal briquettes is still below the requirements of SNI (< 5,000 Kcal/Kg). This happens because it is influenced by the type of raw material; and the type and amount of adhesive (Table 2). The use of tapioca flour as an adhesive in this study is because the price is relatively cheap, but its use tends to reduce the calorific value of charcoal briquettes. Firdaus and Nurdin (2019) stated that the use of resin adhesive for charcoal briquettes can produce a higher calorific value than tapioca flour, because resin has a hydrocarbon content that can increase the calorific value [32]. Meanwhile, according to Nurhayati and Adalina that the more adhesives used for the making of charcoal briquettes, the lower the calorific value [33].

The calorific value of each treatment tends to increase if the nipah fruit shell composition is increased while the fiber composition is decreased. This shows that the shell of the nipah fruit is able to produce more heat than the fiber. In addition, the high moisture content can reduce the calorific value of charcoal briquettes. According to Vuspayani the high mosture content in charcoal briquettes can reduce the calorific value and combustion rate, because calor energy will be used first to remove the water contained in it [31].

The density value of charcoal briquettes for all treatments met the requirements of SNI, namely 0.5-0.6 gr/cm^3. The results of the analysis of the density of charcoal briquettes using the $LSD_{0.05}$ test showed insignificant results between each treatment. Density is the ratio between the weight and volume of charcoal briquettes which is influenced by the amount of pressure applied during charcoal briquette molding. In addition, the density is also influenced by the size and uniformity of the particles that make up the charcoal briquettes. Smaller particle size can expand the bonding area between powders so as to increase the density. In addition, the uniformity of particle size can increase the density and strength of charcoal briquettes.

Table 2. Comparison of the calorific value obtained in this study with the calorific value of several other research results.

Raw material	Adhesive material	Calorific value (Kcal/Kg)	Source
Nipah fruit fiber	Tapioca flour and chalk	2.429.16 – 3.150.82	[22]
Nipah fruit fiber and alaban charcoal	Tapioca flour	4,337.05 – 5,741.64	[34]
Nipah fruit fiber and alaban charcoal	Tapioca flour	4,712.08 – 5,152.54	[23]
Nipah fruit fiber	Tapioca flour	5,438.80	[24]
Nipah fruit fiber and rice husk	Tapioca flour	3,503.79 – 4,980.23	[25]
Nipah palm seed	Distilled water	3,332.00 - 4,093.00	[26]
Nipah fruit fiber and shell	Tapioca and sago flour	5,326.07 – 5,637.50	[27]
Nipah fruit fiber and shell	Tapioca flour	3,308.33 – 3,859.00	This research (2022)
Indonesian National Standard		**Min. 5000**	**SNI 01-6235-2000**

The value of the compressive strength of charcoal briquettes for all treatments meets the requirements of SNI, which is a minimum of 50 Kg/cm^2. Compressive strength is the ability of charcoal briquettes to provide resistance to destruction (break) when given a load. The higher the compressive value of the charcoal briquettes, the better its resistance to breaking. Treatment with the composition of nipah fruit fiber and shell with a ratio of 1:1 had the highest compressive strength value.

4. Conclusions

Nipah fruit has the potential to be used as a renewable alternative energy source by making charcoal briquettes made from fibers and shells. The value of moisture content, ash content, density and compressive strength has met the requirements of SNI, but the calorific value is still below the requirements. The calorific value of charcoal briquettes can be increased through reformulation of the composition and types of raw materials and adhesives.

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