

# **Investigation of Areca Leaves as Biomass Briquettes**

Deepak K.B <sup>1</sup>, Dr.Manujesh B.J <sup>1</sup>, Vivek.S <sup>2</sup>, Yashas B.K <sup>2</sup>

Associate Professor, Department of Mechanical Engineering, Vivekananda College of Engineering and Technology,  
Puttur, Dakshina Kannada, India<sup>1</sup>

U.G. Student, Department of Mechanical Engineering, Vivekananda College of Engineering and Technology, Puttur,  
Dakshina Kannada, India<sup>1</sup>

**ABSTRACT:** As there is a huge demand to find an alternative clean energy that would replace the depleting and non-environmental friendly fossils fuels for industrial and non-industrial purpose, biomass briquette shows great potential. As arecanut is one of the cash crop of Karnataka, their abundance and availability make them suitable as raw material for making biomass briquettes. In order to explore the significance of areca leaf as an alternative for fuel, in this investigation work, areca leaf briquettes have been prepared using different size leaves with sawdust as additive and wheat flour as binder. A total of four briquettes with biomass sizes of 1700 $\mu$  and above, 850 $\mu$ , 600 $\mu$  and 425 $\mu$  were prepared, analysed and the best areca leaf briquette was compared with the commercially available sawdust briquette. Proximate and ultimate analysis were done by using IS 1350 and gross calorific value done as per IS 1448-7. Among the four, briquettes prepared with size of 850 $\mu$  with sawdust as additive has the highest gross calorific value of 14.57MJ/kg, and this value compares well with most biomass energy. ASAE standard were used to determine the initial, maximum, and relaxed density and the values obtained are 0.638gm/cm<sup>3</sup>, 0.877gm/cm<sup>3</sup>, and 0.452gm/cm<sup>3</sup>, respectively. The physical-chemical characteristics of the briquette depicted low moisture content (8.08%) and low ash content (1.47%). The briquettes are also eco-friendly because of low sulphur (0.65%) and nitrogen (0.61%) content. The result augers well with the commercially available sawdust briquettes. Thus, briquettes made from areca leaves of 850 $\mu$  size with sawdust as additive could make a good biomass fuel for households and industries.

**KEYWORDS:** Areca leaf, biomass, briquettes, proximate and ultimate analysis.

## **I. INTRODUCTION**

In today's world, energy is necessary for social and economic growth, and to improve the way people live their life, i.e., have good quality lifestyle [1]. However, a contented human life is paid by excessive energy usage in all its forms [2]. For the past four decades, a lot of research activities have been focused on finding an alternative fuel, which would replace the existing fossil fuel resources so as to meet with the ever-growing energy demand and to turn away from the addiction of crude oil [3]. Despite rapid growth of commercial energy, biomass remains the standard energy source in rural and traditional sectors and contributes 33% of India's energy requirements. Therefore, more importance is given to the renewable energy than non-renewable energy. Energy from biomass has emerged as a potential candidate or alternative to the above problem. Biomass is the energy source derived from organic matter such as plant materials, wood from the forest, agricultural process, industrial, and human or animal waste [7].

Biomass in its normal form is extremely difficult to store, transport, handle, and exploit because of factors that can comprise of high moisture content, low bulk density, and unequal shape and sizes. These difficulties can be overcome by means of densification. Densification or briquetting is the process of compacting biomass residue into a uniform solid fuel called briquettes. It has higher density and energy content and less moisture compared to its raw materials. Briquetting of biomass can be done using various techniques, either with or without binder addition [10]. Examples of biomass studies are sawdust [11], waste paper and coconut mixture [12], cotton stalk [13], spear grass [14], cashew nut

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shell [15], corn cobs and rice husks [16], jatropha seed husks [17], coconut shell, cocoa shell, newspapers [18], and many others.

The main areca nut growing states are Karnataka and Kerala which account for 70 per cent of both area and production in the country. Assam, West Bengal, Meghalaya, Tamil Nadu, Tripura, and Mizoram are other minor areca nut producing states in India. In Karnataka, Chikmagalur district stands first in both area (19.91%) and production (17.38%), followed by Shivamogga and Davanagere district. The top 7 districts, viz., Chikmagalur, Shivamogga, Davanagere, Dakshina Kannada, Tumkur, Chitradurga, and Uttar Kannada occupy 89 per cent of area under areca-nut and contribute around 91 per cent of areca produced in the state [121].

There is no set procedure for making biomass briquettes to be used as biomass energy sources. Instead the briquettes are made from available biomass and because of this they change from place to place. This allows for biomass energy generation that does not require much transportation of purchased materials from a distant location [19]. Briquettes made from biomass can be utilized for domestic purposes (cooking, heating, and barbequing) and industrial purposes (agro-industries and food processing) in both rural and urban areas [20]. The main purpose of using briquettes is mainly to find a suitable replacement for coal, which is widely used in industrial process heat applications (steam generation, melting metals, space heating, brick kilns, and tea curing) and power generation through gasification of biomass briquettes. As biomass briquettes are derived from renewable resources, these briquettes have better qualities as well as ecological benefits in contrast to conventional fuels [21].

In order to explore the significance of areca leaf as an alternative for fuel, in this experimental work, areca leaf briquettes have been prepared using different size leaves with sawdust as additives and wheat flour as binder.

## II. MATERIALS AND METHODS

Areca leaves are found in abundance in the state of Karnataka. Being a common biomass material in majority of the rural areas, in this section, the briquetting of areca leaves is studied and respective analysis has been done. Figure 1 illustrates a sample leaf of the areca tree. In order to prepare the briquettes, a residual sample of the areca leaves was cut and dried in the open sun so as to eliminate the presence of moisture from it. The dried residue was subjected to size reduction by making them pass through a hammer mill. The milled areca leaves were sieved using ASTM E11 [105] and particle sizes of 1700 $\mu$  and above, 850 $\mu$ , 600 $\mu$ , and 425 $\mu$  were selected for the purpose of briquetting as shown in Figure 2.



Figure1: Areca Leaf

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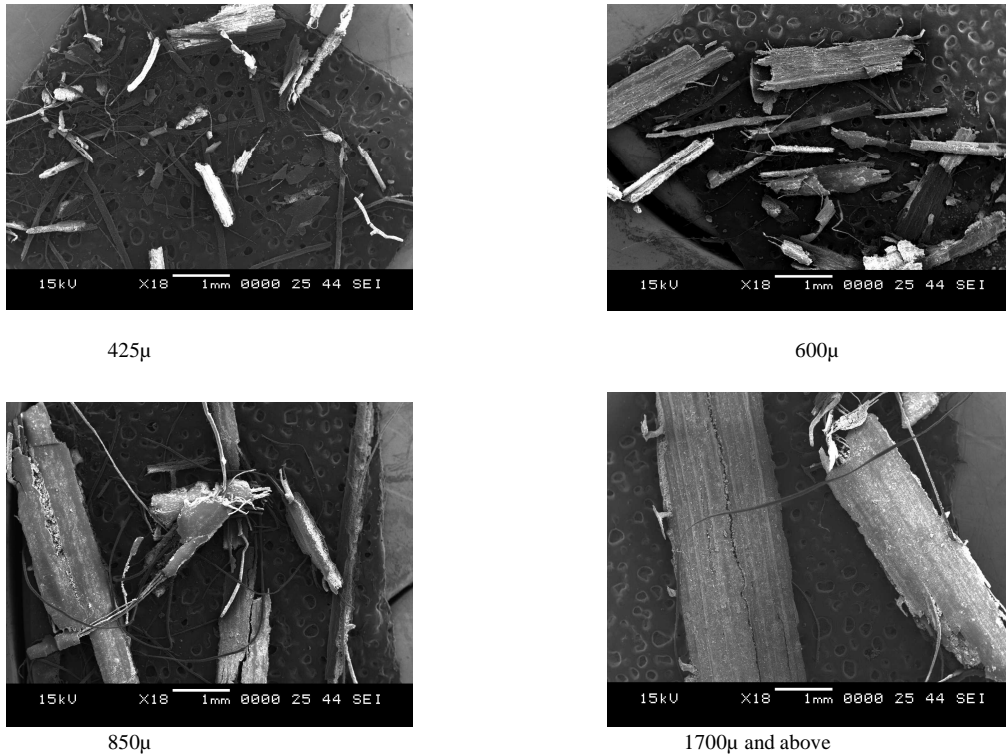


Figure 5.2: SEM images of Areca Leaves of sizes 425µ, 600 µ, 850µ, and 1700µ and above

In this investigate phase, paper, sawdust, and coconut coir, which function as the additive were added to the areca leaves and wheat flour was used as binder. To prepare an optimal mixture for briquetting, areca leaves, the additives, and wheat flour were combined in the ratio of 2:1:1. It was vigorously mixed to produce a uniform mixture that was stored in a container for a couple of days to get it softened for briquetting. Then a fabricated briquetting machine was used to form the briquettes. In this process, the piston press technology was employed. The biomass mixture was filled into the mould of dimension 12x8x10cm, and compressed by a 2ton hydraulic jack at a pressure of 1.28MPa. The briquettes were ejected from the mould after observing a dwell time of 30 seconds [44]. The briquettes so obtained from the mould were sun dried for a period of 19 days [119].

The briquettes were weighed in their wet and dry conditions and their weights are tabulated in Table 1.

Table1: Wet and Dry Weight of the Areca Leaf Briquettes

Sl. No.	Type of briquette	Wet weight (gm)	Dry weight (gm)
<b>Additive used: Sawdust</b>			
i	Areca leaves of 1700µ and above	386.17	215.69
ii	Areca leaves of 850µ	363.71	211.32
iii	Areca leaves of 600µ	335.93	207.55
iv	Areca leaves of 425µ	319.41	204.63

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### III. RESULT AND DISCUSSION

The density of the briquette material is of great significance as a number of factors such as storage, transportation, and ease of handling depend on it. Hence, the density of the briquette was determined immediately after its ejection from the mould by dividing the mass by the volume of the compressed briquette. Further, the mass was obtained by using a digital weighing scale, and similarly, the volume was estimated by taking the linear dimensions such as length, breadth, and thickness of the briquette by means of a standard digital Vernier caliper. In addition, the initial, maximum, and relaxed density was also determined using the ASAE standard methods [107]. 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. The mathematical expression for estimating the relaxed density is given as:

$$\text{Relaxed density} = \frac{\text{Briquettes mass}}{\text{Briquettes new volume}}$$

Furthermore, the density ratio was been estimated as the ratio of relaxed density to maximum density. Mathematically, it is obtained as follows:

$$\text{Density ratio} = \frac{\text{Relaxed density}}{\text{Maximum density}}$$

Here, it should be noted that maximum density represents the compressed density of the briquette immediately after its ejection from the briquetting machine. The other key factor called relaxation ratio is the ratio of maximum density to relaxed density. Mathematically, the relaxation ratio is obtained by the following expression:

$$\text{Relaxed ratio} = \frac{\text{Maximum density}}{\text{Relaxed density}}$$

Ultimately, compaction ratio which is maximum density divided by initial density of the residue has been estimated as follows:

$$\text{Compaction ratio} = \frac{\text{Maximum density}}{\text{Initial density before compression}}$$

Thus, the various parameters of density of the formed briquette have been performed

**Table 2:** Maximum Density, Relaxed Density, Initial Density, Density Ratio, Relaxed Ratio, and Compaction Ratio of Briquettes with Sawdust as Additive and Wheat Flour as Binder

Sl.No	Type of Briquette	Initial Density before Compression (gm/cm <sup>3</sup> )	Relaxed Density (gm/cm <sup>3</sup> )	Maximum Density (gm/cm <sup>3</sup> )	Density Ratio	Relaxed Ratio	Compaction Ratio
1	Areca leaves of 1700µ and above	0.638	0.435	0.907	0.479	2.08	1.42
2	Areca leaves of 850µ	0.638	0.482	0.877	0.515	1.94	1.37
3	Areca leaves of 600µ	0.638	0.458	0.836	0.544	1.82	1.31
4	Areca leaves of 425µ	0.638	0.469	0.808	0.581	1.72	1.26

In order to assess the presence of moisture, ash, volatile matter, and fixed carbon components in the prepared areca leaf briquettes, proximate analysis was performed. It was conducted as per standard IS1350-1 [123] so as to estimate the

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percentage of sulphur, oxygen, nitrogen, and hydrogen. In this experiment, the gross calorific value of the areca leaves was found as per IS1448-7 standard [122].

The results of the ultimate and proximate analysis and gross calorific values of areca leaf briquette of sizes 1700 $\mu$  and above, 850 $\mu$ , 600 $\mu$ , and 425 $\mu$  are shown in the following table.

**Table 2:** Analysis Result for Areca Leaf Briquettes made from Sizes 1700 $\mu$  and above, 850 $\mu$ , 600 $\mu$ , and 425 $\mu$  with Sawdust as Additive and Wheat Flour as Binder

Sl.No.	Parameters	Additive used: Sawdust			
		Areca Leaves of 1700 $\mu$ and above	Areca Leaves of 850 $\mu$	Areca Leaves of 600 $\mu$	Areca Leaves of 425 $\mu$
1	Gross calorific value, MJ/kg	11.22	14.57	11.93	10.78
<b>Proximate analysis</b>					
1	Moisture content, %	6.18	8.08	7.98	7.93
2	Ash content, %	8.30	1.47	1.98	1.87
3	Volatile matter, %	81.58	75.12	75.33	75.40
4	Fixed carbon, %	3.94	14.42	14.71	14.80
<b>Ultimate analysis</b>					
1	Hydrogen, %	6.97	6.23	6.80	6.82
2	Nitrogen, %	0.47	0.61	0.59	0.59
3	Sulphur, %	0.61	0.65	0.59	0.58
4	Oxygen, %	19.42	19.87	19.15	19.15

Now, among the best four areca leaf briquettes, briquettes of 850 $\mu$  made with sawdust as additive has the highest gross calorific value of 14.57MJ/kg, and this value compares well with most biomass energy. This value is sufficient enough to produce the heat required for household cooking and other applications. The results of the calorific value compare well with the results of the heating value of the sawdust briquette obtained by most biomass briquettes, including almond shell briquette (19.49MJ/kg), corncob briquette (20.89MJ/kg), cowpea (14.37MJ/kg), soybeans (12.95MJ/kg), and others.

It is a matter of fact that moisture content is one of the predominant parameters that determine the briquette's worth and combustion efficiency [122]. In general, the lower moisture content of briquettes states a higher calorific value. Taking into consideration the tables, the moisture content of the areca leaves briquette of 850 $\mu$  was 8.08%, and this is sufficient for the combustibility and storability of the briquettes as suggested by [60]. In fact, higher volatility of biomass briquettes depicts its better quality, and typically a good biomass briquette contains high volatile matter of approximately 70% to 86% and low char content. The areca leaves briquette contains volatile content of 75.12% and is a sign of trouble-free ignition of the briquette and balanced raise in flame length as recommended by [79]. The high volatile matter content indicates that during combustion, most of the sawdust charcoal briquette will volatilize and burn.

According to [84], ashes have a major influence on heat transfer to the surface of a fuel as well as diffusion of oxygen to the fuel surface during char combustion. Since ash as an impurity does not burn, fuels with low ash content are better suited for thermal utilization than fuels with high ash content. Higher ash content in a fuel usually leads to higher dust emission and affects combustion volume and efficiency. Keeping this in mind, ash presence analysis was done that depicted that the selected areca leaf briquette contains 1.47% of ash. The fixed carbon of the briquette, which is the percentage of carbon (solid fuel) available for char combustion after the volatile matter is distilled off, is estimated to be 14.42%. Fixed carbon gives a rough estimate of the heating value of a fuel and acts as main heat generator during burning.

The initial, maximum, and relaxed density was obtained as 0.638gm/cm<sup>3</sup>, 0.877gm/cm<sup>3</sup>, and 0.452gm/cm<sup>3</sup>, respectively, which exhibited better compactness of the proposed biomass briquettes, and hence facilitated better portability and better fuel efficiency.

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## IV. CONCLUSION

The results depict that the areca leaves briquettes of size 850 $\mu$  with sawdust as additive possesses a gross calorific value of 14.57MJ/kg, which can be considered as sufficient to produce enough energy. Some of the inferences are given as follows:

- The relaxed density obtained from the areca leaves briquette has sufficient value, which will not allow them to crumble during transportation and storage.
- Due to low percentage of sulphur and nitrogen, and also as the loose biomass is compacted and burnt in solid form, there will be minimum air pollution.
- The gross calorific value of the areca leaves briquettes is enough to produce sufficient heat for purposes of domestic cooking and other applications.

Thus, briquettes made from areca leaves of 850 $\mu$  size with sawdust as additive could make a good biomass fuel for households and industries.

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