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PROCEEDINGS OF THE NUTRITION SOCIETY

ABSTRACTS OF COMMUNICATIONS

The Three Hundred and Twenty-sixth Meeting of the Nutrition Society (The One Hundred and Twenty-eighth of the Scottish Group) was held at the Scottish Hospital Centre, Western General Hospital, Crewe Road, Edinburgh, on Friday 2 *February* 1979, *when the following papers were read:*

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The attenuation of the suppression of appetite resulting from intraduodenal infusions of glucose by vagotomy in young pigs. By D. B. STEPHENS and F. HERON, *ARC Institute of Animal Physiology, Babraham, Cambridge CB2 4AT*

Previous experiments in hungry young growing pigs showed that intraduodenal infusions of 250 ml of 150 g/l glucose solutions 3 min after the start of the meal caused a 30–40% reduction in meal size (Heron & Stephens, 1978). It was not clear what mechanism was involved in the suppression of appetite. The present experiments were designed to investigate the role played by the vagus nerve in mediating sensory stimuli from the duodenum. In addition, the importance of the timing of the infusion in relation to the meal was investigated by infusing 250 ml of 150 g/l glucose 10 min before the pig was allowed access to the food.

Fifteen pigs weighing between 20 and 30 kg were used. The pigs were trained to press a panel with their snouts in order to obtain food; 5–6 g food were delivered with each press of the panel. The pigs were allowed to eat to satiety once daily. The criterion used to define satiety was a 3 min period without the animal pressing the panel. Eleven pigs were fitted surgically with a polyvinyl intraduodenal indwelling cannula which was exteriorized. A further four pigs fitted with intraduodenal cannulas were subjected to intrathoracic bilateral truncal vagotomy.

Food intake in control and vagotomized pigs

No. of pigs	Vagus	Time of infusion	Food intake (g)			
			Day before infusion		Day of infusion	
			Mean	SE	Mean	SE
11	Intact	10 min before start of meal	1060	170	1019	162
4	Sectioned	3 min after start of meal	940	50	912	106

The food intake (mean with SE) of the pigs given an infusion 10 min before the meal are given in the Table. The amount eaten was not significantly different from that ingested on the previous day when no infusion was carried out. In the four pigs which had been vagotomized there was no significant reduction (see Table) in the amount of food consumed compared to the previous day when no infusion was carried out. These observations suggest that any mechanisms which may be active in the control of food intake requires pre-gastric food stimulation related to the act of eating and also that the vagus nerve is involved in mediating the duodenally based suppression of food intake following a 150 g/l glucose infusion during the meal.

Heron, F. & Stephens, D. B. (1978). *J. Physiol.* **284**, 14.

0029–6651/79/3820–326A $00.35

The energy requirements for growth in the early-weaned pig. By W. H. CLOSE, M. W. STANIER and M. R. SANZ SAMPELAYO,* *ARC Institute of Animal Physiology, Babraham, Cambridge CB2 4AT*

In recent years there has been considerable interest in determining the energetic efficiency of growth of farm animals. In the pig, most estimates have been determined on animals above 20 kg body-weight. The present experiments were designed to determine the energetic efficiency of the young, early-weaned pig between 4 and 10 kg body-weight.

Piglets were weaned at 14 d of age and kept in groups of six in mobile pens at an environmental temperature of 23°. During the following 7 d period feed intake was adjusted to one or other of three different levels for different groups, 30, 45 or 60 g food/kg body-weight per d. Two groups of animals were exposed to each treatment. At 21 d of age two animals from each group were slaughtered and the remaining four animals were removed to a calorimeter where heat loss and energy and nitrogen balances were determined for two consecutive 7 d periods. At the end of the investigation, at 35 d of age, the animals were slaughtered. The partition of metabolizable energy (ME) intake into heat loss (H), energy retention (ER) and protein (P) and fat (F) deposition was calculated from both calorimetric and balance techniques and from the comparative slaughter procedure.

Plane of nutrition (g food/kg body-weight per d)	Calorimetric and balance trials ($kJ/kg^{0.75}$ per d)					Comparative slaughter procedure ($kJ/kg^{0.75}$ per d)				
	ME	H	ER	P	F*	ME	H	ER	P	F*
60	1257	722	535	230	305	1257	744	513	257	256
45	1021	686	335	209	126	1021	676	345	230	116
30	592	613	−21	133	−154	592	623	−31	126	−157

*F calculated as the difference between ER and P.

As there was very close agreement between results from the two procedures, the energy costs of maintenance and production have been calculated from the combined results. From the equation

$$ER/kg^{0.75} = 0.83\ (\pm 0.03)\ ME/kg^{0.75} - 514\ (\pm 29)\ (r\ 0.99) \qquad 1$$

the mean maintenance energy requirement (ME_m) was calculated as 619 $kJ/kg^{0.75}$ per d.

The energetic efficiency of protein and fat synthesis was calculated from the equation

$$ME_p = aP + bF \qquad 2$$

where ME_p is calculated as $ME - ME_m$, and P and F are the quantities of protein and fat deposited ($kJ/kg^{0.75}$ per d). The reciprocals of a and b provided estimates of the energetic efficiency of protein (k_p) and fat (k_f) synthesis of 0·84 (±0·03) and 0·81 (±0·03), respectively. These estimates of ME_m, k_p and k_f are decidedly higher than those calculated for pigs above 20 kg body-weight (Close, 1978).

Close, W. H. (1978). *Br. J. Nutr.* **40**, 433.

*On leave from Estacion Experimental del Zaidin, Granada, Spain.

0029–6651/79/3820–326A $00.35

The influence of plane of nutrition on the carcass composition of the early-weaned pig. By M. W. STANIER, M. R. SANZ SAMPELAYO* and W. H. CLOSE, *ARC Institute of Animal Physiology, Babraham, Cambridge CB2 4AT*

Since the early weaning of piglets is now widely practised, the attainment of rapid growth and normal carcass composition in the post-weaned period is of importance in animal management, together with a knowledge of the nutritional levels needed for such attainment. The growth and carcass composition of piglets weaned at 14d of age have been studied at three different feeding levels at an environmental temperature of 23°.

Groups of ten piglets were studied by analysis of the pooled carcasses of two individuals at birth; two at 14 d when the group was weaned in a room held at 23° and had started to eat solid food; two at 21 d when the litter had adjusted to solid food; and the remaining four piglets at 35-d-old. The procedure was carried out on two groups of pigs at each of three planes of nutrition; 30, 45 and 60 g food/kg body-weight per d. Dry matter was measured by freeze-drying the minced empty carcass, fat by Soxhlet extraction of dry matter, energy by bomb calorimetry and nitrogen by a modified Kjeldahl estimation of fresh minced tissue.

Mean body-weight and carcass composition of early-weaned piglets at three planes of nutrition

		Plane of nutrition (g food/kg body-weight per d)		
	Age (d)	60	45	30
Body-weight (kg)	21	5·49	4·19	4·25
	35	9·38	7·94	5·35
Fat (g/100 g fresh tissue)	21	13·54	11·79	10·82
	35	12·74	10·37	7·46
Nitrogen (g/100 g fresh tissue)	21	2·10	2·20	2·22
	35	2·30	2·39	2·48

The final body-weight was directly correlated with feeding level (see Table). The dry matter (DM; %) in the carcass increased during the initial two weeks of suckling, as did the amount of fat (%) and protein and energy concentration of the DM. The fat increased from about 3% at birth to nearly 14% at 14 d and the nitrogen from 1·6 to 2·1%. There was a small decrease in the fat concentration in all groups during the week of adjustment to solid food. At the final stage, at 35 d of age, all groups had approximately equal concentrations of nitrogen in the carcass. The fat and total energy values were correlated with feeding level, the fat being 12·7% of fresh weight in the 60 g/kg piglets and only 7·5% in the 30 g/kg animals (see Table).

The significance of these observations will be discussed in relation to the animal's future development.

*On leave from Estacion Experimental del Zaidin, Granada, Spain.

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Distribution of vitamin A in human liver. By D. S. McLaren, Z. Mawlayi, and A. Downing, *Department of Physiology, Medical School, Edinburgh*

Liver vitamin A has been used extensively as an indication of vitamin A status (e.g. Raica *et al.* 1972) and recommended to assist in defining a deficiency problem (WHO, 1976). Published studies have used determinations on a single small sample to estimate total reserves.

In this study the vitamin A concentration in post-mortem samples of human liver from left and right lobes is compared. Samples with liver pathology or autolysis were excluded by histological examination. Material was obtained from fifty-one foetuses and thirty-three infants dying from various causes and from fifty-nine adults suffering accidental death. Trifluoracetic acid was used in duplicate determinations. Samples were kept at −20° until analysis, at about weekly intervals.

Values distinctly tended to be greater on the right side than on the left in the three groups, most marked in the foetal. In the same liver differences were often great, up to nearly twenty fold. If differences <10% are ignored then R>L (Foetal 45, Infant 27, Adult 39), L>R (Foetal 4, Infant 2, Adult 7) and no difference (Foetal 2, Infant 4, Adult 10). Distributions, means and medians are shown in the Table.

Vitamin A (μg retinol/g fresh liver)	Foetal		Infant		Adult	
	Left	Right	Left	Right	Left	Right
<10	19	7	4	1	1	1
11–100	31	34	12	16	18	12
101–500	1	10	16	14	34	36
>500	0	0	1	2	6	10
Mean	26·1	61·3	166·2	242·4	247·6	310·4
Median	13·6	47·7	56·3	70·7	174·7	231·1

The foetal liver is an asymmetric organ (Healey & Sterling, 1963). Lesser chemical differences have been reported (Emery & Hilton, 1961). The left side receives more highly oxygenated blood. There is twice as mush connective tissue on the left than the right side at birth (Ghosh & Emery, 1970). There is asymmetry in the adult liver circulation (McIndoe & Counseller, 1927). Furthermore, most vitamin A is in parasinusoidal (Ito, stellate, fat-storing) cells, of very irregular distribution, which comprise no more than 1·4% of total liver volume and <5% by weight of non-parenchymal cells.

Emery, J. L. & Hilton, D. J. (1961). *Acta paediat, Stockh.* **50**, 233.
Ghosh, M. L. & Emery, J. L. (1970). *J. clin. Path.* **23**, 599.
Healey, J. E. & Sterling, J. A. (1963). *Ann. N. Y. Acad. Sci.* **111**, 25.
McIndoe, A. H. & Counseller, V. S. (1927). *Archs Surg., Lond.* **15**, 589.
Raica, J. Jr., Scott, J., Lowry, L. & Sauberlich, H. E. (1972). *Am. J. clin. Nutr.* **25**, 291.
World Health Organization (1976). *Tech. Rep. Ser. Wld Hlth Org.* No. 590.

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The effect of either raw or boiled potato juice on the digestibility of a diet based on barley in pigs. By R. M. LIVINGSTONE, B. A. BAIRD, T. ATKINSON and R. M. J. CROFTS, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

The nitrogen of raw potato is poorly digested by the pig and this has been attributed (Whittemore *et al.* 1975) to powerful chymotrypsin inhibitor activity which is heat labile. Untreated potato starch is resistant to α-amylase (Sandstedt & Gates, 1954) and raw potato reduces the digestibility of dietary N and organic matter (OM) in the fore gut (Livingstone *et al.* 1977). The hypothesis now tested was that the reduction in N digestibility is due mainly to the influence of the inhibitor and not due to either physical inaccessibility of much of the protein to enzyme attack or the native protein of the potato being refractory to gut enzymes.

Four pigs, each fitted with an ileal cannula, were fed on a basal diet of barley plus vitamins and minerals to which was added minced raw potato (RP) or a liquid extract of potatoes which was either freeze-dried (LE) or boiled and concentrated (BE). The N contents of the potato materials (g/kg DM) were 20·7, 57·3, 57·9 and the inhibitor levels (units/g DM), 1·22, 2·57 and zero for RP, LE and BE respectively. These materials each contributed 12 g N/pig per d and supplied 30·1, 24·8 and 25·6% of total N intake. Each pig was given 2·1 kg OM/d and in diet RP, 25·5% of this was from potato compared with 7·2 and 7·8% in diets LE and BE respectively.

Digestibility of N in the fore gut was reduced with RP by 9·5% (NS) and with LE by 23% ($P<0·01$) while BE increased it by 24·7% ($P<0·01$) compared with the digestibility coefficient for N in barley. OM digestibility was poorer with RP by 9·5% ($P<0·001$) but with LE and BE it did not change significantly from the control value. Over the whole gut, coefficients for N changed by −19·8% ($P<0·001$), −4·7% (NS) and +9·0% ($P<0·05$) when RP, LE or BE respectively were included in the basal diet. Corresponding changes in OM were +2·4% (NS), +1·9% (NS) and +3·6% ($P<0·05$).

The results suggest that the hypothesis tested is valid and therefore the protease inhibitor in potatoes should be denatured by appropriate treatment.

Livingstone, R. M., Atkinson, T., Baird, B. & Crofts, R. M. J. (1977). *Proc. Nutr. Soc.* **36**, 58A.
Sandstedt, R. M. & Gates, R. L. (1954). *Food Res.* **19**, 190.
Whittemore, C. T., Taylor, A. G., Moffat, I. W. & Scott, A. (1975). *J. Sci. Fd Agric.* **26**, 255.

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Carob meal as an energy source for poultry. By EUGENIA P. KAMARINOU, H. F. WALKER, W. MICHIE and J. H. TOPPS, *School of Agriculture, 581 King Street, Aberdeen AB9 1UD*

Carob beans, the sweet, edible fruit of the Carob tree (*Ceratonia siliqua*) which grows readily in areas with a Mediterranean climate, are a potential source of energy for poultry. Earlier work (Kratzer & Williams, 1951) on carob-bean meal (pods and seeds) showed that they depressed the growth of chicks even at low levels of dietary inclusion. Subsequent studies (Nachtomi & Alumot, 1963) indicated that the presence of condensed tannins was mainly responsible for this adverse effect. Tannins can affect the food intake and nitrogen metabolism of animals but the relative importance of such physiological effects in chicks given carob meal is not clear. Two trials have been performed with growing chicks, the first to measure the metabolizable energy (ME) value of carob meal and any adverse effects it has on protein digestion, and the second to ascertain whether supplementation of diets containing the meal with energy, protein or methionine can overcome a poor growth rate.

In Expt 1 the ME value of carob meal was found to be 5·64 kJ/g. Digestibility of protein fell as the proportion of carob meal in the diet was increased from 0 to 440 g/kg and a depression in proteolytic activity in digesta was found. The pancreas from chicks receiving the highest level of carob meal was significantly heavier than that of the controls. Results of the second trial are shown in the Table.

Performance of growing chicks given diets containing carob meal

Diet no.	Food intake (g/28d)	Weight gain (g/28d)	Food conversion ratio (gain/food)
(1) Low energy control	763	300	0·393
(2) Diet containing 300g/kg carob meal	691	201	0·290
(3) Diet (2) made isoenergetic and isonitrogenous with 1	739	277	0·375
Diet (3) + 20% protein	696	312	0·448
Diet (3) + 20% energy	658	254	0·385
Diet (3) + 20% methionine	717	270	0·376
Diet (3) + 20% protein + 20% energy	665	282	0·424
Conventional control	717	345	0·482
SE of difference between means (14df)	17·2	15·9	0·008

The iron status of the chicks was not affected by the tannin in the carob meal. It may be concluded that carob meal can be used in the diet of growing chicks up to the level of 300 g/kg without an adverse effect on growth and utilization of food provided that the diet contains extra protein and energy to offset the low nutritive value of carobs.

Kratzer, F. H. & Williams, D. E. (1951). *Poultry Sci.* **30**, 148.
Nachtomi, E. & Alumot, E. (1963). *J. Sci. Fd. Agric.* **14**, 464.

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Nutrient intake in elderly women after femoral neck fracture. By J. W. T. DICKERSON, R. SOPER and M. W. J. OLDER, *Division of Nutrition and Food Science, Biochemistry Department, University of Surrey and Royal Surrey County Hospital, Guildford*

Work currently in progress in our laboratory suggests that elderly female patients admitted to hospital with femoral neck fractures are often malnourished and that this contributes to their morbidity and mortality.

The present study was undertaken to assess the nutrients consumed post-operatively by such patients. Ten female patients with a mean age of 77 years (range 54–88 years) with femoral neck fractures treated by operation were studied. Total fluid and food consumption was measured on the third, seventh and fourteenth post-operative days. The amount of food eaten by a patient was calculated by weighing each food item before and after consumption of a meal. All drinks taken were recorded and a record was also made of all extra items consumed between meals. Thus the total food intake for each 24 h period was obtained. The nutrient content of the food consumed was determined with a computer program based on the 'Composition of Foods' (McCance & Widdowson, 1969).

The nutrient intake of these patients was compared with DHSS (1969) recommended intakes for women of a similar age.

The mean total weight of food consumed was similar for all assessed days. On each day the greatest contribution to the total intake was made by milk.

The calculated intake of energy, protein, iron, potassium, vitamin A, thiamin, riboflavin, vitamin C and vitamin D were below the recommended level on 75% of patient days.

The overall energy intake was 50% of the DHSS recommended value and the amounts of thiamin, riboflavin and niacin were reduced in proportion. The intake of vitamin D was very low thus apparently negating the high calcium intake. In all patients the calculated intake of vitamin C barely reached the amount recommended for healthy adults. Other work (Felton, 1978) suggests that due to cooking losses the intake of vitamin C was, in fact, only about 50% of the recommended value. No patient in any day received the minimum recommended intake of folic acid.

The possible importance of these low nutrient intakes will be discussed with particular reference to the metabolic response to trauma and the potential value of a nutritional supplement after surgery in elderly patients.

Department of Health and Social Security (1969). *Report on Public Health and Medical Subjects*, No. 20. London: HMSO

Felton, G (1978). The cooking losses of vitamin C in food served in different kinds of hospitals. BSc Thesis. University of Surrey.

McCance, R. A. & Widdowson, E. M. (1969). *Spec. Rep. Ser. med. Res. Coun.* No. 297. London: HMSO

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Dietary intake in human pregnancy. By D. M. CAMPBELL, B. M. CAMPBELL-BROWN, L. JANDIAL and I. MACGILLIVRAY, *Department of Obstetrics and Gynaecology, University of Aberdeen, Forester Hill, Aberdeen AB9 2ZB*

Over recent years there has been a renewed interest in maternal nutrition in human pregnancy. This has been concentrated in two main areas: firstly, low-birth-weight babies and the possible effect of supplementing the diet in pregnancy and, secondly, the effect of reducing intake by dietary restriction, particularly in obese pregnant women.

There is uncertainty about nutritional intake in many studies because of difficulty in its measurement. This can be overcome to a large extent by a supervised weighed-diet survey for one week and the estimation of 24 h urinary nitrogen which correlates well with protein intake.

A group of women selected as being at risk of delivering a light for dates infant have had their diet measured as described above at about thirty weeks gestation. These women were selected when any two of the following four were present: height less than 1·54 m, weight less than 54 kg, weight for height less than 25th centile (Kemsley *et al.* 1962), weight gain between twenty and thirty weeks less than 0·33 kg/week. Another group of forty-two obese women (i.e. weight for height greater than the 75th centile) have also been studied at the same gestation.

In both groups of women the mean energy intake was similar and was less than that recommended by the Department of Health and Social Security for pregnant women in the United Kingdom. The proportion of women with an adequate energy intake by the recommended standards was 18·6% of low-birth-weight women and 16·7% of obese women.

The mean daily dietary protein intake was similar in both groups with approximately 30% in each group less than the recommended 60 g/d.

Kemsley, W. F. B., Billewicz, W. Z. & Thomson, A. M. (1962). *Brit. J. prev. soc. Med.* **16**, 189.

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Carotenoid and retinol levels in the blood of ulcerative colitis patients and controls. By I. M. SHARMAN, *Dunn Nutritional Laboratory, University of Cambridge and Medical Research Council,* and A. P. DICK, M. J. G. FARTHING, J. R. BRYANT, and S. BEEVOR, *Addenbrookes Hospital, Cambridge*

Reduced absorption of vitamin A has been reported in patients with ulcerative colitis by Page & Bercovitz (1943), who had previously demonstrated a lower level of vitamin A in the blood in about 25% of patients with chronic ulcerative colitis (Bercovitz & Page, 1944). Because of isolated reports of improvement in patients with ulcerative colitis following the consumption of large quantities of carrot juice it was decided to examine levels of carotenoids and retinol in the blood of such patients and to compare the findings with those of control subjects of the same sex and age group.

Carotenoids were measured by their natural yellow colour and retinol with the $SbCl_3$ reagent, in groups of patients with acute, chronic, and quiescent disease and the significance of differences was examined by the paired Students 't' test.

Group		No. of pairs	Carotenoids (μg/100ml)		Retinol (μg/100ml)	
			Colitics	Controls	Colitics	Controls
1.	Chronic cases:					
	♂	14	45·5*	77·3	47·9	50·0
	♀	21	58·5	59·5	36·9**	49·7
2.	Active cases:					
	♂	12	49·7*	96·3	61·6	47·9
	♀	18	68·5***	95·2	62·7	48·1
3.	Quiescent cases:					
	♂	9	79·6	84·2	69·4	55·8
	♀	10	77·9	105·4	65·8	58·4
4.	Further active cases:					
	♂	9	131·0	76·4	48·1	61·0
	♀	14	89·2	112·4	70·4	63·9

*$P<0.05$, **$P<0.02$, ***$P<0.01$.

Although small differences were found in the concentrations of carotenoids and retinol in the blood of patients and controls, only those indicated in the Table were significant. To ascertain whether the slightly abnormal range of carotenoids and retinol in the blood of colitics could be explained by abnormal intakes of food containing these nutrients a dietary survey was carried out. Intakes of carotene and retinol were estimated for one week before the specimens were taken in groups 3 and 4. No consistent relationships between blood levels of the substances and dietary intake were observed. In two patients who had consumed large quantities of carrots or spring greens the concentrations of blood carotenoids were very high.

Bercovitz, Z. & Page, R. C. (1944). *Annls. int. Méd. phys. Physio-Biol.* **20**, 239.
Page, R. C. & Bercovitz, Z. (1943). *Am. J. dig. Dis.* **10**, 174.

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Water holding by dietary fibre in vitro and its relationship to faecal bulking in man. By ALISON M. STEPHEN and J. H. CUMMINGS, *MRC Dunn Clinical Nutrition Centre, Addenbrookes Hospital, Trumpington Street, Cambridge CB2 1QE*

Many of the beneficial effects attributed to dietary fibre are thought to be a result of its ability to increase faecal output in man. The mechanism is unknown, but it is believed that the capacity of fibre to take up and hold water is important.

Various methods have been used in the past to measure water-holding capacity, but none can be successfully applied to both food fibre and gel-forming polysaccharides such as pectin and guar gum. Furthermore, most tests are carried out in conditions which do not resemble those in the gut.

We have therefore developed a new method, whereby the fibre material to be tested is enclosed in a small sack of dialysis tubing, which is then placed in a flask containing simulated ileal solution, and agitated. After 24 h and 48 h, the bag is removed, blotted dry and weighed. Polyethelene glycol is added to the flask at 48 h to simulate colonic absorption and the bag reweighed after a further 24 h.

Using this method, the water holding of seventeen dietary fibre preparations was estimated. The values varied from 56·2 g water/g material at 24 h for pectin to 4·2 g water/g material for bran. These results were compared with those using a centrifugation technique (McConnell *et al.* 1974) and a close relationship was found for the food materials (r 0·85), gels being excluded.

The chemical factors responsible for the uptake of water were studied using three pairs of pure polysaccharides with only slight chemical differences. The materials with more charged groups on the molecule took up more water and it appears that these may hold much of the water through the osmotic pull of counter-ions. This may also hold for the food materials, where a close relationship was found between water uptake and uronic acid content (r 0·86).

Eight of the materials used, namely cabbage, carrot, apple, guar gum, bran, bagasse, Isogel and pectin, had been fed to human volunteers. The effect of these materials on faecal weight could therefore be compared with their water holding ability and a negative exponential relationship, which was highly significant (r 0·96), was found between these two factors. Hence it appears that the greater the water holding capacity of a fibre preparation the less effect it has on faecal bulk. This is the reverse of general expectation and thus the hypothesis relating faecal bulking and water holding requires re-examination.

McConnell, A. A., Eastwood, M. A. & Mitchell, W. D. (1974). *J. Sci. Fd. Agric.* **25**, 1457.

0029–6651/79/3820–326A $00.35

The effects of protein and energy restriction on plasma transport proteins.

By P. S SHETTY, K. WATRASIEWICZ, R. T. JUNG and W. P. T. JAMES, *Dunn Clinical Nutrition Centre (MRC), Addenbrookes Hospital, Trumpington Street, Cambridge CB2 1QE*

Serum transport proteins have been suggested as sensitive indices of nutritional state in protein–energy malnutrition (PEM) (Ingenbleek *et al.* 1975*a*). Little is known about the relative sensitivity of these proteins to selective dietary energy and protein restriction.

A group of twelve obese women were given a high energy diet (HED) for 10 d calculated to maintain weight and provide 167 kJ (40 kcal) /kg desirable weight and then they were given a low energy diet (LED) for 24 d providing only 38·5 kJ (9·2 kcal) energy/kg desirable weight, energy being restricted by decreasing carbohydrate intake. The patients were divided into three groups of four patients, each group receiving daily either 80, 40 or 20 g milk protein (Casilan) /65 kg ideal body-weight. The fat, mineral and vitamin content was normal throughout the study. Plasma obtained on days 7 and 10 of HED and days 6, 12, 18 and 24 of LED were assayed for albumin, transferrin, thyroxine-binding prealbumin (TBPA), retinol-binding protein (RBP) as well as for immunoglobins A G and M (IgA, IgG and IgM).

During the 10 d HED period protein intake had a small but insignificant effect on albumin, transferrin and TBPA concentrations whereas RBP had already dropped within 6 d of low protein feeding (20 g/d) to 55% of the value found in the 80 g/d group; these low concentrations then persisted throughout the study. Energy restriction produced marked effects on TBPA and RBP concentrations even in patients given 40 or 80 g protein/d. RBP declined rapidly in the 40 g/d group and within three weeks on the LED plasma RBP concentrations were similar in the 20 and 80 g protein/d groups. TBPA concentration, which seemed unaffected by a 10 d period of protein restriction, decreased progressively during the LED in all three protein groups. Plasma transferrin declined slowly in the 20 g/d group throughout the study and seemed unaffected by the additional energy restriction; albumin concentration behaved similarly there being no significant change in circulating immunoglobulin concentrations.

Thus there are differential effects of energy and protein restriction on circulating transport proteins with a rapid turnover. The sensitivity of RBP to either protein or energy restriction makes it useful as a short-term test. RBP is bound as a complex with TBPA (Peterson, 1971) and hence explains the parallel response in these substances during rehabilitation of children with PEM (Ingenbleek *et al.* 1975*b*). Our studies show that TBPA is less affected than RBP by protein intake but is markedly influenced by energy restriction. RBP and TBPA concentrations may be helpful in rapid determination of the efficacy of nutritional support in ill and malnourished patients.

Ingenbleek, Y., Van Den Schrieck, H-G., De Nayer, P. & De Visscher, M. (1975*a*). *Clinica. chim. Acta* **63**, 61.
Ingenbleek, Y., Van Den Schrieck, H-G., De Nayer, P. & De Visscher, M. (1975*b*). *Metabolism* **24**, 633.
Peterson, P. A. (1971). *J. biol. Chem.* **246**, 44.

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The effects of beta adrenergic blockade on basal metabolism and peripheral thyroid metabolism. By R. T. JUNG P. S. SHETTY and W. P. T. JAMES, *Dunn Clinical Nutrition Centre (MRC), Addenbrookes Hospital, Trumpington Street, Cambridge CB2 1QE*

The effect of beta-adrenergic blockade on the resting metabolic rate (RMR) was studied in ten obese subjects with a weight of 91·3±3·7 kg and age 42·7±3·0 years (mean ± SEM). Four 10 d subjects were given a high energy diet (HED) calculated to provide 167 kJ (40 kcal) of energy/kg desirable weight and then they were given a low energy diet (LED) for 21 d providing 38·5 kJ (9·2 kcal) energy per kg desirable weight. Both diets consisted of identical protein (80 g/d), fat (10 g/d), vitamins and minerals, the energy being restricted by decreasing dietary carbohydrates. The RMR was measured every third day by the ventilated hood technique.

The four subjects acting as controls showed no significant fall in the RMR on the HED (6·78±0·40 and 6·71±0·34 MJ/d on day 3 and 10 respectively). The other six subjects were given propranolol orally from day 4 to 10. The dose was increased over 3 d to a maximum of 80 mg/6 h. There was a significant fall in the RMR (6·89±0·30 to 6·33±0·27 MJ/d at day 7 of beta-blockade; $P<0·01$). While on the LED four of these subjects were again given propranolol at the same dosage from day 15 to 21 of energy restriction. There was no significant fall in the RMR with beta blockade on this diet; those on diet alone also showed no significant fall in the RMR over the same time period.

Beta-blockade did not alter serum thyroxine on either high or low energy diets but it decreased serum triiodothyronine (T_3) on both diets. With propranolol the fall in T_3 was 0·55±0·18 and 0·39±0·26 nmol/l on HED and LED respectively. Reverse triiodothyronine (rT_3) increased with beta-blockade by 0·148±0·05 ng/ml on the HED and 0·138±0·02 ng/ml on the LED. These responses to propranolol were not significantly different on the two diets.

Beta-blockade appears to affect thyroid metabolism in a similar manner on both high and low energy diets but beta-blockade reduced the RMR on the HED only. Thus, the difference in RMR response while on these diets may not be related to the peripheral thyroid metabolism. The failure of beta-blockade to reduce RMR further on the LED may relate both to decreased catecholamine turnover on semistarvation (Jung *et al.* 1978). and to a specific change in catecholamine-mediated thermogenic mechanisms.

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Changes in hepatic copper stores in pre-ruminant and ruminant lambs given ammonium tetra-thiomolybdate in their diets. By N. F. SUTTLE, *Moredun Research Institute, 408 Gilmerton Road, Edinburgh EH17 7JH*

Most manufactured foodstuffs contain sufficient copper to be considered potentially toxic for sheep. The addition of small amounts of Cu antagonists molybdenum and sulphur reduces hepatic Cu retention and their use in such foodstuffs has been advocated (Suttle, 1977). Mo and S may protect by converting Cu to unavailable thiomolybdate-complexes in the rumen (Suttle, 1974) and therefore we studied effectiveness of a preformed thiomolybdate in limiting the accumulation and enhancing the removal of Cu from the ovine liver.

Four groups of three ABRO Dam line×Dorset Horn lambs, 2 weeks old, were reared on a proprietary milk substitute, containing 10·5 mg Cu/kg DM. They were allocated on the basis of initial liver (biopsy) Cu concentrations to one of four treatments for 21 d (Period A) in a 2×2 factorial experiment, 0 or 5 mg Cu as $CuSO_4.5H_2O$ and 0 to 3 mg Mo/kg DM as ammonium tetra-thiomolybdate (ATM), prepared by the method of Tridot & Bernard (1962). The surviving lambs (10) were then switched to a milk substitute containing only 1·5 mg Cu/kg DM and were re-allocated as before to one of two treatments for 25 d (Period B) 6 mg Mo as ATM or no supplement. After weaning, ATM supplementation was continued for a further 18 weeks (Period C) at a level of 3 mg Mo/kg DM in a pelleted diet based on (g/kg) whole oats 870, blood meal 40, urea 20 and vegetable oil 30 and containing 3·5 mg Cu/kg DM. The changes in liver Cu concentration between successive biopsy samples (start and end of Periods) are given in the Table.

Effects of including ammonium tetra-thiomolybdate (ATM, 7·5 or 15 mg/kg DM) in the diet of pre-ruminant (Periods A and B) and ruminant (Period C) lambs on changes in liver Cu concentration (mg/kg DM) between biopsies.

	Period A Milk substitute		Period B Milk substitute	Period C Largely pelleted oats
Cu in diet (mg/kg DM)	10·5	15·5	1·5	3·5
Diet				
No ATM	235	470	66	−316
ATM	155	308	2	−328
SE of mean	26·5		39·6	36·8

The addition of ATM influenced hepatic Cu storage most markedly when the basal diet allowed a rapid build up of Cu in the liver, i.e. in Period A ($P<0.001$): then, the effect was equally marked at the two dietary Cu levels. The results during Period C suggest that thiomolybdate, at the concentrations given in this experiment, will not greatly accelerate the removal of Cu already accumulated in the liver. The primary effect of ATM would appear to be located in the gut, involving a reduction in the absorbability of Cu, and may be enhanced when most of the dietary Cu is in the inorganic form.

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Rates of loss of hepatic copper during copper-depletion of cattle. By I. McDONALD, C. F. MILLS, A. C. DALGARNO and ANNE M. SIMPSON, *Rowett Research Institute, Bucksburn, Aberdeen*

A study has been made of the rate of loss of liver copper in growing cattle undergoing Cu depletion while being prepared for a variety of experiments on Cu utilization or the effects of Cu deficiency.

Observations were made on two batches of Friesian calves maintained on a semi-synthetic ration containing between 1·0 and 1·4 mg Cu/kg dry matter (DM). Liver samples were obtained by biopsy. The mean weights and rates of weight gain of the calves during these studies were respectively 125 kg and 0·75 kg/d (eighteen animals) and 74 kg and 0·79 kg/d (twenty-one animals).

Despite marked individual differences in liver Cu at the start of depletion (range 137 to 1025 mg Cu/kg liver DM) a highly significant linear relationship was observed between hepatic Cu content and its subsequent rate of decline. Hepatic Cu content at intervals during depletion was predictable from the expression:

$$Cu_{t_1} = Cu_{t_0} e^{-k(t_1 - t_0)}$$

where Cu_{t_0} = hepatic Cu on day t_0 (mg/kg DM);

Cu_{t_1} = hepatic Cu after $(t_1 - t_0)$ d;

$k = 0{\cdot}0273 \pm 0{\cdot}0008$

Results from a further seventy-three Friesian cattle (weight range 98–419 kg) having indicated that total liver DM (kg) is predictable from live weight (W;kg) by the equation.

$$\text{liver DM} = 0{\cdot}300\ (\pm 0{\cdot}073) + 0{\cdot}0033\ (\pm 0{\cdot}0003)\ W$$

we have used these two relationships to estimate daily changes in total hepatic Cu. These estimates suggest that Cu is lost from the livers of cattle on Cu-deficient diets at rates that are determined by existing hepatic reserves of this element. As the rates of hepatic Cu loss from our animals substantially exceeded their net demand for body tissue growth (variously estimated as 0·47 (Suttle, 1977) or 0·85 (calculated from Kirchgessner & Neesse, 1976) mg Cu/kg body-weight gain) we conclude that endogenous losses of Cu must also be directly related to existing hepatic Cu reserves. This argument emphasises the importance of defining liver Cu status and its subsequent changes in experiments intended to estimate the efficiency of utilization of dietary Cu or to estimate Cu requirements.

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