THESES OF DOCTORAL (PhD) DISSERTATION

UNIVERSITY OF WEST-HUNGARY
FACULTY OF AGRICULTURE AND FOOD SCIENCES

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EFFECT OF SELENIUM DOSING TO YIELD OF CULTIVATED CHAMPION (AGARICUS BISPORUS) AND ITS SELENIUM CONTENT

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1. INTRODUCTION AND OBJECTIVES

The physiological role of selenium was in the centre of microelement research in the last decades. Van Vleet proved with his experiments in 1984, that glutathion-peroxidase, which contains the selenium in seleno-cysteine form, together with E vitamin defend the erythrocyte, musculus and hepar cells from the harmful effect of peroxide developing from the lipids and organic acids. The selenium and E vitamin are one and other sinergist. Criqui and co-workers studied the development of the glutathion-peroxidase in dividing cells of germ seeds in 1992. They justified, that the seleno-cysteine not the results of changing of sulphur for selenium after translation but a brand-new genetically coding amino acids. The plants pick up the selenium from the soil, while the animals from the plant food and water. The selenium occurs principally in protein-bounded form in the plants. The selenium supplying is different on the different part of the World. There is middle level in Hungary, but very low in the area of Somogy and Zala counties. The offered income is 1 μg/body-weight kg by the recommendation of FAO/WHO. Lot of publications are connected with selenium content of human food. Many publications deal with utilisation, the accumulation and the physiological role of different selenium forms: SE(IV) and Se(VI) seleno-methionine and seleno-cysteine. There are great variety of medicine, pharmaceutical products, dietary accessories and foods which contain selenium. The cultivated champignon (Agaricus bisporus) is the biggest volume cultivated mushroom all over the world. This champignon seems to become a suitable selenium rich foodstuff in the above-mentioned supply.

The aims of the present study:

How can change the selenium concentration of cultivated champignon depending on the selenium concentration of compost?
How can change the selenium concentration of cultivated champignon applying different selenium forms Se(IV)selenite and Se(VI)selenate?
How can the different selenium forms affect the yield volume of mushrooms? What rate of selenium concentration is beneficial or toxic to the yield of mushrooms?

How can change the take up of the different selenium form in different phase compost?
Is the treatment influenced the dynamism of the yield or not?
What kind of application method of the Se enriched champignon can be?

2. MATERIALS AND METHODS

The examinations was carried out on the University of West Hungary Faculty of Agricultural and Food Sciences Deparment of Chemistry

2.1. Cultivation of champignon (Agaricus bisporus)

The condition to champignon experiences was guarantee by Sampinyon Kft (Máriakálnok). We made our experiences on the seat of the company. We used first and second phase compost to our experiences. We used the plastic bag cultivation method. During the several years experiences we have taken experiences on different selenium concentration of compost (5 mg/kg, 10 mg/kg, 40 mg/kg, 50 mg/kg 60 mg/kg, 100 mg/kg, 250 mg/kg, 500 mg/kg)

2.2. Preparation of mushroom samples to the microelement examinations

The samples was drying to constant weight and its was fractured by mix of nitric acid- hydrogen-peroxide. The selenium content was analysed by using Jobin-Yvon ICP-OES instrument.

3. RESULTS

3.1. Selenium concentration and yield changing of mushroom depending on selenium concentration of the compost

At the prelimilary experiments we studied the changing of selenium concentration of cultivated champignon, when we enriched the selenium content of compost (cultivation medium). Experiments was carried out on second phase compost applying with Se(IV) ions. The selenium and other mineral content of applied compost,

mushroom mycelium, on selenium rich compost cultivated mushroom was measured.

1. table Mineral content of compost (mg/kg)

Element	Pieces	Average	Spread	CV%	Minimum	Maximum
Al	3	890	67,3	7,4	808	966,5
B	3	13,6	2,7	19,7	11,3	17,4
Ba	3	49,7	6,7	13,5	42,5	58,7
Ca	3	32300	2162	6,6	29800	35100
Cd	3	1,0	1,14	112,0	0,170	2,6
Co	3	1,3	0,26	19,9	1,03	1,6
Cr	3	7,2	2,47	34,5	4,96	10,6
Cu	3	31,0	5,44	17,5	25,9	38,6
Fe	3	857	70,3	8,2	784	952
K	3	16000	3242	20,2	13000	20500
Li	3	2,1	0,35	16,6	1,7	2,5
Mg	3	4800	984	20,5	3,8	6,1
Mn	3	186	47,86	25,7	148	254
Na	3	1950	349	17,8	1650	2440
Ni	3	4,3	1,09	25,5	3,3	5,8
P	3	6350	905	14,2	5360	7540
Se	3	≥0,02				
Si	3	8,1	2,20	27,0	5,0	10,1
Sr	3	132	12,6	9,5	122	150
Ti	3	0,8	0,17	20,4	0,6	0,98
V	3	4,4	0,91	20,5	3,6	5,7
Zn	3	80,5	33,24	41,2	54	127

2. table Mineral content of mycelium (mg/kg)

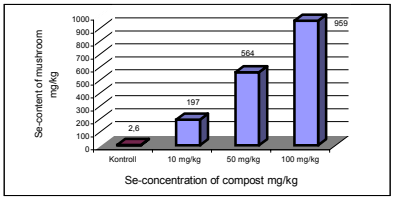
Element	Pieces	Average	Spread	CV%	Minimum	Maximum
Al	3	14,7	1,28	8,7	13,8	16,6
B	3	1,55	0,01	5,3	1,46	1,66
Ba	3	2,79	0,19	6,7	2,53	2,96
Ca	3	3630	1956	53,9	971	5620
Cr	3	1,30	0,29	22,6	1,01	1,71
Cu	3	3,41	0,48	13,9	2,97	4,08
Fe	3	25,9	4,78	18,4	19,6	31,1
K	3	4690	443	9,4	4070	5087
Mg	3	947	79,99	8,4	834	1010
Mn	3	35,4	2,696	7,6	31,7	38,1
Mo	3	0,36	0,07	18,3	0,27	0,42
Na	3	26,8	5,65	21,6	18,9	31,4
Ni	3	0,29	0,06	22,2	0,23	0,38
P	3	3160	290	9,1	2750	3390
Se	3	34,5	9,11	26,4	22,0	43,4
Si	3	15,8	1,63	10,3	13,5	17,4
Sr	3	5,25	0,19	3,7	4,99	5,45
Ti	3	0,19	0,02	8,5	0,18	0,23
Zn	3	27,2	6,33	23,2	20,2	35,5

3. table Mineral content of cultivated mushroom

Element	**mg/kg**	Element	**mg/kg**
1. Al	21,4	13. Mg	10000
2. B	13,0	14. Mn	11,4
3. Ba	6,80	15. Na	630
4. Ca	668	16. Ni	4,55
5. Cd	0,31	17. P	12100
6. Co	0,09	18. Pb	0,67
7. Cr	17,7	19. Se	2,81
8. Cu	36,2	20. Si	14,6
9. Fe	101	21. Sr	3,18
10. Hg	5,77	22. Ti	2,24
11. K	29700	23. V	0,14
12.Li	0,13	24. Zn	79,8

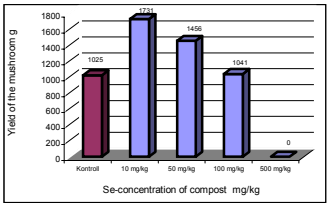
The influence of increasing of compost's selenium content to the mushroom selenium content and yield was studied. It was important to determine the toxic selenium concentration to the mushroom.

It is seen on the 1. figure that increasing of compost's selenium concentration provided increasing of the selenium content of mushroom near 1000 mg/kg value. It was proved at P= 5 % significant level $SzD_{5\%}$: 126,5 mg/kg.



1. figure Changing of selenium content of mushroom depending on compost's selenium concentration

We can see on the 2. figure changing of the yield volume of champignon depending on the different selenium concentration of compost. The selenium concentration of compost affected the yield volume of mushroom. Sporophore not developed on 500mg/kg selenium content of compost. Mycelium developing was limited level.



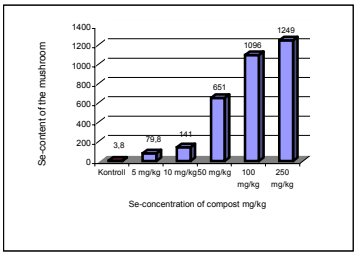
2. figure Changing of yield volume of champignon depending on compost's selenium concentration

It is seen on the 2. figure that the highest yield volume was reached on 10 mg/kg selenium content of compost from different ones. This yield volume was significantly higher than the controll. It is suggested that selenium content of compost affected to the yield of developing champignon.

3.2. Changing of selenium content and yield volume of champignon depending on different selenium forms

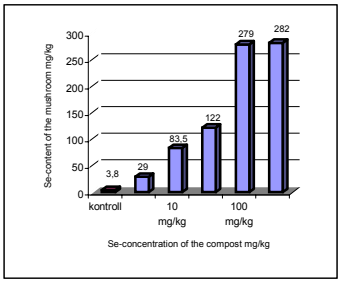
The effect of different selenium forms: the selenite(IV) and the selenate(VI) ions was examined to the selenium content and yield of champignon. The selenium concentration was the following in both selenium forms: 0 mg/kg, 10 mg/kg, 50 mg/kg, 100 mg/kg és 250 mg/kg.

It is seen on the 3. figure which show the effect of sodium selenite that the selenium content of champignon increases when the selenium content of compost increases. The selenium content of mushroom which develop on the highest selenium content of compost higher than 1200 mg/kg value. .

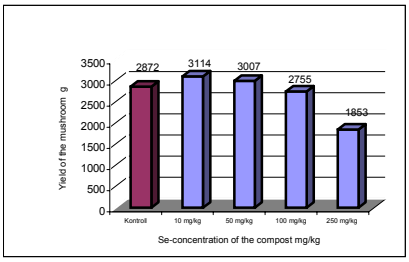


3. figure Changing of selenium content of mushroom depending on compost's selenium concentration using of sodium-selenite

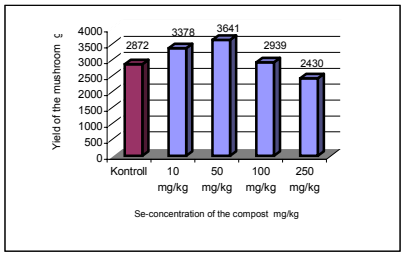
It is seen on the 4. figure which show the effect of sodium selenaite that the selenium content of mushroom also increased when using sodium selenate but the increasing was lower than using sodium selenite.



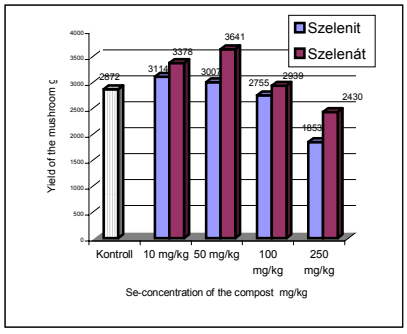
4. figure Changing of selenium content of mushroom depending on compost's selenium concentration using of sodium-selenate



5. figure Changing of yield volume of mushroom depending of compost's selenium concentration using of sodium-selenite



6. figure Changing of yield volume of mushroom depending of compost's selenium concentration using of sodium-selenate

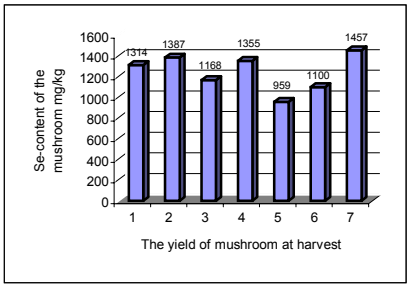


7. figure Changing of yield volumeof mushroom depending of compost's selenium concentration usingof sodium-selenite and sodium-selenate

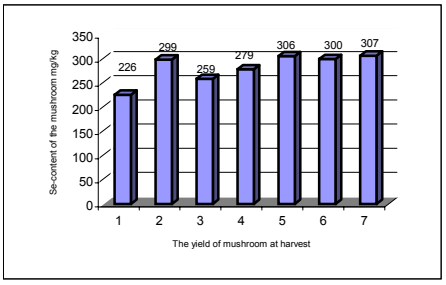
It is seen on the 5. 6. 7. figures, that both selenium forms have favourable effect to yield volumen of champignon, because it is increased at ceartain concentration level. At the same time it is seen on the figures that the yield volumen of champignon was decreased or lower than controll under certain selenium concentration (the Se (IV) ions at lower concentration, than the Se (VI) ions).

3.3. Microelements take up in the time of cultivation

It is important question to examine the changing of mineral content of mushroom on the time of cultivation.

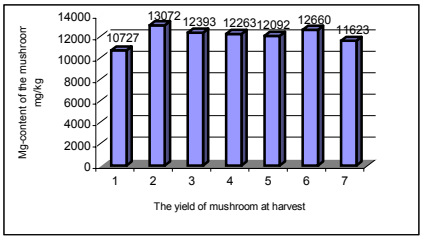


8. figure Formation of selenium content under cultivation (sodium-selenite) 250 mg/kg

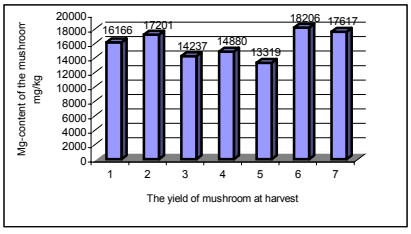


9. figure Formation of selenium content under cultivation (sodium-selenate) 250 mg/kg

It is seen on the 8. and 9. figures that the selenium content of mushroom was similar on the two weeks of cultivation. It is caracterised comparatively low spread level using sodium selenite or sodium selenate. An other element take up was necessary to study in the experiment which concentration is more higher in both the compost and mushroom. The magnesium was served this purpose.



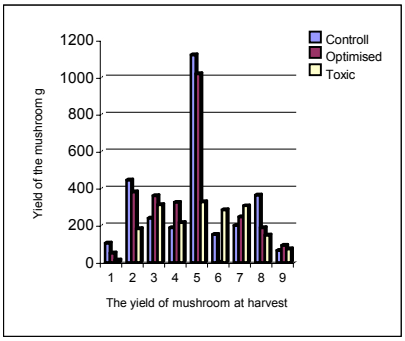
10. figure Formation of magnesium content under cultivation (sodium-selenite) 250 mg/kg



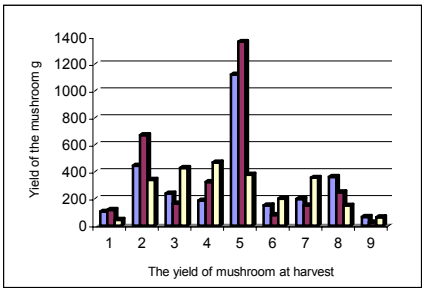
11. figure Formation of magnesium content under cultivation (sodium-selenate) 250 mg/kg

3.4. The effect of selenium enrichment tothe dynamism of cultivation

It was analysed that changing of selenium content of shampignon affect or not the dynamsim of cultivation. The mushroom was cultivated on three different selenium content of compost (controll, optimised and toxic). Dates of this examination was analysed.



12. figure Changing of yield volume of ampignonunder cultivation using of sodium-selenite



13. figure Changing of yield volume of champignonunder cultivation using of sodium-selenate

It is seen on the 12. and 13. figures that the selenium enrichment not affected demonstratively the time of developing of sporophore using of sodium-selenite or sodium-selenate. The development dynamism of champignon not showed significant difference on controll or selenium content compost.

4. NEW SCIENTIFIC RESULTS (RESULTS ACHIEVEMENT)

1. The selenium content of cultivated champion increased significantly by enrichment of selenium content of compost.
2. Both the Se (IV) and the Se (VI) ions are appropriate for the increase of selenium content of cultivated champion.
3. It is possible to reach higher selenium content of mushrooms using of Se (IV), than using of Se (VI). It is possible to produce more than 1200 mg/kg (selenium concentration of compost: 250mg/kg) by using Se (IV) and 360 mg/kg selenium content of mushrooms (selenium concentration of compost 500mg/kg) by using Se (VI).
4. The selenium content of compost influenced the yield of champion in both selenium forms. We reached the highest yield when the selenium concentration of compost was 10mg/kg in case of Se (IV) and selenium concentration of compost was 50mg/kg at Se (VI). The highest yield was reached by using Se (IV).
5. Over certain level the selenium content of compost was toxic to the mushroom in both selenium forms. The Se (IV) ions became toxic for the mushroom at lower concentration from 10-50 mg/kg compost selenium concentrations, while the Se (VI) ions from at 50-100 mg/kg selenium concentrations. Sporophore does not develop when using Se (IV) ions at 500 mg/kg selenium content of compost while it developed half than control using Se (VI) ions.
6. The effect of different selenium forms to the yield of mushroom was studied in different phase composts. It was concluded that both the Se (IV) and Se (VI) was more effective on second phase compost.
7. It was justified that neither selenium nor magnesium content of mushrooms changed during the period of cultivation.
8. The increased selenium concentration of compost did not have any effect to the dynamic of the sprophore's in case of both selenium forms.

9. The high selenium content cultivated champion can be powdered well after drying. The selenium content of powdered mushroom can be adjusted to the desirable value.

5. SUGGESTIONS

One of the aims of the experiments was to examine whether the cultivated champignon is appropriate to appear as food with high selenium content to provide a newer selenium source to the costumers. It is concluded on the basis of the results that the cultivated champignon is can be appropriate to appear on the market as a food of high selenium content on the basis its properties and cultivation technology. It seems that cultivated mushroom is appropriate to guarantee the above-mentioned aims. When it was cultivated on compost of 10 mg/kg-50mg/kg selenium content depending on using Se (IV) or Se (VI) ions. The yield is near 100 mg/kg mushroom with selenium content in both cases. It is deathful to pick up more than 50-100mg/kg selenium to the human being. The selenium enrichment mushroom is able to become part of foods, dietary accessories, medicine or pharmaceutical products. It is necessary to different preparing methods the champignon methods for different using. The selenium rich mushroom is appropriate to use with common cuisine methods for meals.

The ability of any selenium forms for yield of mushroom is the most important property for mushroom farmers. The handling of high selenium content mushroom product is different from others, because its selenium content is high (100-200 mg/kg). The highest yield was reached by sodium-selenate.

The high selenium content cultivated champignon is becoming well treatable in mushroom powder form originated whichever selenium content mushroom.

The high selenium content cultivated champignon can be powdered and grinded well after drying. The mushroom can be pounded the appropriate from in laboratory mortar. The mushroom powder is homogenised well. The selenium content of powdered mushroom can be adjusted to the desirable value.

6. PUBLICATIONS

ORIGINAL PAPERS PUBLISHED IN SCIENTIFIC JOURNALS

In German and English

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Tóásó, Gy. – Schmidt, R. (2000): Szeléndúsítási kísérletek a termesztett kétspórás csiperkével (Agaricus bisporus/Lge./Imbach) NyME Analitikai- és Környezetvédelmi Konferencia Mosonmagyaróvár 2000. október 26-27.

Schmidt, R. – Kalocsai, R. – Tóásó, Gy. – Szakál, P. (2002): Mikroelemek szerepe és felhasználhatóságuk a növénytermesztésben. A magyar tudomány napja 2002 A Kémiai Intézet Tudományos ülése Sopron 2002. november 7.

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Szakál, P. – Schmidt, R. – Tóásó, Gy. – Kalocsai, R. – Giczi, Zs. (2004): Őszi búza szelén és mikroelem trágyázása. Poszter előadás. Szelén az élettelen és élő természetben, Konferencia. Gödöllő.

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