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SOLID STATE FERMENTATION IS A TECHNOLOGY TO CONVERT SAW DUST INTO FUEL BRIQUETTES

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ABSTRACT: Any agricultural waste which is in lignocellulosic nature can be fermented with any cellulolytic fungi. The fungi excrete many extra cellular enzymes which ferment bio molecules (biological macro and micro bio molecules etc. such as protein, lipids, carbohydrates, etc.) of the substrate and mobilize the nutrients from them for their growth and development. We observed that the fungus colonize on the substrate and cover mycelium on the substrate over the period of 15- 18 days and produced fruit bodies on 24 day onwards. The fruit bodies were harvested in three flushes and their yielded was calculated in terms of biological efficiency (BE). It was recorded the fungus yielded 41.11% (BE) on saw dust over period of 65 days, 25.24% (BE) in wood chips and 86.11% (BE) on paddy straw (control substrate) over period of 45 days. After 65 days the fungal fermented saw dust was collected and were pressed into cylindrical (8.5x7.2x7.2) shaped fuel briquettes, the bulk density and calorific value of the briquettes were calculated and tabulated. From this study we arrived on conclusion that sawdust can be converted in to quality fuel briquettes (more colorific value and less emission of smoke) by using *Pleurotus florida* fungus in solid state fermentation.

KEYWORDS: Solid state fermentation, Biological efficiency, calorific value, Sawdust etc.

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1.INTRODUCTION

The solid state fermentation technology has been developed in worldwide because of its taste and low maintenance technology. Most of these are types of low-value lignocellulosic wastes that are primarily derived from agricultural practices or the agro-industry.[1] Increasing dependence on a worldwide level of energy resources is that the interest for other energy sources to increase. At the present time, biomass seems to be the most affordable and cost–effective source of renewable energy [2]. The use of fermentation processes to produce microbial biomass has several advantages over other unconventional processes that rely on agricultural by products.[3-4] Biomass energy production is beneficial to the environment and assuring sustainable future. We need to make sure biomass energy is produced in sustainable and ecologically safe way, with little or no pollution to air, water or soil. Biomass is a solution to growing pollution problem and can become a significant energy source in the future, being a sustainable and renewable energy source. [5] Modern biomass fuel technology means process the biomass matter with a series of advanced transformation technology into the alternative fuel (solid form, liquid form, gas form), those bio–fuels are used in power generation, vehicle fuel, heating stoves, etc. The densified bio–fuel refers to the biomass briquettes products. Last few years, the briquette industry has been developing very fast and the technologies are much mature nowadays. Torre faction is a thermal process to convert biomass into a coal – like material which has better fuel characteristics then the original biomass. Torrefied wood today is regarded as the new coal and besides having many similarities with coal it is predicted to replace many types of biomass in the years to come. Torrefaction combined with densification can create an extremely energy- dense fuel of around 20- 25 GJ/ tonne lower heating value. So far, however, efficiently densifying torrefied biomass has proved challenging. The process removes almost all water and polluting volatile organic matter including part of the lignin, creating a lot more friction in the biomass which makes it harder to densify and creates more wear explains Mogens Knudsen [6]. Biomass refers to substances which occur organically and can be used to generate energy. There are a variety of types of biomass, the most popular being wood. A biomass system uses the energy generated when burning wood pellets (or briquettes), wood chips or logs in a biomass boiler to generate heat and/or energy.[7-10]. Therefore, types of biomass fuels include agricultural waste (straw, animals human dung, husks of all kinds – of grapes, walnut, etc.), wood and wood waste (hubs, sawdust, paddles, chips), energy crops (poplar, willow, willow trees, seed and rape) and solid waste in the municipality [11-12]. The best materials for high-pressure briquetting are sawdust and woody residues because they contain a high proportion of lignin.[13-14]. Therefore in this present study we have used to *Pleurotus florida* an edible wood rotting fungus to ferment saw dust and the fungal fermented saw dust was densified in to energy dense fuel briquettes.

2. MATERIALS AND METHODS

The entire work was carried out in laboratories of Unit of Rural biotechnology, Department of Botany, Saraswathi Narayanan college. Madurai, Tamil Nadu, India by using *Pleurotus florida* as candidate for solid state fermentation of saw dust.

Solid state fermentation

In laboratory, the substrates were prepared and subjected for solid state fermentation (SSF) as shown in the (flowchart-I). It is a bioprocess by which the raw materials are ferment with the help of fungus in controlled environment at its solid state condition. In this study, we have also used wood chips, (substrate for comparison) and paddy straw (control).

***Pleurotus florida* fungus- candidate for solid state fermentation**

Pleurotus florida is a micro fungus. It is a cellulolytic fungus which can grow easily on variety of agro wastes like saw dust, vegetable waste, paper waste, oil palm on variety pericarp and straw in almost seasons. The fungus colonize grow on substrates after the period of the vegetative grow it will produce fleshly fruit bodies, which can be eaten**.** The major aims of this work is to trap cellulolytic capacity of the fungus to degrade lignocellulolytic waste into a substrate for fuel briquettes. To assess the feasibility of applying this fungal technology for briquette production. It is essential to study the biological efficiency of the fungus.

It can be calculated by the following formula given below:

$$BE(\%) = \frac{\text{Total fresh fungal fruit body harvested}}{\text{Total amount of dry substrate used}} \times 100$$

Flow chart: 1 Preparation of saw dust for solid state fermentation

Collection of saw dust

↓

Soak in water over night

↓

Heat treatment of ½ hours

↓

Air dried the substrate for 4-5 hours to get optimum moisture level (60-65%)

↓

Inoculate with white rot fungal spawn @ rate of 150 g / kg

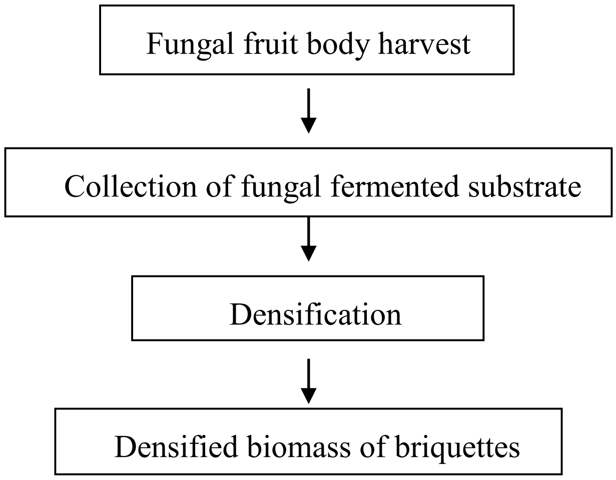
↓

Spawn running

↓

Mycelia colonization

↓



3. RESULTS AND DISCUSSION

Studies on solid state fermentation, showed that the candidate fungus colonized easily on the paddy straw and wood chips substrates. Whereas it was slow on saw dust. Similarly, the fungus initiated its fruit body on 16 and 17 day in wood chips and paddy straw substrate. Whereas, it was on 24 day on saw dust. The fungus requires 30 days to complete its three flushes fruit body production on paddy straw. Whereas, it took 43 and 56 days in wood chips and saw dust respectively (Figure:1).

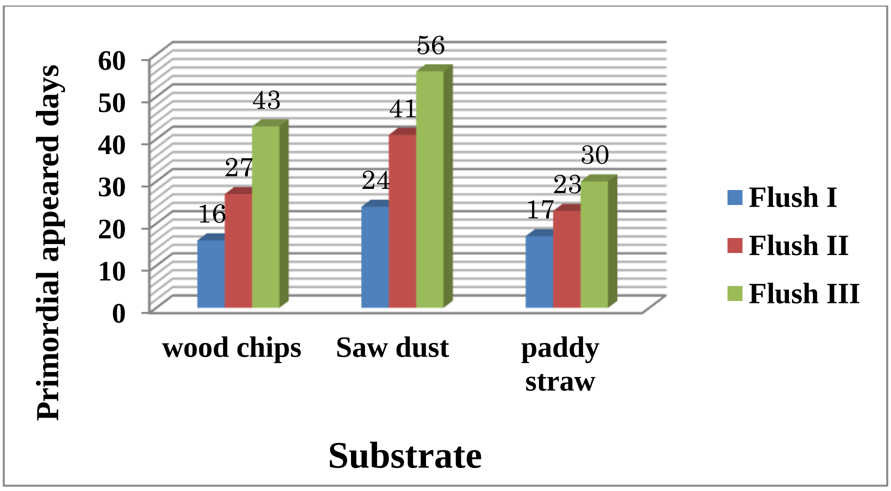


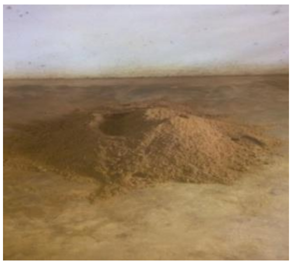
Figure 1: Day in which of primordial appeared

Regarding, fruit body yield, the fungus could produced 41.1% biological efficiency on saw dust, Whereas, it was 86.11% and 25.11% on paddy straw and wood chips respectively (table:1).

Table 1: Biological efficiency of *Pleurotus florida* on wood chips, saw dust substrates

S. No.	Treatment	Amount of Substrate in each fermenter (g)	Amount of fresh and dry fungal fruit body (g)						Total weight of fresh and dry fruit body (g)		% of dry fungal fruit body	Biological efficiency (%)
			Flush I		Flush II		Flush II					
			Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry		
1.	WC	1000	90.2	10.33	37.45	4.12	28.0	3.10	155.52	17.55	11.28	25.24
2.	SD	1000	83.88	9.35	45.55	4.59	58.71	6.51	187.5	20.15	10.74	41.11
3.	PS	1000	226.0	27.85	94.2	9.75	89.2	14.81	409.4	52.41	12.80	86.11

Plate 1:Solid state fermentation of saw dust with *pleurotus florida*



Raw Saw dust

spawned saw dust

Mycelium colonized saw dust

Appearance of fungal fruit body on saw dust

Analysis of the fermentation efficiency of the fungus revealed that the able to reduced 11.82 % dry weight of the saw dust over period 45 days. Whereas it was 38.94 % and 3.82% in wood chips respectively (Table:2)

Table 2: Fermentation efficiency of *Pleurotus florida* on saw dust substrates

S. No.	Substrates	Total dry weight of substrate (g)	Average weight and size of each briquettes		Total no. of briquettes	Bulk density Kg/m3	Calorific value Kcal/kg
			Size (l × w × h)	Weight (g)			
1	* Wood chips	-	-	-	-	-	-
2.	Saw dust	401.07	8.5×7.2 × 7.2	100.25	4	885.25	4379.24
3.	Paddy straw	249.97	8.4×7.2×7.2	83.32	3	729.62	3102.54

* Unable to molded in to briquettes even after solid state fermentation

Sawdust is a by–product from wood sawing process. Actually, sawdust doesn't have much application because of its low burning efficient. However, by pressing the saw dust into pellets, it becomes a kind of high quality bio fuel product – sawdust pellets or wood pellets [15-16].The wood processing plants create large quantities of wood residue waste in the daily production. Now a large part of the sawdust are used to make compressed wood board for furniture producing and wood briquette [17-20]. Saw dust is a natural product which – highly compacted as a briquette or pellets, almost takes on the burning behavior of coal. Owning to their great density wood briquettes has a higher calorific value than the same quantity of firewood. They can be used instead of coal or wood in domestic solid– fuel stoves as well as in industrial furnaces. A popular biomass briquette emerging in developed countries takes a waste produce such as sawdust, and wood chips.

Table 3: Fuel briquettes from fungal fermented saw dusts

S. No.	Treatment	Amount of substrate in each fermenter (g)	Total fresh weight of substrate (g)		Total dry weight of substrate (g)		Duration of Days	Reduction in dry weight during (SSF) (g)	% of dry weight of during (SSF)
			Before (SSF)	After (SSF)	Before (SSF)	After (SSF)			
1.	WC	1000	1150	926.0	614.86	591.36	45	23.5	3.82
2.	SD	1000	1150	837.5	456.05	401.07	62	54.5	11.87
3.	PS	1000	1150	442.0	409.4	249.97	45	159.4	38.94

Burning a wood briquette is far more efficient than burning firewood. Briquettes production is beneficial to the environment, preserving ecosystems and assuring sustainable future. We need to make sure biomass energy is produced in sustainable and ecologically safe way with little or no pollution to air, water or soil [21]. The solid state fermentation seems to be an ideal technology for sustainable biomass energy production from plant biomass[22]. Production of enzymes from rice husks and wheat straw in solid state fermentation was studies by Dayanne et al [23]. Similarly, Biniyam et al applied solid substrate fermentation and conversion of organic waste in to fungal biomass using Aspergillus niger KA- 06 and Chaetomium SPP KC- 06 [24] . However, in this present investigation *Pleurotus florida* was grow on saw dust, wood chips with a view of converting them in to fuel briquettes. Which, resulted that the fungus has utilized about 12% dry solid of raw saw dust, of which it has accumulated 4.41% of dry biomass in their fruit bodies and left fruit bodies and left remaining fermented biomass for briquettes over period of 53 days. It was recorded that the fungus has yielded 41.1% biological efficiency on saw dust during Solid state fermentation. Though, yield was for low when compare with paddy straw but it makes. The venture more profitable. Marikani Kannan reported that the *Pleurotus florida* fungus had a long spawn running period on saw dust [25]. When compare with paddy straw, the current study also gave almost similar results. It was observed that the briquettes prepared from SSF saw dust emitted very little smoke while burning it and it had 885.25 bulk density kg/ m3 with 4379.24 kacl/kg calorific value. The minimum emission of smoke and good bulk density with high calorific value of the briquettes may be due to the elimination VOC (Volatile organic compound) and smoke emission substrates. Saw dust during solid state fermentation. Mogens Knudsen reported that torrefaction of saw dust removes almost all polluting volatile organic matter (VOC) including part of the lignin and densification of torrefied saw dust yielded extremely energy dense fuel.

4. CONCLUSION

One basis of results, observations and cost analysis we can concluded that the solid state fermentation can be applied on saw dust to convert them energy dense fuel briquettes in extremely profitable way and ecological sustainable manner.

CONFLICT OF INTEREST

Authors have no any conflict of interest.

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