Reduction of young coconut waste by pyrolysis to liquid smoke and charcoal briquettes

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Abstract. Young coconut peel waste (YCPW) is still an underutilised material because the waste is generally only transported, dumped, landfilled, or incinerated. The goal of this researc to determine the reliability of the pyrolysis technique in converting coconut shell waste into charcoal and liquid smoke to reduce the amount of waste on the supply. Pyrolysis of 1,000 g YCPW yielded 418.8 g charcoal, 271 g liquid smoke, and 82.2 g tar. The liquid YCPW smoke was tested as a preservative for coconut sap after redistillation. It was shown to have antimicrobial activity, with the following parameters for the sap: (i) prevention of pH drop and (ii) suppression of reducing sugar level. The resulting charcoal powder was mixed with 10% starch paste. The mixture was then hydraulically pressed and sun-dried to produce a compact and dry charcoal briquette. The briquettes were tested according to ASTM D5142-02, and the YCPW briquettes were found to have water, volatile and fixed carbon content; density, strength, and heating value of 7.79, 26.74%, 2.76%, 68.66%, 0.62 g/cm^3, 32.44 kg/cm^2, and 6.21 cal/g, respectively. Thus, the YCPW charcoal briquettes met the quality standards for public fuel according to Indonesian and Japanese standards.

Keyword: Reduction, Young Coconut Waste, Pyrolysis, Liquid smoke, Charcoal Briquettes

1. Introduction

The utilization of coconut products generates peel waste, which leads to water, air and soil pollution. To date, young coconut peel waste in particular is an unused material, as the waste is usually degraded through incineration, accumulation in landfills, and discharge into rivers. These three pathways create pollution problems and, more broadly, contribute to the acceleration of global warming.

Figure 1. (a) unutilized coconut peel waste; (b) causing accumulation problems; and (c) burn it which has a negative impact on the environment.

SRICOENV 2022, October 05-06, Palembang, Indonesia

DOI 10.4108/eai.5-10-2022.2328267

Lignocellulosic biomass waste can be recycled using four methods: Physics, Chemistry, Thermochemistry and Biochemistry [1, 2]. The thermochemical conversion method includes: Combustion, gasification, pyrolysis and charring [2]. Biochemical conversion includes: Composting, silage production, biomethanation (biogas formation), bioethanol fermentation, etc. [2,3].

Liquid smoke has been widely studied as a plant pesticide and preservative, for which many locally available raw materials are available, so there is no need to grow separate bioactive plants. The pyrolysis system can also be mixed with the production of charcoal or tar for wooden and rubber preservatives [3].

The production of charcoal briquettes from corn cobs has shown that the heat generated is 2,912 to 6,757 cal/g, which could be used as alternative energy for the community. The activated carbon produced was also found to be an effective bioabsorbent in the filtration of cooking oil [4]

The solution to the problem of coconut peel waste becomes a useful substance, namely the approach of reduction at source and reuse of resources by applying the 3R principle (reuse, reuse, reduce) [5].

The study objective was to determine the process of reduction of young coconut peel waste (YCPW) through the pyrolysis process to charcoal briquettes and liquid smoke.

2. Experimental

2.1 Materials

Preparation of source younger coconut peel waste (YCPW) turned into received from five exclusive sites (10 kg each) representing its sheller in Tasikmalaya city. The waste changed into crushed to a length of approximately (5 x 5) cm, mixed homogeneously, after which dried inside the sun until it reached a moisture content of 20%, which served as the feedstock for the pyrolysis method in the oven.

2.2 Method

The production of charcoal and liquid smoke from young coconut peel adapted to the procedure of Rahmat *et al.*'s procedures[6]. The feedstock was placed in a furnace made of steel tubes with a diameter and height of 23 and 32 cm, respectively, as a pyrolysis chamber. The young coconut peel as the starting material were heated to 450 °C for 90 minutes.

The YCPW liquid smoke used for palm sap preservation is a liquid smoke produced during redistillation to ensure that it is free of carcinogenic compounds so that it can be safely used for food [7].

Briquettes are produced using the Febrina process [8], which begins with the pyrolysis process and then continues with the grinding and screening of the charcoal. The charcoal powder is mixed with 10% starch glue to obtain a homogeneous mixture, which can then be pressed. The mixture was formed into briquettes using a manual hydraulic press. The molded briquettes were then dried in the sun for two days.

3. Results and Discussion

3.1 Product of Pyrolisis Process

Table 1. Pyrolisis yield of 1.000 g YCPW.

Component of Pyrolisis Product	Batch					Average	%-wt
	1	2	3	4	5		
Charcoal (g)	424	416	426	408	420	418.8	41.88
Liquid Smoke (g)	273.36	281.52	269.28	261.12	273.36	271.728	27.1728
Tar (g)	56	78	80	77	120	82.2	8.22

As shown in Table 1, 1,000 g of young coconut peel produced 418.8 g of charcoal, 271.728 g of liquid smoke, and 82.2 g of tar. All the liquid smoke (crude or grade 3) was further used for two redistillation processes. The result of redistillation was food grade liquid smoke (grade 1) with a volume of 850 ml. Subsequently, the grade 1 liquid smoke was tested as a preservative for palm sap, while the charcoal was processed into charcoal briquettes.

This fact is different from the results of previous studies on the pyrolysis process on wood-waste of 1,000 g was produced charcoal, liquid smoke and tar of 251 g, 442.68 g, and 36.5 g, respectively [9].

The quantity of the components relies upon on the technique. Therefore, to acquire the ultimate outcomes, the temperature must be maintained at the carbonation variety (no longer exceeding 500 °C) and the time need to be lengthened. moreover, the stated composition of the carbonization merchandise was as follows gas, liquid, and solid of 35, 30 and 35 %, respectively [10].

3.2 Application of YCPW Liquid Smoke on Coconut Sap

3.2.1 Coconut sap pH

The changes in pH of coconut sap that occurred after treating the fresh sap with YCPW concentrations of 0, 3, 4, and 5% were observed at 3, 6, 9, and 12 HAI, as shown in Table 2.

Table 2. The effect of YCPW liquid smoke concentration on decreasing the pH of coconut sap.

YCPW LS on Coconut sap (%-v)	pH of coconut sap				pH deflation
	3 HAI	6 HAI	9 HAI	12 HAI	
0	7.7	6.5	4.4	4	3.7
3	6.8	6.9	6.8	6.7	0.1
4	6.5	6.7	6.3	6	0.5
5	6.1	6.4	6	5.8	0.3

Note : LS : liquid smoke; HAI : hour after incubation

Changes in the pH of coconut sap that occurred after fresh sap were treated with YCPW concentrations of 0, 3, 4, and 5% and were observed at 3, 6, 9 and 12 HAI as can be seen in Table 2.

The ANOVA results showed that all YCPW liquid smoke treatments were different from the controls. In the control, the pH value of coconut sap decreased the most sharply over time. On the other hand, the 3% treatment gave the best restriction on decreasing the pH compared to the 4 and 5% treatments.

Thus, the liquid smoke treatment can suppress the damage of the sap by microbial activity, which is indicated by the decrease in the substrate pH due to the increase in acid concentration due to metabolism. The sugar within the sap might be changed by way of spontaneous fermentation related to lactic acid micro organism, yeast, and acetic acid bacteria. *Leuconostoc spp.* and *Lactobacillus spp.* are the preliminary and dominant microorganisms discovered in sparkling sap [11].

3.2.2 Reducing sugar

Table 3. The effect of YCPW liquid smoke concentration on increasing coconut sap reducing sugar.

YCPW LS on Coconut sap (%-v)	Reducing sugar concentration (%-w)				Total sugar increase
	3 HAI	6 HAI	9 HAI	12 HAI	
0	7.75	10.69	8. 96	13.35	5.6
3	5.89	6.13	7.03	8.02	2.13
4	4.47	3.53	3.58	3.75	-0.72
5	4.91	4.26	4.69	4.57	-0.34

Note : LS : liquid smoke; HAI : hour after incubation

All treatments with YCPW liquid smoke differed from the control in their effect on the increase in reducing sugar content in coconut sap. The treatment with concentrations of 4% and 5% had no different effect on the increase of reducing sugar, but both differed from the treatment with 3%. The most effective concentration for obtaining palm sugar with the lowest reducing sugar content was 4%.

A high conceration of reducing sugar is inversely related to the quality of brown sugar, as it reduces its storability. A high conceration of reducing sugar makes the sugar hygroscopic, so it melts easily during storage [12]. On the other hand, a low concentration of reducing sugar leads to a higher quality of sugar as it affects the hardness, color and taste [13].

According to SNI-01-7343-1995, the conceration of reducing sugar is 10% [14]. The experimental results showed that in all treatments the content of reducing sugar was lower than the maximum value, so that the sugar produced met the requirements

High levels of reducing sugars give the sugar a rather brownish color. Lower contents, on the other hand, result in a reddish color of the sugar. In addition, the content of reducing sugars also influences the degree of sweetness, since glucose and fructose have a low degree of sweetness [15].

3.3 Carracterization of YCPW *Charcoal* Briquetts

Table 4. Characteristics of YCPW charcoal briquettes based on test results.

Test Parameter	Value on Sample Briquettes	Standard	
		Indonesian	Japanese
Water content (%)	7.79	8	6 - 8
Volatile content (%)	26.74	15	15 30
Ash content (%)	2.76	8	3 - 6
Fixed carbon (%)	68.66	77	60 - 80
Density (g/cm^3)	0.62	-	1.0 – 1.2
Compression force (kg/cm^2)	32.44	-	60 - 65
Calorific value (cal/g)	6.211	5,000	6,000 – 7,000

3.3.1 Water Content

The water content material of charcoal briquettes affects the calorific value, i.e. the better the water content material, the lower the calorific price. Charcoal briquettes are surprisingly hygroscopic, so the water content may be used as a basis for excellent. The water content of the briquettes from the samples on this have a look at was decrease than the Indonesian standard value, which turned into eight% [16]. This proves that the water content material met the necessities. The excessive or low moisture content of charcoal briquettes is decided by way of the biomass foundation kind, e.g. albazia wooden, which has decrease density than uulin timber and its hygroscopic homes are more potent, so it has better moisture content of charcoal briquettes [17].

3.3.2 Volatile Content

The content of unstable additives inside the test briquettes turned into higher than within the Indonesian and eastern standards. This shows that young coconut peel charcoal briquettes do now not meet the requirements. The higher risky content material produces extra smoke while the briquettes are burning. The smoke is produced by way of the response of carbon monoxide (CO) with alcohol derivatives [18].

3.3.3 Ash Content

The ash content of the test pattern briquettes changed into 2.seventy 2.76%, which is below the Indonesian standard however in the variety of the Japanese preferred. for this reason, the charcoal briquettes are suitable as a potential substitute fuel. Too high ash content material can lessen the calorific value of charcoal briquettes, in order that the first-rate of charcoal briquettes decreases [19].

3.3.4 Fixed Carbon

The effects of the stable carbon content material test of the coconut peel charcoal briquettes confirmed a fee of 68.66%, which changed into lower than the Indonesian standard and within the variety of the Japanese standard, which was consistent with the first-rate of the fuel. The strong carbon content is stimulated through the particular gravity of the raw fabric, the charring method, and risky components. A excessive density of the raw cloth effects in a high stable carbon content material. on the other hand, a low unstable content will increase the solid carbon content material [17].

3.3.5 Density

Young coconut peel charcoal briquettes had a density of 0.62 g/cm^3, which turned into nonetheless underneath the Japanese standard range. It turned into counseled that there were still many empty spaces within the charcoal briquettes, which become because of the choppy particle length and insufficient compaction. preceding research confirmed that charcoal briquettes crafted from coconut peel had the exceptional bulk density of 0.86 g/cm^3, at the same time as charcoal briquettes crafted from madan timber had the lowest price of 0.68 g/cm^3. From this work, it is able to be concluded that the majority density is inspired through the particular gravity of the substance itself [20].

3.3.6 Compression Force

The compressive force of briquettes is the capacity of the briquettes to resist fracture or crushing while a load is carried out to the item. The better the compressive pressure of the charcoal briquettes, the higher the resistance of the briquettes to crushing [21]. The compressive force of the coconut peel charcoal briquettes turned into 32.44 kg/cm^2, which was, but, lower than the Japanese trendy. This showed that the composition and method of compression now not met the requirements. This development in the exceptional of compression energy could be very important for the sturdiness of the briquettes inside the bundle and clean transportation.

Compression pressure was applied to establish contact between the surface of the bonded material and the adhesive. After the adhesive material is mixed and pressure is applied, the still liquid adhesive begins to flow and spread over the surface of the material. The higher the pressure applied, the more briquettes with higher density and compressive strength are generally produced [22].

3.3.7 Colorific Value

The calorific value of the charcoal briquettes from the take a look at turned into 6,211 cal/g, that is inside the form of Eastern requirements and better than the Indonesian standard [16]. The heating value of the charcoal briquettes became better than that of the Nipah fruit-jacketed charcoal briquettes, which turned into 5438.80 cal/g. Consequently, those charcoal briquettes met the requirements primarily based on their heating rate [18].

The purpose of the briquettes was dried to make the briquettes easy to burn and ready for use. The briquettes were dried in an oven for 2 hours at a temperature of 110 ^{o}C [23]. Based on previous studies, the best briquettes were evaluated on the parameters of water content, ash content and calorific value, which consisted of a mixture of 90% peel charcoal and 10% binder [24].

4. Conclusion

Pyrolysis of 1,000 g of young coconut peel waste (YCPW) yielded charcoal, liquid smoke, and tar n of 418.8, 271.728, and 82.2 g, respectively.

In the control, coconut sap pH decreased the most from pH 7.7 to 4 within 12 h. The 3% YCPW liquid smoke treatment limited the pH decrease the most compared to the 4% and 5% YCPW liquid smoke treatments.

All YCPW liquid smoke treatments differed from the control in increasing the reducing sugar content of the coconut sap. The effect of the treatments with a concentration of 4% and 5% on increasing the reducing sugar was not different, but both differed from the treatment with 3%. A concentration of 4% was the most effective treatment to obtain coconut sugar with the lowest reducing sugar content.

After characterization of YCPW charcoal briquettes, the data showed moisture content of 7.79%, volatile matter content of 26.74%, ash content of 2.76%, solid carbon content of 68.66%, density of 0.62 g/cm^3, compressive strength of 32.44 kg/cm^2, and heating value of 6.21 cal/g. The YCPW charcoal briquettes met the quality as an alternative energy for the community based totally on Indonesian and standard requirements.

5. Acknowlegment

The authors would like to thank the Indonesian Ministry of Education and Culture for funding research support through Grant number 055/E5/PG.02.00-PT/2022.

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