# Efficiency of Sawdust Briquettes as an Alternative Source of Energy for Tobacco Curing in Tabora Urban District, Tabora Region

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**Abstract:** ***The growth of tobacco production in Tanzania has become a threat to the woodlands due to the amount of firewood used for curing the crop. This paper examines the efficiency of using sawdust briquettes in curing tobacco. A Bomb Calorimeter was used to determine the calorific value of sawdust briquette and firewood. The grade indices were determined by dividing the value of tobacco in each harvest/reaping per hectare to the weight of dry tobacco per hectare. The grade index produced by each biomass was compared by using t-test to see if they were statistically different. The results indicated that the calorific values of sawdust briquette and firewood were 3133.10 Cal/g and 4218.11Cal/g respectively. The grade indices of tobacco cured by sawdust briquettes and firewood were 1.756 and 2.257 respectively. There was no significant difference at p>0.05 between the quality of tobacco cured by sawdust briquettes and that which was cured by firewood. The heat content within the sawdust briquette was able to remove the amount of water present in green tobacco leaf and the quality of tobacco cured by sawdust briquettes was the same as that cured by firewood.***

**Keywords:** Firewood, Sawdust briquette, Calorific value, Biomass, Grade indices Tobacco curing

## 1. Introduction

Tobacco is a cash crop grown widely in various countries in the world. It is consumed worldwide and has been cultivated in Africa since end of 16th century, but commercial cultivation began around 19th century [1]. Eleven countries (including Tanzania, Zimbabwe and Malawi) account for about 80% of global tobacco production [2]. China alone accounts for about 40%, followed by India, Brazil and United States of America, which collectively account for about 25%.

In Africa, Tanzania is the third largest producer of tobacco after Zimbabwe and Malawi. It is one of the major cash crops benefiting the majority of farmers and other stakeholders. Recently, Monthly Economic Review Report of November 2015, tobacco was ranked as the first foreign exchange earner among the exported cash crops in Tanzania [3]. Tobacco production in Tanzania has steadily expanded annually from 46 728 tonnes in 2006 to 87 231 tonnes in 2015 [4]

The growth of tobacco production is leading to new and severe threats to woodlands. Ecological functions of the woodlands are particularly threatened by the production of flue-cured tobacco which accounts for 99% of the crop's total production in Tanzania [4]. The threat impact comes from the large quantities of wood harvested from miombo woodlands for curing the crop. Small scale farmers consume approximately 43 $m^3$ of firewood (15 000 kg per year) and produce an average of 1400 kg of cured tobacco [5]. Also [6] shows that 19.9 $m^3$ of wood is used to cure one metric tonne of tobacco. [7] in their experimental research on firewood consumption for flue cured tobacco estimated that 14 kg of firewood is required to cure a kilogram of tobacco. These variations in wood consumption can be linked to a number of factors including the types of barns used, state and wood species.

This firewood consumption in flue cured tobacco is accompanied by forest woodland clearance. According [8] more than 300 000 ha of indigenous forests in Zimbabwe are destroyed annually by new small-scale tobacco farmers. [9] conducted a study to find the area of land needed to be cleared annually for tobacco curing and found that 140 000 ha of Miombo woodlands need to be cleared annually and this accounts for 4–26% of the Miombo deforestation. Hence the need for alternative energy source in tobacco curing is crucial.

Curing is the process in which tobacco leaf moisture is removed without affecting its aroma, colour and taste [10]. During curing, tobacco drives off moisture in the leaf, preparing the crop for further manufacturing. According to [11], the initial moisture content of tobacco is 80 to 85% and this moisture is completely removed to approximately 0% at the end of curing.

In order to cure tobacco, there must be an energy input. 30% of the global tobacco production is cured through natural means and remaining 70 to 62% of the global tobacco production is cured through unnatural means. Unnatural means of cured tobacco are of two types, fire-cured tobacco


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(FCT) and flue-cured tobacco referred to as Flue-Cured Virginia (FCV). [12]
About 99% of tobacco produced in Tanzania is FCV. It is cured in simple, homemade barns using firewood placed in a small furnace at one end of the barn. When the firewood is lit, heat is simply drawn up through the barn to dry tobacco hanging from poles that are stacked from the bottom to the top of the barn. This is referred to as flue-cured tobacco [13]

Due to large amount of firewood used for curing which results to deforestation, the use of alternative energy sources in tobacco curing could be of great importance in combating defforestation [14]. An example of alternative energy source which is practical for tobacco curing is through use of sawdust biomass. Biomass is fuel that is developed from organic material, a renewable and sustainable source of energy. Use of biomass residues and wastes for energy production has been increasingly proposed as a substitute for fossil fuels. Biomass residues can also offer an immediate solution for the reduction of the $CO_2$ content in the atmosphere [15]. Due to their heterogeneous nature, biomass residues materials possess inherently low bulk densities, and thus, it is difficult to efficiently handle large quantities of most residues. In order to increase the efficiency of handling bulk biomass, densification is often required. The process of compaction of residues into a product of higher bulk density than the original raw material is known as densification or briquetting [15].

Briquettes can be produced with a density of 1.2 g/cm³ from loose biomass of bulk density 0.1 to 0.2 g /cm³. These can be burnt clean and therefore are eco-friendly arid also those advantages that are associated with the use of biomass are present in the briquettes.

Basing on compaction, the briquetting technologies can be divided into:
a) High pressure compaction
b) Medium pressure compaction with a heating device
c) Low pressure compaction with a binder [16]

In this study low pressure compaction with a binder was used for production of briquettes where by the biomass materials was sawdust and waste paper was used as a binder because papers are known to contain proteinaceous materials that tend to have an excellent adhesive property, making it useful as partial binder material [17].

## 2. Materials and Methods

### 2.1 Research Materials and Design

The seedlings of K 326 variety were raised in a seedbed of 1.5 m wide and 20 m long and fertilized with 5 kg of $N_{10}P_{18}K_{24}$ fertilizer. Eight weeks after sowing, the seedlings were transplanted to the experimental plot of 3 780 m$^2$ at a spacing of 1.2 m between ridges and 0.50 m between plants. Basal fertilizer application $N_{10}P_{18}K_{24}$ at a rate of 30 g per plant was applied seven days after transplanting. Fertilizer CAN 27% was applied at a rate of 8 g per plant two weeks after application of NPK and all other principles of good agricultural practices were followed up to the final stage of crop management. Tobacco harvested from this plot was loaded into two rocket barns whereby in one barn sawdust briquettes was used as source of heat energy and another one firewood was used as a control. Rocket barn was used to assess the efficiency of sawdust briquettes and firewood for tobacco curing. Rocket barn is the energy efficient curing barn that use less amount of firewood for tobacco curing as compared to local barns [18]. A manually operated or low pressure briquetting machine was used to briquette the sawdust using waste paper as binding material.

#### 2.1.2 Fuels
Sawdust and firewood were used as source of energy for curing tobacco. Sawdust was collected from Tabora Saw mills which is located in Tabora town and was transported to trial site which is about 23.5 km from where they were collected. Firewood was collected from the natural forest which was about 2 km from the trial site (Plate 1).

**Plate 1:** Firewood

**Plate 2:** Sawdust briquettes

#### 2.1.3 Briquetting Machine
A low pressure or manually operated briquetting machine which was constructed by MHM Advent Company Limited was used in briquetting sawdust (Plate 4).

**Plate 1:** Low pressure briquetting machine


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**Plate 2:** Waste paper as a binding materials

### 2.1.4 Binding Materials

Waste paper from Jiemel Industries Limited was used as binding materials (Plate 5), this is because paper is known to contain proteinaceous materials that tend to have an excellent adhesive property, making it useful as partial binder material [17]

### 2.1.5 How Sawdust Briquettes were Made

Waste paper which weigh 4 kg was soaked into 80 litres of water for 24 hours. Sawdust which weigh 42 kg was mixed thoroughly with 4 kg of waste paper which was soaked into water then the process of briquetting started. Manually operated or low pressure briquetting machine was used. One bag of sawdust which weigh 42 kg together with waste paper 4 kg which was used as binding materials produced 95 briquettes with weight of 49.40 kg. The briquettes were sun dried before they were used for tobacco curing as shown in Plate 3 above. For the period of 8 hours using four laborers a total of 780 briquettes with weight of 405.60 kg were produced.

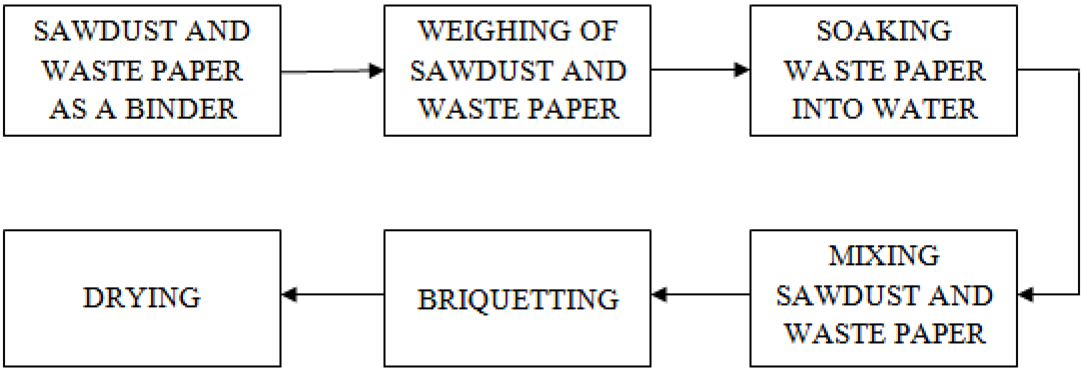


**Figure 1:** Briquette manufacturing process
Source: Own construction

**Plate 3:** Longitudinal section of sawdust briquette

**Plate 4:** Cross-section of sawdust briquette

### 2.1.6 Determination of Calorific Value of Firewood and Sawdust

The heat value of both samples was determined using a standard Gallenkamp Ballistic Bomb calorimeter. 0.50g of each sample of solid wood and briquette were weighed into the steel capsule. A 10cm cotton thread was attached to the thermocouple to touch the capsule. The bomb was closed and charged in with oxygen up to 30 atm. The bomb was fired up by depressing the ignite switch to burn the sample in an excess of oxygen.

The maximum temperature rise in the bomb was measured with the thermocouple and galvanometer system

Formula: $$\text{G.E. (Kcal/g)} = \frac{\text{G.meter deflection x Calibration}}{\text{Weight of sample.}}$$

### 2.1.7 Barn Loading

Tobacco was reaped the day of loading and brought to each barn. It was loaded into each barn on the same day. The quality and maturity of tobacco was kept as even as possible during tying and loading.

### 2.1.8 Weighing

The tobacco was weighed before and after each cure with a 300 kg digital scale (Plate 8). Before the cure the total weight of green leaves were recorded before tying them in sticks. After leaf curing, the tobacco from each barn was off loaded, untied and conditioned. Then the dry weight of tobacco was recorded for each harvest.


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**Plate 5:** 300 kg digital weighing scale

**Plate 6:** Burning of sawdust briquettes in a furnace

**2.1.9 Leaf Curing**

After tobacco was reaped from the field, it was loaded into the barn and the process of curing started. The process of leaf curing was monitored. The total hours required to accomplish one cure was recorded for each barn. The total weight of sawdust briquettes required to accomplish one cure and the weight of firewood required in one curing were also recorded.

**2.1.10 Tobacco Grading and Classification**

Tobacco leaves were graded by skilled laborers according to plant position, type, texture, color and size. The process of grading was done by considering tobacco from each harvest. After grading the process of classification was done by tobacco classifier from TTB. Tobacco classification is the judgment of tobacco by putting grade marks according to grade descriptions/specifications [19]

## 3. Results

### 3.1 Calorific Values of Sawdust and Firewood

The laboratory results indicated that the calorific value of sawdust briquette was 3133.10 Cal/g while that of firewood was 4218.11 Cal/g.

### 3.2 Quality of tobacco cured by sawdust briquettes and firewood

**Table 1:** Effect of sawdust briquettes and firewood on grade index

| | Sawdust briquettes | Firewood |
|---|---|---|
| Mean | 1.756 | 2.257 |
| Variance | 0.125 | 0.3050 |
| Observations | 6 | 6 |
| Pooled Variance | 0.215 | |
| Hypothesized Mean Difference | 0 | |
| df | 10 | |
| t Stat | -1.869 | |
| P(T<=t) two-tail | 0.091 | |

Results in Table 1 indicate that the mean of grade index when tobacco was cured by sawdust briquettes and firewood was 1.756 and 2.257 respectively. Plate 10 indicates one of top grade obtained after curing by using sawdust briquettes.

Since p value (0.091) is greater than the level of significance which was 0.05, hence there is no significant difference between the quality of tobacco cured by sawdust briquettes and that which was cured by firewood.

**Plate 7:** Top grade obtained after curing with sawdust briquettes

## 4. Discussions

### 4.1 Calorific Value of Sawdust Briquette and Firewood

Heat value or calorific value determines the energy content of a fuel. It is the property of biomass fuel that depends on its chemical composition and moisture content. The most important fuel property is its calorific or heat value. The study revealed that, firewood of brachystegia spp has a higher heat value than the sawdust of the same species. Firewood generates more energy or heat per gram compared to the same amount of sawdust briquettes. Firewood had higher calorific value than sawdust briquette possibly due to its higher unit mass.

### 4.2 Quality of Tobacco Cured by Firewood and Sawdust Briquette

The quality of tobacco depends on how tobacco leaf was managed in the field, during reaping, curing, grading and baling. The quality of tobacco was determined by grade index using the following formula;

$$\text{Grade index} = \frac{\text{Grade weight (kg) x Grade price (USD)}}{\text{Dry weight per hectare (kg)}}$$

The results was non-significant, indicating that the quality of tobacco cured by sawdust briquette was more or less the same to that which was cured by firewood


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## 5. Conclusion

The calorific value of sawdust briquette was lower than that of firewood. Despite of the low calorific value of sawdust briquette but the heat content within the sawdust briquette was able to remove the amount of water present in green tobacco leaf which is about 80 to 85% and hence obtaining the quality of tobacco which was the same as that obtained when tobacco was cured by firewood.

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**Conflict of Interest**
The authors declare to have no conflict of interest regarding this paper publication

**Author Contribution**
Muna E., designed this study, collected data, analyzed data, wrote the article; Abdallah J., revised the article; Monella G., revised the article; Ishengoma R., revised the article

**Abbreviation list**
CAN, Calcium Ammonium Nitrate
FCT, Fire Cured Tobacco
FCV, Flue Cured Virginia
NPK, Nitrogen, Phosphorus, Potassium
TIRDO, Tanzania Industrial Research and Development Organization
TORITA, Tobacco Research Institute of Tanzania
TTB, Tanzania Tobacco Board

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