Potential to Produce Biomass Briquettes from Brewery Waste

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Abstract

In this study, the potential to make charcoal briquettes from brewery waste was investigated in a bid to utilize brewery waste and come up with an alternative source of energy. Brewery spent grains were first shredded to reduce the particle size to a range of 2-10 mm and then briquetted at 2 MPa at a 1-minute compaction periods to square biomass briquettes. The briquettes were then carbonized at temperatures varying between 200- 600 °C. The charcoal briquettes formed had calorific values ranging from 25-32 MJ/kg with the optimum calorific value being obtained at 400 °C. The charcoal briquettes produced from brewery waste can be used as an alternative source of energy at the same time managing industrial waste to promote environmental sustainability.

Keywords: Brewery waste, biomass, charcoal briquettes, renewable energy, waste management

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1. Introduction

The brewery industry generates a lot of solid waste during its processing and this waste has potential to be an environmental nuisance if not properly managed (Martins et al., 2016). Brewery waste is mainly composed of cellulose 22.2 (%wt), hemicellulose 26.8 (%wt), lignin 14.1 (%wt) and total carbohydrates 49.1 (%wt.) (Buffington, 2014) and is mainly generated from the malting and brewing processes. Brewery waste like any other lignocelluloses material has potential to be converted to charcoal briquettes (Okamoto et al., 2002) and other bio related energy products like bio ethanol and bio char (Mussatto, 2014). Biomass briquettes are increasingly becoming popular as both a waste management initiative as well as an alternative source of energy (Maia et al., 2014; Romallosa et al., 2017). Consequently, this study assessed the potential to produce biomass charcoal briquettes from brewers spent grains.

2. Materials and Methods

Brewery waste was obtained from a local brewery and shredded to a particle size ranging between 2-10 mm. Briquetting was done using a handmade briquetting machine at an approximate pressure of 2 mega Pascal's (MPa) with a compaction time of approximately 1 minute. The briquettes were 3 cm by 3 cm in size. Carbonization was conducted in a 5L Auger lab scale pyrolysis reactor at temperatures ranging between 200-600 °C.

The brewery waste and biomass briquettes' moisture content, ash content, fixed carbon content and calorific value were determined using standard methods. An *AND* moisture analyzer from Sigma Aldrich, South Africa, was used for moisture content, ash and volatile matter determination of the brewery waste at 105 °C dry basis. The fixed carbon content in the brewery waste and charcoal briquettes was obtained using the formulae: %Fixed carbon = 100% - (%Ash content + %Volatile matter). A Labtronics bomb calorimeter was used for determining the calorific values.

3. Results and Discussion

3.1 Brewery waste charcoal briquettes characteristics

The charcoal briquettes from brewery waste had a moisture content of 5-10% which was 70% lower than the initial moisture content of the brewery waste. This can be attributed to the drying effect done for a week on the briquettes to improve their burning efficiency during use. The charcoal briquettes had a high calorific value ranging between 25-32 MJ/kg. Almost similar calorific values from brewery spent grains were reported by Mussatto *et al*. (2014) with values ranging around 27 MJ/kg. The high calorific values can also be attributed to low ash content in the charcoal briquettes ranging between 9-12% as well as the fixed carbon content which ranged between 75-80%. Low ash content and high fixed value content promotes high ignition temperatures in charcoal briquettes hence high burning periods of the brewer's waste briquettes (Sato et al., 2011). The physicochemical characteristics of the brewery waste and the charcoal briquettes are shown in Table 1.

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Table 1. Brewery waste and charcoal briquettes properties

Parameter	Brewery waste	Charcoal briquettes
Moisture content (%)	17-30	5-10
Ash content (%)	15-20	9-12
Fixed carbon (%)	30-65	75-80
Volatile matter (%)	20-50	8-16
Calorific value (MJ/kg)	13-17	25-32

3.2 Effect of carbonization temperature on calorific value

The calorific value increased from 24.5 MJ/kg to 32.5 MJ/kg with increase in temperature from 200 °C to 400 °C, afterwards it decreased to 27.2 MJ/kg at 600 °C (Figure 1).

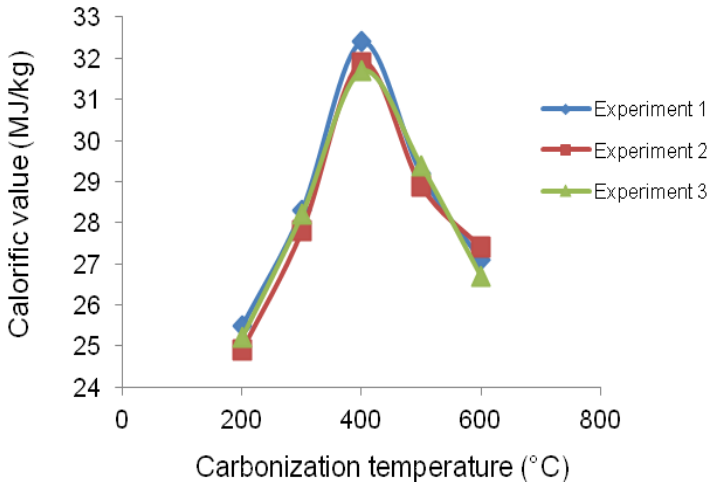

Figure 1. Effect of carbonizing temperature on calorific value

From the results obtained, carbonization temperatures must be maintained around 400 °C. The initial increase in calorific value is attributed to an increase in fixed carbon during carbonization as well as the decrease in volatile matter from 20-50% to 8-16% during carbonization (Table 1). The decrease in volatile matter is a result of chemical dehydration and decarboxylation reactions during the carbonization process (Kim et al., 2015).

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3.3 Effect of brewers waste particle size on calorific value

As the particle size of the brewery waste used to make the charcoal briquettes increased from 2 mm to 10 mm, the calorific value of the charcoal briquettes reduced from 32.4 MJ/kg to 25.9 MJ/kg (Figure 2).

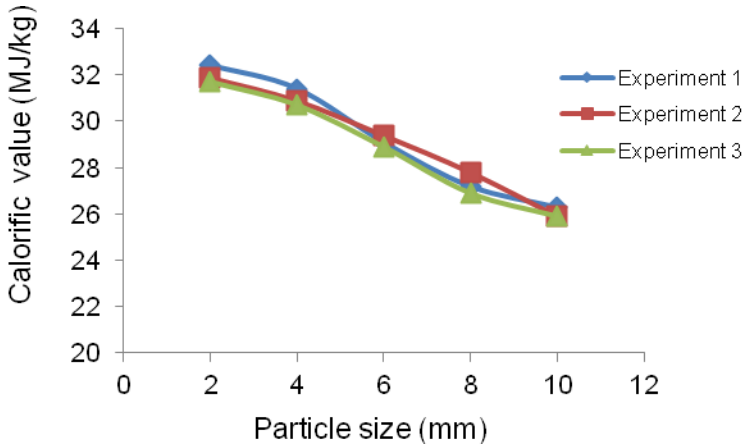

Figure 2. Effect of brewery waste particle size on calorific value, carbonized at 400 °C

It is critical to have smaller particles of the biomass for optimal charcoal briquettes calorific values (Kabir et al., 2015; Krizau et al., 2015). Larger biomass particles tend to promote incomplete carbonization, this has a potential of lowering the fixed carbon content in the charcoal briquettes as well as increasing the ash content hence decreased calorific values.

4. Technology Management for Briquetting Technology

Strategies for adoption and uptake of the biomass briquettes from brewery waste need to be found. Briquettes are ecofriendly and have high energy value making them easy to easy, however, development of smart partnership for the commercialization of the briquetting industry is critical for adoption of biomass briquettes.

5. Conclusion

Brewery waste can be utilized as a raw material for charcoal briquettes production. The charcoal briquettes have a high calorific value averaging around 28 MJ/kg carbonized at 400 °C for brewery waste particle sizes of 2 mm. The physicochemical characteristics of the charcoal briquettes promote high heating values hence their ideal use as an alternative source of energy.

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