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Macro and Micro Element Contents in Fruiting Bodies of Wild Edible Mushrooms from Muğla in Southwest Anatolia, Turkey

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The macro (K, Na, Mg, Ca) and micro (Fe, Zn, Cu, Mn, Cd, Co, Ni) element contents in 8 different wild edible mushroom species were studied in Southwest Anatolia, Turkey. The study investigated the differences in metal accumulation in relation to species. The mean concentrations of metals in the individual species did not vary to a large extent. The tricholomataceae species in this study had higher protein values than the others. The highest mean concentration of macro elements was found for K (135 g/kg), followed by Mg (1.23 g/kg), Na (0.58 g/kg) and Ca (0.33 g/kg) in *Tricholoma terreum* (Schff.: Fr.) Kummer. The mean concentrations of micro elements for all species were in the following order: Fe > Zn > Cu > Mn > Ni > Cd. Pb and Co were not detected in the studied species. The highest amount of micro elements was determined for Cd (8.83 mg/kg), Fe (268 mg/kg) and Zn (100 mg/kg) in *T. terreum* and for Cu (53.1 mg/kg) and Mn (23.5 mg/kg) in *Clitocybe alexandri* (Gill.) Konr.

Key Words: Mushrooms, Micro elements, Macro elements, Protein.

INTRODUCTION

Fungi are non-green organisms, inasmuch as they have no chlorophyll, organic matter is not produced photosynthetically. However, due o the existence of some lignocellulosic enzymes, mushrooms are able to take their nutrients from the environment[1]. So they play an important role in the ecosystem. In addition, mushrooms are important for both nutritive and medicinal values[2–4]. They are a good source of quality protein, minerals and vitamins and are low in calories[1, 5–7]. It has been reported that a total lipid content varying between 0.6 and 3.1% of dry weight was found in commonly cultivated mushrooms. At least 72% of the total fatty acids were found to be unsaturated in all these mushrooms[8]. Therefore, it can be said that mushrooms play a significant role both in human diet and human health.

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Many studies have been carried out on the trace element contents of macrofungi in the Black Sea and South Marmara regions of Turkey[9–22]. However, qualified studies have not been reported on wild-grown edible mushrooms in the southwest part of Turkey. The aim of this study is to determine and to compare the contents of Ca, Cd, Co, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Zn and protein in the fruiting bodies of some mushrooms commonly collected and eaten in Muğla province.

EXPERIMENTAL

Mushroom sampling: Mushroom samples were collected as a result of the routine field studies in Ula district and Yaraş village of Muğla province in 2004 (Fig. 1). The morphological and ecological characteristics of the macrofungi were recorded and were photographed in their natural habitats and then brought to the laboratory. Their spore prints were taken and spores were photographed. Dried specimens were numbered and placed in locked bags. In addition, they were put into a deep freeze for a week against internal and external parasites. The specimens were identified with the help of their macroscopic and microscopic features. Also, previous literature by Moser[23] and Breitenbach and Kranzlin[24] were utilized. All specimens collected were kept in the herbarium of the Muğla University. As a result of this study, 8 species belong to 3 families which are consumed by the local people have been identified. Families, habitats, collection areas and herbarium number of these species are given in Table-1.

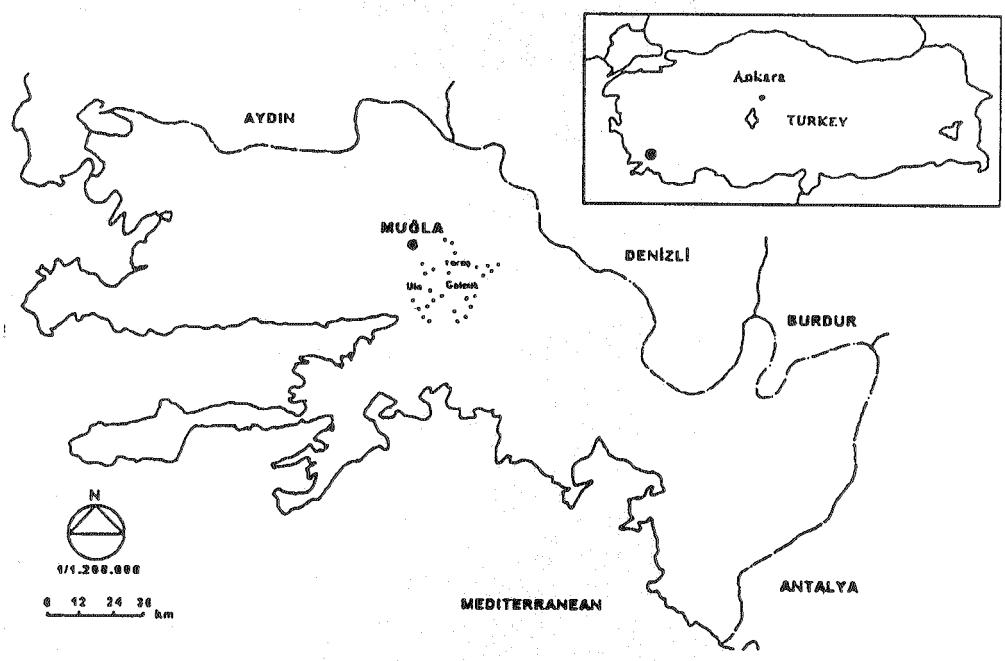

Fig. 1. Collection areas of mushrooms

TABLE-1
FAMILIES, HABITATS, COLLECTED AREAS AND HERBARIUM NUMBER OF SPECIES

Families and species	Habitat	Collected area and berbarium number
Boletaceae		
1. *Suillus luteus* (L.: Fr.) S. F. Gray	In conifer forest	Yaraş, FY. 2390
Russulaceae:		
2. *Lactarius deliciosus* Fr.	In pine forest	Ula, Çiçekli, FY. 2455
3. *Lactarius deterrimus* Groeger	In pine forest	Ula, Çiçekli, FY. 2454
4. *Lactarius salmonicolor* Heim & Lecl.	In pine forest	Ula-Gölcük, FY. 2536
5. *Lactarius semisanguifluus* Heim & Lecl.	In pine forest	Ula-Gölcük, FY. 2452
Tricholomataceae		
6. *Clitocybe alexandri* (Gill.) Konr.	In pine forest	Yaraş, FY. 2516
7. *Clitocybe odora* (Bull.: Fr.) Kummer	In mixed forest	Yaraş, FY. 2520
8. *Tricholoma terreum* (Schff.: Fr.) Kummer	In mixed forest, on chalk	Yaraş, FY. 2509

Chemical analysis : The 53 fruiting bodies (4–18 samples of each species) of 8 different mushroom species were rinsed in bidistilled water to remove adhering particles, dried at 60°C for 48 h and ground in a mortar.

1–2 g of ground mushroom samples and a mixture of pure concentrated acids, HNO_3 and HCl in a volume ratio 4 : 1 were placed in acid-washed 100 mL borosilicate glass beakers and the beakers were covered with watch glasses. These beakers were then placed into a sand bath at 350°C until near dryness. This step was repeated 4 times. Then sample solutions were suction-filtered through 0.45 μm nitrocellulose filters. Filtered sample solutions were diluted to 25 mL with bidistilled water and stored in new high-density polyethylene bottles. Each analysis was repeated two times. In all determinations, the standard addition technique was used.

Ca, Mg, Cd, Co, Cu, Fe, Mn, Ni, Pb and Zn were determined using flame atomic absorption spectrometry (Pye Unicam 929) with deuterium background correction. Only Na and K were determined using flame photometer (Jenway).

The protein was measured using a protein/nitrogen analyzer (LECO FP-528). Total protein was calculated by per cent total Nx factor of 6.38, automatically by the instrument. For calibration, standards having nitrogen as 1.82 and 9.5% were used.

RESULTS AND DISCUSSION

The mean concentrations for each analyzed macro element and protein in the whole fruiting body, together with min and max values for each species are shown in Table 2.

Among investigated wild-grown edible mushroom species, the highest mean concentrations of protein were obtained in *C. alexandri* (42.7) and *C. odora* (46.35). The levels of protein in *Lactarius* species ranged from 16.30–19.66% (Fig. 2). Protein content in the fruiting bodies from *Clitocybe* species are much higher but the others are of the same order of magnitude as in the fruiting bodies of shiitake, *Volvariella bombycina* (Schaeff.: Fr.) Singer, *Marasmius oreades* (Bolt.: Fr.) Fr.

and *Collybia dryophila* (Bull.: Fr.) Kummmer from *Tricholomataceae* family, *Pleurotus ostreatus* species[25-27].

TABLE-2
ELEMENTS AND PROTEIN CONTENTS OF EIGHT SPECIES
(SN: number of samples, M: mean, SD: standard deviation)

			Elements (g/kg dry matter) and protein %				
Species	SN	Value	Protein	Ca	K	Mg	Na
S. luteus	4	M ± SD	20.79 ± 3.85	0.19 ± 0.02	93 ± 6	0.77 ± 0.04	0.54 ± 0.02
		Min-Max	18.4–26.45	0.17–0.21	90–102	0.72–0.81	052–0.58
L. deliciosus	4	M ± SD	19.66 ± 1.34	0.13 ± 0.01	107 ± 10	0.74 ± 0.05	0.35 ± 0.06
		Min-Max	18.78–21.76	0.12–0.14	99–122	0.71–0.81	0.30–0.44
L. deterrimus	4	M ± SD	16.6 ± 0.76	0.12 ± 0.01	101 ± 9	0.74 ± 0.08	0.36 ± 0.05
		Min-Max	15.92–17.68	0.10–0.13	98–117	0.68–0.86	0.31–0.42
L. salmonicolor	4	M ± SD	19.28 ± 2.34	0.12 ± 0.01	128 ± 5	1.08 ± 0.08	0.53 ± 0.04
		Min-Max	17.67–22.78	0.11–0.13	123–136	0.99–1.16	0.49–0.59
L. semianguifluus	6	M ± SD	16.3 ± 1.00	0.12 ± 0.01	98 ± 4	0.69 ± 0.09	0.39 ± 0.06
		Min-Max	15.34–17.45	0.10–0.14	91–102	0.56–0.81	0.32–0.48
C. alexandri	9	M ± SD	42.7 ± 1.98	0.11 ± 0.01	131 ± 6	0.89 ± 0.08	0.46 ± 0.02
		Min-Max	38.98–44.56	0.10–0.13	123–142	0.76–1.00	0.43–0.50
C. odora	4	M ± SD	46.35 ± 2.89	0.12 ± 0.01	129 ± 6	0.81 ± 0.06	0.40 ± 0.02
		Min-Max	43.24–49.65	0.10–0.13	123–135	0.78–0.90	0.39–0.44
T. terreum	18	M ± SD	23.47 ± 0.79	0.33 ± 0.06	135 ± 9	1.23 ± 0.1	0.58 ± 0.04
		Min-Max	22.68–25.34	0.24–0.41	123–150	1.00–1.41	0.50–0.65

All macro elements (K, Na, Mg, Ca) were accumulated in much higher concentrations in fruiting bodies of the studied mushrooms (Figs. 3, 4). Their accumulation in the studied mushrooms decreases in the given order: K > Mg > Na > Ca. *T. terreum* uptakes all these macro elements at highest degree, especially Mg. Ca levels of other species are very close to each other. Differential ratio (max/min) of K, Mg and Na levels in all species are not too large, 1.45, 1.47 and 1.73, respectively (Fig. 4). The contents of macro elements in *L. deliciosus* and *S. luteus* were comparable with literature[28,29]. Higher K and Na, lower Ca and similar Mg contents were detected in this study for these mushroom species.

The mean concentrations of micro elements in the entire fruiting body, together with min and max values for each species are given in Table-3. Pb and Co levels for all studied mushroom samples were not detected. The uptake degree of the studied mushrooms for the investigated other micro elements increases in the given order: Cd < Ni < Mn < Cu < Zn < Fe.

The highest levels of Fe and Zn in *T. terreum* (268 and 100 mg/kg, respectively) and the lowest in *L. semisanguifluus* (87 and 38 mg/kg, respectively) were detected (Fig. 5). The mean concentrations of Fe and Zn in all tested mushroom species were 152 and 58 mg/kg. *C. alexandri* had the highest concentration of Cu and Mn (Fig. 6). For the other tested species, the contents of these elements did not show any marked difference except *C. odora* and *T. terreum* for Cu and *S. luteus* for Mn. The

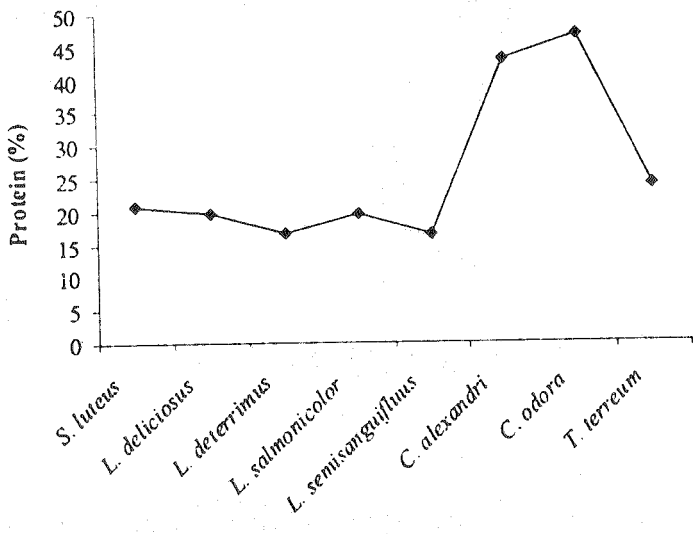

Fig. 2. Comparison of mean concentratiooons of proteins (%) in mushrooms species

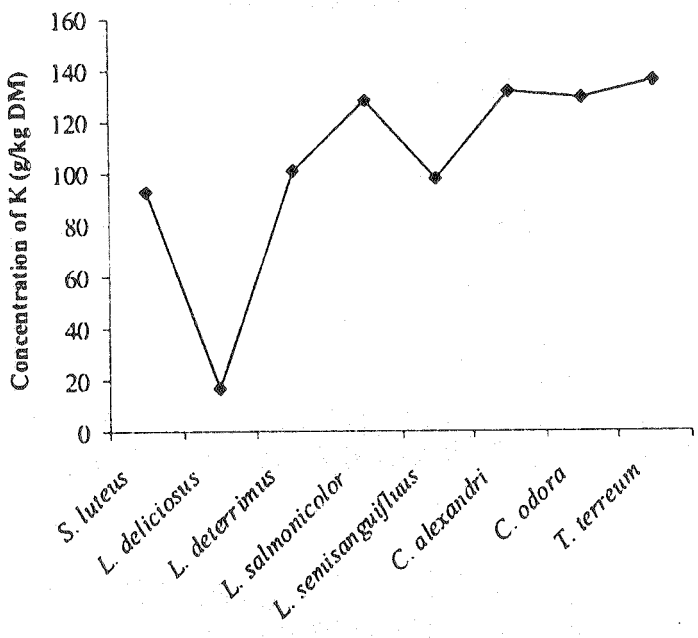

Fig. 3. Comparison of mean concentrations of K (g/kg dry matter) in mushrooms species

mean Ni and Cd concentrations in tested species were much lower than the other metals (Fig. 7). The samples showing the highest level were *L. salmonicolor* reaching up to 6.99 Ni mg/kg and *T. terreum* reaching up to 6.83 Cd mg/kg of dry basis. The Ni content of other tested species were much low, the variation within the species is very less, 0.53–1.130. Cd was also found in less amount in the tested species, especially not detected in *L. salmonicolor* and *C. odora*.

The level of potassium which was the most abundant element in studied species of wild edible mushrooms was in agreement with other studies, even higher in

TABLE-3
ELEMENT CONTENTS OF EIGHT MUSHROOM SPECIES
(SN: number of samples, M: mean, SD: standard deviation)

Species	SN	Value	Elements (mg/kg dry matter)					
			Cd	Cu	Fe	Mn	Ni	Zn
S. luteus	4	M ± SD	0.19 ± 0.4	9.01 ± 0.83	156 ± 24	16 ± 4.1	1.13 ± 0.28	58.2 ± 6.04
		Min-Max	0.15–0.24	8.34–10.23	136–186	13.06–22.24	1.08–1.68	52.4–66.78
L. deliciosus	4	M ± SD	0.65 ± 0.13	7.93 ± 0.99	110 ± 12	6.3 ± 0.73	0.62 ± 0.18	48.1 ± 8.3
		Min-Max	0.51–0.78	6.46–8.78	98–126	5.8–7.45	0.45–0.84	42.1–59.46
L. deterrimus	4	M ± SD	0.68 ± 0.27	6.20 ± 0.98	109 ± 39	5.8 ± 1.29	0.53 ± 0.3	38.2 ± 7.97
		Min-Max	0.35–0.87	5.13–7.54	95–132	4.21–7.24	0.24–0.97	33.41–50.12
L. salmonicolor	4	M ± SD		5.35 ± 0.45	189 ± 17	4.55 ± 0.74	6.99 ± 0.7	61.25 ± 5.26
		Min-Max	ND	5.04–6.03	174–213	3.9–5.6	6.34–7.96	57.78–68.89
L. semisanguifluus	6	M ± SD	0.36 ± 0.16	4.21 ± 1.35	87 ± 14	6.2 ± 2.14	0.77 ± 0.2	37.6 ± 6.52
		Min-Max	0.12–0.48	2.96–6.24	74–104	3.9–9.3	0.56–1.04	28.24–46.24
C. alexandri	9	M ± SD	0.17 ± 0.06	53.1 ± 6	191 ± 24	23.5 ± 4.38	0.77 ± 0.23	50.7 ± 4.89
		Min-Max	0.08–0.25	46.76–64.23	165–234	18.23–32.12	0.43–1.22	47.3–62.32
C. odora	4	M ± SD		43.61 ± 6.07	103 ± 14	6.82 ± 0.94	0.61 ± 0.22	69.74 ± 8.39
		Min-Max	ND	38.76–52.32	92–123	5.66–7.96	0.44–0.92	58.45–76.87
T. terreum	18	M ± SD	6.83 ± 1.01	27.64 ± 4.05	268 ± 28	8.7 ± 1.18	0.68 ± 0.22	100 ± 14
		Min-Max	4.67–8.21	21.36–35.4	230–348	6.58–11.24	0.36–1.23	82–123

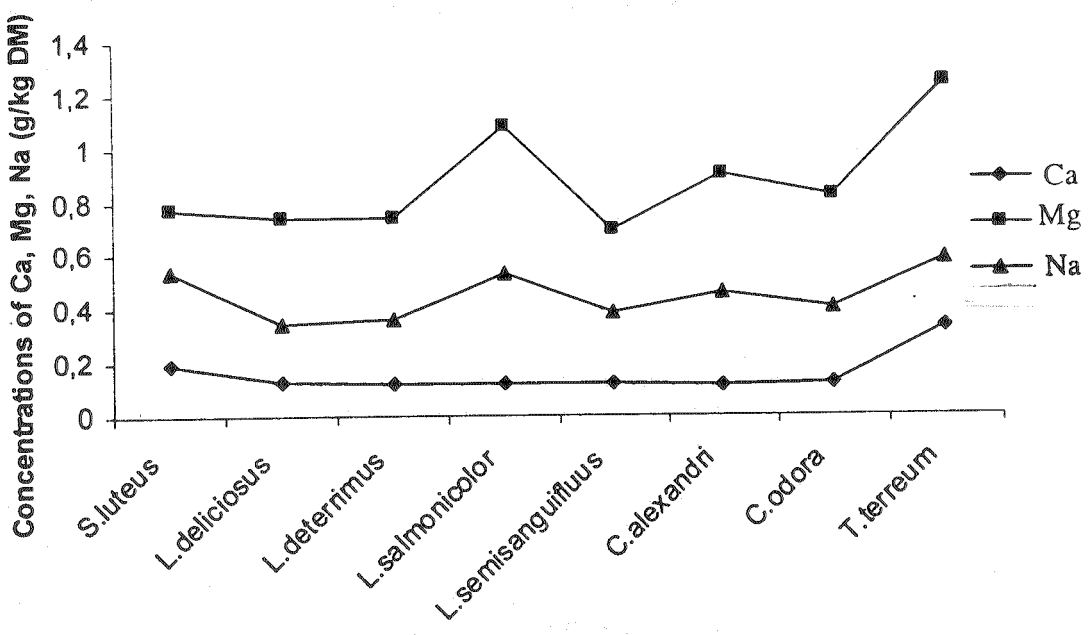

Fig. 4. Comparison of mean concentrations of Ca, Mg and Na (g/kg dry matter) in mushroom species

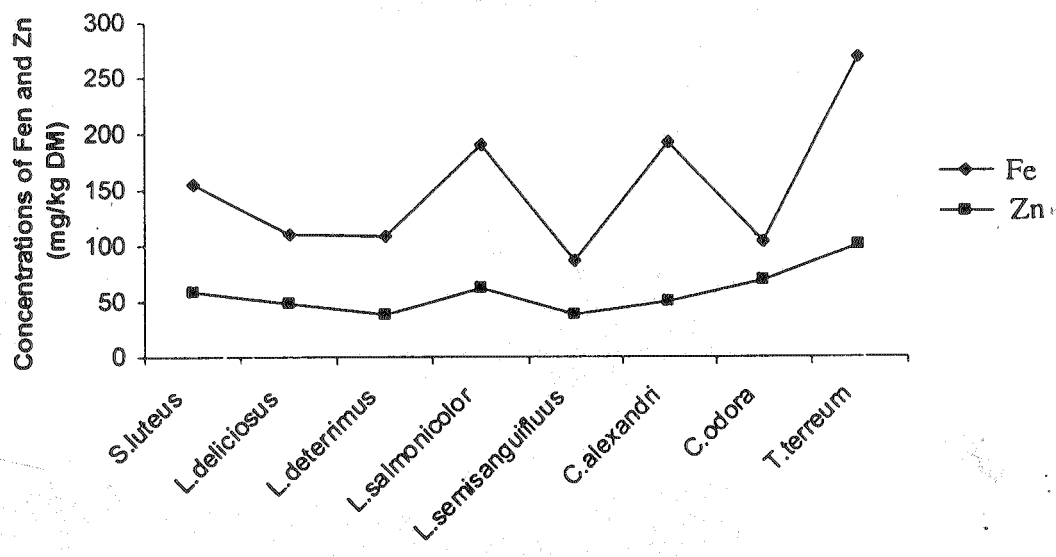

Fig. 5. Comparison of mean concentrations of Fe and Zn (mg/kg dry matter) in mushroom species

some species. In comparison with other macro elements, calcium, magnesium and sodium, the mean concentrations of Mg in studied mushrooms were approximately same, the mean concentration of Na was a little bit higher and the

mean concentration of Ca was slightly lower than earlier published reports[28, 29]. The element content in *T. terreum* in this study was generally higher for Fe, Zn, Cd, Ca, K and lower for Mn, Co, Pb, Cu, Na with respect to previous

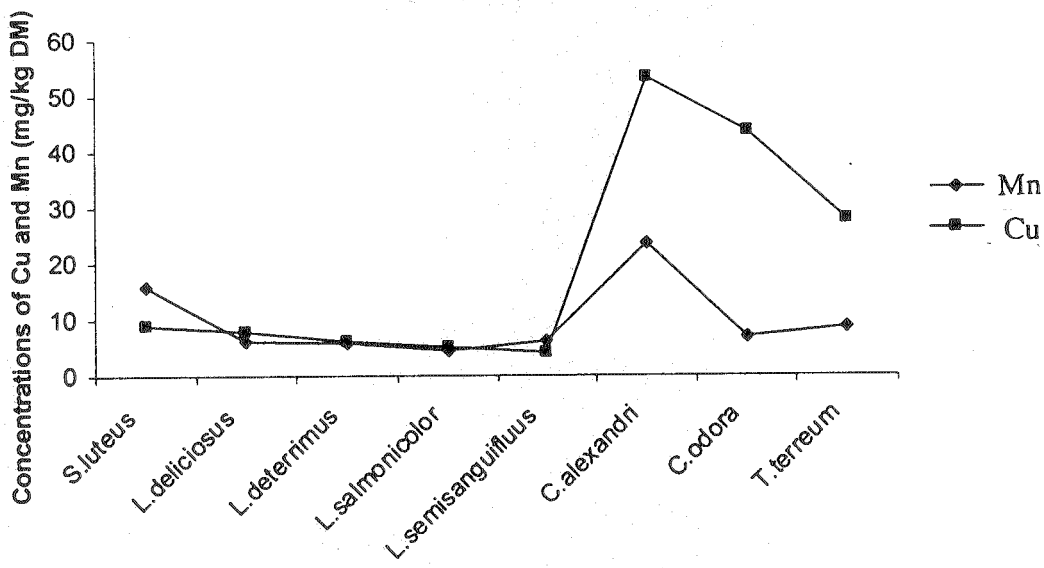

Fig. 6. Comparison of mean concentrations of Cu and Mn (mg/kg dry matter) in mushrooms species

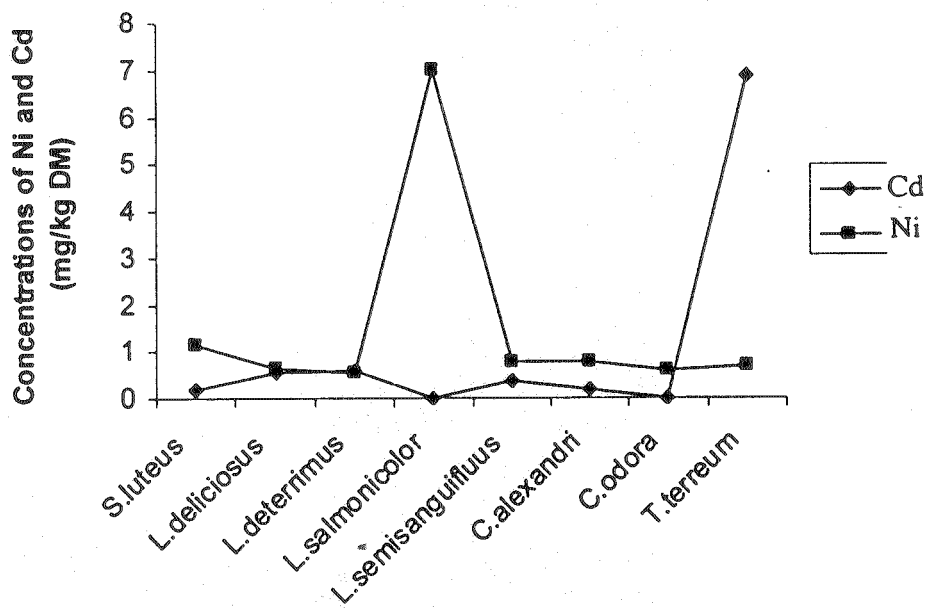

Fig. 7. Comparison of mean concentrations of Ni and Cd (mg/kg dry matter) in mushrooms species

works[11, 12, 18, 28]. The amount of Cu, Cd, Zn, Mn, Fe and Ni in *L. semisanguifluus* from Mugla was lower than from Balikesir[14]. In this study, the content of elements in the common species of mushroom, *L. deliciosus*, was mostly lower for Cu, Mn, Ni, Co, Pb, Ca, Zn, Fe than the previously reported studies*14*, only sometimes higher for Fe, K and Cd.

Na, Mn, Cu and protein contents of *Lactarius* species commonly eaten in Turkey are close to each other and Fe, Zn, Ca, Mg and Ni levels are also close to each other except for *L. salmonicolor.*

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