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COPPER, ZINC AND MOLYBDENUM IN GOAT LIVER

By

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SJØLI, N. E. and A. FRØSLIE: *Copper, zinc and molybdenum in goat liver*. Acta vet. scand. 1979, 20, 45—50. — The concentrations of copper, zinc and molybdenum were measured in the liver of goats from western and south-eastern Norway. The mean copper concentrations in the liver of goats from these two districts were 23 ± 19 $\mu\text{g Cu/g}$ and 59 ± 31 $\mu\text{g Cu/g}$ wet weight, respectively. As for zinc and molybdenum, no difference was found between the two groups of animals. No correlations were detected between copper and zinc, zinc and molybdenum, or copper and molybdenum. The copper levels in Norwegian goat liver are considerably lower than in sheep liver, and the ranges are significantly more narrow. The concentrations of molybdenum in goat liver are at the same levels as in sheep and swine, while the levels of zinc are somewhat lower.

c o p p e r ; z i n c ; m o l y b d e n u m ; g o a t .

Sheep and goat are in many ways closely related species but seem to differ considerably as regards excess of the trace element copper. While chronic copper poisoning is well known in sheep (Clarke & Clarke 1975, Hill 1977a,b, Underwood 1977), this toxicosis hardly occurs in goats.

Chronic cumulative copper poisoning occurs rather frequently in sheep in Norway, and in large parts of the country the sheep are highly over-loaded with this element (Nordstoga 1962, Frøslie 1977).

The present paper reports results of copper analyses, as well as analyses for the interfering elements zinc and molybdenum in goat liver.

MATERIALS AND METHODS

Samples of goat liver were collected at slaughter-houses in two districts of Norway, 81 samples from the western (Nordfjordeid) and 53 samples from the south-eastern (Ås) part of Norway. The goats from western Norway originated from herds

in milk production, and almost all the animals were adult. The samples from eastern Norway originated from the herd at the Agricultural University of Norway, Ås. Two-thirds of these animals were about one year old, the rest were adult. The liver samples were analysed for copper, zinc and molybdenum as described by Frøslie & Norheim (1976) and Norheim & Waasjøl (1977). All the concentrations are given on a wet weight basis in $\mu\text{g/g}$ sample.

RESULTS

The results of the analyses are illustrated in Fig. 1, in which the mean values and the standard deviations are also given.

The two groups of animals, one from each part of the country, were quite different from one another as regards copper. Mean copper concentrations in the liver of goats from Ås were about the double of those in the goats from Nordfjordeid. The difference between the groups was significant ($P < 0.001$, $t = 8.15$) and is illustrated in Fig. 1 A.

It is seen that 25 % of the samples from western Norway had copper concentrations of below $10 \mu\text{g/g}$ in the liver, while only 8.4 % had concentrations higher than $50 \mu\text{g/g}$. Corresponding figures for goats from Ås were quite opposite, 7.5 % lower than $10 \mu\text{g/g}$ and 58 % higher than $50 \mu\text{g/g}$. With all the animals included in the calculation, the percentages of samples that contained copper concentrations beyond these limits were about 20 % below $10 \mu\text{g/g}$ and about 20 % above $50 \mu\text{g/g}$. There was no difference in the copper concentrations between young and adult animals.

As regards zinc and molybdenum, no differences were seen between the two groups of animals. The mean values and distribution pattern are given in Fig. 1 B and C.

The copper, zinc and molybdenum concentrations were also calculated for their intercorrelations. No correlation was found between copper and zinc ($r = 0.25$), zinc and molybdenum ($r = -0.06$), or copper and molybdenum ($r = -0.19$).

DISCUSSION

The main intention of this investigation on the copper levels in goat liver was to compare the findings with those in sheep. From this point of view, two observations in the present material are especially interesting.

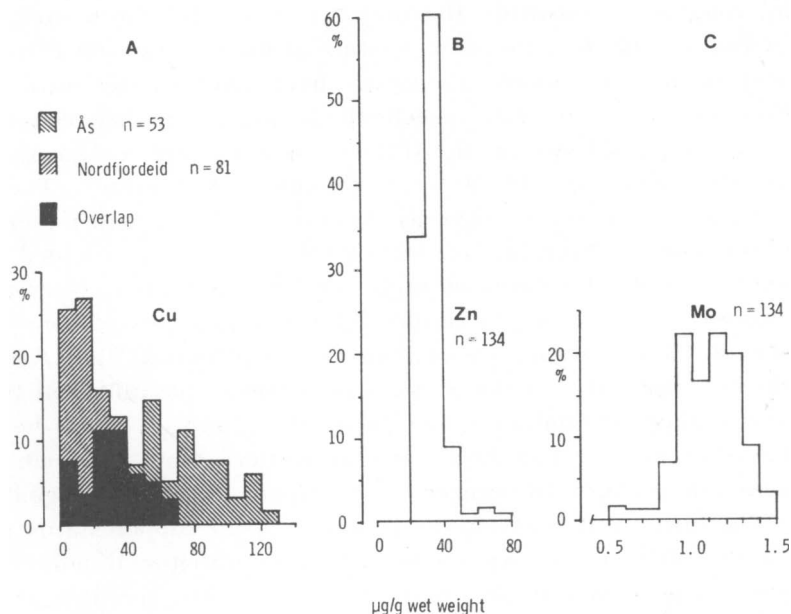


Figure 1. A: The histograms show the distribution of samples as a function of liver copper concentration in goats from western Norway (Nordfjordeid) and south-eastern Norway (Ås). The mean values and standard deviations were 23 ± 19 and 59 ± 31 $\mu\text{g Cu/g wet weight}$, respectively. The dark area shows the overlapping part of the histograms.

B: The histogram shows the distribution of total liver samples as a function of zinc concentration. The mean value and standard deviation were 34 ± 7 $\mu\text{g Zn/g}$.

C: The histogram shows the distribution of total liver samples as a function of molybdenum concentration. The mean value and standard deviation were 1.0 ± 0.2 $\mu\text{g Mo/g}$.

First, it was clearly shown that copper levels in Norwegian goats are considerably lower than in sheep, and that the ranges of copper values in the liver were significantly more narrow. It was also demonstrated that a significant difference occurs between goats from the western and from the south-eastern part of Norway.

The geographical distribution pattern of copper concentrations in goats is in agreement with the findings in Norwegian

sheep (Frøslie 1977). With the feeding pattern taken into consideration, however, this result is somewhat surprising. Herbages and roughages constitute the major part of the sheep diet in Norway (Nedkvitne, personal communication), and the differences in copper concentrations in sheep liver in the autumn (Frøslie) probably reflect geochemical differences between districts. In goats, however, the situation is quite different, as concentrates make up 40—50 % of the diet (Nedkvitne). These concentrates are mostly given as standard mixtures with mineral mixtures added. Since an amount of 1000 mg copper is added to each kilo of standard mineral mixtures for ruminants in Norway, it would be reasonable to think that the high levels of concentrates in the diet would overshadow any geographical differences in the copper status of the goats. It is, however, possible that the mineral supplementation of the goats in the herd at Ås has been somewhat higher than that used in western Norway. Such a factor might cause differences in the copper status of the goats.

The difference between sheep and goats in copper status is, however, difficult to explain only from a nutritional point of view. As pointed out by Frøslie it is generally accepted that sheep fed large quantities of concentrates are by far the animals most susceptible to copper poisoning. In Norway this situation has been accentuated by the copper supplementation in the mixtures of concentrates, and in herds with high levels of concentrates in the diet, or high mineral supplementation, copper poisoning is not rare (Frøslie). From a nutritional point of view, goats in Norway are therefore exposed to feeding conditions with expected higher risk of copper poisoning than sheep. From the fact that spontaneous chronic copper poisoning is hardly seen in goats and from the results of the present investigation, it is obvious that there is a fundamental difference between sheep and goats in their ability to accumulate copper. These results are also in accordance with those of Adam *et al.* (1977) and Sjøli & Nafstad (1978) who found that goats are less susceptible than sheep to repeated administration of excess of copper.

Concentrations of molybdenum in goat liver are at the same level as in sheep and swine (Frøslie & Norheim 1976, 1977), while zinc levels are somewhat lower. It is difficult to evaluate the comparative significance of this difference in zinc status.

The copper metabolism in ruminants depends on both enteral and parenteral factors (Underwood 1977). It is difficult to point

to differences between sheep and goats in the gastro-intestinal tract which could be of significance in the copper metabolism. However, some differences have been demonstrated between sheep and goat in the soluble hepatic zinc- and copper-binding proteins (*Mjør-Grimsrud et al.* in press).

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SAMMENDRAG

Kobber, sink og molybden i geitelever.

Kobber, sink og molybden ble bestemt i lever fra 134 geiter, 81 fra Vestlandet (Nordfjordeid) og 53 fra Østlandet (Ås). Prøvene ble innsamlet i forbindelse med slaktning. Dyrene fra Ås hadde det høyeste kobberinnhold med gjennomsnittsverdi på 59 µg Cu/g lever våtvekt, mens dyrene fra Vestlandet viste et gjennomsnitt på 23 µg Cu/g.

Det ble ikke funnet forskjeller i nivåene av sink og molybden mellom de to distriktene, og det var ingen innbyrdes korrelasjon mellom de tre elementene.

Nivåene av kobber hos norske geiter ble funnet å være betydelig lavere enn hos sau, og spredningen var også mindre. Konsentrasjonen av molybden var imidlertid av samme størrelsesorden som hos sau og gris, mens innholdet av sink var noe lavere enn hos disse dyreartene.

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