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The determination of mineral requirements of sheep and cattle

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ABSTRACT

In determining a mineral requirement an attempt is made to measure the minimum dietary intake of the mineral that is necessary to maintain health and the desired level of production.

Two approaches can be used to determine mineral requirements: (a) observations from practical feeding studies where the animal's response is related to the dietary level of the mineral under investigation; (b) by calculation using data obtained from mineral balance studies where the losses in the urine, faeces and sweat, together with the amounts absorbed, are measured with other investigations to determine the mineral uptake by body tissues and foetus and the amounts secreted in the milk.

Keywords Sheep; cattle; minerals; requirements

INTRODUCTION

Mineral requirements of an animal are an assessment of the dietary intake of mineral necessary to maintain its health and performance at any desired level of production. Mineral requirements can vary according to individuals, age, sex and level of production, while dietary factors (usually other minerals) can interfere with the absorption of some minerals. Therefore, at best, a mineral requirement should be regarded as a guide to the animal's mineral needs and will be re-evaluated as more information becomes available.

Two approaches can be used to determine the mineral requirements for sheep and cattle. These are: (a) observations from practical feeding studies, and (b) by calculation using data from mineral metabolism studies in a quantitative factorial model (Agricultural Research Council, 1980).

PRACTICAL FEEDING STUDIES

One approach is to feed animals synthetic or natural diets of varying but known mineral levels, ranging from deficient to more-than-adequate levels to meet requirements. The change in animal response in terms of growth, reproductive performance or milk production is noted as the dietary mineral level is increased. The minimum mineral requirement is that level of dietary mineral at which the maximum response is reached and maintained. In pasture situations involving grazing animals where there is little control over the environment or ability to 'set' dietary mineral levels, an alternative approach is to place 2 similar groups of animals on a number of pastures of widely varying, but known mineral levels. One group is then supplemented, with the mineral under investigation, at a level which is more than adequate to meet its requirements while the other group acts as a control. The minimum dietary requirement is that dietary mineral level at which there is no significant animal response when the supplemented and control animals are compared.

As an example, the selenium requirements for young sheep have been determined using the supplementation approach. The Se content of pasture from various areas in New Zealand can vary from 0.01 to 0.04 mg Se/kg (Grace, 1983). Groups of lambs (20 to 30 animals) were grazed on pastures of varying Se levels. At each pasture Se level 1 group was supplemented with 2 to 5 mg Se every 4 to 6 weeks while the other group acted as a control. Pasture Se levels were checked and the animals were weighed at regular intervals and the difference between the supplemented and control groups noted. A large number of trials over a wide range of pasture Se levels were carried out. Significant differences in growth rates between supplemented and control animals were noted only when Se pasture levels were less than 0.03 mg/kg DM. It was therefore concluded that the dietary Se requirement of the grazing young lamb was 0.03 mg Se/kg DM (0.03 ppm) and if DM intakes of 1 to 1.3 kg/d are assumed it can be calculated that the daily requirement of the lamb is 30 to 40 μg.

The major disadvantage with practical feeding studies is that the data apply only to the class of stock and diet fed and there is very little information obtained concerning the metabolism of the mineral studied. On the other hand, the quantitative factorial model requires detailed information on the metabolism of the mineral.

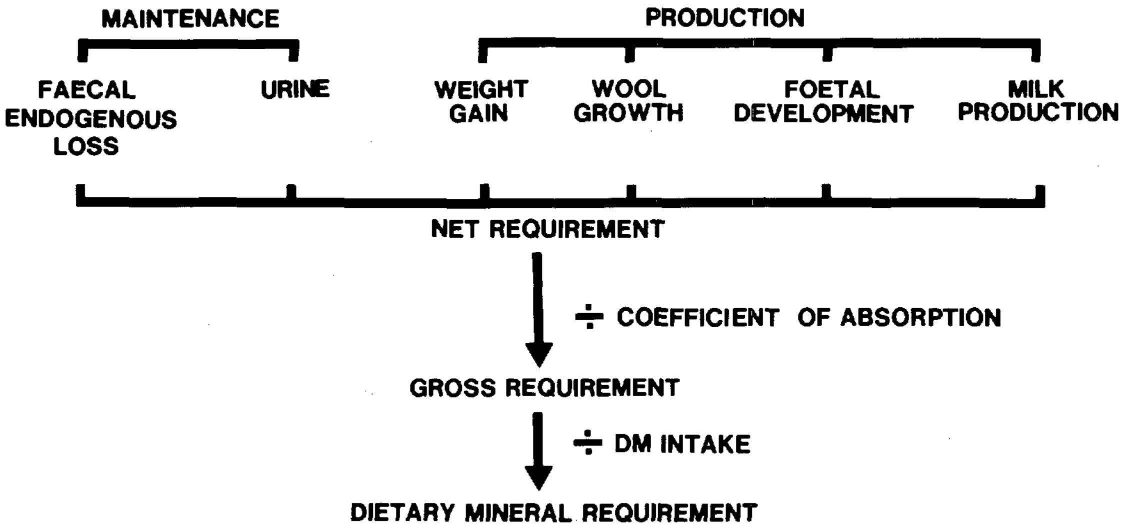

FIG. 1 An outline of the quantative factorial model for the determination of mineral requirements.

THE QUANTITATIVE FACTORIAL MODEL

An outline of the quantitative factorial model is given in Figure 1. The factorial model approach uses the data from nutrition balance studies, slaughter trials and isotope experiments which have been designed to determine the amounts of mineral which are ingested, absorbed, retained, secreted and excreted.

This approach has been used to determine the mineral requirements of Na, K, Ca, P, Mg, Cl as well as Zn and Cu (Agricultural Research Council, 1980). As more data become available it should be possible to determine the S, Fe, Mn and Se requirements using this approach. However for some minerals such as Co and I, the metabolism of which is complex, the above approach is not likely to be applicable.

The main components of the factorial model are:
(a) Maintenance component: The maintenance component is made up of the endogenous faecal loss, the endogenous urinary loss and the losses in the hair and sweat and therefore reflects the inevitable loss of mineral from the body. This loss occurs even when the mineral intake is very low.
(b) Production component: The production component includes the demands of growth, pregnancy and lactation for minerals. The daily amounts of mineral taken up by the body tissues, the wool, the conceptus and secreted in the milk are determined by multiplying the rates of the body-weight gain, wool growth, rate of foetal growth and milk production by the mineral content of the body tissues, wool, conceptus and milk respectively.
(c) Absorption coefficient: To express the net mineral requirement on a dietary basis the coefficient of absorption or availability of the mineral must be known. The coefficient of absorption is that fraction of the ingested mineral which is absorbed. Values for the coefficient of absorption can be above 0.9 for minerals such as Na, K, Cl and I or less than 0.1 for many of the trace elements such as Cu, Mn, Fe, while Ca, P, Mg, S, Zn and Se lie in between these 2 values. The coefficient of absorption is generally higher for young animals than for adults.

Dietary factors have a large influence on the absorption of minerals. For example, an important dietary interaction is the Cu-Mo-S interrelationship where increases in the dietary intake of Mo in the presence of S decrease the absorption of Cu. High intakes of Zn and Fe also decrease the absorption of Cu, while increased intakes of K decrease the absorption of Mg. The uptake and utilisation of I by the thyroid is decreased by dietary organic compounds called goitrogens (Grace, 1983).

The Determination of the Mg Requirements of Sheep and Cattle using the Quantitative Factorial Model

The Mg requirements of sheep and cattle can be calculated using the data given in Table 1. The coefficients

TABLE 1 The amount of Mg associated with the endogenous loss, growth, pregnancy and lactation in sheep and cattle.

	Sheep	Cattle
Endogenous loss mg/kg LW	3	3
Growth g/kg gain	0.41	0.45
Lactation g/kg milk	0.17	0.12
Pregnancy early g/d	0.01	0.12
mid	0.03	0.21
late	0.05	0.33

TABLE 2 Dietary Mg requirements of sheep and cattle.

	Live weight (kg)	Production	Requirement g/d	Requirement g/kg diet
Lamb	20	150 g/d gowth	0.7	1.0
	40	75	0.9	0.8
		150	1.1	0.9
Ewe	55			
maintenance			1.0	1.2
late pregnancy		single lamb	1.3	1.1
		twin lambs	1.5	1.2
lactation		2 kg milk/d	2.9	1.2
Calf	100	0.5 kg/d growth	3.0	1.0
		1.0	4.2	1.2
	300	0.5	6.6	1.2
		1.0	7.9	1.2
Dairy cow	380			
maintenance			6.7	1.5
late pregnancy			8.6	1.5
lactation		20 kg milk/d	21.0	1.6
		30	28.0	1.6
Beef cow	450			
lactation		10 kg milk/d	16.0	1.9

of absorption were taken as 0.7, 0.3 and 0.17 for the suckling, young and adult animals respectively. For example, the Mg requirement of a lactating cow weighing 380 kg and producing 20 kg of milk/d is calculated as following:

Maintenance (380 × 3)	=	1.14 g/d
Lactation (20 × 0.12)	=	2.40
Net Mg requirement	=	3.54
Gross Mg requirement (net ÷ 0.17)	=	21.0

Assuming a DM intake of 13 kg/day, the pasture must contain 1.6 g Mg/kg DM (0.16% DM) to meet the Mg requirements of a lactating cow.

Likewise the Mg requirements for maintenance, growth and pregnancy can be calculated for sheep and cattle as well as for the lactating sheep. These are summarised in Table 2.

The Recommended Dietary Mineral Requirements for Sheep and Cattle

Using the above approach the recommended mineral requirements for sheep and cattle have been determined and are listed in Table 3 (Grace, 1983). As the mineral requirements for maintenance, growth, pregnancy and lactation differ (see Table 2) the highest value for the requirement is given in Table 3. Pastures containing at least the mineral levels shown in Table 3 should provide an adequate mineral intake for grazing sheep and cattle.

TABLE 3 Recommended dietary mineral requirements for sheep and cattle.

	Sheep	Cattle
Major elements (g/kg DM)		
Ca	2.9	4.4
P	2.0	3.2
Mg	1.2	1.9
K	3.6	5.8
Na	0.9	1.2
Cl	1.0	2.4
S	1.5	1.8
Trace elements (mg/kg DM)		
Zn	25	25
Fe	30	40
Mn	25	25
Cu	5	7-10
Se	0.03	0.03
I	0.5-2	0.5-2
Co	0.11	0.09

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