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Briquette Production from Baobab (*Adansonia digitata*) Fruit Shells

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Abstract

The major sources of traditional biomass in the Republic of Malawi are firewood, charcoal, and agricultural residues, which contribute approximately 87%, 6.4%, and 6.6% to the total energy supply. The intense utilisation of charcoal and firewood can contribute to forest degradation and deforestation, particularly around densely populated areas. With an annual deforestation rate of 2.4 percent, forest loss in Malawi is among the highest in Southern Africa. Forest conservation in the country is hampered by the interaction of high population density, poverty, and rural dependence on forests, as well as poor forest management institutions. Agricultural expansion and high demand for wood fuels are two major forest threats.
The use of organic waste material as an alternative fuel can help alleviate this problem. Considering the area-specific biomass availability, related transportation cost and lack of attractive alternative uses, baobab (*Adansonia digitata*) fruit shells are a suitable agricultural residue. These shells are abundant due to the baobabs' wide distribution in the southern region of Malawi, and along the lakeshore in the central and northern regions of the country.
The purpose of this study is to analyse the physical properties of baobab shells, to determine the technological feasibility and fuel efficiency of baobab shell briquettes and crushed shells, and to assess any health risk related to using baobab shell briquette as an alternative fuel.
A briquette screw press machine with a motor capacity of 15 kWh and a capacity of 109.5 kg/h was used in Malawi to produce the baobab shell briquettes. The samples were characterised with regard to major physical properties, i.e. energy content, bulk density, ash content. The technology will be evaluated and recommendations for practice will be presented.

Keywords: *Adansonia digitata*, baobab, biomass, briquettes, energy, fuel, Malawi

Introduction

The major sources of traditional biomass in the Republic of Malawi are firewood, charcoal (Openshaw, 2010). With an annual deforestation rate of 2.4 percent, forest loss in Malawi is among the highest in Southern Africa (UNEP, 2002; Fisher, 2004). The use of organic waste material as an alternative fuel can help alleviate this problem.
Baobab fruit shells are a suitable agricultural residue, due to:

- area-specific biomass availability;
- related transportation cost and;

– lack of attractive alternative uses.

These shells are abundant in the southern region of Malawi, and along the lakeshore in the central and northern regions of the country (Sanchez, 2011). The purpose of the study was to identify the respective advantages and disadvantages of the briquette production from baobab (*Adansonia digitata*) fruit shells, to evaluate it and to present recommendations for practice.

Material and Methods

32 kg of baobab fruits were manually separated into 4 fractions (shell, pulp, fiber, kernels). For further analysis were used these four fractions and three types of baobab briquettes:

− briquettes I (100% baobab shells);
− briquettes II (50% baobab shells and 50% groundnut shells);
− briquettes III (50% baobab shells and 50% *Piliostigma thonningii* leaves).

Briquettes were produced using a „GONGYI SHI JINGYING MACHINERY" briquette screw press machine in Malawi.

Physical characteristics of the samples were determined using standard methods:

− dry matter (the samples were dried in the oven for 24 hours (105 °C), the weight of the dry samples was divided by the weight of the wet samples and multiplied by 100 to get a percentage (Oetzel et al., 1993));
– higher heating value (by using Mettler Toledo TGA/DSC 2 STAR system equipment (Wagner, 2017));
− ash content (dry and wet basis) (dried samples were burned in the oven for 5 hours (550 °C), after then the weight of the samples was divided by the weight of the ash and multiplied by 100 to get a percentage (Marshall, 2010));
– bulk density (the mass of the particles of the sample divided by the total volume (Buckman et al., 1960).

Figure 1. A – baobab fruit; B – baobab fruit shells; C – baobab fruit fibres; D – baobab fruit pulp; E – baobab kernels; F & G – Examples of the baobab fruit shell briquette

Results and Discussion

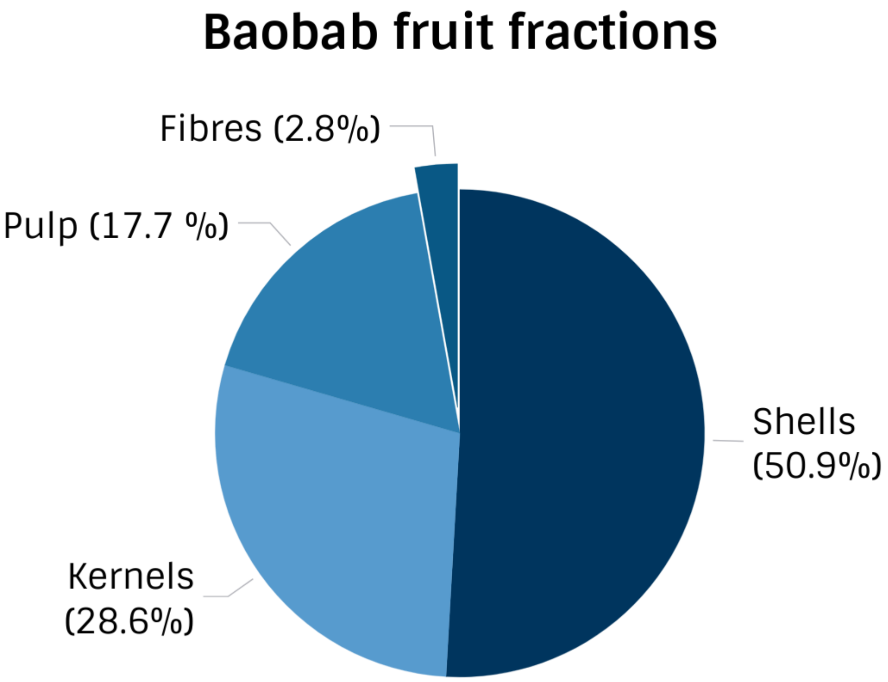

Figure 2. Baobab fruit fractions

The shells make up the main part of the weight of the fractions in the sample. Out of 32 kg of baobab fruits was gotten: 9.1 kg of kernels (28.6%), 5.7 kg of pulp (17.7%), 0.9 kg of fibers (2.8%) and 16.3 kg of shells (50.9%) (Figure 2).

The results of all the analyses made (ash content, higher heating value and bulk density) are shown in Table 1. The ash content value for the briquettes is between 12.8 and 16 % (dry basis), which is higher than ash content in some traditional fuels, such as charcoal or firewoods, however, initial analyses show a high calorific value of the briquettes at 18.75 MJ/kg. Relative to this, the calorific values of the non-briquette fractions, but also those of the briquettes with admixtures, are lower (Table 1). In comparison, higher heating values in biofuels should range from 14.6 to 23.3 MJ/kg dry basis, and ash content should be ranged from 0.17% to 24.36% dry weight basis (Ebeling & Jenkins, 1985).

Heating value per volume could be increased by:

− adding material with higher heating value, such as biomass waste with a high-fat content

− increasing the bulk density of briquettes through using a stronger briquette press

One of the options, especially when no transport is required, can be also the use of crushed baobab shells as a fuel itself, due to lower ash content and less energy needed for processing. For this reason, three different sizes of crushed shells were used while for the bulk density analysis- However the market value of the crushed shells may then be significantly lower than the market value of briquettes. But the market profitability and cost-benefit analysis of baobab shell briquettes are researching by another study group from the Baoquality project, their data will be used for further research.

Table 1. Results of analyses for different samples: fibres, pulp, kernels, shells, briquettes I (baobab shells), briquettes II (baobab shells and ground nut shells), briquettes III (baobab shells and *Piliostigma thonningii* leaves).

	Ash content (wet basis) (%)	Ash content (dry basis) (%)	Dry matter (%)	Rel. Higher heating value (%)	Bulk density (g/cm^3)
Fibres	2.3	2.5	91.4	82	-
Pulp	7.1	7.9	89.8	82	-
Kernels	7.0	7.6	91.9	77.6	-
Shells	5.3	5.7	92.4	80.6	0.52; 0.45; 0.38*
Briquettes I	15.2	16.0	94.9	100	0.90
Briquettes II	11.2	12.8	95.4	92.5	0.92
Briquettes III	12.4	13.0	94.7	67.2	0.98

*** - for the bulk density analysis baobab shells were crushed into 3 different sizes, and each size had its own bulk density: 0.52, 0.45, 0.68 g/cm^3 for 1 kg of crushed shells with average size of pieces 6.87, 0.67, 0.002 cm^3 respectively.**

Conclusions and Outlook

The results themselves may be meaningful but this study needs further observation, however, the research has already given a short overview of the physical properties of baobab fractions, and technological feasibility and the fuel efficiency of baobab shell briquettes. It is already possible to conclude that the production and utilization of baobab shell briquettes as an alternative fuel seems feasible and briquettes from baobab shell can contribute to alleviating forest degradation and deforestation in Malawi. However, further analyses are required to optimize briquette composition and properties.

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