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## THE COMPARISON OF MORPHOLOGICAL FEATURES, WEIGHT AND DRY MATTER CONTENT IN CARPOPHORES OF STRAINS AND CROSSBRED CULTURES OF SHIITAKE (*LENTINULA EDODES* (BERK.) PEGLER)

**Summary.** The subject of the studies were three strains of shiitake: ‘Sylvan 4080’, ‘Akiyama 567’ and ‘Hokken 600’ and 12 crossbred cultures. The substrate from oak sawdust supplemented with wheat bran was used. Morphological features, i.e. cap diameter and thickness as well as stem diameter and length were compared. Weight of carpophore and dry matter content in carpophores were estimated. It was found that the carpophores of original strains and crossbred cultures differed significantly in morphological features. The tested strains and cultures differed in mean weight and dry matter content in carpophores. Most of crossbred cultures were characterized by carpophores of less mean weight than original strains. Dry matter content in carpophores of crossbred cultures was lower than in carpophores of original strains.

**Key words:** shiitake, strain, crossbred culture, carpophore, morphological features, dry matter

### Introduction

Cultivation of shiitake in Poland is not wide-spread, although worldwide carpophores of this mushroom constitute approximately 25% weight of cultivated mushrooms. Shiitake is found in north-eastern Asia (HIBBETT et AL. 1998), as well as Tasmania, New Zealand, Bhutan, Nepal and India (KOMATSU and KIMURA 1968, KOBAYASI et AL. 1973, MORI et AL. 1974, PEGLER 1983, SHIMONURA et AL. 1992). On the basis of morphological differences PEGLER (1983) distinguished three separate species of shiitake, related to the region of their distribution, i.e. *Lentinula edodes* found in north-eastern Asia, *L. lateritia* in south-eastern Asia and Australasia, as well as *L. novaezelandiae* found in New Zealand.

These species may hybridize easily (SHIMONURA et AL. 1992). HIBBETT and DONOGHUE (1996) while investigating ribosomal DNA of shiitake showed affinity

between the above mentioned species and about a dozen strains and distinguished four taxons differing in their geographical origin. HIBBETT et AL. (1998) attempted to establish genetic affinity between strains of shiitake originating from different regions of China and Japan. They found that it is difficult to unambiguously determine the precise origin of strains, of which there are several dozens.

Several authors showed differences between strains of shiitake, e.g. in terms of mycelium growth, yields and morphological characters of carpophores (ROYSE and BAHLER 1986, KALBERER 1989, 1998, 2000, RAASKA 1990, KIRCHOFF and LELLEY 1991, BSKO and BILAY 1996, SIWULSKI and SOBIERALSKI 2000).

## Material and methods

Studies on shiitake (*Lentinula edodes* (Berk.) Pegler) were conducted at the Department of Vegetable Crops, The August Cieszkowski Agricultural University of Poznań, and Farm Producing Cultivated Mushrooms in Łoboz near Jarocin.

The subject of the study were the following strains and crossbred cultures of shiitake:

- ‘Sylvan 4080’ – coming from Sylvan (USA),
- ‘Akiyama 567’ and ‘Hokken 600’ – coming from a company producing *L. edodes* in Japan,
- crossbred cultures of the above mentioned shiitake strains.

The tested strains gave high yields in previous experiments.

The origin of the crossbred cultures is presented in Table 1.

Table 1. Origin of crossbred cultures of shiitake  
Tabela 1. Pochodzenie kultur krzyżówkowych twardziaka jadalnego

| Crossbred culture | Original strains              |
|-------------------|-------------------------------|
| MS 73/11          | ‘Akiyama 567’ × ‘Hokken 600’  |
| MS 134/27         | ‘Akiyama 567’ × ‘Hokken 600’  |
| MS 134/30         | ‘Akiyama 567’ × ‘Hokken 600’  |
| MS 17/29          | ‘Akiyama 567’ × ‘Hokken 600’  |
| MS 204/56         | ‘Hokken 600’ × ‘Sylvan 4080’  |
| MS 371/14         | ‘Hokken 600’ × ‘Sylvan 4080’  |
| MS 380/5          | ‘Hokken 600’ × ‘Sylvan 4080’  |
| MS 387/13         | ‘Hokken 600’ × ‘Sylvan 4080’  |
| KS 14/11          | ‘Akiyama 567’ × ‘Sylvan 4080’ |
| KS 19/3           | ‘Akiyama 567’ × ‘Sylvan 4080’ |
| KS 37/14          | ‘Akiyama 567’ × ‘Sylvan 4080’ |
| KS 48/3           | ‘Akiyama 567’ × ‘Sylvan 4080’ |

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Oak sawdust supplemented with 20% addition of wheat bran was used as substrate. Experiments were conducted in the random design in five replications. Two cultivation cycles were carried out. The cultivation unit consisted of a substrate log of 2.5 kg.

#### **Preparation of substrates and incubation**

Supplemented substrates from oak sawdust were moistened with tap water until moisture content of 60% was obtained. Bags made of polypropylene with PP filter with the gas exchange area of 12.5 cm<sup>2</sup> were filled with 2.5 kg moist substrates per bag. Next substrates were sterilized in an autoclave at 121°C for 2 h. After substrates cooled to room temperature they were spawned with shiitake mycelium. Bags were sealed using a closing machine and placed in an incubation chamber. Incubation was conducted in the dark until substrates were completely overgrown with mycelium. During that time the temperature of 21-22°C and relative air humidity of 90-95% were maintained.

#### **Yielding and harvesting of carpophores**

After incubation plastic was removed and the substrate was placed in a cultivation chamber on metal shelves. Initially for the period of one week air temperature was maintained at 13°C and relative humidity at 90-95%. Within the next 14 days the temperature of 17°C during the day and 13°C at night and relative air humidity of 85-90% were maintained. The day and night cycle was ensured by lighting the cultivation with glow tubes (Day-Light) of 250 lx for 12 h a day. During that time the first crop was harvested for 14 days. After harvest the temperature in the cultivation chamber was raised to 22°C and relative humidity was lowered to 80-85% and maintained at the constant level for two weeks. After that time substrate logs were soaked in tap water of 12-15°C for 8 h. Next logs were again placed on shelves. For the next two-three weeks conditions in the cultivation chamber were identical as during the first cropping cycle. During that time carpophores were formed and the second harvest was conducted. Carpophores were harvested also for 14 days. This procedure was carried out until the fourth crop was obtained, after which the cultivation was completed.

Carpophores were harvested as they were growing to reach an appropriate size, when the margin of the cap was still turned downwards, immediately before its straightening. Carpophores were cut directly at the surface of the substrate and after morphological measurements were taken the stem was cut at 2 cm of the cap.

Results of experiments concerning morphological characters of shiitake were analysed using the analysis of variance at the level of significance  $\alpha = 0.05$ . Results were discussed for mean values from two cycles of cultivation experiments.

#### **Biometric measurements of carpophores**

Morphological characters of carpophores, i.e. the diameter and thickness of the cap, the length and diameter of the stem, mean weight and dry matter content of carpophores were measured on 50 carpophores selected at random from each experimental combination. Morphological characters were determined according to the diagram presented in Figure 1. Measurements were taken using a slide caliper with an accuracy of 1 mm. Dry matter content in carpophores was determined using the weight method as described by WADOWIENKO and SIWULSKI (1998).

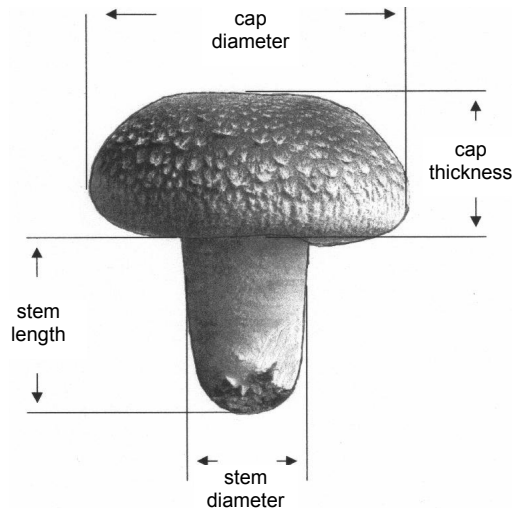


Fig. 1. A diagram of measurement of morphological characters in carpophore of shiitake  
 Rys. 1. Schemat pomiaru cech morfologicznych owocnika twardziaka jadalnego

## Results and discussion

The mycelium growth rate, yielding and morphological characters of the carpophore are varietal characters in shiitake (SCHUNEMANN 1988, PRZYBYLOWICZ and DONOGHUE 1990, RAASKA 1990, ROYSE 2001, SIWULSKI 2005).

It was found that carpophores of strain 'Hokken 600' had the statistically significantly largest cap diameter. A significantly smaller cap diameter was found for crossbred culture MS 387/13 and strain 'Sylvan 4080'. The cap diameter which was significantly smaller than those of all the other strains and crossbred cultures was observed in crossbred cultures MS 134/27 and KS 19/3. In turn, the smallest cap diameter was found in crossbred culture KS 48/3 (Table 2).

Strains and crossbred cultures differed significantly also in terms of cap thickness. Strain 'Hokken 600' had the thickest cap (14 mm). A similar cap thickness as in strain 'Hokken 600' was found for strain 'Sylvan 4080' (13 mm) and crossbred culture MS 387/13 (13 mm). In the other strains and crossbred cultures cap thickness was smaller and ranged from 12 mm in strain 'Akiyama 567' and crossbred cultures MS 204/56 and MS 380/5 to 9 mm in crossbred cultures MS 371/14 and KS 19/3. Crossbred cultures MS 134/27 and KS 48/3 had the smallest cap thickness (7 mm).

Strains and crossbred cultures showed a significant differentiation in stem diameter. It was found that strain 'Hokken 600' was characterized by the thickest stem (14 mm). Strains 'Akiyama 567' and 'Sylvan 4080' and crossbred cultures MS 387/13 and KS 14/11 had significantly smaller (13 mm) stem diameters than the above mentioned strain. In turn, the smallest stem diameter (8 mm) was observed in crossbred cultures KS 19/3 and KS 48/3.

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Table 2. Morphological features, mean weight and dry matter content of carpophores of shiitake strains and crossbred cultures

Tabela 2. Cechy morfologiczne, średnia masa i zawartość suchej substancji w owocnikach odmian i kultur krzyżówkowych twardziaka jadalnego

| Strains and crossbred cultures | Morphological features |                    |                    |                  | Carpophore weight and dry matter content in carpophores |                        |
|--------------------------------|------------------------|--------------------|--------------------|------------------|---|------------------------|
|                                | cap diameter (mm)      | cap thickness (mm) | stem diameter (mm) | stem length (mm) | weight (g)  | dry matter content (%) |
| 'Akiyama 567'                  | 52                     | 12                 | 13                 | 42               | 31.4  | 10.3                   |
| 'Hokken 600'                   | 63                     | 14                 | 14                 | 44               | 46.2  | 9.7                    |
| 'Sylvan 4080'                  | 57                     | 13                 | 13                 | 43               | 42.3  | 11.1                   |
| MS 73/11                       | 42                     | 10                 | 12                 | 41               | 29.9  | 8.4                    |
| MS 134/27                      | 37                     | 7                  | 9                  | 42               | 26.3  | 9.5                    |
| MS 134/30                      | 50                     | 11                 | 10                 | 43               | 32.4  | 10.0                   |
| MS 17/29                       | 48                     | 10                 | 12                 | 42               | 37.2  | 10.3                   |
| MS 204/56                      | 49                     | 12                 | 12                 | 41               | 31.0  | 10.5                   |
| MS 371/14                      | 41                     | 9                  | 9                  | 40               | 28.3  | 8.0                    |
| MS 380/5                       | 53                     | 12                 | 10                 | 42               | 42.5  | 9.7                    |
| MS 387/13                      | 58                     | 13                 | 13                 | 39               | 47.2  | 8.2                    |
| KS 14/11                       | 44                     | 10                 | 13                 | 38               | 38.9  | 9.6                    |
| KS 19/3                        | 38                     | 9                  | 8                  | 36               | 24.3  | 8.1                    |
| KS 37/14                       | 53                     | 11                 | 10                 | 41               | 40.0  | 10.1                   |
| KS 48/3                        | 33                     | 7                  | 8                  | 36               | 29.7  | 8.8                    |
| Mean                           | 48                     | 11                 | 11                 | 41               | 35.2  | 9.5                    |
| LSD <sub>0.05</sub>            | 2                      | 1                  | 1                  | 2                | 2.6   | 0.4                    |

The longest stem (44 mm) was found in strain 'Hokken 600'. Shorter stems were found in carpophores of strain 'Sylvan 4080' and crossbred culture MS 134/30. In carpophores of crossbred cultures KS 19/3 and KS 48/3 the shortest stems were found (36 mm).

The analysed strains and crossbred cultures differed significantly in the weight of carpophores. The biggest weight of carpophores was observed for crossbred culture MS 387/13 (47.2 g) and strain 'Hokken 600' (46.2 g). A significantly smaller weight of carpophores was found next for strain 'Sylvan 4080' and crossbred cultures MS 380/5 and KS 37/14. The other strains and crossbred cultures were characterized by a significantly lower weight of carpophores than the above mentioned strains and crossbred cultures. The lowest weight of carpophores (24.3 g) was observed in crossbred culture KS 19/3.

Dry matter content in carpophores of the strains and crossbred cultures of shiitake fell within a wide range of values. The highest dry matter content (11.1%) was found for strain 'Sylvan 4080', followed by crossbred culture MS 204/56 (10.5%). The lowest dry matter content was observed in crossbred cultures KS 19/3 (8.1%) and MS 371/14 (8.0%).

The results of the study indicate that carpophores of original strains as well as crossbred cultures show a significant morphological variation. Moreover, the analysed shiitake strains and crossbred cultures differed significantly in the mean weight of carpophores and dry matter content (Table 2).

## Conclusions

1. Considerable variation was found for the diameter and thickness of the cap and the diameter and length of the stem of carpophores in shiitake strains and crossbred cultures. Carpophores of KS 48/3 i KS 19/3 crossbred cultures showed morphological characters significantly different from characters of carpophores of the original strains.

2. The weight of carpophores in the analysed shiitake strains and crossbred cultures ranged considerably from 24.3 to 46.2 g. The weight of carpophores of shiitake strains was similar, while crossbred cultures exhibited a very high variation in the weight of carpophores. Most crossbred cultures formed carpophores of much lower weights than those of original strains.

3. Dry matter contents in carpophores of shiitake strains and crossbred cultures fell within a very wide range of values from 8.0 to 11.1%. The highest dry matter content in carpophores was found in strain 'Sylvan 4080'. Crossbred cultures had lower or similar dry matter contents in carpophores in comparison to those of original strains.

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#### PORÓWNANIE CECH MORFOLOGICZNYCH, MASY I ZAWARTOŚCI SUCHEJ SUBSTANCJI OWOCNIKÓW ODMIAN ORAZ KRZYŻÓWEK TWARDZIAKA JADALNEGO (*LENTINULA EDODES* (BERK.) PEGLER)

**Streszczenie.** Przedmiotem badań były trzy odmiany twardziaka jadalnego: ‘Sylvan 4080’, ‘Akiyama 567’ i ‘Hokken 600’ oraz 12 kultur krzyżówkowych tych odmian. Użyto podłoża z trocin dębowych wzbogaconych 20-procentowym dodatkiem otrębów pszennych. Porównano cechy morfologiczne owocników, tj. średnicę i grubość kapelusza oraz średnicę i długość trzonu. Określono również średnią masę owocników i zawartość suchej substancji w owocnikach. Stwierdzono, że owocniki odmian wyjściowych, jak również kultur krzyżówkowych, wykazują istotne zróżnicowanie morfologiczne. Badane odmiany i krzyżówki różniły się istotnie masą owocników i zawartością suchej substancji. Większość kultur krzyżówkowych tworzyła owocniki o masie mniejszej niż odmiany wyjściowe i o mniejszej zawartości suchej masy.

**Słowa kluczowe:** shiitake, odmiana, kultura krzyżówkowa, owocnik, cechy morfologiczne, sucha masa

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