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Biodegradation of Water hyacinth (*Eichhornia crassipes* Mart. Solms-Laubach) into valued added ruminant feed using White rot Fungi

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Abstract:
A 40 day experiment was carried out on the biodegradation of water hyacinth (WH) into value added ruminant feed using two white rot fungi (*Pleurotus florida* (PF) *and Pleurotus sajor caju* (PS)) in a Solid State Fermentation. The chemical composition and *in vitro* gas production degradability of the substrates were determined.

Results revealed that crude protein (CP) increased significantly ($p<0.05$) from 11.65% in untreated WH to12.86% and 14.38% in WH treated with PF and PS respectively. Same trend was observed for ether extract and ash. However, the Crude fibre (CF) decreased significantly from21.23% in untreated WH to 18.23 and 15.25% in WH treated with PF and PS respectively.

The estimated *in vitro* gas production parameters also ranged significantly ($p<0.05$) except for Short Chain Fatty Acids (SCFA) that was not significantly different. It was observed that the fungi treatment enhanced Organic matter digestibility (OMD) and metabolizable energy (ME) compared with the untreated WH. The OMD increased from 48.50% in untreated WH to 52.12% and 53.89% in WH treated with PF and PS respectively, while the ME ranged from 5.68 MJ/Kg DM in untreated WH to 7.56 and 8.39 MJ/Kg DM in WH treated with PF and PS respectively. Gas production increased significantly as the hour of incubation progressed. Methane production decreased significantly from 4.00ml/200mg DM in untreated WH to 2.50 and 2.00 ml/200mg DM in WH treated with PF and PS respectively.

This study reveals that fungi treatment of WH enhanced chemical composition and in vitro degradability. Hence biodegradation of WH will fill the gap for scarcity of feed during the off season and enhance sustainable ruminant production in water hyacinth endemic areas.

Key words: Biodegradation, nutritive value, Solid State Fermentation white rot fungi, water hyacinth

Introduction

Water hyacinth is an aquatic plant that has been described as the most troublesome weed in the world (Mako, 2009), ISSG (2005) called it the ''World's worst invader'' because of its rate of multiplication. It contained nutrients that can meet the requirements of livestock especially ruminants (Akinwande, 2011). The biological value of its protein is as high as that of conventional forages (Mako 2009). It contain considerable quantities of cellulose and hemicellulose that can potential source of energy for ruminant animals. The constraint of water hyacinth in animal nutrition is poor feeding value attributed to low digestibility of dry matter due to poor degradation of lignin-cellulose complex (LC) during rumen digestion. Solid State Fermentation of LC materials is receiving more attention because it resembles the natural conditions under which fungi grow on LC. Hence the need to biodegrade water hyacinth. White –rot fungi has been reported to increase the digestibility of LC substrates (Mukherjee et al 2004)

Therefore the aim of this study is to use different white rot fungi (*Pleurotus florida* and *Pleurotus sajor-caju*) to improve the nutritive value of water hyacinth in order to enhance digestibility of the plant

Materials and methods

Sample collection

Water hyacinth was harvested from river Majidun in Odogbolu local government area of Ogun State. The roots were discarded, then the plant was thoroughly washed and chopped, sundried to remove moisture, then oven dried at 65^{0}C until a constant weight was obtained for dry matter determination

The fungus

The sporophores of *Pleurotus florida* and *Pleurotus sajor-caju* growing in the wild were collected from University of Ibadan botanical garden. These were cultured to obtain fungal mycelia (Jonathan and Fasidi, 2001). The pure culture was maintained on plate of potato dextrose agar (PDA).

Degradation of water hyacinth by Pleurotus florida and Pleurotus sajor caju

The jam bottles used for this study were thoroughly washed, dried for 10 min at 100^{0}C. 25.00g of sun-dried milled water hyacinth were weighed into each Jamb bottle and 70ml distilled water was added. The bottle was covered immediately with aluminium foil and sterilized in the autoclave at 121^{0}C for 15 min. Each treatment was replicated thrice.

Inoculation

Each bottle was inoculated at the centre of the substrate with mycelia disc and covered immediately. The inoculated substrates were kept in the dark cupboard in the laboratory at 30 ^{0}C and 100% RH. After 40 days of inoculation, the experimental bottles were harvested by autoclaving again to terminate the mycelia growth. Samples of the biodegraded substrates were oven dried to constant weight for chemical analysis and *in vitro* digestibility.

In vitro gas production

Carried out as reported by Menke and Steingass (1988)

Chemical composition

DM was determined by oven drying the milled samples to a constant weight at 105^{0}C for 8hours. Crude protein was determined as Kjadhal nitrogen x 6.25.Ether extract and ash were determined according to (AOAC 2012) method.

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and mean separation was by Duncan multiple range tests using SAS (2012) package

Results and discussion

Table 1: Chemical composition (%) of biodegraded water hyacinth

Parameters	WHUT	WHPF	WHPS	SEM
Dry matter	77.90	76.82	77.73	2.20
Crude protein	11.65^{c}	12.86^{b}	14.38^{a}	1.20
Crude fibre	22.13^{a}	18.23^{b}	15.25^{c}	2.13
Ether extract	2.24^{c}	2.62^{b}	3.13^{a}	0.11
Ash	16.81^{c}	17.35^{b}	17.82^{a}	0.20

$^{abc=}$mean onthe same row with different super script differed significantly (p<0.05)
WHUT= water hyacinth untreated; WHPF= water hyacinth treated with *Pleurotus florida*
WHPS= water hyacinth treated with *Pleurotus-sajor-caju*

Table 2: *In vitro* gas parameters of biodegraded water hyacinth

Parameters	WHUT	WHPF	WHPS	SEM
ME (MJ/Kg DM)	5.65^{c}	7.56^{b}	8.39^{a}	0.50
OMD (%)	48.52^{c}	52.12^{b}	53.89^{a}	2.25
SCFA(µmol)	0.52	0.54	0.55	0.10
CH_4 (ml/200g DM)	4.00^{a}	2.50^{b}	2.00^{c}	0.20

$^{abc=}$mean on the same row with different super script differed significantly (p<0.05)
ME= metabolizable energy; OMD=organic matter digestibility; SCFA=short chain fatty acid;
CH_4= methane

Table 1 presents the chemical composition of treated and untreated water hyacinth leaf and stem. The result revealed significant (p<0.05) increase in crude protein contents of treated water hyacinth compared to untreated WH. It ranged from 11.65% in untreated WH to 12.86% and 14.38% in WH treated with PF and PS respectively. These values are higher than value range of 2.2 to 10.3 and 1.9 to 8.9% reported for WH treated with PS and *Pleurotus ostreatus* respectively (Mukherjee *et al.*, 2004). This is in agreement with findings of Ramirez- Bribiesca *et al* (2010) who reported increase in CP content of corn straw treated with *P.ostreatus*. Increase in CP content could be attributed to secretion of extracellular enzymes and synthesis of mycelia protein as degradation progressed (Mukherjee *et al.*, 2004). Although several species of higher fungi possess ligninolytic activity, *Pleurotus* spp. is the most studied fungi since they improved digestibility (Kundu *et al.*,2005). Same trend was observed for and ash, it ranged from 16.81% in untreated WH to 17.35and 17.82% in WH treated with PF and PS respectively, since ash determination is a measure of mineral level, it can be inferred that Solid State Fermentation (SSF) contributed to the elevation of mineral levels in the fermented WH. Similar improvement of ash and ether extract content during SSF has been reported by Shamin et al., (2017). However, there was significant decrease in the crude fibre content ranging from 22.13% in untreated WH to 18.23 and 15.25 and in WH treated with PF and PS respectively. This also corroborates the findings of Mahesh and Mohini (2013). *P.sajor-caju* showed maximum increase in CP, ether extract and ash enrichment. This agrees with the findings of Mukherjee *et al.*, (2004).

Table 2 shows the estimated gas production parameters of treated and untreated WH. No significant difference was observed for SCFA, this agrees with report elsewhere (Akinfemi *et al.*, 2009). SCFA is an end product of carbohydrate fermentation and this contributes to the energy supply for the host animal (Hoffman et al., 2005). OMD varied significantly ($p<0.05$) ranging from 48.50% in untreated WH to 52.12 and 53.89% in WH treated with PF and PS respectively. Same trend was observed for ME, the lowest value (5.68 MJ/Kg DM) in untreated WH is similar to value reported for WH elsewhere (Mako, 2009). The increased value of 7.56 and 8.39 MJ/Kg DM was obtained in WH treated with PF and PS respectively. The extensive degradation of crude fibre and hence, the fibre fractions by the fungi most likely contributed to the increased ME. Methane decreased significantly from 4.00ml in untreated WH to 2.50 and 2.00ml in WH treated with PF and PS, although methane production indicates energy loss to the animal, it was observed that fungi treatment suppressed methane production. This agrees with the findings of Akinfemi (2010).

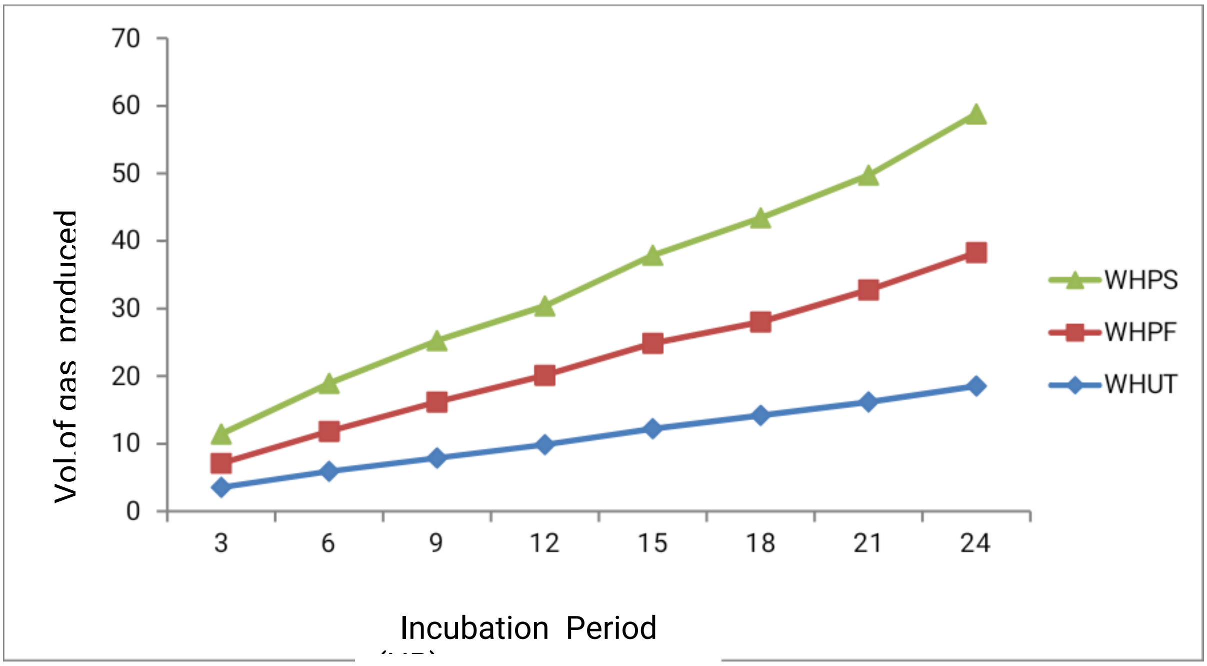

Fig1 : Gas production of biodegraded water hyacinth

Presented in Fig 1, is the cumulative gas production obtained from treated and untreated WH. Gases produced during fermentation are waste products and of no nutritive value to ruminants, but gas production tests are routinely used in feed research as gas volumes are related to both the extent and rate of substrate degradation (Blummel *et al.*, 1997). The highest (20.37ml) gas produced was obtained in WH treated PS followed closely by WH treated with PF (19.77ml) compared to the value of 18.31ml obtained in untreated WH. This is expected since gas production has positive correlation with crude protein (Sallam *et al.*, 2007). Hence fungi treatment enhanced value addition of water hyacinth.

Conclusion

Biological treatments can be employed for improving the feeding value of low quality feed resources, as revealed in this study. *Pleurotus spp* added value to water hyacinth.

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