STUDIES IN RUMINANT NUTRITION

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by

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SUMMARY

The work in this thesis investigates the use of a novel dried sugar beet pulp product manufactured by adding lime before compression to remove water before drying for use as a feed supplement for ruminant livestock. It also investigates the practical use of wheat dark distillers grains arising from fermentation of wheat.

In Section 1, the nutrient content of the novel sugar beet pulp was evaluated. In experiment 1, the metabolisable energy was 11 MJ/Kg.DM and about 1 MJ less than for the other normal sugar beet pulp products. The digestible crude protein was determined to be 47g/kg DM, which was lower by about 10g/kg than for the other normal sugar beet products. The limed sugar beet pulp also contained higher levels of calcium and phospohorus than the normal sugar beet pulps. In experiment 2, the crude protein degradability in the rumen was found to be very similar to those of the other normal sugar beet pulp products, i.e. about 25% for the unmolassed and 60% for the molassed products. In experiment 3, the acceptability and palatability of the novel sugar beet product was assessed in trials involving ruminant livestock in different physiological states and ages. It was observed that intermixing of this product with other readily acceptable and palatable feed supplements could in general enhance palatability and hence intake.

In Section 2, the nutritive value of the limed sugar beet product was assessed in production trials involving pregnant and lactating ewes and beef cows. In experiment 1, with lactating ewes given about 1 kg DM each of hay and concentrate supplement made up of about 60% sugar beet products and 40% wheat dark distillers grain and soya, the mean daily liveweight loss was about 0.26 kg over a three week trial period. The

daily mean liveweight gain of their lambs over the same period was about 0.25 kg. In a comparative trial involving sets of twin and triplet lambs, individual twin lamb outgrew individual triplet lamb very significantly but the total daily liveweight gain of the triplets (570g) was greater than that for the twins (504g).

In experiment 2 in which the variations in the probable colostrum intake on the growth performance of twin lambs was studied, the daily mean liveweight gain of males (0.27 kg) rather than females (0.25 kg) and for Texel was (0.28 kg) rather than Suffolk cross (0.26 kg). In experiment 3, the daily mean liveweight loss to suckler cows given about 6 kg fresh hay and 3 kg fresh concentrate based on limed sugar beet pulp and wheat dark distillers grains daily was 0.19 kg and the daily mean liveweight gain of the suckler calves was 1.1 kg over the first six weeks of lactation.

In section 3, the feeding of a novel wheat dark distillers grains as concentrate feed supplement to lactating dairy cows was compared with a high nutritional quality dairy concentrate compound feed devoid of distillers grain with respect to milk yield and milk fat and protein constituents. The wheat dark distillers grains compared favourably with the compound feed and it could replace the compound feed as a source of concentrate supplement to lactating dairy cows when substituted for 4 kg/day (fresh matter) at mean milk yield of about 9 l/day.

It is concluded that limed sugar beet pulp could be fed as a concentrate feed supplement to productive ruminant livestock especially when incorporated with readily acceptable and palatable feeds with high crude-protein and phosphorus contents without any detrimental effect on the animals or their products. Similarly, supplementing the diet of

lactating dairy cows with wheat dark distillers grains could economically replace a more expensive compound feed without loss of milk yield or reduction in quality.

ABBREVIATIONS

Statistical Conventions

The following statistical conventions are used to indicate the probability of differences between means occuring by chance:

Statistical Convention	Abbreviation
Not significant	NS
Significant at the 5% level of probability	P 0.05*
Significant at the 1% level of probability	P 0.01**
Significant at the 0.1% level of probability	P 0.001***

Statistical terms

Standard error of a mean	SE
Standard error of difference between means	SED
Significance	SIG

Technical Terms

Dry matter	DM
Fresh matter	FM
Apparent digestibility of dry matter	DMD
Dry matter intake	DMI
Organic matter	OM
Apparent digestibility of organic matter	OMD
Apparent digestibility of organic matter in the dry matter	DOMD
Organic matter intake	OMI
Digestible energy	DE
Apparent Metabolisable Energy	ME
Crude fibre	CF

Crude protein	CP
Digestible crude protein	DCP
Rumen degradable protein	RDP
Rumen undegradable protein	UDP
Nitrogen	N
Ammonia-Nitrogen	NH_3-N
Liveweight	LW
Liveweight gain	LWG
Day	d
Kilogramme	kg
Gram	g
Litre	l
Millilitre	ml
Millimetre	mm
Centimetre	cm
Mega joule	MJ
Diameter	diam
Hour	h
Percentage	%

Chemical Terms

Millimole per litre	mmol/l
Hydrochloric acid	HCl
Calcium	Ca
Phosphorus	P
Magnesium	Mg
Copper	Cu
Sodium Chloride (salt)	NaCl

Other Terms

Molassed sugar beet pulp pellets	MSBP
Unmolassed sugar beet pulp pellets	USBP
Normal shredded sugar beet pulp	NSSBP
Plain lime shredded sugar beet pulp	PLSSBP
Limed sugar beet pulp pellets	LSBP
Sugar beet pulp	SBP
Soya bean meal	SBM
Dried grass	DG
Dried wheat dark distillers grains	DDG
Zinc sulphate turbidity test units	ZST
figure	fig.

GENERAL INTRODUCTION

Introduction

The reliance of animals on feed supplied by the environment has been changed by man with the introduction of more intensive systems of livestock rearing. These systems of husbandry have led to the feeding of animals with what is considered best by man in both nutritional and economic senses. In general this is dictated by the local dietary pattern of the human population, the natural availability of raw materials and the economics of imported feeding products. The ability to meet the nutritional requirements of livestock to maximise productive capacity was necessitated by the continuous increase in demand for dietary animal protein by the steadily increasing global human population. This situation had led to competition for food (grains) between man and his livestock, the ultimate end of which was to search for alternatives of feeds that could meet the nutritional requirements of increased livestock production at reasonable cost. By products from sugar beet and the brewing/distilling industry are examples of potentially suitable feeds available almost world-wide.

Rimi (1982) had stated that about two thirds of the world cattle population lie in the developing countries of the tropics but attempts thereby to adequately feed the human population with animal protein could still take long before being accomplished. The increased standard of living has led to the importation of meat and other animal products irrespective of the naturally available resources which could be improved to achieving this aim.

For example, Nigeria with a total of 9.3 million cattle, 8.6 million

sheep, 20.8 million goats, 133.5 million poultry and 0.9 million pigs (Awogbade 1980) is very far from realising her objective of making adequate animal protein available to its people without external sources of supplementation. This situation does not compare in any way with what is obtainable in United Kingdom whose national herd is far less and can meet the need of its people and even export some of these products to needy countries. According to Balogun (1982), the problem in Nigeria is more of a low increase in output caused by inadequate nutrition rather than numerical increase. Other associated factors are poor husbandry systems and the uncompromising attitude of the itinerant major cattle owners towards a change to sedentary life. This problem has always resulted in fluctuation in the live weight of cattle with variation in season (e.g. Minterdof, 1963)

End of season	Liveweight (kg)
1st dry	250
1st rainy	350
2nd dry	255
2nd rainy	382
3rd dry	307

Reliance on pasture alone more often than not fails to meet adequate energy and protein requirements of highly productive animals (Blaxter and Wilson 1963, McDowell 1972, and Green Revolution Report 1981). The possible consequences of these inadequacies could be marked liveweight loss, lower resistance to diseases and deaths but also seasonal anoestrus and prolonged calving intervals of perhaps about 450 days (Oyedipe, Buvanendran and Eduvie 1981). Livestock development is therefore very much dependent on arable agriculture in any nation. Feed supplementation for ruminant livestock through the use of agro-

industrial by products in developing countries like Nigeria has been sugested by Anon (1975) and Nuru, Deleeuw and Abalu (1978) to be of paramount importance in improving production capability.

Feed Evaluation

According to Steg (1975) concentrate diets based on by products have more variable chemical characteristics than the primary products and that information on their nutritive values tended to be limited. This has necessitated the determination of the nutritive values of agro-industrial by-products used as livestock feeds to ascertain that requirements for specific production targets are met. Some of the evaluation techniques used are

i) Feed chemical analyses

ii) Digestibility trials

iii) Rumen protein degradability using a nylon bag in the rumen of a fistulated ruminant.

Feed Chemical Analyses and Digestibility Trials

Chemical analyses of feed are indicative of nutrient content and thus could only serve as an index of usefulness of feed to livestock. On the other hand, digestibility trials provide the basis for the determination of feed nutritive value to animals.

Digestibility trials have provided for the use of feeds in livestock diets at a cost effective rate, and the formulation of balanced rations through an effective determination of feed quality.

Factors Affecting Feed Digestibility

Some of the factors that could either enhance or impede feed digestibility are level of intake (Forbes 1986), chemical composition and combination of various feeds to eliminate gross inadequacies may influence the potential value of feeds (Maynard et al 1979), together with rate of passage of digesta in the digestive tract, stage of maturity of forage at harvest and feed preparation (McDonald, Edwards and Greenhalgh 1988).

Blaxter, Clapperton and Wainman (1966) have reported that age after full development of the rumen had no significant effect on feed digestibility and that digestibility trials with cattle and sheep produced similar values.

The determination of digestibility in ruminant animals does not fully characterise the nutrient value of the feed because of the production of methane and carbon-dioxide which escape from the system after digestion and so reduce the potential feed value. An estimate of metabolisable energy can only be made by utilization of animal calorimetry, gas analysis etc. Such animal facilities are available in only very limited situations. Fortunately however, an accumulating body of evidence is now available to associate digestible energy with metabolisable energy e.g.

ME = 0.81 DE (MAFF et al 1984).

Rumen Protein Degradation and Undegradable Protein

According to Allden and Jennings(1962), Blaxter and Wilson (1963) and Murdoch (1964 and 1967) dry matter intake correlates positively with the

crude protein content of feed and the resultant feed digestibility. This effect has been related to the ability of rumen micro-organisms to degrade feed protein for their own protein synthesis and multiplication (Maeng and Baldwin 1976). In a similar report Balch and Campling (1962) and Conrad (1966) have stated that an increased energy concentration of feed with adequate degradable crude protein had resulted in a greater intake of metabolisable energy and utilization of energy (Blaxter 1962 and Preston 1967).

Often, of course, in growing plant matter the young material will not only contain more protein but less crude fibre and the cell walls will be less lignified. In consequence, young leafy material has a much higher nutritional value than at a later stage of growth both in terms of energy and protein. It also contains more phosphorous. Young leafy materials will support enhanced growth. Older materials may fail to support liveweight by a combination of low inherent nutrient content and digestibility.

In view of the role the rumen micro-organisms play in fibre digestion and their requirement for N for survival and multiplication, Mehrez and Orskov (1977) have suggested the use of nylon bags incubated in the rumen to evaluate feed and crude protein degradability before diet formulation. A maximum incubation time of 36h was suggested by Orskov (1982) for most feeds and the rate of rumen protein degradability in sheep and cattle was reported to be insignificantly different by Evans (1984).

The rumen degradable protein (RDP) values determined by this technique can only serve as an estimate as there are some inherent factors such as diet composition (Ganev, Orskov and Smart 1979) and rumen dilution rate

(Broderick 1978 and Orskov and McDonald 1979) that influence the rate of protein degradation in the rumen.

Increased dietary protein of appropriate amino-acid composition to the duodenum have been reported to induce a high production response in high yielding lactating cows (Clark 1975, Orskov, Grubb and Kay 1977, ARC 1980 and Konig, Oldham and Parker 1984). It does not necessarily follow that the microbiological protein produced in the rumen is appropriate for full productive purposes.

Feeds with highly degraded protein in the rumen could require some treatments when intended to be used for high producing dairy cows or lactating ewes. Some of these methods of treatment have been widely reported and they include

(a) Heat treatment

(b) Formaldehyde treatment

(c) Blood coating (Gonzalez et al 1979, Orskov, Mills and Robinson 1980).

The total quantity of protein (UDP, microbial and RDP that escape rumen degradation) that reaches the duodenum undergoes normal enzymatic digestion and absorption as in simple stomach animals. Naturally these treatments should not reduce overall protein digestibility.

Dietary and Body Fat and Feed Intake

Excessive dietary fat has been reported to reduce cellulolysis by rumen micro-organism (McDonald, Edwards and Greenhalgh 1988). The improvement of energy concentration through dietary fat can be achieved by protection from contact with rumen micro-organisms (Cooke and Scott 1970) to allow for digestion and absorption in the lower portion of the

gut.

According to Cowan, Robinson and McDonald (1982), Garnsworthy and Topps (1983), and Garnsworthy and Gardner (1985) lactating ewes and cows with poor labile fat reserves have an increased voluntary feed intake and thus could be capable of producing more milk from food which is biologically more efficient rather than from body fat reserves as in ewes and cows in good body condition. There was no significant difference between the milk yield, fat and protein contents. Russell and Wright (1982) have reported that excessive tissue fat deposition due to unguided feeding could result in a high incidence of dystocia.

Sugar Beet Products as Feed Supplement for Ruminant Livestock

The use of SBP products to supplement feeds of pregnant and lactating ewes and cows has been widely reported. For example. Fishwick et al (1973, 1974, and 1977), Parkins (1974), Ducker, Fraser and Hemingway (1976) and Fishwick and Hemingway (1989) have all reported that SBP products containing Urea or intermixed with other concentrates of high protein content are good sources of nutrients for steers, pregnant and lactating ewes and cows. The addition of Urea or intermixing SBP with feeds of high CP content could be related to the low CP content and digestibility of these products. Sugar beet products being fibrous concentrate feeds are also low in P and requirements for P has to be met from other feeds or specific phosphorous supplements that contribute to the total dietary intake. Hemingway (1977) had reported that an inadequate dietary P intake could result in a marked reduction in voluntary intake of feed.

Distillers By-products as Feed Supplement for Ruminant Livestock

Barley is the traditional cereal fermented for the production of alcohol in beer and whisky. Maize is also widely used for industrial alcohol production. More recently in Europe import prices have resulted in a decrease in the use of maize for such purposes and substitution with wheat. This change seems to be of a long term nature. There seems to be little information of the nutritive value of the by-products of this process.

Removal of carbohydrate by fermentation obviously leaves a material of increased fibre, fat and protein contents. The product is also quite low in calcium (as are all cereal products) but well supplied with phosphorous. In many ways, it would be complementary to sugar beet pulp when used as a concentrate part of the diet.

OBJECTIVES OF THIS PRESENT THESIS

The objectives of this thesis have been

(A) To asssess the proximate composition of

  (i) a range of sugar beet pulp products and in particular, an entirely novel material produced by adding lime in the extraction process to aid the removal of water.

  (ii) a novel wheat dark distillers grains.

(B) To assess the digestible energy and protein values of these products and the potential values of calcium, phosphorous and magnesium in the sugar beet pulps.

(C) To assess the rumen degradability of the crude protein in these materials.

(D) To investigate the initial palatability to cattle and sheep of the sugar beet products when given alone or with other feeds.

(E) To assess the practical nutritional value of

(i) normal and limed sugar beet pulps when given with wheat dark distillers grains to ewes and to suckler cows in early lactation.

and (ii) to compare wheat dark distillers grains with a more normal compound feed when given to lactating cows.

A subsidiary investigation was to assess the colostrum intake of some lambs born to ewes given the above diet.

SECTION 1

THE NUTRITIVE VALUE OF SOME SUGAR BEET PULP PRODUCTS

Introduction

Some 700,000 tonnes of sugar beet pulp products are manufactured for use as feeds for ruminants in Britain each year and similar products are available worldwide. In Britain most is given to livestock in dried form containing about 40% molasses either as shreds or in nuts (12 mm diam) or pellets (8 mm diam). Sometimes the products are unmolassed, which reduces their palatability, but in which form they are apparently more acceptable to the compound feed trade.

Drying the expressed pulp after sugar extraction is expensive. Nevertheless only limited amounts of undried material are produced because of the cost of transport to the principal areas of livestock feeding.

More recently, a process has been introduced whereby the addition of calcium hydroxide to the wet pulp allows more water to be removed by pressing and thus reduces drying costs. (Randall, Edwards & Camirand, 1988). Such an alkaline addition and the subsequent drying may alter the composition of the pulp and its digestibility by livestock.

The objectives of the present work were to compare this limed pressed pulp with the existing standard molassed and unmolassed products in the following ways.

(a) Digestibility trials with sheep in cages.
(b) Rumen degradation studies.
(c) Comparative palatability trials with a range of both cattle and sheep.
(d) A production trial with ewes in late pregnancy and in early lactation.
(e) An observation trial with beef cows in late pregnancy and early lactation.

The following abbreviations are used

MSBP Molassed sugar beet pulp pellets (normal production).
USBP Unmolassed sugar beet pulp pellets (normal production).
NSSBP Normal unmolassed shredded sugar beet pulp.
PLSSBP Plain limed unmolassed shredded sugar beet pulp.

The mean proximate compositions of these various feeds and the dried grass used in the digestibility trials are given in Table 1.

EXPERIMENT 1

THE EFFECT OF DIFFERENCE IN PREPARATION ON THE APPARENT DIGESTIBILITY OF SUGAR BEET PULP

Introduction

The objective of the experiment was to determine the effect of the differences in the processing and preparation methods on the apparent digestibility by sheep of various sugar beet pulp products. The determinations included gross energy, the normal proximate constituents and the major minerals. Assessments were also made of the water intakes and outputs in relation to the composition of various sugar beet pulp products.

Materials and Methods

Twenty-four Greyface (Border Leicester x Scottish Blackface) x Suffolk cross wether sheep aged about 10 months and with a mean liveweight of 52 kg were used.

These sheep were arranged randomly into four groups. Two of the groups contained eight animals, the remaining two groups contained four animals each. They were all harnessed with rubber bags and put into metabolism cages (Duthie 1959) as earlier grouped and the metabolism cages were labelled with the ear tag number of the animals.

Feed weighing, feeding, watering and management

The apparent digestibilities of the constituents of MSBP, USBP, PLSSBP and NSSBP were determined by feeding daily 0.8 kg fresh sample of each with 0.4 kg pelleted dried grass (DG). There were 4, 4, 8 and 8 sheep respectively for the four diets. In a previous experiment with 8 sheep the apparent digestibility of the constituents of DG had been determined.

Accurately weighed ($\pm$1 g) amounts of these feeds were thoroughly mixed with the DG into paper bags. Sufficient amounts to last the 14 days experimental period were weighed at the start and stored in feed bins.

Feeding was at 08.00 and 16.00 hours daily with approximately half of the daily diet emptied into the feeding troughs in the respective metabolism cages. This feeding time was strictly adhered to in order to limit experimental errors. It was anticipated that the diets would provide about 11.0 MJ ME with DG contributing 2.6 MJ ME as earlier determined and the various products contributing about 8.5 MJ ME of the ration. This is considerably more than the maintenance energy requirement of 7.7 MJ ME for housed 52 kg sheep quoted by MAFF *et al* (1984).

A polythene jug was used to measure amounts of 3.82 kg fresh water into the drinking troughs in the metabolism cages. The sheep were given water when the trough's contents were found to be depleting and the quantity was recorded after the preliminary period of the experiment. During the first seven days (preliminary period) of the 14 days experimental period no collection of urine and faeces were made and the amount of water intake was not recorded as it was allowed for the animals to get adjusted to their respective diets and establish a normal pattern of urine and faeces output.

Urine and faeces collection

During days 8-14 (sample collection period) daily faecal outputs were emptied from the rubber bag into numbered polythene buckets and placed behind the respective metabolism cages.

At the end of the experimental period, the total weight of the faecal output was determined and spread on a flat surface to allow for thorough mixing and a resultant homogenous sample. A small plastic container was used to collect about 0.1 kg of the fresh sample for slurry preparation as described by the Grassland Research Institute (Commonwealth Bureau of Pasture and Field Crops, 1961) for eventual nitrogen determination by a standard Kjeldhal technique. Similarly, about 2 kg each of the fresh faeces were sub-sampled into trays and dried at 95^{o}C for 72 hours. The dry-matter was determined and subsequently the compositional analyses for each of the faeces.

A 4.5 litre polythene jug fitted with a funnel holding glass wool was placed beneath the exit point of the collection tray situated beneath the floor of the respective cages at the commencement of the collection period. Daily urine output was emptied into numbered polythene drums placed behind the cages. About 25 ml of concentrated hydrochloric acid was added to minimise nitrogen loss. The total urine output was noted and after thorough mixing 250 ml samples were taken in

Table 1. Composition of feeds (g/kg DM)

	MSBP	USBP	PLSSBP	NSSBP	D.GRASS
Dry matter	859	839	866	855	881
Crude protein	94.9	89.5	83.3	88.9	126
Crude fibre	142	205	194	193	303
Ether extract	2.7	2.4	0.7	1.4	28.3
N-Free Extract *	669	639	635	659	489
Ash	91.7	63.4	87.1	57.3	54.5
Gross Energy **	16.6	17.1	16.4	17.0	18.4
Calcium	8.0	13.5	24.0	11.4	5.55
Phosphorus	0.9	1.1	2.9	1.0	2.52
Magnesium	1.1	1.5	2.1	1.6	1.80
Copper (mg/kg DM)	11.4	10.6	7.3	4.4	11.5

* N-Free Extract - Calculated by difference.

** MJ/kg DM.

Table 2. Daily feed and water intake, faecal and urine output (kg).

	MSBP	USBP	NSSBP	PLSSBP
Sheep No.	4	4	8	8
Dry matter intake	1.04	1.02	1.04	1.05
Faecal output (DM)	0.240	0.285	0.288	0.321
Water intake	4.78	3.28	2.34	2.63
Urine output	2.68	1.48	0.87	0.88
Water in faeces	0.49	0.60	0.58	0.64
Apparent water retention *	1.61	1.21	0.89	1.11

Range of daily temperature :- 4 - 9.5 C

* Apparent water retention does not account for respiratory losses.

No correction made for soluble salts.

small plastic bottles for subsequent analysis.

Environmental temperature

Daily ambient temperatures were recorded at 08.00 and 16.00 hours for the last seven days of the experimental period.

Weighing and Blood Sampling

The sheep were weighed at the end of the 14 day period. Blood samples for the determination of calcium, phosphorus, magnesium and copper were obtained at both the start and the end of the 14 day period.

Feed samples

Each of the feeds used in the trial was dried at 95°C for 48 hours and determinations of dry matter and composition were made on duplicate samples as shown in Table 1.

RESULTS

On the third day of the collection period, one of the sheep given NSSBP was removed from the group because of inadequate feed consumption.

Rate of feed consumption

The mean daily rates of feed consumption were determined and the MSBP treated group was found to consume their normal half-daily ration within 20 minutes of being served with their diet, but it took the PLSSBP treatment group 28 minutes and the USBP group 65 minutes to consume their diets totally. It however took the NSSBP group 1 hour and 43 minutes (103 minutes) to totally consume their ration without any residue.

Liveweight gain

Over the period of the experiment the overall mean liveweight gain was about 0.1 kg/day. This will be discussed later.

Water intake and output

The mean daily water consumption was determined for the four treatment groups (Table 2). The mean daily water consumption was found

Table 3. Apparent coefficient of digestibility of dry matter and other feed components.

	MSBP		USBP	t	sig P	NSSBP		PLSSBP	t	sig P
Dry matter (DM)	0.895	***	0.826	8.04	0.001	0.825	***	0.780	11.6	0.001
Crude protein (CP)	0.703	*	0.645	2.21	0.05	0.608	**	0.560	2.56	0.01
Crude fibre (CF)	0.911	**	0.725	3.83	0.01	0.785		0.744	0.889	NS
N-Free extract (NFE)	0.961		0.950	0.966	NS	0.944		0.926	1.41	NS
Organic matter (OM)	0.923	***	0.865	7.37	0.001	0.874	***	0.846	4.83	0.001
Ash	0.667	***	0.322	10.5	0.001	0.144		0.131	0.959	NS

N-Free extract calculated by difference.
Significance of the difference:- * - $P<0.05$, ** - $P<0.01$, *** - $P<0.001$

to be highest (4.78 kg) for the MSBP fed group with a resultant highest urine output (2.68 kg) when compared with the other treatment groups. The USBP group ranked second while NSSBP was least with 2.34 kg mean daily urine output. The apparent water retention followed the same pattern with MSBP group ranked highest and NSSBP treated group lowest. The mean daily water consumption, urine output and apparent water retention are shown in Table 2.

Faecal output

Mean daily faecal output was determined and the PLSSBP treated group was found to have the highest mean faecal output (0.32 kg DM per day); USBP and NSSBP treated group produced mean daily faecal outputs of 0.285 kg and 0.288 kg DM respectively while MSBP produced the lowest value of 0.240 kg DM as shown in Table 2.

During the experimental period of 14 days the daily ambient temperature fluctuated between 4^{O} and $9.5^{O}C$.

Apparent coefficient of digestibility

The apparent digestibilities have been calculated by difference after allowing for the indigestible components of the dried grass. It has been assumed that the apparent digestibility of the dried grass remained unaltered throughout.

The apparent coefficient of digestibility for dry matter (DM) and other compositional analyses in respect of the different treatment groups were determined and shown in Table 3. The statistical comparisons relate to the difference between (a) MSBP and USBP and (b) NSSBP and PLSSBP only.

The dry-matter (DM), organic matter (OM) and ash apparent digestibility coefficients for MSBP when compared with the USBP were very significantly ($P<0.001$) higher while MSBP crude fibre (CF) was significant at ($P<0.01$) over USBP but the crude protein (CP) was only significant at ($P<0.05$). The difference in NFE values was insignificant.

Similarly, comparing NSSBP with PLSSBP, the DM and OM digestibilities of NSSBP were significantly ($P<0.001$) higher while the CP digestibility was significant at $P<0.01$. There was no statistical significant difference for the CF, NFE, and apparent coefficient of digestibility of ash when values for NSSBP was compared with PLSSBP.

Table 4. Mean crude protein (g/kg) apparent coefficient of CP digestibility, digestible crude protein (g/kg) and rumen degradable protein (%).

VALUE FROM EXPERIMENT	MSBP	USBP	NSSBP	PLSSBP
Crude protein (CP)	94.9	89.5	88.8	83.4
App. dig. coeff.	0.703	0.645	0.608	0.559
DCP	66.7 *	57.7	54.0 **	46.6
RDP %	59	23	25	25
VALUES FROM MAFF 1986 (Feed Composition)				
Crude protein (CP)	129.1	101.7	101.7	-
App. dig. coeff.	0.612	0.590	0.590	-
DCP	79.0	60.0	60.0	-
+ RDP %	51-70	-	-	-

Significant difference of DCP * P<0.05 MSBP vs USBP
** P<0.01 NSSBP vs PLSSBP

- Data not available.

+ A range of acceptable limit.

RDP = Rumen degradable protein (24 h). Included here for completeness. To be described in Experiment 2.

Table 5. Mean digestible energy and metabolisable energy (MJ) dry matter basis.

	MSBP	USBP	NSSBP	PLSSBP
Digestible Energy (DE)	15.18**	14.57	14.82***	13.58
ME = 0.81 DE	12.3**	11.8	12.0***	11.0
ME = 0.832 DE	12.6**	12.1	12.3***	11.3
ME = 0.845 DE	12.8	-	-	-
ME = 0.16 DOMD %	13.4**	12.5	12.7**	12.2
ME = 0.139 DOMD %	11.6	-	-	-

- Value not applicable
Significance of the difference between MSBP/USBP and NSSBP/PLSSBP pairs:
* P<0.05
** P<0.01
*** P<0.001

The various relationships between DE and DOMD and ME are shown here for completeness. The choice of appropriate values will be discussed later.

Table 6. Mean daily crude protein balance (g) and mean daily liveweight gain (g).

	MSBP	USBP	NSSBP	PLSSBP
Crude protein intake	65.2	60.1	60.8	57.5
Faecal C-protein output	19.4	21.3	23.8	25.4
Urinary C-protein output	25.9	21.6	18.0	22.3
Crude protein balance	19.9	17.2	19.0	10.0
Nitrogen retention	3.2*	2.8	3.0***	1.6
Liveweight gain	120	110	116	70

Note: Faecal and urinary crude protein contributed by dried grass deducted and crude protein balance calculated by difference.

Significant differences are shown between the treatment pairs MSBP/USBP and NSSBP/PLSSBP

Digestible crude protein (DCP) and metabolisable energy (ME)

These values are given in Tables 4 and 5. The mean values for digestible crude protein (DCP) in respect of the feeds were calculated as the product of the value of the feed crude protein (CP) and its apparent Coefficient of Digestibility. The respective t values were determined and the MSBP mean digestible crude protein (DCP) was significant ($P<0.05$) over USBP while the mean DCP values for NSSBP was significantly ($P<0.01$) higher than the DCP mean value determined for PLSSBP.

The mean metabolisable energy (ME) values were evaluated (Table 5) from the prediction equation 0.81 DE = ME (MAFF et al, 1984). Comparing the mean MSBP value of ME with that of USBP, it was significant at ($P<0.01$) while the mean value of NSSBP was very significantly higher ($P<0.001$) when compared with the mean value of ME of PLSSBP.

NItrogen balance and Liveweight gain

The mean nitrogen balance (retention) was calculated for all the respective treatment groups by difference (Nitrogen intake in feed - Nitrogen output in faeces and urine). The mean value for MSBP was significantly greater ($P<0.05$) than for USBP while the mean nitrogen balance for NSSBP was significantly higher ($P<0.001$) when compared with PLSSBP.

The mean liveweight gain by each of the groups over the 14 days experimental period was determined (Table 6). Sheep given MSBP gained 1.68 kg which represented 0.12 kg/day while USBP gained 1.54 kg which amounted to 0.11 kg/day. Sheep given NSSBP and PLSSBP respectively gained a mean liveweight of 1.62 kg and 0.98 kg which represented 0.12 kg and 0.07 kg/day.

Apparent mineral availability

The mean daily calcium, phosphorus, magnesium and copper intakes from both the SBP product and the dried grass and the requirements for the mean daily liveweight gain of 120 g are shown in Table 7 (ARC 1965). The ARC (1965) estimate has been used as the MAFF/DAFS/DANI/UKASTA/BVA report (1983) suggested they be adopted as practical allowances and not the ARC (1980) minimum recommendations.

Table 7 shows the quantitative intake of Ca, P, Mg and Cu from SBP products and the faecal and urinary losses determined by difference to allow for the contributions made by the dried grass.

Table 7. Daily dietary calcium phosphorus, magnesium (g), copper (mg) intake and mean daily requirements.

Total mineral intake	MSBP	USBP	NSSBP	PLSSBP
Calcium	7.46	11.02	9.76	18.56
Phosphorus	1.51	1.63	1.57	2.90
Magnesium	1.39	1.64	1.72	2.08
Copper	11.88	11.16	7.06	9.11
Amount contributed by dried grass				
Calcium	1.96	1.96	1.96	1.96
Phosphorus	0.89	0.89	0.89	0.89
Magnesium	0.63	0.63	0.63	0.63
Copper	4.05	4.05	4.05	4.05

Mean daily requirements ARC (1965) and MAFF/DAFS/DANI/UKASTA/BVA Report (1983).

Calcium = 7.0 g/day
Phosphorus = 3.6 g/day
Magnesium = 1.1 g/day
Copper = 6.6 mg/day

Table 8. Mean coefficients of apparent availability of calcium, phosphorus, magnesium and copper.

Minerals	MSBP	USBP	Sig P	NSSBP	PLSSBP	Sig P
Calcium	0.358	0.338	NS	0.194	0.232	NS
Phosphorus	0.559	0.546	NS	0.377	0.415	NS
Magnesium	0.402	0.411	NS	0.383	0.329	NS
Copper	0.034	0.072	NS	0.059	0.082	NS

NS = Statistically insignificant at P>0.05

For pairs of MSBP vs USBP
NSSBP vs PLSSBP

Table 9. Daily dietary sugar beet pulp products content of calcium, phosphorus and magnesium and daily faecal and urinary losses and balance (g).

	MSBP	USBP	NSSBP	PLSSBP
Calcium				
Dietary source (SBP)	5.50	9.06	7.80	16.60
Faecal losses (SBP)	3.53	6.00	6.29	12.77
Urinary losses (SBP)	0.28	0.54	0.39	0.33
Balance	1.69	2.52	1.12	3.50
Phosphorus				
Dietary source (SBP)	0.62	0.74	0.68	2.01
Faecal losses (SBP)	0.58	0.73	0.72	1.78
Urinary losses (SBP)	0.09	0.04	0.03	0.01
Balance	-0.05	-0.03	-0.07	+0.22
Magnesium				
Dietary source (SBP)	0.76	1.01	1.09	1.45
Faecal losses (SBP)	0.47	0.60	0.62	0.98
Urinary losses (SBP)	0.28	0.38	0.44	0.43
Balance	0.01	0.03	0.03	0.04

Table 10. Mean blood calcium, phosphorus and magnesium concentrations (m mol/litre) at pre and post experimental periods and their expected normal range.

	MSBP	USBP	NSSBP	PLSSBP
Pre-experimental period				
Calcium	2.28	2.36	2.37	2.37
Phosphorus	2.42	2.15	2.15	2.61
Magnesium	0.97	0.94	0.97	1.05
Post-experimental period				
Calcium	2.36	2.38	2.35	2.34
Phosphorus	2.04	1.99	2.02	2.26
Magnesium	0.84	0.88	0.89	0.99

Normal range of blood concentrations (Underwood 1981).

Calcium = 2.3 - 2.6 m mol/litre
Phosphorus = 1.9 - 2.6 m mol/litre
Magnesium = 0.7 - 1.3 m mol/litre

Table 8 gives the coefficients of apparent availability for the four minerals. A total of eleven sheep comprising of 2 each from the MSBP and USBP treated groups and 3 and 4 respectively from the PLSSBP and NSSBP groups exhibited small negative values for the apparent coefficient of availability of Cu, although all the small mean values are positive.

The mean coefficients of availability for Ca, P, Mg and Cu (Table 8) were calculated from ARC (1965) equation:

$$\text{Coeff.of availability} = \frac{\text{Mineral in feed} - (\text{Faecal} + \text{endogenous faecal losses})}{\text{Mineral in feed.}}$$

These determinations were made after accounting for the respective minerals contributed by dried grass. Small differences existed between the treatment groups but comparing the MSBP with USBP, and NSSBP with PLSSBP the differences were insignificant.

Mineral balance

The balances for Ca, P and Mg were separately determined by difference from the equation given below after allowing for the contributions made by dried grass.

Mineral Balance = Dietary mineral intake - (Dietary & endogenous faecal losses + endogenous urinary losses),

All determined values are shown in Table 9.

Blood mineral concentrations

Mean blood concentrations for Ca, P and Mg were determined at Day 1 and Day 14 of the experiment and these values and those of the acceptable normal ranges are in Table 10 for comparison.

DISCUSSION

The experimental technique

It is important in digestibility studies that the animals be well adjusted to their diet to establish a steady state of feed and water intake, faeces output and rumen function. In such experiments the animals are necessarily fed to below appetite to ensure complete feed

consumption. This probably tends to increase diet digestibility.

Usually, single feeds can not be given by themselves due to lack of palatability or their effect on digestive function. In the experiment described, the sheep were given 800 g ± 1 g sugar beet product and 400 g ± 1 g dried grass (fresh matter basis) per day. The digestibility of the dried grass had been established in a previous experiment and was assumed to be unaffected by the various sugar beet pulps when given in these amounts.

Before the present experiment commenced, a previous trial was conducted when the sheep were given either

(a) 1.25 kg fresh dried grass (DG)

(b) 1.00 kg USBP and 250 g DG (fresh matter basis)

or (c) 750 g MSBP and 500 g DG (fresh matter basis)

After about a week on these diets most of the sheep given fresh USBP and DG and a few of those given MSBP and DG developed a very severe watery scour commencing over a variable period, but generally at 7-10 days. There were two consequences to this. Firstly, a probably enhanced rate of passage of feed and hence reduced digestibility. Secondly, it was very difficult to be certain that subsampling the 7 days output of faeces would give an accurate estimation of daily faecal dry matter output. Obviously, the inclusion of molasses increased the tendency to scour and the ratio of USBP to DG may possibly have contributed to these effects.

Calculation of the ME values (DE x 0.81) for these feeds showed obviously very low and clearly erroneous values for individual sheep and the mean values were :

Unmolassed SBP nuts (USBP) 10.4 MJ ME/kg

Molassed SBP nuts (MSBP) 11.3 MJ ME/kg

In the main experiment conducted as described, whilst the faeces of the sheep given MSBP were obviously softer, they were well-pelleted and the inclusion of 33% of dried grass in the diet given in this trial appeared to be satisfactory.

Britain is unusual in having 40% molasses in SBP while 20% or less and frequently nil amounts are common in European Economic Community (EEC) where SBP is normally included in compound feeds. This will be discussed further under palatability trials.

Feed and water consumption, faecal and urinary output and apparent coefficient of digestibility

Groups of sheep given MSBP in this experiment totally consumed their ration faster than other groups almost certainly due to the incorporation of molasses which increased the palatability. This effect of molasses inclusion at 0, 20 and 40% to SBP on the yield and composition of milk of dairy cows was evaluated (Hemingway, Parkins & Fraser, 1986) and they concluded that the 20 and 40% molasses in the SBP resulted in an immediate consumption while there was reluctance in the consumption of SBP in which molasses was not included. The disparity in the rate of consumption for the other feeds in this present experiment may be related to the processing and preparation methods.

The mean daily water intake and urine output (Table 2) were highest for MSBP treated groups and this observation was in agreement with that of Nigerian National Livestock Projects Department's finding (unpublished report) on the Cattle Fattening Programme under the Small Holder Credit Scheme. It was also observed by Castle (1972) that with increased MSBP in the diet of lactating cows there was a significant increase in water consumption relative to barley. Bass (1982), concluded that an increased intake of crude protein seemed to be more important than an increase in crude fibre in relation to water intake by sheep. ARC (1965) and NRC (1978) both reported that an excessive salt or protein consumption increased urine output. Water intake and urine output in respect of this present experiment followed the trend of crude protein (CP) concentration in the rations with MSBP having both the highest CP intake and water consumption and PLSSBP the least (Table 4).

Animal individuality in behaviour to water intake might also possibly contribute to the differing values of water intake and urine output for these treatment groups.

A possible adverse effect of the excessive urination in relation to husbandry is the regular changes of bedding which could be laborious and additional cost of re-bedding which in economic terms could result in an increased cost of production.

Faecal DM output was lowest for the sheep given MSBP while those given PLSSBP had the highest output. There was no statistically significant difference between USBP and NSSBP in faecal output (Table 2). Addition of molasses to MSBP could be suggested to have resulted in

the low faecal output while the preparatory and processing methods could have possibly accounted for the disparity in values of faecal output for the other treatment groups.

The differing values of faecal DM output for each of the treatments were reflected in the differences in values of apparent coefficient of digestibility for DM, OM, and other compositional analyses of the respective feeds (Table 3). The apparent coefficient of digestibility values for MSBP was generally highest and it could be concluded that the incorporation of 40% of almost fully digestible molasses to MSBP could have accounted for this result. Similarly the lowest values of apparent coefficients of digestibility of DM, OM and other compositional analyses could possibly be due to the processing method which involved the use of lime as most of the sucrose in the original product was removed with a higher level of residual calcium and perhaps other minerals. The differing values of apparent coefficient of digestibility for USBP and NSSBP could also be possibly related to the difference in preparation methods of the two feeds.

Digestible crude protein (DCP)

MAFF (1986) reported DCP values of 79 g and 60 g for MSBP and USBP with respective coefficients of apparent digestibility of crude protein (CP) of 0.612 and 0.590. In this present experiment the DCP values for the same types of SBP products (MSBP and USBP) were 66.7 g and 57.7 g with apparent coefficients of CP digestibility of 0.703 and 0.645 respectively. Table 4 shows the mean values of CP, apparent coefficients of CP digestibility and DCP. It could be suggested that the higher values of 79 g and 60 g of DCP reported by Feed Composition MAFF (1986) was as a result of the higher chemically analysed values relative to those obtained in this experiment. The CP was better digested in this trial.

Application of nitrogen containing fertiliser could result in the improvement of plant yield and crude protein concentration (Alder, 1954; Washko & Marriot, 1960; Green & Cowling, 1960 and Beaumont 1981). Similarly, other factors such as soil and climate and plant variety may contribute to the difference in composition of plants grown under different environmental conditions.

ADAS (1976) reported values of 61 g and 59 g respectively for the DCP contents of MSBP and USBP. These values are closely in agreement with about 67 g and 58 g determined in this present experiment.

Feed Composition MAFF (1986) reported an RDP value in the range of 51-70% for MSBP for 9 samples. This was in agreement with what was obtained in this trial (see Experiment 2). The reported value for USBP in the range 51-70% (based on a single sample) by Feed Composition MAFF (1986) however conflicted with the determined value of 23% in this trial. It could be suggested that the feed used in the Feed Composition MAFF (1986) determination may have been dried at a lower temperature as the degree of drying correlates with the RDP values.

Differences in the origin and method of preparation of USBP and NSSBP (pellets and shreds) could have accounted for the differing DCP values of about 58 g and 54 g respectively. It could be concluded that the low mean of the DCP value of about 47 g in respect of PLSSBP was as a result of the processing method and that it is a poorer feed source for crude protein to ruminant livestock when compared with the other SBP products.

METABOLISABLE ENERGY

MAFF et al (1984) assumes 19% of the gross energy (GE) is lost as urinary and methane energy, i.e. (100-81)% = 19%. However in the Rowett Feed Evaluation Unit Report (MAFF, 1978) which included metabolisable energy (ME) determination of 4 samples of molassed shredded and 4 samples of molassed pelleted sugar beet pulps, the combined loss of energy as urine and methane was 15.5% giving the relationship ME = 0.845 x DE. The resultant value for ME is shown in Table 5. It can not be assumed that this factor can be used for unmolassed SBP products as the value for the molassed products could have been influenced by the 40% molasses inclusion.

The Rowett Feed Evaluation Unit Report MAFF (1981) which describes the ME content of 23 compound feeds indicates a mean loss of 16.8% of energy as urine and methane i.e. ME = 0.832 x DE. It may perhaps be appropriate to use this value for the USBP, NSSBP and PLSSBP. The resultant values of these products are indicated in Table 5.

For 4 samples of shredded and 4 samples of pelleted molassed sugar beet pulp, Rowett Feed Evaluation Unit (MAFF, 1978) found the mean relationship to determine the ME from the equation ME = 0.139 x DOMD %. Similarly, MAFF et al (1984) suggested the equation 0.16 x DOMD % = ME for concentrate feeds which may perhaps be taken to indicate SBP products. The resultant values of 11.6 MJ ME from equation 0.139 x DOMD % = ME and 13.4 MJ ME from the equation 0.16 x DOMD % = ME for MSBP

appear to be low and high respectively when compared with the values calculated from DE. The equation 0.16 x DOMD % = ME when used to determine the ME values of USBP and NSSBP seems to be within the range of acceptable limit of about 12.3 ± 0.5 MJ ME (Rowett Feed Evaluation Unit Report (MAFF, 1978) for the mean value for SBP products.

The differing ME values between the USBP and NSSBP as determined from various equations could be attributed to the form of preparation (pellets and shreds) as Van Es (1969) and Van der Honing and Van Es (1974) reported that the efficiency with which dairy cows utilise ME from pelleted feeds was greater but there was reduced ME per unit weight of feed. Assuming that there are similar effects for sheep, it could then be concluded that the difference in ME values was due to the method of feed preparation.

It could be suggested that the ME value for MSBP lies within 12.5 ± 0.3 and the normal unmolassed SBP products could be within 12.3 ± 0.5 (Rowett Feed Evaluation Unit, MAFF 1978 and MAFF et al, 1984). The liming of SBP products is a recent processing method and no other information on the determined ME value is available. It therefore seems reasonable to conclude that it is about 1 MJ less than for the standard unmolassed and molassed products.

CRUDE PROTEIN BALANCE

Crude protein (N x 6.25) balance was calculated by difference after making allowance for the contribution made by the dried grass in the ration. That is, CP balance = Feed CP - (Faecal CP + urinary CP).

All treatment groups were in positive balance as shown in Table 6. The determined value for CP balance depends on previous nutritional status, animal age, amount of feed given, liveweight gain and the nutritive value in a balance trial (Egan 1980). Anon (1978) reported that SBP products are deficient in the essential amino acid methionine. It could therefore be suggested that the CP balance values in the trial could have been possibly higher if methionine were adequately present in SBP products (or in other feeds given at the same time) as its importance in the synthesis of body protein can not be overlooked.

The significance of the determination of crude protein balance lies in the estimation of protein requirements (McDonald, Edwards & Greenhalgh, 1988) rather than weight changes. ARC (1965) suggested that the determination of weight changes by CP balance could be subject to considerable positive bias which could result from disturbance in the

performance of the animals during the trial and in particular by consequent changes in gut fill. The possible excretion of protein in a form not measured by the conventional balance trial technique as hypothesized though yet to be fully defined (ARC 1965) and the contribution by the energy of gains in adult animals in the form of fat deposits could also result in an imprecise weight gain determination from CP balance. It could then be suggested that liveweight determination by scale could only serve as a guide as it may be imprecise. The determined weight gain in Table 6 could include fat deposition as the animals were almost 12 months old and their feeding was about 4.0 MJ ME above their maintenance requirement.

The usefulness of a protein balance trial lies in the determination of body tissue depletion or protein retention to allow the formulation of better feeding regimes to meet the ruminant livestock animal requirement.

MINERALS

The efficiency of absorption of minerals in diets is affected by the chemical nature and form in which they were ingested (Underwood, 1981), soil and climatic conditions in which the plants are grown and stage of maturity of plants (Maynard et al, 1979; Beaumont, 1981), animal age, needs and production (ARC 1965 and 1980). Percentage availabilities of 45% Ca, 60-85% P, 10-40% Mg and 4-10% Cu were reported by ARC (1965 and 1980) and Loosli (1972) which were based on the efficiency of absorption of these minerals generally at mature age.

Calcium availability

For the absorption of calcium, Abdel-Hafeez et al (1982) concluded that a low calcium intake is followed by an increased efficiency of absorption. This suggests that the low coefficient of availability value from this trial for PLSSBP (23%) could have resulted from a high Ca intake resulting from the processing method and possibly the method of preparation (shredded) as NSSBP of similar preparation also had a low availability coefficient (19%). The relatively lower values of 36% (MSBP) and 34% (USBP) compared to the 45% quoted by ARC (1965), could have been that the maintenance need for the animals given these treatments are very low since requirement is a major factor in the determination of availability of Ca (Field 1981, Scott & McLean, 1981) and needs relative to intake (Abdel-Hafeez et al, 1982).

Phosphorus

Field (1981) related P availability to its solubility before the absorption site (Ben-Ghedalia et al, 1982; Scott & McLean, 1981) which is the small intestine. The roles of excess dietary calcium and magnesium relative to phosphorus on the determination of P availability (Table 7) was reported by Pickard (1986). The reports of Pickard (1986) and Field (1981) on the effects of excess calcium and magnesium on the availability coefficient of phosphorus could have accounted for the disparity in values of percentage coefficient of availability for P (MSBP 56%, USBP 55%, NSSBP 38% and PLSSBP 42%) for all the treatment groups and the low range of values (38-56%) relative to that quoted by the ARC (1965). In considering the P homeostatic mechanism, Field (1981) suggested that the volume of saliva produced by sheep on a particular diet may play a role in determining the partition of surplus phosphorus between the routes of excretion (faeces and urine) by influencing increased phosphorus secretion in the saliva. This could possibly have equally accounted for the low values as the salivary secreted phosphorus could be reabsorbed at the expense of the dietary phosphorus. Equally important is the fact that these present animals were mature and their rate of growth was quite limited. Hence requirement for phosphorus at only maintenance level need be met.

Magnesium

The mean availability of Mg reported by ARC (1965 and 1980) was 20-29% and Loosli (1972) and Maynard et al, (1979) reported 10-40% and 30-50% respectively for mature animals. These are in accord with the values obtained in this experiment for all the treatment groups with the SBP products.

The values of the coefficient of availability differ with increased Mg intake as shown on Tables 7 and 8. It could therefore be concluded that a higher intake of Mg could be accompanied by a lower availability.

Copper

The availability of copper is rather less than 9% (Suttle, 1974; Maynard et al, 1979; ARC, 1980). Although the mean availability of copper in this present trial was within 3-8% for all treatment groups, which is in accord with the reports of ARC (1965, 1980), Suttle (1974) and Maynard et al (1979), some of the sheep in all the treatment groups

gave small negative values. This behaviour was not unusual (Hemingway & MacPherson, 1967; Woolliams et al, 1983) for caged or young sheep reared indoors from weaning as they can accumulate copper more rapidly amounting to about 4.4% of intake. Endogenous loss of copper (Suttle, 1978; Simpson, Mills & McDonald, 1981; Woolliams et al, 1983) could be related to the hepatic reserves. This could have accounted for the small negative values of coefficient of availability for copper as exhibited by some of these caged sheep).

MINERAL BALANCE FROM THE SUGAR BEET COMPONENTS OF THE FEED

The major route of excretion of calcium and phosphorus was in the faeces (Table 9) as reported by Field (1981) and Scott & McLean (1981) while urine played a substantial role in the elimination of excess magnesium from the animals body.

Balance in respect of calcium, phosphorus and magnesium for the SBP components of the feed were all calculated by difference after making allowance for the contributions made by the dried grass in the ration as determined in a previous experiment. All the animals were individually and collectively in positive balance for calcium and magnesium but in negative balance for phosphorus for all the SBP products except PLSSBP as shown in Table 9. The positive balance for calcium and magnesium and the negative balance for phosphorus could be related to the total dietary intake as shown in Table 7. Calcium intakes were above and phosphorus below the suggested requirement for such groups of sheep by ARC (1965) and MAFF/DAFS/DANI/UKASTA/BVA report (1983).

It could therefore be concluded that the additional phosphorus content of the limed pulp (PLSSBP) (which really results from a reduced removal of phosphorus from the sugar beet during the extraction process) enabled the animals to stay in positive balance. This was in contrast to the negative balance shown with the three existing sugar beet pulps.

BLOOD MINERAL CONCENTRATIONS

Mean blood concentrations of calcium and magnesium at pre and post experimental periods were fairly constant but there was a slight fall in blood phosphorus at the post experimental period, for all except the sheep given MSBP. The constancy of calcium and magnesium blood concentrations and the slight fall in phosphorus concentration could

have resulted from the dietary intakes of these minerals which was adequate for calcium and magnesium and inadequate for phosphorus. It could be suggested that the SBP products are as good as previous diets of these animals before the commencement of the experiment for calcium and magnesium but relatively poor for phosphorus.

The blood concentrations for these minerals (Ca, Mg and P) were within the normal range reported by Underwood (1981) as shown in Table 10. Normal blood phosphorus concentration could have been maintained through body tissue phosphorus depletion as it has been shown to be in negative balance (Table 9). This homeostatic mechanism could help the animals to survive a short period of phosphorus inadequacy without any deleterious effect on the life of the animals. Of course if the experiment had been conducted for a longer period some greater reduction in blood phosphorus may have occurred.

The inconsistency in the determination of the apparent availability for macro-minerals could lie in the inaccurate estimates of maintenance requirement and possibly the values ascribed to their efficiency of absorption from diets (Field, 1981). The various forms in which minerals are presented in feeds (Beaumont, 1981) and the effects of interaction of minerals also in the feeds (Cooke, 1981) play a significant role in their apparent availability from the diets. Routes of excretion (urine and faeces) and secretion (saliva and sweat) which are determined and possibly dependent on dietary source (Field, 1981) further complicate the possibility of precise determination of respective values for macro-elements at either maintenance or productive levels. These problems could have resulted in the differing values of apparent availabilities reported by various authors.

It could be concluded that the SBP products are generally good dietary sources of calcium and magnesium but need to be supplemented with feeds of higher dietary phosphorus content (Wilson & Brigstocke, 1983) when given to ruminant livestock to afford for better acceptability of feeds and availability of minerals. The phosphorus content of 2.10 gP/ kg for PLSSBP is considerably greater than the value of about 0.90 g P/ kg DM for normal molassed sugar beet pulps. Barley, for example, contains about 4 g P/kg DM and so PLSSBP can not be considered as deficient in phosphorus.

EXPERIMENT 2

EVALUATION OF RUMEN DEGRADABILITY ON SUGAR BEET PULP BY-PRODUCTS USING A DACRON BAG TECHNIQUE

Introduction

In his observations on the rumen by-pass of protein, Chalupa (1975) suggested that the normal processing procedures used in feed ingredients manufacture such as heating and the solvent extraction of oil-rich materials may influence the amount of protein digestion through the alteration of the structural characteristics of the feed stuff. In view of this suggestion, it was necessary to assess the rate at which rumen micro-organisms degraded protein in dried SBP processed and prepared differently during a period of 24 hours as proposed for most feeds by Mehrez & Orskov (1977).

Materials and Methods

Feed samples

The different types of sugar beet pulp (SBP) used in the earlier experiment were evaluated. The pelleted products were broken by hand into lengths of about 6 mm before use.

Dacron bag and feed weighing

The bags made of dacron had a dimension of 14 x 12 cm with 43 μm pore size which limited the loss of particulate matter but allowed entry and exit of rumen fluid. It was fitted at an angle of the open end with 80 cm long nylon cord while part of the loose end of the cord was tied round a short length (5 cm) rubber tubing.

A total of 9 equal portions of 20 g $\pm$ 0.1 g of each feed sample was weighed into the numbered dacron bags. The opened end of the bags were stapled ensuring enough space in the bag for free swelling and movement of the feeds, and the easy entry and escape of rumen liquor when suspended into the rumen (Orskov, 1982).

Fistulated cows and incubation of bags in the rumen

Three dry Friesian cows fistulated at the left para-lumbar fossa as described by Thyfault, Leffel & Derhuang (1975); Oladosu & Akpokodje

Table 11. Composition of the feeds (g/kg DM) and the amounts of dry matter, organic matter and crude protein (g) contained in 20g of each of the feeds

	MSBP	USBP	NSSBP	PLSSBP
Dry matter of feeds	0.879	0.868	0.859	0.858
Crude protein g/kg DM	94.2	90.2	91.6	85.3
Organic matter g/kg DM	905.6	936.1	943.6	912.0
Ash g/kg DM	94.4	63.9	56.4	88.0
Amounts of feed used				
Dry matter g	17.6	17.4	17.2	17.2
Crude protein g	1.66	1.57	1.59	1.47
Organic matter g	15.9	16.3	16.2	15.7
Ash g	1.66	1.10	0.97	1.52

Table 12. The mean degradability coefficient for dry matter, organic matter and crude protein in the rumen.

	MSBP	SE	USBP	SE	NSSBP	SE	PLSSBP	SE
Dry matter (DM)								
4 h	0.41	0.012	0.13	0.019	0.09	0.007	0.15	0.004
8 h	0.60	0.038	0.32	0.025	0.31	0.013	0.29	0.038
24 h	0.75	0.044	0.53	0.057	0.52	0.021	0.51	0.054
Organic matter (OM)								
4 h	0.40	0.010	0.13	0.016	0.09	0.007	0.17	0.003
8 h	0.56	0.032	0.36	0.018	0.28	0.018	0.31	0.018
24 h	0.75	0.046	0.53	0.058	0.52	0.021	0.51	0.054
Crude protein (CP)								
4 h	0.37	0.018	0.01	0.054	0.09	0.006	0.12	0.004
8 h	0.47	0.029	0.14	0.036	0.13	0.024	0.14	0.018
24 h	0.59	0.036	0.23	0.027	0.25	0.010	0.25	0.049

(1975) & Oladosu (1987) and given grass silage and draff were selected for the experimental studies.

Twelve dacron bags containing three samples each of the four feeds were incubated in the rumen of each cow ensuring that they were immersed in the rumen liquor with the rubber bung holding the suspended cords of the bags securely in the cannula.

Each treatment feed was removed at 4, 8 and 24 hours from the respective cows. The removed bags were thoroughly washed and rinsed several times with cold water to remove rumen liquor and accompanying micro-organisms.

Preparation for analyses

Both the fresh feed samples and the residual feeds in the bags were dried at 95^{o}C for 48 hours. The weight of dried residual feed in the bags was determined and the analyses for crude protein and ash were made. Similarly, the dry matter, crude protein, and ash for the samples of fresh feeds were analysed as shown in Table 11.

Results

The analytical values of fresh feed samples in Table 11 are very similar to those given in Table 1. Table 12 gives the mean degradability coefficients as determined at 4, 8 and 24 hours. These results are graphically illustrated in Fig. 1 (Organic matter) and Fig. 2 (crude protein). It is evident that the full degradation of the products was substantially reached after 24 hours incubation as suggested by Mehrez & Orskov (1977).

There were clear and significant differences in the more rapid and extent of degradation of dry-matter (75% for MSBP compared with about 52% for the other products), organic matter (75% for MSBP compared with about 52% for the other products) and crude protein (59% for MSBP compared with about 25% for the other products). The higher value of 59% observed for MSBP crude protein degradability in the rumen over 24 hours relative to the other products could undoubtedly be a reflection of the effect of 40% content of molasses in the original product.

Discussion

The requirement for nitrogen (N) in the form of rumen degradable protein (RDP) by rumen micro-organisms for their growth and multiplication has been reported (e.g.) by Hovell & Orskov (1981); Gill

Figure 1. The percentage degradability of Organic matter of the various S B P products incubated in the rumen over a period of 24 h.

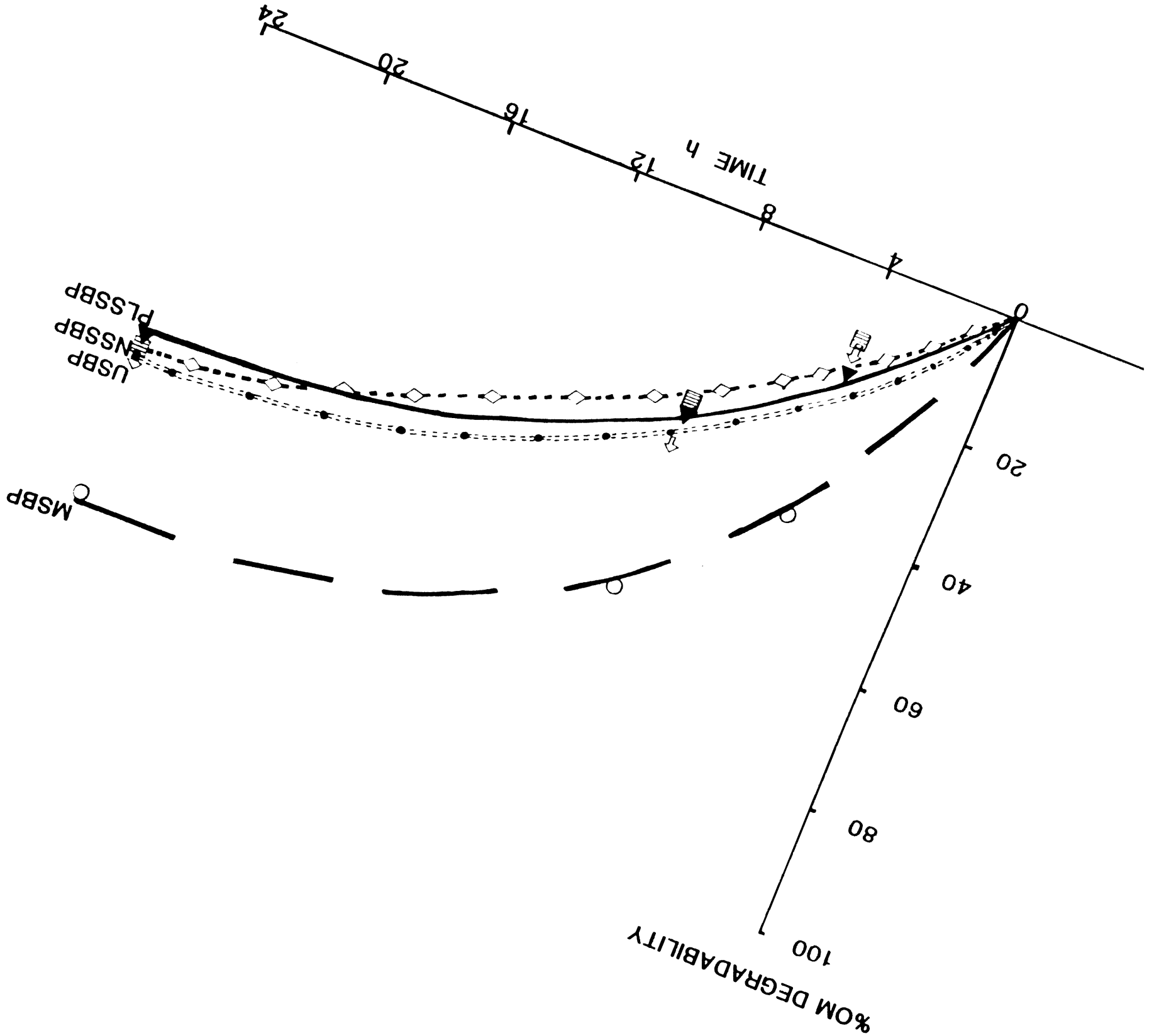
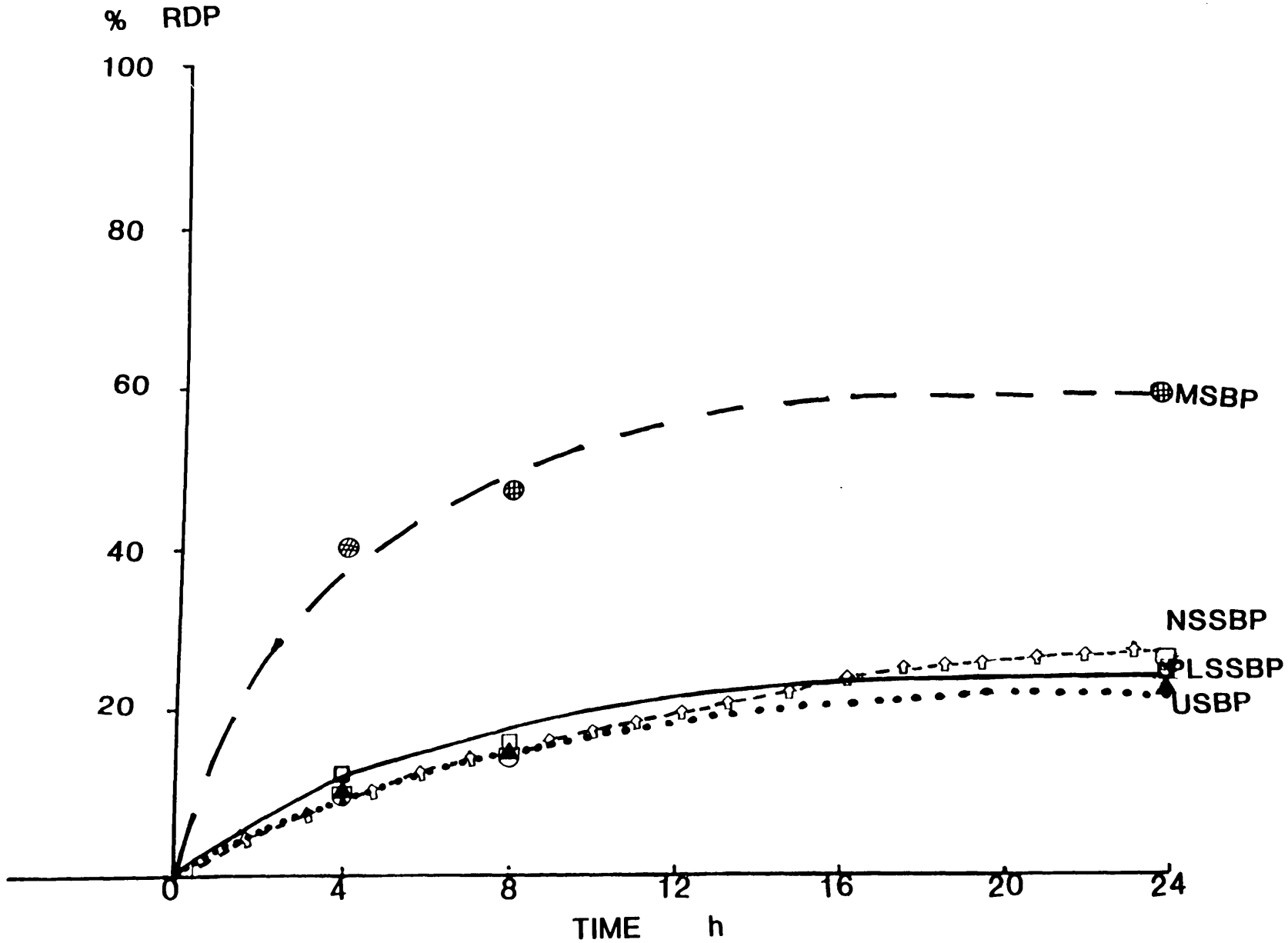

TIME h
0
4
8
12
16
20
24
PLSSBP
NSSBP
USBP
MSBP
0
20
40
60
80
100
%OM DEGRADABILITY

Figure 2. The percentage degradability of Crude protein of the various S B P products incubated in the rumen over a period of 24 h.


% RDP
100
80
60
40
20
0
4
8
12
16
20
24
TIME h
MSBP
NSSBP
PLSSBP
USBP

& Beaver (1982); Cortil, Beever, Austin & Osbourn (1982). Alawa et al, (1986 & 1987) and Alawa, Fishwick & Hemingway (1988) have concluded that increased degradability of supplementary nitrogen (N) may influence the voluntary intake of low-quality roughage feeds through increased quantities of NH_3-N generated in the rumen liquor and that it was important that dietary protein should satisfy the microbial need for ammonia nitrogen if optimum roughage feed consumption and digestibility was to be achieved.

In an earlier evaluation of rumen degradability of various SBP products used for experiments on dairy cows, Hemingway, Parkins & Fraser (1986) and Parkins, Hemingway & Fraser (1986) reported RDP coefficients for dried unmolassed pressed pulp, unmolassed pressed pulp and molassed pressed pulp as 0.13, 0.47 and 0.54 respectively. Their finding showed that the molassed product was more degraded than other products which was in agreement with the result from this present evaluation. The low value of 0.13 for the dried unmolassed pressed pulp was attributed to the elevated drying temperature which would denature the protein. The higher rate of degradation of MSBP in this present experiment and those of Hemingway, Parkins & Fraser (1986) and Parkins, Hemingway & Fraser (1986) may be attributed to the incorporation of molasses which is a readily fermentable carbohydrate containing various simple (and complex) nitrogen sources. However, the rather higher values for RDP found in this experiment for these products relative to those of Hemingway, Parkins & Fraser (1986) and Parkins, Hemingway & Fraser (1986) could perhaps be due to differences in processing, particularly the temperature and length of the drying process.

In the grouping suggested by ARC (1980) for different protein sources based on the extent of protein degradation in the rumen, MSBP fell within the range of degradability (dg) B (0.51-0.70) while the other products are in group D (0-0.31). It was also concluded by ARC (1980) that shortage of degradable protein for microbial needs from over-heating or other forms of treatments could have serious repercussions on the voluntary feed intake due to an ineffective rate of fermentation in the rumen.

In conclusion, the differences in feedstuff processing and preparation could result in differing extents of RDP and the feeds with very low RDP could be detrimental to the rate of growth and multiplication of rumen micro-organism resulting in an ineffective digestion and voluntary intake of roughage feed for which ruminants are

noted. ARC (1980) and Orskov (1985) reported that this technique could enhance the determination of protein needs by ruminant livestock with a resultant improved production. The combined effect of readily fermentable carbohydrate and rumen degraded protein of feed supplements on the improvement of the digestion and voluntary intake of straw with subsequent increased yield of metabolisable energy had been reported by Alawa (1985). It could therefore be suggested that MSBP fed with poor roughages could be more efficient in providing metabolisable energy to ruminant animals than the other SBP products.

EXPERIMENT 3

THE EVALUATION OF PALATABILITY OF DIFFERENTLY PROCESSED AND PREPARED SUGAR BEET PULPS (SBP) BY RUMINANT LIVESTOCK

Introduction

The object of the studies was to determine the rate of consumption of the different SBP products by a wide range of ruminant livestock and to evaluate the effect of inter-mixing these products with other acceptable feeds on the consumption rate by lactating cows.

Materials and Methods

Experiment A

The twenty-three wether sheep in metabolism cages in the digestibility trial experiment were observed for the rate of consumption of the 800 g ± 1 g fresh products of SBP intermixed with 400 g ± 1 g dried grass (DG) given in two half-meals at 08.00 hours and 16.00 hours. The study was by visual observation and time metering scored on a group basis.

Experiment B

In assessing the palatability and acceptability of the SBP products (MSBP, USBP, NSSBP and PLSSBP) groups of 80 pregnant gimmers and 60 pregnant ewes given hay and barley were housed in a polythene shed separated from each other by two short wooden fences along which were feeding troughs on either side.

10 kg and 7.5 kg amounts of the fresh samples of these four SBP products were weighed and put in polythene buckets. The feeds were given in 23 wooden feeding troughs of about 2.5 metres long. These troughs run along the length of the shed on either side. The first trial was at 08.00h and a repeat at 16.00h when the order of feed serving was reversed. This allowed 0.4 m length/sheep. Samples containing 10 kg were given to the gimmers and those of 7.5 kg to the ewes and this was estimated at providing 500 g per head to either group of the animals weighing about 70 kg and about 3 weeks from lambing. Visual observation of the ewes during feeding and the time to consume or partly consume each was recorded.

Experiment C

This was similar to Experiment B but involved a total of 52 adult wether sheep already being fed a mixture of unmolassed SBP, barley husks and soya bean meal. They were housed in the same shed but penned in groups of 5, 7, 8, 9, 11 and 12. They were given the various SBP products at 500 g per head at their normal 16.00 hours feeding time. Pens with 5 and 9 sheep were given MSBP, pens with 7 and 8 with USBP, 11 sheep in one group with NSSBP and 12 sheep in another group with PLSSBP.

Experiment D

A total of 27 heifer Friesian crossed calves grouped into two by age and liveweight were used to assess the palatability of these four SBP products.

The liveweight of the older group of 10 animals was estimated as 280 kg each while the other group containing 17 animals were estimated at 250 kg.

These animals were receiving silage ad-libitum and a barley/protein supplement mixture. 5 kg of MSBP and USBP each and 8.5 kg of NSSBP and PLSSBP each was weighed and given separately at 08.00 hours to supplement their existing feed. The 10 larger animals were given 5 kg fresh product and the 8.5 kg to the younger group. This provided 0.5 kg per head of each of the products and the treatment was reversed at the 16.00 hours feeding time. Observation was visual and time of total feed consumption was recorded.

Experiment E

A further evaluation of the palatability of the four SBP products was assessed in a dairy herd of 80 cows just before the afternoon milking. The basal feed was grass silage. The cows were milked in a traditional byre.

Twenty amounts each of 2 kg of the four SBP products were weighed into paper bags. The cows were in two groups of 40 and the first group were given the appropriate 2 kg of the SBP products in the feed trough in a sequence with the number of the treatment feeds ensuring that each treatment was given to 10 cows. Animals that consumed their allocation were visually assessed and the feeds unconsumed by the other cows were quantified after 30 minutes of feeding.

After 30 minutes, from initial feeding, 450 g of fishmeal

intermixed with 3.63 kg rolled barley was added to the residual SBP products given to the cows and the rate of consumption of the combined feed was re-assessed after a further 30 minutes. The feeding behaviour was observed and any residual feed was recorded.

For the second batch of 40 cows the same quantity of barley and fishmeal were mixed with the same quantity of the SBP products fed to the cows above and given individually to the cows with 10 cows receiving each SBP product. After 45 minutes of feeding, the quantity of residual feeds were quantified and recorded.

RESULTS

Experiment A

The mean consumption time for the treatment group given NSSBP was 103 minutes, although the dried grass (DG) in the ration was selectively consumed earlier than the total time scored for the feed consumption (Table 13). One sheep in this group was found to refuse the consumption of NSSBP for three consecutive days and this resulted in its removal from the treatment group. Within the MSBP treated group, all the ration was consumed in about 20 minutes of feeding. The sheep given PLSSBP consumed their feed completely in 28 minutes. It however took the group given USBP 65 minutes to consume their ration and they also showed preference for DG relative to USBP. There was no noticeable inclination towards feed selectivity for the MSBP and PLSSBP groups.

Experiment B

In the pen with 80 gimmers there was a higher inclination towards the consumption of MSBP than other feeds. A repeat trial in which MSBP was given some time after the other feeds confirmed this. The degree of preference of the other three products over the other was difficult to determine as the gimmers spilt these feeds on the floor in the two trials. Essentially very little of any of them was consumed.

In the two trials with 60 pregnant ewes MSBP was consumed totally in 15 minutes and visual determination of the quantitative residual feeds showed that PLSSBP was the least consumed, followed by NSSBP and USBP as shown in Table 13. The residual feeds were however consumed before the next feeding time.

Table 13. Mean rate of feed consumption by sheep (minutes).

Experiment	A	C	B	B
Type of feed	Caged sheep	Penned wethers	Pregnant ewes	Pregnant gimmers
MSBP	20	18	15	23
USBP	65	133	264	+
NSSBP	103	92	189	+
PLSSBP	28	107	*	+

\+ Obviously very little consumed. Troughs eventually upset.

* Very slowly consumed by the time of next feed.

Table 14. Mean rate of feed consumption by heifer calves (minutes).

	MSBP	USBP	NSSBP	PLSSBP
250 kg Heifer calves	31	237	52	96
280 kg Heifer calves	18	190	20	68

Table 15. Mean percentage of the SBP product consumed by lactating dairy cows (10/group).

	MSBP	USBP	NSSBP	PLSSBP
Byre 1 Straight feeding (SF)	45	38	43	25
followed by addition of SF and barley-fish meal	85	75	80	80
Byre 2 Intermixed SBP with barley and fishmeal	90	80	88	88

Experiment C

The behaviour of the small groups of penned sheep on consumption rate was similar to what was obtained with the group of 60 pregnant ewes. The difference was in a generally faster rate of feed consumption as shown in Table 13. This was almost certainly because these sheep had a long prior experience of consuming unmolassed shredded pulp.

Experiment D

The mean time taken by the younger heifer calves to consume MSBP was scored as 31 minutes and NSSBP as 52 minutes (Table 14). USBP and PLSSBP were not totally eaten after well over 60 minutes but consumption was complete at 96 and 237 minutes respectively for the PLSSBP and USBP.

The older calves were restless while consuming MSBP relative to the other SBP products but they ate both MSBP and NSSBP fairly rapidly. The rates of consumption showed the same trend as for the younger calves.

Experiment E

Table 15 shows the mean estimated amount of feed consumed by the first set of 40 dairy cows after 30 minutes and the effect of subsequent addition of barley and fishmeal on the intake in another 30 minutes. Also after 45 minutes the intermixed feeds given to cows in the second group showed that MSBP, NSBP and PLSSBP were equally consumed and USBP was the least consumed.

DISCUSSION

Due to the similarity in treatments and observations in these trials the results will be jointly discussed.

Mikhatsov and Stepanova (1982) in a palatability trial concluded that the rate of feed consumption depended on feed type, its physical structure and palatability. In a similar study, Mathew et al, (1985) emphasized the importance of the reduction of social dominance and familiarizing animals to the pen and feeding procedure to increase feed consumption rate.

As observed from these trials, the relative improved consumption rate of PLSSBP by the sheep in cages to other trials could be related to an earlier 7 days feeding exposure out of cages which supported the

claim of Mathew et al, (1985). Similarly, behaviour of the pregnant gimmers to the feeds other than MSBP could also be associated with previous unfamiliarity with these feeds, but the unique behaviour to MSBP could be related to molasses incorporated into MSBP. The relative faster consumption rate of all SBP products by the caged sheep and dairy cows in the other trials could be suggested to be the resultant effect of intermixing with DG and barley/fishmeal respectively. This agreed with the conclusions of Phipps et al, (1984) and Mathew et al, (1985) and the suggestion of Hemingway, Parkins & Fraser (1986) that the consumption rate of rejected or less palatable feed can be improved by intermixing with another highly acceptable feed. Hemingway, Parkins & Fraser (1986) and the Rowett Evaluation Unit (1978) have reported that MSBP was more palatable than USBP which agreed with these trials. Similarly, Castle (1972) reported that MSBP was a palatable source of carbohydrate for cattle and that when incorporated into a ration the voluntary intake of dry matter was increased.

It could be concluded that factors such as social dominance and allowing for animals adjustment to feeds by gradual introduction are important guides to a successful husbandry system. The inclusion of additives such as salt or molasses to relatively unacceptable feed or their intermixing with highly acceptable feed could improve the total ration palatability and hence increased voluntary intake with a resultant increased production in ruminant livestock farming. It would be unwise to give obviously unpalatable SBP feeds to sheep in late pregnancy without allowing for gradual introduction and initial intermixing with other feeds.

SECTION 2

LIMED SUGAR BEET PULP IN CONCENTRATE FEED SUPPLEMENTS FOR RUMINANT LIVESTOCK

Introduction

The effects of feeding sugar beet products other than the novel limed product as a major concentrate supplement on the yield and composition of milk in lactating dairy cows have been reported by Hemingway, Parkins & Fraser (1986a and 1986b), Parkins, Hemingway & Fraser (1986) and Fishwick & Hemingway (1987). It was concluded by Fishwick & Hemingway (1988) that over 70% of molassed sugar beet product could be fed as a component of the concentrate part of the diet to pregnant and lactating ewes without any detrimental effect on the performance of the ewes and their lambs and that it compared well with high quality dairy cow concentrate. Castle (1972) demonstrated that molassed sugar beet pulp would replace barley on a dry matter basis in concentrate diets for milk production.

With the recent introduction of the addition of lime to improve the extraction of sugar and water from pulp, the effect of the use of the residual limed sugar beet pulp prepared in pellet form as a main concentrate supplement in the diet of pregnant and lactating ewes was worth evaluation.

EXPERIMENT 1

STUDIES ON THE EFFECT OF FEEDING LIMED SUGAR BEET PRODUCT AS A MAJOR COMPONENT OF THE CONCENTRATE FOR PREGNANT AND LACTATING EWES

Introduction

This experiment compares unmolassed limed sugar beet pulp (LSBP) with normal unmolassed sugar beet pulp (USBP) as major components of the diet of lactating ewes suckling twin lambs. It includes a note on the performance of a smaller number of ewes with triplet lambs.

Materials and Methods

Animals and Management

Experiment 1

The seven weeks trial covering 4 weeks pre-partum and 3 weeks post- partum involved a total of thirty-two Greyface ewes of mixed ages mated at grass to Suffolk and Texel rams and expected to lamb in March. Ewe selection from a larger group at mid-pregnancy was based on the result of scanning (ultra-sound machine) which confirmed that they were all carrying at least twins.

About 4 weeks pre-partum, all the ewes were weighed (mean liveweight of about 70 kg) and bled for analyses of blood calcium, phosphorus and magnesium and their body condition was scored. At lambing the ewes were divided into two equal groups of sixteen on the basis of their liveweight, body condition and birth weight, breeding cross and sex of their twin lambs.

At lambing, the ewes and their lambs were placed in individual pens for about 48 hours and both teats were cleared to ensure milk flow. In observed cases of lamb weakness to suckle or mis-mothering, the lambs were aided to suckle colostrum from their dam. Other management procedures suggested by Ducker & Fraser (1973) including dressing of the navel were strictly enforced to avoid neonatal mortality. By the end of the third week post-partum, the ewes and their lambs were re-weighed and the ewe body condition also re-scored. Blood samples were obtained from all the ewes both 2 days and 3 weeks post-partum to determine the calcium, phosphorus and magnesium concentrations.

In addition, a further six ewes confirmed to be carrying triplets in pregnancy were weighed and the body condition was scored a few days to parturition. The ewes were also bled for the determination of calcium, phosphorus and magnesium. Shortly after parturition, the ewes and their lambs were weighed and the ewes body condition were re-scored. All necessary care to ensure the survival of the lambs and the ewes was taken. At the end of the third week, the ewes and their lambs were all re-weighed and the ewes body condition were re-scored.

Feeds and Feeding

At the commencement of the trial, all the thirty-two ewes carrying

twins and the ewes with triplets were group-fed in troughs with 0.6 kg fresh concentrate in two half meals at 08.00 h and 16.00 h per head per day. This was composed of 61.4% limed sugar beet pulp pellets, 30.7% dried wheat dark distillers grains and 7.7% soya bean meal all as fresh matter. The ration was also supplemented with salt (NaCl), vitamins and trace elements. An estimated fresh hay intake of about 1.3 kg/head/day was also given in racks in two half meals at 08.00 h and 16.00 h. Two weeks before parturition, the quantity of the concentrate fed was increased to 0.8 kg/head/day but the hay intake of about 1.3 kg was unaltered.

After grouping of the ewes post-partum, the dietary treatment was changed for one of the groups to a concentrate mixture based on normal unmolassed sugar beet pulp prepared in pellet form whilst the other group continued on their previous diet. Although the proportions of the soya bean meal was altered, the amount of total concentrate given was also increased. The group given the concentrate based on limed sugar beet pulp was group fed in two meals at the usual time (08.00 and 16.00 h) with 1.25 kg in fresh/head/day. This was made up of 57% limed sugar beet pulp prepared in pellets, 29% dried wheat dark distillers grains and 14% soya bean meal (all as fresh matter). The second group were given a dietary regime similar to those of the first group except that the limed sugar beet product was replaced with fresh normal unmolassed sugar beet pulp prepared in pellet form. About 1.3 kg hay (fresh matter) was also fed in two half meals at the usual time of 08.00 h and 16.00 h /head/day. These dietary treatments lasted 3 weeks within which the lambs were solely fed on milk suckled from their respective dams. After the end of the trial, the lambs were creep fed in anticipation to turning them to grass in May.

In the other subsidiary trial with ewes nursing triplet lambs, the six ewes with triplets were given the concentrate ration based on limed sugar beet product at the rate of 1.5 kg fresh matter/head/day at 08.00 and 16.00 h. Fresh hay of about 2.2 kg was also given in two meals at the same time with the concentrate supplement. These feed compositions were the same as those for twin nursing ewes given concentrate based on the limed sugar beet product. The lambs were also creep fed after the end of the third week experiment and later turned to grass.

Feed compositional analyses and the feed allowances for the pre- and post-partum treatments are shown in Tables 1, 2a and 2b.

The metabolisable energy and digestible crude protein of the

Table 1. Composition (g/kg dry matter) and the metabolisable energy (MJ/kg) and digestible crude protein (g/kg) of feeds.

Diets	Hay	USBP	LSBP	DDG	SBM
Dry matter	855	864	888	910	890
Crude protein	102	89	84	337	489
Crude fibre	387	200	194	91	87
Ether extract	10	2	2	45	11
N-free extract	462	646	625	473	341
Ash	39	63	95	54	72
Calcium	3.9	13.8	27.0	1.1	3.9
Phosphorus	1.8	1.0	2.8	8.7	6.3
Magnesium	1.8	1.6	2.2	2.8	3.3
Metabolisable energy	7.4	11.8	11.0	11.5	12.3
Digestible crude protein	56	57	47	224	440

N-free extract - Determined by difference

Table 2a. Amount of feeds given daily pre-partum and the calculated daily intakes of metabolisable energy (ME) and digestible crude protein

Diets	4 weeks pre-partum	2 weeks pre-partum
Hay (kg/DM)	1.11	1.11
Limed sugar beet pulp (kg/DM)	0.33	0.44
Dried dark distillers grains (kg/DM)	0.17	0.22
Soya bean meal (kg/DM)	0.04	0.05
Salt (g)	14	14
Vitamins & trace elements (g)	3	3
Metabolisable energy (MJ)	14.3	16.2
Digestible crude protein (g)	134	155

Daily requirement of metabolisable energy for 70 kg pregnant ewe increases from 11.2 MJME at 4 weeks before lambing to 15.4 MJME at birth including 5% safety margin - MAFF et al (1984).
Daily digestible crude protein requirement for same weight of pregnant ewe at lambing is 124 g - ADAS MAFF (1976).

Table 2b. Amount of feeds given daily post-partum and calculated daily metabolisable energy (ME) and digestible crude protein supplied.

Diets	Normal sugar beet pulp	Limed sugar beet pulp
Hay (kg/DM)	1.11	1.11
Sugar beet pulp (kg/DM)	0.62	0.63
Dried dark distillers grains (kg/DM)	0.33	0.33
Soya bean meal (kg/DM)	0.16	0.16
Salt (NaCl) (g)	12.5	12.5
Vitamins & trace elements (g)	2.9	2.9
Total ME (MJ)	21.3	20.9
Total DCP (g)	241	238

Daily requirement for 70 kg lactating ewe nursing twins

MAFF (1984) - ME = 28.6 MJ

ADAS MAFF (1976) - DCP = 283 g

normal unmolassed and the plain limed sugar beet product and dried dark distillers grain were previously determined with wether sheep in metabolism stalls (Section 1, Experiment 1 and Section 3, Experiment 1). These values were used to calculate for the contributions made by these feeds with respect to metabolisable energy and digestible crude protein allowance for the pregnant ewes with twins of mean total liveweight of 85 kg and lactating ewes of mean liveweight of 70 kg. Similarly, the metabolisable energy and digestible crude protein of soya bean meal was determined from MAFF et al (1984) while the metabolisable energy and the digestible crude protein values of hay were determined from the prediction equations

ME = 17.1 - 0.22 MADF and DCP = 0.91 CP - 36.7 respectively suggested by MAFF (1972).

These feeds were expected to give an ample amount of metabolisable energy before lambing but less than full requirements after lambing. This was to build some stress on the ewes so as to better determine if there was any difference between the dietary treatments. It was anticipated that the ewes would lose liveweight in early lactation to meet the nutrient (milk) requirements of the lambs.

Results

One of the sixteen ewes expected to be given the concentrate based on normal unmolassed sugar beet pulp was found to be suffering from mastitis. The two lambs were then fostered to other dams that gave birth to singles but had enough milk to nurse two lambs. One of these foster ewes was then introduced into the group as a replacement to the ewe with mastitis to complete the desired number of sixteen ewes. One lamb among those whose dam received concentrate based on normal unmolassed sugar beet pulp was very weak at birth and it was kept under intensive care in the adaptor for a week before being released to suckle freely by itself. The daily liveweight gain over the three week period was 200 g, i.e. somewhat less than for the mean growth rate of all the lambs.

The two dietary concentrate supplements based on the sugar beet products could be assumed to be quite palatable as the rate of consumption was less than 20 minutes after serving. The usual disinclination towards the consumption of the sugar beet products other than the molassed sugar beet pulp was not noticed possibly due to

Table 3. Mean ewe and lamb liveweights (kg) and ewe body condition scores

Dietary treatments	USBP	LSBP	SED
Number of ewes	16	16	
Ewe liveweight (kg)			
-2 weeks	84.8	85.6	3.63
0 weeks	70.1	72.5	3.05
+3 weeks	64.0	66.9	2.99
Ewe liveweight change (kg)	-6.1	-5.6	0.95
Ewe body score			
-2 weeks	3.2	3.0	0.18
0 weeks	2.8	2.8	0.23
+3 weeks	2.4	2.3	0.23
Number of lambs	32	32	
Lamb liveweight (kg)			
0 weeks	5.5	5.4	0.25
+3 weeks	10.7	10.7	0.42
Lamb liveweight gain (kg)	5.2	5.3	0.28
Daily liveweight gain (g)	248	252	-

Weeks before (-), at (0), and after (+) lambing.

Table 4. Daily mineral intake and requirements (g) and mean blood mineral level at pre and post-partum.

Intake	Calcium	Phosphorus	Magnesium
Pre-partum (Limed SBP)			
4 weeks	13.6	4.7	3.3
2 weeks	16.7	5.5	3.8
*Requirement at late pregnancy	13.0	8.1	1.4
3 weeks post-partum			
Treatment A (Limed SBP)	22.3	7.6	4.4
Treatment B (Normal SBP)	13.9	6.5	4.4
*Requirement at early lactation	18.2	13.0	3.7
Blood mineral level (m mol/l)			
4 weeks pre-partum	2.23	1.73	0.93
2 days after lambing	2.13	1.74	0.98
3 weeks post-partum (m mol/l)			
Treatment A (Limed SBP)	2.22	1.70	0.93
Treatment B (Normal SBP)	2.23	1.66	0.95
** Normal blood level (m mol/l)	2.30-2.60	1.90-2.60	0.70-1.30

* Values calculated from ARC (1965)
** Underwood (1981)

inter-mixing with other more acceptable and palatable ingredient like soya (Mathews et al, 1985).

The main results regarding mean ewe and lamb liveweight changes are given in Table 3. Ewe mean liveweight loss over the first three weeks of lactation for the ewes given the concentrate based on normal sugar beet pulp was 6.1 kg while the mean loss over the same period was 5.6 kg for those given the dietary concentrate based on limed sugar beet pulp. These represented mean daily losses of 290 g and 267 g respectively. The differing value in mean losses daily (23 g) or over the trial period (0.5 kg) were statistically insignificant. The body condition score also dropped by 0.2 immediately after lambing with respect to the group given normal sugar beet pulp when compared with those given the limed product.

The mean birth weight of the two groups of lambs were virtually the same (5.5 kg normal SBP and 5.4 kg limed SBP) and the mean liveweight gain over the three weeks trial period (5.2 kg normal SBP and 5.3 kg limed SBP). This was an insignificant difference and it only showed that the lambs suckling ewes given the limed product outgrew those suckling ewes given the dietary supplement based on normal sugar beet pulp by 4 g daily. This is reflected in the daily mean weight gain of 248 g and 252 g for lambs suckling ewes given normal unmolassed sugar beet pulp and those suckling the ewes given the limed product respectively.

Intra treatment comparison of lamb mean liveweight changes according to sex showed that the males in the group given the dietary treatment of normal sugar beet pulp gained 0.51 kg over the females for the 3 weeks trial period. Similarly, the males suckling ewes given the diet including limed sugar beet pulp also gained 0.67 kg over the females for the 3 weeks trial period. These differences in liveweight gain between sex within the same treatment were statistically insignificant.

The mean pre and post-partum blood mineral concentrations were within the acceptable normal range (Table 4).

On the whole the ewes milked well and the lambs also grew well in this style of management with neither neonatal mortality or disease for the lambs and the ewes throughout the trial period.

In a comparative study between the ewes with twin and triplet lambs where limed pulp was given throughout, the mean liveweight loss for the triplet and twin nursing ewes were 3.9 kg and 5.6 kg

Table 5. Metabolisable energy (MJ) and digestible crude protein (g) relationship in ewes suckling twin and triplet lambs/day.

	Twins	Triplets
Concentrate intake (kg fresh)	1.25	1.50
Hay intake (kg fresh)	1.30	2.2
Metabolisable energy intake (MJ)	20.9	29.1
Ewe liveweight loss (kg/day)	0.27	0.19
ME from liveweight loss	9.1	6.4
Total effective ME (MJ)	30.0	35.5
Percentage of total effective ME resulting from liveweight loss	30.3	18
Lamb liveweight gain/day (a set)	504	570
Probable milk yield (litre)*	2.52	2.85
Digestible crude protein intake	238	312

* Liveweight gain x 5 (approx).

respectively over the 3 weeks trial period (Table 5). The body condition score at the commencement and end of the trial appeared similar (3.0 and 2.3) for the two groups of ewes.

The mean liveweight gain to 3 weeks was 5.3 kg for each of the twin lambs and 4.0 kg for each of the triplets. This showed that each twin lamb grew better than each of the triplets by about 62 g/day.

Discussion

The mean birthweight and liveweight gains of lambs that suckled ewes given concentrate containing normal unmolassed sugar beet product were 5.5 kg and 5.2 kg respectively. The mean birth weight for those lambs suckling ewes given limed sugar beet product was 5.4 and their total mean liveweight gain over the trial period was 5.3. This represented a daily mean weight gain of 248 g for the normal and 252 g for the limed product. Although the difference was insignificant, it could be assumed that the ewes given diets based on limed sugar beet product produced insignificantly higher milk which resulted in the marginal increase in liveweight gain over the other group of lambs. This could have possibly resulted from the marginal higher mean liveweight of the ewes at the beginning of lactation (Bocquier, Theriez & Brelurut 1987).

According to Hankey & Willis (1982), the size of lambs at birth on subsequent growth rate was more related to the quantity of milk intake than a genetic factor and that a 1.0 kg difference in birthweight could produce a growth rate increase of about 15 g/day before weaning. The effect of birthweight on subsequent growth rate was therefore relatively insignificant as compared to the quantity of colostrum intake at birth and the quantity of milk consumption before weaning. It could then be suggested that the lamb growth rate related directly with the milk yield by the ewe and the quantity of milk consumption by the lambs. This suggestion is in line with the report of Mendez & Shimada (1987) that the stress of restricted suckling could have a depressing effect on the milk yield by the ewe with a resultant growth retardation of the lamb. In their report, Hossamo & Farid (1981) have suggested that decreased feed supplementation below requirements could depress milk yield. In this trial feed supplementations were adequate and the similarity in available nutrient sources from these supplements could have accounted for the insignificant difference in the lamb weight

gain. It could be suggested that if one diet had been better than the other, the ewe liveweight change would have been adversely affected rather than the lamb weight gain since body tissue depletion could be used to meet the extra needed nutrient for the required milk yield for normal growth rate of the lambs.

A better comparison could possibly be drawn from single and twin lambs since milk yield from ewe nursing twins was more than those of singles (Thomson 1983) although the singles grew faster due to more intake of milk (Gibb & Treacher 1982).

According to ADAS MAFF (1976) the digestible crude protein was adequate in rations formulated pre-partum but inadequate during lactation. G eenty (1979) reported that lamb liveweight gain correlated significantly with both protein and solid non-fat contents of milk. With an inadequate protein intake during lactation, it could be suggested that tissue mobilisation of protein would be necessary to meet the milk protein quality necessary for an acceptable growth rate of the lambs. This suggestion agrees with the conclusion of Paulicks & Kirchgessner (1986) that low dietary protein intake could have a marginal effect on the ewe when the body reserve was good provided the duration of under-nutrition is short. This could however be worse if under-nutrition continued for a long time which could lead to decreased feed intake and digestibility with minimal effect on resultant milk composition. Protein malnutrition could possibly adversely affect the ewe rather more than the lambs in this circumstance.

The metabolisable energy allowance for the pre-partum period (Table 2a) was very adequate when compared with the daily requirements suggested by both ARC (1980) and MAFF et al (1975) in which a safety margin of about 5% was included. The allowed daily metabolisable energy for pregnant ewes agreed with the report of Robinson, Smart & Pennie (1979) that the energy allowance suggested by MAFF et al (1975) was insufficient and had resulted in mobilisation of energy from the body tissues of pregnant ewes. A similar observation was reported by Geenty & Sykes (1986) on the inadequacy of the energy requirement suggested by ARC (1980) for lactating ewes and that an increase of 10 - 20% above the suggested daily requirement by ARC (1980) would suffice if the ewes were underfed pre-partum. It could therefore be suggested that the adequacy of energy intake pre-partum by the ewes could have accounted for their being able to withstand the stress of lactation of the experimental period without problem and with minimal loss in body

condition.

Ewes given the dietary treatment based on normal sugar beet pulp lost 0.5 kg more liveweight (although statistically insignificant) when compared with the other dietary treatment based on the limed product. This loss irrespective of the earlier determined higher metabolisable energy value could have resulted from the abrupt change of feed during the trial (Blaxter 1956) and possibly the insignificant differences of the daily energy yield of about 0.3 MJ ME from the feeds in the concentrate mixture to the ewes over the short experimental period. Cowan et al, (1979) and Cowan, Robinson & McDonald (1982) have both concluded that the energy value of liveweight loss was dependant on the relative changes in the total body water and fat and that liveweight change could be regarded as a poor indicator of change in body energy during lactation.

It could therefore be suggested that the energy loss determination during lactation by the use of liveweight changes resulting from nutritional trials may be imprecise. Gomez, Blas & Galvez (1975) and Castellanos & Valencia (1982) have both concluded that there was a high and significant correlation between liveweight loss and milk yield. Hence, it could be concluded that the depleted body tissue was used for milk synthesis. It should however be remembered that in this current experiment only the first three weeks of lactation were recorded. If this period had been extended to further stress the ewes, some of the similarities in the trial could possibly have differed.

The body condition score after lambing was similar (2.8) for both groups of ewes (Table 3). There was however an insignificant reduction of body condition score of 0.1 by the ewes given limed sugar beet product over those on normal unmolassed sugar beet pulp for the 3 weeks lactation period. It could then be suggested that the loss in the ewe body condition was related to their body fat content at parturition (Cowan, Robinson & McDonald 1982).

Gardner & Hegue (1964) have indicated that the energy value of 1 kg liveweight loss of the lactating ewe is 25.5 MJ. The daily mean losses from normal and limed sugar beet dietary treated ewes were respectively 0.29 kg and 0.27 kg. If it could be assumed by analogy with the lactating cow, that the efficiency of conversion of liveweight loss energy for milk production is 0.82 and the efficiency of utilisation of metabolisable energy of milk production is 0.62, it may be calculated (MAFF et al, 1984) that each kg liveweight loss in the

ewe is equivalent to 33.7 MJ dietary ME. The daily liveweight loss in energetic terms in this trial with respect to the ewes given normal unmolassed sugar beet product was 9.8 MJ and 9.1 MJ for those ewes given the limed product. These energy values would have contributed to the daily nutritional requirements for lactation to the lactating ewes.

Blood mineral concentrations

The dietary phosphorus intake was inadequate (MAFF, 1983) pre-partum but the calcium and magnesium were adequate for the two dietary treatments. Calcium was inadequate in lactation for those ewes given the normal sugar beet product while the magnesium was adequate for the two dietary treatments. The blood concentrations with respect to calcium and magnesium were normal but there was a slight drop in blood phosphorus concentrations (Table 4). The drop in phosphorus level could possibly have resulted from insufficient dietary intake and possibly the excess dietary magnesium intake. Generally, the blood mineral concentrations appeared normal possibly resulting from bone mobilisation for those with insufficient dietary supply. Hence for the diet to meet the nutrient requirement for calcium and phosphorus for lactating ewes, normal unmolassed sugar beet pulp would have to be supplemented with both calcium and phosphorus while supplementation of phosphorus only would suffice with respect to limed sugar beet product.

In the comparative studies between the twins and triplets, the mean lamb birth weight and daily mean liveweight gain differed by 600 g and 62 g in favour of the twins. This was in accord with Gallo & Davies (1984) conclusion that twins grew faster than triplets but that the gain of the entire litter was greater for the triplets. The ewes suckled by twins lost 5.6 kg while those suckled by triplets lost 3.9 kg. Also, the body condition score immediately post lambing and at the end of the trial were the same. The relatively same loss in condition by the ewes suckled by triplets and those of twins irrespective of their being subjected to more stress could have resulted from the very adequate dietary intake (Table 5) when compared with the dietary intake of the ewes suckled by set of twins. The metabolisable energy intake of

the ewes suckled by twins was 20.9 MJ ME while that of ewe suckled by triplets was 29.1 MJ ME. This wide disparity in energy intake is not comparable with the differences in the nutrient demand by the lambs between the two groups. It could therefore be concluded that the ewes suckled by twins were under more stress than those of triplets.

Effectively, taking the metabolisable energy from liveweight loss into account, both groups of ewes had 30 MJ ME (twin suckled) and 35 MJ ME (triplet suckled) available for maintenance and milk production. Ewes with triplets made better use of this as the combined lamb growth was 570 g as opposed to 504 g per day with respect to the twins. If the ewes with triplets had received the same amount of feed as the ewes with twins it could be assumed in all probability that the liveweight loss and body condition score could possibly have differed significantly. Extension of the trial period beyond 3 weeks could also have more pronounced effect on the ewe with triplets due to higher milk demand by the ageing lambs.

Conclusion

Since there were insignificant differences in the ewe liveweight loss between the two dietary treatments and the lamb liveweight gain, it could therefore be concluded that the two feeds are equally satisfactory for pregnant and lactating ewes when intermixed with other highly acceptable and palatable feeds.

EXPERIMENT 2

VARIATIONS IN THE PROBABLE INTAKE OF COLOSTRUM BY TWIN LAMBS AND THEIR EARLY GROWTH PERFORMANCE

Introduction

Losses resulting from neonatal mortality of ruminant animals due to hypogammaglobulinemia is one of the major problems of food-animal producing industries (Campbell 1974; Halliday 1974; Langholz et al, 1987). The ingestion and absorption of colostral immunoglobulin (Ig) are very essential within the first 24h (and perhaps the first 8 hours) of neonatal life of ruminants for their survival and well being (Hemming 1976; Hunter, Reneau & Williams, 1977; Karle et al, 1987) as a result of relationship between the maternal and foetal tissues during pregnancy (epitheliochorial plancentation) which barred the transport of maternal antibodies directly to the foetus (Porter 1976). Larson et al (1974), Smith et al (1975) and Porter (1976) reported that IgG is the most important immunoglobulin in conferring passive immunity and that this contributes about 92% of the total immunoglobulin in the colostrum. It is also important to appreciate the importance of the nutrient content of colostrum in very early life and particularly to counteract serious hypothermia.

Faulk (1976), McFarlane (1976), Al-Jawad & Lee (1985) and Mohammed et al, (1988) have also described the effects of colostrum feeding in early life on the conferment of immunity. Examples of subsequent effects of ewe milk yield and composition on the growth of lambs have been described by Vihan and Sahni (1982), and Karle et al (1987).

In this present work the opportunity was taken to assess the colostrum intake of some of the lambs born to the ewes in Experiment 1, Section 2. Zinc Sulphate Turbidity (ZST) measurements were made on the blood serum of the twin lambs (and a few sets of triplets) and associated with such factors as birthweight, breed/cross and the sex of the lambs. Lamb liveweight gain was also followed to three weeks of age as an assessment of ewe milk yield.

Materials and Methods

Feed treatment of ewes

A total of sixteen Greyface ewes of about 70 kg mean liveweight were divided at parturition into two equal groups of 8 and given either limed or normal sugar beet pulp prepared in pellet form. Prior to lambing all the sixteen ewes had been given 1.25 kg fresh concentrate made up of about 60% limed sugar beet product and about 40% dried wheat distillers grain and soya in two meals at about 08.00h and 16.00h per head daily. In addition, 1.3 kg of fresh hay was also given at the same time daily as described in experiment 1.

Lambs and colostral intake

Thirty-two lambs (16 sets of twins) of about 5.3 kg mean birth weight composed of 12 males and 20 females. These consisted of 22 Suffolk and 10 Texel cross breeds produced by the sixteen Greyface ewes earlier mated with both Suffolk and Texel rams. Some of the sets of twins contained both Texel and Suffolk cross breeds.

The lambs were weighed at birth and after 3 weeks of suckling at will. Lambs with problems of either poor mothering ability or weakness to suckle were aided especially in their first day of life to ensure that maximum colostrum was ingested. Other managment procedures as suggested by Ducker & Fraser (1973) which included individual penning of the ewes and their lambs, clearing of their teats and initial holding of the lambs to suckle were carried out so as to ensure the optimum colostral intake by the lambs.

In a comparative trial, six sets of triplet lambs born to six Greyface ewes that were given 1.5 kg fresh concentrate based on limed sugar beet product and 2.2 kg fresh hay/head daily. All treatments and precautionary measures were similar to the trial involving sets of twins as earlier described.

Blood sampling

All the lambs were bled through the jugular vein within 40-48h post first suckling as the serum immunoglobulin status would have attained an optimal concentration (Halliday 1971; Ducker & Fraser 1976; Langholz et al, 1987) before gradually declining to about 6 weeks (Ducker & Fraser 1976).

About 5 ml of the blood samples taken from each lamb was

centrifuged for 15 minutes and about 2 ml of the resultant serum was pipetted into a small bottle, sealed and frozen.

Zinc Sulphate Turbidity test

The zinc sulphate turbidity test (ZST) was performed on the samples by the use of a Corning Colorimeter as described by McEwan et al (1970). This method of estimating immunoglobulin concentration in lamb sera was reported to be accurate by Ducker & McEwan (1972). Fisher & Martinez (1976) had equated a unit of ZST to 0.98 g of immunoglobulin per litre of blood. All resultant values of ZST units from this evaluation were recorded.

RESULTS

The mean liveweight records at birth and end of the third week, the mean weight gain (kg) and the zinc sulphate turbidity (ZST) units for the twin lambs that suckled ewes given the two sugar beet pulp are shown in Table 1. Table 2 also shows the mean zinc sulphate turbidity values (ZST units), and mean birth weight and liveweight gain (kg) to three weeks of lambs irrespective of the dietary treatment of the ewes. The ewe mean liveweight at lambing and changes in weight (kg) three weeks post lambing are shown in Table 3 while Table 4 shows the comparative weight changes (kg) and the zinc sulphate turbidity units between the twin lambs and the triplets.

The mean birth weight of the lambs that subsequently suckled ewes given concentrate feed based on normal sugar beet pulp was 5.4 kg and those lambs suckling ewes given limed sugar beet pulp was 5.2 kg. At the end of the third week, lambs suckling ewes given the concentrate based on normal sugar beet product gained 5.7 kg over the trial period which represented a daily mean liveweight gain of 271 g. The other set of twin lambs gained 5.6 kg over the same period representing a daily mean liveweight gain of 267 g. The differences in the mean liveweight gains were statistically insignificant.

The mean values for zinc sulphate turbidity for all the lambs receiving the two dietary treatments were 27.1 (normal unmolassed pulp) and 25.1 (limed pulp). This difference was not significant. When comparisons between the two dietary treatments were made in respect of male and female lambs of each particular breed (Suffolk cross and Texel cross) (Table 1) no significant differences were apparent. When the zinc sulphate units were regressed to the daily mean liveweight gain of

Table 1. Mean birthweight, weight gain (kg) and ZST units of lambs suckling ewes on sugar beet pulp products.

Mean	Treatment A Normal USBP	Treatment B Limed USBP	SED	Sig
Birthweight	5.4 (16)	5.2 (16)	0.27	NS
Liveweight at 3 weeks	11.1 (16)	10.8 (16)	0.51	NS
Total liveweight gain	5.7 (16)	5.6 (16)	0.09	NS
Daily liveweight gain	0.271 (16)	0.267 (16)	0.0071	NS
All males	0.283 (5)	0.276 (7)	0.0099	NS
All females	0.259 (11)	0.258 (9)	0.0069	NS
All Suffolk cross	0.260 (12)	0.249 (10)	0.0104	NS
All Texel cross	0.282 (4)	0.285 (6)	0.0096	NS
ZST units	27.1 (16)	25.4 (16)	3.60	NS

( ) = Number of lambs under consideration.
ZST = Zinc Sulphate Turbidity Test units.
NS = Statistical insignificant difference.

Table 2. General comparisons of mean Zinc Sulphate Turbidity (ZST) values, birthweight and liveweight changes (kg) between males-females and Texel-Suffolk cross lambs.

	Males	Females	SED		Texel	Suffolk	SED	
n	12	20			10	22		
ZST units	28.1	24.9	3.18	NS	28.1	26.7	2.44	NS
Birthweight	5.5	5.2	0.164	NS	5.4	5.2	0.342	NS
Liveweight at 3 weeks post lambing	11.3	10.7	0.28	*	11.4	10.6	0.349	*
Total weight gain 3 weeks	5.8	5.5	0.142	*	6.0	5.4	0.21	**
Daily liveweight gain	0.274	0.260	0.007	*	0.284	0.259	0.0087	**

n = Number of lambs.
SED = Standard error of the differerence between two means
NS = No significant difference.

Significant difference * P<0.05
** P<0.01

Table 3. Mean liveweight changes (kg) of lactating ewes given different sugar beet pulp products.

	Normal SBP	Limed SBP	SED	
Number of ewes	8	8		
Liveweight at lambing	72.5	72.2	1.74	NS
Liveweight 3 weeks post lambing	66.1	65.7	1.61	NS
Total liveweight loss	6.4	6.5	0.58	NS
Daily liveweight loss	0.31	0.30	0.0348	NS

SBP = Sugar beet pulp.
SED = Standard error of the difference between two means.
NS = No significant difference

Table 4. Comparison of mean birth and liveweight changes (kg) and zinc sulphate turbidity values of set of twins and triplet lambs.

	Twins	Triplets	SED	
Number	16	18		
Birthweight	5.3	4.7	0.41	NS
Liveweight 3 weeks post lambing	11.0	8.7	0.73	***
Total liveweight gained 3 weeks post lambing	5.7	4.0	0.38	***
Daily liveweight gain	0.271	0.190	0.0169	***
Zinc sulphate units	26.3	23.4	1.38	*

ZST = Zinc sulphate turbidity test unit.
SED = Standard error of the difference between two means.
NS = No significant difference

Significant difference
* P<0.05
** P<0.01
*** P<0.001

the lambs suckling ewes on normal unmolassed sugar beet pulp the resultant equation was, y = [illegible] - 0.009 x and for the other dietary treatment (limed product) the equation was y = [illegible] - 0.005 x. There was no significant difference between these two equations, and liveweight gain appeared to be unrelated to birth weight in the circumstances of this experiment. The lack of difference in mean birth weight was not unexpected as all these ewes had received the same diet until the day of lambing and so no difference could really be expected.

However, inspection of the results for all the males compared with all the females and for all the Texel cross lambs compared with all the Suffolk cross lambs indicated larger differences. These are shown in Table 2.

The liveweight differences with respect to the ewes on the two dietary treatments (Table 3) were insignificant. The mean loss in liveweight of the ewes over the 3 weeks period of lactation has been discussed in Experiment 1, Section 2.

In a comparative study involving all the eight sets of twins and six sets of triplets receiving the limed pulp the twins gained about 80 g daily over the triplets and the mean zinc sulphate turbidity measurement was significantly higher ($P < 0.05$) for the set of twins relative to the set of triplets (Table 4).

DISCUSSION

The importance of colostral immunoglobulin on the survival rate of lambs during neonatal life has been well documented. Porter (1976) and Bowry (1984) have reported that immunoglobulin A (IgA) from colostrum was of paramount importance in the survival of lambs from enteropathogens in early neonatal life. The second lamb of ewes producing twins with very limited colostrum is more prone to hypogammoglobulinemia due to the disparity in the lambing time (Hunter, Reneau & Williams 1977) of about 35 minutes between the first and the second lamb in twining. In overcoming some of the problems that could result in infant mortality in the lambs the precautionary measures suggested by Ducker & Fraser (1973) were adopted in this present work. This probably accounted for the excellent survival of these twin lambs. The ewes were also in good body condition and lambing took place in a good hygienic environment.

The mean birth weight of lambs of the two groups of ewes were not different from each other statistically. This could be attributed to

the resultant effect of the same dietary treatment to which the two groups of ewes received prepartum. The total and daily mean liveweight gain of lambs suckling the ewes given the two sugar beet pulp diets were adequate for the system of husbandry and not significantly different. This could have resulted from the intake of adequate colostrum within the first day of life by the lambs (Halliday 1974) as well as adequate intake of milk from the ewes which was the entire source of the liveweight gain of the lambs (Gokaj, Noga & Haxhija 1986; Mendez & Shimada 1987).

Hankey & Willis (1982) have suggested that the size of lambs at birth may influence the subsequent growth rate which was more a function of the capacity of milk intake rather than any genetic cause. It could therefore be assumed that the insignificant difference in weight by the end of the trial period was as a result of the similarity in birth weight of the lambs suckling adequate milk from the ewes on the two dietary treatments. It is possible that differences due to dietary treatments might have been apparent beyond 3 weeks, but by then the lambs were receiving creep feed.

The mean daily liveweight gain with respect to the sex and breeds of lambs suckling ewes given either normal unmolassed sugar beet pulp or the limed sugar beet product were not significantly different from each other (Table 1). These insignificant differences could be related to the similarity in the sera zinc sulphate turbidity test units (Halliday 1971; Harker 1974; McFarlane 1976; Vihan & Sahni 1982; Karle et al 1987; Langholz et al 1987) and, in addition, the adequate milk intake by all the lambs. On the whole, the males grew better than the females and the Texel cross lambs also grew better than the Suffolk cross lambs reared by ewes given the same dietary treatment.

The mean zinc sulphate turbidity measurements differed insignificantly between lambs suckling ewes given normal unmolassed sugar beet pulp and the lambs of the ewes given the limed products (Table 1). The zinc sulphate turbidity values for the male lambs was insignificantly higher than for the female lambs (Table 2). Halliday & Williams (1979) have reported that male lambs have greater efficiency of colostral absorption and subsequently sera zinc sulphate turbidity values. In this trial, the sera zinc sulphate turbidity measurement was higher for the male lambs but not significantly different, possibly as a result of the relatively smaller number of male lambs compared to the females. It could therefore be suggested that the intake of colostrum

by the twin lambs was generally adequate.

The daily mean liveweight gains were significantly higher ($P < 0.05$) for the male lambs relative to the females and for the Texel cross lambs when compared with the Suffolk cross lambs ($P < 0.01$) (Table 2). The possible explanation for this could be that the male lambs and the Texel cross lambs were born stronger than the females and Suffolk cross lambs respectively. This could then suggest that they were able to consume more milk with a better efficiency of conversion of milk to body gain relative to the female and Suffolk lambs.

There was an insignificant difference in liveweight losses between the ewes given the two dietary treatments irrespective of the rather higher determined metabolisable energy value (1MJ/kg DM) for the normal unmolassed sugar beet pulp relative to the limed products (Section 1, Experiment 1 of this thesis). This could have resulted from the very small difference in metabolisable energy value of (0.3 MJ) per day contributed by the sugar beet products that were used in formulating the rations. This amounted to a total metabolisable energy value of (6.3 MJ) over the trial period. It could therefore be suggested that the differing metabolisable energy value was not significant enough to allow for an appreciable difference in loss of body tissues between the ewes within the short experimental period of three weeks.

In the comparative study involving eight sets of twins and six sets of triplets the birthweight was greater for the twins by 0.6 kg and the daily mean liveweight gain by about 80 g over the triplets. The daily mean liveweight gain of twin lambs (0.271 kg) over that of the triplets (0.190 kg) was statistically significant at $P < 0.001$. This significantly differing value in daily mean liveweight gain could be related to the significant difference of ($P < 0.05$) with respect to zinc sulphate turbidity units determined for the two groups of lambs (Harker 1974; Mcfarlane 1976; Al-Jawad & Lees 1985; Karle 1987; Langholz et al 1987). This result was in accord with the report of Gallo & Davies (1984) who concluded that twins grew faster than triplets but the total litter gain was greater for the triplets. Equally important was the higher quantitative milk intake from the ewes before weaning by the twins as compared to the triplets.

Giving feed of adequate nutritional value to ewes from about 8 weeks pre-partum (Khalaf et al, 1979) could influence the immunoglobulin quality in the colostrum and subsequently sera immunoglobulin in the lambs during neonatal life. This however depended

on the time of ingestion and quantity of absorbed colostrum by the gut of the lamb. The quantity of colostrum and milk production by the ewe had been related to the lamb demand (Shubber et al, 1979). It could therefore be concluded that a concentrate feed supplement based on the limed sugar beet product could be fed to pregnant and lactating ewes after intermixing with highly acceptable and palatable feeds. This could result in a qualitative and quantitative colostrum and milk yields by the ewes and subsequently ingested by the lambs for an acceptable health and growth rate.

EXPERIMENT 3

SOME OBSERVATIONS ON THE USE OF LIMED SUGAR BEET PULP AND DRIED WHEAT DARK DISTILLERS GRAINS AS CONCENTRATE FEEDS FOR PREGNANT AND LACTATING BEEF COWS

Losses of calves in early life and slow liveweight gain due to poor feeding and management practices are detrimental to the economic running of suckler cattle enterprises. Correlations of feed intake with milk yield in lactating beef cows have been widely reported. For example, Owen (1983) and Abornev & Pashinin (1987) have both concluded that malnourished lactating cows produced lower milk yield. The ultimate effect of this on the part of the cows was loss in liveweight and a possible reduced daily liveweight gain on the part of their calves. There is the added possibility of a subsequent reduction in conception rate of the cows.

The object of this observation trial was to evaluate the effect of feeding limed sugar beet pulp and dried wheat dark distillers grains as concentrate feed supplements to beef cows in pregnancy and lactation.

Materials and Methods

Animals and Management

A total of eleven pregnant Hereford x Friesian cross beef cows earlier mated with a Charolais bull were used for the trial. Eight of these had earlier been separated from a larger group of spring calvers for this particular feeding due to their poor body condition (about score 2.0). The other three were all in good condition (about score 3.5). All were within about 7 weeks from calving at the commencement of the experiment.

The cows were weighed at the start and at 3 weekly intervals throughout the experimental period.

The pregnant cows calved in individual loose boxes where adequate colostrum intake by the newborn calves and other appropriate husbandry measures were ensured. The calves were weighed at birth, at 3 weeks and 6 weeks of age respectively.

As a result of the spread of calving dates of the cows and their subsequent transfer to grass, after generally about 7 weeks after calving, liveweight recording and blood samples were collected from

Table 1. Mean composition (g/kg DM) of the various feeds.

	Hay	Limed SBP	Wheat Dark Grains
Dry matter	855	888	907
Crude protein	102	84	337
Crude fibre	387	196	9
Ether extract	10	3	47
N-free extract *	462	621	554
Ash	39	96	53
Calcium	3.9	26.6	1.1
Phosphorus	1.8	2.8	9.2
Magnesium	1.8	2.3	2.9
ME MJ/kg DM **	7.4	11.0	11.5
Digestible crude protein	56	47	224

* N-free extract - Determined by difference.
** Metabolisable energy

Table 2. The dietary calcium, phosphorus and magnesium intake (g/day) and the daily mineral requirements in late pregnancy and lactation.

	Calcium	Phosphorus	Magnesium	
Dietary intake pre-calving (Good condition)	41.3	18.5	12.4	
* Requirement in late pregnancy	33.4	33.5	9.4	**
Dietary intake post-calving (All animals)	55.9	25.5	16.2	
* Requirement in early lactation	46.2	42.8	13.8	**

* Value determined for 500 kg cow producing 10 kg milk (ARC 1965).

** Availability taken as being 20%.

only ten of the eleven cows at 3 weeks post partum and from 7 cows at 6 weeks after calving.

Feeds and Feeding

During pregnancy the cows were individually given 5-6 kg fresh hay per day, with 2 or 3 kg fresh concentrate depending on their individual body condition. After calving, all the cows were group fed with a similar amount of fresh hay (6 kg) together with fresh concentrate (3 kg) irrespective of their body condition.

The concentrate was composed of a mixture of equal parts of limed sugar beet pulp and wheat dark distillers grains both in pellet form. There was no mineral supplementation to the concentrate mixture. Solid feed was not made available to the calves throughout the trial period.

Table 1 details the mean composition of the feeds.

Blood Sampling

About 5 ml of blood were obtained through the jugular vein for the determination of calcium, phosphorus and magnesium concentrations.

Results

The cows readily consumed the mixed concentrate without any problem of palatability.

The mean liveweight changes of the cows in pregnancy and to 6 weeks of lactation are detailed in Table 3 together with the analyses of the blood. The mean post calving liveweight was 46 kg less the mean liveweight at the commencement of the trial. This mean liveweight reduction (46 kg) was coincidentally very similar to the mean calf birthweight (43 kg). In the first 6 weeks of lactation the cows lost 8 kg of their liveweight. The mean daily liveweight gain of the calves was 1.1 kg over the 6 weeks trial period.

The total calcium, phosphorus and magnesium intakes from the diets of beef cows ranged from 41-56, 19-26 and 12-16 g per day respectively depending on the quantity of concentrate and hay intake before and after calving. These dietary mineral intakes were achieved without supplementation.

The calcium and magnesium intakes were quite adequate and the blood concentrations of these minerals were also within the normal expected range. Although the phosphorus intake was below the ARC (1965) requirement (Table 2), the blood concentration was still within an

Table 3. Mean liveweight changes of the cows and their calves (kg) and the concentrations of calcium, phosphorus and magnesium (m mol/l) on the blood of the cows.

Weeks before (-) after (+) calving	-7	-5	0	+3	+6
Cow liveweight changes	523	523	477	473	469
Cow liveweight loss	-	-	-	4	8
Calf birthweight	-	-	43	66	89
Calf daily liveweight gain	-	-	-	1.1	1.1
Cow blood concentrations					
Calcium	2.3	2.1	2.1	2.1	2.2
Phosphorus	1.8	1.8	1.7	1.9	1.8
Magnesium	0.73	0.78	0.84	0.86	0.84

0 = 1-2 days post-calving.

- = Not applicable.

acceptable limit.

Discussion

The calculated mean daily intake of metabolisable energy , MAFF et al (1984) and digestible crude protein ADAS, MAFF (1976) by the cows in early lactation were about 67.4 MJ ME and 657 g DCP respectively. The requirements were about 101 MJ ME and 825 g DCP for the cows (475 kg) assuming a milk yield of 10 kg per day.

In the first 6 weeks of lactation, the mean liveweight loss by the cows was 8 kg (Table 3). This loss was lower than expected. A difference of 33 MJ ME between intake and requirement should be represented by a liveweight loss of about 1 kg/day. The difference could have possibly resulted from group rather than individual feeding, extent of gut fill with feed and water at the time of weighing and possibly due to some limited but variable consumption of straw bedding. Other possible but rather inadequate explanations might be
(a) The cows gave less than the assumed mean milk yield of about 10 kg/day calculated as calf liveweight gain x 10. For example, the calves may have utilized the milk very efficiently or the milk might have had a higher than normal fat content.
or (b) The requirement for the cows at 101 MJ ME/day is overstated as it includes a 5% safety margin.

The calcium intake was high in both pregnancy and lactation (Table 2) but this did not result in the elevation of blood calcium concentration. It could be assumed that the excess dietary calcium intake was mobilised to the tissue for deposition or that the apparent calcium availability related to the tissue demand in the trial (Field 1981; Scott & McLean 1981). The excess would therefore be excreted.

The dietary magnesium intake was quite adequate (Table 2) and the blood magnesium concentration throughout the trial was within the acceptable normal range.

On the other hand, the phosphorus intake in both pregnancy and lactation was 15-17 g P less than the requirement (Table 2). In spite of this lower dietary phosphorus intake, the blood P concentration appeared normal (Table 3) throughout the trial. In an earlier experiment with similar housed cows, Bass et al (1981) reported a reduced voluntary straw intake with a phosphorus-inadequate diet (10-12 g P/day) without depraved appetite. Fishwick et al (1974 and 1977) and Fishwick & Hemingway (1989) did not report a reduced voluntary feed

intake or diet digestibility in similar experiments with a supposed inadequate intake of dietary P (12-28 g/day). Equally important was the fact that the inorganic phosphorus concentration in the blood of the cows in these experiments were not below 1.0 m mol/litre, a point considered by Bass et al (1981) at which voluntary feed (straw) consumption may be significantly reduced. In this present experiment, the low dietary intake of inorganic phosphorus did not also have any effect on dietary DM intake and there was no depraved appetite. Should the experiment have lasted longer than 6 weeks, the observations could possibly be different. There was no problem of conception when the cows went to grass with the bull.

The mean liveweight changes of the beef cows and the mean liveweight gain of the calves over the 6 weeks period of lactation and suckling was quite satisfactory for the system of husbandry. It could therefore be concluded that limed sugar beet pulp and dried wheat dark distillers grains intermixed could be given as concentrate feed supplementation to pregnant and lactating beef cows without any undue effect on their performance.

SECTION 3

WHEAT DISTILLERS DARK GRAINS AS A FEED FOR LACTATING DAIRY COWS

Introduction

Of all domesticated farm animals, the dairy cow is probably the most complex in that she can be simultaneously growing, lactating and pregnant. The physiological states in the dairy cow in addition to the complexities of rumen function has confounded attempts to accurately determine nutrient requirements of the dairy cow.

Studies involving the determination of the effects of nutrients on the compositional changes and total milk yield are influenced by factors such as the plane of nutrition, feed preparation and presentation, fibre content and energy density of feed (Rook & Line 1961; MacLeod, Grieve & McMillan 1983; Sutton 1984 and 1986). Phipps et al (1984) suggested that the level of energy concentration was the major factor influencing the performance of dairy cows and that fat was the most variable component of milk affected by dietary changes (Gurr 1985).

With the introduction of compositional quality of milk as one of the main determining factors for milk price by the Milk Marketing Board in 1984, interest has been centred on improving milk constituents (protein and fats) qualitatively and quantitatively. Indeed milk with a fat content lower than 30g/kg may be rejected (Sutton 1986).

Following the distillation of wheat to produce whisky, the spent grains and a thick residual syrup may be combined, dried and pelleted to produce wheat distillers dark grains (DDG). Taylor & Parkins (1989) described the rumen degradabilities and apparent digestibilities of the proximate fractions of DDG together with estimated metabolisable energy (ME) and digestible crude protein (DCP) values.

DDG is clearly a potentially valuable feed for ruminant livestock and the experiments described here detail the results obtained on the yield and composition of milk produced from lactating dairy cows given DDG and compared with a standard dairy compound feed in two separate winter trials.

Materials and Methods

Animals and Experimental Design

Experiment 1

Twenty-four lactating Friesian dairy cows were divided into two equal groups of twelve. Twelve pairs of cows were matched on the basis of yield, date of calving and lactation number and one member of each pair allocated to a group at random. All cows had been calved for at least 50 days and had already attained peak milk yield. Each group was then assigned at random to one of two dietary treatments.

The trial consisted of two periods each of six weeks. In each six week period there was an initial 2 week adjustment time when the cows were acclimatized to the dietary treatments. After the first period the dietary treatments given to the two groups of cows were interchanged.

All cows were recorded every seven days for milk yield and milk samples were taken and analysed for fat and protein content.

Experiment 2

The experimental design was essentially similar to the single changeover of experiment 1. Twenty cows which had been calved for at least 50 days were grouped into 10 pairs of cows based on similarity of milk yield, date of calving and lactation number. One member of each pair was allocated to one of two groups at random. Each group was then assigned at random to one of the two dietary treatments.

The trial consisted of two periods each of three weeks, the first week was allowed for acclimatization to the diet. Treatments were reversed for the second three-week period. All cows were recorded every seven days for milk yield and samples were analysed for fat and protein content.

Dietary treatments

The composition and nutritional values of feeds used in each trial are detailed in Table 1. The basal ration given to all cows in each trial was silage (ad libitum), 6 kg draff and 2 kg sugar beet pulp. This was calculated to supply the nutrient requirements for maintenance and the production of the first 10 litres (M+10) of milk (Table 2). The sugar beet was unmolassed in Experiment 1 (USBP) and molassed in Experiment 2 (MSBP). The nutritional values were very similar.

Table 1. Composition of feeds (g/kg DM) in diets of cows given distillers grains or dairy concentrates in experiments 1 and 2.

	Silage	Draff	MSBP	USBP	DDG	COMP 1	COMP 2
Dry matter	211	263	875	839	950	917	896
Crude protein	124	243	109	89.5	336	216.5	194
Digestible crude protein	77.5	165	76	58	228	175	136
Crude fibre	354	219	139	205	89	71	111
Ether extract	37.2	103.8	2.1	2.4	46	19.8	76
N-free extract	397	400	669	639	479	610	515
Ash	87	34	81	63	50	83	104
RDP	-	-	0.59	0.25	0.57	0.55	0.55
ME MJ/kg DM	10.1	11.8	12.5	12.2	11.5	11.4	10.7

\- Not determined
USBP: Unmolassed sugar beet pulp (expt.1)
MSBP: Molassed sugar beet pulp (expt. 2)
DDG: Dried distillers grains
COMP 1: Dairy concentrate (ESCA; containing no DDG)
COMP 2: Commercial dairy concentrate
ME: Metabolisable Energy
RDP: Rumen Degradable Protein (coefficient)

Table 2. Dietary allowances for cows given either dried distillers grains (DDG) or dairy concentrate (COMP 1).

	Experiment 1			Experiment 2		
Basal Ration						
kg FM	kg DM	MJME	gDCP	kg DM	MJME	gDCP
38 Silage (ad-lib)	8	80.8	620	8	80.8	620
6 Draff	1.58	18.6	261	1.58	18.6	261
2 USBP/MSBP	1.68	20.5	97	1.75	21.8	133
Totals	11.26	119.9	978	11.33	121.2	1014
Requirements for (M+10 1)		113	840		113	840
Treatments						
A 4 DDG	3.8	43.7	866	3.8	43.7	866
Total (M+19)		163.6	1844	Total (M+19)	164.9	1880
B 4 COMP 1	3.7	41.8	642	3.7	41.8	642
Total (M+19)		161.7	1620	Total (M+19)	163	1656
Requirement for (M+19)		158	1290		158	1290

Over 19 litres: both treatment groups given commercial balanced dairy cake (COMP 2) at 0.4 kg/litre.

The experimental treatments given by an electronic out-of-parlour dispenser, were either 4 kg dried wheat distillers grains (DDG) or 4 kg of a specially produced compound concentrate (East of Scotland College Feed Mill) containing no DDG (COMP 1). The basal diet, together with the out of parlour allowance was calculated to supply sufficient ME for M+19 l milk. The nutrient requirements for any milk produced over 19 litres by individual cows in both treatment groups was supplied by the provision of 0.4 kg/l of a commercial compound preparation (BOCM; COMP 2).

Milk recording and analyses

The milk yield of each cow in Experiments 1 and 2 was recorded every seven days. The daily yield of each cow was recorded from the content level of a graduated milk jar (Alfa Laval) after each of two successive milkings at 15.30 and 05.30 h. Samples were taken at each milking and combined for the later analysis of fat and protein content (Scottish Milk Marketing Board Central Testing Laboratory) using an infra-red analysis technique (Milkoscan 300, Foss Electric Ltd.)

Digestibility and rumen degradability of feeds

Three groups each of four wether sheep of mean liveweight 52 kg were used to determine the digestibility of the concentrate feeds DDG, COMP 1 and COMP 2. Results obtained for the digestible crude protein, and ME (based on digestible energy (DE) x 0.81; MAFF et al, 1984) are given in Table 1.

Rumen degradability of the protein (RDP) of DDG, COMP 1 and COMP 2 were determined by suspension of weighed quantities of the material in a dacron-mesh bag in the rumen of rumen-fistulated cows over a 24 h period (Table 1), as described in Section I, experiment 2..

Statistical analyses

Mean yields of milk, milk fat and milk protein were calculated using the combined individual data of the recordings from each cow-pair during weeks three, four, five and six of each treatment period in experiment 1. Mean analyses of fat and protein contents were similarly calculated. For experiment 2, yields of milk, milk fat and milk protein were calculated using the combined data recorded from each cow-pair during weeks two and three of each treatment period. Mean analyses of fat and protein contents were calculated from the same recordings.

Mean values were compared in each experiment using a covariance analyses programme on a microcomputer ('Minitab' 1985, Ryan, Penn State University).

Results

The results from two pairs of cows were eliminated from experiment 1 as a consequence of one member from each pair becoming unwell for reasons which were unrelated to the dietary treatments. All animals remained healthy in experiment 2.

The rations were well consumed in both experiments with very few refusals of either the DDG or COMP 1 being recorded. Refusals which were small, were recorded almost entirely in the first week of each changeover period.

The mean daily milk yield and yields of milk fat and protein for both experiments are given in Table 3. Graphs depicting the mean daily milk yield recorded for each group of cows in each treatment period for experiments 1 and 2 are shown in Figs. 3 and 4 respectively. Mean fat milk yield (kg/d) for each treatment group in experiments 1 and 2 is shown in Figs. 5 and 6 respectively and mean protein yields are similarly depicted in Figs 7 and 8 respectively.

In experiment 1, where there were feeding periods each of six weeks duration, there were no significant differences in the mean daily milk yield recorded being almost identical (22.8 and 22.6 kg/day for COMP 1 and DDG respectively). However, both the composition (g/kg) and mean daily yield of fat tended to be higher on the DDG treatment (40.3 g/kg with 0.92 kg/d fat yield) compared with the standard dairy compound (COMP 1; 38.4 g/kg with 0.87 kg fat/d). These differences were not significant. Mean milk protein yield was identical (0.72 kg/d) but the mean protein concentration in the milk was higher in the DDG treatment (32.0 g/kg) compared with COMP 1 (30.9 g/kg). Individual yields of milk fat and protein were derived from the product of each cow's milk yield (kg/d) and the respective analysis for fat and protein content. (The meaned yields of these constituents do not necessarily arithmetically equate to the simple product of the overall means of the milk yield and the overall content of fat and protein).

In experiment 2, owing to a stricture on the amount of calendar time left available before the dairy herd was due to go to grass, the experimental feeding periods were reduced to three weeks each. The results (Table 3) are the mean values recorded from the combination of

Table 3. Mean yields and composition of the milk of cows given dried distillers grains (DDG) or dairy concentrate (COMP 1).

	Experiment 1			Experiment 2		
	COMP 1	DDG	SED	COMP 1	DDG	SED
Milk yield (kg day]-1])	22.8	22.6	0.94	23.8	23.6	1.06
Fat (g kg]-1])	38.4	40.3	1.12	39.4	41.3	0.95
Fat (kg day]-1])	0.87	0.92	0.054	0.93	0.98	0.043
Protein (g kg]-1])	30.9	32.0	0.71	29.9	30.6*	0.30
Protein (kg day]-1])	0.72	0.72	0.044	0.71	0.72	0.034

SED Standard of error of difference between two means.
* Significant difference $P<0.05$.

Figure 3. The milk yield (kg/d) by lactating dairy cows given either wheat dark distillers grains (DDG) or a high nutritional quality dairy concentrate (COMP 1) over two periods of 6 weeks.

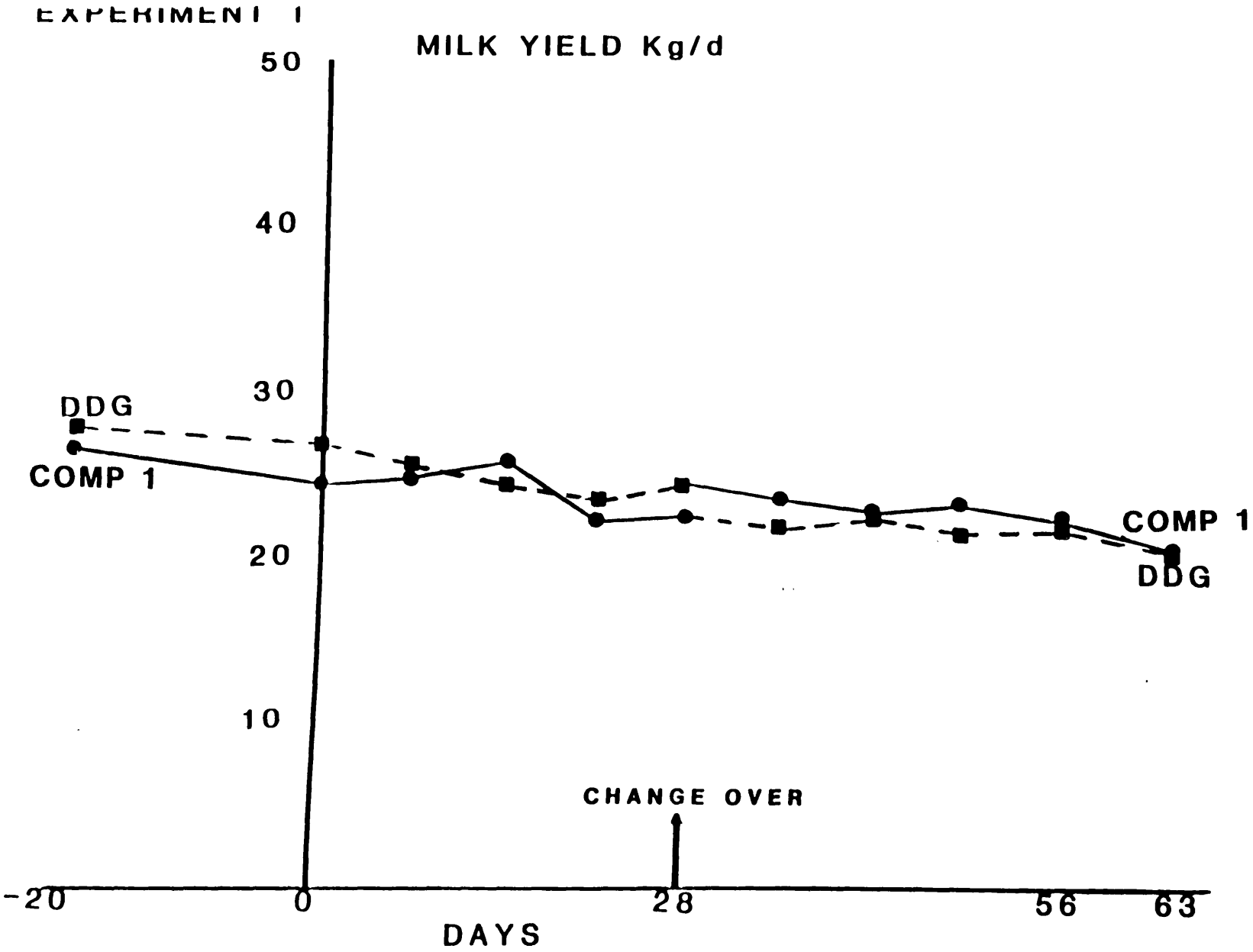

EXPERIMENT 1
MILK YIELD Kg/d
50
40
30
20
10
DDG
COMP 1
COMP 1
DDG
CHANGE OVER
-20
0
28
56
63
DAYS

Figure 4. The milk yield (kg/d) by lactating dairy cows given either wheat dark distillers grains (DDG) or a high nutritional quality dairy concentrate (COMP 1) over two periods of 3 weeks.

EXPERIMENT 2

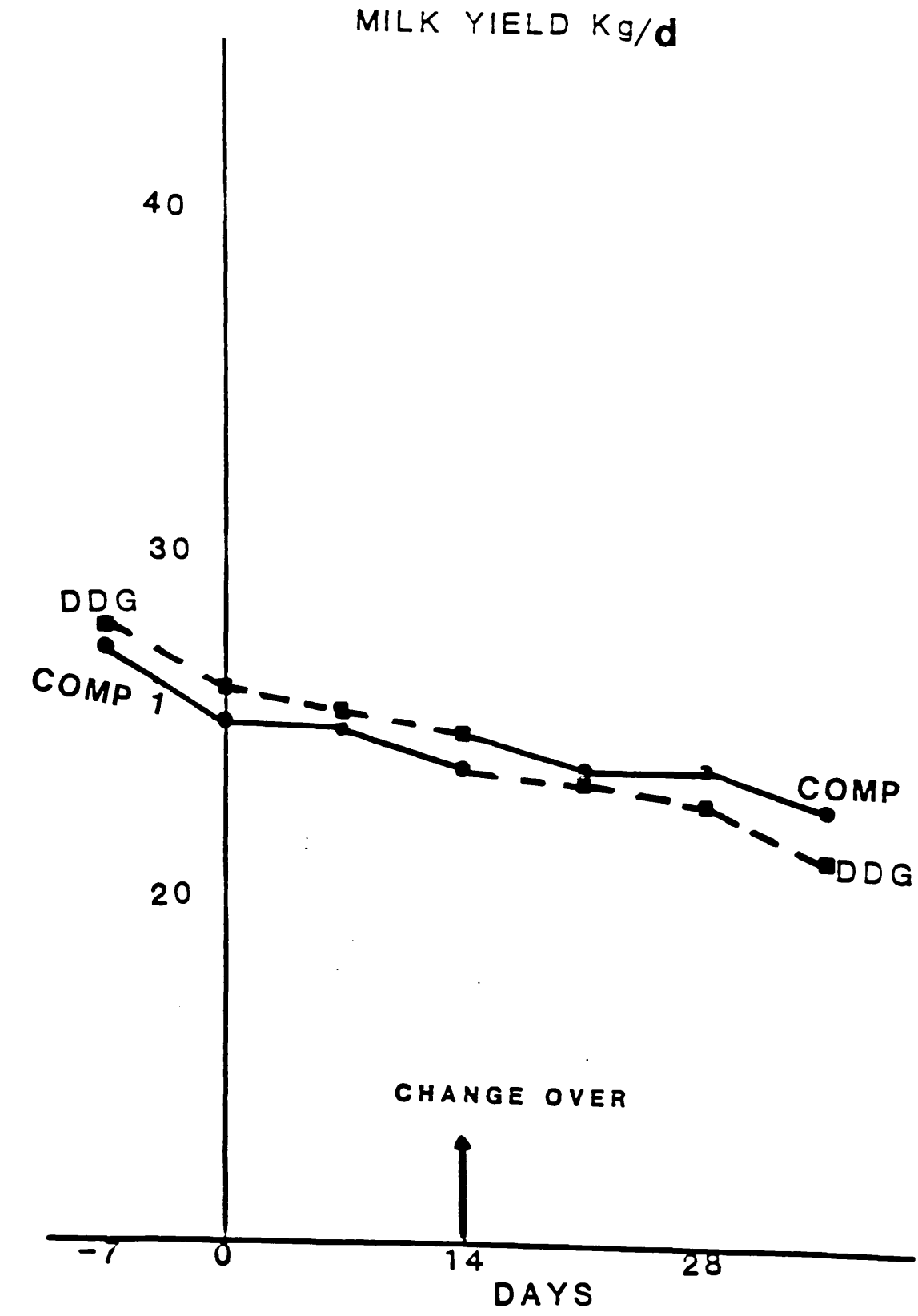


Figure 5. The milk fat yield (kg/d) by lactating dairy cows given either wheat dark distillers grains (DDG) or a high nutritional quality dairy concentrate (COMP 1) over two periods of 6 weeks.

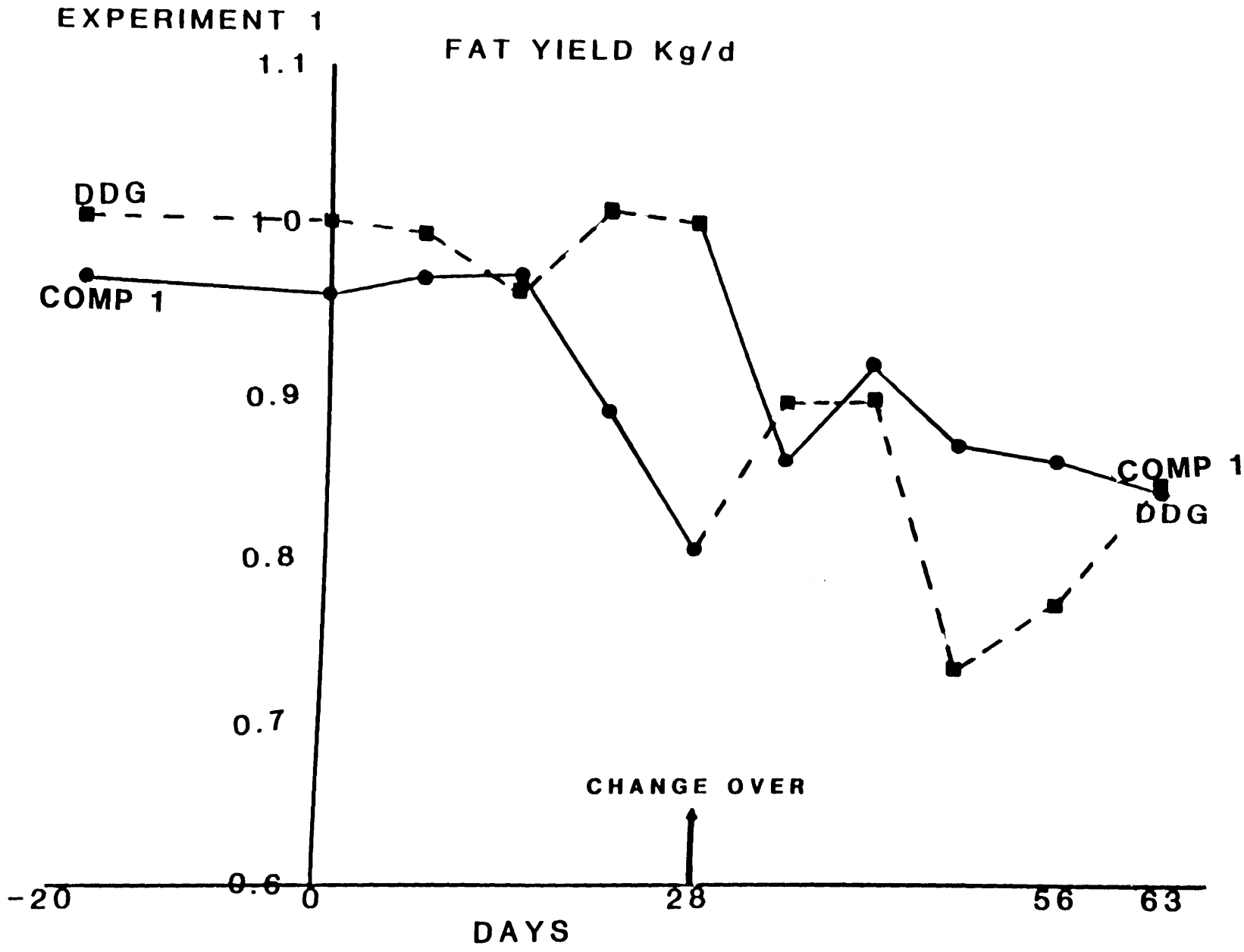

EXPERIMENT 1
FAT YIELD Kg/d
1.1
1.0
0.9
0.8
0.7
0.6
DDG
COMP 1
COMP 1
DDG
CHANGE OVER
-20
0
28
56
63
DAYS

Figure 6. The milk fat yield (kg/d) by lactating dairy cows given either wheat dark distillers grains (DDG) or a high nutritional quality dairy concentrate (COMP 1) over two periods of 3 weeks.

EXPERIMENT 2

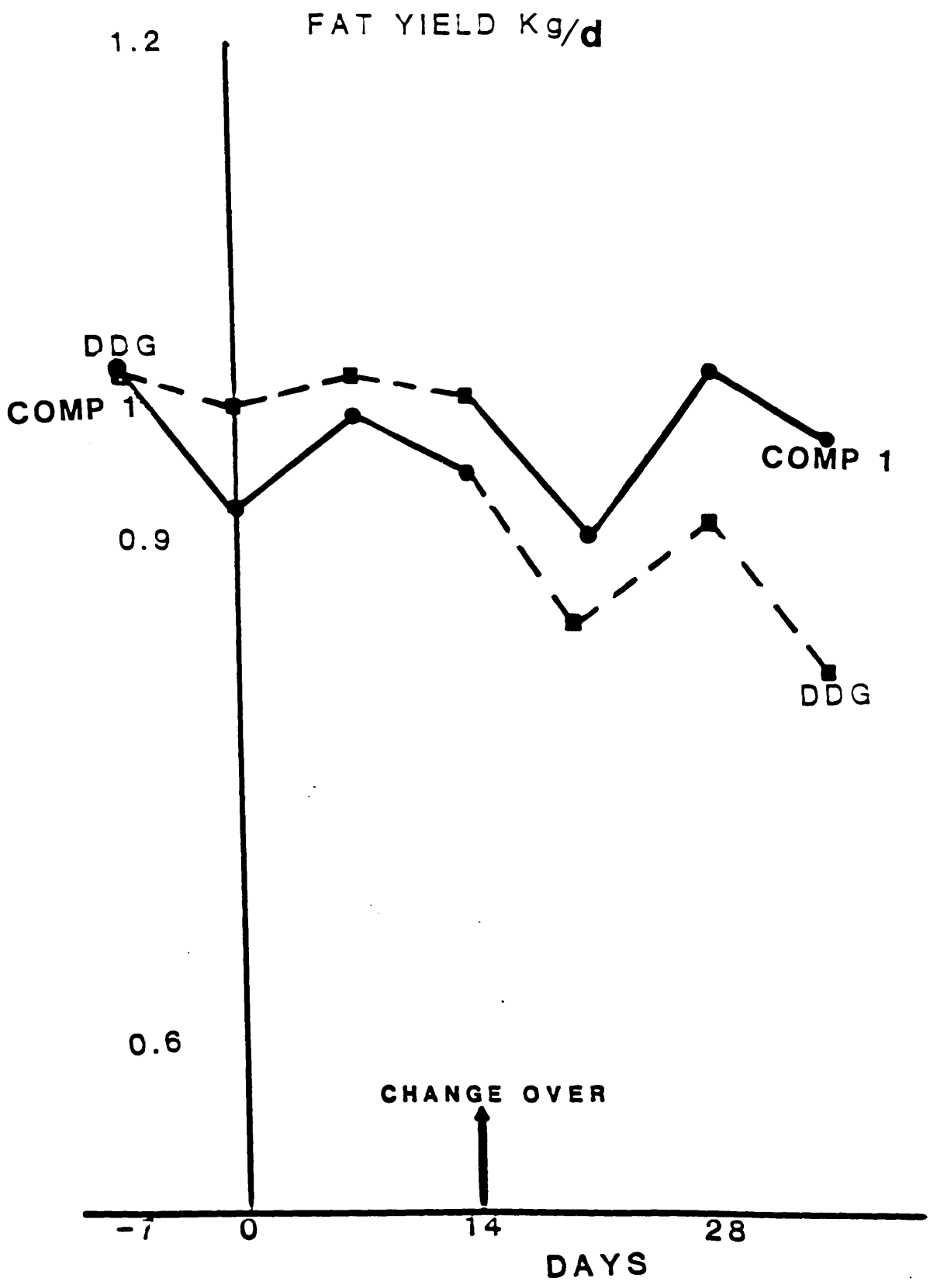


Figure 7. The milk protein yield (kg/d) by lactating dairy cows given either wheat dark distillers grains (DDG) or a high nutritional quality dairy concentrate (COMP 1) over two periods of 6 weeks.

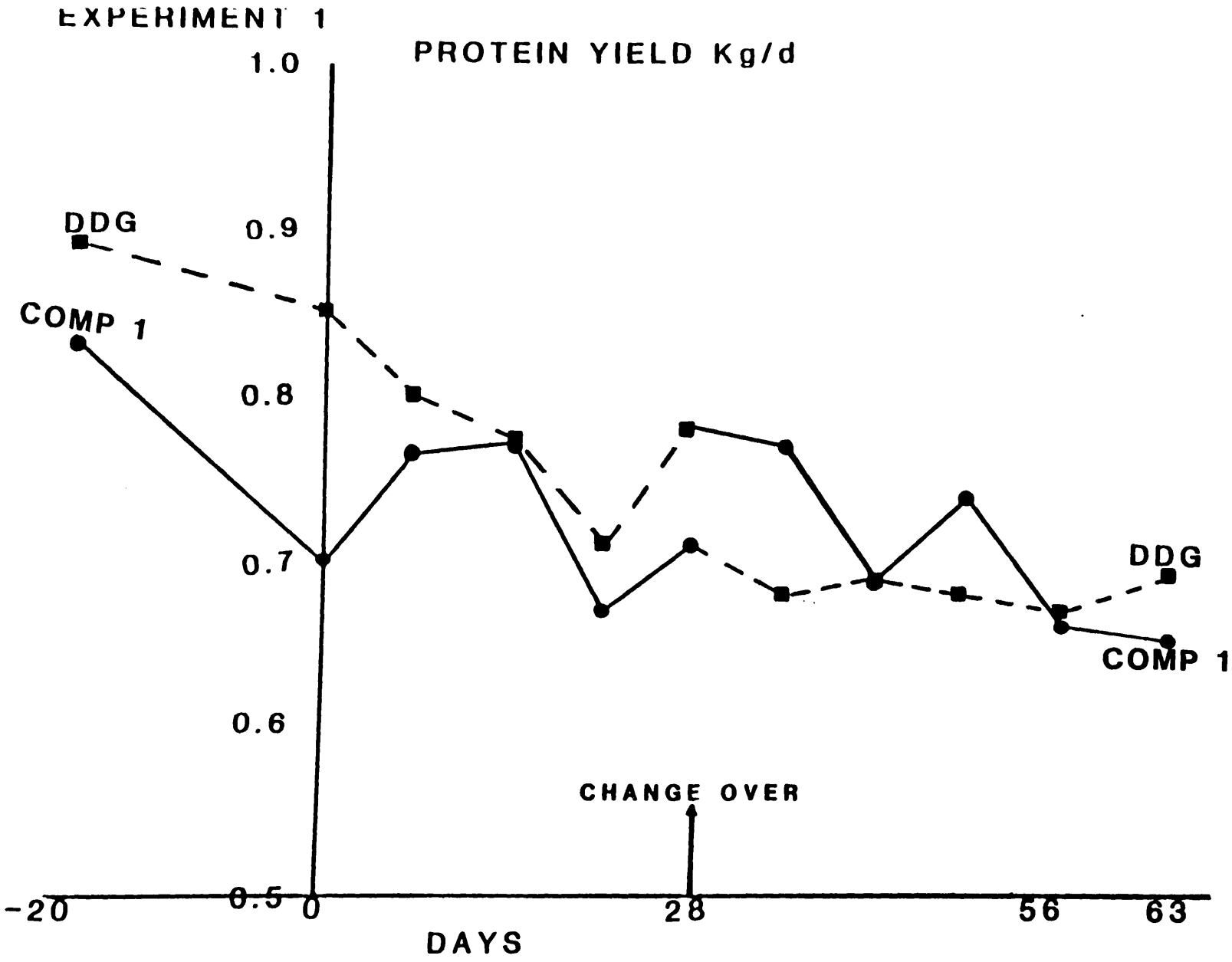
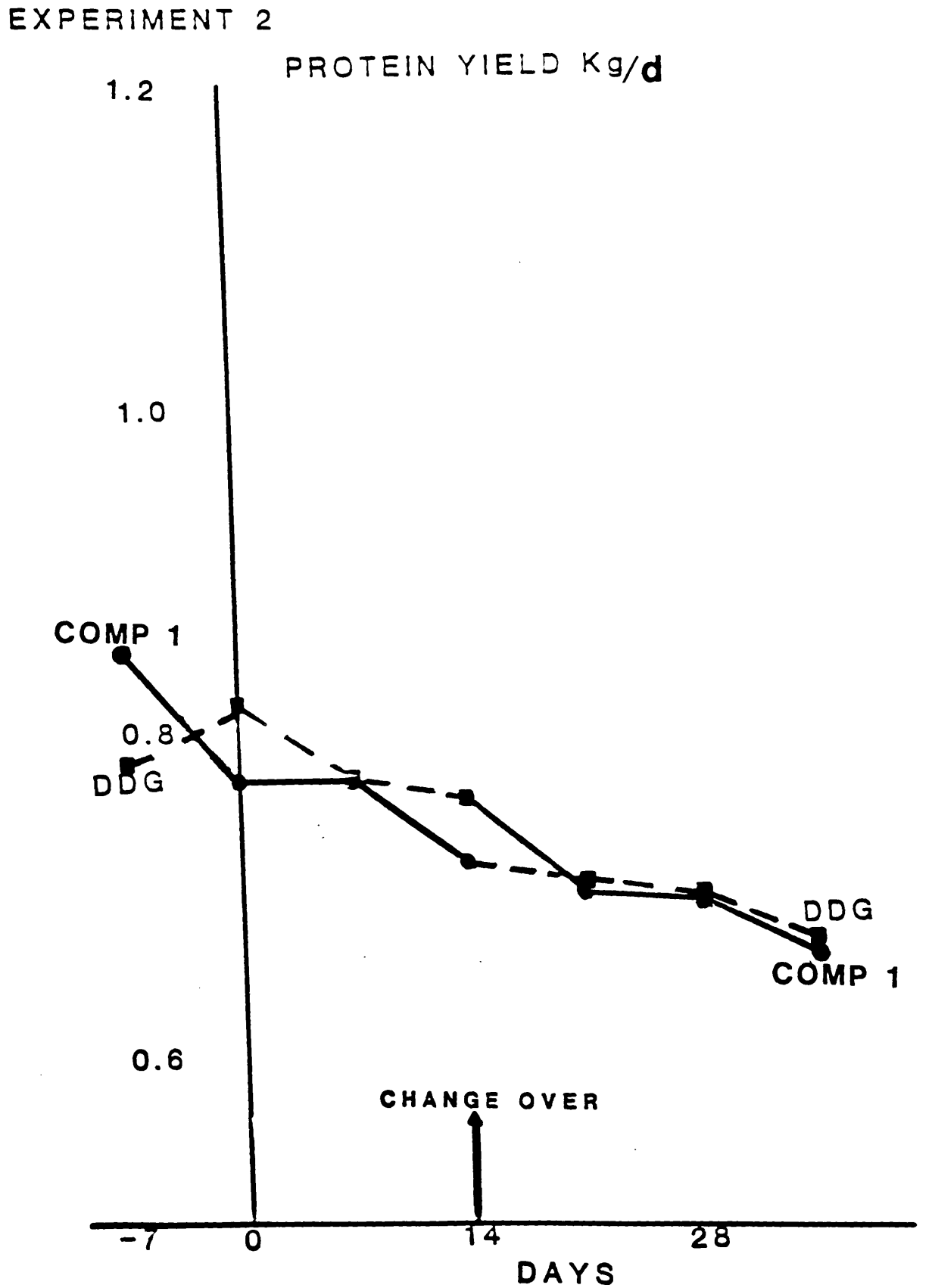

EXPERIMENT 1
PROTEIN YIELD Kg/d
1.0
0.9
0.8
0.7
0.6
0.5
DDG
COMP 1
DDG
COMP 1
CHANGE OVER
-20
0
28
56
63
DAYS

Figure 8. The milk protein yield (kg/d) by lactating dairy cows given either wheat dark distillers grains (DDG) or a high nutritional quality dairy concentrate (COMP 1) over two periods of 3 weeks.


EXPERIMENT 2
PROTEIN YIELD Kg/d
1.2
1.0
0.8
0.6
COMP 1
DDG
DDG
COMP 1
CHANGE OVER
-7
0
14
28
DAYS

results from the last two weeks in each period (compared with four weeks in experiment 1).

The results are very similar to those of experiment 1. Mean milk yields for each treatment was very similar (23.8 and 23.6 kg/d for COMP 1 and DDG respectively) and again the mean milk fat content and daily yield was higher for DDG (41.3 g/kg and 0.98 kg/d) than for the standard COMP 1 (39.4 g/kg and 0.93 kg/d). These differences were not significant. A significantly higher milk protein concentration (30.6 vs. 29.9 g/kg) in the DDG treatment periods was not reflected in an increased daily yield of protein (0.72 and 0.71 kg for DDG and COMP 1 respectively).

Discussion

According to Rook & Thomas (1980) and Johnson (1983), fat was considered to be the most variable milk constituent when dietary changes occurred. The extent of variation was dependent on the total fibre content in the ration (Sutton 1984, 1986 and Olson 1984). Lactose and milk mineral contents are relatively constant with stage of lactation (Rook & Campling 1965) and lactose was the main factor affecting the osmotic pressure of milk (Crabtree 1984) except in malnourished cows (Gurr 1985).

The rumen degradable protein (RDP) and the undegradable dietary protein (UDP) contents of the two dietary treatments here are more than that required and the possible effect of this on milk yield had been widely reported. ARC (1980), Sloan & Rowlinson (1984), Oldham (1984), Murphy & Kennelly 1986 and Murphy et al (1986a and 1986b) reported an increase in feed digestibility of diets of adequate RDP with a resultant increased dry matter intake. This agreed with Gordon (1979) and Mertens & Ely (1980) in which there was an excess intake of dietary protein. Hunter and Rowlinson (1981) also concluded that an excess dietary protein intake could result in improvement of milk yield without any apparent effect on milk fat and solid non-fat milk (SNF). It could be suggested that the RDP and the excess total dietary protein intake contributed to the total energy intake of the cows. Evans (1960) and Rook & Line (1961) had earlier reported that increased milk yield from an increased protein intake could essentially be an energy effect. The difference here between mean milk fat yield (kg/day) were similar in each treatment and possibly due to dietary crude fibre intake also being similar. However the milk protein increase in the DDG treatment

compared with the COMP 1 treatment observed in Experiment 2 is difficult to relate to a dietary cause.

Calculated ME values (derived from determined DE values) for the DDG and the dairy compound, COMP 1 are almost identical at 11.5 and 11.4 MJME/kg DM respectively (Table 1). The value of the commercial concentrate (COMP 2) used to supply nutrients for milk produced over 19 litres was lower at 10.7 MJME/kg DM. COMP 1 was specially prepared and manufactured so as not to contain any distillery byproducts, and was composed of mixed cereals and soya bean meal. The determined digestible crude protein (DCP) contents for DDG, COMP 1 and COMP 2 were 228, 175 and 136 g/kg respectively. Accordingly, for the dietary treatments compiled for M+19 litres of milk in both experiments 1 and 2 there was an apparent excess of DCP of 350 and 550 g for the COMP 1 and DDG treatments respectively. Much of this (261 g DCP) was derived from the supply of 6 kg fresh matter of malt draff in the basal ration. The supply of ME (Table 2) however adequately met the suggested requirements for M+19 litres of milk (MAFF et al, 1984) and the proportion of forage roughage in the ration (as a substrate for milk fat synthesis) was not limiting.

These two experiments showed that in the circumstances where medium quality ad-lib silage together with 6 kg malt draff and 2 kg SBP are on offer for the provision of nutrients in a basal ration designed to meet the requirements for M+10 litres of milk, 4 kg DDG fully replaced 4 kg high nutritional-quality dairy concentrate with respect to milk yield and there was a tendency towards increased milk fat and protein concentrations.

Surplus protein was present in both treatments and further work is needed to examine the potential contribution of the RDP and UDP from DDG in rations for lactating dairy cows in circumstances where protein supply may be limited.

GENERAL CONCLUSIONS

Most produce from arable farming undergoes one form of processing and preparatory method or another before being presented for human consumption. As a result, some waste products or residues are inevitable and these could be used for feeding of livestock especially ruminants that have the capability to better digest fibre.

Apart from the experiments in this thesis which evaluated the nutritive qualities and values of two novel agro-industrial by-products, limed sugar beet pulp and wheat dark distillers grains, the procedures could serve as guides to the process of feed evaluation especially in the developing countries where waste products of considerable variety could be commonly found. It was concluded that both novel feeds were good as feed supplements for ruminants without any undesirable effects and that if both were combined, they compared well with highly nutritional quality concentrate feeds. Hence, their use is cost effective and could result in an increased profit margin in various ruminant livestock enterprises.

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APPENDIX

ANALYTICAL PROCEDURE USED FOR CHEMICAL ANALYSIS

All the analytical methods used were established procedures.

Dry matter

The dry matter (DM) of feed and faecal samples was determined by heating quantities (usually 0.5 to approximately 1.0 kg) in a hot air oven at about 90-95 °C for 48h until a constant weight was attained.

Ash

The ash content of samples was determined by ignition at 550 °C in a muffle furnace for at least four hours.

Gross energy

The gross energy of feed and faecal samples was measured by combustion in a Gallenkamp Adiabatic Bomb Calorimeter.

Ether extract and Crude fibre

The ether extract and crude fibre contents of feed and faecal samples were determined by normal standard methods (The Fertilizer and Feeding Stuff Regulations 1976),

Total nitrogen

The crude protein (NX 6.25) in feed and faecal samples was determined using an automatic Kjeldahl technique (Kjel-foss Automatic 16210). Fresh faecal nitrogen was determined following maceration of faecal samples with distilled water and a small amount of toluene (Grassland Research Institute (C.A.B, 1961).

Calcium and magnesium

The calcium and magnesium contents of feed, faecal samples and blood were determined by Atomic absorption spectrophotometry (Perkin-Elmer, 1976).

Phosphorus

Phosphorus in feed and faecal samples was determined by a modification of the Colorimetric method of Cavell (1955). Blood phosphorus was determined by Colorimetric method of Fiske and Subbarow (1925).

Copper

The copper content of feed and faecal samples was determined colorimetrically following acid digestion by means of Zinc dibenzyldithiocarbonate (Brown and Hemingway, 1962).