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ABSTRACTS OF COMMUNICATIONS

The Two Hundred and Seventy-first Scientific Meeting of the Nutrition Society (One Hundred and Eighth of the Scottish Group) was held in the Queen Margaret College, Clerwood Terrace, Edinburgh, on Thursday, 5 September and Friday, 6 September 1974, *when the following papers were read:*

Supplementation of poor-quality protein with free amino acids. By T. G. Taylor and M. D. Walker, *Department of Physiology and Biochemistry, The University of Southampton, Southampton SO9 3TU*

Free amino acids added to the diet may be absorbed more rapidly than ones liberated from food proteins by the normal processes of digestion, and it is possible therefore that essential amino acids are used less efficiently when added to the diet in the free form than when supplied as protein.

When poor-quality proteins are to be supplemented it is not satisfactory to compare the value of the limiting essential amino acid supplied in the free form with that of a protein containing the same amount of that amino acid, since the protein will be supplying other amino acids as well. In these experiments, therefore, the supplementary value of a protein has been compared with that of a mixture of free amino acids identical to that supplied by the protein on complete hydrolysis.

Three experiments were carried out with chicks and two with growing rats. The experimental animals were given a mixed-cereal diet containing 80 g protein/kg supplemented with either 30 g egg albumen/kg or an amino acid mixture providing the same amounts of each amino acid as the albumen. In one of the rat experiments the animals were fed *ad lib.* and in the other they were given two meals/d, each of 2 h duration. No significant treatment differences were observed in growth or in the gross protein value of the supplements in any of these experiments.

The effects of the two diets on the regeneration of the liver of fasted rats were also studied, but no differences between diets were observed. When the diets were given to rats during pregnancy and lactation no differences were found in the total weights of the litters at birth but the performance of the amino acid-fed rats was marginally better at weaning.

Nevertheless, the concentration of lysine in the plasma of the portal blood of rats was significantly higher after 30 min ($P<0.01$) and after 60 min ($P<0.05$) in animals given the amino acid-supplemented diet than in ones given the albumen.

It may be concluded that although there is evidence that supplements of free amino acids may be absorbed more rapidly than amino acids derived from supplements of protein, the effect of this preferential absorption on the utilization of poor-quality proteins supplemented with free amino acids is unlikely to be of practical significance.

We wish to thank the British Nutrition Foundation for a grant in aid of this work.

Level of dietary protein and toxicity of tannic acid in young turkeys. By T. A. MORELAND, J. H. TOPPS and W. MICHIE, *School of Agriculture, 581 King Street, Aberdeen AB9 1UD*

It is well known that the inclusion of appreciable amounts of grain sorghum in broiler and laying hen diets may depress growth and egg production due to the presence of tannins (Sykes, 1970). There is very little corresponding information concerning the effect of tannins on growing turkeys and whether any toxicity may be offset by additional dietary protein. To obtain such information a randomized block experiment using 240 male turkeys divided into twenty-four groups of ten birds was carried out. Three diets were examined, based on either maize, sorghum or sorghum plus tannic acid (14 g/kg diet), each with two protein contents, 260 and 310 g/kg. All six diets were isoenergetic and had the same methionine:protein and choline:protein ratios. Each diet was allocated to four groups of ten birds and growth rate and food consumption measured from 1 to 29 d of age.

The results are given in Table 1.

Table 1. *Effects of cereal, protein level and tannic acid on the performance of young turkeys to 29 d of age*

Diet	Protein content (g/kg)	Weight gain (g)	Food intake (g)	Food conversion ratio (g food intake/g wt gain)
Maize	260	803	1137	1·42
	310	869	1106	1·27
Sorghum	260	787	1103	1·40
	310	910	1134	1·25
Sorghum + tannic acid	260	672	934	1·39
	310	846	1149	1·36
SE of difference between two means		43·7	32·5	0·05

Addition of tannic acid to the sorghum diet significantly depressed growth ($P<0.05$) and food intake ($P<0.01$) at the lower but not the higher protein level. However, food utilization of the low-protein sorghum diet was not affected by tannic acid, which indicated that the poor growth was due entirely to a low food consumption. Conversely, with the high-protein sorghum diets food utilization was affected ($P<0.05$) by tannic acid, which may suggest an adverse effect not related to intake. There were no significant differences in weight gain, food intake or utilization between the maize and sorghum diets at either protein level.

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Sykes, A. H. (1970). *Grain sorghum in poultry nutrition.* London: US Feed Grains Council.

The nutritive value of barley compared with maize in broiler diets. By L. F. OATES, J. H. TOPPS and W. MICHIE, *School of Agriculture, 581 King Street, Aberdeen AB9 1UD*

Barley in broiler diets has a lower feeding value than maize but the difference

may be affected by age of the bird and previous dietary treatment. An experiment to examine these two factors has been carried out using 480 male chicks divided into twenty-four groups, with four groups allocated to each dietary treatment. Four diets were examined which differed only in their cereal components, viz. all-maize (control), 50:50 and 25:75 maize–barley (diets 1 and 2 respectively), and all-barley (diet 3). The experiment of 60 d duration was divided into initial and final periods of 35 and 25 d respectively. During the initial period 240 chicks, i.e. twelve groups, were given the all-maize diet while each of the diets containing barley was fed to eighty chicks (four groups). After 35 d four of the groups receiving all-maize were changed to a diet containing 25:75 maize–barley, and another four groups were changed to the all-barley diet. All other chicks continued on the diet received in the initial period. Food consumption and weight of chicks were measured weekly, the metabolizable energy value of the diets was determined at the end of each period and the carcasses were chemically analysed at the end of the experiment.

The results are summarized in Table 1. They show that the feeding value of the diets containing barley increased with age of the chicks and that these values during the final period of the experiment were not affected by the diet given in the initial period.

Table 1. *Effects of substituting barley for maize on the growth, food conversion ratio and carcass composition of broiler chicks*

Period 0–35 d	Proportion of barley in diet (%)						
36–60 d	0	0	0	50	75	100	
	0	75	100	50	75	100	SEM
Body-weight at 35 d (g)	998	1012	971	962	957	934	17
at 60 d	2050	2059	1887	1928	1937	1896	43
Food conversion ratio, 7–35 d (g food intake/g wt gain)	1·88	1·96	1·94	2·03	2·19	2·30	0·053
Food conversion ratio, 36–60 d	2·77	3·07	3·46	3·07	3·19	3·43	0·14
ME value of diet at 35 d (kJ/g dry matter)	13·5	13·5	13·4	12·6	11·7	11·0	—
at 60 d	13·6	12·3	11·7	12·8	12·3	11·8	—
Fat in dry carcass (g/kg)	311	267	238	237	276	266	21
Protein in dry carcass (g/kg)	532	572	584	593	558	565	6

ME, metabolizable energy.

The effect of lighting period on the growth of broiler chicks. By P. S. DEANS and A. A. WOODHAM, *The Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

Experiments with growing chickens are normally done at this Institute in single-tier brooders with 13 h red light of approximately 43 lx intensity, followed by an 11 h period during which there is dim red light only. Red light was found to give better weight gains in early experiments (Woodham, 1968). Current commercial practice employs near-continuous (23·5 h) lighting for convenience of flock management.

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Early experiments with broilers (Moore, 1957; Shutze, Jensen, Carver & Matson, 1960) indicated that continuous lighting gave faster growth but poorer food conversion ratio than did shorter periods, but Skoglund, Wabeck & Palmer (1966) found that 12 h light gave similar growth and food conversion efficiency to 24 h.

Three experiments were carried out in which broiler chicks were given diets with 210 g protein (N×6·25)/kg to 4 weeks of age with 23·5, 13, 10 and 8 h red lighting (Table 1). In each comparison of 23·5 h with a shorter period the food

Table 1. *A comparison of near-continuous red lighting with shorter periods for broiler chick performance between 2 and 4 weeks of age*

	Lighting			Mean	Mean		Mean	
	Period	Colour	Approx. intensity	weight gain*	food intake*		protein intake*	
Expt	(h)		(lx)	(g)	(g)	FCR	(g)	TPE
1	23·5	Red	43	1922	3438	1·79	722	2·66
	13	Red	43	1935	3398	1·76	714	2·71
2	23·5	Red	43	2096	3588	1·71	753	2·78
	10	Red	43	2094	3515	1·68	738	2·84
3	23·5	Red	43	2060	3585	1·74	753	2·74
	8	Red	43	2020	3454	1·71	725	2·79

FCR, food conversion ratio (g food intake/g weight gain); TPE, total protein efficiency (g wt gain/g protein intake).

*For groups of six birds: sixteen groups were given each treatment.

and protein consumption were greater under near-continuous lighting, while the efficiency of protein utilization and food conversion were poorer. The differences in mean total protein efficiency were 0·05–0·06 and the SD for the difference between the means for sixteen cages was 0·059, so the superiority of the shorter lighting times does not attain statistical significance.

It appears from these experiments that there is no disadvantage in shortening the lighting period from 23·5 to 8 h. This would allow useful savings in electricity costs under experimental conditions where, in order to avoid problems associated with the feeding of young birds, lighting intensities of the order of 30-50 lx are used, but it seems unlikely that under commercial conditions of very dim lighting the saving would be a significant proportion of the total production cost.

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The retention of calcium, iron, magnesium and zinc in chicks fed on diets containing metal soaps. By W. A. DEWAR, C. C. WHITEHEAD, J. N. DOWNIE and E. POTTER*, *Agricultural Research Council's Poultry Research Centre, West Mains Road, Edinburgh EH9 3JS*

Whitehead, Dewar & Downie (1971) suggested that a decrease in the net retention by chicks of calcium, iron, magnesium and zinc, which resulted from adding fat to a low-fat purified diet, might have been caused by the formation of insoluble soaps in the gastrointestinal tract.

To assess the availability of the four elements as soaps, two experiments were carried out using 1-d-old male broiler chicks. The basal purified diet contained low levels of fat (10 g/kg) and minerals (mg/kg: Ca 100, Fe 10, Mg 10, Zn 6). In the control diet the added metals were provided as inorganic sources (calcium carbonate, ferrous sulphate, basic magnesium carbonate and zinc oxide) whereas in each experimental diet one of the metals was supplied as its soap (see Table 1). In all diets the amounts of metals added (mg/kg) were: Ca 7000, Fe 80, Mg 250, Zn 15.

In the first experiment chicks were offered diets containing Zn as the oxide, oleate or palmitate. All diets supported good growth (Table 1) but the net retention of Zn was significantly lower ($P<0.001$) with zinc oleate or palmitate than with the oxide.

In the second experiment the control diet was compared with three diets in which the Ca, Fe and Mg respectively were supplied as stearates and the other metals were provided in inorganic form. A fifth diet contained 105 g stearic acid/kg. Growth and the percentage net retention of Ca were severely depressed ($P<0.001$) in chicks receiving the diets containing calcium stearate or stearic acid. Although growth was unaffected in chicks given the Fe or Mg as stearate, the percentage net retention of each element was significantly ($P<0.001$) less than in birds receiving the control diet.

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Table 1. *Live weight at 21 d and percentage net retentions of zinc, calcium, iron and magnesium in chicks given diets containing metal soaps*

	Diet or source of metal (see text)	No. of birds in group	Live weight at 21 d (g)		Net retention (%)							
					Zn		Ca		Fe		Mg	
			Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Expt 1	Zn oleate	24	343	9·2	68·0	1·14	—		—		—	
	Zn palmitate	24	351	10·8	64·4	1·59	—		—		—	
	Control	24	351	9·8	77·1	1·10	—		—		—	
Expt 2	Stearic acid	20	256	13·6	—		38·1	3·74	33·5	4·82	54·2	1·01
	Ca stearate	20	209	5·5	—		31·6	2·54	33·0	4·27	49·7	2·06
	Fe stearate	20	386	13·3	—		63·8	1·49	20·0	1·94	78·5	1·55
	Mg stearate	20	412	17·5	—		66·8	1·51	45·9	1·60	66·4	1·06
	Control	20	384	16·8	—		64·7	1·38	35·6	2·25	81·2	2·16

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Rapid spectroscopic method for the estimation of ascorbic acid in infant milks. By DAVID J. CAMERON, *School of Nutritional Science, Robert Gordon's Institute of Technology, Queens Road, Aberdeen AB9 2PG*

This technique utilizes the principles of the redox method first introduced by Tillman's, Hirsh & Jackish (1932). The original method was a titrimetric analysis making use of the following redox couple:

ascorbic acid + dichlorophenol indophenol
(oxidized) (reduced, blue or pink)

↓

dehydroascorbic acid + dichlorophenol indophenol.
(reduced) (oxidized, colourless)

This is a very rapid reaction but there is endpoint drift. To counteract this the end-point can be determined potentiometrically. When biological samples are being used, ascorbic acid will not be the only oxidizing agent present. Any others will react more slowly with the dye than ascorbic acid. A rapid technique would increase specificity. A spectrophotometric technique was devised (Evelyn, Malloy & Rosen, 1938), of which this method is an adaptation.

Standard solutions of ascorbic acid in metaphosphoric acid (50 g/l) were prepared. To 100 μl of the standards was added 0·9 ml standard dichlorophenol indophenol solution. Within 10 s of the addition of the dye $^{10\ mm}E_{520\ nm}$ was measured. A maximum time lapse of 30 s has been quoted (Hughes, 1956). From these results a calibration chart of μg ascorbic acid *v.* $^{10\ mm}\Delta E_{520\ nm}$ was plotted. A linear relationship was found within the range 0–8 μg ascorbic acid per 100 μl sample. $^{10\ mm}\Delta E_{520\ nm}$ values of 0–0·4 absorption units were obtained within this range.

This method has been applied to infant milks in both the dry and liquid forms. The ascorbic acid was extracted using metaphosphoric acid to a final concentration of 50 g/l. Any resulting solid matter was removed by filtration or centrifugation before assaying for ascorbic acid.

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D-Isoascorbic acid investigated in a common cold survey. By K. MARY CLEGG and JENNIFER M. MACDONALD, *Department of Food Science and Nutrition, University of Strathclyde, 131 Albion Street, Glasgow G1 1SD*

A double-blind design was employed for a 15-week survey in which volunteer students were divided into three groups taking 1 g L-ascorbic acid, 1 g D-isoascorbic acid or placebo tablets daily; the number and duration of colds were recorded during this period, omitting the first week. D-Isoascorbic acid is a permitted food

additive in some countries but little information is available about the oral administration of higher levels. Blood samples from volunteers in the three groups were monitored regularly and showed no abnormalities in biochemical or liver function tests.

The results (Table 1) show no difference in the average number of colds per person for the L-ascorbic acid and placebo groups but the group taking D-isoascorbic

Table 1. *Effects of oral administration of* L-*ascorbic acid and* D-*isoascorbic acid on incidence and duration of common colds during* 14 *weeks in winter*

	L-Ascorbic acid (1 g/d)		Placebo		D-Isoascorbic acid (1 g/d)	
	Male	Female	Male	Female	Male	Female
No. persons	42	25	47	23	47	27
No. colds	46	22	43	30	29	22
Average no. colds/person	1·10	0·88	0·91	1·30	0·62	0·81
	1·01		1·04		0·69	
Average duration of cold (d)	6·7	8·3	7·9	7·2	7·1	6·8
	7·2		7·6		7·0	

acid suffered 34% fewer colds ($P<0.05$) than the placebo group. No statistically significant difference in the incidence or duration of colds was found between males and females within any of the groups. Thus, the previously found beneficial effect of L-ascorbic acid (Charleston & Clegg, 1972) was not substantiated during the winter of 1973–4, but the results with D-isoascorbic acid provide academic interest. The ascorbic acid molecule appears to reduce the effect of the common cold virus under certain situations, but not necessarily by the anti-scorbutic metabolic pathway.

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Effect of phytate on zinc absorption and faecal zinc excretion and carcass retention of zinc, iron, copper and manganese. By N. T. DAVIES and R. NIGHTINGALE, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

Phytic acid, which occurs naturally in association with many proteins of plant origin, has been considered an important factor in reducing dietary-zinc availability in many species (Oberleas, 1973). However, no studies have unequivocally demonstrated a direct effect of phytate on Zn absorption in vivo, or on net retention of dietary Zn.

In this study we investigated the effect of dietary phytate on Zn retention in rats given diets which were marginally adequate in Zn or which were Zn-deficient.

The food intake of rats maintained for 21 d on a semi-synthetic diet (Williams & Mills, 1970) supplemented with Zn (15 mg/kg), phytate (10 g/kg) and extra calcium to 13 g/kg decreased, and there was a fall in daily weight gain (84%; $P<0.001$) compared with controls not receiving phytate and which were fed to appetite. Control rats pair-fed to those receiving phytate showed a similarly reduced growth rate. However, from 2 to 14 d, phytate-fed rats excreted 76% more Zn in their faeces than did their pair-fed controls ($P<0.001$). Carcass analyses at slaughter showed that the average daily Zn accumulation in the carcass was reduced by dietary phytate from 61.5 ± 2.4 μg Zn/d (five rats) for pair-fed controls, to 12.9 ± 0.8 μg/d (six rats) ($P<0.001$). In addition phytate reduced carcass retention of iron, copper and manganese by 52%, 55% and 72% respectively.

Rats maintained on the Zn-deficient diet (0·5 mg Zn/kg) supplemented with phytate showed a net loss of body-weight during the period 3–21 d, whereas Zn-deficient controls gained weight slowly. The average daily Zn excretion from 2–14 d was 90% higher by the phytate-fed rats compared with the controls ($P<0.01$). Calculation of average daily Zn accumulation from carcass analyses confirmed that, while the controls were effectively in zero net balance ($+0.36 \pm 0.81$ μg Zn/d, six rats), those receiving phytate were in negative balance (-4.10 ± 0.78 μg Zn/d, six rats) ($P<0.01$). Furthermore, dietary phytate reduced carcass retention of Fe, Cu and Mn by 47%, 55% and 81% respectively.

It appears that phytate impairs both the absorption of dietary Zn and the re-absorption of endogenously-secreted Zn; results of preliminary experiments on the absorption and secretion of Zn into ligated loops of rat intestine in situ are consistent with this possibility.

Results on the retention of Fe, Cu, Mn and Zn indicate that under given dietary conditions phytate may induce a nutritional deficiency of any of these metals.

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The availability to sheep of copper in pig-slurry and slurry-dressed herbage. By J. PRICE, *Edinburgh School of Agriculture, Edinburgh* and N. F. SUTTLE, *Moredun Research Institute, Edinburgh*

The application to pasture of slurry from piggeries where copper is used as a growth stimulant constitutes a potential toxicity hazard to the grazing animal. In order to assess the risk of toxicity, the availability of Cu in slurry and slurry-dressed pasture to sheep was measured.

Slurry was obtained from a piggery where 150 mg supplementary Cu/kg food was used: it contained 425 mg Cu/kg dry matter (DM) and 220 g DM/kg and was applied at 15·6 tonnes/ha to part of a cut perennial ryegrass–white clover sward.

Some slurry was retained and dried at 100° for 48 h. Two groups of six initially hypocupraemic Scottish Blackface ewes, 3 years old, were repleted for 28 d with 800 g/d of a semi-purified diet supplemented with Cu (8 mg/kg) as either $CuSO_4$ or dry slurry, while two groups were repleted with herbage (4 kg/d) from the dressed or undressed sward. Grass was given either fresh (day 0–18) or frozen (day 19–28). The first cut was taken 3 weeks after slurry application and herbage Cu and DM were determined on several cuts. Plasma Cu was measured weekly during repletion and Cu availability was predicted from the observed responses (Suttle, 1974).

The diets containing $CuSO_4$ and slurry produced similar responses (Table 1), indicating that slurry Cu is relatively available and potentially toxic when ingested as a pasture contaminant. The application of slurry to pasture increased herbage Cu from 7·3 to 10·2 mg Cu/kg DM in the first 12 d: thereafter, the differences narrowed to 0·5–1·9 mg/kg, indicating minimal leaf surface contamination. The response in plasma Cu was also increased ($P<0.001$) but enhanced availability contributed to the effect (Table 1).

Table 1. *Availability of copper in pig-slurry and slurry-dressed herbage predicted from the responses in plasma Cu of initially hypocupraemic ewes after 21 d repletion*

	Dietary Cu		Δ Plasma Cu	Cu availability*
Cu source	Concentration (mg/kg DM)	Intake (mg)	(μg/l)	(%)
$CuSO_4$†	8·9	6·4	335±72	4·3
Dry slurry†	9·4	6·8	285±73	3·8
Grass	6·6	6·2	373±46	4·8
Slurry-dressed grass	8·5	7·0	620±48	5·8

DM, dry matter.
*Predicted by the technique of Suttle (1974).
†Added to low-Cu semi-purified diet.

The main risk in applying high-Cu slurry to pastures lies in the ingestion of contaminant Cu by the grazing animal: this risk can be minimized by treating cut swards, delaying grazing, and using cattle rather than sheep.

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The interaction between copper, molybdenum and sulphide in rumen contents of sheep. By I. BREMNER, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

The effects of molybdenum and sulphur on copper metabolism in ruminants may originate in the rumen and result either from the formation of a non-available complex containing Cu and Mo (Dowdy & Matrone, 1968) or from Mo-induced

changes in ruminal S^{2-} concentrations (Mills, 1960). The relative merits of these proposals were studied in an in vitro system.

Rumen contents, collected from two sheep maintained on dried grass, were incubated at 39° under N_2–CO_2 (95:5, v/v) after the addition of 0·1, 1·0 or 10·0 μg/ml of Cu (as $CuSO_4$) and Mo (as Na_2MoO_4). The changes in the concentrations of S^{2-} in the medium and of Mo and Cu in the supernatant fraction (38 000 *g* for 1 h) were determined at intervals over 4 h. During this time, concentration of S^{2-} in the control incubation mixtures increased 3–5-fold, that of soluble Cu decreased by 5–18% and that of soluble Mo was unchanged.

The changes observed on incubation in the presence of added Mo were concentration-dependent. High concentrations (10 μg Mo/ml) tended to decrease S^{2-} concentration relative to the control values by about 25% and increase that of soluble Cu by 50%. The latter effect was not simply a consequence of decreased CuS production, however, as there was an over-all increase in both soluble Cu and S^{2-} during incubation and the addition to the incubation mixture of other salts which modified S^{2-} concentration did not markedly alter Cu solubility. There was, therefore, a specific reaction between Cu and Mo, dependent on metabolic activity, which rendered Cu more soluble.

At lower levels of added Mo (0·1 μg/ml), S^{2-} production was increased by about 10% relative to the controls. The associated decrease of 20% in Cu solubility may have arisen from precipitation of CuS or of the Cu–Mo complex (Dowdy & Matrone, 1968). To test the second possibility, rumen contents from sheep maintained on dried grass containing 40 mg Mo/kg were incubated in the presence of added Cu (1·0 and 10·0 μg/ml). Final S^{2-} concentrations were 15% greater than in the controls and soluble Mo concentrations were decreased by 45%. As the latter effect was not dependent on the microbial activity of the system, the results are consistent with formation of the Cu–Mo complex, with consequent reduction in the inhibiting effect of Mo on S^{2-} production.

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Site of magnesium absorption in the sheep. By N. H. Strachan and J. A. F. Rook, *Hannah Research Institute, Ayr KA6 5HL*

Wether sheep were prepared with cannulas in the rumen, duodenum (close to the pylorus) and ileum (close to the ileo-caecal valve). They received an artificial, low-magnesium diet (g/kg: washed straw, 267; cellulose powder, 267, maize starch, 267; casein, 74; invert sugar, soya-bean oil, minerals and vitamins, 125). The Mg content of the dry matter of the diet was 40 mg/kg. Experimental periods were of 7 d duration. In initial and final control periods distilled water was infused continuously into the rumen. Over successive periods in between, Mg (1 g/d) in the form of

$MgCl_2.6H_2O$ (18 g/l) was infused into the rumen, duodenum and ileum, in that order in one sheep and in the reverse order in a second sheep. In the second sheep, after the completion of the final control, there was a further sequence of infusions into the rumen, duodenum and ileum with the infusate supplying 2 g Mg/d.

The mean values for the last 4 d of each period were as follows:

Sheep no.	Period	Site of infusion	Rate of infusion of Mg (g/d)	Plasma Mg concentration (mg/l)	Urinary Mg excretion (g/d)
1	1	Rumen	0	8·7	0·009
	2	Rumen	1	23·3	0·249
	3	Duodenum	1	14·5	0·037
	4	Ileum	1	13·9	0·017
	5	Rumen	0	6·3	0·013
2	1	Rumen	0	6·7	0·006
	2	Ileum	1	6·4	0·005
	3	Duodenum	1	6·3	0·005
	4	Rumen	1	16·8	0·324
	5	Rumen	0	5·8	0·003
	6	Rumen	2	18·7	0·573
	7	Duodenum	2	11·1	0·010
	8	Ileum	2	9·7	0·006

Thus, significant absorption of Mg appeared to occur only prior to the duodenum.

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