Cultivation of oyster mushrooms (*Pleurotus* species) to improve the *in vitro* dry matter digestibility of wheat straw for feeding to ruminants

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Introduction Wheat straw is an underutilized energy resource for animals: it is indigestible and has a low protein content. Most methods for improving the digestibility are not cost effective or have potential health and environmental hazards. This paper focuses on using a biological pre-treatment with *Pleurotus* spp, lignin degrading white-rot fungi, to improve wheat straw from low to high available energy feed. *Pleurotus* spp. are able to degrade the lignin in a selective way (Kerem & Hadar, 1993) thus making cellulose available for ruminants. *Pleurotus* spp. are widely cultivated worldwide to produce oyster mushrooms and have a high protein content, are free from cholesterol and are rich in carbohydrates, fibre, vitamins and minerals (Kues & Liu, 2000). *Pleurotus* spp. also have a medicinal potential. The aims of this study were to investigate the ability of different *Pleurotus* spp. to increase the protein content, degrade lignin and improve digestibility of the wheat straw. Production of edible mushrooms was also considered.

Material and methods Five *Pleurotus* spp. were screened for their ability to increase the protein content, degrade lignin and improve digestibility of wheat straw. Four of the *Pleurotus* strains used came from local resources (*P. ostreatus*: P. ost x TW, P. ost x TG, Po x K; *P. florida*) and 1 commercial strain of *P. pulmonarius* was purchased (Mycelia, Ghent, Belgium). Wheat grain was infected to inoculate straw. Straw was chopped into lengths of 3-5 cm and soaked in water for 20 mins and left to drain. Culture bags were each filled with 1 kg of soaked straw and a microelement solution was added (Per bag: $ZnSO_4.7H_2O$: 0.017 mg, $MgSO_4.7H_2O$: 0.32 mg and $CuSO_4$: 0.025 mg). Bags were autoclaved sterilised and inoculated by adding 60 g of colonised grain. Bags were sealed and incubated for 19 or 42 days in total, in duplicate. Those which were incubated for 42 days in total were incubated for 19 days for colonisation at 22 °C, 65% relative humidity, 1 day cold shock at 10 °C and 22 days fruiting at 24 °C, 75% relative humidity with a 10 hours per day light cycle (470-700 nm). In the final stage pinholes were made in bags to support air exchange and this allowed emergence and proper development of fruit bodies. The other set of bags were incubated for 19 days as above. For each treatment, 2 bags without fungal inoculation were used as controls. Crude protein, and lignin content were determined (Halliday 1985), while the Modified Faeces Liquor technique (Omed *et al*. 1989) was used for digestibility estimation. The statistical analysis was performed using SPSS 14.2.

Results During the experiment all strains produced fruit bodies, but not all fruiting bodies reached the point of harvest at the experiment end. Increases in digestibility and crude protein were highly significant (p=0.000), especially after 42 days incubation but lignin decreases were not (p=0.386) (Tables 1-3).

Table 1 Relative increase compared to control, *statistically different from the control (p<0.01))

Strain	Digestibility (%)		Crude protein (%)		Lignin (%)	
	19 days	42 days	19 days	42 days	19 days	42 days
P. ostreatus x TG	23.92	103.77*	54.94 *	141.55*	7.61	20.93
P. ostreatus x TW	9.57	91.19*	55.64 *	128.97*	20.41	6.5
P. ostreatus x K	50.25 *	125.78 *	83.75*	121.38*	13.77	19.63
P. pulmonarius	57.41*	125.78*	66.80*	69.22*	13.30	13.72
P. florida	19.13	116.35 *	71.45*	160.81*	9.08	9.95

Table 2 Pooled SEM

Treatment	Pooled SEM for IVDMD (%)	Pooled SEM for crude protein (%)	Polled SEM for Lignin (%)
19 days	1.0775	0.055	0.45
42 days	0.9601	0.064	0.78

Table 3 P value for the effect of straw source, Pleurotus species, and interaction between straw source and *Pleurotus* species.

Analysis	Effect of straw source	Effect of *Pleurotus* spp.	Effect of straw source and *Pleurotus* spp.
Protein	p=0.000	p=0.000	p=0.000
Lignin	p=0.03	p=0.94	p=0.356
Digestibility	p=0.000	p=0.000	p=0.000

Conclusions This study showed that with fungal treatment it was possible to achieve increase in digestibility with small reductions in total lignin content (2-5% lignin). Combined with this were significant crude protein increases. These improvements increased with longer incubation periods. However the extent of the changes in digestibility, crude protein and lignin content was strain specific. The current research demonstrated that it is possible significantly increase digestibility, protein content of wheat straw and produce edible fruit bodies at the same time. It can be also assumed that feeding animals with protein enriched substrate and transformed substrate will not only constitute feed but may also be beneficial due to the immuno-stimulation properties of *Pleurotus*. The cultivation of *Pleurotus* species is also an economically sound strategy to convert agro-residues into nutritional foods and medicinal products.

References

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