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Mineral elements in some wild mushrooms

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Major and trace mineral elements were measured from three species of mushrooms, *Lactarius rufus*, *Suillus variegatus* and *Russula paludosa* and from the humus at their growing sites. The elements measured were K, Na, Ca, Mg, Mn, Fe, Cu and Zn. A correlation was found between the Mg content of the humus and the mushrooms. The difference between the stipe and the pileus was very clear. The Fe content of *S. variegatus* was tens of times higher compared with that of the other species. The positive correlation between Cu and Zn was highly significant in the three mushroom species studied.

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Introduction

The aim of the present study, which is still in process, is threefold: 1) to determine the concentration of certain major and trace elements in mushrooms growing in unfertilized heath forests; 2) to measure the possible differences in the element contents of the pileus and the stipe; 3) to investigate the possible correlation between the element concentrations in the mushrooms and in the soil.

Material and methods

The species under study are *Lactarius rufus*, *Suillus variegatus* and *Russula paludosa*. Material was collected from 4 different heath forests in Northern Finland close to Oulu (65° N). The types of forests were: A = *Cladonia*-type (CIT), B = *Empetrum-Vaccinium*-type (EVT), C = marshy EVT, D = *Vaccinium*-type (VT).

The mushroom samples were wet-digested (25 ml HNO_3 and 5 ml $HClO_4$). From the solution K, Na, Ca, Mg, Mn, Fe, Cu and Zn were measured by using a Perkin Elmer atomic absorption spectrophotometer. It seems that this method is not suited to the alkali metals, because a large portion of potassium and sodium precipitates and crystallizes.

From each growing site, ten samples were collected from the humus (H1 from the upper level and H2 from the lower level of the humus). These samples were extracted with ammonium acetate (pH 4.65).

Results and discussion

The method used resulted in contents of K and Na lower than those reported by other authors, which are 2 000-5 370 mg/100 g for K (Souci et al. 1969, Isotalo 1971, Kreula et al. 1976) and 14-700 mg/100 g for Na (Souci et al. 1969, Kreula et al. 1976).

The content of Ca was about the same in the different species of mushrooms (14-42 mg/100 g in medium). The contents were lowest in *R. paludosa* (Fig. 1). The stipes of *L. rufus* and *S. variagatus* contained about twice the amount of Ca found in the pilei of the same species. No such difference was observable in *R. paludosa*. There was a significant difference ($P<0.05$) in *L. rufus* collected from two different growing sites (A and C). The content of Ca in mushrooms can vary remarcably, from 6.6 to several hundreds of mg/100 g (Hinneri 1975).

The mean content of Mg in the mushrooms studied was 24-130 mg/100 g. The contents were lowest in *L. rufus* (Fig. 1). The Mg content of the stipe is about half of that of the pileus in the three species.

The Mg content reported in the literature varies within 30-273 mg/100 g (Hinneri 1975).

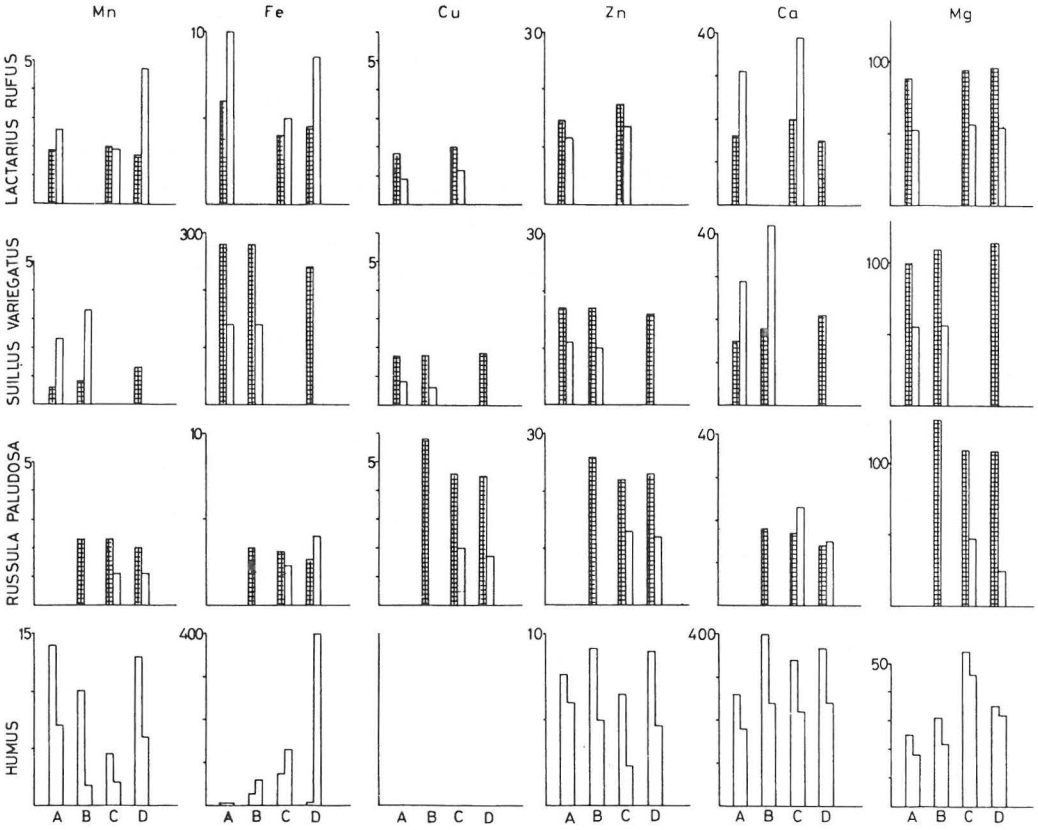
Soil samples showed that the Mg content of the humus in ClT (A) is significantly lower than that in forests of other types. This could also be noted in *L. rufus* and in *S. variegatus*. *L. rufus* displayed a significant difference between the growing sites A and C ($P<0.01$). In the same way, there was a significant difference in *S. variegatus* between the growing sites A and B ($P<0.05$), as well as A and D ($P<0.05$) (Fig. 1).

The Mn content was at its lowest in the pileus of *S. variegatus*, 0.6-1.3 mg/100 g, on an average. The content of Mn in the stipe was remarkably higher, 2.3-3.3 mg/100 g (Fig. 1). In contrast to that, *R. paludosa* had a Mn content of the stipe lower than that of the pileus. *L. rufus* had a significant difference between the stipe and the pileus only in CIT (A).

The Mn content varied in the mushrooms studied, being 0.6-4.7 mg/100 g, on an average, which is in agreement with the values reported in the literature (Hinneri 1975).

The amount of Fe was very high in *S. variegatus*, 140-280 mg/100 g, on an average, while *L. rufus* and

Fig. 1. Mineral elements in different mushroom species (mg/100 g) and in the soil samples (mg/l). A = ClT, B = EVT, C = marshy EVT, D = VT. The checked columns = the pileus of mushrooms; the white columns = the feet of mushrooms. In the soil samples the left column = H1 (the upper level of the humus); the right column = H2 (the lower level of the humus).



R. paludosa had an average content of Fe of 2.3-9.6 mg/100 g (Fig. 1). The Fe content of the stipe of *L. rufus* was higher than that of the pileus, while *S. variegatus* had the highest Fe content in the pileus. *R. paludosa* had no significant difference between the stipe and the pileus.

Other authors have also observed considerable variation in the Fe content of mushrooms, 3.1-140 mg/100 g (Hinneri 1975), the most common level being 8-10 mg/100 g. This is about the same as the findings for *L. rufus* and *R. paludosa* in this study, whereas the Fe content in *S. variegatus* is remarkably high compared with other mushrooms.

The Cu contents of *L. rufus* and *S. variegatus* were very similar, being 0.6-2.0 mg/100 g, on an average (Fig. 1). The Cu content in *R. paludosa* was significantly higher ($P<0.001$) than that in the other two mushroom species, 1.7-5.8 mg/100 g. All the three species had more Cu in the pileus than in the stipe.

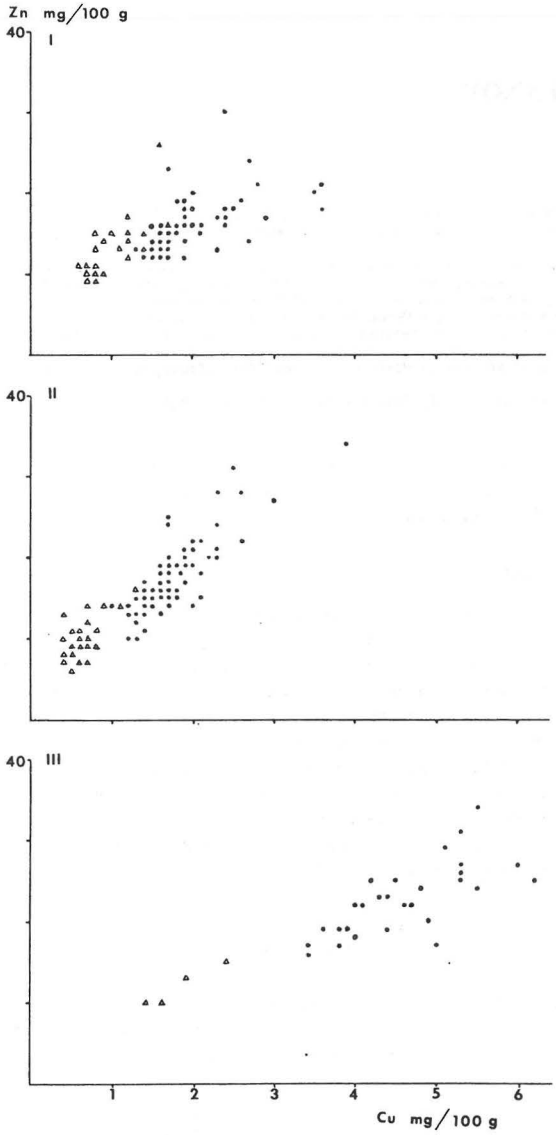
The values of Cu reported in the literature are 0.3 - 29 mg/100 g (Hinneri 1975), but the common level is 2-6 mg/100 g, which is in agreement with the present findings.

The Cu content of the humus was not revealed by the method used, or it was quite low.

The Zn content in the mushrooms studied was about 6 times higher than that of Cu, 10-26 mg/100 g (Fig. 1). The highest amount of Zn reported in the literature is 120 mg/100 g (Hinneri 1975), but the contents of Zn are commonly lower than 50 mg/100 g.

The content of Zn was higher in the pileus than in the stipe. The Zn content of *R. paludosa* was significantly higher ($P<0.01$) than that of *L. rufus* and *S. variegatus*. The positive correlation between

Fig. 2. Correlation between Cu and Zn contents of the pileus (·) and the stipe (Δ). I = *Lactarius rufus*, II = *Suillus variegatus*, III = *Russula paludosa*.



Cu and Zn is highly significant in the three mushroom species (Fig. 2). The correlation coefficient is 0.75 for *L. rufus*, 0.89 for *S. variegatus* and 0.86 for *R. paludosa*.

It can be assumed from the Cu and Zn contents in the soil studied that the mushrooms have absorbed all the available Cu and Zn. In contrast, there seems to be more Mn in the soil than can be used, and the mushrooms have absorbed only the optimal amount, which is not more than the amount of Cu. The Mg contents were also relatively high in the mushrooms compared with those of the soil samples, and it is possible that the mushrooms have absorbed Mg, similarly to Cu and Zn, as much as they have been able to extract from the soil. This can explain the difference in the data obtained for *L. rufus* and *S. variegatus* collected from different growing sites, where the contents of soil samples varied.

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