DIFFERENCES IN NUTRITIONAL COMPOSITION OF SHIITAKE MUSHROOMS (*LENTINULA EDODES*) PRODUCED IN PORTUGAL

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Abstract – The aim of this study was to evaluate and compare the nutritional composition of shiitake mushrooms (*Lentinula edodes*) obtained by different cultivation processes from different areas (fruiting induced by sprinkler from Amarante or dipping method from Sintra). Macronutrient, vitamin B1 and B2, minerals and contaminant trace metals were quantified in three samples.
Variability among the different samples regarding macronutrients, minerals content was found. Regarding contaminants content, only one sample showed an atypical high value for arsenic. The results obtained indicate that the shiitake mushroom is an important dietary source of several nutrients, and the sample fructified by dipping seems to be nutritionally richer and chemically safer.

Keywords: mushrooms, shiitake, *Lentinula edodes*, nutritional composition.

Target – Determination of the nutritional composition and heavy metals profile of Shiitake mushrooms obtained by different cultivation processes from different areas.

1. INTRODUCTION

The growing adoption of the shiitake mushroom by Western consumers, due to its nutritional, medicinal and organoleptic properties, resulted in a major expansion of the natural habitat of this species, being currently the second most popular edible mushroom in the world.[8] The cultivation of shiitake mushroom in nature is very similar to manipulated cultivation method most used today – log cultivation.[8] The production process begins with the selection and preparation of logs and spawn; followed by inoculation of logs; incubation; fruiting; and harvesting.[5]
It is known that this species is rich in vitamin B, essential amino acids, proteins and minerals, with a water content between 88-92%.[2][5][8] However, different factors affect the nutritional composition of shiitake mushroom and probably its contaminant profile: cultivation process, strain used, method and fruiting conditions, species of wood used for the underlying base structure, weather and the region of production.[10]

2. MATERIALS AND METHODS

2.1. Sample characterization

Three samples of organically cultivated *Shiitake donko* mushrooms were collected (A1, A2, A3), each one with 0.5 kg. A1 e A2 were produced in Amarante (Portugal) by a similar process, using the sprinkler method to induce the fruiting. A1 and A2 came from spawns produced by a Portuguese or a Belgian company, respectively. A3 comes from a production located in Sintra (Portugal). The fruiting of this sample was induced by dipping.

2.2. Sample preparation and methods utilized

Each sample of fresh mushrooms was divided into two subsamples of 0.25 kg. One was freeze-dried and the other was immediately used to macronutrient and vitamin analysis.

2.2.1. Macronutrients

Moisture was quantified by the gravimetric method ash content by incineration process (525 °C), fat matter by acid hydrolysis with extraction, total protein trough Kjeldahl method and total sugar content by Munson and Walker method. Fiber content was also analyzed. Carbohydrates were quantified by difference.

2.2.2. Micronutrients

Vitamins B1 and B2

Vitamin B1 and B2 were analyzed by HPLC using a fluorescence detector . Analytical separation was carried out on reversed-phase.

Minerals and trace elements

The study of minerals comprised the copper, manganese, iron, zinc, magnesium, calcium, sodium, phosphorus, potassium and selenium. Freeze-dried samples were digested in microwaves in closed vessels, with subsequent determination by inductively coupled plasma optical emission spectrometry (ICP-OES), with exception of selenium that was determined by ICP-MS.

2.2.3. Contaminants profile

Samples were previously freeze-dried and subjected to digestion by microwaves in pots. Trace elements (arsenic, cadmium, lead and chromium) were quantified by inductively coupled plasma mass spectrometry (ICP-MS).

2.3. Quality assurance and traceability

A rigorous quality assurance program followed the ISO 17025 requirement was implemented for analysis. Certified Reference Material GBW 10014 Cabbage and NIST 1548a Typical Diet was used to test the accuracy and precision of the method of analysis Recoveries between 80% and 120% were obtained. The repeatability was always below 10%. The detection limits was estimated by repetitive analysis of procedural blank samples (n=10) as described in EFSA document.[1] Laboratory performance was demonstrated through a successfully participation in PT schemes runs by an accredited provider. All samples were analysed in triplicate. A Quality Control (QC) sample was included in each group of twelve test samples to validate the test run. Instrumental drift was monitored by difference between result of first and last QC samples (< 5%).

3. Results

3.1 Macronutrients

The nutritional composition of the analyzed samples of shiitake mushroom is presented in Table 1. Moisture content ranged between 79.0 (sample A3) and 90.6 g/100 g (sample A1) of fresh mushrooms. Bisen et al. (2010) reported a moisture content between 88-92 g/100 g in the fruitbodies of *L. edodes*.[2] Ash content ranged from 0.7 g/100 g (sample A1) to 1.1 g/100 g (sample A3). Published studies reported a higher ash content in shiitake mushrooms.[7] Fat content (0.4 g/100 g) showed no variability between the different samples. Protein content ranged from 1.6 g/100 g (sample A1) to 2.0 g/100 g (sample A3).

Relative high protein and low fat content of shiitake mushroom were also reported by many researchers and make this mushroom an interesting dietary protein source.[1] It is known that the shiitake mushroom has a high content of fiber.[3][4] This is consistent with the results obtained in this study where fiber content ranged from 4.1 g/100 g (sample A2) to 6.7 g/100 g (sample A3).

A large difference between samples regarding the carbohydrate content was observed. Carbohydrate content ranged from 1.0 g/100 g (sample A1) to 6.7 g/100 g (sample A3). The results obtained for total sugars in the different samples ranged between 1.0 to 4.1 g/100 g. This results are generally lower than the sugar content related by previous studies.[9]

Table 1. Moisture, ash and macronutrient content of analyzed shiitake mushrooms (g/100 g fresh weight)

	Samples		
	A1	**A2**	**A3**
Moisture	90,6	87,5	79
Ash	0,7	0,8	1,1
Fat	0,4	0,4	0,4
Protein	1,6	1,8	2
Fiber	4,6	4,1	6,7
Carbohydrates	1	4,4	6,7
Sugar	1,1	1	4,1

3.2. Micronutrients

Several studies have identified the shiitake mushroom as being rich in vitamin B1 and B2.[2][5] Our study showed a significant content of vitamin B2 in shiitake mushrooms (Table 2). Lower variability in vitamin content was observed. Differences between the values are within the uncertainty of the method.

Table 2. Vitamin B1 (thiamine) and vitamin B2 (riboflavin) content of analyzed shiitake mushrooms (mg/100 g fresh weight).

	Samples		
	A1	**A2**	**A3**
Vitamin B1	< 0,05	< 0,05	< 0,05
Vitamin B2	0,18	0,17	0,19

Minerals and trace elements were found in all samples (table 3). Potassium was the most abundant mineral element, followed by the phosphorus, magnesium, calcium, and finally the sodium. The literature describes that the potassium and phosphorus are the two dominant elements of the mineral content of this mushroom.[4] [8] In relation to minor elements, zinc was present at higher and copper at lower amounts.
Sample A3 showed higher mineral content than samples A1 and A2. The amount of minerals is highly correlated with the ash content of the samples.

Table 3. Mineral content of analyzed shiitake mushrooms (mg/100 g fresh weight).

	Samples		
	A1	**A2**	**A3**
Cu	0,09	0,13	0,14
Mn	0,3	0,35	1,61
Fe	0,34	0,36	0,4
Zn	0,51	0,5	0,68
Mg	14,57	15,03	18,86
Ca	1,9	1,92	7,42
Na	1,62	2,89	6,4
P	76,41	78,38	84,45
K	314,41	358,95	510,19
Se	0,001	n.d.	0,002

3.3 Contaminants

The profile of contaminants and trace elements showed low values for all elements in the different samples, with the exception of arsenic in A2 which (Table 4). Still, all arsenic results are in the normal range found in shiitake mushrooms produced in non-polluted areas (0.5-5 mg/kg).[6]

Table 4. Trace elements content of analyzed shiitake mushrooms (mg/kg fresh weight)

	Samples		
	A1	**A2**	**A3**
As	0,06	0,2	0,005
Cd	0,04	0,06	0,04
Pb	n.d.	n.d.	n.d.
Cr	0,02	0,03	0,04

4. CONCLUSIONS

The study involves a critique and comparative analysis about the nutritional composition and contaminants of three samples of shiitake mushrooms cultivated by different processes in different areas. Variability among the different samples regarding macronutrients, minerals content was found. With respect to contaminants, only sample A2 showed an atypical high value for arsenic, however, these levels doesn't present a risk to the consumer.[1] [6]
In conclusion, the results obtained in this study indicate that the shiitake mushroom is an important dietary source of several nutrients, and the sample fructified by dipping (sample A3) seems to be nutritionally richer and chemically safer.

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