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ASSESSMENT OF BIODEGRADATION POTENTIAL OF *PLEUROTUS OSTREATUS* ON SOME SELECTED AGRO – WASTES IN KEFFI, NIGERIA

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Abstract. The agricultural industry is challenged with large tones of lignocellulosic wastes disposal which distort the aesthetical beauty of our environment. This study aimed at assessment of biodegradation potential of *Pleurotus ostreatus (P. ostreatus)* on some selected agro-wastes in Keffi, Nigeria. The samples (cassava peels (CP), banana leaves (BL), saw dust (SD), yam peels (YP) and groundnut shells (GS) were inoculated with equal proportions of *Pleurotus ostreatus* for a period of four weeks. The proximate composition, lignocellulosic content and the carbon-nitrogen ratio and pH of the substrateswere determined and compared. Significantly (P < 0.05) was an improvement of protein and crude fibre above the undegraded samples, and protein enhancement was highest in banana leaves (13.29%) and lest in saw dust (2.49%), crude fibre enhancement was highest in banana leaves (32.45%) and lest in yam peels (9.45%). The fungus also delignified the “wastes” with significant (P < 0.05) reduction in the lignin, cellulose and hemicellulose contents. Lignin for instance reduced by 50.00% in CP, 39.49% in BL, 25.58% in SD, 39.12% in YP and 28.19% in GS; Cellulose reduced by 21.32% in CP, 10.57% in BL, 10.93% in SD, 26.44% in YP and 15.88 in GS; Hemicellulose reduced by 21.04% in CP, 18.06% in BL, 15.29% in SD, 26.16% in YP and 26.32% in GS while Fibre reduced by 27.92% in CP, 27.13% in BL, 21.75% in SD, 28.44% in YP and 21.23% in GS.

Keywords: Lignocellulosic, Biodegradation, *Pleurotus ostreatus,* Agro-wastes, Substrates, Proximate, Carbon-Nitrogen, Mushroom.

Introduction

Agriculture is one of the most important sectors of human activities, and it is considered as one of the most residue-producing sector in the world. Farming activities have both positive and negative impact on the environment, generation of large amount of residues of wastes tagged it negative impact while production of crop for man consumption tagged it positive impact to the society. The amount of organic solid wastes from agro industries is increasing every day and it is estimated that about 998 million tones of this agricultural waste is produced yearly. There are several attempts to improve the biodegradation of agro industrial residues, to diminish the organic load with an efficient mechanism (Bayr *et al*., 2012; Frank-Whittle and Insam, 2013; Pagés-Díaz *et al*., 2013). Every year approximately 38 billion tons of agro-wastes are produced worldwide. Disposal and environmental friendly management of these wastes has become a global priority. Therefore, much attention has been paid in recent years to develop low-input and efficient technologies to convert such nutrient rich organic wastes into value-added products for sustainable land practices (Domiguez, 2012; Babita, 2017). Hence, using *Pluerotus ostreatus* to degrade agro-wastes is an efficient method for agricultural waste management that is cost effective and contributes less in environmental pollution. (Nicolcioiu *et al*., 2016). Biodegradation is the conversion of wastes to a form that offers no threat to the environment and our health involving microorganisms. (Kaplan, 2018).

Agricultural wastes are the most abundant wastes on the surface of the earth, comprising 50% of all biomass with an estimated annual production of 50 billion tons (Smith *et al.,* 2011). It is a common practice in Nigeria either to feed the agricultural wastes to the animals, burn or left on the farm to rot. Burning has received global condemnation in the recent past and therefore the need for bioconversion. One of the strategies to utilize agricultural wastes and by products is to grow edible fungi such as *Pluerotus ostreatus* that will not only reduce the fibre content but also help in obtaining protein rich substrates. Mushrooms are able to convert wide variety of lignocellulosic materials due to the secretion of extracellular enzymes (Rajarathman *et al.,* 2018). *Pleurotus ostreatus* are fleshy fruiting bodies of a basidiomycetes fungi growing on decayed organic matter above the ground level (Rajarathnam *et al*., 2018). *Pleurotus ostreatus* grow on decayed organic matters rich in lignin, cellulose, and other complexed carbohydrates.

Different kinds of agricultural wastes have been used or tried for the growing of various species of edible mushrooms in the world (Sharma and Arora, 2010; Peng, 2013).

Lignocellulosic materials

Lignocelluloses are the most abundant materials present on earth, comprising 50% of all biomass with an estimated annual production of 5×1010 tones (Nicolcioiu *et al*., 2016).

According to Smith *et al.*, (2011), the most abundant renewable biomass on earth consists of cellulose, between 5 and 15 tons per person being synthesized annually by photosynthesis. Much of the cellulose in nature is bound physicochemically with lignin. Because lignin is highly resistant, it protects cellulose against attack by most microbes, and it must be degraded by chemical or biological means before the cellulose can be utilized.

The use of the polysaccharides in the lignocellulosic complex is limited due to their high lignin content (Khouloud *et al*., 2014). It has also been estimated that about one-half the total production of plant residues from agriculture and industrial processes remains unused and burdens the environment (Mojeed *et al.,* 2015). Chang *et al.* (2015) noted that all agricultural production from plant crops generated enormous waste, because little of each crop was actually used; typically 80-90% of the total biomass of agricultural production is discarded as waste and this is because only part of the organic matter synthesized through photosynthesis every year is directly edible in the form of fruits, vegetables and food grains and assumes various forms, such as inedible sugarcane bagasse and corn cobs.

The handling and disposal of these lignocellusic residues are often problematic due to their chemical structure and decomposition properties. Lignocellulosic biomass is not only a renewable resource but also the most abundant source of organic components in high amount on the earth. However, various problems associated with the practical utilization of these materials have not yet been solved (Philippoussis *et al.*, 2011). One of the key problems hindering the effective utilization of this renewable resource as raw material for chemical reactions and feeds is the low susceptibility of lignocellulose to hydrolysis, which is attributable to the crystalline structure of cellulose fibrils surrounded by hemicellulose and the presence of the lignin seal which prevents penetration by degrading enzymes (Huang *et al.*, 2015). Production of edible or medicinal mushroom is an example of agro-waste biodegradation (Shrivastava *et al*., 2011; Ghorbani *et al*., 2015).

Biodegradation of Lignocelluloses Materials

Lignocellulose is a complex substrate and its biodegradation is not dependent on environmental conditions alone, but also the degradative capacity of the microbial population (Waldrop *et al*., 2014). The composition of the microbial community charged with lignocellulose biodegradation determines the rate and extent thereof (Stefan *et al*., 2018). The concerted actions of enzyme systems possessed by these microbial communities are required for complete hydrolysis and utilization of lignocellulosic materials (Waldrop *et al*., 2014). Lignocellulose degradation is essentially a race between cellulose and lignin degradation (Rai *et al.*, 2015).

Lignocellulose-degrading fungi are divided into three major groups. These groupings depend on the type or morphology of rot they cause in the material (substrate). Thus we have white-rot, brown-rot and soft-rot fungi (Steffen, 2015). Of these groups, the white-rot fungi are the most rapid and extensive lignin degraders (Isroi *et al*., 2011; Yago *et al.*, 2015). The white-rot group of fungi is heterogeneous by nature, classified in the division Basidiomycota. They are obligate aerobes deriving their nourishment from thebiological combustion of wood or lignocellulosic materials using molecular oxygen as a terminal electron acceptor (Makela and Minou, 2014). Different white-rot fungi vary considerably in the relative rates at which they attack lignin and carbohydrates in lignocellulose or woody tissues. The white-rot type exhibit two gross patterns of decay: a) selective decay, where lignin and hemicellulose are degraded significantly more than cellulose, and b) non-selective (i.e. simultaneous) decay, where equal amounts of all components of lignocellulose are degraded (Yago *et al.,* 2015; Tamilarasan *et al.,* 2017). Some examples of white-rot fungi are *Planerocheate chrysosporium, Phellinus nigrolimitatus, Ceriporiopsis subvermispora, Phlebia radiate, Formes fomentarius, Pleurotus ostreatus,* etc. Nowadays, the most extensively used agro-wastes for production of edible mushrooms are wheat or rice straw, sawdust or wood chip, sugarcane bagasse, cotton waste and cotton seed hull, corn cob, rice or wheat bran, chicken or horse manure. Other green materials, such as cotton stalk and soybean straw, coffee pulp etc. have also been used or tried for growing edible mushrooms in some countries (Pandey *et al*., 2013). Although many scientific research work have been conducted to determine the potential of biodegradation ability of *Pleurotus ostreatus* on mixture of agro-wastes. However, further research work is required to investigate the biodegradation potentials of thefungus on specific lignocelluloses agro-wastes.

Materials and Methodology

Autoclave, gas cylinder, polyethylene waterproof bags, wire loop, forceps, rubber ban, weighing balance, plastic bath, aluminium foil paper, masking tape, cotton wool, iron box, 2 inches plastics pipes, measuring tape, hut and wire gauge.

Substrate Preparation

The substrates (Cassava peels, Yam peels, banana leaves, Saw dust, and Groundnut shells) were gotten, dried, and shredded. Three (3) kg of each of the substrates were weighed differently and mixed with 30g of $CaCO_3$ and 20g of $CaSO_4$. $CaCO_3$ (lime) minimize the slippery nature that compost normally tend to have. $CaSO_4$ (gypsum) fortify the substrates. Water was added to soak the substrates and mixed until 64% moisture content was achieved. The wetted substrates were bagged in polyethylene bags in triplicates, corked and wrapped with aluminium foil paper. The aluminium foil paper is to protect the polyethylene bags from melting during sterilization in the autoclave (Fanadzo *et al*., 2010).

Sterilization

The bagged substrates were sterilized in autoclave for 15 minutes prior to inoculation at the temperature of 121ºC (Falana *et al*., 2011).

Inoculation of the substrate

Following sterilization, inoculation of ramified bottle spawns was done aseptically into the sterilized and cold bags of substrates. The spawned bags were placed in disinfected iron box, covered with the lid and placed in the hut. The hut floor was flooded with water morning and evening to keep the temperature low and the humidity high. The mycelium colonised the substrates within three weeks (Zenebe *et al.,* 2016). This is commonly referred to as the spawn run, during spawn run the mycelium grows through the substrate. The spawn run time depend on the size of the bag, amount of spawn used, the strain used and the temperature.

Proximate analysis

All the moisture, fat, ash, protein and carbohydrate content were determined by the guideline given by Association of Official Analytical Chemists (AOAC 2016).

Statistical analysis

All experiments were carried out in triplicates. Data obtained were analyzed by one-way analysis of variance (ANOVA) and means were compared by Duncan's New Multiple Range test (SPSS 21.0 version). Differences were considered significant at $p<0.05$.

Results and Discussion

The degradation of Cassava peels (CP), Banana leaves (BL), Sawdust (SD), Yam peels (YL) and Groundnut shells (GS) starts with the breakdown of polysaccharides into oligosaccharides short chains and later hydrolyzed by glycosidase into their component monomer. The metabolism of these monomers releases energy and carbon for the growth of the microorganism as reported by Dereje (2013). The appearance of the fungi mycelia on the substrates after forty-eight (48) hours was an indication that degradation has commenced. This was inline with Oluchukwu and Ugwuoke (2015) thus confirms suitable environmental condition for the fungi.

Proximate composition of substrates

Pleurotus species have the potential to convert these agro-wastes into valuable protein at a low cost (Vijay *et al*., 2011). Lateef *et al*. (2016) studied the effect of solid-state fermentation of some agro-wastes with the fungus *Rhizopus stolonifer* and the protein contents of the substrates increased significantly up to 94.8%. Yang *et al*. (2017) also reported an increase of Crude protein content up to 60.9 % after the harvest of mushrooms from the residual substrate.
In this research protein content of Cassava peels, Banana leaves, Sawdust, Yam peels and Groundnut shells were measured of the raw samples before degradation with the organism and the values are presented as this 3.40, 10.80, 0.98, 6.03 and 16.69 (%) respectively. The crude protein content of substrates increased significantly ($P< 0.05$) with degradation following degradation with *Pleurotus ostreatus*. The substrates had an improvement in the protein level of 5.10, 13.29, 2.49, 8.44 and 28.29 percent respectively at the end of the 4 weeks of degradation (Table 3.1 and 3.2). The higher initial crude protein value for Groundnut shells might be due to the fact that it is a leguminous crop residue since legumes have high protein levels. Optimum fermentation period occurs after complete colonization of the substrates by the organism (Nortey *et al*., 2015). The increase in crude protein may be due to the addition of fungal protein or the bioconversion of carbohydrates in the colonized substrates into mycelia protein or single cell protein (SCP) by the growing fungus during the degradation process (Iyayi, 2014). It may also be partly due to the secretion of some extracellular enzymes such as cellulases and amylases by the fungus in an

attempt to use cellulose and starch as sources of carbon (Oboh *et al*., 2013; Raimbault, 2016). In general, the observed increases in crude protein content are indications of the positive effects that *Pleurotus ostreatus* and other fungi species have on cheap lignocellulosics and low-grade agro-wastes, transforming them into protein-rich products at low cost (Vijay *et al.,* 2011; Ojo-Omoniyi *et al.,* 2016; Miszkiewicz *et al.,* 2016; Sadh *et al.,* 2018). Ash constitutes on the average 12 to17% of plant biomass (Akinfemi and Mako, 2012; Kim *et al.,* 2016). The ash content of all the *Pleurotus ostreatus* degraded samples increased significantly ($P < 0.05$). The initial values in the substrates were 6.30, 6.77, 2.95, 4.45 and 4.13 percent whereas 9.75, 8.97, 6.19, 4.92 and 8.35 percent after the four (4) weeks of degradation for Cassava peels, Banana leaves, Sawdust, Yam peels and Groundnut shells respectively (Table 3.1 and 3.2). These increments could be attributed to the fact that the mycelia of the fungus had enriched the mineral content of the substrates (Bano *et al.,* 2010). Similar results were also reported by other workers (Joseph, 2011; Asmah, 2013; Nortey *et al*., 2015) who found various levels of increases in ash during *Pleurotus ostreatus* fermentation of corncobs and cocoa pod husk (CPH), rice straw (RS) and groundnut shells (GS) respectively. This proves that the *P. ostreatus* had a positive influence on the substrates by causing significant changes in the degraded substrates. Crude fibre constitutes on the average 30 to 36% of plant biomass (Akinfemi and Mako, 2012; Kim *et al.,* 2016). Lateef *et al*. (2016) studied the effect of *Rhizopus stolonifer* LAU 07 on cocoa pod husk (CPH), cassava peel (CP), and palm kernel cake (PKC) and discovered that the crude fibre contents decreased by 7.2%, 8.6% and 44.5% in CPH, CP, and PKC, respectively after the fermentation. In this research, the crude fibre (CF) content of the *Pleurotus ostreatus* degraded samples decreased significantly ($P < 0.05$) from 11.45 to 9.25 for cassava peels, 28.54 to 22.45 for banana leaves, 30.47 to 24.21 for sawdust, 9.02 to 7.45 for yam peels and 16.20 to 12.22 respectively at the end of the four (4) weeks of degradation period (Table 3.1 and 3.2). The decrease in crude fibre levels is supported by Kutlu *et al*. (2012) and Nortey *et al.* (2015) who reported a reduction in crude fibre levels in the substrates they degraded with *P. ostreatus*. The reduction in the crude fibre content could possibly be due to the action of the enzymes secreted by the fungus, as suggested by Miszkiewics *et al*. (2016). During biodegradation the enzymes secreted by the fungus break down polysaccharides into less complex structures (Dereje, 2013).

Lignocellulosic degradation with *Pleurotus ostreatus*

The cell wall fraction includes hemicellulose, cellulose, lignin, cutin and silica. In most crop residues, the cell wall fraction accounts for 60-80% of dry matter (Xing, 2016). Cellulose constitutes on the average 30 to 50% of plant biomass, whiles lignin forms 4.5 to 13.7% of plant biomass (Akinfemi and Mako, 2012; Kim *et al*. 2016). As microbes grow under conditions closer to their natural habitats, they become more capable of producing enzymes such as proteases, cellulases, lignases, xylanases, pectinases and amylases (Jecu, 2014). Generally there were significant decreases in the levels of lignocellulose fractions in all the substrates. Vijay *et al*.

(2011) stated that most *Pleurotus* species possess the ability to degrade lignin, cellulose and hemicellulose. Rolz *et al*. (2014) reported that fungi (particularly white-rots) have the enzymatic potential to use lignocellulose component as sources of carbon and energy. This results in biomass breakdown and lignin removal, accompanied by the removal of polysaccharides. Thus the results obtained in this work are in agreement with those of other researchers (Table 3.3 and 3.4).

Generally the reductions were significantly different ($P < 0.05$) for all the substrates within the period of four (4) weeks of degradation. The percentage decreases are shown in Table 3.3 and 3.4. The reduction in levels of cellulose might be due to the activities of extracellular fungal hydrolases (collectively known as cellulases) that degrade cellulose materials (Datta and Chakravarty, 2015).

The hemicellulose content of all the substrates decreased significantly ($P < 0.05$) with degradation time. Hemicellulose level reduced from 23.90 to 18.88%, 28.56 to 24.04%, 26.75 to 24.66%, 21.98 to 16.23%, and 17.86 to 14.16% for Cassava peels, Banana leaves, Sawdust, Yam peels and Groundnut shells respectively (Table 3.3 and 3.4). These reductions may be due to the activities of hemicellulolytic enzymes secreted by *P. ostreatus* on the substrates. *P. ostreatus* species have the ability to produce enzymes that are capable of breaking down a variety of β-(1,4) linked glucan substrates as well as glycosides. The results are in agreement with previous studies on various agro-wastes which reported 20-45% reduction in hemicellulose (Nortey *et al.,* 2015).

The levels of lignin of degraded samples reduced significantly ($P < 0.05$) with degradation period. Cassava peels, Banana leaves, Sawdust, Yam peels and Groundnut shells recorded 7.50 to 3.75, 15.42 to 9.33, 25.53 to 19.00, 5.24 to 3.19 and 18.52 to 11.78 percent reductions respectively at the end of the four (4) weeks of degradation (Table 3.3 and 3.4). According to Brimpong *et al*. (2017), *P. ostreatus* inoculation decreased lignin content of corn cobs by 42.3% at the end of the degradation period. According to Argyropoulos and Menachem (2011), lignin impedes the biological degradation of cellulose and hemicelluloses. Therefore the extent of lignin degradation recorded suggests the availability of cellulose and hemicelluloses for the fungus to easily break down and subsequently utilize**.** Extracellular enzymes produced by the *P. ostreatus* oxidise both the aromatic rings and the aliphatic side chains of lignin to produce low-molecular weight products that can easily be absorbed by the fungus (Lo *et al*., 2010).

Table 3.1: Proximate composition of substrates before degradation with *Pleurotus ostreatus*

	SUBSTRATES				
Parametres	**C P**	**B L**	**S D**	**Y P**	**G S**
MC (%)	10.10	7.28	4.13	10.26	5.67
DM (%)	89.90	92.72	95.87	89.74	94.33
CP*(%)	3.40	10.80	0.98	6.03	16.69
LP (%)	0.98	5.20	0.23	3.00	2.28
ASH (%)	6.30	6.77	2.95	4.45	4.13
CHO (%)	54.48	54.20	56.42	55.55	55.74
CF (%)	11.45	28.54	30.47	9.02	16.20

Keys: MC = Moisture content,DM = Dry matter, CP* = Crude protein, LP = Lipid, ASH = Ash content, CHO = Carbohydrate, CF = Crude fibre, = Cassava peels, BL = Banana leaves, SD = Saw dust, YP = Yam peels and GS = Groundnut shells.

Table 3.2: Proximate composition of substrates after degradation with *Pleurotus ostreatus*

	SUBSTRATES				
Parametres	**C P**	**B L**	**S D**	**Y P**	**G S**
MC (%)	13.34	11.20	8.61	14.03	11.90
DM (%)	86.66	88.80	91.39	85.97	88.10
CP* (%)	5.10	13.29	2.49	8.44	18.29
LP (%)	2.10	5.54	1.77	3.64	5.47
ASH (%)	9.75	8.97	6.19	4.92	8.35
CHO (%)	52.47	52.02	54.54	55.28	53.29
CF (%)	9.25	22.45	24.21	7.45	12.22

Keys: MC = Moisture content,DM = Dry matter, CP* = Crude protein, LP = Lipid, ASH = Ash content, CHO = Carbohydrate, CF = Crude fibre, CP = Cassava peels, BL = Banana leaves, SD = Saw dust, YP = Yam peels and GS = Groundnut shells.

Table 3.3: PercentageLignocellulosic content of the substrates before degradation with *Pleurotus ostreatus*

	SUBSTRATES				
Parametres	**C P**	**B L**	**S D**	**Y P**	**G S**
NDF (%)	35.60	61.10	91.45	38.08	77.85
ADF (%)	23.90	38.70	85.37	23.59	60.00
CEL (%)	37.90	53.45	50.80	28.25	41.48
HEM (%)	23.90	28.56	26.75	21.98	17.86
ADL (%)	7.50	15.42	25.53	5.24	18.52

Keys: NDF = Neutral detergent fibre,ADF = Acid detergent fibre, CEL = Cellulose, HEM = Hemicellulose, ADL = Acid detergent lignin, CP = Cassava peels, BL = Banana leaves, SD = Saw dust, YP = Yam peels and GS = Groundnut shells.

Table 3.4: Percentagelignocellulosic content of the substrates after degradation with *Pleurotus ostreatus*

	SUBSTRATES				
Parametres	**C P**	**B L**	**S D**	**Y P**	**G S**
NDF (%)	31.44	54.24	76.74	31.97	71.90
ADF (%)	17.22	28.20	66.80	16.88	47.26
CEL (%)	29.82	49.80	47.25	20.78	35.48
HEM (%)	18.88	24.04	24.66	16.23	14.16
ADL (%)	3.75	9.33	19.00	3.19	11.78

Keys: NDF = Neutral detergent fibre,ADF = Acid detergent fibre, CEL = Cellulose, HEM = Hemicellulose, ADL = Acid detergent lignin, CP = Cassava peels, BL = Banana leaves, SD = Saw dust, YP = Yam peels and GS = Groundnut shells.

Table 3.5: Carbon-Nitrogen ratio and pH of the substrates before degradation with *Pleurotus ostreatus*

Substrates	C (%)	N (%)	C:N	pH
Cassava peels	54.48	3.40	16.0:1	7.1
Banana leaves	54.20	10.80	5.0:1	4.9
Saw dust	56.42	0.98	57.6:1	7.1
Yam peels	55.55	6.03	9.2:1	6.9
Groundnut shells	55.74	16.69	3.3:1	5.8

KEYS: C = Carbon content, N = Nitrogen content and C:N = Cabon-Nitrogen ratio.

Table 3.6: Carbon-Nitrogen ratio and pH of the substrates after degradation with *Pleurotus ostreatus*

Substrates	C (%)	N (%)	C:N	pH
Cassava peels	52.47	5.10	10.3:1	3.5
Banana leaves	52.02	13.29	3.9:1	4.2
Saw dust	54.54	2.49	21.9:1	3.6
Yam peels	55.28	8.44	6.6:1	5.8
Groundnut shells	53.29	18.29	6.3:1	3.2

KEYS: C = Carbon content, N = Nitrogen content and C:N = Cabon-Nitrogen ratio.

Carbon-Nitrogen ratio of the substrates before and after degradation by *Pleurotus ostreatus*

Organisms use carbon for energy and nitrogen for protein to grow and reproduce. Carbon and nitrogen levels vary with each organic material. Carbon-rich materials tend to be dry and brown such as leaves, straw, and wood chips. Nitrogen materials tend to be wet and green such as fresh grass clippings and food waste (Siqueira *et al.,* 2011).A previous analysis of the raw materials is important in order to identify their contents carbon and nitrogen (Carvalho *et al.,* 2010).
There was a steady decrease in carbon content and increase in nitrogen content which also led to a steady decrease in the C/N ratio after degradation by *P. ostreatus* for all the substrates in this work. The C/N ratio analysis in this research of the substrates before degradation by *Pleurotus ostreatus* showed that the concentrations ranged from 3.3 to 57.6:1 (Table 3.5). This finding is in contrast with Carvalho *et al.,* 2010 who stated for oyster mushroom cultivation, the initial C/N ratio ranges from 80 to 100/1 when carried out under natural conditions. Spent mushroom substrates (after degradation by *Pleurotus ostreatus*) C/N ratio ranged from 3.9 to 21.9:1 (Table 4.6) for this research. This is inline with the previous work of Carvalho *et al.,* 2012. C/N ratios required are narrower in the axenic cultivation.

Conclusion

Pleurotus ostreatus has a great potential of degrading wide variety of agro-industrial wastes. They secrets extra-cellular enzymes (cellulase, lignicellulase, laccase, phenol oxidase) that act on the agro waste material to degrade them and yielding a desirable products. The inoculation of *Pleurotus ostreatus* on agricultural wastes will go a long way in removing large tones of these agro-wastes thereby restoring the aesthetic beauty of our ecosystem.

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