Cibtech Journal of Zoology ISSN: 2319–3883 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/cjz.htm
2015 Vol. 4 (2) May-August, pp.76-82/Hadizadeh et al.

Research Article

EVALUATION THE NUTRITIONAL VALUE AND DIGESTIBILITY OF RICE STRAW ENRICHIED BY OYSTER MUSHROOM (*PLEUROTUS FLORIDA*)

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ABSTARCT

The objective of this study was to evaluate the nutritional values and digestibility of rice straw enriched by oyster mushrooms (*Pleurotus florida*). The mushrooms spawns were prepared in polythene packets from Agriculture and Natural Resources Research Center, Kerman, Iran. Rice straw were boiled in water bath for 10-15 min and packed in polythene bags and then mixed with the spawns. Protein, fat, ash and organic matters were determined with the procedure recommended by AOAC. The crude fibers and calcium was determined with procedure recommended by Ranganna . Also NDF and ADF were determined by Van Soest method. For evaluation digestibility and nutritional values of enriched rice straws we used A) Laboratory (*in vitro*) and B) Gas production (*in vivo*) methods. The GLM procedure of SAS was used for data analysis of variance as completely randomized design and the significant difference among the mean were calculated by T. test multiple range tests. Data from chemical composition showed that DM would be increased by enrichment rice straw. Although OM, NDF, ADF and CF were tended to decrease but also CP was higher than base rice straw significantly. Data for crude ash showed that CASH was higher on enriched rice straw than its base form. These result showed that there were significant differences between dry mater for base and enriched rice straw. Data from this study showed that there were significant differences between dry mater and organic matter between treatments. Also we demonstrated that enrichment by *Pleurotus florida* could increase DM, OM, OM/DM and Metabolizable energy of rice straw none significantly. Enriching rice straw by *Pleurotus florida* decreased the averages of effective degradation of dry matter and they were differenced with rates of passage at 2, 4, 6 and 8 hours. We could explain that the enrichment of rice straw with *Pleurotus florida* could beneficial effect on digestibility, degradability and could increase the nutritional values of rice straws compared to base rice straws.

Keywords: *Rice Straw, Pleurotus Florida, Digestibility, Nutritional Value, Degradability*

INTRODUCTION

Rice straw is the vegetative part of the rice plant (*Oryza sativa*, L.), cut at grain harvest or after. It may be burned and left on the field before the next ploughing, ploughed down as soil improver or used as a feed for livestock (Kadam *et al.*, 2000). Rice straws contain only 3 to 5 percent crude protein. Animals on an unsupplemented straw diet will usually not gain any weight and very often will actually lose weight. To obtain any production the straw must be supplemented, preferably with nitrogen and protein and energy. For good growth on straw diets, a level of 8 to 10 percent protein is needed for young stock; this also improves consumption and thus increases energy intake. The level of phosphorus in rice straw (0.02 to 0.16 percent) is less than the level of about 0.3 percent that animals need for growth and normal fertility. A level of about 0.4 percent of calcium in the diet is usually considered adequate for livestock, and many samples of rice straw have this amount, the range being from 0.25 to 0.55 percent (Negi, 1971). It can be treated in order to improve its nutritive value. Those treatments are designed to enhance feed intake and digestibility. In past years, several studies have been reported on the physical and chemical characterization and utilization of rice straw as ruminant feed (Vadiveloo, 2003). Rice straw is usually fed untreated without supplements in spite of the fact that many methods for improved utilization of rice straw have been developed and recommended. Improving digestibility may be achieved through mechanical, chemical, heat and pressure treatments. Mushrooms are one kind of edible fungi belonging to the genus Pleurotus under the class Basidiomycetes. Oyster mushroom (*Pleurotus florida*) is an edible mushroom having excellent flavor and taste. The quality of the waste product (rice straw) is improved due to the degradation of cellulose and hemicelluloses by mushroom enzymes and hence has been rendered more digestible. Thus rice straw is transformed to valuable roughage and mushrooms provide an additional income without an extension of the limited acreage (Mueller and Cantner, 1990). *Pleurotus florida* is suitable for bioremediation of contaminated soils because of its ability to degrade highly condensed polycyclic aromatic hydrocarbons (PAH) and its high tolerance of these substrates. The aim of this contribution is to provide an overview of existing knowledge on how to treat rice straw to increase its feed value for ruminants. The present study deals with the cultivation of *Pleurotus florida* on rice straw for conversion in food and evaluation of its effects on degradability and nutritional values for animal feed.

MATERIALS AND METHODS

Rice straws were procured from local market. The straws were washed several times under running tap water, dried in hot air oven at 50°C and cut into 1 cm pieces. This was utilized as the substrate for fungal growth.

Spawn was prepared in polythene packets from Agriculture and Natural Resources Research Center, Kerman, Iran. Rice straw were boiled in water bath for 10-15 min and packed in polythene bags (of 700 × 400 mm. size) and sterilized in an autoclave at 121°C, for 30 min. After sterilization, the bags were inoculated with actively growing mycelium of the *Pleurotus florida* from malt extract slants and incubated (at 24 ± 5°C) for mycelia growth without any light for 16 - 17 days until the mycelium fully covered the straws. After that on 18 days the samples took out and dried with oven at 60°C temperature for 48 hours and they were stamping with 1mm pores.

Chemical Analysis

Protein, fat, ash and organic matters were determined with the procedure recommended by AOAC (2000). The crude fibers and calcium was determined with procedure recommended by Ranganna (1986). Also NDF and ADF were determined by Van Soest (2006) methods.

Digestibility Determinations

A) Laboratory Method (in vitro)

The method includes two steps that suggested by (Tilley and Terry, 1963). This method includes preparation of rumen liquor, preparation of artificial saliva, aerobic and anaerobic digestion of acidic pepsin.

B) Gas Production Method (in vivo)

Incubations are performed using 30 ml of buffered rumen fluid according to Menke and Steingass (1988). Approximately 200 mg of feed is weighed and placed into a 100 ml graduated glass syringe. Pistons are lubricated with Vaseline and inserted into the syringes. Buffer and mineral solution are prepared and placed in a water bath at 39°C under continuous flushing with CO2.

Rumen fluid is collected from cows or sheep fed a high forage diet into a pre-warmed thermos flask. The rumen fluid is filtered and flushed with CO_2, and the mixed and CO_2 flushed rumen fluid is added to the buffered mineral solution (1: 2 v/v), which is maintained in a water bath at 39°C, and combined. Buffered rumen fluid (30 ml) is pipette into each syringe, containing the feed samples, and the syringes are immediately placed into the water bath at 39°C Three syringes with only buffered rumen fluid are incubated and considered as the blank.

The syringes are gently shaken every 2 h, and the incubation terminated after recording the 72 h gas volume. Total gas values are corrected for the blank incubation, and reported gas values are expressed per g of dry matter.

Statically Analysis

The GLM procedure of SAS software (SAS, 2001) was used for data analysis of variance as completely randomized design. In addition the significant difference among the mean were calculated by T. test multiple range tests (Duncan, 1995).

RESULTS AND DISCUSSION

Results

The chemical compositions of enriched rice straw by *Pleurotus florida* are shown in Table 1.

Table 1: The chemical compositions of base and enriched rice straw

Chemical composition %	**Treatments**		**SEM**	**P value**
	Base straw	**Enriched rice straw**		
DM	95.41±0.08	95.49±0.57	0.58	0.02
OM	83.50±0.05	79.60±0.10	0.72	0.02
CP	2.28±0.21	5.28±0.22	0.31	0.15
NDF	66.21±0.62	62.9±0.26	0.68	0.01
ADF	42.58±0.91	41.94±1.25	1.51	0.70
CF	1.43±0.03	1.22±0.03	0.04	0.93
CASH	16.60±0.51	18.98±0.62	0.81	0.81

Whereas: DM: Dry matter, OM: Organic matter, CP: Crude protein, NDF= Natural detergent fiber, ADF: Acid detergent fiber, CF: Crude fat and CASH: Crude ash

These result showed that DM would be increased by enrichment rice straw. Although OM, NDF, ADF and CF were tended to decrease but also CP was higher than base rice straw significantly. Data for crude ash showed that CASH was higher on enriched rice straw than it, s base form. These result showed that there were significant differences between dry mater for base and enriched rice straw.

Table 2: Evaluation digestibility and energy value of enriched rice straw (*in vitro*)

Parameters %	**Treatments**		**SEM**	**P value**
	Base straw	**Enriched rice straw**		
DM	62.15±0.42	52.48±0.57	0.70	0.70
OM	46.76±0.75	58.11±1.42	1.61	0.44
OM/DM	38.99±0.63	46.24±1.41	1.54	0.33
ME	5.80±0.10	6.51±0.18	0.21	0.47

Whereas: DM: Dry matter, OM: Organic matter, OM/DM: Organic matter per Dry matter, ME: Metabolizable energy (MJ/Kg)

Data from Table 2 showed that there were significant differences between dry mater and organic matter between treatments.

Table 3: Average volume of gas produced of enriched rice straw by *Pleurotus florida*

Incubation time (Hours)	**Gas production (Ml/200mg)**		**SEM**	**P value**
	Base straw	**Enriched rice straw**		
2	1.0±0.17	1.0±0.12	0	0.90
4	2.5±0.28	3.0±0.21	0.28	0.70
8	4.8±0.28	4.3±0.57	0.64	0.40
16	13.3±0.57	16.8±0.28	0.64	0.40
24	25.5±0.28	29.5±1.44	1.47	0.70
48	28.8±2.02	44.3±0.57	1.10	0.15
72	46.7±0.04	53.66±0.57	1.04	0.13
96	53.8±0.86	57.33+0.28	0.86	0.15
Digestibility and energy				
IVOMD	4.10±0.33	44.6±1.33	1.35	0.12
ME	5.80±0.10	6.5±0.18	0.21	0.46

Whereas: IVOMD: in vitro organic matter digestibility (%) and ME: Metabolizable energy (MJ/Kg)

Also we demonstrated that enrichment by *Pleurotus florida* could increase DM, OM, OM/DM and Metabolizable energy of rice straw none significantly. According to NDF and ADF values on those treatments we could explain that decreasing on ADF and NDF could increase digestibility and energy value for enriched rice straw with *Pleurotus florida*.
Average volumes of gas produced of rice straw and enriched rice straw by *Pleurotus florida* per 200 mg dry matter are shown on Table 3. In this study with increasing incubation time from 2 to 96 hours the volume of gas produced were increased and only a minor decrease was observed in 8 hours. We could explain that part of the high gas production was related to the relative quality and quantity of their crude protein contents.

Table 4: Average dry matter degradability on rumen of enriched rice straw by *Pleurotus florida*

Degradability parameters	**Treatments** Base straw	**Enriched rice straw**	**SEM**	**P_{value}**
a	12.3±0.91	24.6±0.23	0.94	0.12
b	45.3±18.9	68.45±0.59	18.20	0.01
a+b	57.6±0.12	93.5±0.34	0.05	0.01
c	0.008±0.002	0.02±0.001	0.002	0.33
Effective degradation				
K=0.02	28.7±1.11	33.83±0.11	1.12	0.03
K=0.04	17.05±0.73	22.12±0.14	0.75	0.08
K=0.06	12.16±0.41	15.89±0.13	0.43	0.19
K=0.08	9.42±0.22	12.16±0.18	0.29	0.83
NVI	37.84±1.34	27.98±0.23	1.36	0.06

Whereas: a: fast degradable part, b: slow degradable part, a+b: degradable part, c: degradation constant, NVI: Nutritional index value

The components degradability per 200 ml rumen liquor were determined and result showed that there were twice increasing in fast degradable parts and significant increasing in slow degradable and degradable parts for enriches rice straws. The degradation constant also showed that the act of degradation of a and b parts for enriched straws were higher compared to base straws. We also mentioned that it was related to lesser ADF and NDF content of enriched rice straws. Data from this study showed that the averages of effective degradation of dry matter were differenced with rates of passage at 2, 4, 6 and 8 hours. According to Table 4 with increasing of passage rate from 2 to 8 the effective degradation would decrease.

Discussion

The concept of preferential delignification of lignocelluloses materials by white-rot fungi has been applied to increase the nutritional value of forages (Akin *et al.*, 1995). Abd El-Rahman *et al.*, (2014) concluded that can be used biological treated straw in growing calves ration, whereas improved nutrients digestibility, body weight gain and economic efficiency on dairy cows.
These positive results could be also supported by the earlier investigations in using even raw rice straw in small or large ruminant's rations, which recorded positive improving in nutrients digestibility and nutritive value (El-Ashry *et al.,* 2002). This result may be due to the fungus depend on carbohydrates including soluble carbohydrate and crude fiber and its fraction as carbon source to produce CO_2 and energy and use this energy with nitrogen sources in the media to grow up and convert them to microbial protein. The improvement of CP content could be attributed to fungus growth (El-Ashry *et al.*, 2002). Dhanda *et al.*, (1994) found that crude protein content of spent straw increased from 3.42 to 6.19% with biological treatment. The biological treatment for rice straw reduced NDF, ADF, ADL, hemicelluloses and cellulose compared with untreated rice straw. Delignification of rough forages particularly straw were compared with chemical and biological methods by Hans *et al.,* (1992) and it was shown that chemical methods are mainly caused to loss of lignin, in biological methods not only is happened degradation of

lignin but also increased the quality and nutrient value of product. According to researchers, such as Hadizadeh (1998) and Leng (1991) the crude protein of treated straw by fungi was more than untreated straw and increasing in true protein with high quality and remaining of some vitamins in treated rough forages was the reason of degradation increasing of structural polysaccharides and microbial efficiency too. White-rot fungi, belonging to the wood decaying basidiomycetes, as lignocellulolytic microorganisms are able to decompose and metabolize all plant cell constituents (cellulose, hemicellulose and lignin) by their enzymes (Eriksson *et al.*, 1990). Karunanandaa *et al.*, (1995) reported the effect of incubation of rice straw for 30 days with three white root fungi, showing that *Pleurotus sajorcaju* enhanced IVDMD, in both leaves and stems of rice. However, entire rice straw (leaf and stem) treated with Cyathus stercoreus had the highest IVDMD compared to the other fungi. Rodrigues *et al.*, (2008) were able to extract the enzymes from white-rot fungi that are responsible for breaking down the bonds in lignin and within the matrix of cell wall carbohydrates, but without also extracting enzymes affecting hemicelluloses and celluloses. Using these enzymes on wheat straw the *in vitro* NDF degradability (IVNDFD) increased. Issaka *et al.*, (2003) showed that the crude protein of the Pleurotus treated samples increased significantly (P <0.05) by 56 - 127 % depending on type of residue. 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 by the growing fungus during the fermentation process (Iyayi, 2004). It may also be partly due to the secretion of some extracellular enzymes such as celluloses and amylases by the fungus in an attempt to use cellulose and starch as sources of carbon (Oboh *et al.*, 2002). Ortega *et al.*, (1992) reported that white rot fungi *Pleurotus ostreatus* and *Pleurotus sajorcaju* are potent to degrade lignin, cellulose and hemicellulose contents of agro-residues and having strong ligninolytic activity together with variable cellulolytic and xylanolytic action. Ferdousi and Alimun (2013) showed that the acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents of the fermented rice straw were significantly reduced in mixed culture with filamentous fungi and *Pleurotus sajorcaju.* Akindahunsi *et al.*, (1999) reported that the fermented sample was very rich in some essential minerals. Digestibility of the straw is dependent on the deploymerisation of its structural carbohydrates. Enzymatic degradation of these macromolecules in the straw will result in degradation and increase in digestibility and availability of carbohydrates (Fazaeli *et al.*, 2004). Shrivastava *et al.*, (2011) also reported significant decrease in cell wall constituents like ADF, NDF, hemi-celluloses, lignin and cellulose to the extent of 35.00, 38.88, 45.00, 37.48 and 37.86%, respectively in *Pleurotus ostreatus* fermented straw.

Conclusion

We could explain that the enrichment of rice straw with *Pleurotus florida* could beneficial effect on digestibility, degradability and could increase the nutritional values of rice straws compared to base rice straws. Also future studies are needed for more explanation.

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