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# Studies On Physical Characteristics Of Briquettes Prepared From Maize Cobs

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**ABSTRACT**

In this study, physical properties of briquettes made from maize cobs was evaluated. The physical properties namely compressed density, relaxed density, relaxation ratio, water absorption, shatter resistance, moisture content, compressive strength were evaluated by standard procedures. A high pressure briquetting machine operated at 118 MPa was used to produce maize cob briquettes. The obtained value of bulk density of milled maize cobs before briquetting was 313.3 kg $m^{-3}$. The moisture content of briquette was 12.93%. The compressed density and relaxed density of briquettes was 821.02 and 850.82 kg $m^{-3}$. The shatter resistance, water absorption of maize cob briquettes were 62.36 and 166.66% respectively. The compressive strength of briquette was 53.61 kPa. It was noted that the change in dimensional stability of briquette in longitudinal direction after 3 days, 5 days, 7 days and 20 days were 1.30 %, 1.67%, 0.42% and 0% respectively. The change in dimensional stability of briquette in diametral direction after 3 days was 5% and no change in stability after 3 days to 20 days. It was concluded that diametral expansion was more compared to longitudinal expansion after 3 days of briquettes production. This results showed that maize cob briquettes was feasible and are environmentally friendliness.

Many of the developing countries produce huge quantities of agro residues but they are used inefficiently. It is estimated that approximately 500-550 million tonnes of crop residues are produced per year in India (MNRE, 2009). Agriculture waste management during processing is one of the most serious rural-urban environmental problems in India. The disposal of these residues in the fields is being done mostly by burning, thereby causing health hazards and air pollution. Adequate means of disposing these wastes are lacking. Hence, converting them to other useful products such as briquettes for fuel is desirable.

Maize (*Zea mays*) known as Queen of Cereals, also called corn is one of the most important cereal crops of the world. Among the cereal crops, maize with annual production of around 22.5 million tonnes from 8.67 million hectares, India ranks third in production. Maize has emerged as an important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the highest production (4.14 million tonnes) and productivity (5.26 t $ha^{-1}$) (DEAS, 2015).

Maize cobs, a residue of the maize crop, are a lignocellulosic biomass material which contains high amount of organic constituents and energy. About 180 kg of cobs are obtained from each tonne of maize shelled (Evers *et al.,* 1994). However, maize cobs are noted to have low lignin content (5.6%), low water soluble carbohydrates (1.1%) and low protein (2.5%). These chemicals are largely responsible for forming solid bridge bonds during densification or briquetting (Kaliyan and Morai, 2010). Therefore, densification of maize cobs would require a high compacting pressure and/or an external binder.

In Guntur district, large quantities of maize cobs are produced annually. These residues are being left to rot away or burning directly in the field which causes environmental pollution. The residues are bulky and have low energy density which make them difficult to handle, store, transport and utilize in their raw form. Hence, there is the need to subject them to conversion process in order to mitigate these problems. Lot of research has been done on briquetting technology in other countries and stoves for domestic use to utilise these briquettes were also developed. In our country, still briquettes were not utilized to full extent. In our state, briquette production is not yet commercialized due to various reasons. So, it is necessary to utilize these residues to convert into useful source as fuel which replaces fossil fuel need in future.

The objective of the present study was to investigate the physical properties of briquettes prepared from maize cobs. It provides valuable

information on physical properties at high pressure compaction to know the quality of briquettes.

## MATERIAL AND METHODS

Maize cobs was collected from the Agriculture College Farm, Bapatla. Prior to briquetting the moisture content of the sample was determined using ASTM procedure. Briquettes of maize cobs was produced by using high pressure briquetting machine, in which the piston exerts a high pressure of 118 MPa .

**Maize cob briquettes**

### Physical analysis of Briquettes

Physical properties of the briquettes are very important to know the quality of briquettes. Physical properties like compressed density, relaxed density, relaxation ratio, moisture content, diametral expansion, longitudinal expansion, shatter resistance, water absorption and compressive strength were determined by standard procedures.

### Determination of Compressed Density

Briquettes were randomly selected from production batch for evaluation of physical properties. The compressed density also called maximum density (density immediately after compression) of the briquette was determined immediately after ejection from the moulds. The densities of the briquettes were then determined as the ratio of mass to volume (ASTM D 2395 – 14$^{\varepsilon 1}$ (2015)).

Compressed density, kg m $^{-3}$ =

$$\frac{\text{Weight of the sample, kg}}{\text{volume of the sample, m}^3}$$

### Determination of Relaxed Density

It is the density of the briquette determined in dry condition after about 19 days (Oyelaran *et al*. 2014). The relaxed density was calculated as the ratio of the briquette weight to the new volume.

Relaxed density, kg m$^{-3}$ =

$$\frac{\text{Weight of the sample, kg}}{\text{New volume of the sample, m}^3}$$

### Determination of Relaxation Ratio

It was calculated as the ratio of the maximum density to the relaxed density (oyelaran *et al.* 2014).

$$\text{Relaxation ratio} = \frac{\text{Compressed density}}{\text{Relaxed density}}$$

### Determination of Moisture Content

The moisture content of maize cob briquette samples was determined in accordance to moisture measurement method of ASTM E871"82 (Reapproved 2013) by using hot air oven method. Five briquettes produced from maize cobs were weighed and oven-dried (103 ±1° C) to constant masses. The loss in mass, expressed as a percentage of final oven-dry mass, was taken as the moisture content of the briquettes.

The percent moisture in the analysis sample was calculated as follows;

$$\text{Moisture in analysis sample, \%} = \frac{(Wc - Wf)}{(Wc - Wi)} X100$$

where,

$W_c$ = Weight of container, g
$W_i$ = Initial weight of sample, g
$W_f$ = Final weight of sample, g

### Determination of Shatter Resistance

A test sample of briquettes of known weight was placed in a plastic polythene bag. The bag was dropped from a height of 2 m on to concrete floor three times. After the dropping, the briquettes and fractions were placed on top of a 0.35 cm mesh screen and sieved (ASTM D440-86 (1998)).

The durability rating for each type of briquette was expressed as the ratio of weight of material retained on the screen to weight of briquettes before the dropping.

The handling durability of the briquettes was computed as follows;

Shatter index = $\frac{B_z}{B}$ x 100

Where,

$B_z$- Weight of briquette retained on the screen after dropping (g).

B- Weight of briquettes before dropping (g).

**Determination of Water Absorption**

A measure of the percentage of water absorbed by a briquette when immersed in water was determined. Each briquette was immersed in water at room temperature for 30s (Koushik *et al.* 2009) and the percent gain was then calculated and recorded as follows;

$$\text{Water absorption (\%)} = \frac{A-B}{A} \times 100$$

Where,

A= Weight of briquette (g)

B = Weight of saturated surface sample (g)

**Determination of Compressive Strength**

Compressive strength was determined by using a force gauge (Make: Lutron-Taiwan, Model: FG-20KG) of 20 kg capacity. A sample of briquette to be tested was placed horizontally on stationary hard surface. Load was applied by forcing the tip into the sample until the briquette failed by cracking. Readings were noted which were displayed in negative magnitude for compression.

The compressive strength of the briquettes was computed as follows;

Compressive strength (N $mm^{-2}$) =

$$\frac{\text{Load at fracture point (N)}}{\text{Cross sectional area } (mm^2)}$$

**Determination of Diametral and Longitudinal Expansion**

Generally, Briquette stability is measured in terms of its dimensional changes when exposed to the atmosphere (Sotannde *et al*. 2010). The stability of briquettes produced from the maize cobs and cotton stalks with two binder ratios examined in this study was determined in terms of dimensional expansion as shown in Plate 3.13 and Plate 3.14. Immediately after production of briquette from the mould, the briquette length and diameter were measured using vernier calipers. Additionally, the dimensions of each briquette formed were measured after 3, 5, 7 and 20 days to determine the diametral and longitudinal expansion.

The percentage dimensional stability was obtained from equation below as expressed by (Oladeji and Enweremadu, 2012)

$$\text{\% Expansion} = \frac{I_f - I_i}{I_i} \times 100$$

Where,

$I_i$ = Initial height of briquettes, cm

$I_f$= Final height of briquettes, cm

## RESULTS AND DISCUSSION

**Density of briquette**

The moisture content and bulk density of milled maize cobs were 12% and 313.3 kg $m^{-3}$ respectively. Densification process increased bulk density from 313.3 kg $m^{-3}$ and 821.02 kg $m^{-3}$(Fig. 1). Relaxed density of maize cob briquettes is 850.82 kg $m^{-3}$. The density of briquettes prepared from maize cobs is varied after 20 days. The relaxed density of maize cob briquettes is more compared to compressed density (Fig. 2).

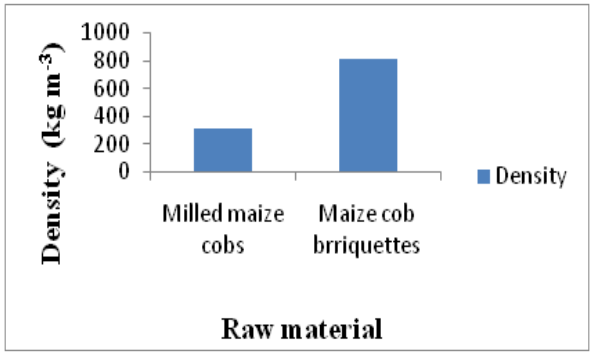


**Fig.1 Comparison of density before and after briquetting Dimensional stability of maize cob briquette**

The stability of the briquettes, which is expressed in terms of percentage longitudinal and diametral expansions when exposed to atmospehere.

It was observed that there was a change in dimensional stability of briquette in longitudinal direction after 3 days, 5 days, 7 days and 20 days. The fixed diameter of briquette was 4 cm at the time of production of briquette from mould. It was observed that there was a change in dimensional stability of briquette in diametral direction after 3 days, 5 days, 7 days and 20 days (Fig. 3).

It was inferred that for diametral expansion there is no change after 5 days. It implied that maize cob briquette stability is best in terms of diametral expansion.

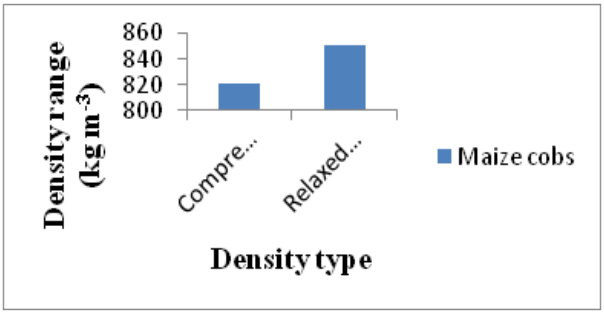


**Fig.2 Effect of density on maize cob briquette**

The moisture content, shatter resistance, water absorption of maize cob briquettes were 12.93%, 62.36% and 166.66% respectively (Fig.4). The compressive strength of briquette was 53.61 kPa.

These results are within the limits of 15% recommended by Kaliyan and Morey (2009). Shatter resistance measured briquettes resistance to mechanical action, which affects its handling and transportation Maize cob briquettes recorded low shatter index because of its poor porosity and the ability of its cell wall constituents to collapse easily during briquetting, which prevented effective inter-fibre bonds. It was easily liable to disintegration due to the low lignin content, low water soluble carbohydrates and low protein in the maize cobs.

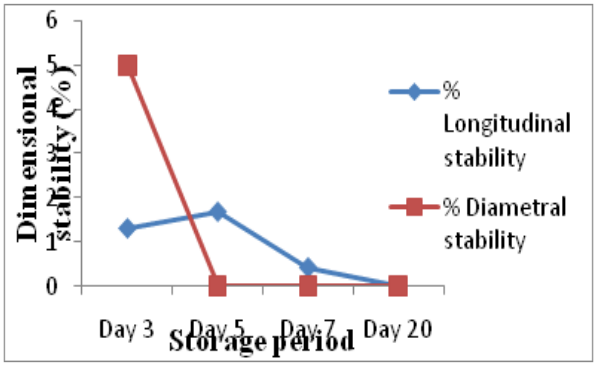


**Fig.3 Effect of dimensional stability on maize cob briquette**

The moisture content, shatter resistance, water absorption of maize cob briquettes were 12.93%, 62.36% and 166.66% respectively (Fig.4). The compressive strength of briquette was 53.61 kPa

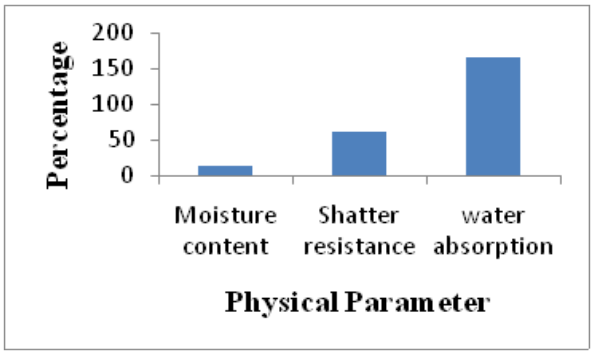


**Fig.4 Effect of moisture content, shatter resistance and water absorption on maize cob briquette**

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## Conclusion

In this study, physical properties of briquettes produced from maize cobs was evaluated. It was concluded that briquettes prepared from maize cobs density was more compared to untreated milled maize cobs. It was proved that densification increased density of raw material. Dimensional stability of maize cob briquette is more in diametral direction compared to longitudinal direction. This results showed that maize cob briquettes was feasible and are environmentally friendliness.

## LITERATURE CITED

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