Development by Product of Mung Bean as Agroindustrial Product for Liquid Smoke and Charcoal Briquettes

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Abstract

"Bakpia" is one of food agroindustrial products that use mung bean (Vigna radiata) as raw material. Mung bean peel waste is a source of organic materiali and available in abundance in Yogyakarta. One scenario to improve by-products of bakpia is utilize them as raw material of charcoal briquettes, as alternative energy and due to the decline of petroleum reserves and a dramatic explosion in demand for energy, and liquid smoke for food preservation. This study is conducted to evaluate the critical variables that effect on the production of liquid smoke and charcoal of mung bean peel waste on pyrolysis. This study converted by product of "bakpia" to high value product as liquid smoke and charcoal brequettes. To ensure its quality, pyrolysis process in difference in temperature and the time were conducted. Quality liquid smoke is determined by phenol content, acidity, and the pH value. The production of charcoal, pyrolysis treated in addition based on the temperature and duration of operation, also the weight ratio of the adhesive mixture and pressure. Quality parameters of charcoal briquettes based on physic-chemical properties, namely: water content, ash content, volatile content and calorific value assessed, bound-carbon content, density, and performance of combustion. Besides the technical criteria, financial aspects also be taken into consideration their financial feasibility such as; NPV, IRR, PBP and PI. It was found that charcoal production of mung beans peel waste based on temperature and the duration of the pyrolysis 400 °C for 3 hours, with the results of 7.31 % water content , 22.21 % ash content, 57.03 % volatile compound , and 6696,041 cal/g calorific value. Charcoal Quality obtained at 5 % the amount of adhesive, 50 Kg/m2 pressure of pressing, which 4.93 % of ash content, 14.84 % volatile content, 6188.53 cal/g calorific value, 76.37 % bound carbon content, and has a density of 0.63 g/cm3. The performance of combustion, reached in 6th minute and longer burning flame. The financial feasibility of charcoal briquettes and liquid smoke of mung beans peel waste produce PBP of 1.12 years, NPV of IDR 35,947,702, - IRR of 73.6% and PI of 5.15.

Keywords: *by product development, charcoal, liquid smoke, food industry, mung bean peel waste.*

1. INTRODUCTION

The outbreak of food industries that use raw materials of mung beans, bring up issues related to waste results in the peeling mung beans, which reached 10% of it. "Bakpia" is one of the food products that use mung beans for raw materials. There are two business groups in these centers and involved more than 62 business units of Bakpia (Disperindagkop, 2010).

Astawan (2004) in Anggraeni (2008), suggest that the mung beans consists of 3 parts: 10 % mung bean peel waste, 88% cotyledons and 2% of the buds. Thus the potential of mung beans peel waste from industry "Bakpia Pathuk" have reached an average 2133 kg (2.1 tons) per month. Peel waste of mung beans are not processed and usually only for feed with a selling price around IDR 1000/20 kg.

Mung beans peel waste contain cellulose of 27.09%, 26.69% hemicellulose, lignin amounted to 17.81% and 16.88% water content. Mung beans peel waste also contain soluble components (extractive) such as grease, wax, resin acids, terpenoids, and inorganic components such as metals calcium and potassium (Sjȍstrȍm, 1995). Potential of mung-beans peel waste as raw material for the production of liquid smoke and charcoal briquettes is very large. This is in line with the high demands on the material for food preservation (food grade) from natural sources, such as liquid smoke, and renewable energy, such as charcoal briquettes.

Abhimanyu et al. (2009) stated that the mung beans peel waste consists of three basic elements, namely carbon, oxygen and hydrogen which are in the polymer macroscopic complex, the forms in question is cellulose [(C6H10O5) x], hemicellulose [(C5H8O4) y], and lignin {[(C9H10O3) (CH3O) 0,9-1.7] z},. The heat produced from the combustion of biomass depends on the presentation of the three main elements. Lignin has the highest thermal energy 23.63 MJ/kg, while for holocellulosa (cellulose and hemicellulose) amounted to 17.46 MJ/kg.

Development of by-products from mung bean peel waste process into a liquid smoke product, that is useful to the food industry, plantation and timber industries likely to provide benefits and value-added mung bean based food industries.

2. MATERIAL AND METHODS

2.1 Material and Equipment

The main material that used in this study was mung bean peel waste. It is a waste of “bakpia” production, especially the residue/by-product of mung beans commodity processing. As for the equipment used is pyrolysis reactor unit to set the operation temperature and duration.

2.2. Data Collection

The type and method of data collection, there are two group of data resourcess that are: (1) The data pyrolysis used liquid smoke productioan, the pyrolysis operation conditions, especially the operation temperature difference (400 °C and 450 °C) and the duration of pyrolysis (120, 150 and 180 minutes). Quality parameters of liquid smoke is determined by the content of phenol, acids and pH value, and (2) The data pyrolysis used charcoal briquettes production, the condition of charcoal briquette production, pyrolysis treated in addition based on the operation temperature difference (400 and 450 °C) and the duration of pyrolysis (120, 150 and 180 minutes), also the weight ratio of the adhesive mixture (5%, 10% and 15 %) and the pressing pressure difference (50, 75 and 100 kg/cm2). Quality parameters of charcoal briquettes are water content, ash, volatile and calorific value.

2.3 Liquid Smoke and Charcoal Briquette Production

Working procedure production of liquid s moke and charcoal briquettes can be done as fo llows; starting from mung bean peel waste dryi ng is still wet, take 1 kg of dry mung bean peel waste and inserted into the pyrolysis reactor th at had been prepared in advance, and then seale d. Smoke conduit coupled to the pyrolysis react or and cooling column, liquid smoke was a con tainer mounted on the bottom of the cooling co lumn and the smoke conduit. After the installat ion is ready, the heater is turned on in accordan ce with the temperature and duration you have specified. The temperature in the pyrolysis will spread from 30 °C to 400 °C for 30 minutes an d 450 °C for 45 minutes.

Smoke coming out from the reactor flows through pipelines smoke through cooling columns that have flowed cooling water so the smoke will be condensed and liquefied. The smoke that condense accommodated in a container that has been inserted and the rest of the other smoke wasted through pipelines smoke residue. Pyrolysis process occurs at a temperature and for a predetermined time, the heater will be turned off and the temperature is gradually decreased. Production of charcoal briquettes of mung bean peel waste can be done by mixing the adhesive of tapioca with a certain weight ratio, forming of charcoal briquettes products with a certain pressure and then dried.

2.4 Data analysis

Temperature and time of pyrolysis for the production of liquid smoke and charcoal of mung beans peel, as well as the ratio of the weight of the mixture of adhesive and pressing pressure difference with charcoal briquettes. The statistical analysis using two way ANOVA to determine significant difference between the dependent variable with each independent variable (Santoso, PB., 2005).

The financial analysis using multiple stages, from defining initial investment, determine the cost of production, determine revenue, specify the break-even point, prepare cash flow, and followed by calculating the feasibility of investments that include; Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (IP) and Payback Period (PBP) (Subagyo, 2007).

3. RESULTS

3.1 Pyrolysis Process Parameters of Liquid Smoke

The effect on the production (Table 1) of liquid smoke from mung bean peel waste resulting from the treatment of the pyrolysis process parameters, such as temperature and time as well as their interactions can be observed in Table 2.

Phenol with high molecular weight affected on color, flavor and aroma. The content of phenol in commercial liquid smoke ranges from 14 to 39 mg/ml (Mega, 1987; Girard, 1992). It resulted mung bean peel waste to the temperature difference and the duration to produce phenol values ranged from 0.06 to 0.18%. The highest phenol content obtained from the pyrolysis with a temperature of 400 ° C for 120 minutes was the lowest of the pyrolysis at 450 °C for 3 hours. Rising of pyrolysis temperatures and the duration showed decreased levels of phenol produced.

Phenol content of liquid smoke pyrolysis results of mung bean peel waste to the temperature difference and the duration to produce phenol values ranged from 0.06 to 0.18% (Table 3). The phenol content value below the value of commercial phenol content whose value ranges between 0.2 to 2.9% (Mega, 1987 in Rikhana, 2002). The low content of phenol can be caused due to the lignin content in mung bean peel waste is also low, in addition to content the water is still too high. the highest phenol content is obtained from the pyrolysis with a temperature of 400 °C for 120 minutes was the lowest of the pyrolysis at 450 °C for 3 hours. Rising of pyrolysis temperatures and the duration showed decreased levels of phenol produced.

It is indicated that the phenol content of liquid smoke produced no significant difference (significance value <0.05) in both the temperature difference, time difference, or interactions. Rated R squared of 0.258 with the value of Adjusted R squared of 0.091 indicates the strength of inter-relationship between phenol content as the dependent variable invitation to changes in temperature and time as the independent variable is very weak (9.1%) due to quantity and nature of the phenolic compounds contained in the fumes directly related to the temperature pyrolysis of wood and allegedly closely associated with material storage systems that are less good.

Differences in temperature and duration of the pyrolysis process showed value of acid contentm significantly different for both the temperature and time treatment with significant value <0.05. Pyrolysis temperature of 400 ° C showed a value higher than the pyrolysis temperature of 450 oC. Against the pyrolysis duration, duration of 150 minutes showed the highest value compared to 120 and 180 minutes duration. Similarly, the interaction of treatment time and temperature pyrolysis against acid content results in liquid smoke, also showed significantly different with a significance value of < 0.05. Rated R square of 0.979 with a value of adjusted R square of 0.970 indicates that the strength of inter-relationship between acid levels as the dependent variable with the independent variable temperature and time is very strong.

Table 1. Components composition of mung bean peel waste

Materials	Repeat	Components Composition, (%)			
		Moisture content	Cellulose	Hemicellulose	Lignin
Mung bean peel	1	17.08	26.58	26.48	18.21
waste	2	16.68	27.59	26.89	17.41
Average		16.88	27.09	26.69	17.81

Table 2. Average of liquid smoke production on the two treatment variations and interactions per 1000 g mung bean peel waste

No	Temperature	Duration			Average
		120 minutes	150 minutes	180 minutes	
1.	400 ºC	300 g (30.0%)	360 g(36.0%)	350 g(35.0%)	337 g(33.7%)
2.	450 ºC	350 g (35.0%)	390 g(39.0%)	340 g(34.0%)	360 g(36.0%)
Average		325 g(32.5%)	375 g(37.5%)	345 g(34.5%)	349 g(34.9%)

Table 3. Composition phenol content, acidic and the pH value of the results of pyrolysis liquid smoke mung bean peel waste.

Quality Indicator	Temperature	Duration			Average
		120 minutes	150 minutes	180 minutes	
Content of phenol, %	400 ºC	0,18	0,10	0,11	0.13
	450 ºC	0.11	0.08	0.06	0.08
	Average	0.15 [a]	0.09 [b]	0.08 [b]	0.11
Content of acids, %	400 ºC	8.00	9.50	8.80	8.79
	450 ºC	4.25	4.00	2.00	3.42
	Average	6.13 [a]	7.75 [a]	5.40 [c]	6.10
pH Value	400 ºC	4.69	4.59	4.71	4.66
	450 ºC	5.45	5.66	6.20	5.78
	Average	5.04[a]	5.13[b]	5.46[c]	5.22

Description: The notation in the form of the alphabet behind the figures show no significantly at the 0.05 significance value for each parameter.

Related with the pH value of quality parameters, showed that higher pyrolysis temperature (450 °C) resulted in a mean pH values higher (5.78) than the lower temperature (400 ° C) to produce a pH value 4.66. Similarly, the effect of pyrolysis time, the longer the time of pyrolysis showed higher pH values. Pyrolysis treatment duration of 120, 150 and 180 minutes at different temperatures to produce a pH value in a row 5.45, 5.66 and 6.20 (see Table 3). When compared to commercial liquid smoke pH (pH 2.3 - 2.5) and pH liquid smoke quality standards in Japan (pH 1.5 - 3.7), the pH of liquid smoke from mung bean peel waste has a higher value.

3.2 Pyrolysis Process Parameters of Charcoal Briquettes

Table 4 shows the average production of pyrolysis with a treatment difference in temperature and duration is 437 g/1000 g (43.7%). The quality potential of charcoal produced from mung bean peel waste, is determined by the quality parameters, Including water content, ash, volatile and calorific value. The test results of some of the quality parameters of charcoal briquettes material as presented in Table 6.

The parameter testing is done in the form of briquettes with the addition of adhesive in the same amount (10%) and the pressure is relatively the same as well. Briquettes cuboid with the average size of 4x4x2 cm weight and density are presented in Table 5.

Water content as one of the parameters that affect the quality of the content of the calorific value of briquettes produced. The water content of the lower calorific value of briquettes higher and better quality. In Table 6 shows that the highest water content (9.43%) were produced by pyrolysis operating at a temperature of 400 ° C for 120 minutes and the lowest (6.03%) to result from the pyrolysis at 450 ° C for 180 minutes. When compared to standard commercial briquette moisture in Indonesia (7.57%) then there is only one treatment (a temperature of 400 °C within 120 minutes) that do not meet the standards. Effect of treatment temperature and time pyrolysis tested showed significantly depending on water content are produced.

Table 4. Average of charcoal production on the two treatment variations and interactions

No	Temperature	Duration			Average
		120 minutes	150 minutes	180 minutes	
1.	400 ºC	520 g (52.0 %)	470 g (47.0%)	400 g (40.0%)	463 g (46.3%)
2.	450 ºC	430 g (43.0 %)	420 g (42.0%)	380 g (38.0%)	410 g (41.0%)
Average		475 g (47.5 %)	445 g (44.5%)	390 g (39.0%)	437 g (43.7%)

Table 5. The specification of charcoal briquettes product.

Specification	Temperature	Duration			Average
		120 minutes	150 minutes	180 minutes	
Weight (g)	400 ºC	18.00	20.00	20.50	19.50
	450 ºC	20.00	18.00	18.00	18.67
	Average	19.00	19.00	19.25	19.08
Dencity, (gr/cm3)	400 ºC	0.56	0.63	0.64	0.61
	450 ºC	0.63	0.56	0.56	0.58
	Average	0.60	0.60	0.60	0.60

Ash content is a parameter of quality charcoal briquettes as important and in proportion to the content of inorganic materials in the timber. One element that is unfavorable to the calorific value and is in the ash is silica. Effect of treatment temperature and duration pyrolysis against ash content are higher and the duration pyrolysis would increase the ash content. The test results of the treatment time and temperature pyrolysis against briquette charcoal derived from mung bean peel waste shows that the ash is the material remaining in burning up to continuous heavy. Low levels of ash on pyrolysis temperature 400°C for 120 minutes showed that yet as the material is left up to the constant weight. The resulting ash content of each treatment temperature and time that show significantly different. Low ash content (8.73%) was generated in the pyrolysis temperature of 400 °C for 120 minutes, is being produced at the highest temperature pyrolysis with a temperature of 450 °C for 150 minutes.

The test results in the volatile content of mung bean briquettes peel waste pyrolysis results with the treatment temperature and time showed that higher temperatures produce higher levels of volatile and reverse over time, the longer the time pyrolysis does not always produce smaller. Volatile smallest levels of 55.78% is generated in the pyrolysis temperature of 100 ° C for 150 minutes and a high of 74.13% resulting from the pyrolysis with a temperature of 450 ° C for 150 minutes (Table 6). The volatile content of the range is better than the volatile content of the corn cob (88.84%), peanuts peel (85.7%) and sawdust (88.52%).

The content of volatiles generated due to differences in temperature pyrolysis showed significantly depending on the significance 0.05. However, differences in levels of volatile because of the time difference pyrolysis showed no significantly different at the same level of significance.

Table 6. Charcoal briquettes quality parameters influence of the pyrolysis temperature and time treatment

Quality Indicator	Temperature	Duration			Average
		120 minutes	150 minutes	180 minutes	
Water content, %	400 ºC	9.34	6.79	7.31	5.38
	450 ºC	7.36	7.10	6.03	4.82
	Average	8,35[b]	6.95[a]	6.67[a]	5.10
Ash content, %	400 ºC	8.73	29.59	22.21	12.77
	450 ºC	26.12	32.25	29.64	19.46
	Average	17.42 [a]	30.92 [b]	25.92 [b]	16.11
Volatile content, %	400 ºC	71.60	55.78	57.03	42.46
	450 ºC	72.75	74.13	65.75	48.96
	Average	72.17 [a]	64.95 [a]	61.39 [a]	45.71
Calorific value, Cal/g	400 ºC	5801.78	6658.72	6696.04	4153.50
	450 ºC	6230.51	5583.94	603394	3938.15
	Average	5615.71 [a]	6658.72 [b]	6696.04 [b]	4091.48

Description: The notation in the form of the alphabet behind the figures show no significantly at the 0.05 significance value for each parameter.

The amount of heat generated or caused by a gram of the fuel to raise the temperature of 1 gram of water of 3.5-4.5 ° C with a unit of calories, is called calorific value. The calorific value resulting from the burning of charcoal briquettes peel of mung bean waste to the treatment temperature and time of the smallest pyrolysis 5,583.94 cal./ g is produced from a temperature of 450 ° C for 150 minutes and the highest 6,696.04 cal./g is produced from pyrolysis temperature of 400 ° C for 180 hours (see Table 6). The range of calorific value of briquettes mung bean waste peel and relatively high when compared to standard USA (6,000-7,000 cal/g) and Japan (6,230 cal/g), there are several treatments that have met.

3.3 Adhesive Ratio and Pressing Treatment of Charcoal Briquettes

Charcoal briquettes produced by the difference in treatment ratio of adhesive and pressures, has a product specification with the same of shape and diameter, are cylindrical with a diameter 2,34 cm, but the length and weight of briquettes is different depending on the percentage of adhesive and the pressure difference (see Table 7).

Adhesive ratios and pressure are presented in Table 8 shows that an important parameter briquettes, the water content of the briquettes affect calorific value or heat generated. The heat produced will be used to evaporate the water content first, then produce heat that can be utilized. The water content of the briquettes also affect combustion performance, the higher the water content the more difficult to burn. The water content in the briquettes is affected by the composition of the briquettes and the pressure of the formation. In Table 8, seen the lowest water levels occur in 5% of the adhesive with a pressure of 50 kg/cm2 (3.85%) and the lowest at 15% of adhesive with a pressure of 100 kg/cm2 (9.40%).

Average moisture content of mung bean peel waste briquettes product compared to some standard, such as Japan (6.0-8.0%), the USA (6.2%), Indonesia (7.57%), and the UK (3.6%) (BPPH, 1994), and SNI (max 8.0%) (SNI. 2011), so the potential to meet each standard treatment with the adhesive composition and the pressure was adjusted.

The lowest ash content of 3.81% resulting in 15% of the adhesive with a pressure of 100 kg/cm2, and the highest ash content of 4.93% resulted in 5.0 % adhesive with a pressure of 50 kg/m2. The range of values of the ash content compared to the quality standards in Japan (3.0-6.0%), USA (8.3%), Indonesia (5.51%), the UK (5.9 %) (BPPH , 1994) and the SNI (max 8%)(SNI. 2011), briquette of mung bean peel waste of a whole variety of hits.

Results assay volatile in briquettes of mung bean peel waste on the differences adhesive composition and pressure, showed levels of volatile highest (24.04%) was found in 15% of the adhesive with a pressure of 100 kg/cm2, and the levels of volatile lowest (14.84%) resulted in 5% adhesive with a pressure of 50 kg/cm2 (see Table 8), The range of levels of volatiles in charcoal briquettes of mung bean peel waste, when compared with the quality standards of Japan (15-30%), USA (19-18%), Indonesia (16.145%), and UK (16.4%) (BPPH, 1994) and SNI (Max 15%) (SNI. 2011), has great potential to be developed, although not all treatment variations in but most have been hits.

Table 7. Product specifications of charcoal briquettes

Pressure (kg/cm^2)	Dimension	Adhesive Ratio			Average
		5%	10%	15%	
50	length, cm	4.87	4.55	4.41	4.61
	weight, g	13.15	13.51	14.35	13.67
75	length, cm	4.76	4.55	4.31	4.54
	weight, g	13.32	14.06	14.41	13.93
100	length, cm	4.68	4.46	4.28	4.47
	weight, g	13.47	14.28	14.58	14.11

The calorific value of charcoal briquettes of mung bean peel waste at treatment difference adhesive composition and pressure of 5492.3 cal/g indicates lowest calorific value obtained at 15% of adhesive composition and a pressure of 100 kg/cm2, while the high calorific value 6188.5 cal/g is produced from the composition 5 % adhesive and a pressure of 50 kg / cm2 (see Table 8).

In conjunction with charcoal briquettes of mung bean peel waste, low density (0.63 g/cm3) resulting from the treatment of 5% adhesive with a pressure of 50 kg/cm2, while the highest density of 0.79 g/cm3 is produced at 15% of adhesive with a pressure of 100 kg/cm2. When compared with the standard in some countries, the density charcoal briquettes of mung bean peel waste is not all treatments meet the standards, such as the Japanese standard (1.0 - 1.2 g/cm3) and the USA amounted to 1.0 g/cm3, but for the UK standard for 0.46 g/cm2 and Indonesia amounted to 0.44 g/cm3 to meet the standard.

Special parameters of burning rate (mg/s) and the loss of mass (g) the pressure applied to the pressing of the best (highest calorific value and low moisture content), 50 kg/cm2 with a variety of adhesive ratio of 5%, 10% and 15%. Tests conducted during the burning time 42 minutes. The results of the second test the performance parameters show a relatively similar pattern, namely for mass reduction rate; of the initial mass of the three treatments are relatively similar ranges between 40.13 - 40.18 g at the end of consecutive testing of adhesive ratio of 5, 10 and 15% live 5.41, 4.22 and 3.77 g. In the process, the briquettes are derived from the ratio of the adhesive 5% reduction in its mass tends to be slower. Similarly to the parameter rate of combustion, of the three treatments also showed relatively the same phenomenon, namely the peak combustion occurs in the sixth consecutive minutes starting from a ratio adhesive 5, 10 and 15% is 45.92, 50.4, 53.42 mg/s and at the end of the process (42 minutes) the firing rate stayed 2.75, 3.17 and 3.17 mg/s.

3.4 Financial Analysis

Financial viability of liquid smoke produce of mung beans peel are NPV of Rp. 16,737,662, IRR of 36 % and PBP for a 2.53 year and PI of 1.62. The financial feasibility of charcoal briquettes and liquid smoke produce of mung beans peel waste are become PBP 1.12 years, NPV Rp 35,947,702, - IRR of 73.6% and PI of 5.15.

CONCLUSIONS

Potential of mung beans peel waste as a raw material of liquid smoke seen from cellulose content of 27.09%, 26.69% hemicellulose, and 17.81% lignin, which produce liquid smoke containing phenol 0.0576 - 0.180%, the acid content of 2.0 - 9.5%, and the pH value is 4.59 to 6.20, occurred on the operating conditions of pyrolysis at temperatures of 400 ° C and within 150 minutes.

It was found that charcoal production of mung beans peel waste based on temperature and the duration of the pyrolysis 400 °C for 180 minutes, with the results of water content of 7.31 %, 22.21 % ash content, volatile compound of 57.03 %, and calory 6696,041 cal/g. Quality charcoal obtained at 5 % the amount of adhesive, pressure of pressing of 50 Kg / m2, which 4.93 % of ash content, volatile content of 14.84 %, 6188.53 cal/g calorific value, 76.37 % carbon content, and has a density of 0.63 g/cm3 . The performance of combustion reached after 6 minutes and longer burning flame.

Financial feasibility of liquid smoke produce of mung beans peel waste are NPV of Rp. 16,737,662, IRR of 36 % and PBP for a 2.53 year and PI of 1.62. The financial feasibility of charcoal briquettes and liquid smoke produce of mung beans peel waste are become PBP of 1.12 years, NPV of Rp 35,947,702, IRR of 73.6% and PI of 5.15.The addition of solid waste into the biogas production system can increase the volume of biogas and the resulting methane content. For vegetable solid waste, petsai was the best material for co-feeding with 246 ml biogas production and 2.62% methane content. While the addition of solid waste of tofu and the source of microorganisms from cow manure was able to produce a much larger volume of biogas as much 715 ml in a shorter time of 7 days.

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