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Utilization Study of Carbonized Coal Briquette as Beef Rendang Cooking Fuel

Utilization Study of Carbonized Coal Briquette as Beef Rendang Cooking Fuel

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Abstract. Finding the cheaper alternative fuels and shortening the rendang cooking time are the potential efforts to reduce the production cost of rendang. This study aims to use low-rank cheap coal to cook beef rendang and to develop a more efficient rendang cooking method. First, the raw coals were carbonized, then the charcoals obtained were crushed and mixed with the filler and binder. After that, the charcoal mixture was molded into briquettes. Furthermore, the carbonized coal briquettes resulted were characterized and used as fuel to cook beef rendang in a semi-closed moveable-grate stove. To get a more efficient cooking time, a modified cooking method was developed. From the research has been obtained that there was almost no significant odor and smoke emissions during the cooking process except at the initial ignition period, which takes between 10-15 minutes. The modified cooking method took time 3 hours to get the dry beef rendang, 1 hour shorter than that of the normal cooking ones. Briquettes consumption for 1 kg of beef rendang cooking,using the modified cooking method, was about 0.75 kg, equivalent to USD 0.18 if 1 kg of briquette is priced USD 0.24. Finally, it can be summarized that carbonized coal briquette is a solid smokeless fuel that is safe and cheap to cook beef rendang.

1. Introduction

Besides being delicious, beef rendang is also very nutritious food. According to [1], the digested protein content in rendang beef increased by about 44% compared to fresh beef. Apart from containing high digested protein, rendang is also safe to consume. The saturated oil and fat content of beef rendang, which is dominated by long and medium-chain of fatty acids, are not easily degraded [1]. In addition, the presence of spices in the rendang mixture can inhibit the degradation of fatty acids [2]. The friendliness of fatty acids derived from coconut milk for human health has also been previously mentioned in [3].

The cooking process of rendang,ata cooking temperature ranging from 80-93 ^{o}C,takes time between 5-6 hours [2]. The rendang cooking process mechanism consists of water evaporating, converting coconut milk into oil, deactivating various enzymes present in the beef and coconut milk, and associating the spices in the rendang mixture.Dry beef rendang has a long shelf life. The lower the water content of beef rendang, the longer its shelf life will be and vice versa.

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IOP Conf. Series: Materials Science and Engineering **990** (2020) 012012 doi:10.1088/1757-899X/990/1/012012

The long cooking process of rendang (5-6 hours) cause fuel consumption to be high and increase the degradation potency of the rendang dough. This is one of the main problems of the rendang food business. This study aims to use low-rank cheap coal to cook beef rendang and to develop a moreefficientrendang cooking method. Various problems in using coal as fuel, such as initial ignition difficulty, smoke formation prevention, combustion control difficulty, and user comfort, as stated in [4], have been resolved in this study.

2. Methodology

The implementation of this research consisted of several stages, namely the briquette manufacturing stage, the briquette characterization stage, and the rendang cooking stage. The brief descriptions of each stage were given below.

2.1. Briquettes Manufacturing Procedure

The manufacturing flow diagram of the carbonized coal briquette used here was shown in figure 1. The low-rank coal from Muaro Jambi area, Jambi Province, Indonesia was carbonized by indirect heating in a multi-retort carbonizer for ± 6 hours. The charcoals obtained were then crushed, ground, and screened to get -8 mesh coal particles.The particles that pass through the 8 mesh sieve were fed to the mixing vessel to make the briquette dough while the rest was returned to the grinding process.

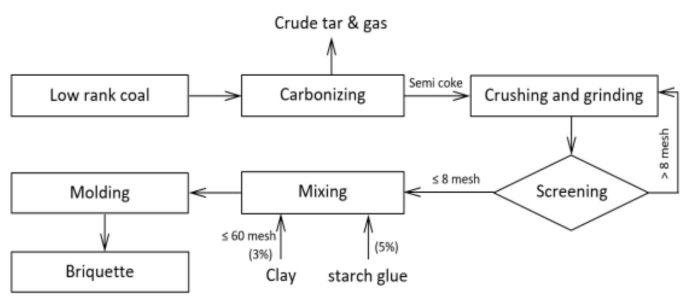

Figure 1. Flow diagram of the carbonized coal briquettes making process

The composition of the briquette mixture consisted of charcoal 92%, filler 3%, and binder 5%. The use of filleris intended to absorb gas emissions and to reduce the fly ash phenomenon during the cooking process. Meanwhile, the use of binder is intended to provide strength to the briquettes so that they are not easily destroyed during transportation, storage, and use[5]. The last step of the briquette making process was the briquettes molding, which was conducted manually.

2.2.The Briquette Characterizations

2.2.1. Physical Characterizations. One of the briquette physical characteristics determined here was density. The briquette density will correlate to the transportation and storage costs; the smaller the briquette density, the greater the transportation and storage volume required, resulting in higher handling costs. In addition, briquettes with small density tend to have low energy content. Conversely, if the briquette density is too high, the combustion performance of the briquette will be low due to the low porosity of the briquette. The quality standard of the briquette density is between 1.0 - 1.5 gr/ml [6].

The briquette density determination referred to ASTM D2395-17 [7]. The procedures were as follows: (a) weighing the mass of a briquette, (b) putting a briquette into a fully filled water vessel, (c) determining the volume of water that is removed from the vessel and record it as the volume of a briquette, (d) calculating the briquette density through equation (1); where ρ is briquette density, m is briquette mass and v is briquette volume. The briquette density was calculated based on an air-dried basis (adb).

$$\rho = \frac{m}{v} \tag{1}$$

Another physical property of the briquettes determined in this study was the shatter index.The shatter index indicated the briquette strength;whether the briquettes could stand or not during transportation, storage, and usecan be assessed from the shatter index value. For domesticfuel briquettes, the minimum shatter index required is 0.9 [8].

The determination of the shatter index referred to ASTM D440-86 [9]. The procedures for determining the shatter index were as follows; (a) weighing the initial weight of a briquette, (b) dropping the briquette by gravity from a height of 2 meters onto the metal floor 3 times, (c) weighing the residual weight of the briquette that has been resisted in an 8 mesh sieve, and (d) calculating the shatter index of the briquette through the equation (2).Variable I_s is a shatter index, m_{BI} is an initial mass of briquette, and m_{BR} is a residual mass of briquette [10].

$$I_s = \frac{m_{BR}}{m_{BI}} \tag{2}$$

2.2.2.Proximate Analysis. The parameters determined in the proximate analysis of briquette were water, volatile matter, fixed carbon, and ash contents. Proximate analysis was carried out on an air-dried basis (adb). The determination of the briquettes heating value ,using bomb calorimeter, was also conducted in this step.

2.2.3. Initial Ignition Time. The initial ignition time of the briquettes is the length of time it takes from the first time the briquettes are ignited until the fixed carbons of the briquettes wereburnt stably. The unit of time of thebriquettes ignition was expressed in minutes. There were two kinds of ignition materials used in this research, namely kerosene and dry wood branches.

The procedures of using kerosene as an ignition material were as follows: (1) soaking some briquettes into the kerosene liquid for ± 5 minutes, (2) placing the soaked briquettes in the briquette pile, (3) igniting the briquettes with a match, (4) waiting for the fixed carbon of the briquette was burnt stably, (5) recording the time required for initial ignition. If the briquette hasn't been burned yet until the ignition material runs out, inject the kerosene until the briquettes were burnt stably.

Meanwhile, for the dry wood branches ignition material, the procedureswere as follows: (1) chopping the dry wood branches up to 5-10 cm in sizes, (2) puttingthe chopped of dry wood branches in a briquette pile, (3) igniting chopped dry wood branches, (4) waiting for the fixed carbon of the briquettes was burnt stably, and (5) recording the time required for initial ignition. If the briquette hasn't been burned yet until the ignition material runs out, add some chopped dry wood branches until the briquetteswere burnt stably.

2.2.4.The HottestLayer Position. There are two placements of the hottest layer in the briquette stove that were tested in this study, namely placement at the top and at the bottom of the briquettes pile. If the stove combustion chamber is first filled with briquettes and ignited later from the top, then the hottest layer position of the briquettes pile is at the top (figure 2.a). Conversely, if the stove combustion chamber is ignited first at the bottom and filled later with briquettes until it is full, then the position of the hottest layer of the briquettes pile is at the bottom (figure 2.b). The position of the hottest layer at the briquette pile will affect the smoke emission of a briquette stove.An illustration of the hottest layer positions in the briquette stove were shown in figure 2.

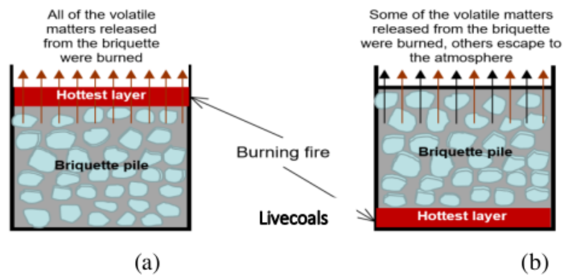

Figure 2. Illustration of the hottest layer position in the briquette pile

2.3. Cooking Test of Beef Rendang Using Briquettes

The type of stove used in the beef rendang cooking test was a semi-closed moveable grate stove, wherethe grate of the stove can go up and down, as shown in figure 3.According to [11], the recent problem of briquette stove design does not lie in the fuel combustion efficiency but lies in the heat transfer efficiency from the furnace to the cooking vessel.The moveable grate of the stove allows the hottest layer of the briquette pile always close to the cooking vessel so that the thermal efficiency of the stove would be better. The average thermal efficiency of this stove in the water boiling test was reported about ± 50% [12].

There were two cooking methods of beef rendang used in this study, namely: (1) a normal method, in which coconut milk and spices were cooked first until the dough releases oil (± 1 hour), then added the beef, and cooked until the dough dries, and (2) a modified method, where at first the beef and spices were sautéd with a little oil for ± 30 minutes, after that thick coconut milk was added and cooked until the dough dries. The time required to cook the beef rendang for both cooking methods was compared.

3. Results and Discussion

3.1. Physical Properties

The briquettes produced in this study was in the form of jengkol briquette with an equivalent diameter of about 41 mm. The appearance of the jengkol briquettes was shown in figure 4. The average density of the briquettes obtained was 1.17 gr/ml. This density value is within the density standard of fuel briquette, namely 1 – 1.5 gr/ml [6]. Meanwhile, the shatter index value of the briquettes obtained was about 96%. This value is above the minimum shatter index, namely 0.9 [8]. From these results, it could be seen that briquettes produced in this study have met the physical standard of the domestic fuel briquette.

3.2.Proximate Analysis

The proximate analysis results of the carbonized coal briquettes and quality standards of the fuel briquette[13], on the air-dried basis (adb), were shown in table 1. From the table, it could be seen that, in terms of moisture and calorific value, the values of proximate analysis of the coal briquettes produced have met the quality standards of fuel briquettes. But in terms of the volatility, the value was greater than the standard. Besides being caused by the incomplete carbonization process, the addition of tapioca flour was also the cause of the high content of volatile matters from the resulting briquettes. The addition of the tapioca flour used here was 5%, greater than that was recommended by Suganal, namely 3% [5].

Table 1. Proximate analysis of the carbonized coal briquette

No.	Parameter	Value		
		Experiment	SNI*	Suganal's
1.	Moisture, %	6.21	7.5	4.29
2.	Volatile matter, %	19.62	≤ 15	30.81
3.	Fixed carbon, %	57.05	n.d**	29.63
4.	Ash, %	17.12	n.d**	35.27
5.	Calorific value, kkal/kg	5.223	≥ 5000	4.412

* SNI = Standar Nasional Indonesia ** n.d = not be defined

3.3.Initial Ignition Time

The initial ignition time of the briquettes for the kerosene and wood branches was almost the same, ranging from 10-15 minutes. This time on average was slightly longer than the initial ignition time of coal briquettes reported by Suganal in [5], which was ± 10 minutes. This is because the volatile matters of the briquettes used here (19.6%) are lower than the volatile matters used by Suganal, which was 28.7%. The initial ignition time of the briquettes is directly proportional to the reactivity and the volatile matters content of the briquettes. The higher the content of the volatile matter of briquette, the higher its reactivity and the faster its initial ignition time [5].

Both types of ignition substances gave smoke emission at the initial ignition periode, where the smoke emission produced by the kerosene tended to be more than of the dry wood branches. The smoke formation occurred because of the volatile matters that come out from the briquettes were released into the environment without having time to burn in the stove combustion chamber. It was because the stove temperature at the initial use was still low. As time goes by, the temperature of the stove combustion chamber continued to rise, and the fixed carbon of the briquettes started to burn. As a result, the temperature of the stove combustion chamber was higher and the volatile matters of the briquettes would be burned in the combustion chamber before escaping to the environment.

3.4.Hottest Layer Position

From the two positions of the hottest layer that were varied in this study, it was found that the placement of the hottest layer at the top of the briquette pile was better in reducing the smoke emission than the placement of the hottest layer at the bottom. It was because when the hottest layer is at the top, the evolution of the volatile matters from the briquette will pass through and will be burned in the layer so that the smokes emission was not formed. Conversely, when the placement of the hottest layer is at the bottom of the briquette pile, the evolution of the volatile matters will escape to the environment without passing the hottest layer. As a result, a part of the volatile may be burned in the stove combustion chamber but others may be released to the environment as smoke.

Apart from being determined by the placement of the hottest layer position, smoke formation is also influenced by the stove design. The open stove system tends to produce more smoke than the stove with a closed system. This is because, in an open stove system, the evolution of volatile matters can leave the stove from many directions so that it does not always pass through the hottest layer of the stove. In addition, the hottest layer of an open stove system tends to have a lower temperature than a closed stove system, so it is not completely capable of burning the volatile matters that pass through it. The use of a semi-closed stove in this study gave a positive contribution to the absence of smoke.Even though the volatile matter content of the briquette used was slightly above the quality standard, but there is no smoke emission released from this combustion test.

IOP Conf. Series: Materials Science and Engineering **990** (2020) 012012 doi:10.1088/1757-899X/990/1/012012

3.5.Cooking Test Results of Beef Rendang Using Briquettes

The appearance of the dry beef rendang resulted from this study was shown in figure 5.From the two cooking rendang methods used here, it was obtained that the cooking time required for 2 kg of beef rendang, using the normal cooking method was ± 4 hours, while the cooking time required using the modified cooking method was about 3 hours. This happens because, in the normal cooking method, some time is sacrificed to produce oil from coconut milk after which the oil is associated with spices and beef[1]. Meanwhile, in the modified cooking method, the association of spices and meat is carried out using an external source of oil, so that this method requires less time.In terms of aroma and taste, the beef rendangs resulted from both of the cooking methods were similar, qualitatively. While, the protein and fatty acid contentsof the beef rendangs resulted from both of the cooking methods need further investigation.

Figure 3. Semi-closed Movcable grate stove

Figure 4. Typical jengkol briquette

Figure 5. dry beef rendang

This study also revealed that the fuel consumption for cooking 2 kg of beef rendang by the modified cooking method was 1.5 kg of briquettes. While in the normal cooking method, the briquette consumed was 2.1 kg. If 1 kg of briquettes is priced at USD 0.24, then the fuel cost of 1 kg of beef rendang will be USD 0.18.

4. Conclusion

The cooking test of beef rendang using carbonized coal briquettes on a semi-closed moveable grate stove has been successfully carried out. Several results have been obtained, among them: (1) in general, the quality of the coal briquettes produced can meet the quality standards of fuel briquettes; both physically and chemically, (2) the initial ignition of coal briquettes, for both ignition materials, takes time between 10-15 minutes, (3) placing the hottest zone at the top of the briquette pile is more effective in reducing smoke emissions than placing it at the bottom, (4) using the briquettes as fuel in a semi-closed moveable grate stove did not emit smoke except during initial ignition, (5) cooking rendang using the modified cooking method was more efficient than that of the normal cooking method, (6) the quality of the beef rendangs resulted from both of the cooking methods needs further investigation, especially in terms of protein and fatty acid contents, (7) the length of time needed to cook 2 kg of beef rendang by the modified cooking method was 3 hours with a briquette consumption of ± 1.5 kg, and (8) if the price of the carbonized coal briquettes is USD 0.24 per kg, the fuel cost for cooking 1 kg of beef rendang is about USD 0.18. Finally, it could be concluded that cooking beef rendang using carbonized coal briquettes is safe and cheap.

References

[1] Rini, Azima F, Sayuti K and Novelina 2016 Agriculture and Agricultural Science Procedia**9** 335-341

[2] Azima F, Novelina and Rini2016 International Journal on Advanced science Engineering Information Technology**6** 465-468

[3] Lipoeto N I, Agus Z, Oenzil F, Wahlqvist M L and Wattanapenpaiboon N 2004 *Asia Pac J Clin Nutr***13** 377-384

[4] Pasymi, Sari E and RahmanE D 2012 National seminar proceeding ReSaTek **II** TK-E1-9

[5] Suganal 2009 Jurnal Teknologi Mineral dan Batubara**05**17 – 30

[6] Boasiako A and Acheampong B B 2016 Biomass and Bioenergy**85** 144 - 152

[7] ASTM D2395-17 2017*Standard Test Methods for Density and Specific Gravity of Wood and Wood-Based Materials;* ASTM International: West Conshohocken, PA, USA

[8] Borowski G, Stępniewski W and Oliveira K W 2017 *Int. Agrophys.* **31** 571 – 574

[9] ASTM D440-86 2002*Standard Test Method of Drop Shatter Test for Coal*; ASTM International: West Conshohocken, PA, USA

[10] Kpalo S Y, Zainuddin M F, Manaf L A andRoslan A M 2020 Production and characterization of hybrid briquettes from corncobs and oil palm trunk bark under a low pressure densification technique*Sustainability* ***12*** 2468

[11] Olumethodomi J O, Modestus O O & Lagouge K T 2019 part a: recovery, utilization, and environmental effects 1-19

[12] Aprizon, Ardian B, Pasymi and MartynisM2013 Modification of the coal briquette stove *Abstract of Undergraduate Research* Faculty of Industrial Technology Bung Hatta University **1**(4)

[13] SNI 4931 2010 Coal briquette: Indonesian National Standardization Body

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