

APPLICABILITY OF THE USE OF WASTE FROM DIFFERENT BANANA CULTIVARS FOR THE CULTIVATION OF THE OYSTER MUSHROOM

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ABSTRACT

The objective of this research was to evaluate the oyster mushroom *Pleurotus ostreatus*- (Jacq.: Fr.) Kumm. cultivation in substrates based on different combinations of wastes (leaf, pseudo-stem and pseudo-stem + leaf) and banana cultivars - *Musa* spp. (Thap Maeo, Prata Anã, Pelipita and Caipira) during 49 days. Organic matter loss in the substrate by action of the fungus was also evaluated during that period. It was verified that the pseudo-stem waste provided the best averages of biological efficiency among all cultivars tested and best rates were obtained by Thap Maeo (61.5%). The highest organic matter loss (OML) was obtained from pseudo-stem + leaf wastes (Prata Anã – 78.6%; Thap Maeo – 67.6%; Pelipita – 64.8%; Caipira – 60.6%). Therefore, the use of those wastes showed itself viable for *P. ostreatus* cultivation due to its availability and low cost, besides decreasing discards to environment.

Key words: *Pleurotus ostreatus*, mycelium, organic matter, biological efficiency, supplementation.

INTRODUCTION

The oyster mushroom is the third most cultivated edible mushroom in the world (24). There isn't official statistics about mushroom production in Brazil, but different *Pleurotus* species have been cultivated and *P. ostreatus* is the most important oyster mushroom grown in that country (30).

Fungi belonging to the *Pleurotus* genus, also known as white rot wood fungi, develop with efficiency in lignocellulosic wastes, such as wheat and corn straw, wastes

from cotton and coconut, sugar cane bagasse, sawdust, etc. They have specific enzymes that degrade lignocellulosic compounds present in those types of raw material (1, 5). The waste from the banana tree is another material with high potential for utilization as substrate in edible mushroom cultivation (4, 17, 29, 32).

The banana is the third most exported fruit in Brazil (10); the Northern region the third biggest producer. The state of Amazonas is the second biggest producer in that region, followed by the state of Pará. After the production of the

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banana bunch, which occurs only once and usually 18 months after cultivation, most of the banana tree is discarded and only 50cm of the pseudo-stem is left to serve as source of nutrition to the sprouts (2).

Considering that the pseudo-stem and the adult plant reach about 1.2 to 1.8 meters high and their weight of approximately 10 to 100 kg, a huge amount of waste is generated after harvest (6, 7). Both pseudo-stem and leaves of the banana tree have high content of lignolitic fibers (31), with high potential for development of edible mushrooms.

The *Pleurotus* spp cultivation carried out with that waste lead to satisfactory results in relation to enzyme production in substrate degradation and productivity obtained in cultivation (17, 22, 29, 32). The cultivation technology of edible mushrooms in the Amazon region is still little developed. Thus, considering that the region presents high potential to such practice due to the great availability of timber and agricultural wastes (26), researches are necessary to spread the knowledge obtained and provide popularity to the product.

Therefore, the objective of this work was to evaluate the production of *P. ostreatus* in substrates based on wastes (leaf, pseudo-stem and pseudostem + leaf) of four banana cultivars (Thap Maeo, Prata Anã, Pelipita and Caipira), as well the organic matter loss of the substrates by the fungus action.

MATERIALS AND METHODS

The experiments were carried out at the Edible Fungus Cultivation Laboratory of the Coordination of Research in Forest Products – CPPF, Amazônia National Research Institute (INPA), Manaus, Amazonas, Brazil, in the period from February to June, 2009.

The *P. ostreatus* strain used was POS 09/100, proceeding from the Mushrooms Module of the School of Agronomic Sciences, UNESP, Botucatu, São Paulo, Brazil. According to the records of the Institute, the strain was obtained from a commercial grower from the region of Sorocaba/SP. That

strain is stored (in mineral oil) at the mycology collection of the Edible Fungus Cultivation Laboratory of the CPPF/INPA.

Wastes from banana tree cultivars belonging to the *Musa* spp genus of cultivars Thap-Maeo, Prata-anã, Pelipita and Caipira (genomic groups AAB, AAB, ABB and AAA, respectively) were obtained from the experimental unit of Embrapa Amazônia Ocidental, Rod. AM-10, Km 29, Manaus, Amazonas, Brazil. Pseudo-stems and leaves were collected and then processed by chopping leaves in a DPM 4, 3.300 RPM forage chopper, according to the methodology described by Sales-Campos (27). The chopped material was distributed in nets and submitted to natural drying. After that procedure, they were stored in raffia bags until the beginning of the experiments. The pseudo-stem was firstly sectioned in the middle and then exposed to environmental temperature until the reduction of water excess. The wastes were processed in the same chopper previously used and stored in nets, in order to complete the drying process, which was also naturally carried out. After, they were stored in raffia bags until the beginning of the experiments.

The experiment was totally randomized in 3x4 factorial scheme, corresponding to 3 combinations of wastes (pseudo-stem, leaf and pseudo-stem + leaf) and 4 banana cultivars (Thap-Maeo, Prata-anã, Pelipita and Caipira), with 6 repetitions, totalizing 72 experimental units (Table 1). The data was submitted to ANOVA variance analysis by using the SISVAR 4.2 statistic program, developed by the Department of Exact Sciences of the Federal University of Lavras, Minas Gerais, Brazil. (UFLA). Next, the averages were compared by using the Tukey test with 5% of probability.

A primary matrix of the POS 09/100 strain of *P. ostreatus* was used for the production of the spawn (secondary matrix), which was inoculated in Petri dishes containing PDA (Potato Dextrose Agar) medium.

The substrate used for *P. ostreatus* growth was prepared individually, according to waste types (pseudo-stem, leaf and pseudo-stem + leaf) (Table 1). The mixture made up with 80%

of waste and 20% of wheat bran was added with distilled water until reaching 75% of moisture. After that, the substrate was inserted into 72 PEAD bags (Polyethylene of High Density) with

cotton vent in the upper lateral, in the proportion of 200g for each package. The bags were hot-sealed and sterilized at 121°C for 60 minutes.

Table 1. Treatments utilized for production of the POS 09/100 strain of *Pleurotus ostreatus* in substrates based on banana waste plus 20% of wheat bran.

Waste	Banana cultivar
Pseudo-stem Leaf	Thap-Maeo
Pseudo-stem + leaf (1:1)	
Pseudo-stem Leaf	Prata-anã
Pseudo-stem + leaf (1:1)	
Pseudo-stem Leaf	Pelipita
Pseudo-stem + leaf (1:1)	
Pseudo-stem Leaf	Caipira
Pseudo-stem + leaf (1:1)	

After substrate cooling, each package was weighed and cuts were made at the sides of each bag inside a laminar flow chamber. Through this hole, a sectioned round segment of the inoculum was added to each substrate. The bags were hot-sealed again, identified and randomly distributed in a BOD incubation chamber (Biological Oxygen Demand) adjusted to 25°C and air moisture of 95%, until total colonization of the substrate.

The primordia induction occurred after the complete colonization of the substrate, 20 days after the inoculation. For that, the incubation temperature was decreased to 20°C and maintained during 24 hours. After that, the BOD was adjusted back to the previous temperature (25°C). After the second day from thermal shock (22 days after inoculation), primordia formation occurred in some treatments and in the 4th day after the shock, the first harvest was manually performed, before the sporulation stage, by withdrawing the whole branch. Next, the stem was cleaned to avoid harvest wastes. Then, productivity was expressed by means of biological efficiency (BE), which represents conversion percentage of the substrate into fungic biomass (mushrooms), established by the formula:

$$BE(\%) = \frac{\text{total fresh mass of mushrooms (g)}}{\text{inicial dry mass of substrate (g)}} \times 100$$

The organic matter loss (OML) was also evaluated, which represents the decomposition of the substrate by the fungus, determined by the formula:

$$OML(\%) = \frac{\text{inicial substrate dry mass (g)} - \text{residual (g)}}{\text{inicial substrate dry mass (g)}} \times 100$$

The C:N ratio (carbon/nitrogen) determination was carried out according to Lanarv's (14) method. Samples of the initial substrate were analyzed at the Fertilizers and Correctives Laboratory of the FCA/UNESP, Botucatu-SP.

The data of the experiments were submitted to ANOVA variance analysis, by using the SISVAR 4.2 statistical software, developed by the Department of Exact Sciences of the Federal University of Lavras, Minas Gerais (UFLA). Averages were compared by the Tukey's test with 5% of probability.

RESULTS AND DISCUSSION

The cultivation of *P. ostreatus* in wastes of four banana tree cultivars using three combinations (pseudostem, leave and pseudostem + leave) was carried out during 49 days. The evaluation of the production was performed by means of biological efficiency (BE) (Figure 1). The substrates based on wastes of Pelipita, Thap Maeo and Caipira obtained highest BE when the pseudo-stem waste was used (45.5; 61.5 and 32.2%,

respectively). The substrate based on pseudo-stem + leaf showed the highest values (44.2%) for Prata Anã. Higher results were obtained by Kurt and Buyukalaca (13) testing wastes of vine, wheat straw, rice straw and sesame straw, supplemented with wheat bran in the proportion of 2:1 for *Pleurotus* spp. cultivation and obtained values of BE of 75.5; 112.7; 84.6 and 88.4%, respectively. Sturion (32), using banana wastes for *Pleurotus* sp. cultivation, obtained values of BE ranging from 19.5 to 93%.

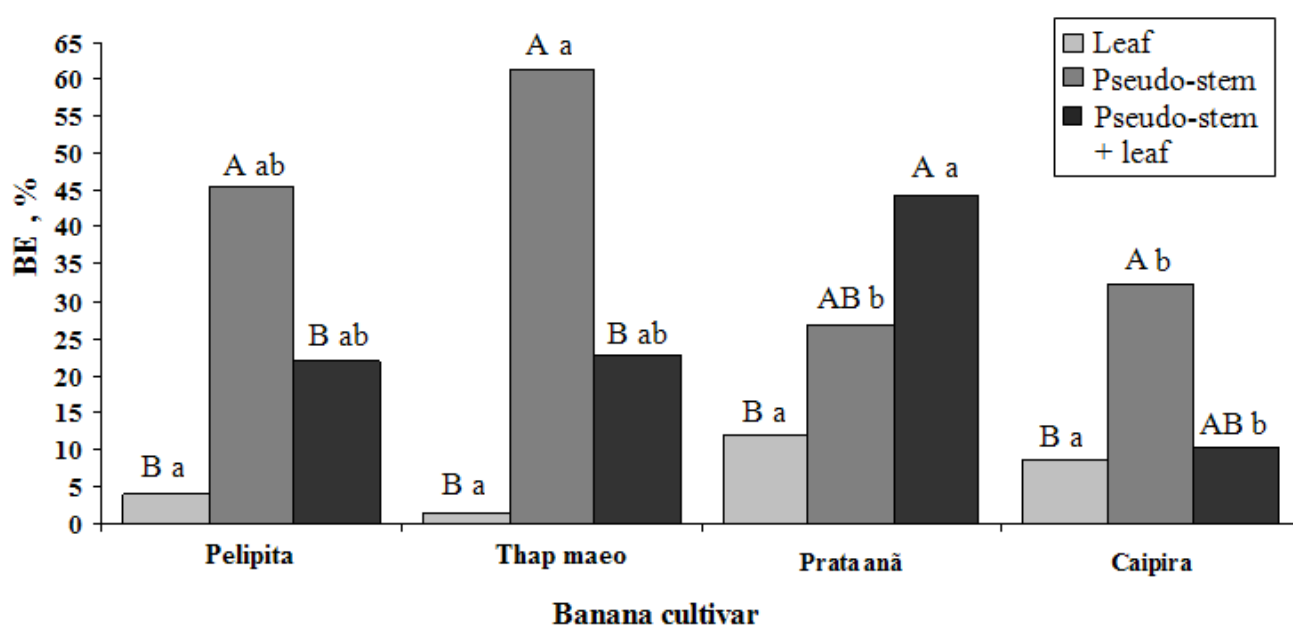


Figure 1. Biological efficiency (BE) (%) of the 09/100 strain of *Pleurotus ostreatus* in different substrates based on leaf, pseudo-stem and pseudo-stem + leaf waste of four banana cultivars (Thap Maeo, Prata Anã, Caipira and Pelipita). Uppercase compare averages inside of a same banana cultivar; lowercase compare averages inside a same type of waste. Averages followed by same letter were not distinguished (Tukey, 5%). CV (%) = 54.62 (average of six repetitions).

By analyzing each waste separately, it was observed that substrates based on leaves did not present significant differences among the banana cultivars (Figure 1). The highest biological efficiency was observed for Thap Maeo (61.5%), using pseudo-stem waste. Finally, in the combination of pseudo-stem + leaf waste, the best result was obtained for the Prata Anã cultivar (44.2%). These results confirm the influence of the banana tree cultivar in biological efficiency. Marino *et*

al. (15) tested coconut shell sawdust supplemented with wheat and rice bran in different rates for oyster cultivation, obtaining results of BE (%) among 0 to 7.5%, similar to the treatments based on leaf of Thap Maeo and Pelipita, which were 1.5 and 3.9% respectively.

Wang *et al.* (33), growing oyster, utilized grains from the beer process, supplemented with corn bran, wheat, rice and okara (waste from the process of soy milk); they verified

production results similar to the present experiment, with values ranging from 2.3 to 12.3%. Rany *et al.* (21) obtained lower results than the treatment with highest BE (pseudo-stem of Thap Maeo – 61.5%) when growing *P. ostreatus* in banana stem, obtaining biological efficiency of 33%. Similar values were obtained by Obodai *et al.* (19), who used banana leaves supplemented with rice bran as substrate for oyster mushroom cultivation, obtaining productivity of 37.15%.

Belewu and Belewu (3), growing *Volvariella volvacea* utilizing banana waste without supplementation, obtained values of BE of 15.21%. Still, satisfactory results were obtained by Sturion (32) using substrates based on banana leaves straw reaching 93% of productivity, similar result obtained by Sales-Campos *et al.* (28), who cultivated oyster mushroom using timber and agroindustrial wastes (sugar cane and pupunha stem chopped), obtaining BE ranging from 64.6% to 125.6%.

In the treatments based on Pelipita pseudostem and pseudostem + Prata anã leave, biological efficiency values similar to the ones obtained in the present experiment (47.7 and

44.2 %, respectively) (Figure 1) were observed by Rangunathan *et al.* (20) by using wheat straw and crushed sugar cane in the cultivation of *P. sajor caju*, whose EB values were 36.78 and 34.29%, respectively.

Kalmis *et al.* (12), using residual water from olive oil processing in several concentrations as supplement for *P. cornucopiae* and *P. sajor-caju* with wheat straw, obtained BE of 37.7% and 65.9%, respectively. Gregori *et al.* (11), using a mixture of wheat straw (20%) with grains (10%) from beer processing for *P. ostreatus* cultivation, obtained BE of 51%, similar to the results obtained for the substrate utilizing Thap Maeo pseudo-stem (61.5%) (Figure 1).

Many factors may influence the production, such as C/N ratio and substrates composition (18). A previous analysis of the raw materials is important in order to identify their viability for cultivation (34). The results of the C/N ratio analysis showed that concentrations ranged from 20 to 43/1 (Table 2). For oyster mushroom cultivation, the initial C/N ratio ranges from 80 to 100/1 when carried out under natural conditions. C/N ratios required are narrower in the axenic cultivation (9).

Table 2. Centesimal composition, pH and C/N ratio of the initial substrates (raw materials with supplementation of 20% of wheat bran).

Treatments	C (%)	N (%)	C:N	pH
Pseudo-stem – Thap Maeo	47.8	1.1	41:1	6.5
Leaf - Thap Maeo	47.8	2.1	23:1	6.6
Pseudo-stem + leaf – Thap Maeo	46.5	1.5	30:1	6.5
Pseudo-stem - Prata Anã	45.9	1.1	40:1	6.9
Leaf - Prata Anã	44.4	2.1	21:1	7.1
Pseudo-stem + leaf – Prata Anã	45.3	1.7	27:1	7.1
Pseudo-stem - Pelipita	45.0	1.1	40:1	6.7
Leaf - Pelipita	45.3	2.2	20:1	7.0
Pseudo-stem + leaf – Pelipita	44.7	1.4	33:1	6.8
Pseudo-stem - Caipira	47.2	1.1	43:1	6.0
Leaf - Caipira	45.3	2.2	21:1	6.8
Pseudo-stem + leaf – Caipira	36.5	1.7	27:1	6.4

Substrates based on leaves usually obtained the minor averages of biological efficiency (Thap Maeo – 1.5%, Pelipita - 4%, Caipira 8.5% and Prata Anã - 12%) and analyses

performed in the initial substrate showed that those substrates present higher concentration of nitrogen and narrower C/N ratio (20 to 23/1). Therefore, it is suggested that high

concentrations of nitrogen might affect the development of the fungus because, according to Donini *et al.* (8), a substrate with a high content of nitrogen might not favor the lignin degradation by the fungus, thus retarding or inhibiting the mycelial growth.

Rossi *et al.* (23), testing different supplementations in the micelial development of *L. edodes*, observed a minor mycelial growth speed in media with high content of rice bran. Similar

results were reached by Moda *et al.* (16) growing *P. sajor-caju* in substrate based on crushed sugar cane using corn bran as supplement, who obtained lower BE (15.66%), in comparison with control substrate without supplementation (26.63%).

In general, the highest organic matter loss (OML) was obtained in the substrates based on pseudo-stem + leaf (Prata Anã – 78.6%; Thap Maeo – 67.6%; Pelipita – 64.8%; Caipira – 60.6%) (Figure 2).

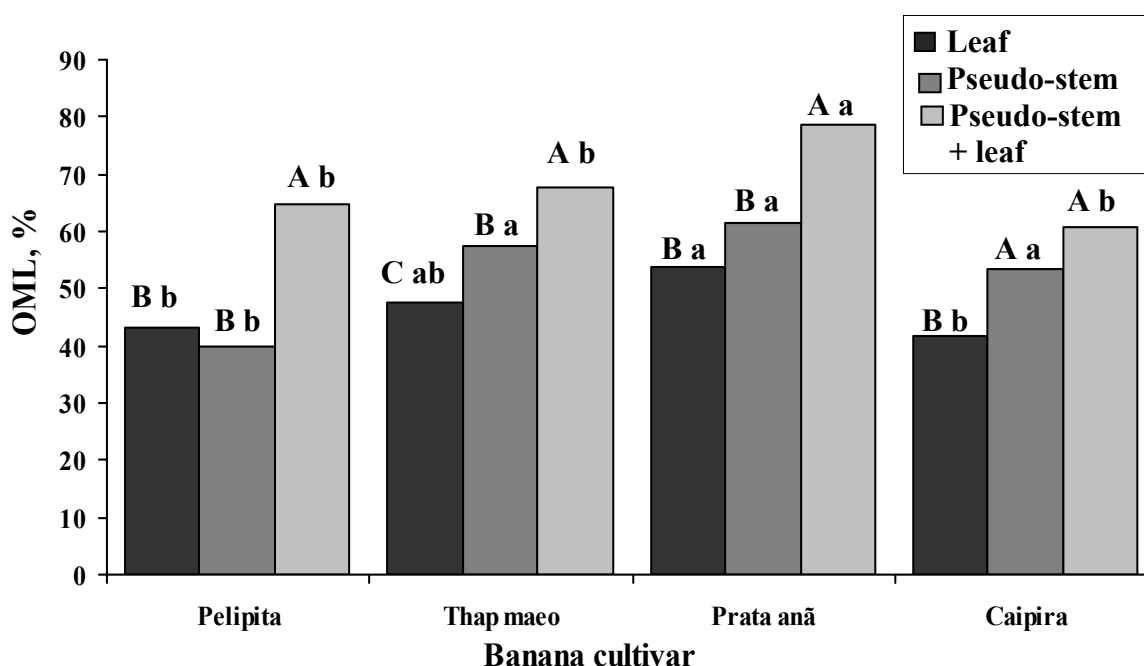


Figure 2. Organic matter loss (OML) (%) of the substrates based on wastes (leaf, pseudo-stem and pseudo-stem + leaf) of four banana cultivars (Thap Maeo, Prata Anã, Caipira and Pelipita) by growing 09/100 strain of *Pleurotus ostreatus*. Uppercase compares averages inside of a same banana cultivar; lowercase compares averages inside a same type of waste. Averages followed by a same letter were not distinguished (Tukey, 5%). CV (%) = 5.79 (average of six repetitions).

By analyzing the results among the wastes, the highest OML was observed in the Prata Anã cultivar (53.6%) in substrates based on leaf. For the pseudo-stem waste, the highest values of OML were obtained for Prata Anã, Thap Maeo and Caipira cultivars, with averages of 61.5; 57.3 and 53.4%, respectively. Finally, in substrates based on pseudo-stem + leaf waste, the highest OML was obtained for Prata Anã (78.6%).

According to Zadrazil (34), a high OML rate is not always correlated with an increased biological efficiency because OML occurs due to CO₂ and H₂O losses during the metabolism of microorganisms and not only from the removal of materials from basidiomata construction. By comparing organic matter loss (%) (Figure 2) with biological efficiency (Figure 1), we observed that most treatments did not show relation between both parameters, i. e., the substrates with less OML

provided the highest BE. Similar results of BE that ranged from 59.91 to 71.83 were obtained by Sales-Campos *et al.* (28). The authors report that OML (%) was not related to BE because the substrates that present highest productivity were not the ones presenting highest OML. Lower OML (38.7%) was obtained by Ruegger *et al.* (25) cultivating *Oudemansiella canarii* in composts based on crushed sugar cane. In that situation, the highest OML was related to BE. Thus, OML cannot be an indicative parameter of productivity because there was no consonance between OML and BE values observed in this experiment and in literature.

CONCLUSION

1. All the banana cultivars tested were favorable for *P. ostreatus* cultivation.
2. The substrate based on banana pseudo-stem is the most recommended for oyster mushroom cultivation.
3. The highest organic matter loss occurred in the substrates based on pseudo-stem + leaf of banana tree waste.
4. The use of banana tree wastes for the cultivation of *P. ostreatus* shows itself as a promising raw material due to its great local availability and low or no cost. Besides, it helps in the reduction of its disposal in the environment and the consequent impacts.

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