ABSTRACTS OF COMMUNICATIONS

The Two Hundred and Twenty-fourth Scientific Meeting of the Nutrition Society was held in The Atkins Building, Queen Elizabeth College, London, W8, on Friday, 25 September 1970, at 15.30 hours, when the following papers were read:

The physical form of a barley grain and barley straw diet and nitrogen metabolism in sheep.

By P. Jackson, J. A. F. Rook and K. G. Towers, *Department of Agricultural Sciences, University of Leeds*

Two wether sheep fitted with ruminal and duodenal re-entrant cannulas received a daily diet of 700 g barley grain and 300 g barley straw, supplemented with minerals, vitamins and 1 g chromic oxide, which was given in twenty-four equal parts at hourly intervals. In successive 42 d periods the diet was offered (a) as rolled grain, chopped straw and (b) in a finely-ground, pelleted form. There was no access to drinking water but throughout the first 21 d of each period there was a continuous intraruminal infusion of 2 l water daily and in the second 21 d the water was replaced by a solution of ammonium salts (mainly acetate) which supplied 7 g nitrogen/d. In each 21 d period, balance studies were carried out over days 10–18, measurement of the flow to the duodenum on days 19–21. Samples of duodenal contents were taken on days 19–21 and of ruminal contents on day 21.

Marked differences were observed in the abomasal output of N (adjusted for 100% recovery of chromic oxide in the faeces) but these appeared to be related more to the pattern of fermentation established in the rumen than to the treatments themselves. Six of the eight recorded values lay within the comparatively narrow range of 12·8–15·9 g N/d but during two experimental periods, when unusually high values (32·4 and 38·1%) for the molar proportion of propionic acid in rumen liquor were observed, higher values for abomasal output of 20·4 and 24·8 g N/d were recorded. For all values there was a highly significant relationship between abomasal output of N and the molar proportion of propionic acid ($y=7{\cdot}33+0{\cdot}43$ ($\pm 0{\cdot}07)x$; $P<0{\cdot}001$) and also an inverse relationship with the molar proportion of butyric acid ($y=25{\cdot}42-0{\cdot}53$ ($\pm 0{\cdot}14)x$; $P<0{\cdot}01$). The abomasal output of α-ϵ-diaminopimelic acid N also was related to the molar proportion of propionic acid ($y=2{\cdot}00$ ($\pm 0{\cdot}23)x$; $r=0{\cdot}94$, $P<0{\cdot}001$) as was the passage to the duodenum of α-linked glucose polymers ($y=0{\cdot}73$ ($\pm 0{\cdot}23)x$; $r=0{\cdot}85$, $P<0{\cdot}01$). For all treatments, approximately half of the N passing to the duodenum was present as α-amino-N.

Relationship between the pattern of ruminal fermentation and the flow of materials to the duodenum in sheep receiving a diet of barley, flaked maize and ground hay.

By M. Ishaque, P. C. Thomas and J. A. F. Rook, *Department of Agricultural Sciences, University of Leeds*

Five wether sheep fitted with ruminal and duodenal re-entrant cannulas were used.

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In initial periods they were offered a diet either of hay or of hay, barley and flaked maize. They were then transferred to a standard diet of 900 g/d of ground hay, barley and flaked maize (24:56:20), supplemented with minerals, vitamins and chromic oxide (1·8 g/d) and given in twenty-four equal parts at hourly intervals. Water (2 l/d) was given as a continuous intraruminal infusion. This procedure was designed to establish in different sheep, or in single sheep on different occasions, fermentation patterns characterized either by a high molar proportion of butyric plus acetic acids or a high molar proportion of propionic acid.

Once the sheep were established on the standard diet, a 6 d balance trial was carried out and this was followed by a 3 d period during which the flow of digesta to the duodenum (adjusted to give 100% recovery of chromic oxide in the faeces) was measured and samples of the digesta were taken. Samples of rumen digesta were taken throughout the 9 d period.

The fermentation patterns observed were invariably one of two distinct types. In five experiments the molar percentage composition of the mixture of short-chain fatty acids was: acetic, 58±1·6; propionic, 15±0·8; butyric, 23±1·2. In five others the composition was: acetic, 46±3·5; propionic, 33±1·9; butyric, 12±1·5. Corresponding values for rumen ammonia concentration (mg/100 ml) were 27·9±2·8 and 11·3±1·7. Figures for duodenal flow and faecal output are shown in Table 1.

Table 1. *Mean values, with their standard errors for duodenal flow and faecal output (mean of four values only) as percentage of dietary intake for the 'butyric acid' and 'propionic acid' fermentation groups*

	Duodenal flow		Faecal output	
	Butyric acid group	Propionic acid group	Butyric acid group	Propionic acid group
Organic matter	20·9±1·5	34·4± 4·5	12·9±0·4	17·7±1·2
Nitrogen	57·5±2·3	104·1± 3·5	22·2±1·0	38·9±3·2
Ether extract	25·3±2·6	48·1±15·6	15·5±0·9	21·4±3·4
N-free extract	13·0±1·4	23·5± 7·1	11·0±0·2	14·0±1·2
Crude fibre	43·9±8·9	84·0±17·8	25.6±1·1	35·9±3·0
Starch	4·7±0·9	5·5± 0·6	0	0·1±0·0
Cellulose	43·4±4·1	81·2±12·2	23·8±1·1	34·2±3·7
Gross energy	24·2±2·1	40·7± 4·8	15·9±1·1	19·8±1·4

These results are consistent with those in the previous communication and suggest that the micro-organisms associated with the 'propionic acid' fermentation are more effective converters of dietary materials into microbial mass than are those associated with the 'butyric acid' fermentation. This may be at the expense of a less efficient production of 'waste products' of value to the host. A clear consequence of the improved efficiency is an increased uptake of nitrogenous materials from the intestine and an investigation is now required of the nutritional importance of this increased uptake.

The effects of diet and pentagastrin on the influx of urea into the rumen of sheep. By C. J. F. HARROP and A. T. PHILLIPSON, *Department of Veterinary Clinical Studies, Madingley Road, Cambridge CB3 0ES*

The transfusion of urea into the alimentary tract is of interest in sheep as the ammonia derived from its hydrolysis is a source of nitrogen for the bacteria of the rumen. Urea enters the rumen in saliva (McDonald, 1948) and by diffusion across the rumen wall (Houpt, 1959), but ammonia is also produced from the degradation of dietary proteins (McDonald, 1952).

One of us (C.J.F.H.) observed that the increase of ammonia in the rumen of conscious sheep maintained on a low-protein diet (11·3 g N/d) is considerably greater following the intravenous injection of urea (0·28 g/kg) than in sheep maintained on a high-protein diet (20·7 g N/d). Subsequently it was found that periods of 24 h fasting reduced the response of sheep maintained on the low-protein diet, but did not alter that of sheep maintained on the high-protein diet.

This dietary contrast, with the effect of fasting, suggested that the response to intravenously injected urea might be influenced by hormones originating from the alimentary tract. The effect of a synthetic gastrin was investigated.

Single, subcutaneous injections of Peptavlon pentagastrin (Imperial Chemical Industries Ltd), given at the same time as the intravenous injections of urea, restored the response of conscious, fasted sheep maintained on the low-protein diet to that found when food was offered at the usual times. They had no observable effect on fasted sheep maintained on the high-protein ration.

Experiments were carried out with anaesthetized sheep maintained on both the low- and high-protein diets after a period of 24 h of fasting, in which the rumen was emptied and filled with isotonic solutions containing the major electrolytes and steam volatile fatty acids. In the experiments with sheep maintained on the low-protein diet, urea was administered intravenously via the jugular vein as a booster injection (0·28 g/kg), followed by a continuous infusion (16·0 mg/kg per h), but not to sheep given the high-protein diet. All experiments consisted of two 3 h periods; in period 1, saline (0·9% NaCl) was infused via the jugular vein, and in period 2, a subcutaneous booster injection of pentagastrin (6 μg/kg) followed by a continuous infusion of pentagastrin (5 μg/kg per h) were given. In all experiments pentagastrin

Table 1. *Effect of the continuous infusion of pentagastrin on (a) the entry of urea-nitrogen into the rumen, and (b) the volume of urine excreted*

		Expt no.					
	Period	Low-protein diet			High-protein diet		
Measurement	no.	1	2	3	4	5	6
(a) Net increase of	1*	+30·9	+47·6	+33·5	−3·7	−23·6	+26·4
urea-N+ammonia-N	2*	—	—	+46·2	—	—	+26·1
(mg) in rumen	2†	+228·9	+170·8	—	+36·3	+26·1	—
(b) Vol. urine	1*	6·2	80·4	154·1	26·1	71·2	39·8
excreted (ml)	2*	—	—	158·3	—	—	31·5
	2†	29·9	155·4	—	52·5	170·4	—

*Control period: saline infused intravenously.
†Test period: pentagastrin infused intravenously.

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caused a marked increase in the entry of urea into the rumen (Table 1); control experiments (Expts 3 and 6; Table 1) eliminated the possibility of these responses being due to the experimental periods.

Pentagastrin increased the secretion of abomasal juice in the abomasum, although little or no acid appeared in the secretions from sheep maintained on the high-protein diet. It caused a diuresis (Table 1) and a consequent increase in the output of urinary urea, as well as a marked increase of blood packed cell volume.

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The energy cost of a task after the ingestion of protein, fat or carbohydrate.

By R. GOLDSMITH, *Department of Physiology, The Medical School, University of Nottingham, Nottingham NG7 2RD*, and G. S. RIDDELL, I. F. RUSSEL, MADELEINE M. SAWYER and R. B. SMITH, *Department of Physiology, The University of Aberdeen* (introduced by O. G. EDHOLM)

It has been suggested that a part of an excess calorie intake in man may be 'burnt off' by increasing the energy cost of a physical task, representing a possible feedback mechanism to assist in the maintenance of a steady weight (Miller & Payne, 1962). This concept has been dubbed dietary induced thermogenesis (Grafe, 1933; Miller, Mumford & Stock, 1967). A series of simple experiments was performed to investigate the size of this effect during moderate but controlled exercise.

Five male and three female subjects aged between 19 and 23 years took part in the experiments. Their weights ranged between 59·6 and 74·7 kg, with a mean of 66·1 kg. The mean of their heights was 173·5 cm (range 159–187 cm).

Energy expenditure was estimated by measuring $\dot{V}_{O_2}$ and $\dot{V}_{CO_2}$ while the subjects were working at a rate of approximately 600 kg m/min on a friction-braked bicycle ergometer. Heart and respiration rates were also measured. Measurements were made once a week for 4 weeks.

On each experimental day, every subject performed a series of four 7 min work tests at hourly intervals. The first test on each day was performed in the morning after an overnight fast; the mean $\dot{V}_{O_2}$ during the last 2 min of the first tests each day was 23 ml/kg per min (SD $\pm$ 2·9). Between the end of the first test and the beginning of the second, the subjects had a meal made up very largely of one nutrient only. Each 'meal' had a calorific value of 500 kcal.

The calories were derived from either: (1) protein (Casilan, Glaxo Research Ltd), (2) fat (double cream), or (3) carbohydrate (glucose). All these were taken with 750 ml water; as a control, the subjects drank 750 ml water only.

The order in which these 'meals' or the water only were presented to the subjects on the different experimental days was arranged according to a Latin square design.

The comparison of the mean $\dot{V}_{O_2}$ during exercise before the 'meals' with that after, showed that the average increase after protein was 15% ($P<0.001$), the range was 6–16%. After fat it was 9% ($P<0.02$) with a range from 2 to 20 %. No significant increases of $\dot{V}_{O_2}$ occurred after taking carbohydrate (4%) or water (2%). Following the ingestion of protein or fat, the highest mean $\dot{V}_{O_2}$ was recorded in the fourth test.

Though it would have been reasonable to expect a rise in heart rate commensurate with the rise in $\dot{V}_{O_2}$, this was not observed.

These results suggest that a part of a calorie intake is dissipated by a decrease in the efficiency of performing work and that this could play a part in maintaining body-weight.

This work was carried out with the aid of a WHO grant, which is gratefully acknowledged.

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Protein nutrition and drug-metabolizing enzymes in the liver of the growing rat. By J. W. T. Dickerson, T. K. Basu and D. V. Parke, *Department of Biochemistry, University of Surrey, Guildford*

The rate of metabolism of drugs and the activity of NADPH-dependent enzymes in adult rat liver is closely related to the protein content of the diet (Kato, Oshima & Tomizawa, 1968; Marshall & McLean, 1969). However, other work has shown that a diet deficient in protein increases the resistance of adult rats to the toxic effects of carbon tetrachloride (McLean & McLean, 1966).

In the present experiments, male weanling Wistar rats were divided at 24 d of age into three groups. Group A (controls) were fed *ad lib.* a stock diet (Spillers, containing 21% protein). Group B ('protein-deficient') were fed the stock diet diluted to 7% protein with pure potato starch with appropriate additions of minerals and vitamins. The food intake of these animals was recorded, and Group C ('calorie-deficient') were given the amount of stock diet containing the same amount of protein as that consumed by group B. In the first experiment, twenty-four animals were used in each group, and eight of them killed after 7, 14 and 28 d respectively on the diet. In a second experiment, ten animals reared on each of the three dietary regimens were given 10 mg/kg body-weight of phenobarbitone intraperitoneally on 3 successive d until 24 h before killing in groups of five animals at 7 and 28 d respectively.

The activities of biphenyl 4-hydroxylase, *p*-nitrobenzoate reductase, cytochrome P-450, and the amount of whole liver and microsomal protein were determined (Basu, Dickerson & Parke, 1970).

During 28 d on the different diets in the first experiment, the mean weights of the rats rose from 52 g to 210 g (group A), 143 g (group B) and 85 g (group C). The

corresponding liver weights at this age were 9·6 g, 5·2 g and 2·9 g respectively. The results of the experiments, with and without induction of the enzymes with phenobarbitone, showed that in group C there was a deficit in the total activity of biphenyl 4-hydroxylase per liver whereas in group B there was a raised activity per g liver and a normal total activity. However, in group C there was a raised activity of *p*-nitrobenzoate reductase per g liver whereas in group B the activity per g liver was normal. The result of these changes and of those in liver weight was that the absolute amount of this enzyme was reduced to the same level by both deficient diets. At 28 d the activity of cytochrome P-450 per g liver weight was higher in group C than in group B.

Thus, biphenyl 4-hydroxylase, an oxidizing enzyme, is susceptible to a deficiency of total calories, whereas *p*-nitrobenzoate reductase is susceptible to the amount of protein and independent of calories.

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A rat model for the study of compensatory growth. By A. M. STEWART, *Department of Agriculture, University College of Rhodesia, Salisbury, Rhodesia*

A combination of the rotation technique of Cox, Morgan & Nathans (1954) and the 'large-litter' technique of Widdowson & McCance (1960) was used to produce differences in rates of weight gain to weaning of litter-mate male, Sprague-Dawley rat pups. Group A animals (weaning weight approximately 65 g) and group B animals (weaning weight approximately 40 g) were successively rotated among three lactating females. Group C animals (weaning weight approximately 28 g) were reared in litters of sixteen to 21 d. Group D animals (weaning weight approximately 52 g) were reared in a large litter to 10 d and were subsequently placed in a rotation regimen. All animals were fed a diet containing 24% casein *ad lib.* after weaning.

Percentage increments in weight during the early stages of growth are shown in Table 1.

Table 1. *Mean 10 d increments in weight expressed as a percentage of the starting weight for each period*

Period from birth (d)	Animal group A	B	C	D
0–10	284·3	189·0	113·1	125·1
10–20	120·3	106·0	93·6	226·9
20–30	86·1	112·2	114·6	71·0
30–40	63·4	65·5	73·5	67·2

A rapid rate of realimentation from 10 d enabled group D animals to attain a mature weight of the same order as that of animals in group A. There were no differences between groups in the time taken to reach peak growth rate. There was,

however, some indication that the growth curves of animals which grew very slowly to weaning had a slightly later point of inflexion.

Thanks are due to Miss Jenny Ambrose and Mr. E. Kumbula for technical assistance.

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The implication of ruminal thiaminase in cerebrocortical necrosis. By E. E. Edwin and Gwyneth Lewis, *Ministry of Agriculture, Fisheries and Food, Central Veterinary Laboratory, Weybridge*

Though it is considered unnecessary to supplement ruminant rations with B vitamins, it is now evident that deficiency of thiamin must precede the onset of cerebrocortical necrosis in sheep and cattle. Not only are tissue values of this vitamin low in affected animals, compared with healthy animals of similar age, but blood pyruvate and lactate are raised (Edwin, 1970), and erythrocyte transketolase lowered (Pill, 1967). Affected animals generally respond dramatically to thiamin administration, the clinical and biochemical signs being progressively reversed.

Examination of the ruminal contents of affected animals has shown the presence of a thiaminase (Edwin, Spence & Woods, 1968) which rapidly destroys any thiamin incubated with it in vitro. This enzyme has also been found to pervade the whole of the digestive tract, and to be present in freshly voided faeces of affected animals. Thiaminase activity has also been detected in the faeces of some in-contact, but clinically unaffected, animals.

Using various ^{14}C-labelled substrates it has been demonstrated that the thiaminase is of type I, requiring a co-substrate for activation. It has also been found that nicotinic acid is a strong activator for this reaction, the product has been isolated and identified as N-(2′-methyl-4′-amino-pyrimidyl (5′))- methyl-3-carboxy pyrimidinium chloride. Its structure has elements of similarity to the thiamin antagonists, amprolium and pyrithiamin; therefore, it may be expected to have antithiamin characteristics. As the administration of amprolium has been shown to lead to a condition indistinguishable from field cases of cerebrocortical necrosis (Markson, Terlecki & Lewis, 1966), a mechanism is advanced whereby this disease can occur in ruminants.

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Protein requirements of growing lambs. By J. L. Black, (introduced by D. E. Tribe), *School of Agriculture, University of Melbourne, Victoria, Australia*

There is an extremely large variation in the estimated protein requirements of young lambs. It is probable that much of this variation is a result of differences in

the extent of degradation within the rumen of the dietary proteins used for the determinations. It can be reasoned that, depending upon the extent of breakdown of protein in the rumen, the true requirements of the lamb's body for protein may be either underestimated or overestimated when solid diets of increasing protein content are fed. An experiment was therefore conducted to determine the protein requirements of lambs weighing from 8 to 30 kg by using entirely liquid diets which passed direct to the abomasum.

Seventy-four lambs (Merino × Border Leicester × Dorset Horn) were removed from their mothers when 2 d of age and artificially reared on reconstituted cow's milk. They were divided into four groups, and 8 d nitrogen balance trials were conducted with lambs of mean weights of 7·8 kg (group 1, twenty-three lambs), 12·6 kg (group 2, seventeen lambs), 20·8 kg (group 3, twenty lambs) and 30·4 kg (group 4, fourteen lambs). During 6 to 8 d preliminary periods and the balance periods, the lambs were given isocaloric diets (constituted from whole milk powder, whey powder, glucose, butterfat and micro-nutrients) which contained from 10 to 40% of the digestible energy in protein (protein calorie %), and a digestible energy intake of 310–330 kcal/kg $W^{0.73}$ per d.

When the intersection of the line representing the linear increase in N retention in response to increases in protein intake and the horizontal line representing the maximum N retention was taken to be the optimal protein requirement (Hegsted, 1964), values of approximately 26·0, 23·5, 17·5 and 12·0 protein calorie % were obtained for groups 1, 2, 3 and 4 respectively. However, when expressed in these terms the requirements can be applied only to lambs fed liquid diets containing milk proteins. To enable the results to be also applied to either weaned or unweaned lambs receiving any protein source, the requirements were expressed as g reference protein (defined as a theoretical protein which is used solely for tissue synthesis; FAO, 1965) per 100 kcal net energy. The reference protein requirement was estimated from a summation of the maximum protein retention and the endogenous protein losses, whereas net energy was calculated from the metabolizable energy intake by the factors estimated by Walker & Jagusch (1969). Hence, requirements of 4·84, 4·31, 3·34 and 2·57 g reference protein/100 kcal net energy were established for groups 1, 2, 3 and 4.

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Effects of the fenfluramine derivative 'S992' on body-weight and blood lipids in man. By G. L. S. PAWAN, P. M. PAYNE and E. C. SHELDRICK. *Metabolic Division, Department of Medicine, The Middlesex Hospital Medical School, London, W1*

The fenfluramine derivative, 'S992', (meta-trifluoromethyl-phenyl)-1-[β-(benzyloxy) ethyl] amino-2-propane, has been shown by Duhault & Malen (1970)

to produce an increase in plasma free fatty acids (FFA) and glycerol and loss of body-weight in rats. A preliminary study was made of the effect of oral administration of 'S992' on thirty adult human volunteers on *ad lib.* diets. The procedure was as follows: week 1, control; week 2, 150 mg/d; week 3, 300 mg/d; week 4, 450 mg/d; week 5, 600 mg/d; week 6, final control week. Blood samples were obtained on the first and last days of each week, in the morning after an overnight fast with subjects at rest, for analysis of plasma FFA, free glycerol, triglycerides, ketones, cholesterol, and glucose, by methods previously described (Pawan, 1969). Results are shown in Table 1.

Table 1

(Mean values with their standard errors)

Week	1	2	3	4	5	6
S992 (mg/d)	none	150	300	450	600	none
Glucose (mg/100 ml)	84·2±1·9	76·6±3·1	82·9±3·5	82·2±2·7	83·3±3·0	76·1±5·1
FFA (μequiv./l)	653±31	628±35	627±28	755±81	627±54	669±38
Glycerol (mg/100 ml)	1·04±0·08	0·88±0·06	1·10±0·07	1·05±0·07	0·95±0·06	1·12±0·09
Triglycerides (mg/100 ml)	82·3±5·8	91·2±8·6	81·9±5·5	91·5±8·1	90·6±5·6	93·3±5·3
Ketones (mg/100 ml)	0·85±0·06	0·84±0·09	1·03±0·13	1·16±0·1	1·50±0·21	1·01±0·08
Cholesterol (mg/100 ml)	226±6	224±7	219±6	203±6	214±5	216±6
Body-weight (kg)	74·0±2	73·2±2	72·6±2	71·7±2	71·1±2	70·6±2

The drug caused a significant loss in body-weight and affected the blood lipids.

We thank Selpharm Laboratories Ltd of the UK, and Les Laboratoires Servier of France, for supplies of 'S992'.

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An experimental study on the variability of measurements of skinfold thicknesses by three observers on twenty-three young women and twenty-seven young men. By J. V. G. A. Durnin, W. H. Armstrong, and J. Womersley, *Institute of Physiology, University of Glasgow*

An objective measure of 'fatness' is now possible with reasonable accuracy, at least in some populations (Durnin & Rahaman, 1967), and is surely preferable to either subjective assessment or the use of a table of so-called 'ideal' weight. The simplest technique makes use of skinfold calipers to measure the thickness of the skinfold at various sites on the body. However, the reproducibility of this measurement using different observers and subjects seems to have been assessed only once on a British population (Edwards, Hammond, Healy, Tanner & Whitehouse, 1955).

In the present study, three observers, only one of whom was experienced, used three calipers of different design to measure skinfold thickness at four sites (biceps, triceps, subscapular and supra-iliac regions) on twenty-seven male and twenty-three female medical students on nine occasions over a period of 5 weeks.

The results showed that (a) there was no significant difference in the total skinfold thickness on any one subject by any one observer, that is each observer produced consistent results; (b) there was no significant difference due to caliper; (c) there was a statistically significant difference in the total skinfolds between the observers but the amount of the difference was small and of little importance for the prediction of total body fat in the subject; (d) in the female subjects, the variation in skinfolds during the menstrual cycle produced inconclusive results but indicated a possibility that the changes in fluid balance known to occur in the cycle might exert a measurable effect on the skinfolds.

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Absorption of glucose and vitamins of the B complex by germ-free and conventional chicks. By D. J. FORD and MARIE E. COATES, *National Institute for Research in Dairying, Shinfield, Reading RG2 9AT*

The presence of the conventional microflora is generally considered to induce a state of mild inflammation in the gastro-intestinal tract and may in consequence impair the absorptive capacity of the intestine.

To gain evidence on this point, the absorption of glucose and some vitamins of the B complex has been studied in everted sacs of small intestine from germ-free and conventional chicks. Groups of eight birds were taken from each environment at 24 d of age. Everted sacs were prepared by a modification of the method of Wilson & Wiseman (1954) from five sites along the small intestine of each bird. The sacs were filled with 1 ml of Krebs bicarbonate buffer containing 0·1% glucose and incubated at 37° for 1 h in 10 ml of the Krebs bicarbonate glucose buffer to which had been added thiamin 30 μg, riboflavin 60 μg, nicotinic acid 400 μg, pantothenic acid 150 μg, biotin 2 μg and pteroylmonoglutamic acid 7 μg. Portions of the serosal fluids from the five sacs from each bird were pooled and analysed by standard microbiological procedures; glucose was determined by a glucose oxidase method (Dahlqvist, 1964). The amount of each nutrient that had passed into the serosal fluid was calculated per cm length of intestine.

The concentration of glucose in the serosal fluid increased during incubation, indicating that the sacs were capable of active transport of nutrients. The ratios of serosal to mucosal concentrations were 3·88 and 2·65 for germ-free and conventional birds respectively.

The table shows the amounts of each vitamin, in ng/cm intestine, that passed into the serosal fluid.

Sac	Nicotinic acid	Pantothenic acid	Riboflavin	Thiamin	Biotin	Pteroylmonoglutamic acid
Germ-free	2600	390	17	25	4·2	3·2
Conventional	1500	140	12	17	2·2	3·2
Significance	$P<0·001$	$P<0·001$	None	$0·05>P>0·01$	$P<0·001$	None

The increased transport of glucose and several of the vitamins by the germ-free intestine lends support to the suggestion that the presence of micro-organisms in the conventional gastro-intestinal tracts decreases its ability to absorb some nutrients.

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Plasma amino acid patterns of growing pigs given barley diets supplemented with fish meal. By D. O. ANDAH and A. G. CHAMBERLAIN, *Department of Agriculture, University College of North Wales, Bangor, Caerns*

In a Latin square experiment, four 18 kg litter-mate gilts were given mineral–vitamin supplemented barley diets with 3%, 10%, 15% and 20% white fish meal. The diets supplied 11·6, 15·9, 19·0 and 22·1% crude protein in the dry matter respectively. Each diet was given to each pig twice a day for a period of 14 d, according to a scale relating live weight to dry-matter content of the diet. Blood samples were collected from the vena cava 3 h from the time the morning feed was given, on the 7th and 14th days. The two plasma samples of each pig were pooled and deproteinized with sulphosalicylic acid prior to analysis by automated ion-exchange chromatography.

Significant linear regression equations of positive slope of plasma amino acids on dietary protein were calculated for most amino acids. The essential amino acids that failed to produce significant regressions were phenylalanine, methionine, arginine and tryptophan. Lysine response was the greatest. However, for all amino acids the difference between the plasma amino acid levels of the pigs given diets containing 15·9 or 19% protein was small and this may indicate that the rate of incorporation of amino acids into tissues was at its greatest between these protein levels.

An apparent synergy between copper sulphate and Payzone in improving the performance of growing pigs. By R. BRAUDE, K. G. MITCHELL and R. J. PITTMAN, *National Institute for Research in Dairying, Shinfield, Reading RG2 9AT*

Payzone is a guanidine derivative produced by Cyanamid of Great Britain Ltd. In a random block design (blocking on litters) the following four treatments were involved: (1) control, (2) copper sulphate, 250 mg Cu/kg diet, (3) Payzone, 20 mg/kg diet, (4) the two additives together. Two replicates, each with twelve individually fed pigs per treatment, were completed. The standard Shinfield diet was fed twice daily, water being added just before feeding in the ratio of 2·5:1. The 'semi *ad lib.*' method of feeding was used; whenever a pig consumed all its feed on 2 consecutive d, the daily allowance was increased by 0·1 kg until the daily maximum of 2·95 kg/pig was reached.

The daily live-weight gain and the feed per gain ratio were significantly and similarly improved by supplementation of the diet with either copper sulphate or Payzone. When both supplements were added to the diet, the performance of the pigs

was further improved and was significantly better than that obtained with either supplement alone.

Lipoprotein lipase activity in the adipose tissue of rats fed sucrose or starch. By D. J. NAISMITH and N. A. KHAN, *Department of Nutrition, Queen Elizabeth College, London, W8*

A sucrose-rich diet, compared with a starch-rich diet, induces a rise in the concentration of triglycerides in the plasma of the rat. This hypertriglyceridaemia results from an increased synthesis of lipids in the liver (Naismith & Khan, 1970*a*), which, in turn, promotes an increased throughput of triglycerides in the plasma (Naismith & Khan, 1970*b*). Pawar & Tidwell (1968) have claimed that rats reared on a diet rich in polyunsaturated fat show reduced plasma total lipid concentrations and an elevation in the activity of lipoprotein lipase in adipose tissue. It has also been reported (Persson, Björntorp & Hood, 1966) that a negative correlation exists between the serum triglyceride level and the lipoprotein lipase activity in the adipose tissue of man.

When consideration was given to the quantitative aspects of this relationship, the total circulating triglyceride in the fasting rat (approximately 6 mg), and the daily throughput of triglycerides in the plasma (at least 400 mg), it seemed to us much more likely that the hyperlipidaemia associated with sucrose feeding should be accompanied by a rise, rather than a fall in the activity of the enzyme in adipose tissue. This hypothesis was put to the test.

Eight litter-mate pairs of weanling rats were given fat-free diets containing 65% of sucrose or starch for 50 d. The animals were then killed, blood was drawn from the heart for lipid estimations, and samples of epididymal adipose tissue were taken for estimation of lipoprotein lipase by the method of Björntorp & Furman (1962). The results are summarized in the table.

Diet	Plasma triglycerides (mg/100 ml)	Adipose tissue lipoprotein lipase activity (μequiv. FFA/g per h)
Starch	48·2 (36·3–55·7)	7·0 (5·8–9·3
Sucrose	77·3 (60·0–96·3)	11·5 (8·0–14·2)

Values in parentheses give ranges; FFA, free fatty acids.

Animals that were maintained on the sucrose-rich diet had significantly higher plasma triglyceride concentrations than had their litter-mates given starch ($P<0.001$). The high-sucrose diet also induced a large increase in the activity of lipoprotein lipase in the adipose tissue ($P<0.05$).

The hypertriglyceridaemia in rats resulting from feeding sucrose is, therefore, not caused by an inability of these animals to clear this lipid fraction from the blood.

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