# Se, Cu, Zn and Fe metabolism of the young lamb

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## ABSTRACT

The intake, apparent absorption, availability and retention of Se, Cu, Zn and Fe were measured in young lambs using nutritional balance and comparative slaughter techniques. Balances were carried out when the lambs were aged 5 to 11 d, 21 to 28 d, 63 to 70 d and 92 to 98 d. During the first and second balance periods the lambs were fed 175 and 300 g dry matter (DM)/d as milk replacer. In balance 3, 210 g DM/d as milk replacer was fed with fresh pasture *ad libitum* and during balance 4, only fresh pasture was fed *ad libitum*. The mean liveweight gain was 250 g/d. The fractions of the ingested mineral which were apparently absorbed on the milk replacer diet were Se 0.95, Cu 0.92, Zn 0.62 and Fe 0.50. These progressively decreased to Se 0.45, Cu 0.10, Zn 0.16 and Fe 0.20 for the all pasture diet. From the comparative slaughter study it was found that 44μg Se, 1.1 mg Cu, 25.5 mg Zn and 46 mg Fe were associated with each kg gain in fleece-free empty body weight.

**Keywords** Lambs; milk replacer; pasture; availability; requirements; Se; Cu; Zn; Fe.

## INTRODUCTION

Although Se, Cu and other trace element deficiencies have been well documented in sheep in New Zealand there is a dearth of information on the trace element metabolism and requirements of the young lamb (Millar, 1983; Grace 1983a). The lamb changes from a monogastric to a ruminant over 6 to 9 weeks of age and this is associated with a major change in the digestive tract as the abomasum becomes proportionally smaller while the reticulo-rumen becomes fully functional. These physiological changes, together with the change of diet from all milk to pasture must influence the intake, excretion and apparent absorption of all minerals including the trace elements. A marked decrease in Cu availability associated with age and weaning in young lambs has been reported (Suttle, 1975).

In this study the intake, excretion, apparent absorption and availability of Se, Cu, Zn and Fe were determined using nutritional balances while the net body retentions were measured by a comparative slaughter technique in lambs from birth to 98 days of age. The data was then used to calculate the dietary Se, Cu, Zn and Fe allowances for the lamb.

## MATERIALS AND METHODS

### Nutritional Balance Studies

Eight male lambs were removed from their dams after 2 d and housed indoors in metabolism cages. The cages were constructed of wood, had a stainless steel grated floor while the faecal and urinary collectors, the feeders and water containers were made from fibreglass or plastic. All balance studies were carried out in these crates. After being indoors for 28 d the lambs were put out on good quality pasture and only returned indoors for the nutritional balances.

For balance 1, the lambs aged 5 to 11 d were fed 175 g DM/d as milk replacer (1 ℓ of milk in 3 feeds) while for balance 2, the lambs aged 21 to 28 d were fed 300 g DM/d as milk replacer (1.7 ℓ of milk in 3 feeds). Likewise for balance 3, lambs aged 63 to 70 d were fed 210 g DM/d as milk replacer (1.2 ℓ of milk in 2 feeds) along with *ad libitum* pasture and for balance 4, lambs aged 92 to 98 days were fed only pasture. The milk replacer was prepared by mixing thoroughly 220 g of milk powder with 1 ℓ of cold water. The pasture was cut each morning at a height of 8 to 12 cm and after a DM determination a total of 400 g and 800 g DM/d was offered twice daily in balances 3 and 4 respectively. The daily DM intakes were calculated after determining the DM associated with the feed residues. During the nutritional balances the daily intakes, faecal and urinary outputs were measured and suitable samples collected for Se, Cu, Zn and Fe analysis. All lambs were weighted, without fasting, at weekly intervals.

### Comparative Slaughter Study

The total amounts of Se, Cu, Zn and Fe associated with the fleece-free empty body weight were determined by slaughtering groups of 8 lambs at

birth, 28 and 98 days of age. The lambs slaughtered at 28d were on the same feeding regimen at those on the nutritional balance and the lambs slaughtered at 98d were those used in the nutritional balance. All sheep were shorn, except for the new born, and weighed before slaughter. All blood was collected, the digestive tract was removed and digesta washed out. Samples of carcass, viscera, offals, liver, blood, skin and wool were taken so that the total Se, Cu, Zn and Fe content of the fleece-free empty body could be measured.

### Analytical and Statistical

The samples of diet, faeces, urine, carcass and other tissues were wet ashed in a $HNO_3$:$HC10_4$ mixture (4:1), 2MHCl was added to the ashed residue and the Cu, Zn and Fe determined by inductively-coupled argon plasma emission spectrometry (Lee, 1981). The Se was determined separately by the method of Watkinson (1979).

The relationship between the fleece free empty body weight and its total Se, Cu Zn and Fe content was determined by regression analysis.

## RESULTS AND DISCUSSION

The mean pasture DM intakes were 300 g and 650 g/d for lambs in balances 3 and 4 respectively. The mean lamb growth rate over the study period was 250 g/d.

### Intake, Output and Availability of Se, Cu, Zn and Fe

The mean intake, faecal and urinary output together with the apparent absorption and availability of Se, Cu, Zn and Fe from lambs aged 5 to 98d are presented in Table 1. Availability is the fraction of the ingested trace element which is apparently absorbed. The intakes of Cu, Zn and Fe increased markedly as the intake of pasture increased. The faeces was the major route of loss for all trace elements except in the case of Se where the urinary and faecal Se outputs were similar in the pasture fed lambs. The availabilities were greater than 0.9 for Se and Cu and 0.5 for Zn and Fe when the lambs were fed milk replacer. However as the amount of pasture eaten was increased the availabilities decreased to Se 0.45, Cu 0.09, Zn 0.42 and Fe 0.19 for an all pasture diet.

**TABLE 1** Mean (± SE) intakes, faecal and urinary outputs, apparent absorption and availability of Se, Cu, Zn and Fe in lambs from 5 to 98 days of age.

| Parameter | | Lamb age (d) 5-11 | 21-28 | 63-70 | 92-98 |
|---|---|---|---|---|---|
| **Selenium** | | | | | |
| Intake | (μg/d) | 39.0[1] | 25.0 | 25.2 ± 0.5 | 33.0 ± 2.1 |
| Faecal output | (μg/d) | 2.0 ± 0.2 | 2.9 ± 0.3 | 11.5 ± 0.7 | 18.1 ± 1.8 |
| Urinary output | (μg/d) | 1.3 ± 0.1 | 1.4 ± 0.1 | 2.4 ± 0.1 | 12.2 ± 1.2 |
| Apparent absorption | (μg/d) | 37.0 ± 2.2 | 22.1 ± 4.5 | 13.7 ± 0.4 | 14.9 ± 2.1 |
| Availability | | 0.94 | 0.88 | 0.54 | 0.45 |
| **Copper** | | | | | |
| Intake | (mg/d) | 0.84 | 1.44 | 3.88 ± 0.21 | 4.29 ± 0.19 |
| Faecal output | (mg/d) | 0.06 ± 0.01 | 0.15 ± 0.01 | 1.89 ± 0.19 | 3.88 ± 0.22 |
| Urinary output | (mg/d) | 0.02 ± 0.01 | 0.03 ± 0.01 | 0.11 ± 0.01 | 0.05 ± 0.02 |
| Apparent absorption | (mg/d) | 0.78 ± 0.02 | 1.29 ± 0.01 | 1.99 ± 0.23 | 0.41 ± 0.14 |
| Availability | | 0.93 | 0.90 | 0.51 | 0.09 |
| **Zinc** | | | | | |
| Intake | (mg/d) | 7.2 | 12.4 | 18.4 ± 0.6 | 15.5 ± 0.7 |
| Faecal output | (mg/d) | 3.5 ± 0.4 | 5.1 ± 0.4 | 10.5 ± 0.7 | 9.0 ± 0.4 |
| Urinary output | (mg/d) | 0.1 ± 0.1 | 0.1 ± 0.1 | 0.2 ± 0.1 | 0.1 ± 0.1 |
| Apparent absorption | (mg/d) | 3.7 ± 0.4 | 7.3 ± 0.4 | 7.9 ± 0.7 | 6.5 ± 0.7 |
| Availability | | 0.51 | 0.59 | 0.43 | 0.42 |
| **Iron** | | | | | |
| Intake | (mg/d) | 2.6 | 4.4 | 57.0 ± 2.3 | 99.5 ± 2.1 |
| Faecal output | (mg/d) | 1.3 ± 0.5 | 2.1 ± 0.2 | 45.8 ± 5.0 | 81.4 ± 3.8 |
| Urinary output | (mg/d) | 0.2 ± 0.1 | 0.2 ± 0.1 | 0.7 ± 0.1 | 0.4 ± 0.1 |
| Apparent absorption | (mg/d) | 1.3 ± 0.4 | 2.3 ± 0.2 | 11.2 ± 4.9 | 18.1 ± 0.1 |
| Availability | | 0.50 | 0.52 | 0.20 | 0.19 |

[1]First batch of milk powder fed was high in Se.

### Amounts of Se, Cu, Zn and Fe Associated with Liveweight Gain

The amounts of Se, Cu, Zn and Fe associated with liveweight gain were determined from the comparative slaughter groups. Significant ($P<0.01$) linear relationships were found between the trace element retained and the fleece-free empty bodyweight gain. Each kg gain in fleece-free empty body weight was associated with 44 µg Se, 1 mg Cu, 25.5 mg Zn and 46 mg Fe.

### Se, Cu, Zn and Fe Dietary Allowances for Lambs aged 25 and 100 d

The data obtained from nutritional balances and comparative slaughter were used to calculate the dietary Se, Cu, Zn and Fe allowances of the young lamb based on the factorial model approach (Agricultural Research Council, 1980). The availabilities of the trace element when milk or pasture are fed were determined from the nutritional balances while the growth component was determined from amount of trace element associated with liveweight gain. The maintenance component was estimated from the endogenous loss on the assumption that this reflects the minimum quantities of the trace element needed to maintain the various physiological and biochemical functions of the animal. The following endogenous loss values (µg/kg live weight) were used namely 0.2 Se (Grace and Watkinson, 1985), 4.0 Cu (Agricultural Research Council, 1980), 100.0 Zn (Suttle, *et al.*, 1982) and 14.0 Fe (Suttle, 1979).

The dietary allowances of Se, Cu, Zn and Fe for lambs aged 25 d, weighing 10 kg, and consuming 1.9 ℓ milk/d and aged 100 d, weighing 25 kg, and ingesting 1 kg DM/d as pasture are given in Table 2. The net requirement is the amount of the trace element which must be absorbed to meet the needs for maintenance as well as the greater needs for growth in the young lamb. Given the availabilities (Table 1) and the intakes for milk and pasture, the gross requirements and the daily allowances of Se, Cu, Zn and Fe can then be calculated from the net requirements.

As the coefficients of absorption of Se and Cu for the milk fed lambs were greater than 0.90 only small differences were found between the net and gross Se and Cu requirements. This is in contrast to the pasture fed lambs where the availabilities are low. For example, in the case of Cu where the availability is 0.09 or lower (Suttle, 1983), there was a large difference between the net and gross trace element Cu requirement. The absorption of some trace elements can be influenced by other dietary factors. In this regard the availability of Cu can show a large variation as increased intakes of Zn and Fe, as well as Mo in the presence of S, can decrease the absorption of Cu (Suttle, 1983) and therefore markedly alter the gross requirement and dietary allowance of Cu. A range of values for the gross requirement and dietary allowance of Cu are given based on the availabilities of 0.04 and 0.08 (Table 2).

A litre of ewe's milk can provide 5 µg Se, 0.2 mg Cu, 6,9 mg Zn and 0.5 mg Fe (Grace, 1983b). A 25-day-old lamb, consuming 1.9 ℓ/d of ewe's milk will receive an adequate intake of Cu, a marginal intake of Se and Zn and an inadequate intake of Fe to meet its requirements. However as 25-day-old lambs ingest increasing amounts of pasture this provides the extra quantities of Se, Cu, Zn and Fe needed to supplement those provided by the milk.

To maintain good growth rates in young lambs they must have access to good quality pasture containing 35 µg Se, 4 - 7 mg Cu, 21 mg Zn and 56 mg Fe per kg DM.

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**TABLE 2** Calculated dietary allowances for Se, Cu, Zn and Fe for lambs aged 25 and 100 d.

| Lamb age (d) | Component | Mineral Se (µg) | Cu (mg) | Zn (mg) | Fe (mg) |
|---|---|---|---|---|---|
| 25 | Maintenance (live weight 10kg) | 2.0 | 0.04 | 1.0 | 0.1 |
| | Growth (0.3 kg/d) | 13.0 | 0.30 | 7.5 | 15.0 |
| | Net daily requirement | 15.0 | 0.34 | 8.5 | 15.1 |
| | Gross daily requirement | 16.0 | 0.36 | 17.0 | 30.3 |
| | Dietary allowance (per ℓ milk) | 8.4 | 0.19 | 8.9 | 15.9 |
| 100 | Maintenance (live weight 25kg) | 5.0 | 0.1 | 2.5 | 0.3 |
| | Growth (0.25 kg/d) | 11.0 | 0.2 | 6.3 | 11.0 |
| | Net daily requirement | 16.0 | 0.3 | 8.8 | 11.3 |
| | Gross daily requirement | 35 | 4 - 7 | 21 | 56 |
| | Dietary allowance (per kg pasture) | 35 | 4 - 7 | 21 | 56 |

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