Experimental Analysis of Physical and Fuel Characteristics of Areca Leaves Briquette

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Abstract: ***India produces large amount of agro waste annually, which are burnt or destroyed in loose form causing air pollution. This study aims at converting leaves of areca plant which is a cash crop of the farmers in Karnataka, into briquettes so that energy crisis faced in rural area can be addressed. Areca leaves were collected, dried, reduced and sieved to a size of 600µ for the purpose of making biomass briquettes. These areca leaves were mixed with sawdust and wheat flour which acted as additive and binder respectively, in 2:1:1 ration and densified. Proximate and ultimate analysis were done by using IS 1350 and gross calorific value done as per IS 1448-7. ASAE standard were used to determine the compaction, relaxation and density ratio of the briquettes. Results from analysis showed that areca leaves had a gross calorific value of 3269.08 Kcal/Kg, which is sufficient to produce sufficient heat. The percentage of moisture content was 7.93%. The initial, maximum and relaxed densities were 199.2 Kg/cm^3, 871.7 Kg/cm^3 and 334.6 Kg/cm^3 respectively. The initial, maximum and density ratio of areca leaves briquettes were 4.37, 2.605 and 0.383 respectively. Other properties like percentage of carbon, oxygen, sulphur and nitrogen were within the permissible limits of a good biomass briquette. The experimental study concluded that biomass briquettes prepared by using areca leaves would make a good biomass fuel, thus addressing the energy crisis faced by people in rural area.***

Keywords: areca leaves, biomass, briquettes, proximate and ultimate.

1. Introduction

India is the country of villages. There are total 6, 40,867 villages in India [3]. Despite rapid growth of commercial energy, biomass remains principle energy source in rural and traditional sectors and contributes a third of India's energy [1]. About 30% of total population resides in the villages which consider a good sum of 0.36 billion of total population. In the domestic household sector cooking is the largest end user accounting for almost 90 percent of the total domestic energy use. The rural masses mostly depend on biomass or kerosene for their energy needs. In order to cushion fuel price hike, the rural masses are shifting more to biomass. So, emphasis is given to the renewable energy program [2].

Biomass is considered as great potential renewable energy source, both for the richer countries and for the developing world. At present, briquetting is commonly used in developing countries [4]. Briquetting is a process of compaction of residues into a product of higher density than the original material [5].

A lot of research is being done in the field of biomass briquettes. Some examples of biomass studies include sawdust [6], rice husk [7], newspaper [8], corn [9], coal and corn cob [10], rice husk, groundnut shell, sugarcane bagasse and maize cob [11], and many others.

Arecanut or Betelnut plays an important role in Asian culture, especially in India. Arecanut is a widely grown cash crop in the malnad belt of Karnataka. India has the largest area under arecanut cultivation (1.74 lakh hectares) with a production of 2.31 lakh tonnes constituting about 45 per cent of the total area and 48 per cent of the total production of the India. It is followed by Kerala which has an area of 1.08 lakh hectares with a production of 1.10 lakh tonnes and Assam with an area of 0.70 lakh hectares with a production of 0.68 lakh tones (Anon., 2009). In Karnataka state, Shimoga, Dakshina Kannada, Davangere, Tumkur, Chickmagalur and Uttara Kannada are the important districts where arecanut is extensively grown [12].

A good review of how to manufacture a briquette is provided by Olorunnisola [13]. Various parameters of briquettes like dwell time, binder content, density, handling characteristics moisture content, relaxation behavior have been studied by many authors , which are of paramount importance in the manufacture of a biomass briquette.[13]-[15].

There is no set formula for biomass briquettes to be used as biomass energy sources. Instead the briquettes are made from available biomass, and this will change from area to area. This allows for biomass energy generation that does not require much transportation of purchased materials from a distant location [16].

In this experimental analysis, study was carried out to investigate the physical and fuel characteristics of biomass briquettes prepared from areca leaves to ascertain whether they are quantifiable as renewable energy, and can be used for domestic purpose in rural area. This could a long way in meeting the energy deficient in villages in India.

2. Material and Methods

Areca leaves as shown in fig.1 was used for making biomass briquettes were obtained from a farm. The residues were sun-dried for a few days until most of the moisture dried out. The residues were chopped and subjected to size reduction process through the use of hammer mill. The milled areca leaves were sieved using ASTM E11 [17] and a particle size of 600µ was choosen for the purpose of briquetting.

Figure 1: Areca leaf

Sawdust and wheat flour were used as additive and binding agent respectively. The additive and binders were mixed with biomass in 2:1:1 ratio, i.e., 100gms of biomass, 50gms of sawdust and 50gms of wheat flour along with the required quantity of water. These blends were mixed rigorously to ensure a proper mix and stored in a container for a couple of days to get a softened mixture.

For the purpose of briquetting a simple prototype briquetting machine as shown in fig.2 was fabricated. The machine worked on hydraulic ram principle. The biomass blend was filled into the mould and compressed by a 2 ton hydraulic jack at a pressure of 1.28MPa. A dwell time of 5 minutes was observed and the briquettes were ejected after the dwell time [18].

Figure 2: Briquetting Machine

The wet briquettes were sun dried for a period of 19 days [19], after being taken out of the mold cavity and later weighted. The wet and dry weight of the briquettes is as shown in Table I, below:

Table 1: Wet and dry weight of the areca leaf briquettes

Sl.No	*Type of briquette*	*Wet weight (kg)*	*Dry weight (kg)*
	Additive used: Saw dust Binder used : Wheat flour		
1	Areca leaves 600 µ	0.452	0.177

The gross calorific values of areca leaves of 600 µ sizes were found as per IS1448-7 [20]. Proximate analysis was done as per IS 1350 to determine, the percentage of moisture content, ash, volatile matter and fixed carbon. Ultimate analysis was done as per IS 1350 [21] to determine the percentage of sulphur, oxygen, nitrogen and hydrogen.

The density of briquette was determined immediately after ejection from the mould by dividing the mass by the volume of the compressed briquette. The mass was obtained by using a digital weighing scale, while the volume was estimated by taking the linear dimensions (length, breadth and thickness) of the briquette by a standard digital Vernier caliper.

The initial, maximum and relaxed densities were also determined using ASAE standard methods [22]. The relaxed density of the briquette was determined in the dry condition after nineteen days. It was calculated as the ratio of the briquette's mass to the new volume. Relaxed density also known as the spring-back density is defined as the density of the briquette obtained after the briquette has remained stable.

$$Relaxed\ density = \frac{Briquettes\ mass}{Briquettes\ new\ volume} \quad (1)$$

Density ratio is calculated as the ratio of relaxed density to maximum density i.e.

$$Density\ ratio = \frac{Relaxed\ density}{Maximum\ density} \quad (2)$$

Maximum density is the compressed density of briquette immediately after ejection from briquetting machine.

Relaxation ratio is calculated as the ratio of maximum density to relaxed density i.e.

$$Relaxed\ ratio = \frac{Maximum\ density}{Relaxed\ density} \quad (3)$$

Finally, compaction ratio which is defined as the maximum density divided by the initial density of the residue and calculated as:

$$Compaction\ ratio = \frac{Maximum\ density}{Intial\ density\ before\ compression} \quad (4)$$

3. Results and Discussion

The results of the physical and fuel characteristics and combustion characteristics of areca leaves briquettes are shown in Tables 2 and 3 respectively.

Table 2: Physical and fuel characteristics

Parameter	*Unit*	*Value*
Moisture content	%	7.93
Length of the briquette	m	0.122
Breadth of the briquette	m	0.085
Thickness of the briquette	m	0.005
Weight of the briquette	Kg	0.177
Hydrogen content	%	6.82
Nitrogen content	%	0.59
Sulphur content	%	0.58
Oxygen content	%	19.20
Ash content	%	2.00
Volatile matter	%	75.68
Fixed carbon	%	14.39

Table 3: Combustion characteristics of areca leave briquettes

Parameter	*Unit*	*Value*
The heating value	Kcal/Kg	3269.08
Initial density	Kg/m^3	199.2
Maximum density	Kg/m^3	871
Relaxed density	Kg/m^3	334
Density ratio	Kg/m^3	0.383
Compaction ratio	Kg/m^3	4.37
Relaxation ratio	Kg/m^3	2.605
Volume before briquetting	m^3	960
Volume after briquetting	m^3	666.12
Reduction in briquette volume	%	30.62

The moisture content of areca leaves residue from proximate analysis is 7.93 %, these results satisfy the limits of 15 % recommended for briquetting of agro-residues [23]. The percentage content of hydrogen, nitrogen, sulphur and oxygen from the analysis of ultimate analysis are 6.82%, 0.59%, 0.58% and 19.20%. The amount of hydrogen contents is very satisfactory, as they contribute immensely to the combustibility of any substance in which they are found [24]. The low percentage of sulphur and nitrogen found in areca leaves briquette, is an indication of less air pollution when burnt, is a welcome development as there will be minimal release of sulphur and nitrogen oxides into the atmosphere [25].

From the proximate analysis, the % content of ash, volatile matter and fixed carbon for areca leaves briquettes were 2.00 %, 75.68 %, and 14.39 % respectively. The values of volatile matter are good and acceptable as higher the percentage of volatile matter, faster and complete combustion takes place. Fewer amount of ash results in a cleaner grate and less space for dumping of ash. Areca leaves briquettes have a heating value of 3269.08 Kcal/Kg. This value compares well with most biomass energy. For examples, sawdust [6], rice husk [7], newspaper [8], corn [9], coal and corn cob [10], rice husk, groundnut shell, sugarcane bagasse and maize cob [11]. This heat value is sufficient enough to produce heat required for household cooking and other applications.

The values of maximum density, relaxed density and relaxation ratio obtained for areca leave briquettes were $871Kg/m^3$, $334Kg/m^3$ and 2.605 respectively. The value of maximum and relaxed density obtained in this work agrees well with the value obtained from other biomass briquette research works [26]-[27].

The relaxation ratio of 2.605 obtained from areca leaves briquette is also good enough and it is close to the values obtained for briquettes of coconut husk [27]. The results in Table 2 show that the volume of areca leaves briquette were reduced by about thirty percent (30%) after compaction to form a useful product like briquette. This reduction is desirable as it results in reduced cost for situation like material storage, packaging and transportation.

4. Conclusion

Now a day there is a large worldwide interest in bio-mass briquettes as a renewable energy source because it does not negatively affect the environment. In Dakshina Kannada, Karnataka, as areca plant is grown as a cash crop, there is an abundant supply of areca leaves that can be availed for the conversion of biomass briquettes. In view of this, briquettes made from areca leaves can be used as an alternative energy sources for domestic cooking in rural India and also serve as a measure in curbing air pollution posed by loose burning of agricultural products.

The present work examined the physical and fuel characteristics and also the combustion characteristics of briquettes produced from areca leaves of size 600µ, with sawdust and wheat flour as additive and binder respectively. Based on the experimental analysis and findings of this study, the following conclusion can be made:

1) The briquettes made from 600µ size areca leaves would make a good biomass fuels.
2) The relaxed density obtained from areca leaves briquette has sufficient value which will not allow them to crumble during transportation and storage.
3) Because of low percentage of sulphur and nitrogen present, and also as loose biomass is compacted and burnt in solid form there will be minimum air pollution.
4) The relaxed density of the briquettes is higher than the initial density of the residue materials. This results in a volume reduction, which provides cost reduction benefits and desirable for material packing, storing and transportation.
5) The gross calorific value of areca leaves briquettes are enough to produce sufficient heat for the purpose of domestic cooking and other applications..

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