Utilization of Pongamia Pod Shell and Tamarind Shell for the Production of Fuel Pellets

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Abstract— In this work pongamia pod shell, tamarind shell, crude glycerine which is a biodiesel by-product and distillery yeast sludge were used for the production of fuel pellets. Fuel pellets were produced in small pelleting die and pressure applied manually using lathe machine. The produced pellets were tested for calorific value, moisture content, ash content, volatile matter and fixed carbon contents using standard procedures. The results confirmed that better quality fuel pellets were produced for 50% Pongamia, 25% sludge and 25% crude glycerine. The fuel pellets produced in this study can be used in variety of applications where heat is required.

Keywords: Biomass, energy, pellet, pongamia pod shell, tamarind shell, crude glycerine and distillery yeast sludge

1 Introduction

Most of the developing countries across the globe producing huge quantities of agro wastes but these are used inefficiently resulting extensive pollution to the environment. The agro wastes are rice husk, bagasse, coffee husk, groundnut shells, jute sticks, mustard stalks, cotton stalks and coir pith [1, 2]. Direct utilization of agro wastes includes many problems like high transportation cost, high storage cost, and difficulty in handling, also direct burning of agro wastes in conventional furnaces is associated with very less thermal efficiency and creates high air pollution [3]. This difficulty can be overcome by pelleting or densification. Pelleting is the process of increasing the density of loose biomass material to produce compact solid material of required size and shape with the application of pressure [4]. Fuel pellets is mainly used to replace the coal in industrial and food process heat applications (melting metals, steam generation, space heating, tea curing, brick kilns, etc) and power generation via gasification of biomass pellets [5].

Binders are added to raw materials to form strong pellets. The addition of binder's results in increased bonding and stable properties in the briquettes obtained and the amount of binder to be blended depends on the binding properties of materials used and the binding agent [6]. It is required to blend different particle size material to produce high quality durable briquettes. When blending different particle size materials, the inter-particle bonding with almost no inter-particle spaces between raw materials could be created, and this helps to produce briquettes with high tensile strength and impact strength. [7, 8]. Fuel pellets were obtained from wheat straw and binders (crude glycerol, lignosulfonate, bentonite, pretreated wood residue, and wood residue). The calorific value, tensile strength, density and specific energy consumption of the fuel pellets made were estimated. Results confirmed that the specific energy consumption for wheat straw compaction significantly decreased with the addition of bentonite, pretreated wood residue, wood residue and lignosulfonate with crude glycerol. The tensile strength of wheat straw fuel pellets was increased with values ranging from 1130 to 1630 KPa when binders added during the production of fuel pellets. Significant increase in the higher heating value (17980 KJ/kg to 18770 KJ/kg) when pretreated wood residue, crude glycerol and wood residue were utilized as binders [9]. From the literature it was found that densification as an attractive technique to convert waste to energy. Hence this research work aimed at utilizing the pongamia pod shell, tamarind shell, glycerine and yeast sludge for the production of fuel pellets.

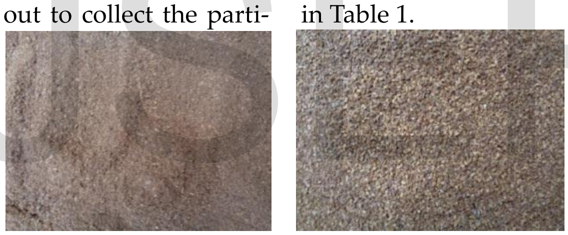
2 Materials

Different raw materials like pongamia pod shell, tamarind shell, distillery yeast sludge and crude glycerine were used for the production of fuel pellets. Pongamia pod shell was collected from biodiesel extraction unit, Shivamogga (Fig.1), tamarind shell was collected from Hemmanabethur, Davangere (Fig.2), distillery yeast sludge was collected from Samsons Distilleries Private Limited, Duggavathi, Davangere (Fig.3) and crude glycerine was collected from biodiesel extraction unit, Tholahunase, Davangere (Fig.4).


Fig. 1: Pongamia pod shell Fig. 2: Tamarind shell


Fig. 3: Distillery yeast sludge Fig. 4: Crude glycerine

Generally, pelletizing requires the particle size of ground raw material to be less than 3mm. Hence, the ground raw material obtained from hammer mill is sieved out to collect the particles less than 3mm (Fig.5). All the feedstock's were blended in different compositions and blended compositions are shown in Table 1.



(a) (b)

Fig. 5: (a) Ground pongamia pod shell (b) Ground tamarind shells

Table 1: Feedstock blending composition

Samples	**Composition**
Sample-1	Pongamia shell-100%
Sample-2	Pongamia shell -50%, Sludge-40%, Crude glycerine-10%
Sample-3	Pongamia shell -50%, Sludge-25%, Crude glycerine-25%
Sample-4	Pongamia shell -60%, Sludge-30%, Crude glycerine-10%
Sample-5	Pongamia shell -50%, Tamarind shell -10%, Sludge-30%, Crude glycerine-10%
Sample-6	Pongamia shell -50%, Tamarind shell -20%, Sludge-20%, Crude glycerine-10%

3 Methods

The ground feedstock's were mixed manually in the required proportion and filled in a hollow cylinder of inner diameter 12 millimeters. The filled cylinder is then fixed in the headstock of the lathe. The biomass is compressed by a cylindrical rod which is fixed in the tailstock of the lathe (Fig. 6 and Fig. 7). Under the high pressure and temperature, the biomass particles will fuse into a solid mass, thus turning into a pellet.

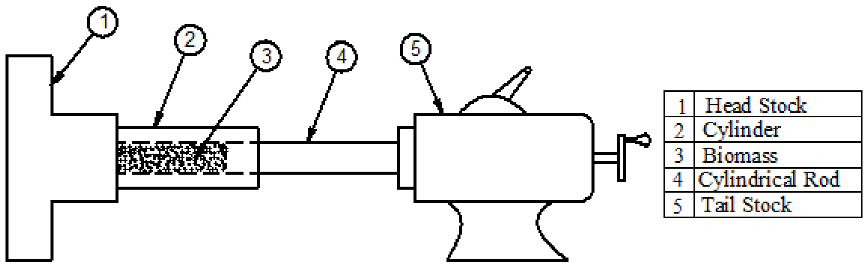


Fig. 6: Diagram of densification process

Fig. 7: Fuel pellets making process

Proximate analysis and heating value of the produced pellet samples are determined according to the Indian Standard Methods- IS: 1350(Part I)-1984 (Reaffirmed 2002) [10] and IS: 1350(Part II) - 1970 (Reaffirmed 2000) [10] respectively. Proximate analysis includes moisture content, ash content, volatile matter and fixed carbon

4 Results and discussions

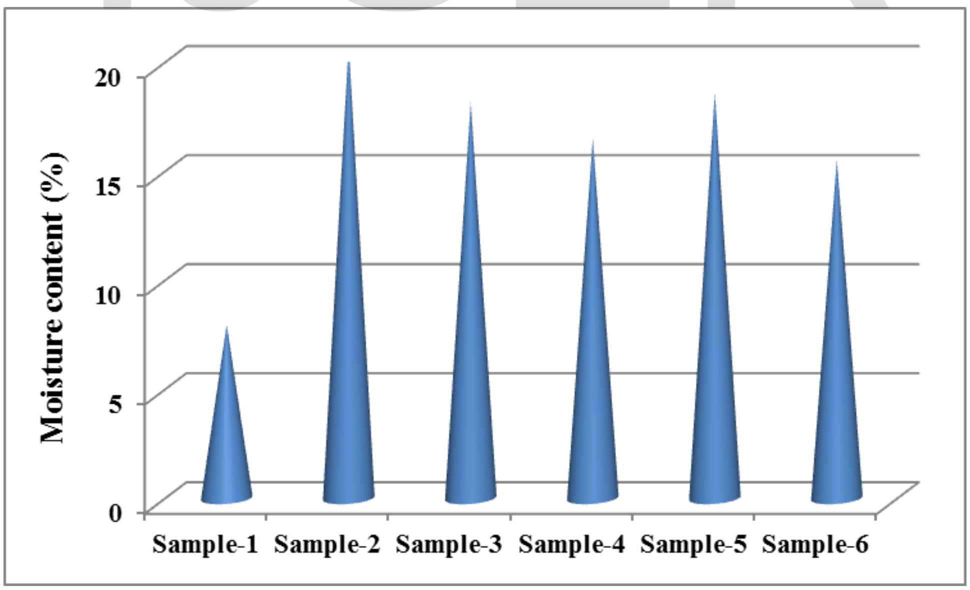


Fig. 8: Moisture content in different samples

Fig. 8 shows the variation of moisture content in different samples. The lowest moisture content was recorded in sample-1 consisting of 100% Pongamia, followed by samples 6, 4, 3, 5 and 2. High percentage of moisture in biomass prevents their application for thermochemical conversion processes including combustion. Similarly the water content has an influence on the net calorific value, the temperature of combustion and the combustion efficiency. It is observed that increasing the crude glycerine and sludge percentage in pellets increases the moisture content in which sludge has the significant effect. Increased moisture content resulted in decreased density of the pellets considerably even at high applied pressures. Similar results were obtained for other types of pellets [11][12][13].

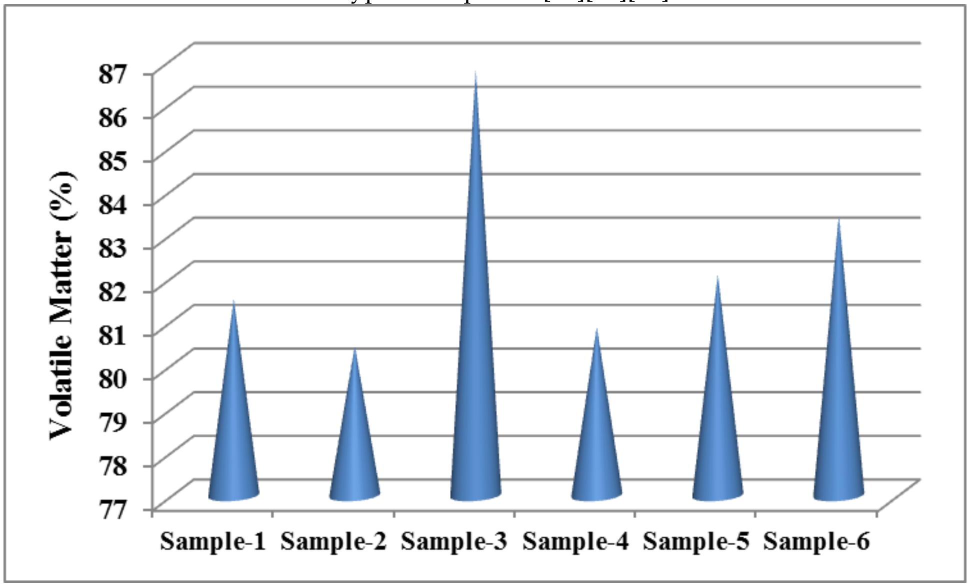


Fig. 9: Volatile matter in different samples

Fig. 9 shows the variation of volatile matter in different samples. The highest volatile matter content was witnessed in sample-3 containing 50% Pongamia, 25% sludge and 25% glycerine followed by samples 6, 5, 1, 4 and 2. According to Van and Koppejan [14], the quantity of volatiles in biomass fuels is high and usually varies between 76 to 86% in woody biomass. The higher proportion of volatiles results the major part of the biomass fuel being vaporized before homogeneous gas-phase combustion reaction take place. The remaining char undergoes heterogeneous combustion reactions. The char oxidation lasts considerably longer than the oxidation of combustible gases during the combustion process. The amount of volatile matter therefore strongly influences the thermal decomposition and combustion behavior of solid fuels. Fuels with lower volatiles or conversely a very high fixed carbon value need to be burnt on a grate as they take a long time to burn out if they are not pulverized to a very small size. Similar trend was observed in other biomass based fuels [15][16][17].

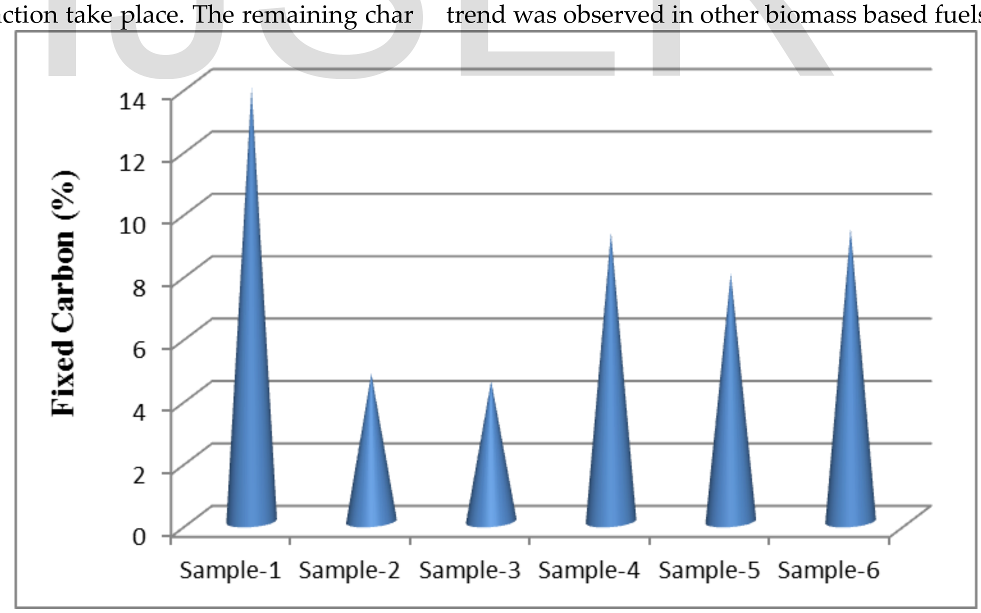


Fig. 10: Fixed carbon in different samples

Fig. 10 shows the variation of fixed carbon in different samples. The lowest fixed carbon content is recorded in sample- 3 containing 50% Pongamia, 25% sludge and 25% glycerine followed by samples 2, 5, 4, 6 and 1. It is observed that the sample containing 100% Pongamia possess very high fixed carbon content, which decreases with the addition of glycerine and sludge. The high fixed carbon content prolongs the cooking time by its low heat release. It also reduces the calorific energy of the pellets by causing fuel-saving effect. Similar results were obtained for other types of bio fuels [18][19][15].

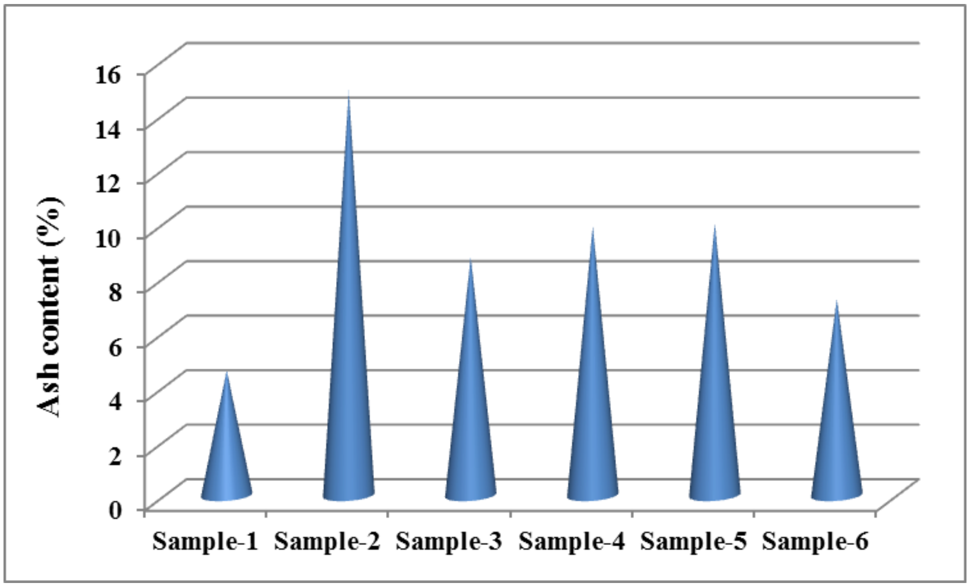


Fig. 11: Ash content in different samples

Fig. 11 shows the variation of ash content in different samples. The lowest ash content is noticed in sample-1 containing 100% Pongamia, followed by samples 6, 3, 4, 5 and 2. It is observed that increasing the sludge quantity in samples increases the ash content. One particular problem that is encountered during thermal processes of biomass is the deposition and agglomeration caused from minerals in ash melts. Baxter (1993) stated that ash behavior of agro-wastes during thermochemical conversion is one of the most important matters to be studied. These results are consistent with other various bio based fuels [11][20][15].

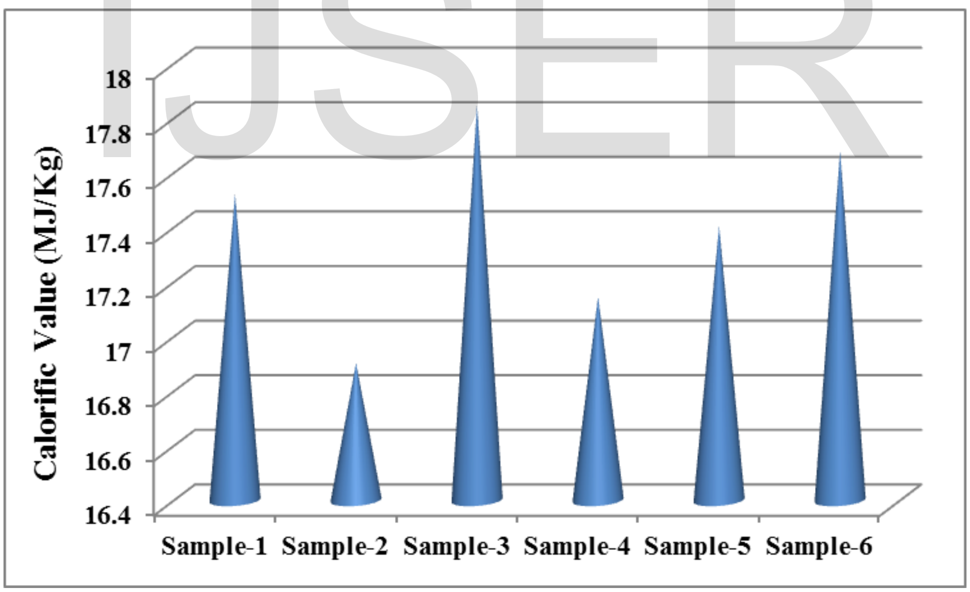


Fig. 12: Calorific value in different samples

Fig. 12 shows the variation of calorific value in different samples. Heating value determines the energy content of any fuel. It is the important property of biofuel that depends on its chemical composition. The calorific value can be used to calculate the competitiveness of a fuel in a given market situation and it should be recognized when selecting the raw material input. The highest calorific value is witnessed in sample – 3 containing 50% Pongamia, 25% sludge and 25% glycerine followed by samples 6, 1, 5, 4 and 2. From sample-2 it is noticed that addition of sludge decreased the calorific value of the pellets whereas increase in calorific value is noticed in sample-3, with the addition of higher proportion of crude glycerine. Addition of more tamarind also increased the calorific value as in sample-6. But further addition of tamarind resulted in poor pellet strength. Similar trend was observed in other biomass based fuels [12][16][19][13][21].

5 Conclusion

The results from standard method analysis indicated that the use of Pongamia pod shell and crude glycerine in pelletizing process is suitable for combustion as an energy source. Crude glycerine affected on the heating value of the pellets ranging from 17521.76 KJ/Kg to 17848.25 KJ/Kg which met pellet standard. As the amount of glycerine increased, the heating value of the pellets increased as well. It is also noticed that the increase in distillery sludge increased the pellet strength but it decreased the calorific value and volatile matter, increased the fixed carbon and ash content. Similarly addition of tamarind upto 20% increased the calorific value. The best pellet is produced from 50% Pongamia, 25% sludge and 25% crude glycerine, followed by 50% Pongamia, 20% tamarind, 20% sludge and 10% crude glycerine. Thus, biomass from agricultural wastes, crude glycerol – a biodiesel by-product and distillery sludge can be used to produce biomass fuel pellets which are compact, energy dense and simple to use.

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