

THE NUTRITION OF THE EARLY-WEANED CALF

II. A COMPARISON OF COMMERCIAL GROUNDNUT MEAL, HEAT-TREATED GROUNDNUT MEAL AND FISH MEAL AS THE MAJOR PROTEIN SOURCE IN THE DIET.

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In a previous communication (Preston *et al.*, 1960) we reported no difference in nitrogen retention between calves given diets containing either 15% groundnut meal or 10% groundnut meal and 5% white fish meal. In a concurrent feeding trial using similar diets there was no difference in live-weight gain from 3 days to 84 days of age although increase in height at withers and food conversion ratio were significantly better for the diet containing white fish meal. These experiments can be criticised, however, on the ground that (a) the substitution of 5% white fish meal for groundnut meal altered the quality of only 20% of the total nitrogen in the diet; and (b) the level of crude protein in the diet was only slightly below that required to promote maximum nitrogen retention when groundnut meal alone was the major protein source in a diet given at a level of 8% of metabolic body weight (Whitelaw, Preston and Ndumbe, 1961). The fact that the ratio of protein to energy in the control diet was near optimum means that any attempt to increase the nutritive value of the protein by reducing its solubility (Chalmers, Cuthbertson and Synge, 1954), or by improving its biological value, would have only a marginal effect on nitrogen storage since any increase in the amount of nitrogen absorbed as amino acid would be surplus to the animal's requirement and would be deaminated and excreted in the urine.

The following experiment was designed to investigate further the relative value of fish meal and groundnut meal for early-weaned calves. The importance of the solubility of the nitrogen source was also studied by comparing two groundnut meals which had received different degrees of heat treatment during processing.

MATERIAL AND METHODS

Calves

Six early-weaned Ayrshire bull calves approximately 80 days old and weighing on average 70 kg. were used.

Diets

Three protein sources were compared at concentrations equivalent to approximately 43% of the total nitrogen of the diet. The ratio of crude protein to starch equivalent in all diets was 1:4.4 which, in relation to the previously determined optimum of 1:3.8 (Whitelaw, Preston and Ndumbe, 1961), was thought to be sufficiently wide for differences in protein quality to be detected.

The protein sources were: (a) A commercial decorticated extracted groundnut meal of high solubility (processing unknown) hereafter referred to as the 'control' groundnut meal. (b) A decorticated hexane-extracted groundnut meal from which the solvent had been removed by heating initially to 80–90° C. for 20 minutes followed by the addition of 'live' steam for 5 minutes. The temperature was then raised to 110° C. for 30 minutes and maintained at 100° C. for a further 24 hours. This treatment was thought to be sufficient to cause appreciable denaturation of the protein. (c) A Peruvian fish meal (processing unknown). The 'available lysine' content of this sample was 7.0 g. per 16 g. nitrogen, indicating that the sample was of high quality (Carpenter *et al.*, 1957).

TABLE 1
Composition of diets (%)

	A (Control groundnut)	B (Heat-treated groundnut)	C (Fish meal)
Flaked maize	40.0	40.0	40.0
Oats	20.7	19.6	26.2
Molassine meal†	13.0	13.0	13.0
Grass meal	9.0	9.0	9.0
Ext. dec. groundnut meal	14.0	—	—
Heat treated ext. dec. groundnut meal	—	15.0	—
Peruvian fish meal	—	—	10.0
Ground limestone	0.80	0.86	0.20
Dicalcium phosphate	1.25	1.29	0.35
Salt	0.5	0.5	0.5
Vit. A and D supplement‡	0.5	0.5	0.5
Antibiotic supplement§	0.25	0.25	0.25

† Contains 75% molasses and 25% sphagnum moss (Molassine Co. Ltd., Greenwich, London, S.E.10).

‡ Contains 1000 i.u. vitamin A and 200 i.u. vitamin D per g.

§ Contains 7.9 mg. chlortetracycline per g.

The compositions of the diets are given in Table 1 and their proximate analyses in Table 2. The solubilities of the total nitrogen in the diets and in the test proteins are also given in Table 2. The calves' requirements for calcium and phosphorus (Loosli *et al.*, 1958) were met by adding appropriate amounts of limestone and dicalcium phosphate to each diet. Preparation of the diets and feeding levels were as described in an earlier paper (Preston *et al.*, 1960). Feeding was at the daily rate of 8% of the 'metabolic body weight' ($W^{.74}$) based on the live weight of the calf at 7 a.m. prior to feeding on the first day of each preliminary period. Times of feeding were 7 a.m. and 7 p.m.

Design

Allocation of the calves to the diets was decided according to two 3×3 Latin squares. The calves were given each diet in turn for a period of 11 days of which the first 5 days served as a preliminary feeding period and the second 5 days for collection of faeces and urine. On the eleventh day,

venous blood samples for urea estimation were withdrawn at hourly intervals over a period of 12 hours according to the procedure outlined by Preston and Ndumbe (1961). The metabolism cages and sampling procedures for urine and faeces have been described previously (Preston *et al.*, 1960).

Analytical techniques

Nitrogen was determined by the macro-kjeldahl procedure. Protein solubility was determined by shaking three-gramme samples with 100 ml.

TABLE 2

Proximate analysis of diets (% of dry matter) and details of nitrogen solubilities

	A (Control groundnut)	B (Heat-treated groundnut)	C (Fish meal)
Crude protein	16.94	16.38	16.31
Nitrogen-free extractives	68.07	68.41	67.84
Ether extract	3.65	3.62	4.71
Crude fibre	5.00	5.51	5.51
Ash	6.34	6.08	5.63
Solubility of nitrogen in protein sources (%)	83.8	65.8	13.6
Solubility of total nitrogen in diet (%)	47.6	39.6	17.6
% of total nitrogen derived from protein source	46.0	43.6	41.8

M. NaCl for 3 hours, filtering through Whatman No. 4 filter paper and determining the nitrogen content of the filtrate. 'Available' lysine was determined by the procedure of Carpenter *et al.* (1957) with modifications suggested by Ellinger, (1960, personal communication). Urea was determined on 0.2 ml. samples of whole blood by the method of Conway (1957).

RESULTS

Nitrogen balance data, digestibility coefficients, blood urea concentrations and live-weight gains relating to the three diets are given in Table 3. All values represent the means for 6 calves; the figures for blood urea were calculated from values which were themselves the means of 12 consecutive hourly samples. The variation in blood urea concentration on the three diets over the 12 hour period following the 7 a.m. feed is illustrated in Figure 1.

Nitrogen retention expressed either as a percentage of intake, in g./day or in g./W^{0.75}/day, was highest on the fish meal diet and least on the control groundnut. Differences between diets were highly significant. The same was true for live-weight gain. Urinary nitrogen also differed significantly between diets, being least on fish meal and highest on control groundnut. For all these measurements heat-treated groundnut gave intermediate values, although there was a tendency for these to be closer to the values obtained with the control groundnut than to those obtained with the fish meal. This trend was even more apparent in the data for blood urea concentration; fish meal gave a significantly lower value than either of the two groundnuts but the difference between the groundnuts was not significant.

Faecal nitrogen did not differ significantly between the two groundnut diets but was significantly less on fish meal than on the other two diets. This difference was reflected in a slightly higher apparent digestibility of nitrogen

TABLE 3

Nitrogen balance data, digestibility coefficients, blood urea concentrations and live weight gains for calves given diets containing control groundnut meal, heat-treated groundnut meal or fish meal

	A (Control groundnut)	B (Heat- treated groundnut)	C (Fish meal)	S.E. differences	Level of significance of treatment differences
Nitrogen retention (g./day)	17.2	18.9	21.6	±0.7	P<0.001
Nitrogen retention (g./W ^{0.74} /day)	0.69	0.77	0.88	±0.03	P<0.001
Nitrogen retention (% of dietary N)	38.0	43.0	51.0	±1.5	P<0.001
Urinary nitrogen excretion (g./W ^{0.74} /day)	0.61	0.52	0.40	±0.02	P<0.001
Faecal nitrogen excretion (g./W ^{0.74} /day)	0.50	0.49	0.46	±0.011	P<0.01
Apparent nitrogen digestibility (%)	72.0	72.2	73.7	±0.64	N.S. (P<0.1)
Dry-matter digestibility (%)	73.0	73.0	74.0	±1.2	N.S.
Mean blood urea concentration (mg./100 ml.)	16.0	14.9	12.6	±1.1	P<0.05
Weight gain (g./day)	363	442	636	±39	P<0.001

on the fish meal diet. There were no significant differences between diets in digestibility of dry matter.

There was no significant evidence of first order carry-over effects of treatments in one period on results in the subsequent period. Significant differences between animals were found in urinary nitrogen (P<0.05), faecal nitrogen (P<0.05) and apparent digestibility of nitrogen (P<0.05).

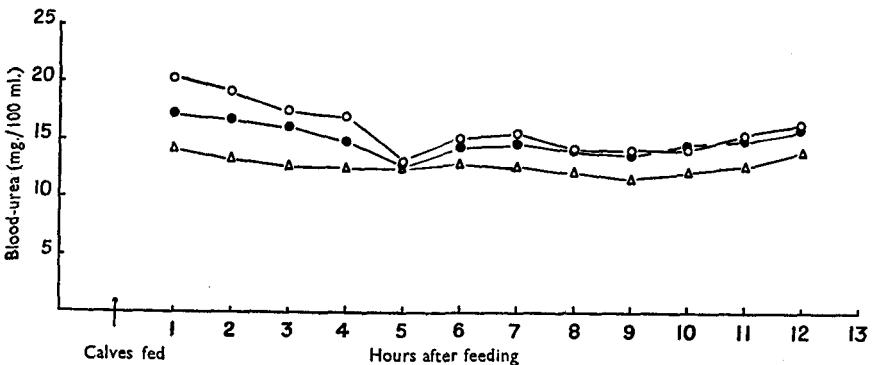


FIG. 1. Mean blood-urea concentrations at hourly intervals after feeding, for six calves fed diets containing control groundnut ○, heat-treated groundnut ● and fish meal △ as major protein sources.

DISCUSSION

The results obtained in this experiment differ from those reported previously (Preston *et al.*, 1960) in that substitution of groundnut by fish meal brought about a significant increase in nitrogen retention and in live-weight gain. This difference may have been due to the lower levels of protein or to

the higher rate of replacement (40% of total nitrogen compared with 19% in the previous experiment) or to both of these factors. It is worth noting that the values obtained for nitrogen retention as a percentage of intake or as $g./W^{.74}/day$ on the fish meal diet are greater than any we have recorded previously (Whitelaw, Preston and Ndumbe, 1961; Preston *et al.*, 1960). The figure for percentage retention on fish meal (51%) is in fact of an order more frequently encountered with growing pigs (Jones, Hepburn and Boyne, 1961) than with ruminants. It is interesting to note that the differences between diets in nitrogen retention were reflected in the live-weight gains.

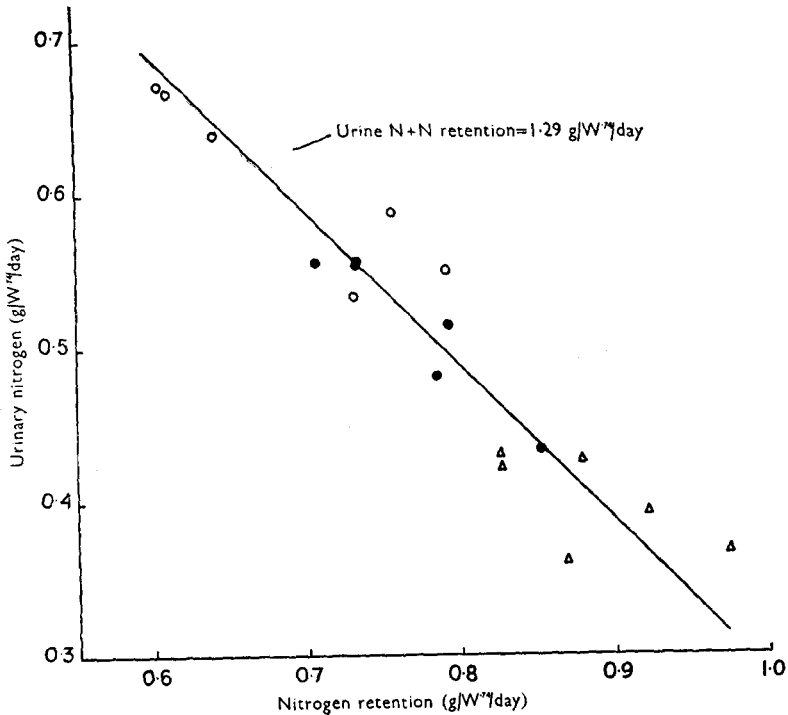


FIG. 2. Relation between urinary nitrogen excretion and nitrogen retention on diets containing control groundnut ○, heat-treated groundnut ● and fish meal △ as major protein sources.

Differences in nitrogen utilisation between protein sources were due almost entirely to differential losses of nitrogen in the urine; only slight differences were observed in faecal nitrogen excretion. The relationship between urinary nitrogen excretion and nitrogen retention is such that when the sum of these two quantities is analysed no significant differences exist between treatments, i.e. Urinary N+N retention = a constant. This is illustrated in Figure 2. The overall mean value for the constant is $1.29 g./W^{.74}/day$ with a residual coefficient of variation of 1.6%.

It is evident that there is a real difference in nutritive value between the protein of fish meal and that of groundnut when fed as supplements in high carbohydrate early-weaning diets. This superiority of the fish meal

could be due to its better amino acid balance or to its lower solubility relative to the groundnut meals. Since there were significant differences in nitrogen retention between the two groundnut meals it would appear that solubility is an important factor in determining the value of protein to ruminating calves. On the other hand, the two groundnut meals were not of the same origin and might well have differed in factors other than their solubility.

The beneficial effect of rendering a protein less soluble is thought to be due to the reduction in nitrogen wastage by limiting the extent of protein hydrolysis and subsequent ammonia production in the rumen (Chalmers,

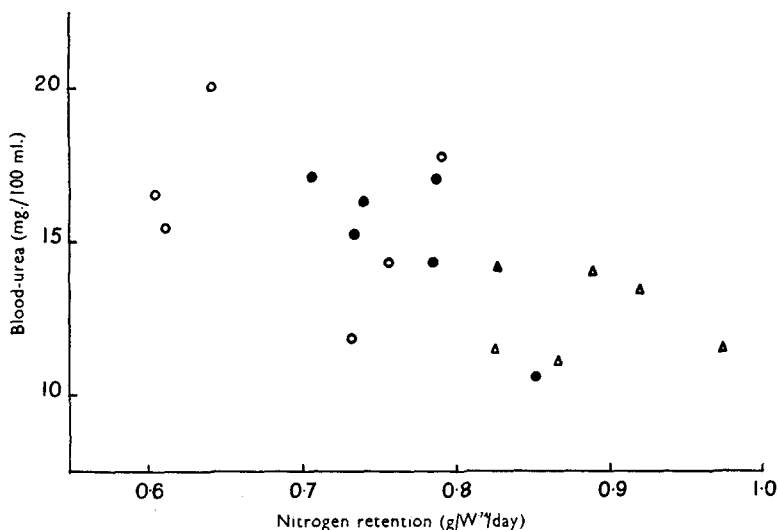


FIG. 3. Relation between mean hourly blood-urea concentration and nitrogen retention for diets containing control groundnut ○, heat-treated groundnut ● and fish meal △ as major protein sources.

Cuthbertson and Syngé, 1954). Since peripheral blood urea concentrations have been shown to reflect with certain exceptions the degree of nitrogen wastage by ruminal ammonia formation it has been proposed that this measure, which requires a less involved sampling procedure than does rumen ammonia, can be used as a supplementary test for the efficiency of protein utilisation (Lewis, 1957). This hypothesis assumes, however, that in general only a small fraction of feed protein escapes bacterial attack and takes no account of urea derived from deamination in the liver of absorbed or catabolic amino acids. Such an assumption may not hold with calf early-weaning diets composed almost entirely of concentrates and supplemented with antibiotics which have been shown to depress rumen fermentation (Preston, Dinda and MacLeod, 1959). In the present experiment (Figure 3), blood urea concentrations, while broadly reflecting the solubility of the nitrogen in the diets, were not in strict proportion to the efficiency with which the nitrogen was utilised. In fact, after eliminating period, treatment and animal differences from each set of measurements, there was no significant residual relationship between nitrogen retention (either in g./day or in g./W⁷⁴/day)

and blood urea concentration. The overall low values for blood urea concentration after feeding are in close agreement with the results reported by Lewis (1957), for diets having a high proportion of flaked maize.

SUMMARY

1. Nitrogen balance studies were conducted on 6 early-weaned calves fed three diets containing respectively commercial groundnut meal, heat-treated groundnut meal and fish meal as the major protein sources.

2. Nitrogen retention and live-weight gain differed significantly between diets, being highest on the fish meal diet and least on the commercial groundnut diet.

3. Blood urea concentration was significantly lower on the fish meal diet than on either of the groundnut diets but differences between the groundnuts were not significant.

4. Differences between diets in nitrogen utilisation were due almost entirely to differential urinary nitrogen losses.

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