Mineral intake on commercial dairy farms in GB in comparison with recommended levels

Research Partnership: Cattle health, welfare and nutrition

Work Package FS3: Mineral and trace-element requirements of dairy cows

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DairyCo

Contents

1.1 Farmer Recommendations

- A significant number of dairy farms are feeding excess minerals during the winter feeding period. This could be costly and increase the environmental impact of dairy farming.

- For copper in particular, excess amounts are generally being fed. It is recommended that a forage analysis should be conducted in the first instance, as many farms are feeding additional Cu in the belief that levels of antagonists such as molybdenum are high. In the vast majority of cases this is not the situation.

- In contrast, a smaller number of farms are feeding some minerals below requirements and supplementation is justified to improve animal performance and health.

- The contribution to total daily mineral supply from concentrates, the forage mix, water and other sources varies greatly from farm to farm.

- It is important that the mineral supply from all dietary sources is known, and that one person has overall responsibility for the mineral nutrition of the herd.

1.2 Executive summary

Fifty commercial dairy farms were randomly selected in the Midlands and North of England to determine the intake of 10 key minerals from all dietary sources. The farms were visited once between November 2011 and March 2012 when the cows were housed and being fed winter rations. Of the farms visited, 10 were chosen to have organic accreditation and a maximum of 7 farms were selected that were using one feed company or nutritionist. The basal ration fed to the high and low (where appropriate) groups of milking cows were sampled with additional samples of clamp, big bale silage and concentrates collected as required. Samples of fresh drinking water were taken and data collected on the source and quantity of supplementary minerals being fed. Feed, forage and water samples were analysed for their concentration of 10 minerals. A summary of farm characteristics and mineral intake, expressed as g or mg/kg DM intake is presented in Table S1.

Table S1. Selected mineral concentrations in the diet of early and late lactation dairy cows fed during the winter of 2011-2012 on 50 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources.

	NRC (2001) recommendations	Mean	SD	Median	Max	Min
Herd Size (cows)		245	320	177	2297	37
Milk yield (kg/cow/yr)		7982	1494	8000	12600	4000
Macro elements (g/kg DM)						
Sodium	2.2-2.3	3.15	0.82	3.15	5.04	0.74
Potassium	10.0-10.7	22.6	4.24	22.1	33.8	14.6
Calcium	6.0-6.7	9.46	2.91	8.39	19.7	5.08
Magnesium	1.8-2.1	3.11	0.68	2.96	4.97	1.78
Phosphorus	3.2-3.8	4.20	0.71	4.17	5.76	2.56
Trace elements (mg/kg DM)						
Copper	11	24.2	8.35	22.9	44.3	12.9
Zinc	43-55	77.5	28.5	72.1	169	30.8
Iron	12.3-18	315	99.6	308	591	111
Manganese	13-14	100	31.1	97.7	193	41.2
Molybdenum	--	1.18	0.84	1.02	0.28	5.16

In conclusion:

- There was a considerable range in the dietary concentration of macro-minerals, with on average a 49 % excess of Ca and 20 % excess of P, with one farm feeding 210 % excess Ca and 65% excess P. In contrast, some farms were supplying only 80% of Ca and 73 % of P requirements.
- There was a considerable range in micro-mineral dietary concentration, with many farms supplying substantially above but some below requirements.
- When accounting for all sources of Cu, 4 farms were supplying above 40 mg/kg DM with a further 10 above 30 mg/kg DM. These levels if fed long term are likely to lead to Cu toxicity. A total of 31 out of 50 were feeding above the recommended Cu allowance of 20 mg/kg DM.
- Based on the dietary Mo concentrations, for the vast majority of farms there was no justification for high dietary Cu concentrations to be fed.
- Although the number of organic herds was small, they tended to feed above average levels of Ca and K, similar amounts of Mg and P and lower amounts of Cu and Zn.
- The contribution to total daily mineral supply from the concentrates, forage mix, water and other sources varied greatly from farm to farm.

2. Introduction

Minerals are a key component in the diet of dairy cows and their effects on performance, health, fertility and welfare are well documented. Traditionally, dairy cows have been supplemented to avoid deficiencies, although more recently dietary recommendations incorporate effects on animal health, fertility and product quality. In the case of minerals such as phosphorus, recent long term studies in the UK indicate that dietary levels can be reduced substantially without compromising performance, bone strength or fertility (Ferris et al., 2010a,b). Reducing dietary levels not only decreases diet cost, but also minimises potential negative effects on the environment. Studies in the United States however indicate that a high proportion of dairy cows are being supplemented at levels well in excess of requirements. For example, 50% of farms in Wisconsin were feeding Zn at levels significantly above that recommended by NRC (2001), whilst 94% of farms were feeding Cu in excess of requirements (Li et al., 2005). There is also a growing body of evidence in the UK that minerals are being fed at levels well in excess of requirements, with an increasing number of cow deaths presented to veterinary investigation centres as a consequence of Cu poisoning (Anon 2001; Bidewell et al., 2000; ACAF, 2010). There is, however, a lack of accurate information on mineral intake levels on GB dairy farms, particularly in situations where minerals are provided from several sources (e.g. in-feed, free access supplements, boluses, drenches).

2.1. Objectives

To determine the intake of 10 key minerals from all dietary sources on 50 commercial dairy farms in the Midlands and North of England and compare these to recommended levels. This information can then be used to under pin more accurate rationing on farm, reducing feed costs, decreasing mineral excretion and improving animal health.

3. Materials and Method

3.1. Farm selection and characteristics

A random sample of 50 dairy farms located in the Midlands and North of England were selected from a database of dairy farms supplied by DairyCo. The farms were visited once between November 2011 and March 2012 when the cows were housed and fed full winter rations. Of the farms visited, 10 were selected to have organic accreditation and a maximum of 7 farms were chosen that were using one feed company or nutritionist. The farm characteristics (e.g. herd size, milk yield, calving interval and pattern), feeding system (e.g. total mixed ration (TMR), bunker feeding, self-feeding forage, in-parlour or out of parlour feeding), mineral supplementation (e.g. in ration, free access minerals, licks, injections, boluses, in-water) were recorded on the day of the visit, along with any nutritional details on the supplements being used.

3.2 Sample collection

The basal ration fed to the high and low (where appropriate) groups of milking cows were sampled within 10 min of feed out, with approximately 12 grab samples taken at roughly 5 second intervals (Li et al., 2005). Samples of clamp and big bale silage fed on the day of the visit were collected as described by Sinclair (2006), with approximately 500 g collected per sample. Individual samples were bulked, thoroughly mixed and a composite sample of approximately 1 kg placed in an air tight plastic bag, voided of air and sealed. Concentrates and mineral/vitamin supplements were sampled by taking at least 12 grab samples from their respective storage areas, bulked, thoroughly mixed and a composite sample of 500 g placed in an air tight bag, voided of air and sealed. All samples were stored at -20°C prior to analysis. Samples of fresh drinking water were collected from the running water of a water trough located in the cow housing; the water was left to run for 1-2 min before a sub-sample was collected and stored at -20°C.

3.3. Sample analysis

Samples of the basal ration and supplementary concentrates were analysed for their mineral content as described by Cope et al., (2009). The samples were defrosted, dried to a constant weight at 70°C according to AOAC (2000) and ground through a 0.5 mm mill. A sub-sample was extracted using a DigiPREP digestion system (Qmx Laboratories, Essex, UK) and analysed for Na, K, Ca, Mg, P, Cu, Zn, Fe, Mn and Mo by ICP-MS (Thermo Fisher Scientific Inc., Hemel Hempstead, UK). An official EU reference sample of hay and dairy concentrate (EU Commission Joint Research Centre certified reference materials BCR-129 and BCR-70 respectively) were routinely extracted and analysed to ensure that the results fell within the expected range. Extraction conditions were optimized for the above ten minerals and as a consequence the values obtained for Co and Se did not consistently fall within the reference range. The results for Co and Se have therefore not been reported.

3.4. Data handling, calculations and analysis

Daily milk yield (kg) was calculated for each study farm for cows at day 56 (early) and day 245 (late) of lactation, based on the stated annual milk yield and using the equations of Morant and Gnanasakthy (1989). From the daily milk yield, daily dry matter (DM) intake was predicted according to NRC (2001) as: DMI (kg) = $(0.372 \times MY + 0.0968 \times BW^{0.075}) \times (1 - e^{(-0.192 \times (WOL + 3.67))})$ where MY = milk yield, BW = body weight (kg) and WOL = week of lactation. For farms that fed parlour concentrate (40 out of the 50 farms sampled), feed rate was calculated as the amount fed (based on the predicted milk yield and the farmers stated feed rate), or calculated using the Feedbyte® rationing software (version 3.77; SAC 2010) using Feed into Milk intake equations (Thomas, 2004), and the diet composition provided by the farmer. Water intake was calculated according to Little and Shaw (1978) as: 12.3 + 2.15 x DMI + 0.73 x MY, where DMI = DM intake (kg/d) and MY = milk yield (kg/d).

The quantity of mineral supplied by additional sources (e.g. bolus, mineral lick block, free access minerals, injections) on the day of the visit was calculated using the farmers estimated rate of use and the companies stated mineral concentration. On a number of farms a mineral bolus was administered to the cows at drying off or shortly after calving. Using the manufacturers stated rate of release, the bolus mineral supply was added to the daily supply only if it was predicted to be releasing minerals at day 56 or 245 of lactation. On some farms a bolus was administered to the heifers only during the summer grazing period. In these circumstances it was calculated whether the bolus would still be contributing to the daily mineral supply on the day of sampling, and if appropriate included in the calculations. Some dairy farms administered additional macro minerals at calving, either through drenching, liquid feeds or routine injection. None of these were calculated to supply the early or late lactation cows with minerals on the day of sampling, and have therefore been excluded.

The sum of the daily supply of minerals from the diet, water and supplementary sources was divided by the daily DM intake to provide a mineral concentration (g or mg/kg DM). The total dietary allowance was considered, and no account was taken of potential differences in either forage or mineral source on net absorption. The mineral concentration (g or mg /kg DM) for the early and late lactation diets were analysed using the general descriptive statistics component of Genstat (version 14.1). Results were compared to recommended levels (NRC 2001) for an average cow at day 56 or 245 of lactation. Typical mineral concentration across a range of intakes and milk yields as recommended by NRC (2001) is presented in Appendix 2; Table 8.

4. Results

4.1. Farm characteristics

The location of the 50 farms visited during the study is provided in Figure 1. The farms ranged from Lancashire in the North to Worcestershire in the South, and from Powys in the West to Derbyshire in the east. Cheshire had the most farms sampled.

The mean milk yield of the farms sampled was 7982 kg, approximately 7 % higher than the UK national average (DairyCo 2012). The predicted daily milk yield and DM intake for a cow in early lactation was 38 and 23 kg respectively, whilst that for the late lactation cow was 15 and 18 kg respectively. Mineral lick blocks were the most popular source of supplement used, being offered on 54 % of the farms surveyed, with boluses used on 36 % of farms (Figure 2). One farm used an in-water mineral supplement.

4.2. Mineral supply: early and late lactation

Calculated mean and median dietary concentration of macro-minerals in the diet of early lactation dairy cows was in excess of recommended guidelines (Table 2). For example, there was on average a 67% excess of Ca and 28% excess of P, with some farms feeding up to 192% excess Ca and 66% excess P. There were however, a number of farms feeding some minerals below recommended levels. For example, the minimum Ca concentration of 4.98 g/kg DM was 18% below the recommend dietary concentration, whilst the lowest P level fed was 19% below requirement. Similarly, compared to recommended values, mean and median micro-mineral concentrations were in excess of requirements. For example, Cu was on average, 154% in excess, with one farm supplying nearly 50% above the legal limit of 40 mg/kg DM. The dietary concentration of Zn was 82% above requirement, whilst Fe and Mn were also well in excess. Dietary concentrations of Mo were generally low at 1.13 mg/kg DM, although one farm had a high concentration at 4.75 mg/kg DM. Some farmers justified the high levels of dietary Cu due to a perceived high background concentration of Mo. The relationship between dietary Mo and Cu concentration was however, poor ($R^2 = 0.03$), and in most instances did not justify the high levels of Cu being fed (Fig 3). On farms with a high dietary concentration of Mo, below average Cu levels were being fed.

The amount of minerals fed to late lactation dairy cows was lower than that to early lactation animals, but still in excess for all minerals determined (Table 3). For example, the concentration of P was approximately 22% above the recommended value, and Ca 41% in excess. Although the mean concentration of P was lower in late than early lactation diets, the highest P concentration of 6.19 g/kg DM was fed to cows in late lactation, approximately 93% above requirements. The mean and median micro-mineral dietary concentration was also lower in the late lactation diets. For example, the mean and median Cu concentration was approximately 21 mg/kg DM, compared to 28 mg/kg DM in early lactation. Similarly, the Zn concentration in late lactation diets was 68 mg/kg DM compared to 88 mg/kg DM in early lactation, although this value was still well in excess of the 43 mg/kg DM recommended by NRC (2001). Dietary Mo concentrations were similar between early and late lactation diets, as this element is seldom added to the diet of dairy cows and is therefore a reflection of the background feed levels.

To reflect that the net mineral supply to dairy cows during a lactation is a combination of the early and late lactation diets, the average mineral concentration was calculated to be the mean of the early and late lactation diets (Table 4). As indicated by the standard deviation of the mean, in general, farms that fed high levels of minerals in early lactation also tended to feed high amounts in late lactation. The calculated average mineral supply was intermediate between the early and late lactation diets, with an excess of all minerals tested. When accounting for all sources of copper, 4 of the farms sampled were supplying above 40 mg/kg DM with a further 10 above 30 mg/kg DM. These levels if fed long term are likely to lead to Cu toxicity. Of the 50 farms sampled, some 31 were providing Cu above the recent recommended maximum allowance of 20 mg/kg DM (ACAF 2010), and 48 (96 %) were supplying above the 11 mg/kg DM recommended by NRC (2001).

4.3. Mineral supply in organic herds: early and late lactation

Of the 50 farms visited only 10 were organic, and caution should therefore be exercised when interpreting the data from such a small subset. The dietary concentration of Ca fed on organic herds in early lactation was above that of the overall mean, and some 113% of requirements (Table 5). In contrast, dietary P was very similar in organic and conventional herds at 4.67 g/kg DM and 4.48 g/kg DM respectively. The dietary concentration of Cu was approximately 18% lower in organic herds than the mean or median for all herds, but was still more than twice the recommended concentration, although the data were skewed with one organic herd feeding over 50 mg/kg DM. The lowest dietary concentration of Cu fed in early lactation (12.9 mg/kg DM) was recorded on an organic herd. Two organic herds were also had some of the highest dietary concentrations of Mo at 3.05 and 4.75 mg/kg DM, although both of these herds fed below average levels of Cu at approximately 18 mg/kg DM.

Similar to early lactation, the dietary concentration of K and Ca in organic herds in late lactation were higher than the overall mean, with the concentration of P being similar (Table 6). Dietary Cu levels fed in late lactation were lower in organic herds than the average for all herds, with a mean of 15.6 and median of 13.9 mg/kg DM. Similarly, the Zn concentration in the diet of late lactation organic herds was closer to recommended values. The standard deviation of the total dietary supply (mean of early and late lactation diets) was similar between the early, late and average mineral concentration, indicating that farms that fed high or low levels of minerals in early lactation also tended to do so in late lactation (Table 7). In general, compared with the mean of the 50 farms (which included the 10 organic farms), organic farms tended to feed higher levels of Ca and K, similar amounts of P, Mg and Na. In contrast, dietary Cu and Zn concentrations tended to be lower in organic herds than the overall average.

4.4. Contribution to daily mineral supply from different dietary sources

The contribution from the parlour concentrates, forage mix (forages plus added straight feeds, concentrates and minerals), water and other sources to total daily mineral supply for cows fed parlour concentrates (n = 40) is presented in Fig 4. On average, for cows in early lactation (Fig 4a), on average the parlour concentrates contributed approximately 20% of daily supply of K, to 50% of daily Cu supply. On individual farms, parlour concentrate contributed up to 78% of the total daily supply of Cu, or 47 mg/kg DM which on its own exceeded the legal requirement. The proportion of daily supply from water was relatively small, particularly for the trace elements, but for certain farms water could contribute approximately 6% to the daily supply of Ca, Na and Mg. When expressed as a proportion of daily requirements, this equated to around 10% of requirements. The contribution from other sources of minerals varied greatly from farm to farm, but could supply up to 53% of Cu intake or 23 mg/kg DM. For cows in late lactation (Fig 4b) the contribution of parlour concentrates to total daily mineral supply decreased as feeding level decreased, and the contribution from the forage mix increased, with water and other sources providing a similar amount.

The contribution from the TMR (forages plus added straight feeds, concentrates and minerals), water and other sources to total daily mineral supply for herds that fed only a TMR (n = 10) is presented in Fig 5. In early lactation (Fig 5a) the majority of minerals were supplied as part of the TMR, and on average the contribution from water and other sources was small. On an individual farm basis however, water could contribute between 6-12% of Na, Mg and Ca supply, or 10-20% of daily requirements. Similarly, on individual farms, other sources of minerals could supply up to 32% of Zn and 40% of Cu supply. There was a similar pattern for TMR fed cows in late lactation (Fig 5b).

5. Conclusions

When accounting for the mineral supply from all sources there was a considerable range in the amount of minerals being fed. When compared to recommended dietary concentrations, most farms were feeding an excess of macro-minerals. Similarly, there was an excess of micro-mineral supply, although a smaller number farms were underfeeding. The high levels of dietary Cu did not appear to be justified by high dietary Mo concentrations, with no relationship (P = 0.265) between dietary Mo and Cu concentrations. Although the number of organic herds sampled was small, on average they tended to feed above average levels of Ca and K, and similar amounts of Mg, P and Na. Organic herds fed lower amounts of the micro-minerals Cu and Zn.

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7. Appendix 1.

Table 1. Characteristics of the 50 dairy farms surveyed to determine the quantity of minerals being fed over the winter of 2011-2012.

	Mean	SD	Median	Max	Min
Herd Size (cows)	245	320	177	2297	37
Milk yield (kg/cow/yr)	7982	1494	8000	12600	4000
Calving interval (d)	412	23	410	470	365
Milk yield (kg/d)[1]					
Early lactation	37.8	6.9	37.8	59.9	19.0
Late lactation	14.8	2.7	14.8	23.5	7.4
Total DM intake (kg/d)[2]					
Early lactation	23.4	2.6	23.7	31.0	16.1
Late lactation	17.6	1.4	18.0	21.2	13.7
Parlour concentrate (kg/d)[3]					
Early lactation	6.6	2.3	6.0	10.5	2.0
Late lactation	1.1	1.1	0.5	4.0	0.0

[1]Predicted from the equations of Morant and Gnanasakthy (1989) from the stated milk yield and calving interval for a 3rd lactation dairy cow. Early lactation = day 56 post calving and late lactation = day 245 post calving.
[2]Predicted from NRC (2001) as: $DMI (kg) = (0.372 \times MY + 0.0968 \times BW^{0.075}) \times (1 - e^{(-0.192 \times (WOL + 3.67))})$ where MY = milk yield, BW = body weight (kg) and WOL = week of lactation.
[3]Calculated from the predicted milk yield and the remainder of the ration being offered. Forty herds used parlour concentrates.

Table 2. Selected mineral concentrations in the diet of early lactation[1] dairy cows fed during the winter of 2011-2012 on 50 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis.

	NRC (2001) recommendations[2]	Mean	SD	Median	Max	Min
Macro elements (g/kg DM)						
Sodium	2.3	3.29	0.80	3.38	4.81	0.96
Potassium	10.4	21.3	3.84	21.0	31.8	13.9
Calcium	6.1	10.2	2.94	9.21	17.8	4.98
Magnesium	1.9	3.36	0.71	3.21	5.18	1.81
Phosphorus	3.5	4.48	0.70	4.44	5.82	2.82
Trace elements (mg/kg DM)						
Copper	11	27.9	9.85	25.8	57.9	12.9
Zinc	48	87.3	31.2	82.1	207	31.6
Iron	15	316	90.9	308	595	124
Manganese	14	102	28.9	100	191	42.5
Molybdenum	--	1.13	0.73	1.00	4.75	0.33

[1]Early lactation was assumed to be day 56 post calving
[2]Based on a standard diet. The requirement for minerals can be affected by antagonists and may therefore be higher, or lower than described. Individual animal requirements on each farm will also be affected by parameters such as live weight, milk yield and intake. A typical range of mineral requirements across a range of milk yields and DM intakes is presented in Appendix 2, Table 8.

Table 3. Selected mineral concentrations in the diet of late lactation[1] dairy cows fed during the winter of 2011-2012 on 50 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis.

	NRC (2001) recommendations[2]	Mean	SD	Median	Max	Min
Macro elements (g/kg DM)						
Sodium	2.2	3.00	0.95	3.08	5.45	0.51
Potassium	10	23.9	5.21	23.7	37.2	15.3
Calcium	6.2	8.72	3.14	7.86	21.6	5.02
Magnesium	1.8	2.86	0.79	2.77	5.21	1.46
Phosphorus	3.2	3.91	0.85	3.93	6.19	2.10
Trace elements (mg/kg DM)						
Copper	11	20.6	9.68	21.3	44.0	4.89
Zinc	43	67.6	30.5	65.8	155.9	27.7
Iron	12.3	314	123	309	662	99.3
Manganese	14	98.1	37	92.8	206	38.2
Molybdenum	--	1.23	0.97	1.06	5.56	0.17

[1]Late lactation was assumed to be day 245 post calving
[2]Based on a standard diet. The requirement for minerals can be affected by antagonists and may therefore be higher, or lower than described. Individual animal requirements on each farm will also be affected by parameters such as live weight, milk yield and intake. A typical range of mineral requirements across a range of milk yields and DM intakes is presented in Appendix 2, Table 8.

Table 4. Selected mineral concentrations in the diet of early and late lactation dairy cows fed during the winter of 2011-2012 on 50 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis.

	NRC (2001) recommendations[1]	Mean	SD	Median	Max	Min
Macro elements (g/kg DM)						
Sodium	2.2	3.15	0.82	3.15	5.04	0.74
Potassium	10	22.6	4.24	22.1	33.8	14.6
Calcium	6.2	9.46	2.91	8.39	19.7	5.08
Magnesium	1.8	3.11	0.68	2.96	4.97	1.78
Phosphorus	3.2	4.20	0.71	4.17	5.76	2.56
Trace elements (mg/kg DM)						
Copper	11	24.2	8.35	22.9	44.3	12.9
Zinc	43	77.5	28.5	72.1	169	30.8
Iron	12.3	315	99.6	308	591	111
Manganese	14	100	31.1	97.7	193	41.2
Molybdenum	--	1.18	0.84	1.02	0.28	5.16

[1]Based on a standard diet. The requirement for minerals can be affected by antagonists and may therefore be higher, or lower than described. Individual animal requirements on each farm will also be affected by parameters such as live weight, milk yield and intake. A typical range of mineral requirements across a range of milk yields and DM intakes is presented in Appendix 2, Table 8.

Table 5. Selected mineral concentrations in the diet of early lactation[1], organic dairy cows fed during the winter of 2011-2012 on 10 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis.

	NRC (2001) recommendations[2]	Mean	SD	Median	Max	Min
Macro elements (g/kg DM)						
Sodium	2.3	3.23	1.08	3.38	4.81	0.96
Potassium	10.4	25.7	4.07	24.5	31.8	18.9
Calcium	6.1	13.0	2.90	11.7	17.8	8.26
Magnesium	1.9	3.47	0.77	3.32	4.92	2.34
Phosphorus	3.5	4.67	0.75	4.80	5.41	2.82
Trace elements (mg/kg DM)						
Copper	11	23.0	10.9	18.3	51.0	12.9
Zinc	48	67.1	26.3	62.3	129	31.6
Iron	15	314	114	279	534	176
Manganese	14	92.5	29.9	86.1	128	42.5
Molybdenum	--	1.89	1.18	1.41	4.75	0.83

[1]Early lactation was assumed to be day 56 post calving
[2]Based on a standard diet. The requirement for minerals can be affected by antagonists and may therefore be higher, or lower than described. Individual animal requirements on each farm will also be affected by parameters such as live weight, milk yield and intake. A typical range of mineral requirements across a range of milk yields and DM intakes is presented in Appendix 2, Table 8.

Table 6. Selected mineral concentrations in the diet of late lactation[1], organic dairy cows fed during the winter of 2011-2012 on 10 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis.

	NRC (2001) recommendations[2]	Mean	SD	Median	Max	Min
Macro elements (g/kg DM)						
Sodium	2.2	2.75	1.05	2.73	4.41	0.51
Potassium	10	27.5	6.29	27.4	37.2	17.2
Calcium	6.2	11.6	4.27	9.64	21.6	6.99
Magnesium	1.8	2.93	0.98	2.62	5.02	1.75
Phosphorus	3.2	3.97	0.77	4.26	4.62	2.30
Trace elements (mg/kg DM)						
Copper	11	15.6	7.44	13.9	28.8	5.05
Zinc	43	48.0	17.8	43.4	81.2	27.7
Iron	12.3	304	141	266	590	126
Manganese	14	92.5	33.3	81.5	147	40.0
Molybdenum	--	2.14	1.48	1.74	5.56	0.76

[1]Late lactation was assumed to be day 245 post calving
[2]Based on a standard diet. The requirement for minerals can be affected by antagonists and may therefore be higher, or lower than described. Individual animal requirements on each farm will also be affected by parameters such as live weight, milk yield and intake. A typical range of mineral requirements across a range of milk yields and DM intakes is presented in Appendix 2, Table 8.

Table 7. Selected mineral concentrations in the diet of early and late lactation, organic dairy cows fed during the winter of 2011-2012 on 10 herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis.

	NRC (2001) recommendations[1]	Mean	SD	Median	Max	Min
Macro elements (g/kg DM)						
Sodium	2.2	2.99	1.00	3.11	4.21	0.74
Potassium	10	26.6	4.84	26.0	33.8	19.3
Calcium	6.2	12.3	3.30	10.8	19.7	7.63
Magnesium	1.8	3.20	0.84	2.88	4.97	2.04
Phosphorus	3.2	4.32	0.69	4.45	5.02	2.56
Trace elements (mg/kg DM)						
Copper	11	19.3	8.37	15.5	39.9	12.8
Zinc	43	57.6	20.2	51.5	105	30.8
Iron	12.3	309	120	252	562	165
Manganese	14	92.5	30.4	79.2	41.2	133
Molybdenum	--	2.02	1.33	1.54	5.16	0.80

[1]Based on a standard diet. The requirement for minerals can be affected by antagonists and may therefore be higher, or lower than described. Individual animal requirements on each farm will also be affected by parameters such as live weight, milk yield and intake. A typical range of mineral requirements across a range of milk yields and DM intakes is presented in Appendix 2, Table 8.

Fig 1. Distrubtion of the 50 dairy farms sampled to determine their mineral feed rate.

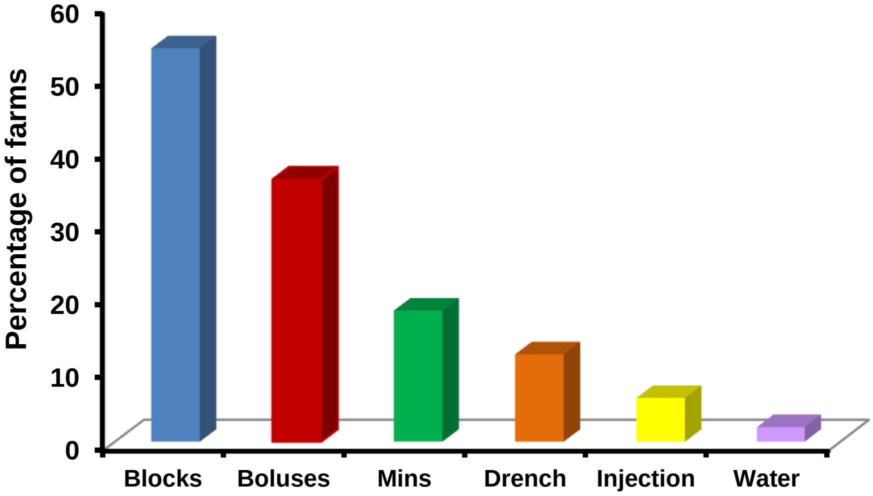

Fig 2. Supplementary mineral sources used on the 50 surveyed dairy farms.

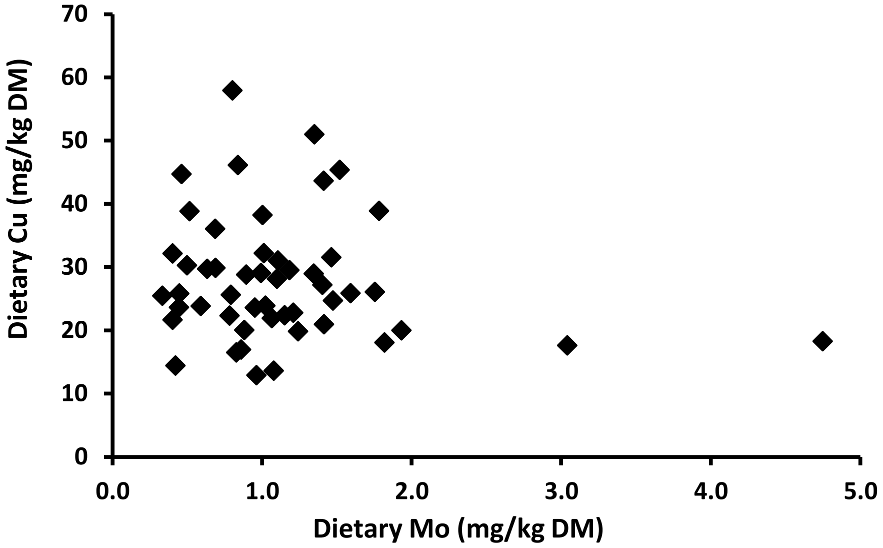

Fig 3. Relationship between dietary Mo and Cu concentrations fed in early lactation on 50 dairy herds in the Midlands and North of England. Values represent the contribution from the diet, water and supplementary sources, and are expressed on a kg DM intake basis. $y = 30.4 - 2.18x$. $P = 0.265$; $R^2 = 0.03$.

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a)

b)

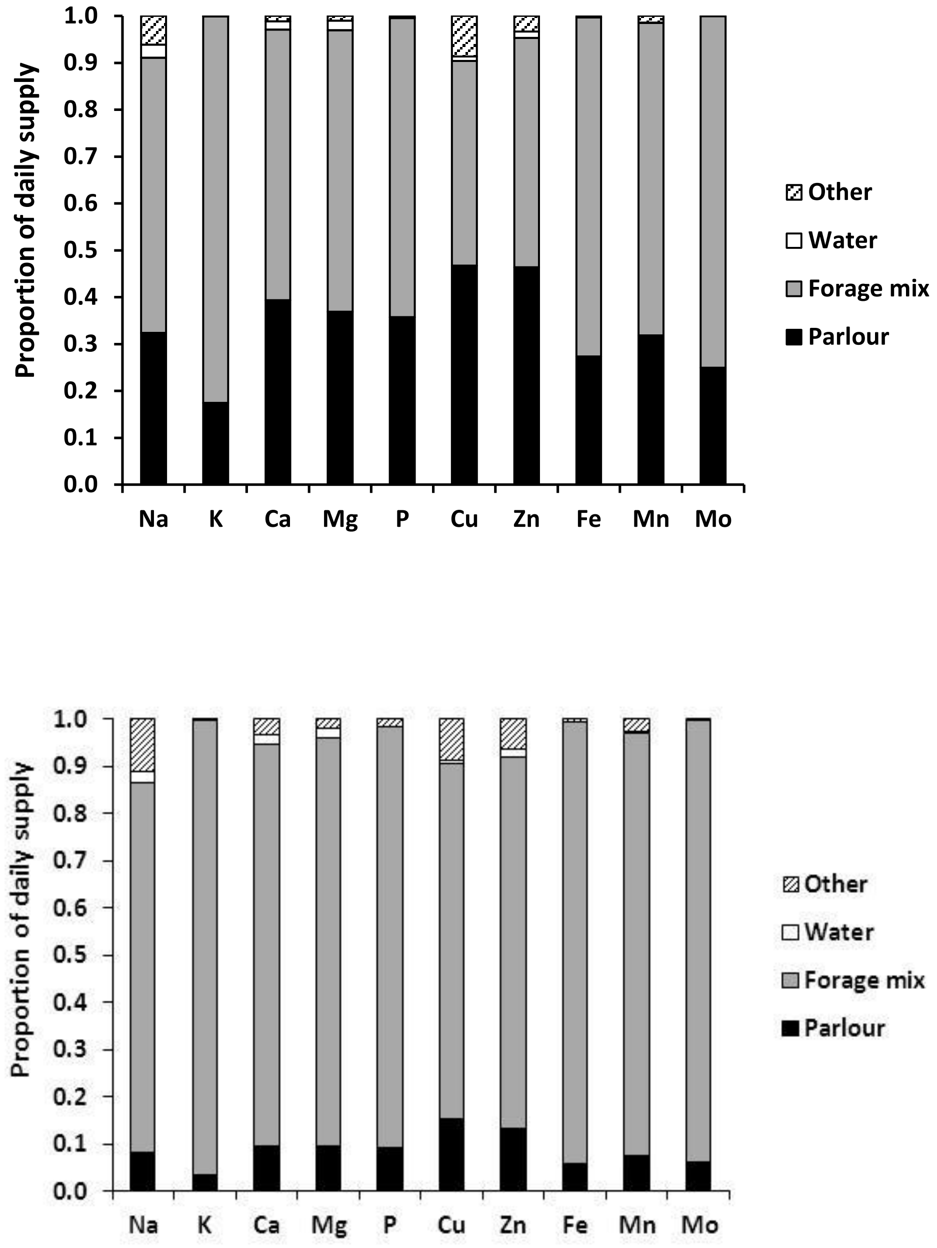

Fig 4. Relative contribution to daily mineral supply from parlour concentrates, forage mix, water and supplementary sources in a) early lactation (56 d post calving) and b) late lactation (245 d post calving) dairy cows that were fed parlour concentrates (n = 40). Note that the forage mix contribution includes that from the basal forage and any added concentrates and minerals.

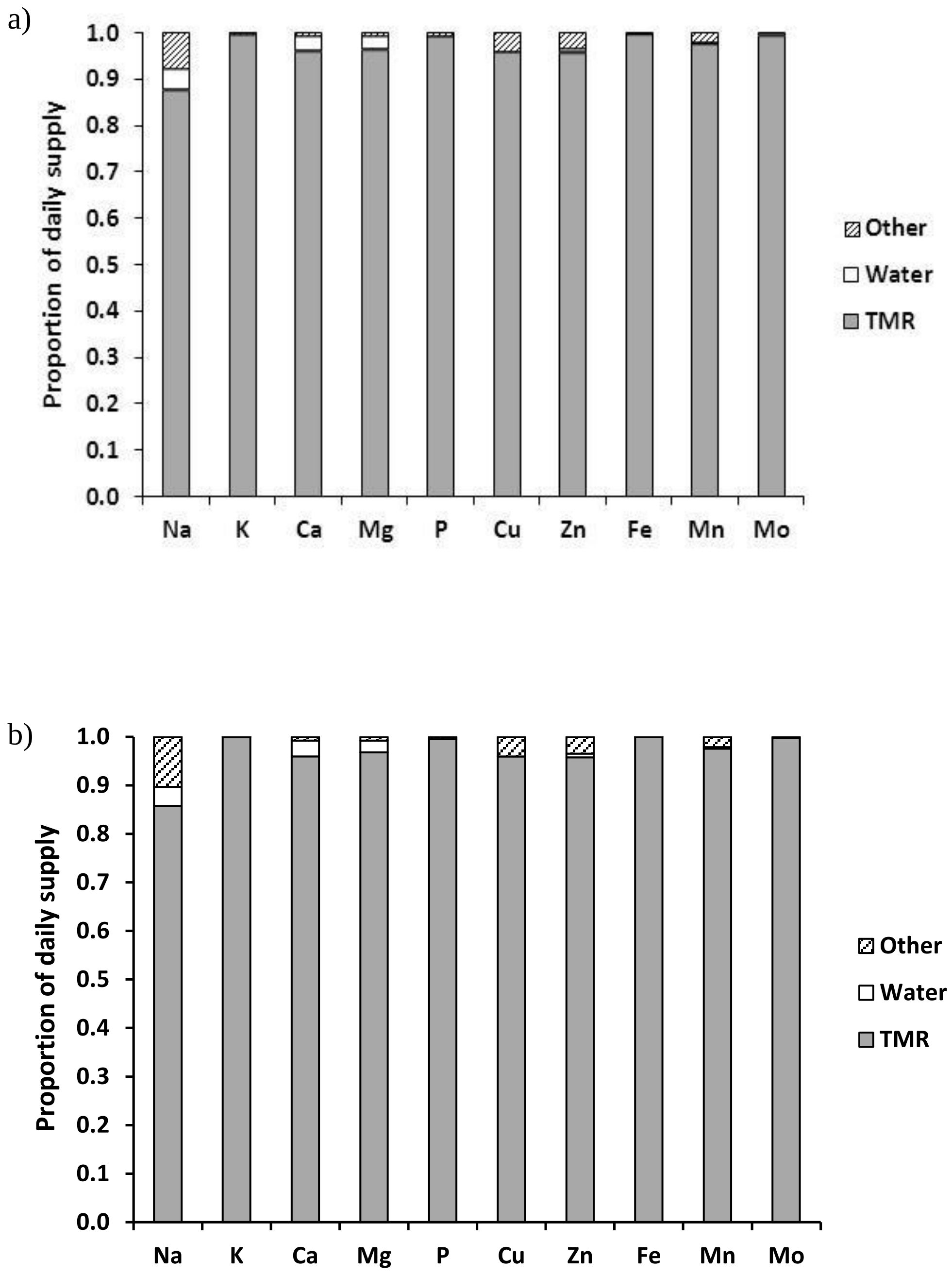

Fig 5. Relative contribution to daily mineral supply from the total mixed ration, water and supplementary sources in a) early lactation (56 d post calving) and b) late lactation (245 d post calving) dairy cows that were fed only a total mixed ration (n = 10). Note that the total mix ration includes minerals from the basal forage and any added minerals.

Appendix 2.

Table 8. National Research Council (2001) mineral requirements of lactating dairy cows as determined using standard diets. Values are for a 680 kg Holstein cow with a body condition of 3.0, 65 months of age, under standard environmental conditions. Adapted from NRC (2001).

	Milk yield, kg/d			
	25	35	45	54.4
Intake, kg DM/d	20.3	23.6	26.9	30.0
Macro elements (g/kg DM)				
Sodium	2.2	2.3	2.2	2.2
Potassium	10.0	10.4	10.6	10.7
Calcium	6.2	6.1	6.7	6.0
Magnesium[1]	1.8	1.9	2.0	2.1
Phosphorus	3.2	3.5	3.6	3.8
Trace elements (mg/kg DM)				
Copper	11	11	11	11
Zinc	43	48	52	55
Iron	12.3	15	17	18
Manganese	14	14	13	13
Molybdenum	---	---	---	---

[1]Assumes no interference from dietary K or excess non-protein nitrogen. Under conditions of high K and non-protein nitrogen requirements can be increased to 3-3.5 g/kg DM.
[2]High dietary Mo, S and Fe can interfere with Cu absorption and metabolism, increasing the requirements.

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