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INFLUENCE OF *CYNARA CARDUNCULUS* IN THE *PLEUROTUS ERYNGII* YIELD*

Summary. Since edible mushrooms are adapted to grow on several lignocellulosic wastes, it is possible to use a wide variety of unconventional materials to cultivate *Pleurotus* spp., which production has greatly increased in the last years. This study was performed to evaluate yield, biological efficiency and quality of *Pleurotus eryngii* fruit bodies, produced on a sterilized substrate of wheat straw and *Cynara cardunculus* mixtures. Substrates composed by 75% of wheat straw and 25% of *C. cardunculus* improved the highest yield and biological efficiency; however mushrooms with bigger dimensions were obtained with a mixture of 25% of wheat straw and 75% of *C. cardunculus*.

Key words: mushrooms, cultivation, thistle, quality parameters

Introduction

In recent years the edible fungi consumption, appreciated in many European and Oriental diets, is increasing, not only for their organoleptics characteristics, but also for the high nutritional and medicinal values of some species. Mushrooms have been an attractive crop in developing countries for many reasons; one of the reasons is that they can grow on different agricultural wastes. They are a good source of amino acids, minerals and they have high vitamins level, such as thiamine, riboflavin, niacin and ascorbic acid, when compared with other foodstuffs (CHANG and MILES 1989, BONONI et AL. 1999). Mushroom cultivation is one of the most efficient and economically viable biotechnological ways of conversion of lignocelluloses waste materials into high quality

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protein food and this will naturally open up new job opportunities especially in rural areas. The culture system, in controlled conditions, allows obtaining mushrooms, all year long, with shorter production cycles, larger productivity and better quality of the product (RAJARATHANAM 1992, POPPE 2000).

A diversity of cultivation methods utilizing logs, shelves, boxes, bags and bottles have been developed and agro-wastes including straw were a good source for substrate growing mushroom.

The popularity of *Pleurotus* spp. has increased due to its ease cultivation methods, high yield potential and high nutritional value. The species is quite adaptable to an environment range and substrate materials, making itself the second most common mushroom produced worldwide following button mushroom (KONG 2004). *Pleurotus eryngii* (DC.:Fr.) Quel, commonly known as thistle mushroom, has an excellent quality, but is more difficult to cultivate than other species of the *Pleurotus* genus (GARCIA ROLLAN 2003). However, its commercial exploration at a great scale has been avoided, when cultivated only on wheat straw, needing a substrate supplementation, in order to increase the productivity (CHANG 1980, MADAN et AL. 1987, STURION and OETTERER 1995).

The aim of this research was to evaluate the yield and quality of these edible mushrooms, when cultivated on wheat straw supplemented with different amounts of *Cynara cardunculus*.

Material and methods

The *P. eryngii* strain belongs to the INRB L-INIA culture collection. It was kept on potato dextrose agar (PDA) at 4°C. Spawn was prepared from hydrated oats seeds. 400 g of hydrated grains (wet weight) were placed in polypropylene bags, and then sterilized at 121°C for 1 h. Once cooled, each bag was inoculated with *P. eryngii* mycelia. Inoculated bags were incubated in darkness at 24°C until mycelia had completely covered the oat grains. Different mixtures of wheat straw and *C. cardunculus* (thistle) were used as substrate growing (Table 1).

Table 1. Substrate growing composition for *Pleurotus eryngii* cultivation
Tabela 1. Skład podłoża przeznaczonego do hodowli *Pleurotus eryngii*

Substrate	Composition
A	Wheat straw (100%)
B	Wheat straw (75%) + *Cynara cardunculus* (25%)
C	Wheat straw (50%) + *Cynara cardunculus* (50%)
D	Wheat straw (25%) + *Cynara cardunculus* (75%)

The experiment was designed to determine the best *P. eryngii* substrate growing. For all substrates seven sample replicates were made, in order to undertake the analyses.

Dry wheat straw and thistle were cut into 1- to 3-cm fragments with an electric thresher. These substrates were hydrated in water for 12 h, and then excess moisture was allowed to run off until moisture content of 60% was reached. Each mixture (1 kg) was placed in a polypropylene bag and sterilized three times at 121°C during 1 h. Each bag was inoculated with 100 g of spawn and incubated at 24±2°C in complete darkness. After total colonization, the bags were placed, without their plastic covering, in a controlled environment and under favourable conditions for fruiting: 16±2°C, relative humidity of 85±5% and 12 h daily illumination.

Quality parameters were assessed on fruit bodies harvested:

– fresh weight (W) – fruit bodies weighed immediately after harvest,
– number of fruit bodies (N) – counted for each bag/substrate growing,
– height (H) – measured in centimeters from the base to the stipe of the pileus,
– diameter of pileus (d) – measured from one edge of the pileus, across the stipe, to the other.

The quantification of the production was made by:

– yield (Y) – relationship, in percentage, between fresh mushrooms and fresh substrate,
– biological efficiency (BE) – relationship, in percentage, between fresh mushrooms and dry substrate.

The results were treated with the Statistical V.6 program, for Principal Components Analysis (PCA) and Factorial Discriminate Analysis (FDA).

Results and discussion

The results of *P. eryngii* yield cultivated in different substrate growing (A, B, C and D), are shown in Figure 1. The higher value was obtained with substrate B (75% wheat straw + 25% thistle) and it is possible to observe a yield decrease when thistle percentage increases (substrates C and D). However, the substrate A (100% wheat straw) showed an intermediate yield value (41.0%) between substrates B and C (45.2% and 39.2%, respectively), which shows that thistle supplementation, from 0 to 25%, had a positive influence.

Concerning biological efficiency, the substrate B shows the higher value and substrates A and D have a similar value (Fig. 2). Comparatively to the yield, the beneficial effect of 25% thistle addition to the substrate growing is still more evident.

Figure 3 shows the influence of the thistle supplementation on the mushrooms number. Substrate C has produced more fruitbodies followed by substrate B.

What concerns the fresh weight/fruitbody, substrate A has produced mushrooms with bigger dimensions, followed by substrate B (Fig. 4). In this case, it was not possible to relate the mushroom fresh weight with the thistle supplement, once substrate C presented an intermediate value between substrates B and D. However, substrate D showed the mushrooms larger dimensions (diameter of pileus and height of stipe) (Figs. 5, 6).

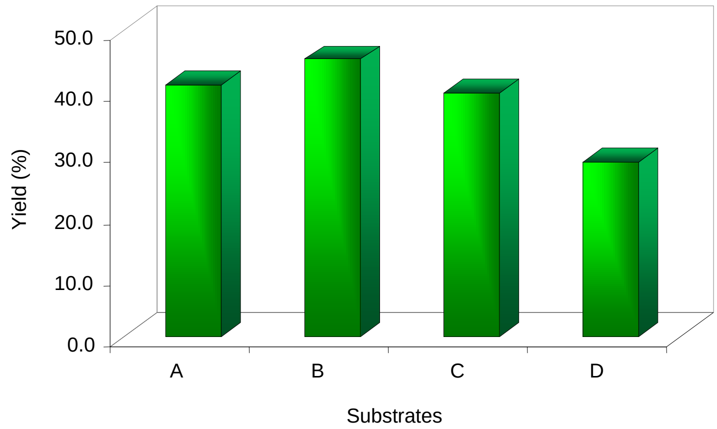

Fig. 1. The yield of *Pleurotus eryngii* grown on different substrates
Rys. 1. Plon *Pleurotus eryngii* hodowanego na różnych podłożach

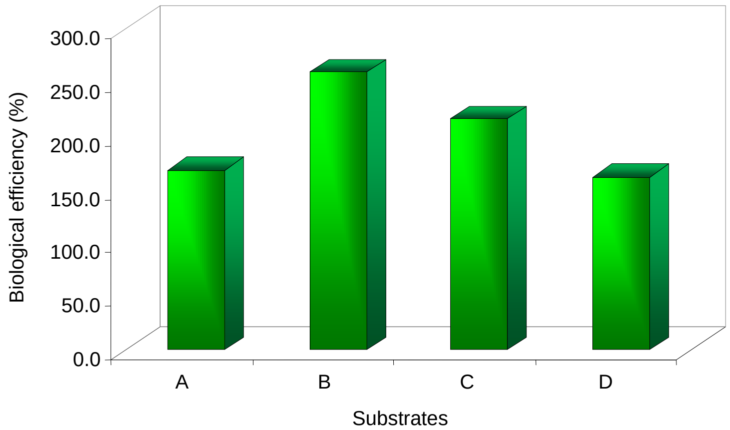

Fig. 2. The biological efficiency of *Pleurotus eryngii* grown on different substrates
Rys. 2. Wydajność biologiczna *Pleurotus eryngii* hodowanego na różnych podłożach

Using a Principal Components Analysis (PCA), the relationship between the productivity and the morphology characterisation of mushrooms (Fig. 7) was observed, where 93.67% of the total variance could be explained by the two first components, respectively, 61.82% and 31.83%. The analysis was performed with six original variables, biological efficiency, yield, number of mushrooms, weight of mushrooms, diameter of pileus and height of stipes, being initial contribution of 16.66%.

The first component seemed very important in explaining the variables influence, with positive contribution yield (0.914), biological efficiency (0.853) and number of mushrooms (0.706); with negative contribution diameter of pileus (–0.951) and height

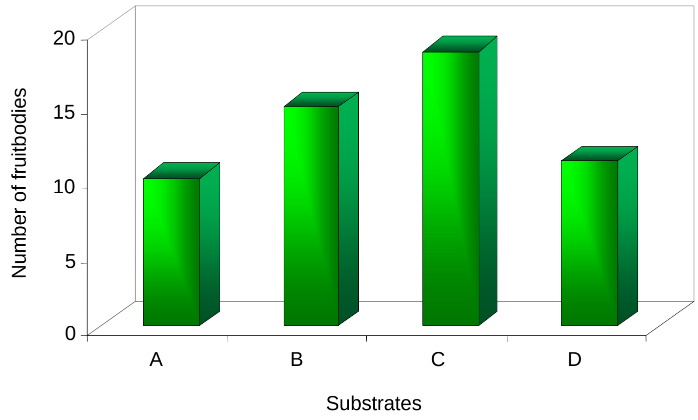

Fig. 3. The number of fruitbodies of *Pleurotus eryngii* formed on different substrates
Rys. 3. Liczba owocników *Pleurotus eryngii* uformowanych na różnych podłożach

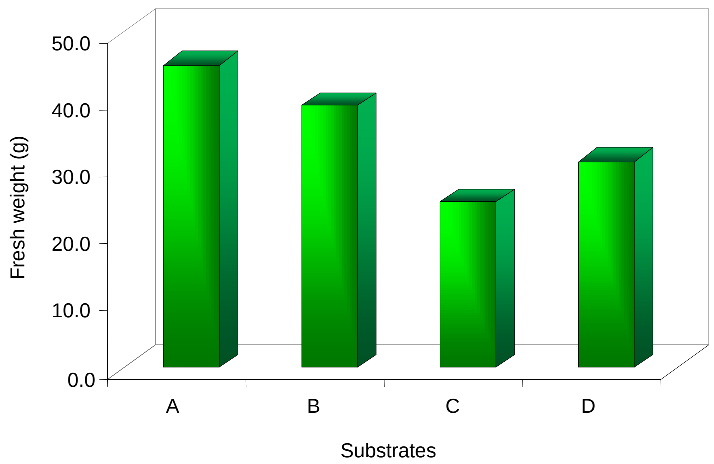

Fig. 4. The fresh weight of fruitbodies of *Pleurotus eryngii* formed on different substrates
Rys. 4. Waga świeżych owocników *Pleurotus eryngii* uformowanych na różnych podłożach

of stipes (–0.863). The second component is justified positively by the number of mushrooms (0.708) and negatively by weight of mushrooms (–0.996).

Both Factorial Discriminate Analysis (FDA) (Fig. 8) and distribution of the experimental points, allowed us to conclude that the weight of mushrooms is more linked to substrate A, yield and biological efficiency to B, number of mushrooms to C and

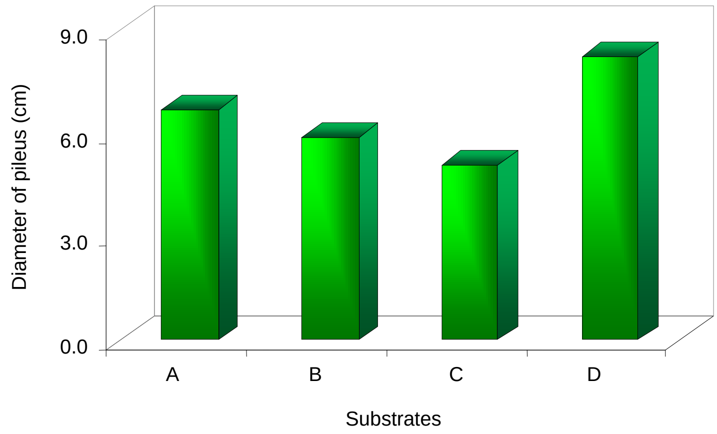

Fig. 5. The diameter of pileus of *Pleurotus eryngii* formed on different substrates
Rys. 5. Średnica kapelusza *Pleurotus eryngii* uformowanych na różnych podłożach

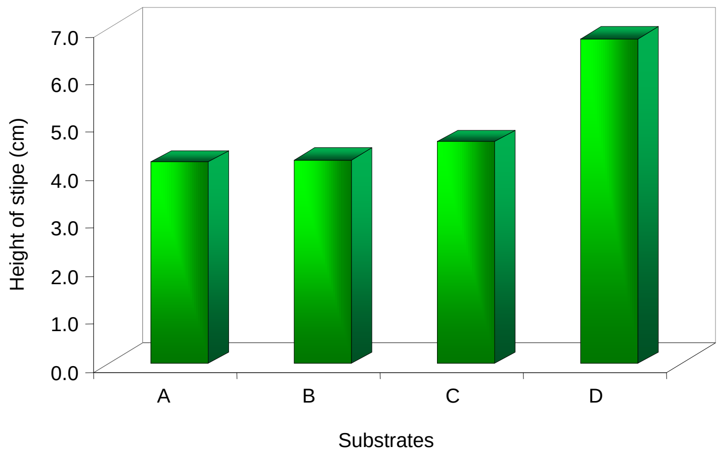

Fig. 6. The height of stipe of *Pleurotus eryngii* grown on different substrates
Rys. 6. Wysokość trzonka *Pleurotus eryngii* hodowanych na różnych podłożach

mushrooms dimensions mostly linked to substrate D, in opposition to yield. This analysis can confirm the mushrooms behaviour in different growing substrates and easily allows observing the formulation effect on the *P. eryngii* yield.

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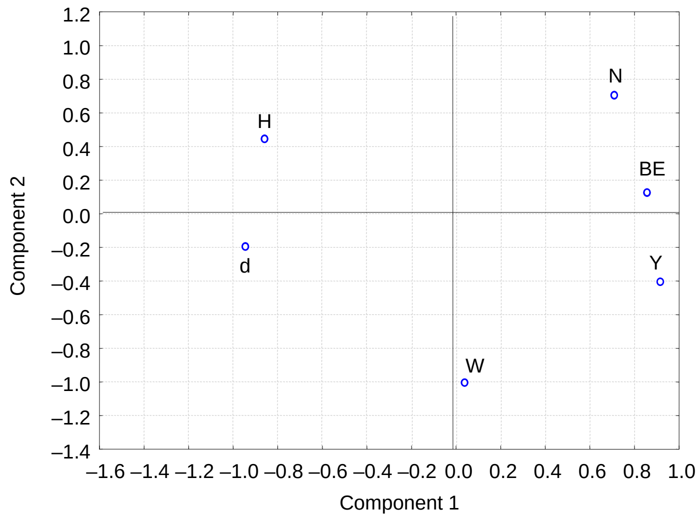

Fig. 7. Principal Components Analysis (PCA): BE – biological efficiency, Y – yield, N – number of mushrooms, W – weight of mushrooms, d – diameter of pileus, H – height of stipes

Rys. 7. Analiza Głównych Składowych (AGS): BE – wydajność biologiczna, Y – plon, N – liczba grzybów, W – waga grzybów, d – średnica kapelusza, H – wysokość nóżek

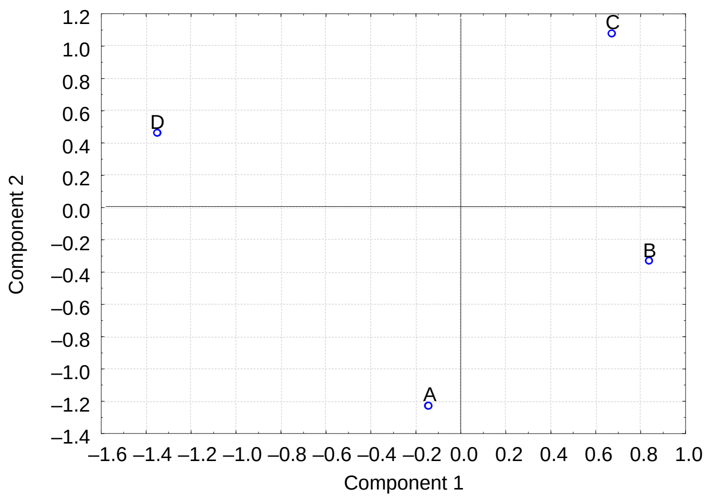

Fig. 8. Factorial Discriminate Analysis (FDA): A – substrate A, B – substrate B, C – substrate C, D – substrate D

Rys. 8. Analiza Czynnikowa Dyskryminacyjna (ACD): A – podłoże A, B – podłoże B, C – podłoże C, D – podłoże D

Conclusions

The results suggested that 25% of *C. cardunculus* supplementation increase the *P. eryngii* productivity, when cultivated in wheat straw substrate. However, using thistle, up to 75%, the inhibition of synthesis of lignin degrading enzymes can occur, rising a yield decrease, however improving the fruit bodies production with bigger dimensions. *Pleurotus eryngii* cultivation with *C. cardunculus,* as supplement, can be a viable alternative to improve the consumer's demand, and may have a great potential, especially at industrial scale, but additional work is necessary in order to optimize this methodology.

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WPŁYW *CYNARA CARDUNCULUS* NA PRODUKCJĘ *PLEUROTUS ERYNGII*

Streszczenie. Uprawa grzybów jadalnych jest możliwa na wielu rodzajach podłoży z odpadów lignino-celulozowych. Daje to możliwość stosowania różnorodnych niekonwencjonalnych materiałów do uprawy boczniaka (*Pleurotus* spp.), którego produkcja znacząco wzrosła w ostatnich latach. Celem badań była ocena produkcji, wydajności biologicznej i jakości owocników grzyba *P. eryngii* uprawianych na wysterylizowanych mieszaninach składających się ze słomy pszenicznej i karczocha hiszpańskiego (*Cynara cardunculus*). Mieszaniny złożone w 75% ze słomy pszenicznej i w 25% z *C. cardunculus* dawały największą wydajność i efektywność biologiczną, jednak owocniki boczniaka o największych wymiarach uzyskano z podłoża złożonego w 25% ze słomy pszenicznej i w 75% z karczocha hiszpańskiego.

Słowa kluczowe: grzyby, uprawa, podłoże, parametry jakościowe

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