Novelty Journals

ISSN 2394-9651

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 4, Issue 2, pp: (22-27), Month: May - August 2017, Available at: www.noveltyjournals.com

PRODUCTION OF BRIQUETTES FROM *Prosopis juliflora* STEM AND ANTHILL SOIL

Wiseman Tumbo Ngigi

Department of Chemical & Process Engineering, Moi University, P.O. Box 3900-30100, Eldoret-Kenya

Email: wisemanngigi@gmail.com

Abstract: **Invasive weeds are being explored as alternative sources of energy. *Prosopis juliflora* is an invasive weed. It was investigated to establish if it is a viable and sustainable source of energy. *Prosopis juliflora* stem (biomass) was used in the production of briquettes using anthill soil as binder. The first part of the study involved the determination of the best particle size of biomass in relation to the calorific value of briquette. The particle size of biomass was varied at 100, 250, 425, 600 and 850µm. Each size of biomass was blended with anthill soil (particle size 0.25mm) at a ratio of biomass: anthill soil (1:0.2). Mixing was done using a laboratory scale mixer. The briquettes were formed using a hydraulic piston press and compaction was done using a force of 15Mpa. The calorific value of the briquette formed from each particle size was determined and the particle size which gave the highest calorific size was used for further studies. The results of this study indicate that the briquette produced from a particle size of 425 µm had a calorific value of 22.42MJ/kg which was higher than 15.42, 17.53, 21.37 and 19.34MJ/kg for 100, 250, 600 and 850µm particle size respectively. The moisture content, durability test index, volatile matter content, ash content, fixed carbon content, and density of the briquette produced at 425 µm was established to be 9.6%, 93.25%, 76.2%, 1.25%, 12.95% and 746kg/m^3 respectively. From the findings, the briquettes produced from *Prosopis juliflora* stem and anthill soil as binder can be used as an alternative source of fuel especially in the rural and peri-urban areas of Kenya. Since *Prosopis juliflora* is found in plenty in Baringo County, it can serve as a sustainable and environmentally friendly source of energy.**

Keywords: **Binder, Calorific Value, Density, Fixed Carbon, Moisture, *Prosopis juliflora*, Volatile Matter, Weed.**

I. INTRODUCTION

Energy consumption can be used as an indicator of the economic development of a country. The main energy sources include fossil fuels (crude oil, natural gas, coal, tar sands, and shale oil), geothermal, solar, wind and hydro. In the rural set up, these main sources of energy are available in low supply and in some areas they are not available due to the associated high cost. This has lead to the use of alternative sources of energy by the rural and peri urban society especially from biomass sources such as wood, agricultural wastes (straws, maize stalks, maize cobs, rice husks, cotton stalks) and many others. However the amount of energy that is derived from these agri wastes is low when used in their raw form. There are ways of increasing the amount of energy that can be extracted from these wastes. One of the methods is densification which results from combining agri wastes using a binder to produce briquettes. Apart from the low cost of producing briquettes from these wastes, the use of agri wastes as a source of energy addresses issues to do with environmental pollution and reduce the use of fossil fuels whose reserves are diminishing. Briquetting helps to increase the density of agri wastes which improves the handling, storage and transportation of this form of energy. Kenya has not been left out in the search for environmentally safe, available and sustainable sources of energy. The country has a huge supply of biomass resources which can be used to provide energy to the rural and peri urban society. One such biomass type that is available in plenty is *Prosopis juliflora*. *Prosopis juliflora* is a weed. It has rough barks which are redbrownish in colour while the tap root allows the tree to access very deep water tables. The leaves are dark green in colour and contain high levels of tannin [8]. Its pods are the fruits and are green in colour when in the growth phase and eventually turn yellow upon attaining maturity [7]. In Kenya, planting of *Prosopis juliflora* was done within Mombasa County in a place called Bamburi in the 1970s [9]. *Prosopis juliflora* was also introduced in Baringo County through the fuel wood afforestation extension project in the 1980s [9]. The main aim of the project was to engage the locals in tree growing in order to address problems such as shortage of firewood and prevent soil erosion [6]. During the initial phases, *Prosopis juliflora* was accepted because it had the ability to grow on almost barren land where no other plant would survive. It was able to manage soil erosion and provided pods which were used as livestock feed [6]. After a period of ten years the growth of *Prosopis juliflora* began to pose an ecological challenge. It spread rapidly and became uncontrollable. *Prosopis juliflora* trees produce excellent firewood, charcoal and timber which is an indication of high quantity of cellulose which can be used to produce briquettes [10]. So far the only planned commercial use of *Prosopis juliflora* in Kenya is in electricity generation through burning of *Prosopis juliflora* tree logs in high pressure steam boilers for power generation [10]. Effective briquette production requires a suitable binder. Baringo County is classified into arid and semiarid areas which supports the establishment of anthills. Anthills consist of a pile of clay, sand and earth in varying composition depending on the activity of the ants. Normally, the worker ants are the ones that carry small quantities of earth from inside their colony and deposit it outside the colony which develops into an anthill over time. The anthills are capable of withstanding severe weather conditions like strong wind, heavy rain, sun and even cyclones. The activity of the ants has a profound effect on the composition of the pilling earth, clay and sand. There are many anthills in Baringo County which will act as a source of anthill soil to be used as a binder. Anthill soil contains clay that will be utilized as binder. In addition, unlike the ordinary soil, anthill soil is rich in organic matter (phenols and cellulosic polysaccharides) [13] which are beneficial to the final fuel property (calorific value) of the briquette. In this research study, *Prosopis juliflora* stem was used to produce briquettes using anthill soil as binder. These two raw materials are available in Baringo County in plenty.

II. MATERIALS AND METHODS

2.1 Research equipments

Laboratory milling machine was used for size reduction of biomass and anthill soil. Furnace was used for determining the ash content. An electric oven was used to determine the moisture content of briquettes, electronic weighing balance, laboratory test sieve with a set of screens and a vernier caliper were required in this research.

2.2 Collection and preparation of samples

Prosopis juliflora stem samples (biomass) and anthill soil were collected from Baringo County and dispatched to the Department of Chemical and Process Engineering. The samples were dried in the sun for five days before further processing.

2.3 Preparations of briquettes

Prosopis juliflora stem was chopped into 2 cm sized chips followed by further size reduction using a laboratory milling machine. The particle size of biomass was varied at 100, 250, 425, 600 and 850µm. Anthill soil was crushed and sieved to pass 0.25mm sieve opening. Each size of *Prosopis juliflora* stem and anthill soil was mixed at a ratio of 1:0.2 respectively to form a mixture weighing 100g. The briquettes were formed in a piston press with a gauge which consisted of a cylinder with an internal diameter of 55.30mm and 52.50mm internal chamber length/height. Compaction was done using a force of 15Mpa and a pressing time of 10 seconds. The briquettes were dried in the sun for two days. The calorific value of each briquette was established and the briquette that gave the highest calorific value was used to establish the moisture content, durability test index, volatile matter content, ash content, fixed carbon content and the density. The procedures used to establish the above parameters are described below.

2.1 Moisture Content

The moisture content of the briquettes was established according to [1] and calculated using equation 1.

$$\%\ \text{Moisture content} = \frac{M_1 - M_2}{M_1 - M} \times 100 \qquad (1)$$

Where:

M = Weight of empty crucible, (g)

M_1 = Weight of crucible and sample before drying, (g)

M_2 = Weight of crucible and sample after drying, (g)

2.2 Volatile Matter

The procedure used to determine the volatile matter content of the briquettes was based on [2]. The percentage volatile matter content was calculated using equation 2 and 3.

$$\% \text{ Weight loss} = A = \frac{W_2 - W}{W_1 - W} \times 100 \qquad (2)$$

Where:

W = Weight of empty crucible, (g)

W_1 = Weight of crucible and sample before heating, (g)

W_2 = Weight of crucible and sample after heating, (g)

% Volatile Matter = A – B (3)

Where B is the % moisture content found by equation 1.

2.3 Ash content

The procedure used to determine the ash content of briquettes was based on [3]. The percentage ash content was calculated using equation 4.

$$\% \text{ Ash content} = \frac{M_2 - M}{M_1 - M} \times 100 \qquad (4)$$

Where:

M = Weight of empty crucible, (g)

M_1 = Weight of crucible and sample before ignition, (g)

M_2 = Weight of crucible and sample after ignition, (g)

2.4 Fixed Carbon

The amount of fixed carbon (FC) was estimated using equation 5.

% Fixed Carbon = 100–B –C - D (5)

Where:

B = % Moisture Content from equation 1

C = % Volatile Matter content from equation 3

D = % Ash Content from equation 4

2.5 Density

The mass of the resulting briquette was measured using the electronic weighing balance and recorded. The dimensions of the briquette were measured using a vernier caliper. The volume of the briquette was calculated using equation 6. Finally, the bulk density was calculated using equation 7.

$$\text{Volume} = \pi r^2 h \qquad (6)$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad (7)$$

2.6 Calorific Value

A bomb calorimeter was used to establish the heating value of the briquettes.

2.7 Durability Test

A durability test was done by placing a known mass of briquette on a sieve which was shaken for 8 minutes. The mass of briquette that remained on the sieve (crumbled) was measured and durability calculated using equation 8.

$$\text{Durability Test index (\%)} = \frac{\text{Mass of Crumbled Briquette (Mass that Remained on the Sieve)}}{\text{Original Mass of Briquette}} \text{X100} \quad (8)$$

III. RESULTS AND DISCUSSION

The results of the effect of particle size of biomass on calorific value of briquette are shown in table I.

Table I: Effect of Particle Size of Biomass on Calorific Value of Briquette

Particle Size, µm	Calorific Value, MJ/Kg
100	15.42
250	17.53
425	**22.42**
600	21.37
850	19.34

The results in table I were plotted as shown in figure 1. Form the results the particle size which gave rise to the highest calorific value was 425 µm. This can be attributed to better blending and compaction of biomass and binder at this particle size. A briquette that is well blended and compacted has a higher density which results into high calorific value [11].

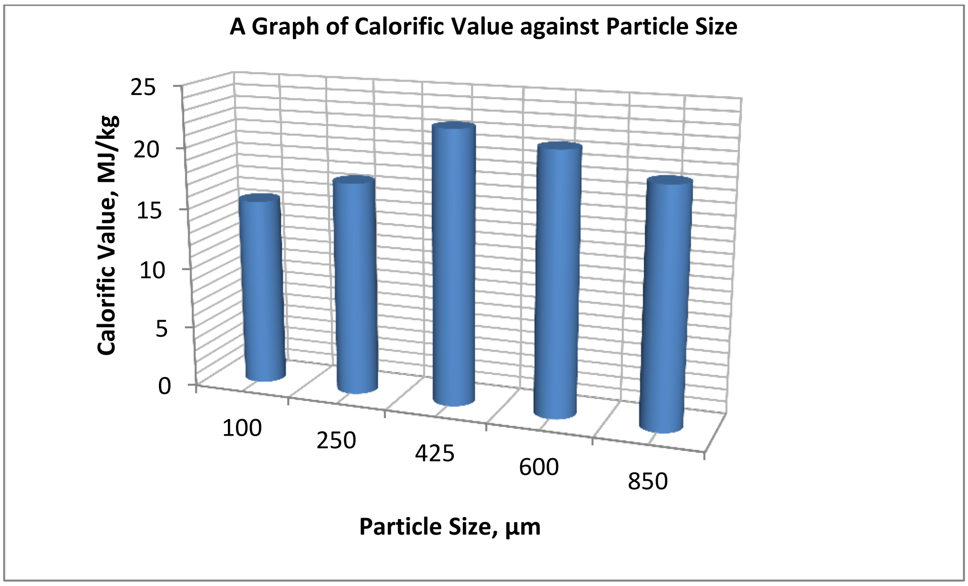

Fig.1: Effect of Particle Size of Biomass on Calorific Value of Briquette

Table II shows the results of moisture content, volatile matter content, ash content, fixed carbon content, density and durability test for the briquette produced from a particle size of 425 µm.

Table II: Properties of *Prosopis* juliflora stem briquette at 425 µm particle size

Parameter	Value
Moisture, (%)	9.6
Volatile matter, (%)	76.2
Ash, (%)	1.25
Fixed carbon, (%)	12.95
Density, Kg/m^3	746
Durability test, (%)	93.25

The calorific value of briquettes made from *Prosopis juliflora* stem and anthill soil as binder (22.42 MJ/Kg) at 425 µm particle size is higher than 18.41 MJ/Kg that is reported in [11]. This can be attributed to the use of anthill soil as binder. Ant hill soil binder contains organic material (including accumulated faeces and ant remains) arising from the activity of the ants [13]. This contributed to an increase in energy content of the resulting briquettes because the organic matter in the ant hill soil will also burn and generate energy. The moisture content reported above (9.6%) is lower than that reported by [11]. This can be attributed to the ability of the anthill soil binder to allow for faster drying of the briquette due to its properties (modified texture, structure and porosity) that are induced by the activities of ants [5]. Reference [10] reported a moisture content of 9.81% for *Prosopis juliflora* stem. The difference can be attributed to the addition of anthill soil. The value of moisture content indicates that the briquettes will easily and efficiently burn. In addition, low moisture content contributes significantly to the high calorific value because the presence of high moisture content leads to loss of energy during combustion as latent heat of vaporization. According to [12], durability is used as an indicator of the handling (storage and transportation) of the briquette. Briquettes produced using anthill binder had a durability index of 93.25%. This can be attributed to the clay that is found in anthill soil. The high value of durability index indicates that the briquettes can be handled (transported and stored) without breakages. The presence of clay acted as glue/binder within the briquette structure. The ash content of the briquette (1.25%) is slightly higher than 1.0% reported in reference [10] for *Prosopis juliflora* stem. The difference in ash content can be attributed to the introduction of anthill soil binder which contains organic matter and clay which also contributes to the generation of ash during combustion of the briquette. Low ash content indicates that the briquettes can be used without damaging refractory bricks in high temperature furnaces in addition to minimizing the accumulation of fouling deposits in combustion equipments.

IV. CONCLUSION & RECOMMENDATION

4.1 Conclusion

Prosopis juliflora is an invasive weed (biomass) available in abundant quantities in Kenya. This provides an opportunity for making briquettes in areas where it is found. Such areas include Baringo and Mombasa Counties. In addition, Baringo County has many anthill moulds which can be used in the production of briquettes as binders. From the study, the following conclusions were made.

i. *Prosopis juliflora* stem briquettes produced from biomass of 425µm particle size have sufficient energy content (calorific value of 22.42MJ/kg) which can be utilized in households found in rural and peri-urban areas in Kenya as a source of fuel.

ii. *Prosopis juliflora* stem briquettes can be transported and stored without damage/breakage due to a high durability index. This ensures that the briquettes do not break easily during transportation and storage. In addition a durability index of 93.25% indicates that the briquettes can withstand tear, wear and eventual loss of briquette during handling.

iii. The clay found in anthill soil acts as a suitable binder while the organic matter (accumulated faeces and ant remains) acts as the filler which enhances the combustion performance of the *Prosopis juliflora* stem briquettes by improving the calorific value.

iv. The moisture content of the briquettes is within that which is acceptable (10%) for efficient combustion of the briquettes.

v. The production of briquettes in Baringo County will provide employment opportunities through the setting up of small scale industries which will lead to improvement in the economic well being of the people employed in such industries.

vi. Dependence on forest resources for fuel will reduce leading to an increase in forest cover in Kenya since the briquettes can easily be transported and sold in other parts of the country where firewood and charcoal from forest resources are used as sources of energy.

vii. The overall effect of producing briquettes from *Prosopis juliflora* stem will be a reduction in environmental degradation. Finally this venture will help mitigate the negative impact of *Prosopis juliflora* weed on other land uses.

4.2 Recommendation

I recommend further tests be done to establish the effect of biomass and binder particle size on the strength of the briquettes. In the alternative, an optimization study can be carried out to find out optimum briquette production parameters such as optimum compaction pressure and the optimum ratio of biomass to binder.

REFERENCES

[1] ASTM. (2006). Standard Test Method Moisture Analysis of Particulate Wood Fuels, E 1871-82. Annual book of ASTM standards.

[2] ASTM. (2006). Standard Test Method for Volatile Matter in the Analysis of Particulate Wood Fuels, E 872 – 82. Annual book of ASTM standards.

[3] ASTM. (2007). Standard Test Method for Ash in Biomass, E 1755-01. Annual book of ASTM standards.

[4] ASTM. (2008). Standard Test Method for Compressive Strength of Wood, D2166-85. Annual book of ASTM standards.

[5] Jouquet, P., Lepage, M., Velde, B. (2002). Termite soil preferences and particle selections: strategies related to ecological requirements. Insectes Sociaux 49, 1–7.

[6] Lenachuru, C. I. (2003). Impacts of *Prosopis* species in Baringo District. Proceedings of workshop on integrated management of *Prosopis* species in Kenya, pp. 41-47.

[7] Masilamani, P. and Vadivelu, K.K. (1997). Seed Development and Maturation in honey mesquite. *Bangladesh Journal of Forest Science*, 26(1), 68-73.

[8] Mathews, S. and Brand, K. (2004). Africa invaded. The growing danger of invasive alien species. *The Global Invasive Species Programme*, 28-29.

[9] Maghembe, J.A., Kariuki, E.M. and Haller, R.D. (1983). Biomass and nutrient accumulation in young *Prosopis juliflora* at Mombasa, Kenya. *Agro forestry Systems*, *1*, 313-321.

[10] Ngigi, W., Menzwa, D. and Kiprop, A. (2016). Hydrolysis of Pretreated *Prosopis Juliflora* Stem to Simple Sugars using Immobilized Enzymes. Proceedings of Sustainable Research and Innovation Conference [S.I.], 238-249.

[11] Samodini, S. N., Chittaranjan, N. G., Sandip, G. K. D. (2013). Studies on Characterization of Biomass Fuel. *International Journal of Agricultural Engineering*, 6 (2), 547-551

[12] Temmerman M., Rabier F., Jensen P.D., Hartmann H., Böhm T. (2006). Comparative study of durability test methods for pellets and briquettes. *Biomass and Bioenergy*, 30,964-972.

[13] Kristiansen S.M. and Amelung W. (2001). Abandoned anthills of Formica polyctena and soil heterogeneity in a temperate deciduous forest: morphology and organic matter composition. *European Journal of Soil Science*, 52, 355 – 363.