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Comparing the Energy Use of Agro Waste by Briquetting with Organic Binding Material

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Abstract

This paper presents an experimental exploration of fuel properties of bio- briquettes made from a combination Teakwood sawdust, groundnut shell, bagasse, coconut waste. In the present work, binary briquettes have been made from in combination in the ratio of 25, 50, 75, and 100% by weight using polyester resin and epoxy resin as a binder. Furthermore, a comparative study between the based biomass briquettes with firewood, coal and conventional sawdust briquettes are also included in this study. Raw materials were collected and were kept for open sun drying. The dried matter was then transformed into a pulverized form and eventually converted to briquettes. The performance of different briquettes with different binders were analyzed. The percentage of moisture content, percentage volatile matter content, ash content percentage, fixed carbon content and calorific values of the briquettes were investigated. The results showed that the composite briquettes had improved combustion characteristics like higher calorific value and more volatile matter content compared with briquettes. The percentage volatile matter content of agriculture waste briquette enhanced from 71.72% to 83.2% for the composite briquette of agricultural waste.

1. Introduction

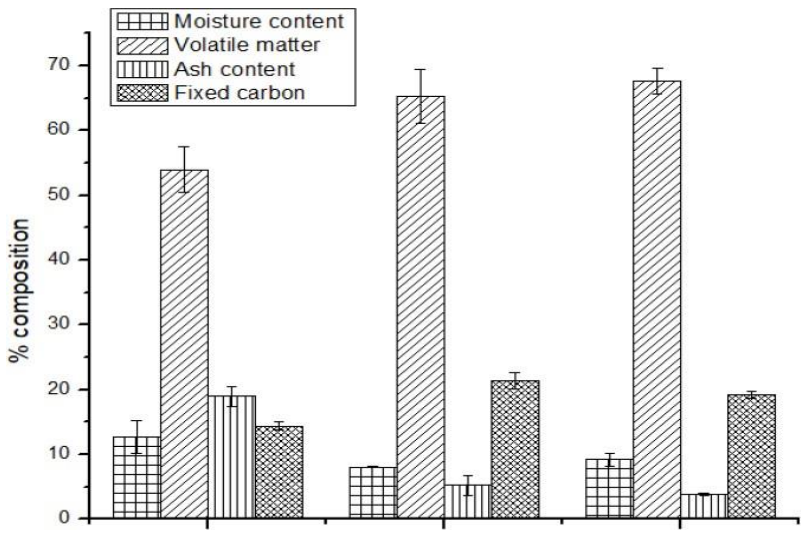
In the last four decades, the researchers have been focusing on alternate fuel resources to meet the ever-increasing energy demand and to avoid the dependence on crude oil. Biomass appears to be an attractive feedstock because of its renewability, abundance and positive environmental impacts resulting in nonet release of carbon dioxide and very low sulfur content. Biomass is very difficult to handle, transport, store and utilize in its original form due to factors include high moisture content, irregular shape and sizes and low bulk density. Densification can produce densified products with uniform shape and sizes that can be more easily handled using existing handling and storage equipment and thereby reduce cost associated with transportation, handling and storage. Biomass densification processes into extrusion, and briquetting, which arecarried out using a screw press, piston press, or roller press. Briquetting and pelleting are the most common biomass densification methods pelleting and briquetting are the most common densifications used for solid fuel applications. Many of the developing countries to produce huge quantities of agro waste but they are used inefficiently causing extensive pollution to the environment. The major agro waste are bagasse, groundnut shells, Sawdust and coconut waste a milling residue is also available in huge quantity. Apart from the problems of transportation, storage, and handling, into direct burning of loose biomass in conventional grates is associated with very low thermal efficiency and widespread air pollution. Briquettes are mostly used in the developing world, where cooking fuelsare not as easily available. There has been a move to use of briquettes in the developed world, where they are used to heat industrial boilers in order to produceelectricity from stream.

2. Materials and Methods

Materials: The bio-residues utilized in this study were the Groundnut Shells, Bagasse, Coconut waste, Teakwood saw dust. The Agro Waste was collected from an Agro field. The binding agent used was Epoxy Resin, Polymeric Resin, Wheat flour and Maida flour was selected due to its availability. Material Preparations and Briquette Invention: Handpicking technique was employed for the initial removal of a foreignmaterials from the raw samples of Groundnut shells, Biogases, Coconut waste andTeakwood saw dust. The Agro waste was then pulverized to obtain the required fines for the densification of process. The sieved samples of Agro waste were then stored separately in a zip-locked polythene bag. The agro waste was adequately collected and sun-dried in 7 days for the moisture reduction. The average time of sun-drying was 6 hours per day. After drying, the agro waste waspulverized using an electrical grinding machine. It was later sieved to particle sizelower than 0.5 mm. continuously stirred until the slurry formed as smooth paste.Agro waste and sawdust were weighed using the electronic weighing balance andblended at different mixing ratios between 10 and 90 wt%. Samples were also formed from only pure (100%) Agro waste and respectively. The binder (inorganic and organic) at 5% of the total mass of the materials was used for the respective agglomerate samples.

3. Results and Discussion

Characteristics of Raw Samples: Agro waste has the highest moisture (7.8 wt %) and volatile matter (82.0 wt %) contents. Similarly, Sawdust has high moisture (6.8 wt %) and volatilematter (77.7 wt %) contents. The trend of the volatile matter contents for Agro waste are in agreement with the findings of Lasode et al. and Prins et al. wherethe studies reported 82.3 wt% for teak dust and 79.0 wt% for Switch grass dust, respectively. However, the volatile matter of Agro waste was lower when compared to the other raw materials. This could be due to its production process (carbonization), wherein a degree of devolatilization could have occur. The carbonization process used in Agro waste production may have led to its higher calorific value (23.4 MJ/kg). The Agro waste have the highest ash content (5 wt %).This could be detrimental to its overall combustion properties. This means that the sawdust and Agro waste were better with regards to ash Proximate, ultimate and heating value characteristics of raw Agro waste. From the results, a higher calorific value implies that the energy in Agro waste was greater when comparedto other samples. Hence, better combustion characteristics could be achieved by blending both Agro waste as briquette using the binding agent to obtain a betterfuel. Physical Properties: Samples of the resultant agricultural waste raw material after carbonization are shown in Figure. It was observed that after carbonization, the agricultural wastes all retain their inherent morphological structure. The moisturecontent, volatile matter, ash content and fixed carbon of the agro waste. Higher moisture contents at 12.7 %, followed by 9.3 % for groundnut shells and 8.1 %. For agro waste. Agro waste also had the highest ash contents of 19 % respectively. The relatively high volatile matter content in all the raw materials (> 54 %) make them more readily devolatilized because of increased ignitabilitypotential. Moisture contents for all of the agricultural wastes raw materials were all lower than 10 % and 18 % as being necessary for successful briquetting .Lowmoisture content values are preferred because higher levels of moisture content in biomass-based fuels result significant amounts of energy being used to evaporate water, which lowers the combustion efficiency.



Teak wood sawdust Biogases Groundnut shells

FIGURE 1. Agro waste Raw materials

Heat Transfer Analysis along Composite Briquettes: Heat flow through the developed composite briquettes was studied. The composite briquettes the same length and area, the heat flux through the composite briquette depends upon the individual heat of transfer coefficients as well as thermal conductivities of constituent briquettes. Flows as a result of thelengths and thermal conductivities of the individual waste, i.e., groundnut shells. Water Content: Water content of the brown coal briquettes are influenced by the type of adhesive used. The adhesive of the starch contains lower water compared to the adhesive of cassava starch as well as castor oil plant starch at the composition of5 % and 10 % adhesive. At the composition of 15 % adhesive, the highest water content was in starch. The result of water content of the brown coal briquettes.

TABLE 1 the Results of Proximate Analysis and Calorific Value of the Agro WasteBriquettes

Test Para-meter	Types of Adhesive	The composition of Adhesive in Briquette (%)		
		5	10	15
Water content (%)	Starch	2.00	2.67	3.33
	Cassava starch	2.33	2.67	3.00
	Castor oil plant starch	2.33	3.00	3.00
Ash content (%)	Starch	8.33	7.33	5.00
	Cassava starch	12.33	8.33	7.67
	Castor oil plant starch	14.00	11.67	9.67
Volatile matter (%)	Starch	16.67	16.67	18.33
	Cassava starch	14.33	18.00	18.33
	Castor oil plant starch	14.33	16.00	18.33
Fixed carbon (%)	Starch	73.00	73.33	73.34
	Cassava starch	71.01	71.00	71.00
	Castor oil plant starch	69.34	69.33	69.00
Calorie (cal/gr)	Starch	4595.9	4645.8	4678.7
	Cassava starch	3256.9	3925.9	4291.7
	Castor oil plant starch	3405.3	3162.7	3445.1

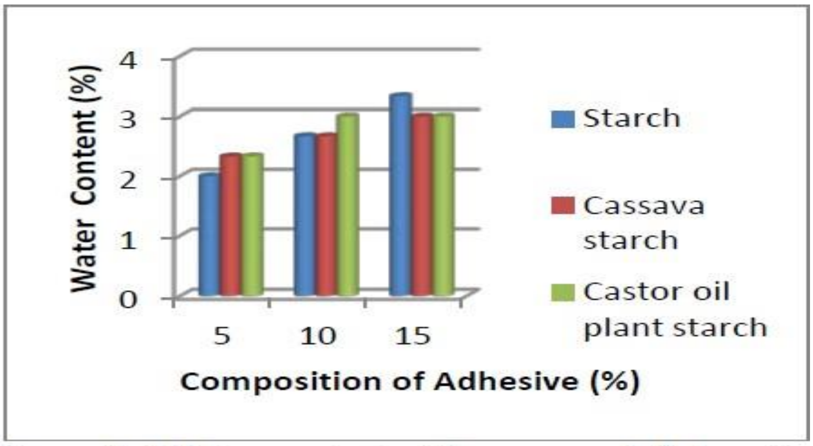


FIGURE 2. Water Content of Agro Waste Briquettes

Ash content: The ash content of the brown coal briquettes is influenced by adhesive composition, in the sense that the bigger the adhesive composition the higher theash composition. This is because the adhesive contains high organic matter resulting in a high ash when baking is done. Figure 22 shows brown coal briquettes' ash content for the three types of adhesives.

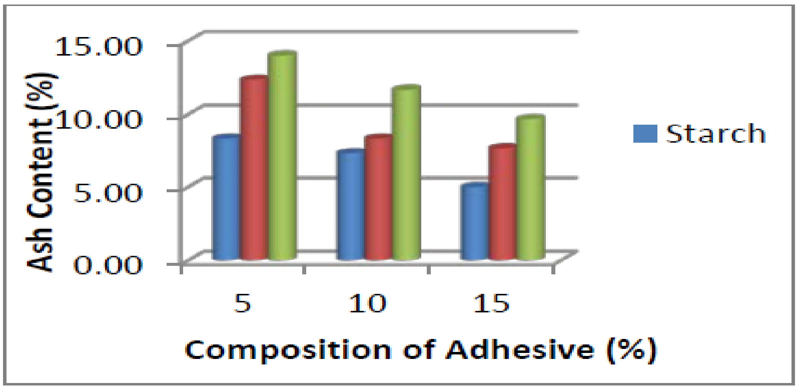


FIGURE 3. Ash Content of Agro Waste Briquettes

Volatile Matter: Volatile matter content in the adhesive contributes positively to brown coalbriquettes. The greater the adhesive composition of the greater the volatile mattercomposition is. The composition of the volatile matter in the brown coal briquettes can improve the quality of the briquette. However, if excessive, the composition can reduce the quality of the briquettes. Of the three types of adhesives. Starch is the one that provides most volatile matter, i.e. 18.33%.

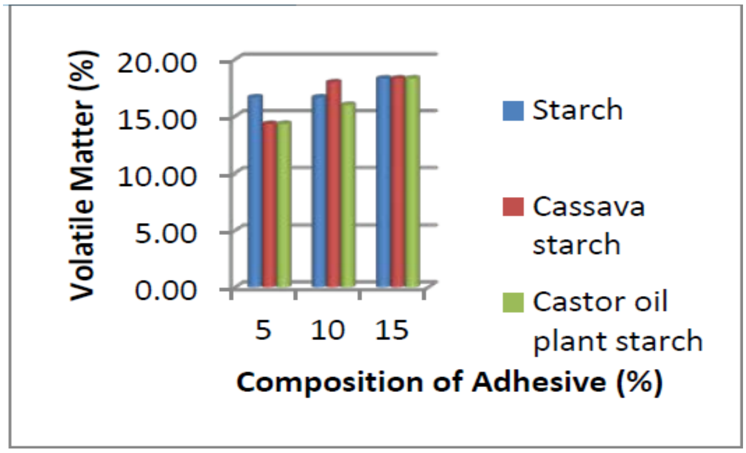


FIGURE 4. Volatile Matter Content of Agro Waste Briquettes

Fixed Carbon: Fixed carbon content of the briquette determines the calorific value. The addition of adhesive does not directly influence the increase of fixed carbon, butrather due to changes in water content, ash content, and volatile matter of browncoal briquettes. Figure shows the fixed carbon of brown coal for some of the adhesive compositions.

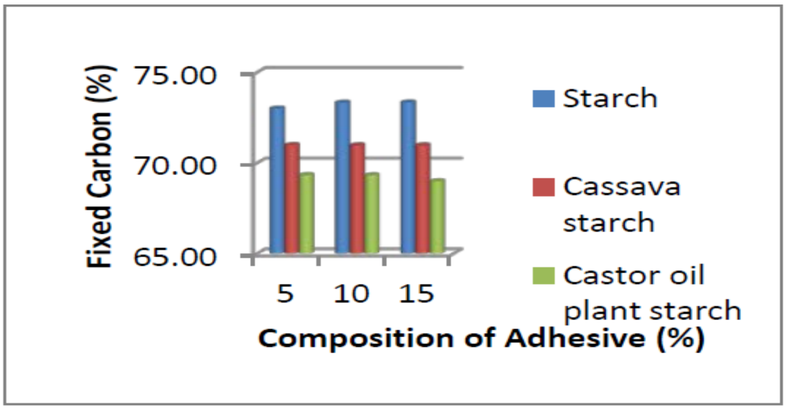


FIGURE 5. Fixed Carbon of Agro Waste Briquettes

Result of Calorific Value in Agro Waste Briquettes: The results of the analysis of the coal briquettes using Bomb Calorimeter are presented in Table 1. From the results of this analysis, it is found that the highest calorific value of brown coal briquettes is in the composition of15% for starch adhesive with a calorific value of 4678.7.

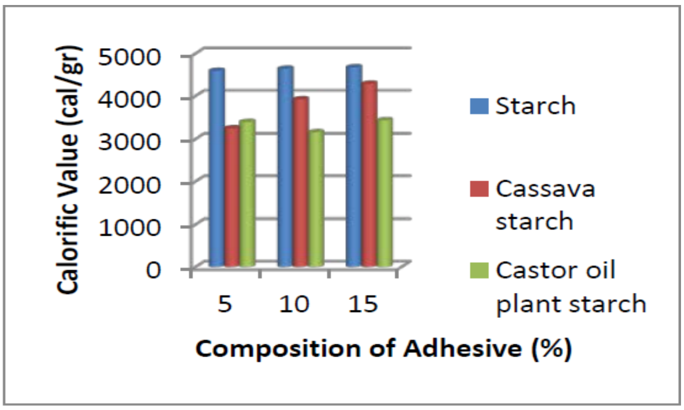


FIGURE 6. Result of Calorific Value in Agro Waste Briquettes

FIGURE 7. Briquettes

TABLE 2. Results Of Above Showed Briquettes

Fuel	**Density Kg/m^3**	**Calorific value Kcal/Kg**	**Ash Content(%)**
Coal	1300	3800-5300	20-40
Bio Mass Briquettes From:			
Sawdust	1100	4600	0.7

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Page 1 of 1

REPORT NUMBER: STS/RE/2021-22/0155 DATE: 16.04.2021

TEST REPORT

Issued To : MR.M.RAJIV, 206/B, MAIN ROAD, THIRUVIDAIMARUTUR (TK), KUMBAKONAM, THANJAVUR DT.

Sample Description : SAWDUST WITH IN-ORGANIC BINDER FEVICOL (BRIQUETTE)
Sample Quantity Received : 500g (approx.)
Date of Receipt of Sample : 15.04.2021
Date of Start of Analysis : 15.04.2021
Date of Completion of Analysis : 16.04.2021
Sampling Done by : Customer
Technical Reference/Method : ASTM

PROXIMATE ANALYSIS

SL.NO	PARAMETER	RESULT	REMARKS
1.	Ash Content	2.3%	-
2.	Moisture	3.7%	-
3.	Volatile Matter	78.5%	-
4.	Fixed Carbon	15.5%	-
5.	Calorific Value	4899kcal	-

Analyzed By: Sowmiya.S

Important Note:
**The given results reflect our findings of the submitted sample only. Reports shall not be reproduced except in full without the written permission from the laboratory.*
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FIGURE 8a. Test Report

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Page 1 of 1

REPORT NUMBER: STS/RE/2021-22/0154 DATE: 16.04.2021

TEST REPORT

Issued To : MR.M.RAJIV, 206/B, MAIN ROAD, THIRUVIDAIMARUTUR (TK), KUMBAKONAM, THANJAVUR DT.

Sample Description : GROUNDNUT SHELL WITH ORGANIC BINDER MAIDA FLOUR (BRIQUETTE)
Sample Quantity Received : 500g (approx.)
Date of Receipt of Sample : 15.04.2021
Date of Start of Analysis : 15.04.2021
Date of Completion of Analysis : 16.04.2021
Sampling Done by : Customer
Technical Reference/Method : ASTM

PROXIMATE ANALYSIS

SL.NO	PARAMETER	RESULT	REMARKS
1.	Ash Content	4.3%	-
2.	Moisture	4.9%	-
3.	Volatile Matter	71.0%	-
4.	Fixed Carbon	19.8%	-
5.	Calorific Value	4900kcal	-

Analyzed By: Sowmiya.S

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FIGURE 8a. Test Report

FIGURE 9. Photography of results

4. Conclusion

The combustion characteristics of fuel briquettes made from Agro waste, sawdust and their agglomerates using gelatinized Agro waste as the binder were examined. The mixing ratios variation of the biomass samples had significant effects on all the properties investigated on the briquette produced. An increase in the Agro waste increased the fixed carbon content and the heating value of the briquettes. Sawdust increased the oxygen and hydrogen contents of the briquettes and lowered their carbon contents. The proximate, elemental, and heating values analyses of the produced fuel briquettes depicted that they have better combustion. Thus, the produced briquettes made from Agro waste and material agglomerates would be a good source of energy for domestic and industrial applications.

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