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The influence of flushes on some constituents of mushrooms (*Agaricus bisporus*) cultivated on different composts

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Abstract

The effect of two different composts: horse manure and broiler chicken manure and the influence of flushes during the growing cycle on some chemical components contained in the mushroom (*Agaricus bisporus*) was studied. The strain Somycel 11 was analyzed. The following determinations were made: dry matter, total nitrogen and crude protein, nitrates, nitrites and amino acids composition. It has been noted that the crude protein from combined flushes III to VI of mushrooms cultivated on horse manure was about 24% higher than in those grown on broiler chicken manure. Some changes in amino acids composition, especially lysine, histidine, arginine, aspartic acid, serine, methionine, glutamic acid and alanine were observed, depending on the size of the fruit-body, flushes and type of compost.

INTRODUCTION

Yields of cultivated mushrooms vary singificantly over the flushes or breaks of the crop cycle. The extent of fluctuation in cropping intensity varies in part with the strain of the mushroom involved. Presumably, the variation in yield is directly related to the metabolic activity of the mushroom strain; i.e. periods of increased metabolic activity would result in increased yields, while periods of decreased metabolic activity would result in a decreased yield (Parrish et al., 1976). Undoubtedly metabolic activity of the mushrooms is affected by environmental factors such as temperature, relative humidity and levels of carbon dioxide which are known to be key factors in controlling the growth process.

The nutritional requirements of the cultivated strains of *Agaricus bisporus* and also the methods by which those substances are prepared and provided, are at least equal in importance to environmental factors. The unpredictable nature of compost — the substrate — imposes a major limitation not only in growing, but also in the quality of mushrooms and their nutritional value (Hayes, 1972).

The literature data and information whether the quality and chemical composition of mushrooms are affected by different compost preparation and whether compositional changes can occur over the flushes or breaks of the crop cycle, are rather limited. Gapiński and Gierszyński (1974) found that dry matter content of *Agaricus bisporus* is affected by compost preparation and the method of cultivation. Maggioni et al. (1968) reported that the strain Somycel 87, produced mushrooms during the fourth break which contained 15–25% more crude protein than those produced during the first break. They also found that mushrooms cultivated on compost supplemented with urea plus ammonium sulfate exhibited a lower total amino acids content with limited production of proline and arginine while exhibiting an increased production of methionine, aspartic acid, valine and alanine as compared with mushrooms grown on composts supplemented with ammonium sulfate alone. These changes in composition became less pronounced during successive breaks. Hughes et al. (1958), on the other hand, did not detect any differences in the protein content of an unspecified strain of *Agaricus bisporus* harvested during the first, third or fifth breaks. Only the amount of tyrosine decreased with each successive break.

MATERIALS AND METHODS

For research concerning the influence of the growing substrate on the dynamics of fruiting and chemical composition of *Agaricus bisporus*, two different composts: horse manure and broiler chicken manure were prepared. The study was carried out using the Somycel 11 strain.

The following determinations were performed, according to the methods described by Bąkowski and Kosson (1985): dry matter, crude protein, nitrates, nitrites, amino acids composition. All determinations were made using two different sizes of fruit-body: 25–35 mm in diameter of pileus described as small and > 35 mm in diameter of pileus described as large. The results were evaluated statistically. Confidence limit values were evaluated by the Dean and Dixon test (1951).

RESULTS AND DISCUSSION

Yield comparison of the mushrooms cultivated on two composts

The total yield was not affected by compost preparation being respectively 20.5 kg per square meter for horse manure and 20.6 kg per square meter for broiler chicken manure (Fig. 1). There were differences in the yield of the flushes. Yield intensity of mushrooms cultivated on horse manure in the first flush was much higher than for mushrooms cultivated on broiler chicken manure. Opposite results were obtained in the second flush. Since the combined yield of the initial three flushes of mushrooms for both composts made up the greatest part of the total yield (above 75%), the differences in the yield over the next flushes are less significant. The quality of mushrooms from the first, second, third and fourth flush was good. A characteristic of mushrooms from the second flush of both composts was a tendency to form smaller fruit-bodies. Mushrooms from the fifth and sixth flush cultivated on broiler chicken manure were of a somewhat worse quality because of developing scales (V flush) and occurring bacterial bleach (Fig. 1).

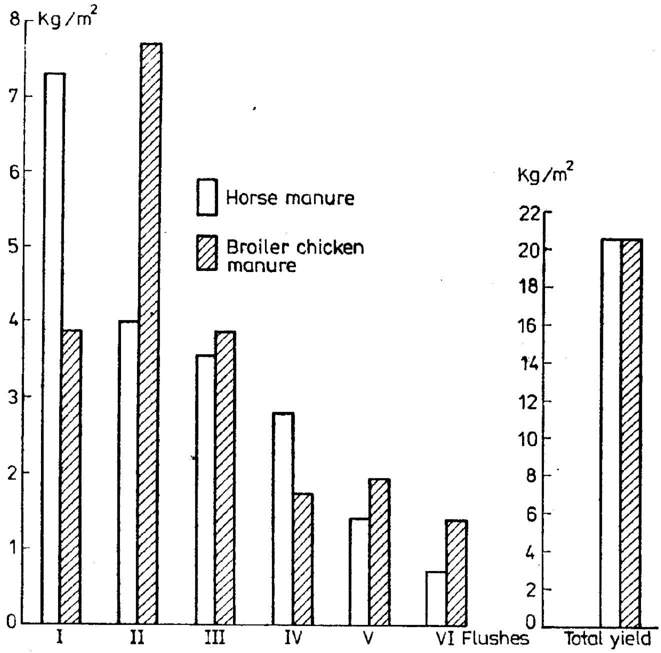

Fig. 1. Variation in the yields during the crop cycle of mushrooms (*Agaricus bisporus*) cultivated on two composts

Chemical composition of mushrooms cultivated on two composts

Dry matter content does not change significantly for large fruit-bodies over the flushes for both composts (Table 1). There are some significant differences for small mushrooms among the flushes. Mushrooms cultivated on horse manure from the IV flush exhibited a significantly higher dry matter content as compared with the I, II, III and V flush. Similarly, small mushrooms cultivated on broiler chicken manure from the VI flush had a higher dry matter than those from the I, II, III and V flush. Gapiński and Glebionek (1978) reported that the dry matter content did not change significantly during the crop cycle for four white strains

Table

Dry matter content, total nitrogen and crude protein in cultivated mushrooms (*Agaricus bisporus*)

Type of compost	Component	Approximate 25–35 mm Flush I	II	III	IV
Horse manure	Dry matter, %	7.07±0.7	6.4±0.8	6.8±0.8	8.1±0.1
	Total N (% dry weight without $N\text{-}NO_3$, $N\text{-}NO_2$)	5.15±0.10	6.32±0.19	7.91±0.02	7.11±0.13
	Crude protein N×4.38 (% dry weight)	22.61±0.44	27.68±0.83	34.65±0.09	31.14±0.07
Broiler chicken manure	Dry matter, %	8.9±0.4	8.3±0.8	8.4±0.1	9.0±1.1
	Total N (% dry weight without $N\text{-}NO_3$, $N\text{-}NO_2$)	5.38±0.24	6.00±0.04	5.95±0.08	5.59±0.41
	Crude protein N×4.38 (% dry weight)	23.56±1.05	26.28±0.18	26.06±0.35	24.48±1.80

Table

Amino acids composition of cultivated mushrooms (*Agaricus bisporus*) from successive flushes

Amino acid	Flush I		Flush II		Flush
	approximate diameter of the pileus				
	25–35 mm	> 35 mm	25–35 mm	> 35 mm	25–35 mm
Lysine**	6.81±0.44	6.79±0.76	5.87±0.33	6.69±0.52	4.88±0.13
Histidine**	2.32±0.17	2.08±0.29	2.08±0.10	2.11±0.15	1.92±0.36
Arginine**	3.94±0.41	3.75±0.14	3.51±0.13	3.73±0.35	3.63±0.06
Aspartic acid	9.83±0.74	9.27±0.81	10.00±0.58	9.57±0.49	8.99±0.22
Threonine**	3.90±0.35	3.11±0.12	3.77±0.40	3.40±0.06	3.92±0.39
Serine	4.02±0.34	3.47±0.30	4.61±0.26	4.21±0.21	3.49±0.20
Glutamic acid	20.50±1.30	19.11±1.71	19.96±0.62	19.60±1.05	19.33±0.94
Proline	4.57±0.11	4.95±0.05	5.38±0.26	4.61±0.29	6.13±0.30
Glycine	3.63±0.10	3.36±0.38	3.66±0.52	3.63±0.14	3.34±0.14
Alanine	5.61±0.29	5.59±0.33	5.57±0.22	5.47±0.05	5.47±0.06
Valine**	3.65±0.24	3.54±0.29	3.56±0.55	3.94±0.16	3.63±0.44
Methionine**	1.20±0.05	1.00±0.18	1.10±0.14	0.88±0.13	0.91±0.05
Isoleucine**	2.75±0.16	2.66±0.12	2.61±0.05	2.83±0.33	2.56±0.16
Leucine**	5.26±0.57	4.83±0.42	5.03±0.16	5.09±0.23	4.69±0.22
Tyrosine**	2.52±0.35	2.41±0.14	2.47±0.10	2.44±0.18	2.34±0.23
Phenyloalanine**	3.22±0.08	2.84±0.26	3.04±0.33	3.12±0.16	2.88±0.06
Total essential amino acids**	35.57	33.01	33.04	34.17	31.36
Total amino acids	83.73	78.76	82.22	81.26	78.11

* Averages from three independent replicates ± confidence limits at p = 0.95, evaluated according to Dean and

** Essential amino acids.

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from successive flushes, grown on two composts, horse manure and broiler chicken manure

diameter of pileus							
			> 35 mm				
number							
V	VI	I	II	III	IV	V	VI
7.5±0.5	8.3±0.7	7.2±0.7	6.5±0.8	6.9±0.9	7.8±0.6	7.0±0.8	8.4±1.1
6.31±0.11	6.73±0.16	5.13±0.14	6.29±0.07	7.57±0.01	7.06±0.06	6.14±0.20	6.42±0.12
27.64±0.48	29.48±0.70	22.47±0.09	27.55±0.39	33.16±0.04	30.92±0.26	26.89±0.88	28.12±0.53
8.9±0.5	10.9±1.1	8.8±0.3	8.0±0.9	8.0±0.8	8.9±1.2	8.6±0.8	9.7±1.0
5.23±0.10	5.54±0.34	5.14±0.14	5.75±0.20	5.79±0.12	5.56±0.32	5.02±0.16	5.26±0.28
22.91±0.44	24.72±1.49	22.51±0.61	25.19±0.88	23.56±0.53	24.35±1.40	21.99±0.70	23.04±1.23

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growing on horse manure (expressed in grams per 16 grams of nitrogen [g/16g N])*

III	Flush IV		Flush V		Flush VI	
> 35 mm	25–35 mm	> 35 mm	25–35 mm	> 35 mm	25–35 mm	> 35 mm
4.68±0.13	4.43±0.36	7.27±0.77	5.19±0.25	4.75±0.68	6.83±0.59	7.14±0.26
1.65±0.22	1.67±0.36	1.88±0.22	1.61±0.16	1.65±0.10	1.77±0.20	2.18±0.38
3.86±0.08	4.32±0.34	4.20±0.47	3.90±0.31	3.54±0.32	4.55±0.20	4.63±0.23
9.40±0.64	9.68±0.19	8.93±0.32	9.05±0.18	8.75±0.13	11.12±0.18	12.71±1.08
3.61±0.29	4.03±0.35	3.78±0.22	3.56±0.13	3.23±0.22	3.97±0.18	4.71±0.36
3.87±0.07	4.24±0.17	4.04±0.12	3.91±0.29	3.88±0.05	4.73±0.49	5.55±0.62
22.33±1.74	20.30±0.32	20.04±0.88	20.15±0.22	20.39±0.52	24.07±1.11	22.25±0.60
4.55±0.38	4.10±0.13	4.11±0.08	3.93±0.06	4.25±0.06	4.22±0.35	4.19±0.10
3.44±0.09	3.60±0.13	3.28±0.28	3.26±0.13	3.41±0.18	4.57±0.04	4.63±0.16
6.07±0.35	5.28±0.14	5.42±0.29	4.71±0.16	4.96±0.26	5.67±0.26	5.86±0.39
3.67±0.47	3.81±0.47	3.52±0.08	3.26±0.10	3.59±0.44	4.27±0.46	4.40±0.39
0.90±0.13	0.84±0.04	0.93±0.07	1.04±0.08	0.96±0.09	1.16±0.08	0.98±0.03
2.52±0.07	2.66±0.08	2.45±0.17	2.55±0.14	2.53±0.10	2.93±0.16	2.62±0.14
4.86±0.33	4.99±0.13	4.83±0.23	4.48±0.33	4.29±0.11	4.70±0.26	4.38±0.07
2.40±0.12	2.49±0.25	2.26±0.29	2.16±0.18	2.18±0.06	2.49±0.13	2.34±0.14
3.13±0.14	3.35±0.18	2.92±0.26	2.67±0.26	2.81±0.04	3.06±0.10	2.87±0.13
31.28	32.59	33.51	30.42	29.52	35.73	36.35
80.95	79.79	79.33	65.43	75.16	90.11	91.53

Dixon test.

of *Agaricus bisporus*. On the other hand Lemke (1971) found that mushrooms at the beginning of the fruiting cycle had the highest dry matter content. It can be observed (Table 1) that the dry matter content of small mushrooms cultivated on broiler chicken manure is significantly higher for nearly all respective flushes, in comparison with those cultivated on horse manure. For large fruit-bodies this difference is observed only in the first flush.

Mushrooms cultivated on horse manure exhibit an increase in crude protein content to a maximum value in the third flush, and the fourth and fifth show a decrease (Table 1., Fig. 2). For small and large fruit-bodies the average highest value in the third flush is 33.9% on the dry weight basis, and the lowest in the first flush

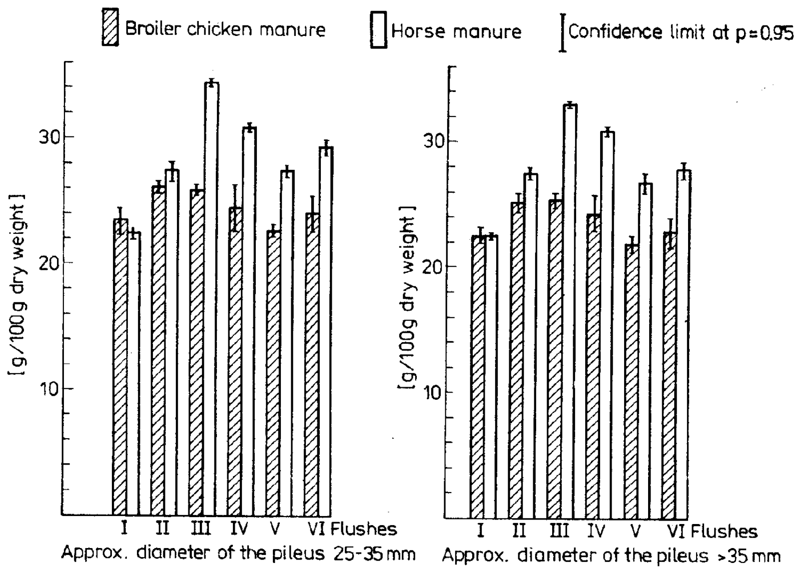

Fig. 2. Changes in crude protein content of the mushrooms (*Agaricus bisporus*) cultivated on two composts

22.5% on the dry weight basis. On the other hand, it is observed that for broiler chicken manure only mushrooms from the second and third flush have a higher level of crude protein content in comparison with those from the first and fifth flush (also for large fruit-bodies sixth flush). By comparing the crude protein content of mushrooms cultivated on different composts it was observed that mushrooms from the III, IV, V and VI flush, and also for large fruit-bodies from II flush growing on horse manure have a significantly higher level of crude protein than those from the respective flushes cultivated on broiler chicken manure. The average content of crude protein from combined flushes III–VI of mushrooms cultivated on horse manure is about 24% higher than of those growing on broiler chicken manure.

The nitrate level in mushrooms is rather low in comparison with some vegetables. The nitrite level is also very low but significant. A trend for both composts can be observed in that the nitrates in mushrooms from the last two or three flushes is higher than in those from the two or three initial flushes. Nitrates content of mushrooms cultivated on broiler chicken manure is about twice that of those cultivated on horse manure. A similar effect is observed for nitrites (Fig. 3).

The lowest lysine value was detected in mushrooms from the third flush grown on both composts (Fig. 4). Large fruit-bodies from the fourth flush grown on horse manure contain about 60% more lysine than small ones. Usually small fruit-bodies from the initial two flushes contain significantly more lysine than those from the third, fourth and fifth flushes. The lysine content of mushrooms from the sixth flush, grown on horse manure, is considerably higher than of those grown on broiler chicken manure. Similar difference can be observed for large fruit-bodies from the fourth flush.

The only significant difference for small and large fruit-bodies is that the level of histidine in mushrooms from the first and second flush cultivated on horse manure is higher than of those grown on broiler chicken manure (Tables 2, 3).

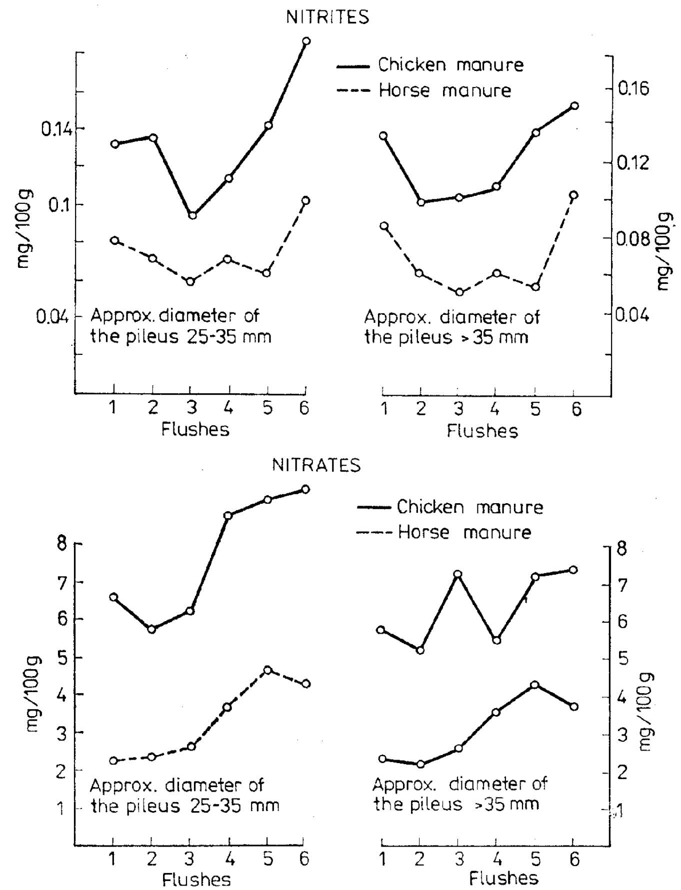

Fig. 3. Influence of successive flushes on nitrates and nitrites content in the mushroom *Agaricus bisporus* cultivated on horse manure and broiler chicken manure

Table

Amino acids composition of cultivated mushrooms (*Agaticus bisporus*) from successive flushes

Amino acid	Flush I		Flush II		Flush
	approximate				
	25–35 mm	>35 mm	25–35 mm	> 35 mm	25–35 mm
Lysine**	5.92±0.32	6.10±0.16	5.85±0.32	5.65±0.51	4.44±0.26
Histidine**	1.68±0.09	1.66±0.12	1.41±0.20	1.65±0.09	1.41±0.20
Arginine**	4.17±0.17	4.13±0.26	4.33±0.12	4.13±0.22	3.61±0.04
Aspartic acid	9.96±0.21	9.63±0.29	10.11±1.04	10.95±0.20	9.39±1.04
Threonine**	3.45±0.16	3.76±0.35	3.05±0.23	4.11±0.29	4.02±0.13
Serine	3.85±0.21	3.84±0.23	3.90±0.27	4.49±0.29	3.56±0.04
Glutamic acid	23.43±2.21	24.49±1.39	24.35±0.97	24.41±0.66	22.63±2.20
Proline	3.95±0.07	4.59±0.06	4.30±0.17	3.90±0.06	6.98±0.10
Glycine	4.39±0.16	4.55±0.08	4.39±0.35	4.39±0.25	3.46±0.13
Alanine	6.13±0.21	6.16±0.10	6.32±0.35	6.53±0.09	4.89±0.06
Valine**	4.22±0.17	4.25±0.13	4.00±0.22	4.10±0.29	3.56±0.05
Methionine**	1.03±0.12	1.00±0.08	1.23±0.10	1.15±0.11	0.98±0.09
Isoleucine**	3.08±0.18	2.96±0.14	2.88±0.16	2.68±0.21	2.70±0.16
Leucine**	5.66±0.04	5.47±0.13	5.59±0.36	5.39±0.29	5.23±0.48
Tyrosine**	2.40±0.27	2.45±0.20	2.45±0.22	2.21±0.23	2.40±0.26
Phenyloalanine**	3.13±0.06	3.06±0.07	3.16±0.26	3.03±0.23	3.01±0.17
Total essential amino acids**	34.74	34.84	33.94	34.10	31.36
Total amino acids	86.63	88.10	87.31	88.77	82.27

* Averages from three independent replicates ± confidence limits at p = 0.95, evaluated according to Dean and
** Essential amino acids.

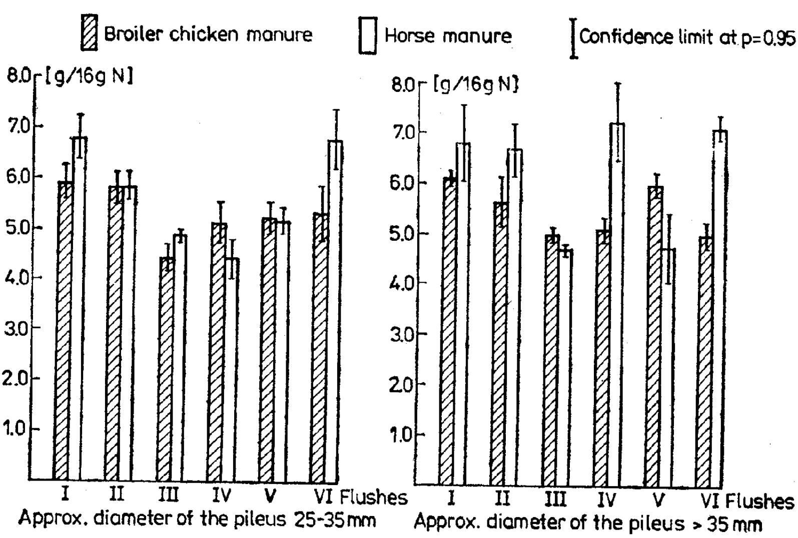

Fig. 4. Changes in lysine content of the mushrooms (*Agaricus bisporus*) cultivated on two composts

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growing on broiler chicken manure (expressed in grams per 16 grams of nitrogen [g/16g N])*

III	Flush IV		Flush V		Flush VI	
diameter of the pileus						
> 35 mm	25–35 mm	> 35 mm	25–35 mm	> 35 mm	25–35 mm	> 35 mm
4.98±0.18	5.15±0.40	5.10±0.23	5.24±0.31	6.01±0.25	5.37±0.52	5.02±0.23
1.67±0.18	1.73±0.14	1.66±0.18	1.73±0.13	1.78±0.17	1.63±0.04	1.48±0.13
4.04±0.10	4.15±0.44	4.05±0.12	3.88±0.30	3.87±0.13	3.91±0.14	3.59±0.08
9.01±0.19	8.72±0.45	8.40±0.65	8.10±0.14	8.10±0.16	8.04±0.34	7.61±0.38
3.44±0.12	3.61±0.20	3.38±0.14	3.84±0.22	3.36±0.20	3.18±0.09	3.39±0.07
3.70±0.04	3.94±0.18	3.70±0.04	3.56±0.16	3.53±0.26	3.49±0.31	3.38±0.18
22.48±0.65	21.38±0.52	20.57±0.61	18.20±1.24	18.22±0.13	19.75±0.86	19.39±1.07
6.18±0.46	6.36±0.53	6.12±0.14	5.67±0.81	6.01±0.89	4.79±0.42	7.12±0.31
3.54±0.08	3.59±0.13	3.49±0.13	3.49±0.05	3.51±0.21	3.36±0.14	3.26±0.13
5.19±0.30	5.15±0.14	4.90±0.06	4.78±0.27	5.01±0.06	4.99±0.18	4.67±0.17
3.60±0.34	3.57±0.21	3.47±0.13	3.30±0.17	3.73±0.18	3.82±0.42	3.23±0.14
0.93±0.04	0.81±0.10	0.70±0.10	0.87±0.08	0.86±0.04	0.83±0.05	0.83±0.05
2.66±0.07	2.63±0.12	2.57±0.04	2.64±0.12	2.69±0.12	2.47±0.14	2.36±0.13
5.03±0.17	4.80±0.40	4.65±0.13	4.92±0.08	5.01±0.36	4.91±0.16	4.59±0.07
2.39±0.12	2.30±0.04	2.18±0.25	2.35±0.19	2.25±0.32	2.18±0.05	2.15±0.16
2.98±0.07	2.88±0.17	2.68±0.25	2.85±0.07	2.89±0.08	2.87±0.10	2.71±0.12
31.72	31.63	30.44	31.62	32.51	31.17	29.35
81.82	80.77	77.62	75.42	76.86	75.59	74.78

Dixon test

The content of arginine in mushrooms from the sixth flush cultivated on horse manure is significantly higher than of those grown on broiler chicken manure (Tables 2, 3).

The highest amount of aspartic acid is observed in mushrooms from the sixth flush cultivated on horse manure (Table 2).

The mushrooms cultivated on horse manure contain significantly higher levels of serine as compared with those grown on broiler chicken manure (Tables 2, 3).

A significantly higher content of glutamic acid is observed for small and large fruit-bodies from the initial two flushes grown on broiler chicken manure as compared with those growing on horse manure. Opposite changes are noted for mushrooms from the last flush (Tables 2, 3).

Changes in proline levels are observed in mushrooms growing on broiler chicken manure (Table 3). The content of proline in fruit-bodies from the first and second flush is pronouncedly lower than from the remained ones. There are also some irregular changes.

The mushrooms from two initial flushes grown on broiler chicken manure contain significantly higher amounts of alanine than those from the remaining flushes, and also more than mushrooms of the two respective flushes grown on horse manure (Table 2). Opposite changes in alanine content are also observed for mushrooms grown on the two compared composts in the last flush.

Some irregular changes can be observed depending on the size of the fruit-body, flushes and compost preparation. For small fruit-bodies grown on horse manure, the level of methionine decreases up to the fourth flush and then increases (Fig. 5). Similar trends of decreasing, however, but not so pronounced are observed for fruit-bodies of both sizes grown on broiler chicken manure. The methionine level is constant for large fruit-bodies grown on horse manure. Small fruit-bodies from the sixth and fifth and large ones from the sixth and fourth flush grown on horse manure, are characterized by a higher quantity of methionine in comparison with the corresponding fruit-bodies of the respective flushes grown on broiler chicken manure.

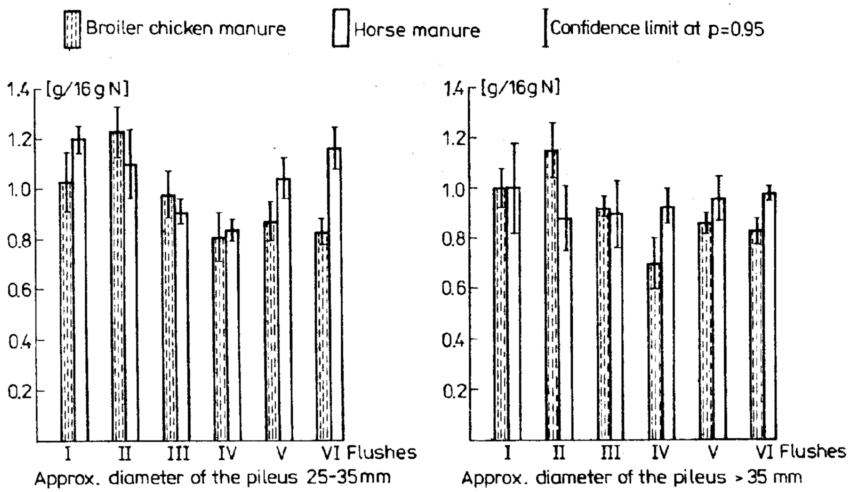

Fig. 5. Changes in methionine content of mushrooms (*Agaricus bisporus*) cultivated on two composts

Other amino acids contents as threonine, glycine, valine, isoleucine, leucine, tyrosine, phenylalanine do not differ significantly in mushrooms grown on different composts and some changes during the flushes are rather irregular (Tables 2, 3). In contrast with Hughes et al. (1958) in this study was not observed a decreased amount of tyrosine with each successive flush.

Total amino acids content (Tables 2 and 3) in mushrooms grown on both composts is usually higher in the initial two flushes, while the highest value (90.8 g 16g N) is reached in the sixth flush on horse manure.

CONCLUSION

1. The total yield was not affected by compost preparation, however some differences in the yield of the flushes were noted. The yield intensity of mushrooms cultivated on horse manure in the first flush was higher, and lower in the second in comparison with that of mushrooms cultivated on broiler chicken manure.

2. On both composts small fruit-bodies contained more dry matter in the last flushes. Small fruit bodies grown on broiler chicken manure were characterized by a higher dry matter content than those from horse manure.

3. The average content of crude protein from combined flushes III to VI of mushrooms cultivated on horse manure was about 24% higher than of those grown on broiler chicken manure.

4. Some irregular changes in amino acids composition can be observed depending on the size of the fruit-body, flushes and type of compost. Lysine, hisitidine, arginine, aspartic acid, serine, and methionine usually are present in higher amounts in mushrooms from some flushes grown on horse manure than on broiler chicken manure. Total amino acids content in mushrooms grown on both composts is usually higher in the initial two flushes.

5. The nitrate and nitrite levels are rather low in comparison with some vegetables. Nitrates and nitrites contents in mushrooms cultivated on broiler chicken manure are about twice as high as in those cultivated on horse manure.

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Wpływ terminów owocnikowania na niektóre składniki pieczarek (*Agaricus bisporus*) uprawianych na różnych podłożach

Streszczenie

Badano wpływ rodzaju podłoża (nawóz koński i kurzy) oraz wpływ kolejnych rzutów pieczarek na zawartość niektórych składników w grzybach *Agaricus bisporus*. W doświadczeniu wykorzystano rasę pieczarek — Somycel 11. Analizowano plonowanie pieczarek, zawartość suchej masy, azotu ogółem, białka, azotanów, azotynów oraz skład aminokwasowy. Stwierdzono, że rodzaj podłoża nie wpływał na plon ogólny pieczarek, aczkolwiek zaobserwowano zróżnicowane plonowanie na każdym z podłoży w poszczególnych rzutach grzybów. Owocniki małe, pochodzące z ostatnich rzutów, zawierały więcej suchej masy w porównaniu do owocników z rzutów początkowych. Zauważono, że zawartość białka w pieczarkach uprawianych na nawozie końskim z rzutów od III do VI była o około 24% większa w porównaniu z pieczarkami uprawianymi na nawozie kurzym. Poziom zawartości azotanów i azotynów w badanych grzybach jest raczej niski w porównaniu do warzyw. Pieczarki uprawiane na nawozie kurzym zachowały około dwa razy więcej azotanów i azotynów w porównaniu do pieczarek uprawianych na nawozie końskim. Wykryto również różnice w zawartości niektórych aminokwasów takich jak: lizyna, histydyna, arginina, kwas asparaginowy, seryna, metionina, alanina i kwas glutaminowy w pieczarkach zależnie od wielkości owocników, rzutów i typu kompostu, na którym uprawiano grzyby.