Revista Mexicana de Micología
ISSN: 0187-3180
gerardo.mata@inecol.edu.mx
Sociedad Mexicana de Micología
México

Vega, Aracelly; Caballero, Rosa Elena; García, José Renán; Mori, Noboru
Bioconversion of agroindustrial residues by Pleurotus ostreatus cultivation
Revista Mexicana de Micología, núm. 20, junio, 2005, pp. 33-38
Sociedad Mexicana de Micología
Xalapa, México

## Introduction

Edible mushrooms are able to bioconvert a wide variety of lignocellulosic materials due to the secretion of extracellular enzymes [3, 11]. Literature reports that the bioconverted materials show an increase in their protein contents and a decrease in their fiber content[10,15] being possibly used as ruminant feed supplements [4, 5].

Traditionally, the evaluation of the quality of the converted materials is under the same criteria as those applied to the evaluation of conventional forages [14]. Nutrient availability is evaluated by chemical analyses such as dry matter, ash, protein, lignin, cellulose and hemicellulose determinations. Digestibility is evaluated through *in vitro* and *in vivo* assays and palatability suppose feed selection trials with whole animals [1, 8].

There is an increasing tendency to avoid animal experimentation. This implies the usage of even more indirect assays for the estimation of digestibility. For instance, Japan Livestock Technology Association recommends an enzymatic fractionation of dry matter into cell contents and cell wall. In turn, these are also fractionated in organic cell contents and organic cell wall. Cell wall is further divided into high digestibility and low digestibility fractions. Organic cell contents and the high digestibility fraction are assigned with a 100% and 95-100% digestibility respectively. Depending on the assayed material, the low digestibility fraction may have from 40% to 50% digestibility [9].

With respect to the protein content it should be quoted that most of the work in biodegradation of lignocellulosic wastes discusses the changes on the total protein content as obtained by Kjeldahl analysis. Nevertheless the protein fraction potentially available to cattle is that fraction neither covalently associated with lignin nor compromised in Maillard polymers [14]. Therefore our research group considered important to judge the quality improvement of a biodegraded substrate in terms of the available protein contents.

Large quantities of rice straw, coffee pulp and banana leaves are produced as agricultural wastes in Panama. These wastes are not well managed. Even though rice straw is known to be used in soil preparations, this application is not documented [6].

The cultivation of edible mushrooms on rice straw, coffee pulp and banana leaves may generate an additional value to fundamental produces. If the converted substrate proves to have the appropriate characteristics so as to be used in cattle feeding, then local agrobusiness would grow into a sustainable activity.

The objective of our research group was to perform a first approach on the bioconversion of the above mentioned agricultural by-products from the Republic of Panama after cultivation of a *Pleurotus ostreatus* strain.

## Materials and methods

### *Pleurotus ostreatus* cultivation

*P. ostreatus* (RN 8) was obtained from the culture collection of the Natural Resources Laboratory, Province of Chiriquí, Republic of Panama. The fungus was maintained at 23 ± 1 °C in potato dextrose agar media (PDA) with periodic transfers.

Substrates used in this experiment were rice straw, coffee pulp and banana leaves, obtained from different cultivars at the Province of Chiriqui, Republic of Panama. Spawn and substrate preparation, seeding, incubation and cropping stages were done accordingly to Guzmán *et al*. [7]. For pasteurization three baskets of 20 kg (wet substrate) were used. Each basket was divided into 10 kg sub-samples (see below for substrate sampling procedure). A 5% inoculation level was used on a total of 30 bags of 2 kg each (wet

## Results and discussion

Table 1 shows means comparison within substrates through t (student) paired test for the chemical parameters or response variables.

After 60 days of cultivation period, there was not a significant change in the available protein and hemicellulose contents for coffee pulp ($P>0.05$), whereas the C/L ratio showed a significant increase ($P<0.05$). In turn, lignin and cellulose exhibited a significant decrease ($P<0.05$).

For banana leaves, the available protein content showed a significant decrease, as well as the lignin, cellulose and hemicellulose contents ($P<0.05$). The C/L ratio did not show significant changes on this substrate ($P>0.05$).

Available protein content showed a significant decrease on rice straw ($P<0.05$), while no significant changes were seen on the lignin, cellulose and hemicellulose contents, as well as on the C/L ratio.

In terms of the chosen chemical indicators or response variables the process had an evident bioconversion effect over coffee pulp, except for the available protein and hemicellulose contents. For banana leaves, these response variables also evidenced a bioconversion process except for the C/L ratio. Results for the fibrous components for rice straw did not support a bioconversion effect. The observed decrease on the available protein showed a negative bioconversion effect over rice straw and banana leaves, since an increase in the availabe protein content may be expected after mushroom growth. A more detailed study is needed.

Present results in coffee pulp and banana leaves with respect to the lignin content could be regarded as positive from the standpoint of feed quality. Ruminants are adapted to food sources which are fiber rich. Fiber quality is judged partly in terms of the degree of delignification since lignin limits the availability of cellulose, hemicellulose and nitrogen [4, 14]. In turn, cellulose to lignin ratios can be used as delignification indicators. Our results show a positive bioconversion effect over coffee pulp in terms of fiber quality and degree of delignification.

Table 2 shows means comparison within substrates through t (student) paired tests for the digestibility response variables.

After 60 days of mushroom cultivation coffee pulp showed significant changes for OCC, OCW and Ob ($P<0.05$). These changes are positive from the standpoint of

Table 2. Digestibility response variables means and standard error within each substrate.

| Variable | Rice straw | | Coffee pulp | | Banana leaves | |
|---|---|---|---|---|---|---|
| | Fresh | Residue | Fresh | Residue | Fresh | Residue |
| OCC | $21.24\pm0.69^a$ | $35.32\pm1.92^b$ | $26.47\pm0.69^a$ | $45.88\pm1.92^b$ | $17.70\pm0.69^a$ | $51.66\pm1.92^b$ |
| OCW | $67.89\pm1.00^a$ | $51.34\pm1.55^b$ | $62.65\pm1.00^a$ | $52.26\pm1.55^b$ | $76.26\pm1.00^a$ | $56.80\pm1.55^b$ |
| $O_A$ | $2.31\pm1.37^a$ | $11.51\pm0.83^b$ | $0.42\pm1.37^a$ | $1.17\pm0.83^a$ | $0.10\pm1.37^a$ | $7.78\pm0.83^b$ |
| $O_B$ | $65.58\pm1.01^a$ | $39.82\pm1.03^b$ | $62.23\pm1.01^a$ | $51.09\pm1.03^b$ | $76.15\pm1.01^a$ | $49.02\pm1.03^b$ |
| IVDMD | $37.17\pm2.55^a$ | $32.25\pm1.51^a$ | $21.56\pm2.55^a$ | $37.88\pm1.51^b$ | $36.14\pm2.55^a$ | $36.96\pm1.51^a$ |

Mean values in fresh and residue stages for each substrate with no common superscript differ ($P<0.05$).
All percentage values (dry weight basis).
OCC=organic cell contents; OCW= organic cell wall; $O_A$=high digestibility fraction; $O_B$= low digestibility fraction; IVDMD= in vitro dry matter digestibility.

7. Guzmán, G., G Mata, D. Salmones, C. Soto Velasco, L. Guzmán-Dávalos, 1993. El cultivo de hongos comestibles. Con especial atención a especies tropicales y sub-tropicales en esquilmos y residuos agroindustriales. Instituto Politécnico Nacional. México, D.F.
8. Hanza, A.S., t.f. Mohammady, A. Majcheaczyk, 2003. Evaluation of five oyster mushrooms species grown on corn stalks to be used as animal feed. Proceedings of the International Symposium on the horizons of using organic matter substrates in horticulture 608:141-148.
9. JLTA. 2000. Technical Manual for Feed Analysis, Japan Livestock Technology Association. Tokyo.
10. Leifa, F., A. Pandey, C.R. Zoclo, 2000. Solid state cultivation; an efficient method to use agroindustrial residues. Journal of Basic Microbiology 40: 187-197.
11. Rajarathnam, S., M. Shashirekha, Z. Bano. 1998. Biodegradative and Biosynthetic Capacities of Mushrooms: Present and Future Strategies. Critical Reviews in Biotechnology 18: 91-236.
12. Searle, S.R. 1971. Linear models. 1st Edition. John Wiley and Sons. New York.
13. Tilley, J.M.A., R.A. Terry, 1963. A two-stage technique for the in vitro digestion of forage crops. Journal of British Grassland Society. 18: 104-111
14. Van Soest, P. 1982. Nutritional Ecology of the Ruminant. O & B Books Inc. Portland, Oregon. pp, 81-84, 107-109.
15. Zhang, R., X. Li, J.G. Fadel, 2002. Oyster mushroom cultivation with rice and wheat straw. Bioresource Technology 82:277-284.