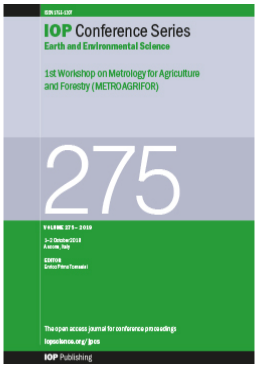

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Preface to EREE 2022

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Preface to EREE 2022

The 2022 International Conference on Environment, Resources and Energy Engineering (EREE2022) was scheduled to be held in Bangkok, Thailand, however, due to unexpected global surge in COVID-19 variant in the last three months, for safety and also travel restriction reasons, the conference was held virtually via “Zoom”.

Delegates from around the world including Thailand, Bulgaria, Ecuador, Indonesia, Cambodia, Chile, Philippines and Sri Lanka took the opportunity to share their research results and discuss potential scientific and engineering development from their work that contributed to the success of the conference.

All papers in these proceedings have passed the vigorous review process involving reviewers of the International Technical Committee. Authors benefited from valuable comments and improved their submissions to the satisfaction of reviewers. The virtual presentation serves as another opportunity for the conference delegates to address critiques in the real time online meetings with the expert audience.

There were four keynote speakers and two invited speakers who gave talks covering different areas of the conference. The keynote speakers are (i) Prof Kaimin Shih (The University of Hong Kong, China) who gave a talk on on “Metal Stabilization and Resource Recovery Examples in Urban Environment”, (ii) Prof. Nur Islami (University of Riau, Indonesia) who gave a talk on “A Valuable Approach to Study Groundwater Contamination in a Shallow Aquifer System”, (iii) Prof Danny Sutanto (University of Wollongong, Australia) who gave a talk on “Solid State Transformer for Smart Power Grid Applications”, and (iv) Prof Phebe Ding (Universiti Putra Malaysia, Malaysia) who gave a talk on ”Role of Postharvest Technology in Producing Quality Fresh Horticultural Products.”. The invited speakers are (i) Assoc. Prof Chunrong Jia (University of Memphis, Tennessee, USA) who gave a talk on “Apportioning variability of polycyclic aromatic hydrocarbon (PAHs) in the ambient air in the Memphis Tri-State Area, USA”, and (ii) Assoc. Prof Farhad Shania (Murdoch University, Australia) who gave a talk on “Recent and Future Research in Microgrid Cluster”.

The proceedings record papers presented during the conference, all of them have been divided into 3 sessions in the proceedings: Session 1-Resource & Environment Management and Sustainable Development, Session 2-Energy Chemistry and Chemical Engineering, and Session 3 Renewable Energy Technology and Energy Consumption Analysis.

The variety of research topics presented in the conference and novelty exhibited in the papers published in the proceedings once again demonstrated the value of EREE2022.

On behalf of the conference committee, I would like to thank the Technical Program Committee members, the Conference Program Coordinator, the keynote speakers and all participants, whose papers are presented in the conference proceedings, all contributing to the success of the conference.

Danny Sutanto
Conference Committee Chair
University of Wollongong, Australia
June 2022

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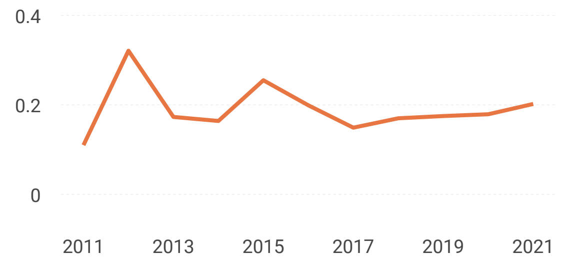

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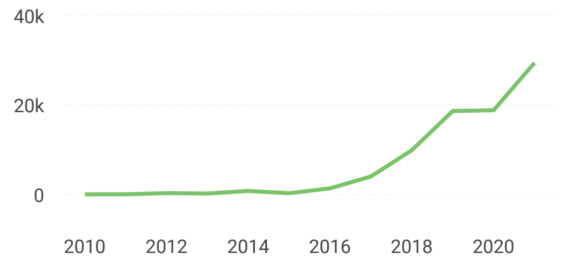

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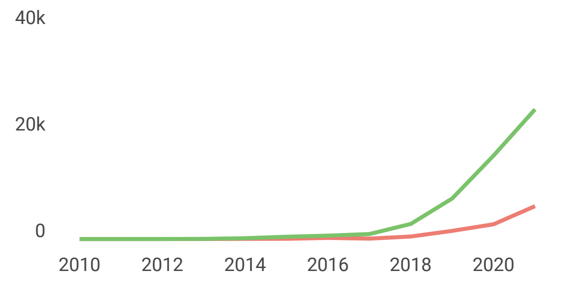

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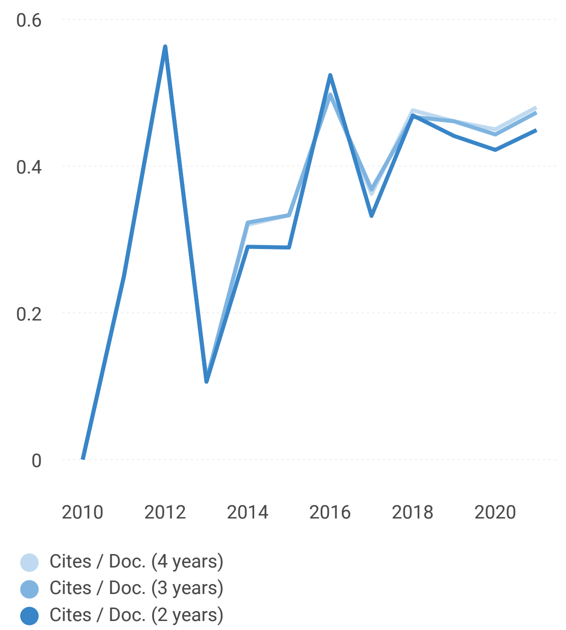

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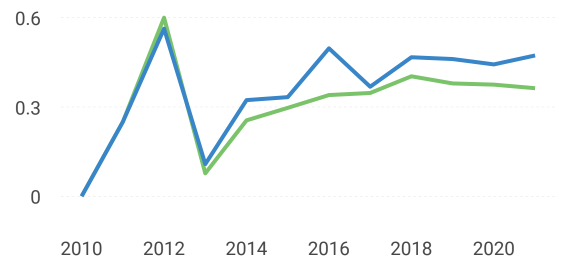

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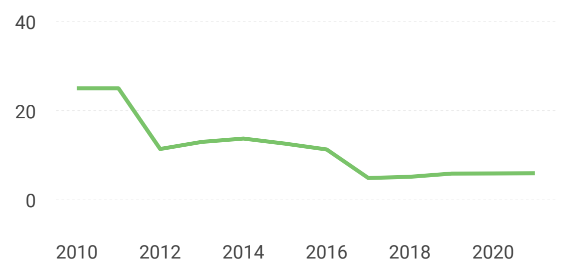

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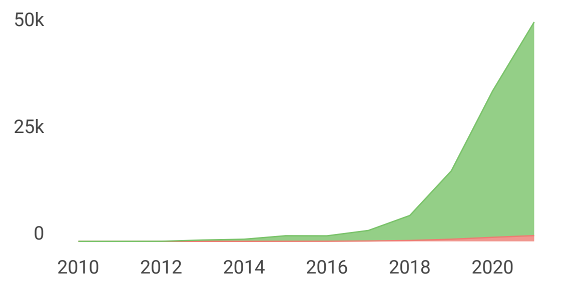

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Sustainable product development of biomass briquette from *Samanea saman* leaf waste with rejected papaya as the binding agent in Indonesia

Sustainable product development of biomass briquette from *Samanea saman* leaf waste with rejected papaya as the binding agent in Indonesia

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Abstract. The depletion of solid fuels in the world triggers the requirement for the existence of an alternative fuel product as a substitute. In several studies, briquettes have become one of the alternatives used to deal with this problem. However, the selection of briquette material that considers its impact on economic, social, and environmental aspects has not been widely carried out. To solve this problem, the selection of raw materials for briquettes must be determined using the concept of sustainable product development (SPD). SPD is a concept that can be used to determine a new product by considering various aspects, including economic, environmental, and social aspects. Briquette fuel that is derived from leaf waste and rejected fruit as a binding agent can be an alternative to renewable solid fuels since the raw materials come from wastes that have no selling value. The methodology used in this research is by conducting a survey at five markets in Surabaya and proceeding with interviews with the local government official. Pugh Matrix Concept Selection (PMCS) method is used to determine the suitable raw materials and to analyze the sustainability of the product development. Through PMCS, the results show that the best material for briquette production based on economic, social, and environmental aspects is a mixture of *Samanea saman* leaf waste with a 12.83 rating value and rejected papaya as the binding agent with a 10.44 rating value. Briquette with a mixture of 95% *Samanea saman* leaf waste and 5% rejected papaya is produced with a mesh size of 60 or 250 µm and a compression pressure of 2 MPa and is identified to have a heating value of 4025.87 Kcal/Kg.

1. Introduction

The increased human population leads to larger energy demand, including thermal energy. However, the availability of thermal energy in the form of fossil fuels is currently running low. According to the Ministry of Energy and Mineral Resources, the availability of natural gas is expected to run out within the next 22 years, while solid fuels are expected to be exhausted in the next 65 years [1]. Since fossil fuels are not environmentally friendly and non-renewable, the reliance on them as the primary sources of thermal energy is not sustainable [2, 3].

Briquette is one alternative for fossil fuel and it can be composed of various types of biomasses such as sawdust, agricultural waste, food waste, and paper waste. One of the most common materials found in the manufacture of waste-based briquettes is plant waste and fruit waste [4]. Several studies on briquettes have been carried out by Anggono et al. [5,6] in making briquettes from leaf wastes and research by Nurhilal et al. [7] also studies the composition of briquettes from mahogany tree wastes with tapioca as the binding agent. From those past studies mentioned, it can be understood that the selection of briquette materials did not examine the product development sustainability.

To reduce human reliance on fossil fuels, alternative sources of thermal energy are necessary. For the past decades, various alternatives have been proposed. However, their application is hindered by their production sustainability. To consider the sustainability of the alternative, a sustainable product development concept can be implemented to further prevent damage to the environment [8]. One method that can be used to implement the sustainable product development concept is to utilize the PMCS. This method has been used by several researchers such as Thakker et al. [9] in selecting an impulse turbine product concept. Another work by Mustafa et al. [10] implements the Pugh Matrix Concept method to select and verify Kenaf plant fibers as an alternative to environmentally friendly friction materials in the automotive industries.

SPD has three crucial aspects, which are economic aspects, social aspects, and environmental aspects. A product can be regarded as sustainable if the product has a balance between the three SPD's crucial aspects [11, 12]. The three crucial aspects of the SPD concept were used as criteria and further subcategorised into design for social intervention, design for society, design for social innovation, design for cost, design for manufacturing, design for supply chain, and design for environment [13]. Briquettes made of the selected materials were then tested in the laboratory to obtain calorific values using proximate analysis to better understand the properties.

With regards to the need for sustainable fossil fuel alternatives, this study focuses on determining the best material for briquettes by applying the PMCS method based on the sustainable product development concept. The research aims to overcome the lack of previous studies where the selection process of briquette materials did not use any evaluation method and did not pay attention to the economic, social, and environmental aspects. The present study uses PMCS evaluation method with a sustainable product development concept as a criteria to get the suitable material for briquette from leaf waste and rejected fruit.

2. Experimental method

The first step of this research is conducting a survey at five markets in Surabaya, Indonesia (Citraland Market, PPI Market, Keputran Market, Darmo Market, and Keputih Market). The initial data taken are the types of fruit sold at each market and the average amount of rejected fruit each week. After obtaining data on various types of fruit sold and the average amount of rejected fruit, all data were collected and then used as a reference in making a questionnaire. The second step of this research is to obtain answers from fruit sellers at the market by interview. The questions include the kind of fruit they sell, the fruit that has the most waste, and the amount of the waste. The type of answer is in the form of multiple choices answers. After the answers were collected, the results were converted into numbers and averaged.

The results from the questionnaire show that *Raja* bananas, pineapples, papayas, and oranges have the most waste. Therefore, they were included as the four candidates in PMCS. Interviews were conducted at the local government official to obtain data on leaf waste in the city of Surabaya. The questions asked during the interview are regarding the most dominating tree species in the city of Surabaya. From the interview, the local government official informed that the most dominating trees in Surabaya are the *Pterocarpus indicus* tree, *Samanea saman* tree, palm tree, and *Cerbera manghas* tree.

The aspects used in determining the criteria in the Pugh Matrix Concept Selection were determined based on research conducted by He [13]. All aspects are then entered into the objective tree, as similarly conducted by Mustafa et al. [10] to determine the weight factor of each criterion. The calculation of weight factors value is determined using the WDM (Weight Decision Matrix) method where the value of all decision matrices sums to '1' [10,14]. The objective tree of leaf waste and fruit waste is illustrated in Figure 1(a) and 1(b) respectively. The level of each criterion was determined based on the level of importance in the manufacture of waste briquettes.

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Consideration was given to the economic, environmental, and social aspects. In the economic aspect, the calorific value is the most important criterion since a high calorific value will produce a better yield which is closer to the standard provisions for wood charcoal briquettes. In addition, the high calorific value will also affect the selling value of the briquettes where it meets the requirements of a sustainable product, namely cost design. In the environmental aspect, the criteria are its role in reducing the volume of waste and the impact that will occur when the waste is not cleaned immediately. These criteria were chosen due to their inseparable relations as part of the design for environmentally sustainable products. In the social aspect, the most important criterion in making a sustainable product is the design for society. It includes the job openings as a consequence of the briquette manufacturing plant, which translates to an additional income and a health impact on the community.

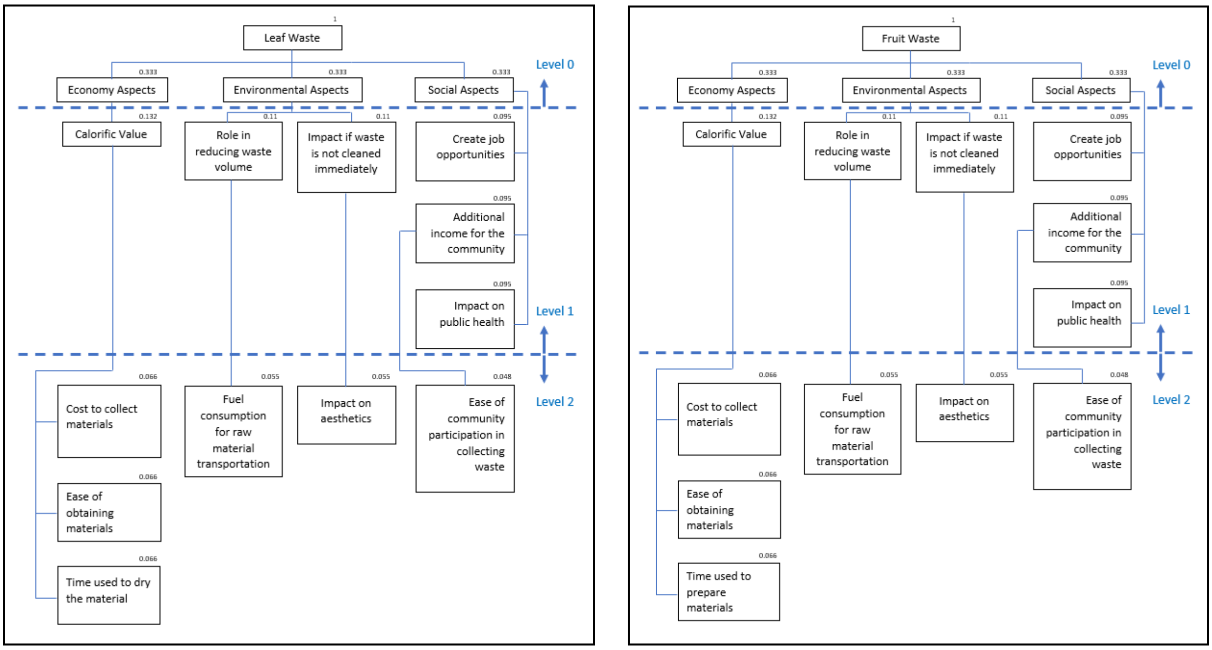

Figure 1. Objective tree of Pugh Matrix Concept implementation on the (a) leaf waste and (b) fruit waste

After obtaining all the criteria, Pugh Matrix Concept Selection was applied to determine the best materials for briquette production. The scoring on the Pugh Matrix uses a scale of 1-10, where 1 is the worst value and 10 is the best value. After assigning the score, the rating was calculated by multiplying the score by the weight factor. In the value column, the data filled were obtained from the interview results and analysis of the data. The raw material chosen for making briquettes was prepared to be processed into briquettes, following similar methods as described [5, 6]. In this study, leaf waste needs to be dried by directly exposing them under the sun for approximately 1-2 days. The dried leaf waste was then crushed into small particles. The size of the dried leaf waste particle is a mesh size of 60 or 250 µm. After the leaf waste was shifted, it was combined with the squashed fruit waste in a briquette mold (25 mm in diameter, 26 mm in height) with a ratio of 95% : 5%. The mold was pressed with a hydraulic press machine with 2 MPa pressure as shown in Figure 2. The briquettes that have been molded as shown in Figure 3 were then tested for their calorific values at the Sucofindo Laboratory using proximate analysis under SNI standards.

Figure 2. Hydraulic press machine

Figure 3. Briquette final product

3. Results and discussion

Based on the results of the survey conducted at the five markets in Surabaya, *Raja* bananas, pineapples, papayas, and oranges are the fruits suitable as candidates for the selection process in the Pugh Matrix Concept Selection due to their sufficient amount of waste and availability at the markets. These fruits were then assessed and calculated using the Pugh Matrix as demonstrated in Figure 4. From the evaluation, it can be determined that the fruit with the highest rating is papaya (10.44). Therefore, it is used in this study for the briquette production and further analysis. As for the leaf waste, based on the interviews with the government official of Surabaya City, the most dominating trees are the *Pterocarpus indicus* tree, *Samanea saman* tree, palm tree, and *Cerbera manghas* tree. Thus, the four trees are the candidates for the selection process in the Pugh Matrix. The assessment and calculation of leaf waste in the Pugh Matrix are illustrated in Figure 5. After evaluating the leaf waste potential using the Pugh Matrix Concept, *Samanea saman* leaf waste was found to have the highest rating with a value of 12.83, and therefore it was chosen as the main raw material for making briquettes in this study.

Briquettes were tested for their calorific value at the Sucofindo Laboratory, Surabaya, Indonesia using proximate analysis under SNI 01-2891-1992 standards, and the results are shown in Figure 6. Comparison of the current briquette's calorific value with those from the previous studies are shown in Figure 7. With composition of 95% *Pterocarpus indicus* leaf waste and 5% rejected papaya, the calorific value is 4338.79 KCal/Kg [6], while at 95% *Samanea saman* leaf waste and 5% rejected papaya, the calorific value is 4025.87 KCal/Kg. With composition of 95% *Pterocarpus indicus* leaf waste and 5% rejected pineapple, the calorific value is 4169.76 Kcal/Kg [15].

4. Summary

Pugh Matrix Concept Selection method was implemented to determine the best raw materials for briquette production in Surabaya, Indonesia. Through analysis and calculations carried out using PMCS concerning the environmental, economic, and social aspects, rejected papaya and *Samanea saman* leaf waste were found to be the most ideal raw materials. Therefore, these wastes were used as the material for making briquette and the composition ratio of 95% leaf waste and 5% fruit waste were found to have a calorific value of 4025.87 KCal/Kg. This promising result using PMCS method that pay attention to the SPD concept for material selection process of making briquette can also be applied in other region or countries according to various availability of leaf and fruit waste resources.

	No	Criteria	Weight Factor	Raja Banana Fruit Waste			Pineapple Fruit Waste			Papaya Fruit Waste			Orange Fruit Waste		
				Value	Score	Rating	Value	Score	Rating	Value	Score	Rating	Value	Score	Rating
Economy Aspect	1	Calorific value (Kcal/Kg)	0.135	96.51	2.2	0.30	233.32	5.4	0.72	435.02	10	1.35	36.2	0.8	0.11
	2	Cost to collect materials (Rupiah/Ton)	0.066	Rp3,316,089	6.4	0.87	Rp3,635,277	5.9	0.79	Rp2,673,211	8	1.08	Rp2,979,712	7.2	0.97
	3	Ease of obtaining materials (Kg/Arm Roll truck 14m^3)	0.066	4386	5.8	0.78	3931	5.2	0.70	5283	7	0.95	4822	6.4	0.86
	4	Time used to dry materials (day)	0.066	1.7	6.5	0.87	1.34	5.1	0.69	2.1	8	1.08	1.89	7.2	0.97
Environmental Aspect	5	Role in reducing waste volume (Kg/m^3)	0.11	301.1	7.2	0.97	280.8	6.7	0.90	377.4	9	1.22	344.5	8.2	1.11
	6	Impact if waste is not cleaned immediately	0.11	Non Acceptable	7	0.95	Non Acceptable	3	0.41	Non Acceptable	3	0.41	Non Acceptable	3	0.41
	7	Impact on aesthetics	0.055	Acceptable	7	0.95	Non Acceptable	3	0.41	Non Acceptable	3	0.41	Acceptable	7	0.95
	8	Fuel consumption for raw material transportation (Liters/Ton)	0.055	100	5.6	0.75	107	5.2	0.70	79	7	0.95	87	6.4	0.86
Social Aspect	9	Create job opportunities	0.095	1	5	0.68	1	5	0.68	1	5	0.68	1	5	0.68
	10	Additional income for the community (Rupiah/Kg)	0.095	Rp649	9.1	1.23	Rp711	10	1.35	Rp523	7.4	0.99	Rp583	8.2	1.11
	11	Impact on public health	0.095	Dangerous	6	0.81	Very dangerous	1	0.14	Very dangerous	1	0.14	Dangerous	6	0.81
	12	Ease of community participation in collecting waste	0.048	Very easy	9	1.22	Easy	7	0.95	Very easy	9	1.22	Very easy	9	1.22
					TOTAL RATING	10.37			8.43			10.44			10.04

Indicator: ideal solution 10, excellent 9, very good solution 8, good solution 7, good solution with a few drawbacks 6, satisfactory solution 5, tolerable solution 4, poor solution 3, weak solution 2, very inadequate solution 1, totally useless solution 0

Figure 4. Pugh Matrix Concept Selection on fruit waste

	No	Criteria	Weight Factor	*Cerbera manghas* Leaf Waste			*Samanea saman* Leaf Waste			*Pterocarpus indicus* Leaf Waste			Palm Leaf Waste		
				Value	Score	Rating	Value	Score	Rating	Value	Score	Rating	Value	Score	Rating
Economy Aspect	1	Calorific value (Kcal/Kg)	0.135	4287.5	8.8	1.18	4897	10	1.35	4427.6	9.0	1.22	4242	8.7	1.17
	2	Cost to collect materials (Rupiah/Ton)	0.066	Rp8,873,611	6.8	0.92	Rp7,583,382	8	1.08	Rp9,717,110	6.2	0.84	Rp23,445,871	2.6	0.35
	3	Ease of obtaining materials (Kg/Arm Roll truck 14m^3)	0.066	1668.1	5.8	0.79	2001.7	7	0.95	1455.8	5.1	0.69	788.6	2.8	0.37
	4	Time used to dry materials (day)	0.066	2	4	0.54	1	8	1.08	1	8	1.08	0	10	1.35
Environmental Aspect	5	Role in reducing waste volume	0.11	119.2	7.5	1.01	143	9	1.22	104	6.5	0.88	56.3	3.5	0.48
	6	Impact if waste is not cleaned immediately	0.11	Very dangerous	2	0.27	Not dangerous	8	1.08	Not dangerous	8	1.08	Dangerous	5	0.68
	7	Impact on aesthetics	0.055	Medium	5	0.68	Small	8	1.08	Small	8	1.08	Big	2	0.27
	8	Fuel consumption for raw material transportation (Liters/Ton)	0.055	18	7	0.95	15	9	1.22	28.5	5	0.68	38	3	0.41
Social Aspect	9	Create job opportunities	0.095	1	5	0.68	1	5	0.68	1	5	0.68	2	7	0.95
	10	Additional income for the community (Rupiah/Kg)	0.095	Rp1,736	8.5	1.15	Rp1,483	10	1.35	Rp1,901	7.8	1.05	Rp4,587	3.2	0.44
	11	Impact on public health	0.095	Very dangerous	2	0.27	Dangerous	5	0.68	Dangerous	5	0.68	Dangerous	5	0.68
	12	Ease of community participation in collecting waste	0.048	Very easy	8	1.08	Very easy	8	1.08	Easy	5	0.68	Not Easy	2	0.27
					TOTAL RATING	9.51			12.83			10.63			7.40

Indicator: ideal solution 10, excellent 9, very good solution 8, good solution 7, good solution with a few drawbacks 6, satisfactory solution 5, tolerable solution 4, poor solution 3, weak solution 2, very inadequate solution 1, totally useless solution 0

Figure 5. Pugh Matrix Concept Selection on leaf waste

Parameter	Unit	Result	Method
Moisture	% mass	10.40	SNI 01-2891-1992, point 5.1
Ash	% mass	1.51	SNI 01-2891-1992, point 6.1
Crude Protein (N x 6.25)	% mass	3.48	SNI 01-2891-1992, point 7.1
Fat	% mass	6.55	SNI 01-2891-1992, point 8.1
Raw Fiber	% mass	12.31	SNI 01-2891-1992, point 11
Carbohydrate	% mass	1.75	By differences from the other compositions
Calorific Value	cal/100 gr	4025.87	By Calculation

Figure 6. Proximate analysis results of *95% Samanea saman leaf waste* with 5% rejected papaya briquette

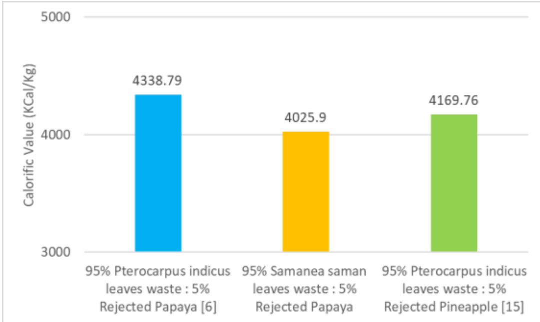

Figure 7. Calorific value of various briquettes

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