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PROCEEDINGS OF THE NUTRITION SOCIETY

ABSTRACTS OF COMMUNICATIONS

The Three Hundred and First Meeting of the Nutrition Society (The One Hundred and Twentieth of the Scottish Group), for the presentation of original communications, was held at 10.30 *a.m. on Friday,* 4 *February,* 1977 *in the Queen's Hotel, Leonard Street, Perth, when the following papers were read:*

The effect of drying temperatures upon the nutritive value of barley for growing chickens. By A. A. WOODHAM, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB,* and P. H. BAILEY, *Scottish Institute of Agricultural Engineering, Bush Estate, Penicuik, Midlothian EH2 6OPH.*

Seven samples of Zephyr barley were dried at temperatures from 54° to somewhat in excess of 90° using driers of concurrent flow or fluidised bed type (Bailey, 1972). Each dried sample was evaluated 4 times by a chick growth test of Total Protein Efficiency type (Woodham, 1968); the 19% crude protein diets were based on those used previously for comparison of barley varieties and contained groundnut meal as a source of supplementary protein (Woodham *et al.* 1972). Weight gain and protein consumption were measured between 2 and 4 weeks of age.

Weight gain and protein consumption were similar for all 7 diets. Differences just reaching statistical significance were found in the range of 4 concurrent flow dried barleys (*t* 5%), but not for the 3 fluidised bed dried samples (Table 1).

Table 1. *Total protein efficiency (TPE) results for mixtures of groundnut meal with each of 7 barleys dried under different conditions*

Drying conditions				TPE				
	Grain temp.			Experiment				
Air inlet temp (°)	Max. (approx)	(°) mean	Drier type*	1	2	3	4	Mean
171	>90	—	cf	1·94	1·97	1·96	2·01	1·98
115	83	—	cf	1·98	2·00	2·01	2·03	2·01
89	67	—	cf	2·01	2·04	2·01	2·02	2·02
68	54	—	cf	2·04	2·00	1·92	1·97	1·97
124	—	80	fb	2·00	2·02	2·01	2·02	2·01
102	—	74	fb	2·05	2·02	2·01	2·03	2·02
64	—	52	fb	2·02	2·02	2·03	2·05	2·03

*cf, concurrent flow; fb, fluidised bed.
SE of difference between means ±0·018.

It appears that, for the chick, the nutritive value of barley is not affected materially by a grain temperature of 90°. This is in line with work on wheat in which Milner & Woodforde (1965) found that drying for 2 h at a mean grain temperature of 89° did not affect the nutritive value for poultry, and on maize where Emerick, Carlson & Winterfeld (1961) showed that an inlet air temperature of 177°—similar to the maximum used in the current work—did not depress nutritive value for chicks. A maximum grain temperature of 94° adversely affected the quality for chicks of a mixture of barley and leaf protein concentrate (Duckworth & Woodham, 1961). Factors other than temperature, such as time of exposure and grain moisture content, should be taken into consideration, but it is suggested that maximum grain temperature during drying should not exceed 90°.

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Milner, C. K. & Woodforde, J. (1965). *J. Sci. Fd Agric.* **16**, 369.
Woodham, A. A. (1968). *Br. Poult. Sci.* **9**, 53.
Woodham, A. A., Savić, S., Ayyash, B. J. & Gordon, S. J. (1972). *J. Sci. Fd Agric.* **23**, 1055.

Attempts to overcome anti-nutritive factors in field beans (*Vicia faba* L) and field peas (*Pisum sativum*) fed in diets to laying hens. By J. DAVIDSON, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

Field beans. Previous work (Davidson, 1973) has suggested that field beans contain an anti-nutritive factor which becomes increasingly disruptive to egg production as the concentration of beans in the diet rises above 15%. On the assumption that this factor might be heat-sensitive like the toxic factor in the navy bean (*Phaseolus vulgaris*) or like the antitrypsin factor in soya beans, experiments were conducted with field beans, subjected to 2 types of heat treatment. These were included in diets which had been supplemented with methionine to the levels found in control fishmeal diets. The treatments were (i) autoclaving at 120° for 15 min and (ii) infra-red heating of whole beans in a continuous-flow system for about 70 s at 150° immediately before flaking by passing through rollers (micronisation).

The results indicated that autoclaving the ground beans and pelleting the resultant diets had no greater effect than pelleting a diet containing unheated beans. With 25 and 35% beans in diets supplemented with methionine, production remained 10% below that on a control fishmeal diet. Micronising the beans appeared to be beneficial at a 35% level of inclusion in the diet but not at 15%; an inconclusive result, with egg production 6 to 18%, respectively, below that on the control diet.

Pelleting itself is, in effect, a short heating process, and an experiment to assess its value showed no consistent increase in egg production as a result of pelleting. Any increase was associated with increased feed consumption. In this experiment also, a white-flowering and therefore low-tannin variety of bean, Threefold White, was fed to test whether the tannin present mainly in the brown seed coats of other varieties had a detrimental effect. Results indicated that the presence of tannin in the seed coat was without significant effect on egg production.

Field peas. In several of the experiments, ground field peas were tested. They too had a supplementary protein value for egg production lower than that of fishmeal. When diets contained 17% and 37% peas, production was 20% and 45%, respectively, lower than that on the control diet. With the 37% concentration, either the addition of 0·2% methionine or heat treatment of peas by micronisation improved production to rates still 20% below that obtained with fishmeal. With methionine addition as well as the heat treatment, production was further improved to that obtained on the fishmeal control diet. As with the bean diets, there was an indication that some mechanism associated with feed uptake was involved.

Davidson, J. (1973). *Br. Poult. Sci.* 14, 557.

Milk replacers based on non-milk constitutents for lambs. By H. S. SOLIMAN, E. R. ØRSKOV and R. I. SMART, *The Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

In a previous report (Soliman *et al.* 1976) it was shown that undried fish protein hydrolysate (FPH) prepared by enzymatic hydrolysis (Mackie, 1974) could replace all milk proteins with little or no effect on lamb growth rate, when the fat was lard and coconut or butter fat and the carbohydrate source was lactose.

The replacement of milk lactose with starches has generally been unsuccessful possibly because of the low pancreatic amylase and intestinal maltase activities in calves (Dollar & Porter, 1957), or lambs (Walker, 1959). However, if partially pre-digested and given in small quantities at a time, starch can replace milk carbohydrates and possibly a portion of milk fat with little effect on lamb growth (Soliman & Ørskov, unpublished results). The utilization of starch in milk diets is likely to be affected by the protein source (Coombe & Smith, 1974), but the effect on food utilization of including partially pre-digested starch (Protamyl 110, Roquette Freres, 62 Lestrem, France) in milk diets based on non-milk protein (FPH) is not known.

Four experimental diets were prepared daily to contain, per kg dry matter (DM), 320 g protein (casein or FPH), 380 g fat (butter or lard and coconut fat 90:10) and 250 g lactose or Protamyl 110. All the diets were supplemented with minerals and vitamins. Four lambs received each diet from one week of age and were fed every 3 h at a level of 1·046 MJ/kg$^{0.75}$ per day for 33 d. The animals remained healthy during the experiment. The live weight gains of lambs given FPH were slightly lower during the first 15 d. This was compensated in the second period, so that over the whole 33 d there were no significant differences. The food conversion ratios and DM, N and fat digestibility were similar for the four diets, and starch contents of the faeces were negligible. This experiment demonstrates that it is possible to rear a lamb from one week of age on a liquid diet that contains no milk constituents. The practical implications of this work are being explored with a larger number of lambs.

Protein source:	Casein	Casein	Casein	FPH	
Fat source:	Butter	Butter	Lard and coconut	Lard and coconut	SE of
Carbohydrate source:	Lactose	Protamyl	Protamyl	Protamyl	mean
Live weight gain (first 15 d; g/d)	151	167	128	112	16·2
Live weight gain (33 d; g/d)	174	183	154	170	14·8
Overall food conversion ratio (kg DM/kg gain)	1·02	1·06	1·08	1·00	0·07
DM digestibility	0·978	0·965	0·964	0·954	—
N digestibility	0·969	0·949	0·939	0·936	—
Fat digestibility	0·989	0·980	0·977	0·976	—

Coombe, N. B. & Smith, R. H. (1974). *Br. J. Nutr.* **31**, 227.
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Soliman, H. S., Ørskov, E. R., Mackie, I. M. & Dodsworth, T. L. (1976). *Proc. Nutr. Soc.* **35**, 91A.
Walker, D. M. (1959). *J. agric. Sci., Camb.* **53**, 374.

Partition of non-urinary loss of blood urea and sulphate between the rumen and postruminal tract of sheep. By P. M. KENNEDY and L. P. MILLIGAN, *Department of Animal Science, University of Alberta, Edmonton, Alberta, Canada, T6G 2E3*

The rates of irreversible loss of urea and sulphate from the blood by non-urinary routes were studied in sheep given 66 g dry matter (DM)/h of brome grass (*Bromus inermis*) pellets or 52 g DM/h of lucerne (*Medicago sativa*) pellets. Two Suffolk wethers, with cannulae in rumen and abomasum, were given a continuous intravenous infusion of $Na_2{}^{35}SO_4$ and [^{15}N]urea for 48 h. During the final 8 h of infusion blood and rumen samples were taken for analysis. A subsequent infusion of [^{103}Ru]phenanthroline, [^{51}Cr]EDTA, $^{15}NH_4Cl$ and $Na_2{}^{35}SO_4$ was made into the rumen for 6·5 d. Samples of blood, rumen fluid and abomasal digesta were taken during the final 3 d. Movements of N and S through and between blood urea and sulphate pools, and rumen ammonia and sulphide pools were calculated using the equations presented by Nolan, Norton & Leng (1976).

The brome grass and lucerne diets provided 32·6 g N/d, and 2·23 and 2·63 g S/d, respectively. Of the 19·6 and 24·6 g N/d irreversibly lost from the blood urea pool, 10·5 and 6·0 g N/d were lost by non-urinary routes, 5·9 and 5·6 g N/d by a non-rumen route, presumably into the postruminal tract. There was incorporation of 3·2 and 0·6 g N/d from blood urea into microbial N leaving the abomasum in sheep given brome grass or lucerne, representing 0·21 and 0·03 of microbial N production. Partition of the 0·91 and 2·19 g S/d, respectively, irreversibly lost from the blood sulphate pool revealed that 0·41 and 1·0 g S/d was lost by non-urinary routes, 0·40 and 0·96 g S/d by routes not involving transfer into the rumen. Of microbial S leaving the abomasum, 0·04–0·02, or 33–22 mg S/d was derived from blood sulphate.

There were gains of 4·9 and −2·2 g non-ammonia-N/d and 390 and −635 mg organic S/d in the forestomachs of sheep given brome grass and lucerne, respectively. Of the N gain, 0·65 was due to microbial incorporation of recycled blood urea, with 1·7 g N/d attributed to secretion of gastric juices and salivary protein in the sheep given brome grass. In contrast, only 0·08 (33 mg S/d) of the gain of organic S in the forestomachs could be attributed to microbial incorporation of recycled blood sulphate; 357 mg S/d of the net gain was derived from other sources, probably principally from salivary proteins. Our results indicate that there can be substantial differences in the extent of urea-N transfer from blood to rumen as a result of dietary differences, but that transfer of blood sulphate-S may not be meaningfully influenced. Transfer of endogenous organic S is of greater quantitative significance than is transfer of sulphate-S to the rumen. Consequently S inadequacy may develop in the rumen of sheep more readily than would N inadequacy (Kennedy, Williams & Siebert, 1975).

Kennedy, P. M., Williams, E. R., & Siebert, B. D. (1975). *Aust. J. Agric. Res.* **28**, 31.
Nolan, J. V., Norton, B. W. & Leng, R. A. (1976). *Br. J. Nutr.* **35**, 127.

Incorporation of urea nitrogen into microbial-N in the stomach of the young steer: experiments with ^{15}N. By D. N. SALTER and R. H. SMITH, *National Institute for Research in Dairying, Shinfield, Reading RG2 9AT*

Net responses in duodenal nitrogen flow to differences in the amount and kinds of N compounds consumed by a ruminant have been widely studied (e.g. Roffler & Satter, 1975), but there is little information on the true efficiency of incorporation of non-protein-N into microbial-N in the stomach.

Young steers with rumen and simple duodenal cannulas received straw (1 kg/d) in the evening only, and one of the concentrate mixtures shown in the table, with vitamin and mineral (including sulphate) supplements, given twice/d. After about 2 weeks on a diet a recovery experiment was made in which a coarsely ground morning feed was added directly to the rumen. Polyethylene glycol (PEG) as a marker was given with the urea which was labelled with ^{15}N. In some experiments one third of the urea–PEG mixture was given with the tapioca feed and the remainder in equal amounts 2 and 4 h later. In each experiment no evening feed was given but normal feeding was resumed the following morning. Samples of duodenal contents were taken periodically for 24 h (calf 1) or 48 h (calf 2) and samples of rumen contents were also taken.

Relative recoveries at the duodenum of PEG and ^{15}N (as non-ammonia-N) were determined and absolute recoveries of ^{15}N estimated. Mean results for 3 (calf 1) or 2 (calf 2) replicate experiments for each diet were:

Calf no.	Main feed components (kg dry matter/d)				Proportion of diet ^{15}N recovered at duodenum	
	Tapioca	DCGM†	Peptides‡	Urea	Mean	SEM
1	0·70	—	—	0·033	0·39	0·023
	0·65	0·07	—	0·019	0·50	0·040
	0·60	0·14	—	0·005	0·68	0·003
2	0·70	—	—	0·033	0·37	0·023
	0·70	—	—	0·033*	0·38	0·015
	0·65	—	—	0·019	0·52	0·023
	0·65	—	0·05	0·019	0·46	0·014

†Decorticated groundnut meal.
‡Bacto-Peptone (Difco Lab. Inc., Detroit, USA)
*Given in three equal amounts with and 2 and 4 h after tapioca.

Even for the lowest urea intake, when rumen ammonia concentration was low (mean maximum 5·4 mM), conversion of urea-^{15}N to microbial-^{15}N was incomplete. Increasing amounts of urea in the diet led to decreasing recoveries of ^{15}N and the poorest recoveries were associated with accumulation of ammonia in the rumen. Reduction in this accumulation (from mean maxima of 45 to 19 mM) by spreading urea intake over 4 h did not lead to an improvement in recovery. Recovery was poor even when 0·019 g urea formed the only major dietary N source so that N supply almost certainly limited rumen bacterial growth.

Roffler, R. E. & Satter, L. D. (1975). *J. Dairy Sci.* **58**, 1889.

The effect of the level of feeding and composition of the diet on milk secretion in the Ayrshire cow. By J. S. CHALMERS, P. C. THOMAS and MORAG E. KELLY, *The Hannah Research Institute, Ayr KA6 5HL*

Eight Ayrshire cows in their 2nd–3rd month of lactation were used in a duplicated 4×4 Latin Square comparison of four dietary treatments. Two treatments (designated F) included chopped hay (100) and two (designated M) included a mixture of chopped hay and flaked maize (50:50), given at a level sufficient to meet the animals' metabolizable energy (ME) requirements for maintenance. In addition, dairy concentrate cubes were given to supply either 0·8 (designated L) or 1·1 (designated H) of the ME requirements for milk production. Milk yields for the animals receiving the FL, ML, FH and MH diets were 16·28, 17·05, 17·91 and 18·0±0·45 kg/d. Corresponding figures for milk solids-not-fat content were 83·9, 85·4, 85·7 and 87·5±0·5 g/kg and for milk protein content were 29·4, 31·2, 30·7 and 32·5±0·57 g/kg. The composition of the crude protein fraction of the milk and the milk lactose content varied little with the dietary treatments, but the milk fat content was inversely related to the protein content. The low fat contents associated with the M diets were linked with low proportions of palmitic acid and high proportions of oleic acid in the fat.

A second 4×4 Latin Square experiment was conducted with 4 non-lactating rumen-cannulated cows given the diets described above at a level sufficient to meet their ME requirements for maintenance plus a 'production ration' equivalent to that required for a milk yield of 7 kg/d. In these animals the compositions of the mixture of short-chain fatty acids in the rumen (molar proportion of acetic acid:propionic acid:butyric acid) for the FL, ML, FH and MH diets were, respectively, 69·2:17·2:10·5; 64·5:18·0:13·2; 65·9:18·0:12·2 and 62·9:19·9:13·0.

The results of the first experiment show that the effects of diet on milk composition traditionally associated with a change in the 'plane of energy nutrition' (Rook & Line, 1961) can be obtained through an appropriate alteration of the composition of the diet without an increase in the level of feeding. The results of the second experiment indicate that 'an appropriate alteration of diet' leads to a change in ratio, propionic acid:acetic acid in the rumen but not necessarily to a marked increase in the proportion of propionic acid.

The authors are grateful to Dr. D. D. Muir for the analyses of the composition of the milk crude protein. J.S.C. is grateful to the Department of Agriculture and Fisheries for a postgraduate award.

Rook, J. A. F. & Line, C. (1961). *Br. J. Nutr.* 51, 109.

The effect of abomasal glucose or casein infusion on milk yield and milk composition in cows in early lactation and negative energy balance. By E. R. ØRSKOV and D. A. GRUBB, *The Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

High yielding dairy cows have been reported to increase yield when casein was infused into the abomasum (Clark, 1975). In a preliminary experiment we also found abomasal infusion of casein to increase the yield and protein concentration of milk of cows in early lactation that were calculated to be in negative energy balance. Equal amounts of glucose had no effect.

To obtain more quantitative results four potentially high yielding Friesian cows were fitted with abomasal catheters within 2 d post partum. They were given a basal diet consisting of ground barley straw (34%), molasses (5%), rolled barley (57%), urea (1·4%) and minerals (2·2%). It contained 131 g crude protein (N×6·25)/kg dry matter. This diet was offered in quantities calculated to be sufficient for maintenance and a yield of 10 kg/d of fat corrected milk (FCM) according to Moe *et al.* (1970). For periods of 12 d the cows were given various quantities of casein and glucose (see table) according to a latin square design.

The data on milk yield and composition and calculated energy balance are given below:

Casein (g/d)	Glucose (g/d)	Milk yield (kg/d)	Milk fat (g/kg)	FCM (kg/d)	Milk protein (g/kg)	Calculated net energy deficit (MJ/d)
0	750	16·8	48·2	18·9	25·2	20·5
250	500	19·8	49·8	22·7	28·4	30·5
500	250	21·6	51·0	25·2	29·6	38·6
750	0	21·4	54·0	26·1	31·5	41·0
SE of mean		0·8	1·2	—	0·6	—

As casein replaced glucose there was a significant increase in milk yield ($P<0·05$), milk fat content ($P<0·01$) and milk protein content ($P<0·001$). The highest level of casein infusion increased FCM yield by 7·2 kg/d and doubled the calculated deficit of energy (i.e. the difference between the net energy intake and that required for maintenance and milk production). If the value of 0·82 for efficiency of body fat utilization for milk production (Moe *et al.* 1970) is used, the casein infusion is calculated to increase body fat mobilization from 0·65 to 1·3 kg/d.

The results indicate that the limiting factor for milk yield in early lactation can be protein, since it apparently stimulates mobilization of body energy reserves.

Clark, J. H. (1975). *J. Dairy Sci.* **58**, 1178
Moe, P. W., Tyrrell, H. F. & Flatt, W. P. (1970). *Energy Metabolism of Farm Animals.* [A. Schurch and C. Wenk, editors]. Zurich: Juris Verlag.

The effect of intra-abomasal infusions of glucose or casein on milk secretion in Saanen goats receiving a low-protein diet. By S. M. A. FARHAN* and P. C. THOMAS, *The Hannah Research Institute, Ayr KA6 5HL*

Three goats, with permanent abomasal cannulae, in a 3×3 Latin Square experiment were given a diet adequate in energy but low in protein (100 g crude protein/kg) consisting of rolled barley and chopped hay (49:51). Each experimental period was 14 d and the treatments were a control without infusion, a continuous intra-abomasal infusion of casein solution at a rate equivalent to 38·4 g crude protein/kg dietary dry matter (about 75 g/d) or an isoenergetic infusion of glucose solution. Some of the results of the experiment are shown in Table 1. On average the glucose infusion had only a small effect on the yield of milk or milk constituents but there was a much greater response to the infusion of casein solution. Treatment differences in yield were not significant, largely because of the failure of the goat which received casein in the 3rd period of the experiment to respond markedly to the infusion. The effect of both glucose and casein infusions on milk composition was small although the casein produced significant ($P<0.05$) increases in milk non-protein nitrogen and potassium contents and a significant decrease in milk fat content. The latter was linked with a depression in palmitic acid and an increase in oleic acid content of the fat.

Table 1. *The yield and composition of milk and the concentration of plasma glucose in goats given a low-protein control diet or the same diet plus intra-abomasal infusions of solutions of glucose or casein*

	Control	Glucose infusion	Casein infusion	SE of the difference between two means
Milk yield (g/d)*	1261	1335	1644	±105
Milk fat (g/kg)†	30·8	29·6	27·1	±0·6
Milk protein (g/kg)‡	33·7	33·6	34·3	±1·4
Milk lactose (g/kg)	41·4	42·5	41·1	±0·5
Milk total solids (g/kg)	114·2	114·1	111·0	±0·8
Plasma glucose (g/l)§	638	739	656	±63

*Values are for the last 7 d of each period.
†All analysis on two samples representative of 4 successive milkings between days 10–12 and days 12–14 of each period.
‡N×6·38.
§Values are means for 2 samples taken from each animal on two successive days.

The results indicate that the supply of protein in the diet influences the synthesis of lactose in the mammary gland, and thus milk yield, not through limitations on the availability of glucose formed from amino acids (see Thomas, 1976), but through a mechanism dependent on the availability of the amino acids themselves.

The authors are grateful to Mrs. M. E. Kelly for the milk fatty acid analyses. S.M.A.F. is grateful to the University of Baghdad for study leave.

Thomas, P. C. (1976). *World Rev. Anim. Prod.* **XI**, 33.

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The effect of processing potatoes on the apparent digestion by pigs of organic matter and nitrogen measured overall and at the terminal ileum. By R. M. LIVINGSTONE, T. ATKINSON, B. BAIRD and R. M. J. CROFTS, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

Four growing pigs, each fitted with a Y-shaped, moulded PVC cannula located in the ileum, 150 mm from the ileo-caecal junction, were used to evaluate the effects on digestion of thermal or mechanical processing of potatoes. The basal diet contained barley, minerals and vitamins. Potatoes were comminuted using a large industrial mincing machine to give a maximum particle size (m.p.s.) of 8 mm. Additional processing was either steam injection to raise 50 kg of potatoes to boiling point for 20 min, with cooling for 12 h, or further reduction of m.p.s. to 1 mm, using a laboratory mill. The processed potatoes replaced either 50 or 100% of the organic matter (OM) from the barley component of the basal diet. The feed allocation was 100 g OM/kg live weight $(W)^{0.75}$d, and Cr_2O_3 was used as a reference material. Results are given in the table:

Table 1. *The digestibility index to the terminal ileum and the apparent digestibility coefficient overall for the OM and N of each diet*

Barley OM replaced by potato OM ...	Barley diet	Potato diets						
	0	50%			100%			Approx. SEM
		Steamed	Raw		Steamed	Raw		
m.p.s. (mm)	3	8	8	1	8	8	1	
n	4	4	4	4	3	3	3	
Apparent digestibility								
OM								
to ileum	0·74	0·69	0·58	0·49	0·68	0·30	0·29	±0·021
overall	0·81	0·84	0·79	0·82	0·87	0·79	0·83	±0·008
N								
to ileum	0·64	0·47	0·15	0·17	0·34	−0·13	−0·01	±0·041
overall	0·68	0·63	0·60	0·57	0·59	0·39	0·51	±0·036

Digestion of the OM and N of the barley diet was essentially completed in the fore gut. The over-all coefficient for OM for both steamed and raw potatoes was similar to that for barley. To the terminal ileum, steamed potatoes tended to be less well digested than barley while the raw had significantly lower coefficients. Particle size did not affect the results for OM. Overall N digestibility was reduced with potatoes, particularly when the larger particle size was used without barley. The impairment of N digestibility in the fore gut by potatoes was marked, the raw resulting in negative coefficients and in deleterious effects on the utilization of barley N.

The effect of okra mucilage (*Hibiscus esculentus* L.) on the plasma cholesterol level in rats. By JENNIFER A. WOOLFE, *Department of Nutrition and Food Science, University of Ghana, Legon, Ghana*

There is currently a great deal of interest in the hypocholesterolaemic effects of dietary fibre, which, depending upon the plant species, may include variable amounts of mucilage. Many mucilaginous polysaccharides have been found to be hypocholesterolaemic in studies with cockerels (Fahrenbach, Riccardi & Grant, 1966). This study was undertaken to investigate the possible effects of okra mucilage on plasma cholesterol in rats. Okra (*Hibiscus esculentus* L.) is a mucilaginous vegetable occurring frequently in the diet of West Africans.

Two groups, each of 10 albino rats were fed *ad lib.* for 3 weeks, one on a basal diet and the other on a diet containing 3% okra mucilage as dried okra. For 5 d during the final week, weights of food eaten and faeces expelled by each rat were determined. The rats were weighed twice weekly throughout the experimental period. At the end of this time the rats were anaesthetised with chloroform and blood obtained by heart puncture allowed to flow into heparinised tubes. The plasma was analysed for cholesterol by the method of Abell, Levy, Brodie & Kendall (1952).

There was no significant difference in the plasma cholesterol levels of the control and experimental groups of rats. The amount of food eaten by the 2 groups was not significantly different, even though the okra-containing diet was sticky when wetted and might have been expected to cause some discomfort to the rats. The rats on the okra diet on the whole showed a tendency towards lower weight gains than the rats on the basal diet. However, the difference was not statistically significant. Faecal losses were significantly higher from the okra-fed than from the control group. These greater faecal losses appeared to be due to moisture content which was significantly higher in the okra group faeces. Okra mucilage has been found to be extremely hydrophilic (M. L. Woolfe, private communication). The laxative effects of vegetables such as okra might partially explain the high stool weights and low incidence of bowel disorders which have been reported for Africans (Burkitt, 1973).

In this study, the plasma cholesterol level was not found to be affected by okra mucilage. It has been suggested, however, that rats may be relatively resistant to the plasma cholesterol lowering action of dietary fibre (Kay & Truswell, 1975). The possible effect of okra mucilage on human plasma cholesterol remains to be investigated.

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Burkitt, D. P. (1973). *Proc. Nutr. Soc.* **32**, 145.
Fahrenbach, M. J., Riccardi, B. A. & Grant, W. C. (1966). *Proc. Soc. Exp. Biol. Med.* **123**, 321.
Kay, R. M. & Truswell, A. S. (1975). *Proc. Nutr. Soc.* **34**, 17A.

Carbohydrate tolerance in man after six weeks of pectin administration.

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Prolonged administration of dietary fibre as wheat bran is associated with improved carbohydrate tolerance in patients with diverticular disease, and other high-fibre diets have been claimed to reduce the insulin requirement of diabetics. Pectin, a partially methoxylated polymer of galacturonic acid obtained from citrus peel, has been shown to reduce postprandial glucose and insulin levels when taken with a carbohydrate meal, and is hypocholesterolaemic. We therefore studied carbohydrate tolerance and cholesterol levels in 3 male medical students before and after adding 36 g pectin daily to 6-week metabolically controlled diets. Three weeks after a control metabolic diet a breakfast containing 102 g carbohydrate, without pectin, was eaten after an overnight fast. The meal was taken over 8–10 min and blood, for glucose and insulin determinations, was drawn at the times shown in the table. This procedure was repeated at the end of the subsequent 6-week pectin period.

Table 1. *Blood glucose and serum insulin levels after a 102 g carbohydrate breakfast, taken before and after 6 weeks' supplementation with 36 g pectin*

Blood glucose (mmol/l) (mean±SEM)

Time (min)	0	15	30	45	60	90	120
Control	4·97±0·33	6·07±0·36	7·82±0·22	7·56±0·5	6·74±0·53	5·09±0·41	4·57±0·80
Post Pectin	4·51±0·28	5·77±0·39	7·77±0·53	7·19±0·38	6·18±0·38	5·26±0·55	4·16±0·39

Serum insulin (mU/l) (mean±SEM)

Time (min)	0	15	30	45	60	90	120
Control	5±1	24±1	59±15	57±13	52±10	43±7	18±1
Post Pectin	4±6	26±1	66±20	67±18	49±13	47±8	19±1

Blood glucose and serum insulin levels were similar after control and pectin diets. At the end of 6 weeks of pectin administration serum cholesterol had fallen 35±6 mg/100 ml (mean±SE) from control levels (251±16 mg/100 ml, a 13% fall, $P<0.05$). Bodyweight changes were less than 1 kg in each subject.

It is concluded that pectin does not exert a long term effect on carbohydrate tolerance in healthy young men when added to metabolic diets in sufficient quantity to lower serum cholesterol levels significantly. Since it is possible that pectin may have therapeutic applications, the finding that pectin does not impair insulin output after long term administration in normal subjects is regarded as important. The reports of improved carbohydrate tolerance after long term wheat bran administration in studies which employed self selected diets may have been due to a concomitant increase in absorbable carbohydrate intake.

Nutritional quality of food purchased by Asian families participating in the National Food Survey. By R. W. WENLOCK and D. H. BUSS, *Nutrition Section, Ministry of Agriculture, Fisheries and Food, London SW1P 2AE*

The prevalence of rickets and osteomalacia in Asian communities in Britain has prompted a number of surveys of vitamin D intakes by immigrants in selected areas (Dunnigan & Smith, 1965; Ruck, 1974; O'Hara-May & Widdowson, 1976). We now extend this information by describing the nutritional quality of food purchased by Asian households among the 21 452 households participating in the National Food Survey between 1972 and 1974.

Because this survey does not indicate ethnic origin, Asian households were identified from the meal descriptions in logbooks which had been preselected as showing weekly purchases of flour, rice, onions, dried pulses, butter or 'other fats' (ghee) above the normal range. Forty-seven households were identified in this way, and only three more after inspection of every logbook from areas where immigrants congregate. The nutrients in the week's food were evaluated in relation to the recommendations of the Department of Health and Social Security (1969) to allow for the age, sex, occupational activity and number of meals eaten out by each member of the family (Ministry of Agriculture, Fisheries and Food, 1974).

On average this food provided twice as much energy as required, so the value for each nutrient was divided by that for energy (Hansen, 1973). This index of nutritional quality indicates how other nutrient requirements are met by the amount of food which satisfies the requirement for energy. Nutritional quality was also evaluated more conventionally as nutrients per MJ.

Table 1. *Nutritional quality of food in Asian households compared with the national average*

	Index of nutritional quality (see text)		Nutrients /MJ	
	Asian	Average	Asian	Average
Protein	1·03	1·20	6·2 g	7·2 g
Calcium	1·55	1·85	87 mg	101 mg
Iron	1·04	1·13	1·1 mg	1·2 mg
Retinol equivalent	1·24	1·84	77 µg	128 µg
Thiamin	1·13	1·28	0·11 mg	0·12 mg
Riboflavin	0·76	1·26	0·10 mg	0·18 mg
Nicotinic acid equivalent	1·37	1·85	2·1 mg	2·9 mg
Vitamin C	1·32	1·78	3·7 mg	5·3 mg
Vitamin D	0·44	0·84	0·16 µg	0·28 µg

These Asians would have been among the most settled of their community, for they must have been both on the electoral register and willing and able to co-operate with survey personnel. Yet the quality of their diet was much lower than the national average for riboflavin and vitamin A as well as for vitamin D.

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Energy intakes per meal of Ghanaian pre-school children eating traditional foods. By ERICA F. WHEELER, *Department of Human Nutrition, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1 7HT,* and JENNIFER A. WOOLFE, *Department of Nutrition and Food Science, University of Ghana, Legon, Ghana*

The energy intakes of small children may be limited by the amount of food they are able or willing to consume at one time, the amount of food available, the quantity they are offered, the frequency of feeding and the energy density (kcal or kJ/g) of the food. The low intakes observed in some tropical countries have been attributed to all factors, but the first of these (the amount which a child can consume at one time) has received less attention than the other four.

We have measured the energy value of meals consumed by children between 1 and 3 years of age in Ghana; in a state orphanage in Accra and in a roadside village, some 15 miles outside the city. Food intakes were weighed, and the energy densities of food samples were measured by bomb calorimetry.

Table 1. *Energy intake (kJ/kg bodyweight) at individual meals of 1–3-year-old Ghanaian children eating traditional foods only*

	Village				Orphanage			
Meal	No. meals	Mean energy intake per meal	SD	Highest value	No. meals	Mean energy intake per meal	SD	Highest value
Breakfast (1)	16	61·9	46·8	213	(Omitted, as included milk)			
(2)†	15	51·8	5·8	100				
Midday	15	102	56·9	234	43	123	52·3	226
Evening*	24	71·1	39·9	172	45	103·3	43·4	204
No. of children	6				7			
Wt/Ht as % of Harvard 50th percentile	93·8±12·9				91·2±11·3			

†Excluding one very high value (213 kJ/kg)
*'Village' and 'Orphanage' mean values significantly different: $0{\cdot}01 > P > 0{\cdot}001$.

Table 1 shows the energy intake of the children at separate meals. Meals which contained imported, non-traditional foods, such as milk, white sugar, tinned foods or packaged cereals, have been excluded. The energy density of the foods ranged from 8·42–1·96 kJ/g prepared foods, in the case of staple foods, and 18·4–0·74 kJ/g in the case of relishes and soups. None of the children was severely malnourished by anthropometric standards.

We are grateful to Dr R. Orraca-Tetteh for his help in setting up this study, to S. Laryea-Brown and Mrs Wilhelmina Van Dyke for their valuable assistance, to the staff of the Osu Childrens' Home, Accra, to all the women and children who participated and to the Inter-University Council for financial support.

The utilization of ribonucleic acid as a source of amino-nitrogen in the rat. By D. G. PEERS, *Department of Animal Nutrition, Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG*

Animals do not have a dietary requirement for nucleic acids since they can be synthesized de novo, but the extent of salvage of dietary nucleic acid-N in the non-ruminant is not known.

A basal purified diet was formulated to contain essential amino acids (EAA) in quantities calculated to satisfy the rat's requirement for growth (NRC, 1972), but without non-essential amino acid N (NEANN). Eighteen young male rats (130±2 g) in individual metabolism cages were given either the basal diet or diets in which part of the starch component of the basal diet was replaced by protein-free yeast RNA or glutamic acid (GA), at N levels calculated to supply the rat's requirements for NEAAN. The diets were given in amounts previously determined to be just below appetite (15 g/d), for a preliminary period of 4 d followed by a 7 d balance. Separate bulk collections were made of faeces and urine, both maintained at pH 3 with sulphuric acid. N balance results are presented below:

	Diet			
	Basal	Basal with glutamic acid	Basal with RNA	SE* of Difference
N intake (mg/d)	119[b]	200[a]	200[a]	3·3
N digestibility†	0·880[a]	0·935[b]	0·902[c]	0·007
Faeces N (mg/d)	14[a]	13[a]	20[b]	0·7
Urine N (mg/d)	28[a]	49[b]	70[c]	2·8
N retained (mg/d)	77[a]	138[b]	110[c]	3·4
Weight gain (g/d)	2·5[a]	3·9[b]	3·0[c]	0·19

*Treatment differences are significant ($P<0.001$). Means with different superscripts are significantly different ($P<0.05$).
†Apparent digestibility.

Supplementing the basal diet with GA or RNA increased apparent digestibility of N, urinary N excretion, N retention and growth rate. Faecal N excretion for the rats fed the basal and GA-supplemented diets was 1·04 and 0·93 mg N/g DM consumed. Maynard & Loosli (1962) quoted a figure of 1 mg N/g DM consumed for metabolic faecal nitrogen (MFN) excretion in rats. It can be concluded that true digestibility of N for these diets was 1·0. If MFN excretion is assumed to be the same on the RNA-supplemented diet then the true digestibility of RNA-N can be calculated as 0·926.

Supplementing the basal diet with 81 mg GA-N or with 81 mg RNA-N increased N retention by 61 and 33 mg/d, respectively. If it is assumed that the RNA contained equal proportions of the four nucleotides it can be calculated that from the 75 mg/d RNA-N absorbed, the theoretical yield of NH_3-N from pyrimidine catabolism and purine deamination would be 35 mg/d. This value is close to the increase in N retention found. It may be concluded that in situations where NEAAN is limiting, complete salvage of N from pyrimidine catabolism and purine deamination takes place.

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Influence of riboflavin status on the red blood cell fragility in rats. By F. M. HASSAN and D. I. THURNHAM, *Department of Human Nutrition, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT*

Erythrocytes deficient in glucose-6-phosphate dehydrogenase are known to be susceptible to haemolysis upon exposure to various drugs possibly due to a diminished generation of NADPH (Beutler, 1960). It has been suggested that the oxidative changes observed during haemolysis, e.g. loss of reduced glutathione (GSH) and oxidation of haemoglobin, are manifestations of the presence of hydrogen peroxide (Mills & Randall, 1958). Glutathione reductase, a riboflavin dependent enzyme, is important for the maintenance of GSH and possibly for controlling the redox state of $NADP^+$ in tissues (Rall & Lehninger, 1952).

Experiments have been done to determine whether a marginal deficiency of riboflavin in riboflavin-deficient rats impairs the physiological function of red blood cells. Washed red blood cells (0·5 ml of 6% haematocrit in Krebs–Ringer phosphate buffer, KRP) from 6 normal, 6 pair-fed and 8 riboflavin-deficient rats and an H_2O_2-generating system (hypoxanthine, 1·6 mM; xanthine oxidase, various amounts) were incubated with 2·3 ml oxygenated KRP, pH 7·0, in a total volume of 3·0 ml in 10 ml conical flasks. In addition, red blood cell fragility was measured by incubating the washed red cells (as above) with 2·5 ml sodium chloride solutions (0·9, 0·72, 0·54 and 0·36%). All incubations were done at 37° for 45 min in a shaking waterbath. Erythrocyte glutathione reductase activity coefficients were estimated in every blood sample as a measure of riboflavin status by a modification of the method of Glatzle, Weiser, Weber & Wiss (1973).

The results showed on using 0·02 units xanthine oxidase a highly significant correlation between riboflavin status (as measured by the AC) and the degree of haemolysis produced by exposure to the H_2O_2-generating system (r 0·756, $P<0·01$). The slower production of peroxide produced by 0·008 units of xanthine oxidase caused less haemolysis but an even closer correlation (r 0·829, $P<0·01$). Measurements of red cell haemolysis made with decreasing concentrations of saline showed that erythrocytes from riboflavin-deficient rats were more easily haemolysed than those from control and pair-fed animals but this was apparent only when 0·36% saline was used. Under these conditions the degree of haemolysis was correlated with the riboflavin AC (r 0·531, $P<0·02$).

It has been suggested that an increasing susceptibility to haemolysis may be due to a lower GR activity being unable to generate sufficient GSH (Kaplan, 1971). The results presented suggest that riboflavin-deficiency through its effect on EGR activity may also reduce GSH levels and affect the stability of the red blood cell, for the H_2O_2 and salinity experiments show that a high EGR AC is associated with increased red cell fragility.

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