LOW PHOSPHORUS INTAKES BY BEEF SUCKLER COWS IN LATE PREGNANCY AND EARLY LACTATION

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SUMMARY

Two groups each of 10 suckler cows were given a basal diet of oat straw and pressed unmolassed sugar beet pulp for the last 19 weeks of pregnancy and the first 6 weeks of lactation. One group received 0·88 kg extracted soya bean meal (SBM) in pregnancy and 1·03 kg in lactation. The other was given 0·27 kg of a liquid supplement (LS) (containing *inter alia* urea and phosphoric acid) in pregnancy increasing to 0·33 kg in lactation. Both diets provided about the same amounts of digestible crude protein and about 10 g phosphorus (P) per day in pregnancy and 12 g P per day in lactation.

Cows given SBM consumed marginally more straw but there were no differences in total diet digestibility. Cows given LS lost significantly more liveweight but their calves grew equally well.

There were indications that cows given LS had slightly higher mean blood inorganic P and lower mean blood calcium (Ca) concentrations. Mean blood inorganic P concentrations were not below 1·4 mmol/l in pregnancy or 1·2 in lactation. There were no signs of reduction in voluntary straw intake or depraved appetite. When transferred to grass with a bull at the end of the experiment all cows were served within 24 days.

It is concluded that these amounts of dietary P were adequate over the 25 weeks.

INTRODUCTION

The Agricultural Research Council (ARC) proposed (ARC, 1980) that the previous (ARC, 1965) minimum dietary requirement for phosphorus by a 500 kg cow be reduced from 33 to 17 g P/day during the last 2 months of pregnancy and from 43 to 27 g P/day in lactation when giving 10 kg milk per day. The factorial system used to estimate dietary requirements did not take into account the movement of phosphorus in and out of bone and ARC (1980) indicated that the only way of testing the applicability of the proposed requirements was 'by practical experience accruing from their use'.

These ARC requirements were not intended to be synonymous with practical dietary allowances. In 1983 a working party composed of members of the Ministry of Agriculture, Fisheries and Food, Department of Agriculture for Scotland, Department of

Agriculture for Northern Ireland, the United Kingdom Agricultural Supply Trade Association and the British Veterinary Association recommended that the ARC (1965) requirements for phosphorus should be adopted as practical daily allowances and would include an adequate margin of safety.

Earlier work with other colleagues involving low phosphorus diets composed of fixed amounts of molassed sugar beet pulp (SBP) and urea with *ad libitum* oat straw has given varied results. Fishwick *et al.* (1974) reported that increasing the phosphorus intake from about 6 g to 17 g P/day (with dicalcium phosphate) did not influence the voluntary intake or digestibility of straw by beef heifers over a 3-week period in late pregnancy although inorganic blood P concentrations were as low as 1·2 mmol/l.

Subsequently, Fishwick *et al.* (1977) gave beef cows during the last 15 weeks of pregnancy and the first 6 weeks of lactation either about 12 g or increased to about 28 g P/day with dicalcium phosphate. Although mean blood inorganic P concentrations were reduced to about 0·7 (compared to about 2·9) mmol/l by 2 weeks before calving there was no difference in voluntary straw intake or digestibility until 3–6 weeks after calving. By then the contrasting intakes of straw dry matter (DM) and overall diet metabolizable energy (ME) were 3·8 and 5·9 kg DM and 56 compared with 75 MJ ME. Loss of bone material was detected after, but not before, calving. Later, Bass *et al.* (1981) compared a basal P intake of about 5 g P/day over the last 16 weeks of pregnancy and about 6 g P/day over the first 6 weeks of lactation with total dietary intakes of about 9 g and 12 g/day respectively resulting from supplementation with 3·7 g P/day supplied as phosphoric acid in solution. Normal straw intakes and digestibilities were recorded in pregnancy by both groups although the blood P concentration fell quickly to about 1·1 (compared to 1·7) mmol/l. By 3–6 weeks after calving mean voluntary intakes of straw DM and diet ME were 4·9 and 6·9 kg DM and 53 compared to about 74 MJ ME. There were no significant differences in the radiographic density of the tail bones of the cows.

It is possible that the contrasting results obtained by giving 10–12 g P/day obtained by Fishwick *et al.* (1977) (unsatisfactory) and by Bass *et al.* (1981) (satisfactory) may have been due to the provision within the total 10–12 g P/day intake of 3·7 g P/day as phosphoric acid in liquid form and perhaps of high dietary availability. This present experiment investigates the comparative effects of phosphorus present in a vegetable source (extracted soya bean meal) with phosphoric acid on the voluntary straw intake and performance of beef cows in late pregnancy and early lactation.

MATERIALS AND METHODS

Two groups each of 10 paired Hereford cross beef cows (mean liveweight 470 kg, mean body condition score, 2·9) in calf to a Charolais bull were housed in a byre with individual feeding arrangements from 19 weeks before to 6 weeks after calving.

Two diets were given in association with *ad libitum* oat straw. Diet A consisted of pressed unmolassed sugar beet pulp (PSBP) (8·5 kg in pregnancy, 12·3 kg in lactation) supplemented with a fully soluble liquid supplement (LS) ('Granstock', ICI Agricultural Division, Billingham, Cleveland) of specific gravity 1·33 and containing (g/kg) 1076 crude protein (N×6·25) as urea, 27·6 Ca and 1·41 P plus salt, molasses, trace elements and vitamins (as described by Bass *et al.*, 1981). In pregnancy and lactation the daily amounts given were 200 ml (0·27 kg) and 250 ml (0·33 kg) respectively.

Diet B consisted of PSBP (4·70 kg in pregnancy, 7·80 kg in lactation) plus extracted soya bean meal (SBM) (0·88 kg in pregnancy, 1·03 kg in lactation), so as to provide the same amounts of ME and crude protein as diet A. Appropriate amounts of calcium carbonate, sodium chloride trace elements and vitamins were added to diet B to be equivalent to diet A.

Table I summarizes the amounts of total dry matter and nutrients provided by diets A and B and Table II gives the compositions of the feeds. Both diets (without the oat straw) provided about 6 g P/day in pregnancy and about 7·5 g P/day in lactation.

The PSBP was stored in a bunker silo protected with a weighted sheet. The LS and the SBM were intermixed at the appropriate rates with the PSBP for each individual cow each day at the time of feeding (0730 hours). Oat straw was offered *ad libitum* at 0800, 1200 and 1600 hours or as required. Residues were collected each day.

The cows were weighed and body conditions scored and samples of blood were obtained regularly throughout the experiment. Voluntary straw consumption was measured during weeks 16–15 and 6–5 before calving and in week 4–5 after calving. During these periods and for 1 week before each of the cows was given 10 g chromic oxide/day intermixed with the PSBP diets. During the times when straw intakes were recorded, representative samples of faeces were obtained (3 grab samples/day between 0730 and 1730 hours bulked for 7 days) to assess diet digestibility.

The cows calved in individual loose boxes. The calves were subsequently tied behind the cows and released three times/day to suckle to satiation.

The methods of analysis of the feeds, faeces and blood were as described by Bass *et al.* (1981).

Table I

The amounts (kg) of pressed sugar beet pulp (PSBP), soya bean meal (SBM) and liquid supplement (LS) given each day to the cows and the calculated amounts of metabolizable energy (ME), digestible crude protein (DCP) and phosphorus supplied

	Pregnancy		*Lactation*	
Supplement	*LS*	*SBM*	*LS*	*SBM*
PSBP	8·50	4·70	12·30	7·80
LS	0·27	—	0·33	—
SBM	—	0·88	—	1·03
DM (kg)	1·73	1·72	2·55	2·54
ME (MJ)	21·3	21·2	31·4	31·2
DCP (g)	401	409	524	512
P (g)	5·7	6·1	7·5	7·6

RESULTS

The PSBP with SBM diets were readily consumed by all the cows. One of the 10 cows given PSBP with LS consistently refused about 0·1–0·3 kg of the mixture and two other cows ate it rather slowly.

Table II
Mean compositions (g/kg DM) of oat straw, pressed sugar beet pulp (PSBP) and soya bean meal (SBM)

	Oat straw	*PSBP*	*SBM*
Dry matter	832	205	889
Composition of DM			
Crude protein	21	105	492
Crude fibre	455	200	73
Ether extract	10	3	13
N-free extract	449	612	350
Ash	65	80	72
Ca	2·6	12·0	3·8
P	0·7	1·1	6·4
Estimated ME (MJ)*	—	12·3	12·3
Estimated DCP (g/kg)*	—	66	443

*Ministry of Agriculture, Fisheries and Food, Department of Agriculture for Scotland, Department of Agriculture for Northern Ireland (1984).

Table III
Mean cow liveweights and body condition scores and calf liveweights

Weeks before (−) or after (+) calving	*PSBP+LS*	*PSBP+SBM*	*SE diff.*
Cow liveweight (kg)			
−19	470	469	18·5
After calving	433	469	—
+6	411	471	—
Cow liveweight changes (kg)			
−19 to after calving	−37**	0	9·0
Calving to +6	−22**	+2	4·9
Cow body condition score			
−19	2·9	2·7	0·32
+6	1·8	2·2	0·30
Change, −19 to +6	−1·1*	−0·5	0·27
Calf liveweight (kg)			
Birth	40·6	42·4	2·36
+6	79·7	79·8	—
Gain/day (kg)	0·93	0·89	0·067

*$P<0·05$; **$P<0·001$.

Table III gives the changes in mean cow liveweight and body condition score and mean calf liveweights in abbreviated form in the interests of brevity. Over the whole period of the experiment the cows given SBM maintained liveweight but those given LS lost significant amounts both in pregnancy and in lactation. This was reflected in reduced mean body condition scores. The birth weights and liveweight gains of the calves were similar for both groups.

There were no significant differences in the voluntary intake of straw or digestibility of the total diet by the cows either before or after calving although those given SBM consumed slightly more straw than those given LS (Table IV).

Table V gives the mean concentrations of urea, calcium and inorganic phosphorus in the blood of the cows. Concentrations of inorganic phosphorus and urea tended to be slightly higher and calcium slightly lower for the cows given LS, especially during lactation.

Table IV
Mean voluntary intakes of oat straw and total diet organic matter (OM) and crude protein (CP) digestibility coefficients

Parameter	*Weeks before (−) or after (+) calving*		
	−16 to −15	*−6 to −5*	*+4 to +5*
Straw intake kg DM			
PSBP+LS	5·63	5·62	6·64
PSBP+SBM	5·97	5·99	7·33
SE diff.	0·482	0·501	0·375
Digestibility coeff. OM			
PSBP+LS	0·43	0·47	0·51
PSBP+SBM	0·45	0·47	0·54
SE diff.	0·037	0·029	0·022
Digestibility coeff. CP			
PSBP+LS	0·47	0·50	0·52
PSBP+SBM	0·45	0·48	0·49
SE diff.	0·040	0·039	0·025

DISCUSSION

For the class of livestock and the system of husbandry, the liveweight changes in the cows and the growth rate of their calves were considered to be satisfactory. Providing soya bean meal gave slightly higher voluntary straw intakes with resulting calculated increases of about 4·5 and 10·0 MJ ME per day in pregnancy and lactation respectively which was reflected in the superior liveweight and body condition score of those cows. It was not, however, reflected in the liveweight gain of the calves. The mean milk yield of the cows in both groups would have been similar at about 9 kg/day.

When the amount of straw consumed was taken into account the total daily phosphorus intakes of the cows in pregnancy were 9·8 g (LS) and 10·3 g (SBM) and in lactation were 11·9 g (LS) and 12·6 g (SBM). Cows given LS had slightly higher

Table V
Mean concentrations of urea, calcium and phosphorus in the blood of the cows (mmol/l)

Concentration	*Weeks before (−) or after (+) calving*				
	−19	*−15*	*−5*	*+3*	*+6*
Urea					
PSBP+LS	5·51	6·46	5·34	3·79	4·55
PSBP+SBM	5·78	5·89	4·50	4·40	4·41
SE diff.	0·340	0·374	0·476	0·384	0·241
Calcium					
PSBP+LS	2·34	2·26	2·33	2·27	2·32
PSBP+SBM	2·35	2·35*	2·39	2·41**	2·39
SE diff.	0·033	0·033	0·030	0·033	0·044
Phosphorus					
PSBP+LS	1·80	1·86	1·37	1·45	1·56*
PSBP+SBM	1·68	1·60	1·43	1·26	1·18
SE diff.	0·154	0·127	0·135	0·179	0·123

*$P<0·05$; **$P<0·001$.

concentrations of inorganic phosphorus and slightly lower concentrations of calcium in their blood throughout the whole experiment than did those given SBM.

The voluntary intakes of straw and the digestibility of the diets throughout and the performance of the cows and their calves were very similar to those recorded earlier by Bass *et al.* (1981) for cows given molassed sugar beet pulp and the same phosphoric acid-containing liquid supplement to give daily phosphorus intakes of about 9 g in pregnancy and 12 g in lactation. None of the cows in the present experiment at any time had a concentration of inorganic phosphorus in their blood below 1·0 mmol/l considered by Bass *et al.* (1981) to be the point below which voluntary straw consumption may be significantly reduced.

It is noteworthy that in both the present experiment and the earlier ones reported by Fishwick *et al.* (1977) and Bass *et al.* (1981) (where phosphorus inadequacy resulted in markedly reduced voluntary straw intakes) at no time did the cows give any indication of depraved appetite even though they were fed from wooden-fronted troughs and had wooden racks for straw.

Bass *et al.* (1981) considered that the successful use of such a low phosphorus intake was due to the presence of about 3·7 g P/day as phosphoric acid which is fully soluble in the rumen (as opposed to dicalcium phosphate which is insoluble as used by Fishwick *et al.*, 1975, 1977) and so can immediately supplement a perhaps initially low return of phosphorus via saliva after calving. This present experiment, however, does not confirm that the phosphorus in phosphoric acid is superior to that in soya bean meal.

The experiment confirms that the ARC (1980) requirement of 22 g P/day for a 470 kg cow producing about 7·5 kg milk/day is adequate. It must, however, be recognized that the cows were housed and individually given both the feeds and supplements and that the experiment was not continued beyond 6 weeks after calving.

Immediately following the experiment the cows and their calves were transferred to grass with a bull. Service dates were recorded. After mean periods of 24 days (SBM cows) and 22 days (LS cows) all 10 cows in each group were served. These results are comparable to those recorded by Fishwick *et al.* (1977) and Bass *et al.* (1981) in similarly conducted experiments with low phosphorus diets.

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