YIELDING CAPACITY OF SOME *PLEUROTUS ERYNGII* MUSHROOM STRAINS

CAPACITATEA DE PRODUCȚIE A UNOR TULPINI DE CIUPERCI DIN SPECIA *PLEUROTUS ERYNGII*

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Abstract. *Pleurotus eryngii mushrooms are widely produced for their excellent nutritional and medicinal qualities. This experiment was conducted to investigate the yielding capacity of three P.eryngii strains (Pery-G, Pery-K and Pery-26) cultivated on three variants of lignocellulosic substrate, four replicates/variant. The trail was performed in the mushroom house and the spawned bags (2 kg substrate) were randomized on racks with two levels. Pery-G strain showed the biggest production in the V2 variant (75% straws + 20% sawdust + 5% wheat bran and corn flour 1/1) with 544 g/bag (27.20%) and in the V1(95% straws + 5% wheat bran and corn flour), with 534 g/bag (26.70%). Pery-26 strain yielded the best result of the experiment in the V2 with 548 g/bag (27.40%). All three experimental strains yielded the smallest harvests in the V3 variant (50% straws + 30% sawdust + 15% corn cobs + 5% wheat bran and corn flour 1/1).*
Key words: *Pleurotus eryngii*, lignocellulosic substrate, yield

Rezumat. *Ciupercile Pleurotus eryngii sunt produse pe larg datorită excelentelor calități nutritive și medicinale. Acest experiment s-a desfăşurat cu scopul de a evalua capacitatea de producție la trei tulpini de P.eryngii (Pery-G, Pery-K şi Pery-26) cultivate pe trei variante de substrat lignocelulozic, patru repetiții/variantă. Trialul s-a desfăşurat în ciupercărie, cu sacii însămânțați (2 kg substrat) dispuşi randomizat pe stelaje cu 2 nivele. Tulpina Pery-G a dat producția cea mai mare pe variantele de substrat V2 (75% paie + 20% rumeguş + 5% tărâțe de grâu şi mălai 1/1) cu 544 g/sac (27,20%) şi, respectiv V1 (95% paie + 5% tărâțe de grâu şi mălai), cu 534 g/sac (26,70%). Tulpina Pery-26 a realizat cea mai mare producție a experimentului pe varianta V2, cu 548 g/sac (27,40%). Toate tulpinile experimentale au realizat recoltele cele mai slabe pe varianta V3 (50% paie + 30% rumeguş + 15% ciocălăi + 5% tărâțe de grâu şi mălai 1/1).*
Cuvinte cheie: *Pleurotus eryngii*, substrat lignocelulozic, recoltă

INTRODUCTION

The *Pleurotus eryngii* (King oyster) mushrooms present excellent nutritional and culinary qualities, being considered among the most tasteful mushrooms of *Pleurotus spp*. group. They posess clear therapeutic valences too, the basidiocarps and the mycelium constituting sources of bioactive compounds

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that are capable of reducing disease risk and treating some diseases (Chang 2010; Zhiming *et al*., 2016; Sanchez, 2017). The culture substrate can be prepared from different renewable lignocellulosic materials, most of them being agroforestry subproducts/wastes (Akyuz and Yildiz, 2007; Kirbag and Akyuz, 2008; Phillipoussis, 2009; Kazemi Jeznabadi *et al*., 2016). The *P.eryngii* mushroom culture extends more and more in the world, being realized in different technological variants: outdoor /indoor culture, with the substrate being filled into plastic bags/bottles made of PP, with/without soil or peat casing layer (Kirbag and Akyuz, 2008; Rodriguez Estrada *et al*., 2009; Yamanaka, 2011). In Romania, *Pleurotus eryngii* mushrooms are very little known, some cultivation attempts being recorded, but only for testing the market.

In this work the pilot-mushroom farm level research results are presented having as objective the production potential checking of some *P.eryngii* strains on subtrates obtained from lignocellulosic subproducts/wastes, available in big quantities in our country.

MATERIAL AND METHOD

The biologic material was represented by three strains of *Pleurotus eryngii* of different origins, all from the *RDIVFG Vidra* collection: Pery-G, Pery-26, Pery-K. Pure cultures of mycelium grown on MEA/PDA culture media were inoculated in flasks containing 650 g granular support (wheat grains) prepared and sterilized according to the usual method used in our lab. (Mateescu, N., Zăgrean, A.V., 2003). The flasks were incubated at dark, for 21-23 days at 24-26°C and then, used for spawning.

The culture substrate was made in three different variants: V1 = straws (wheat, barley) 95% + nutritional supplement 5% [Str 95% + Supp 5%]; V2 = straws 75% (wheat, barley) + poplar and beech sawdust, shavings (1/1) 20% + nutritional supplement 5% [Str 75% + Ssh 20% + Supp 5%]; V3 = straws (wheat, barley) 50% + poplar and beech sawdust, shavings (1/1) 30% + corn cobs 15% + nutritional supplement 5% [Str 50% + Ssh 30% + Cc 15% + Supp 5%]. *Supp = wheat bran and corn flour, mixed 1/1 (w/w). The shredded and humidified material was homogenized and mixed with plaster (4%), then filled into autoclavable PP bags (2 kg/bag) and sterilized for 90 minutes at 121°C. After cooling, the bags were each inoculated with 60 g of spawn (3%) and placed for incubation at 22-24°C, 70-80% RH, CO_2 concentration above 3000 ppm, at dark. Finally, 36 bags were prepared: 4 bags for each substrate variant and strain, resulting a total of 72 kg of substrate. The bags were randomly placed on racks in the pilot mushroom farm for 2-3 days at 12-14°C, RH 85-90%, CO_2 concentration below 800-900 ppm. The light was provided by fluorescent lamps, for 8-10 hours/day. The foil from the top of the bags was cut afterwards. The next 3-4 days, the temperature was kept at 15-16°C, RH at 80-85%, CO_2 concentration below 900 ppm. After primordia formation, the parameters were set to the specific microclimate conditions of the fructification stage: 14-18°C, RH 80-85%, CO_2 concentration below 1000-1500 ppm, light at 500-1000 lux 8-10 hours/ day.

The parameters of the microclimate were measured using a Wohler KM410 multitester, with sensors for CO_2 concentration, temperature and RH. Production was measured in grams of mushroom/bag, and the harvest yield in percentages, respectively grams of fresh mushroom/100 grams of substrate. The statistical interpretation of the results was done through the variation analysis method.

RESULTS AND DISCUSSIONS

The first flush of Pery-G mushrooms occured 7 days after the fruiting induction by thermal shock. The other strains formed primordia after 9 days (Pery-26) and 12 days respectively (Pery-K). The mushrooms of the first flush occured 35-40 days after spawning and they developed in 8-10 days, depending on strain and substrate variant. The second flush came after a pause of 18-19 days, it lasted 12 days and it was more quantitatively reduced than the first one.

The growing cycle ended 75-80 days (2.5 months) after spawning, a period quite close to that signalled by others (Sonnenberg *et al*., 2006; Rodriguez Estrada *et al*., 2009).

The Pery-G strain has obtained very good harvests on two of the three substrate variants, recording 544 g/bag (27.20 %) in 2 flushes on the V2 variant and, respectively 534 g/bag (26.70 %) on the V1. It was surpassed only by the strain Pery-26 on the V2 variant, with 548 g/bag (27.40 %), this being also the maximum value of the experiment. Poorer results achieved the strain Pery-K, being situated on the third place on all of the substrate variants.

The Pery-G strain colonized the substrate faster the other strains, prooving a notable vigor, being manifested as such and at the reproductively stage level - fructification. The results synthesis concerning the influence of the strain on the mushroom harvest obtained on three culture substrates is presented in table 1.

Table 1

The strain influence on the yield of *P. eryngii*

No.	Strain	Yield (average value for three substrates)		Difference (±d)	Significance of difference
		(g)	(%)	(g)	
1	Pery-G	523.33	133.96	+132.67	***
2	Pery-26	482.66	123.55	+92.00	***
3	Pery-K (ctrl)	390.66	100.00	0	-
DL 5%			=	3.23 g	
DL 1%			=	4.39 g	
DL 0,1%			=	5.88 g	

The results analysis shows that, indifferently of the used substrate, Pery-G and Pery-26 strains have yielded larger crops than Pery-K, both very significant statistically assured. Thus, on the three substrates, Pery-G achieved an average of 523.33 g/bag, exceeding the control with 132.67 g/bag. Pery-26 gave 482.66 g/bag, with an increase of 92 g/bag over Pery-K (control), recorded with 390.66 g/bag.

The synthesis of the experimental results concerning the influence of the culture substrate on the mushrooms harvest (2 flushes) at all the three *P.eryngii* strains verified is presented on Table 2.

Of all the three substrate variants, V2 and V1 have ensured - in this order - superior results over V3, at all the three verified strains. The averages of the

recorded productions by all the three strains on V2 (490 g/bag) and on V1 (474. 66 g mushrooms/bag) exceeded very significant the obtained average on V3 variant (control), with 58.00 g/bag (V2) and 42.66 g/bag respectively (V1).

Table 2

The substrate influence on the yield capacity of three strains of *P. eryngii*

No.	Substrate	Yield (average value for three strains)		Difference (±d)	Significance of difference
		(g)	(%)	(g)	
1	V1	474.66	109.87	+42.66	***
2	V2	490.00	113.42	+58.00	***
3	V3 (ctrl)	432.00	100.00	0	-
	DL 5 %	=		3.23 g	
	DL 1 %	=		4.39 g	
	DL 0,1%	=		5.88 g	

The C/N values are lower for the wheat straws (48.8-59.6) than for the corn cobs (64.2-71.6) and much lower than for the sawdust (150-450) (Philipoussis, 2009). In our research, the V3 substrate [Str 50% + Ssh 30% + Cc 15% + Supp 5%], with the highest sawdust percentage and, subsequently, the highest C/N ratio, yielded the lowest harvest during the two production flushes, respectively 432 g/bag – the average yield of the three used strains.

It was observed that, by adding organic nitrogen supplements (soy flour, wheat/barley bran), the C/N value of the growing substrate is decreasing, thus obtaining increases in production. Therefore, there have been reported higher production values, respectively 25-35 kg mushroom/100 kg substrate (yielding capacity 25-35%), for the *Pleurotus eryngii* strains cultivated on substrates having 1.4-1.5% nitrogen, compared to 20 kg mushroom/100 kg damp substrate, obtained on 0.8% nitrogen substrates (Sonnenberg *et al*, 2006). In high quantities, the sawdust influences negatively the physical and granulometric (particle sized) structure of the substrate. When humidified, the substrate is highly compacted, becoming hardly accessible for mycelium to penetrate; the mycelium demands aerobic conditions in order to obtain a fast and healthy colonization. Improper conditions may lead to the formation of a mycelium with very thin hyphae and a poorly developed network, with a low growing speed, slow colonization of the substrate and low harvest yield – in case of high sawdust and shredded straws percentage (Kazemi Jeznabadi *et al*, 2016). This brings, by similarity, a confirmation for our results, considering the higher production obtained for the V1 and V2 substrates, with more straws, having, in plus, higher values of the cellulose/lignin ratio than in the V3 substrate with less straws and more sawdust: 2.2-5.3 is the value of cellulose/lignin ratio in straws and 1.7-2.0 in sawdust, according to Philippoussis (2009).

The first flush of fructification was quantitatively and qualitatively superior to the second one for all the strains and substrates. Flush 2 represented less than

30% of the total yield for the Pery-G and Pery-26 strains, on all three substrate variants. Only the Pery-K strain has fructified in the second flush more than 30% of the summed yield of the two flushes 32.2% (V1), 30.9 (V2) and 34.65% (V3).

The analysis of the combined influence of both strain and substrate, over the mushroom production, highlights the fact that the Pery-G strain, when cultivated on the three substrate variants, assures very significant yield differences, compared to the Pery-K control, grown on the V3 substrate (Table 3). Therefore, the Pery-G strain has exceeded the control by 134 g mushrooms/bag, on the V1 substrate, by 144 g mushrooms/bag on the V2 substrate (second result of the experiment, after Pery-26/V2), and by 92 g mushrooms/bag on V3. Similarly, if compared to the control, Pery-26 has given very significantly higher yield on V1 (96 g/bag) and V2 (148 g/bag – best result of the experiment), but insignificant results on V3 (4 g/bag). The Pery-K strain had a lower production on all the substrates, than the other two strains. With Pery-K strain, the V2 and V1 variants of substrate assured insignificantly lower yields compared to the V3 control.

Table 3

Combined influence of strain and substrate on yield capacity of *P. eryngii*

Strain	Substrate	Yield		Difference (±d)	Significance of difference
		(g)	(%)	(g)	
Pery-G	V1 [Str 95% + Supp 5%]	534	133.3	+134	***
	V2 [Str 75% + Ssh 20% + Supp 5%]	544	136.0	+144	***
	V3 [Str 50% + Ssh 30% + Cc 15% + Supp 5%]	492	123.0	+92	***
Pery-26	V1 [Str 95% + Supp 5%]	496	124..0	+96	***
	V2 [Str 75% + Ssh 20% + Supp 5%]	548	137.0	+148	***
	V3 [Str 50% + Ssh 30% + Cc 15% + Supp 5%]	404	101.0	+4	-
Pery-K	V1 [Str 95% + Supp 5%]	394	98.5	-6	-
	V2 [Str 75% + Ssh 20% + Supp 5%]	378	94.5	-22	-
	V3 [Str 50% + Ssh 30% + Cc 15% + Supp 5%]	400	100.0	0	-

DL 5% = 30.46 g
DL 1% = 41.41 g
DL 0,1% = 55.31 g

CONCLUSIONS

1. The Pery-G and Pery-26 strains had high yields, producing on the three substrate variants an average of 523.33 g mushrooms/bag with 2 kg substrate, (26.17% yield), respectively 482.66 g/bag (24.13% yield) - high, statistically very significant values, superior to the Pery-K strain, recorded with an average harvest yield of 390.66 g/bag (19.53%). This recommends them for further research, for approval and introduction into production

2. The first flush of fructification was highly superior, in both quality and quantity, to the second one, for all the strains and substrates.

3. The V2 substrate (75% straws + 20% sawdust and shavings + 5% nutritional supplement) and V1 substrate (95% straws + 5% nutritional supplement), in this order, have favorized superior harvest yields, compared to the V3 substrate (50% straws + 30% sawdust and shavings + 15% corn cobs + 5% supplement). The average yield of the three strains, on the V2 substrate (490 g/bag) and the V1 substrate (474.66 g/bag), have very significantly exceeded the average yield obtained on the V3 substrate. (432 g/bag). The results recommend the V1 and V2 substrates for the potential growers of *Pleurotus eryngii* mushrooms.

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