Amino acid metabolism in the piglet

3. Influence of lysine level in the diet on energy metabolism and in vivo oxidation*

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1. Supplementing a lysine-deficient diet (5 g lysine/kg) with five increments of lysine, each of 2 g/kg, resulted in increases in growth rate of Yorkshire piglets, aged between 3 and 7 weeks, up to the highest level of lysine (15 g/kg).

2. The free lysine concentration of plasma tended to increase as the dietary lysine level increased from 13 to 15 g/kg, and plasma threonine concentration decreased significantly as the lysine content of the diet was increased from 11 to 15 g/kg indicating that threonine was the second limiting amino acid in the diet.

3. Oxygen consumption and carbon dioxide production of the piglets were not influenced by supplementing the diets with lysine. The heat production was 0·313 kJ/min per kg body-weight in the 6 h experimental period.

4. Supplementation of the diet with lysine had no consistent effect on the recovery of ^{14}C as $^{14}CO_2$ from a single dose of L-[U-^{14}C]lysine.

5. Adjustment of the determined recoveries of the tracer dose of lysine for the differences in the plasma concentrations of free lysine for the pigs receiving the graded levels of dietary lysine simplified the relationship between recovery and dietary lysine level: it was linear for the first four increments in dietary lysine and then increased sharply for the fifth increment. This indicated that a marked change in the rate of lysine catabolism occurred as the level of dietary lysine was increased from 13 to 15 g/kg.

6. The results of this experiment indicate that the piglets' requirement for lysine is between 13 and 15 g lysine/kg in a diet which contained 181 g crude protein (nitrogen × 6·25)/kg.

The influence of amino acid level in the diet on growth and carcass development of growing-finishing pigs is well defined and the 'requirements' for the essential amino acids recommended by the Agricultural Research Council (1967) and the (US) National Research Council (1973) are widely used as a basis for the formulation of practical diets. In contrast, the influence of amino acid levels in the diets of young pigs (less than 10 kg live weight) are less well defined and their 'requirements' are based on extrapolation from results obtained with older pigs. Thus it would be useful to study the influence of dietary levels of amino acids on the growth and development of young pigs (3 weeks of age and 5 kg live weight).

There have been difficulties in defining the amino acid requirement of the young pig using techniques which have been used with older pigs. Gallo, Pond & Logomarsino (1968), who used growth as a response measurement found that young pigs (7–14 kg live weight) did not respond to amino acid supplementation of a low-protein diet as well as older pigs (50–100 kg) had done in an earlier experiment (Gallo & Pond, 1968). Knipfel, Keith, Christensen & Owen (1972) were unable to determine the methionine requirement of the weanling pig (7 kg) by measuring the influence of dietary methionine level on the methionine concentration in serum, even though the technique had been used satisfactorily with pigs weighing 18 kg (Keith, Christensen &

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Owen, 1972). Oestemer, Hanson & Meade (1973) attempted to determine the isoleucine requirement of the young pig (6 kg) but found different estimates with each of the response measurements they used; their estimates ranged from 3·8 g/kg diet when they used free isoleucine concentrations in plasma, to 5·2 g/kg diet when they used growth rate. Both values are less than the 'requirements' of 9 and 6·9 g/kg diet recommended by the Agricultural Research Council (1967) and the (US) National Research Council (1973) respectively. However, Zimmerman (1975) estimated the tryptophan requirement of the young pig (5–10 kg) to be 1·5 g/kg diet, and this estimate was consistent whether he used growth rate, food conversion, free tryptophan concentration in plasma or plasma urea concentration as response criteria.

As the intake of an amino acid increases from levels lower than the amount which is needed for the maximum rate of protein synthesis to levels greater than this amount, there will be a shift in the metabolic fate of the incremental amount of the amino acid from anabolism to catabolism. There are several indicators of this change: growth rate reaches a plateau, there is an increase in the concentration of the amino acid in the plasma (Zimmerman & Scott, 1965), there is an increase in the rate at which the amino acid is oxidized (Brookes, Owens & Garrigus, 1972), and there is a decrease in the conversion of the nitrogen from the other dietary amino acids to urea (Brown & Cline, 1974).

Excessive levels of dietary protein reduced energy retention in the young pig (Gray & McCracken, 1974), however, no effects of amino acid (methionine) balance in the diet on energy retention were found by Walker (1974) who worked with lambs, or by Trela (1973) who used chickens.

In the present study, growth, energy metabolism and amino acid metabolism of young pigs receiving diets containing graded levels of lysine were studied, in an effort to define the dietary levels which would support maximum growth and which would minimize lysine catabolism.

EXPERIMENTAL

Twenty-four Yorkshire piglets were weaned at 18 d of age and transferred to individual cages in the laboratory. Details of the lysine-deficient basal diet are given in Table 1, it was supplemented with five increments of 2 g L-lysine HCl/kg. Samples of the diets were analysed; the proximate composition was determined using the Association of Official Agricultural Chemists' (1970) procedures and the amino acid composition of an hydrolysate of the diet was determined as described by Chavez & Bayley (1976).

The piglets received the experimental diets *ad lib.* and water was available at all times. The piglets were weighed each week for the 4-week experimental period and food consumption was recorded daily. A catheter was passed through a jugular vein into the vena cava to permit blood sampling and infusion of the tracer dose of ^{14}C-labelled amino acid, as described by Newport, Chavez, Horney & Bayley (1976). Blood samples, gas exchange and amino acid oxidation studies were done when the piglets were between 6 and 7 weeks of age.

Table 1. *Composition (g/kg) of the experimental basal diet*

Ingredients	Lysine-deficient	Chemical composition	Lysine-deficient
Maize starch*	409·5	Ash	51·3
Isolated soybean protein†	—	Gross energy (MJ/kg)	16·9
Sunflower meal	235·0	Calcium	7·0
Maize-gluten meal	165·0	Phosphorus	7·2
Cellulose‡	118·5	Essential amino acids	
Maize oil	20·0	Methionine	5·2
Limestone	8·0	Cystine	1·0
Dicalcium phosphate	24·0	Lysine	4·7
Salt (NaCl)	3·0	Arginine	8·1
Vitamin mix§	5·0	Histidine	3·4
Mineral mix‖	10·0	Isoleucine	6·9
DL-methionine	2·0	Leucine	17·9
Chemical composition		Phenylalanine	9·0
Moisture	89·3	Tyrosine	5·8
Crude protein (nitrogen × 6·25)	191·0	Threonine	5·1
Fat	28·0	Valine	8·2
Crude fibre	112·8		

* 'Pearl Starch'; St Lawrence Starch Co. Ltd, Port Credit, Ontario, Canada.
† 'Promosoy-100'; Central Soya Co. Inc., Chicago, Illinois, USA.
‡ 'Alpha-Floc'; Brown Co. Inc., Berlin, New Hampshire, USA.
§ Supplied (mg/kg diet): nicotinic acid, 44, calcium D-pantothenate 28·4, riboflavin 6, pyridoxine 3·6, thiamin HCl 3, pteroylmonoglutamic acid 2, D-biotin 0·2, choline chloride 1000, DL-α-tocopheryl acetate 15, phytylmenaquinone 0·2, retinyl acetate 0·8, cholecalciferol 0·011, cyanocobalamin 0·044, ethoxyquin 500.
‖ Supplied (mg/kg diet): potassium (as carbonate) 1000, magnesium (as sulphate) 400, iron (as sulphate) 125, zinc (as sulphate) 100, manganese (as sulphate) 20, copper (as sulphate) 6, selenium (as sodium selenite) 0·1.

Measurement of oxygen consumption, carbon dioxide and $^{14}CO_2$ production

The pig was confined in an environmental chamber (980 × 600 × 900 mm) (Accumatic test chamber; Hotpack Ltd, Waterloo, Ontario, Canada), from which air was withdrawn with variable-speed pumps (Fig. 1). The total volume of air was measured using dry test meters (DTM 200; Canadian Meter Co. Ltd, Milton, Ontario, Canada). The temperature in the chambers was maintained at 26° and the relative humidity 40%. A ventilation rate of approximately 15 l/min was sufficient to ensure that the concentration of CO_2 remained below 1% in the air pumped from the chamber. A sample of air from either of the two chambers could be passed through O_2 and CO_2 analysers (models G2 and IR215A respectively; Beckman Instruments Inc., Fullerton, California, USA), and then returned to the main gas stream. The outputs from the gas analysers were digitized and recorded on a teleprinter (Compact 1 Data Logger; Solartron Ltd, Farnworth, Hants, UK).

Six analyses of the gas which was being pumped from each of the two chambers were made during each hour of the 6 h experimental period. All the air from the chambers was passed through a series of traps which contained organic solvents to absorb the CO_2. The solvents in the CO_2 absorbers were changed at 30, 60, 90, 120, 150, 210, 270 and 360 min after the pumps were restarted 30 min following infusion of the ^{14}C-labelled lysine. The gas analysers were calibrated using gas mixtures

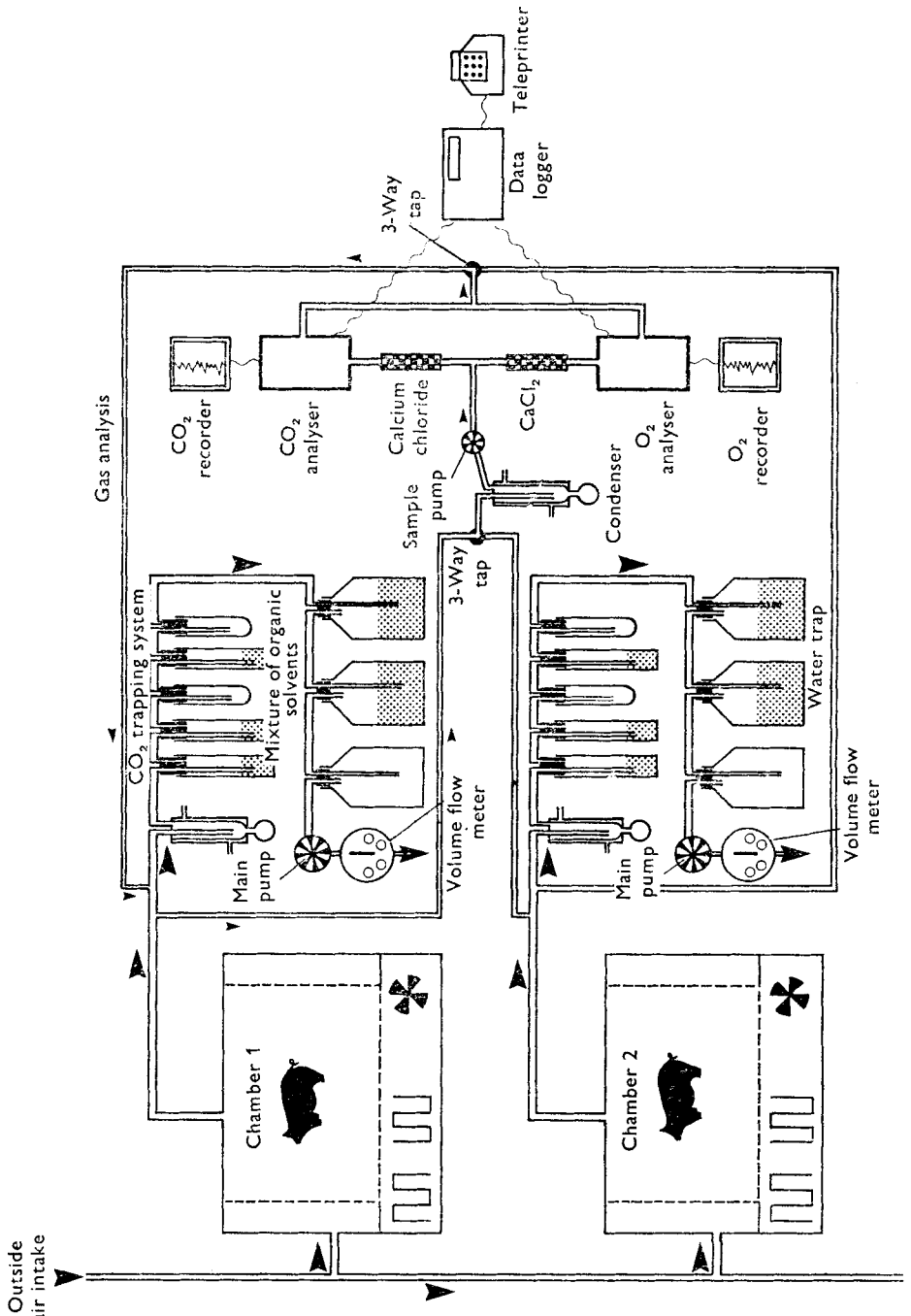

Fig. 1. Apparatus used to collect $^{14}CO_2$ in organic solvents and to measure oxygen and CO_2 concentrations in the air pumped from the environment-controlled chambers containing pigs which had received a dose of L-[U-^{14}C]lysine.

prepared from cylinders of high purity CO_2, N_2 and O_2 (Matheson Ltd, Whitby, Ontario, Canada) with precision gas-mixing pumps (models SA-18 and -27; Wosthoff AG, Bochum, W. Germany). Heat production was calculated from O_2 consumption and CO_2 production using the relationship described by Kleiber (1961). The amount of radioactivity in the CO_2 absorbed by the solvents was determined by liquid-scintillation counting as described by Newport *et al.* (1976).

The samples were counted with an efficiency of 67%. The procedure for collecting $^{14}CO_2$ was verified by infusing 1 μCi $NaH^{14}CO_3$ into the pigs: 90% of the activity was recovered in the organic solvents in the 6 h collection period.

Infusion of labelled amino acids and blood sampling

L-[U-^{14}C]lysine (318 mCi/mmol) was purchased from Amersham-Searle Ltd, Don Mills, Ontario, and was diluted in saline (9 g NaCl/l) so that the 1 ml dose contained 2 μCi [^{14}C]lysine. The piglets were weighed and at 19.00 hours were placed in the chamber where they had access to water but no food. The chambers were ventilated but there were no solvents in the CO_2 absorption vessels. At 09.00 hours the next day the chamber was opened, a blood sample taken from the catheter, and the tracer dose of ^{14}C-labelled lysine infused. The catheter was flushed with heparinized saline and the appropriate diet was placed in a feeder inside the chamber. The chamber was sealed and solvents were placed in the CO_2 absorption vessels.

The blood samples were prepared for amino acid analyses as described by Chavez & Bayley (1976).

The results were subjected to analyses of variance and the statistical significance of the results assessed by calculating the 'honestly significant difference' of Tukey at $P < 0.05$, as described by Steel & Torrie (1960).

RESULTS

The lysine-deficient diet contained 4·7 g lysine/kg (Table 1) which is only half the 'requirement' recommended by the (US) National Research Council (1973), and on the basis of these requirements there were marginal deficiencies of the sulphur amino acids and of threonine; the isoleucine content was equal to the requirement.

Cumulative average daily food consumption and weight gain (Table 2) indicated that the pigs grew faster as the level of lysine in the diet was increased. There was no indication that a plateau had been reached in the growth response of these pigs by increasing the level of lysine to 15 g/kg diet.

Increasing the level of lysine in the diet had no significant effect on the lysine concentration in the plasma (Table 3), however, there was a significant increase in the concentrations of leucine and valine as the lysine level in the diet was increased from 13 to 15 g/kg. In contrast there was a significant decrease in the concentration of threonine in the plasma as the level of lysine in the diet increased, with a marked decrease as the dietary level was increased from 11 to 13 g/kg. These changes in the plasma threonine concentrations are particularly noteworthy, because calculation

Table 2. *Cumulative daily food consumption (g) and body-weight gain (g/d), each week for 4 weeks, for growing piglets given graded levels of lysine in a semi-purified diet* containing 200 g crude protein (nitrogen × 6·25)/kg*

(Mean values for four piglets/treatment)

Dietary lysine (g/kg) ...		5	7	9	11	13	15		
Age (weeks)								SE (18 df)	hsd
3–4	Food intake	162	139	108	148	171	199	23	103
	Wt gain	81^{ab}	54^{b}	47^{b}	92^{ab}	101^{ab}	176^{a}	27	121
3–5	Food intake	188	183	154	204	201	234	24	108
	Wt gain	65^{b}	74^{b}	71^{b}	112^{ab}	76^{ab}	151^{a}	17	77
3–6	Food intake	195^{ab}	191^{ab}	180^{b}	225^{ab}	237^{ab}	264^{a}	18	79
	Wt gain	70^{a}	91^{a}	88^{a}	122^{a}	98^{a}	146^{a}	17	77
3–7	Food intake	195	192	221	242	275	278	21	92
	Wt gain	63^{b}	100^{ab}	94^{ab}	123^{ab}	134^{ab}	152^{a}	16	74

hsd, 'Honestly significant difference' of Tukey at $P > 0{\cdot}05$, as described by Steel & Torrie (1960). Values with the same superscript were not significantly different: $P \leqslant 0{\cdot}05$.
* For details of composition, see Table 1.

Table 3. *Essential amino acid concentrations (μmol/l) in the plasma of growing piglets given graded levels of lysine in a semi-purified diet* containing 200 g crude protein (nitrogen × 6·25)/kg*

(Mean values for four piglets/treatment)

Dietary lysine (g/kg) ...	5	7	9	11	13	15		
Amino acid							SE (18 df)	hsd
Lysine	99	88	72	83	88	125	18	79
Arginine	35	37	43	48	67	52	11	49
Histidine	35	35	35	39	38	31	5	21
Isoleucine	37^{b}	40^{b}	47^{ab}	48^{ab}	45^{ab}	69^{a}	6	27
Leucine	59	55	64	66	69	99	10	45
Methionine	27	34	33	31	28	32	3	14
Phenylalanine	51	54	47	50	50	57	5	22
Threonine	179^{a}	153^{ab}	129^{abc}	125^{abc}	88^{bc}	67^{c}	18	82
Valine	89	85	99	103	94	134	13	60
Total	611	581	569	593	567	666		

hsd, 'Honestly significant difference' of Tukey at $P > 0{\cdot}05$, as described by Steel & Torrie (1960). Values with the same superscript were not significantly different: $P \leqslant 0{\cdot}05$.
* For details of composition, see Table 1.

indicated that it was the second limiting amino acid in the lysine-deficient basal diet. These values suggested that the supply of threonine in the diet began to be limiting as the level of lysine was increased from 11 to 13 g/kg diet.

The studies of energy metabolism in the pigs were made after they had received the experimental diets for 2 weeks, and those which had received the lower levels of dietary lysine tended to weigh less than those which had received the higher levels of dietary lysine (Table 4). They all consumed food during the experimental period but the low values obtained for respiratory quotients (RQ) indicated that only a small part was digested and metabolized during this period. However, the RQ for the pigs which had received the diet containing 11 g lysine/kg was significantly higher than for those which had received the diet containing 5 g lysine/kg. Heat production was unaffected

Table 4. *Oxygen consumption, carbon dioxide production and heat production, during a 6 h period, of growing piglets (6–7 weeks of age) given graded levels of lysine in a semi-purified diet* containing 200 g crude protein (nitrogen × 6·25)/kg*

(Mean values for four piglets/treatment)

Dietary lysine (g/kg) ...	5	7	9	11	13	15	SE (18 df)	hsd	Over-all mean
Body-wt (kg)	5·5	5·8	5·5	6·7	6·3	6·6	0·28	1·26	6·06
Food intake (g/kg body-wt)	12·9	21·8	16·1	26·6	16·5	21·7	4·32	19·4	19·20
O_2 consumption (mmol/min per kg body-wt)†	0·70	0·67	0·69	0·63	0·68	0·64	0·04	0·18	0·67
CO_2 production (mmol/min per kg body-wt)	0·53	0·55	0·56	0·55	0·55	0·53	0·04	0·18	0·55
Respiratory quotient	0·76	0·82	0·81	0·87	0·80	0·82	0·02	0·09	0·81
Heat production:									
kJ/min per kg body-wt	0·318	0·305	0·314	0·293	0·359	0·293	0·033	0·151	0·313
kJ/min per $kg^{0·75}$	0·485	0·473	0·490	0·469	0·490	0·469	0·025	0·113	0·481

hsd, 'Honestly significant difference' of Tukey at $P > 0·05$, as described by Steel & Torrie (1960).
* For details of composition, see Table 1.
† Molar volume at standard temperature and pressure: O_2 22·392 l, CO_2 22·263 l.

Table 5. *Summary of effect of dietary lysine level on plasma lysine concentration, and total and radioactive carbon dioxide produced by growing piglets given a semi-purified diet* containing 200 g crude protein (nitrogen × 6·25)/kg, after infusion of 2 μCi* L-[*U*-^{14}C] *lysine*

(Mean values for four piglets/treatment)

Dietary lysine (g/kg) ...	5	7	9	11	13	15	SE (18 df)	hsd
Body-wt (kg)	5·5	5·8	5·5	6·7	6·3	6·6	0·2	—
Food intake during gas-exchange study (g)	71	122	86	177	105	146	—	—
Plasma lysine concentration (μmol/l)	99	88	72	83	88	125	18	79
CO_2 produced during gas-exchange study (mol)	1·05	1·14	1·09	1·32	1·24	1·25	0·08	0·36
Radioactivity recovered as $^{14}CO_2$: disintegrations/min (× 10^{-4})	14·1	14·8	16·3	13·2	10·8	16·5	0·97	4·4
% dose	$3·20^{ab}$	$3·35^{ab}$	$3·68^{b}$	$2·99^{ab}$	$2·45^{a}$	$3·73^{b}$	0·22	0·97

hsd, 'Honestly significant difference of, Tukey at $P > 0·05$, as described by Steel & Torrie (1960). Values with the same superscript were not significantly different: $P \leqslant 0·05$.
* For details of composition, see Table 1.

by the level of the lysine in the diet and the over-all mean value was 0·313 kJ (75 cal)/min per kg body-weight.

Less than 4% of the activity from the tracer dose of [^{14}C]lysine was recovered as $^{14}CO_2$ from the piglets which had received any of the diets containing the different lysine levels (Fig. 2), and there was no indication of reaching a plateau in activity.

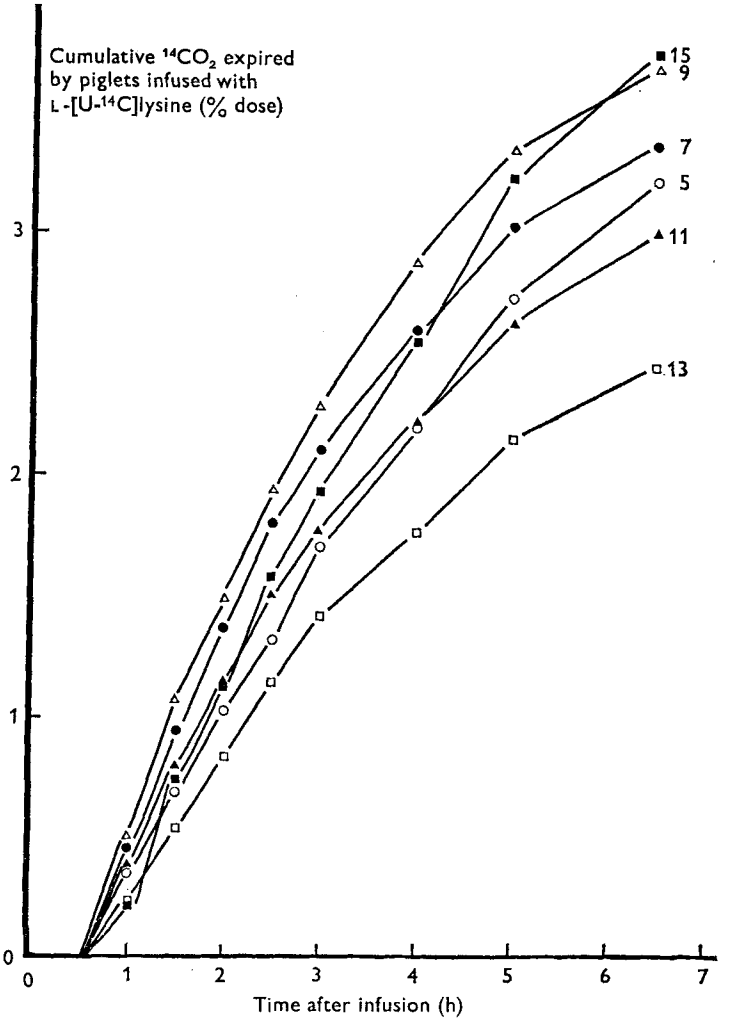

Fig. 2. Cumulative recoveries (% dose) of ^{14}C as $^{14}CO_2$ in 6 h after the infusion of a dose of 2 μCi L-[U-^{14}C]lysine to piglets of 5·5–6·7 kg live weight receiving diets containing graded levels of lysine (g/kg): (○), 5; (●), 7; (△), 9: (▲), 11; (□), 13; (■), 15; four piglets/diet. Pumps started to ventilate environmental chambers 30 min after infusion of dose. For details of diets, see Table 1, and of experimental procedures see p. 371.

There was no simple effect of level of lysine in the diet on recovery of the dose: the highest recovery was from the piglets which had received the diet containing the highest level of lysine (15 g/kg), whilst the lowest recovery was from the piglets which had received the second highest level of dietary lysine (13 g/kg).

The summary of the results obtained after the infusion of the [^{14}C]lysine (Table 5) indicated that although the dietary lysine was increased from 5 to 15 g/kg, there were no significant increases in total CO_2 production as a result of increasing the lysine level of the diet. However, there was a tendency for the recovery of $^{14}CO_2$ to increase as the level of dietary lysine increased from 5 to 9 g/kg, but as the dietary level of lysine increased from 9 to 13 g/kg the recovery tended to decrease. However, the last

increment in dietary lysine, from 13 to 15 g/kg, resulted in a marked increase in the recovery of the activity in the CO_2. The difference between the recoveries from the diets containing 13 and 15 g lysine/kg was statistically significant ($P \leqslant 0.05$).

DISCUSSION

The Yorkshire piglets in this study responded to increasing the level of dietary lysine by increasing growth: Mitchell, Becker, Jensen, Norton & Harmon (1965) found a similar response when they increased the level of lysine from 9·1 to 15·1 g/kg in a semi-purified diet containing 220 g crude protein/kg, however, they concluded that their young pigs (2–8 weeks of age) required 12·4 g lysine/kg. This estimate is higher than the value of 9·6 g/kg recommended by the (US) National Research Council (1973).

The primary objective in measuring the concentrations of the free amino acids in the plasma in this study was to allow an estimation of the dilution of the dose of ^{14}C-labelled lysine, and thus the samples were taken from piglets which had been adapted to the dietary regimen for at least 14 d and which had been fasted overnight. Even with this pretreatment increasing the level of lysine in the diet from 13 to 15 g/kg tended to increase the concentration of free lysine in the plasma. Braude, Fulford, Mitchell, Myres & Porter (1974) have reported that the level of dietary lysine had its maximum effect on the concentration of lysine in the plasma of growing pigs 2 h after consumption of the meal. Mitchell, Becker, Jensen, Harmon & Norton (1968) took blood samples from *ad lib.*-fed pigs which were older than those used in the present study and found that the free lysine concentration in plasma increased from 118 to 400 μmol/l as the level of lysine in the diet increased from 6·8 to 11·8 g/kg. They also noted a tendency for the total concentration of the free amino acids in the plasma to decrease as the dietary level of lysine was reaching the requirement; the same trend was found in the present study. The significant decrease in the concentration of threonine in the plasma when the level of dietary lysine was increased from 11 to 13 g/kg supported the conclusion that it was the second limiting amino acid in the experimental diet. Stockland, Meade & Melliere (1970) found a similar effect of dietary lysine level on the concentrations of lysine and threonine in the plasma of rats, and Kroening, Pond & Loosli (1965) found that the growth response of piglets was limited by the threonine content of their basal diet.

In these experiments no influence of dietary balance, with respect to lysine on the heat production was found, extending the findings of Walker (1974) with lambs, and Trela (1973) with chickens, to the piglet. In these studies the 5–9 kg piglets were releasing 0·313 kJ/min per kg body-weight. This value compares well with those of 0·279 and 0·347 kJ/min per kg body-weight from two experiments with 5-d-old suckled piglets, and is approximately twice the values for 24 h-fasted, 5-d-old piglets (0·133 and 0·181 kJ/min per kg body-weight) found in a previous study (Bayley & McDonald, 1970). Jordan & Brown (1970) found values of 0·175 kJ/min per kg body-weight for 36 h-fasted, 3-week-old piglets.

Nielsen (1970) worked with pigs of 24 kg body-weight and found heat outputs of

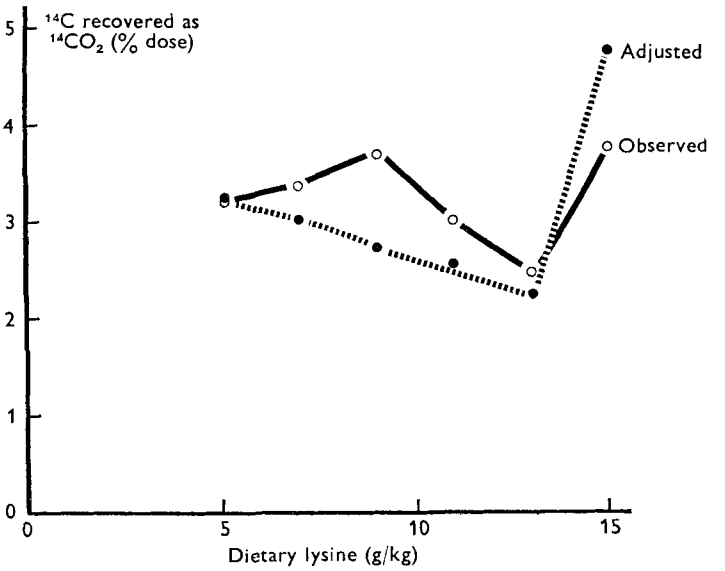

Fig. 3. Determined (○—○) and adjusted ●····●) recoveries (% dose) of ^{14}C as $^{14}CO_2$ in 6 h after the infusion of a dose of L-[U-^{14}C]lysine to piglets of 5·5–6·7 kg live weight receiving diets containing graded levels of dietary lysine. Adjusted values were calculated on the basis of equal dilution of the tracer dose in the blood plasma using the concentration of free lysine in the plasma of the piglets receiving the diet containing 5 g lysine/kg. For details of diets see Table 1, and of experimental procedures, see p. 371.

0·254 kJ/min per kg body-weight which was similar to the values of 0·245 reported by Gray & McCracken (1974) for 22 kg pigs. Thorbek (1975) found that the heat output of 24 kg pigs was 0·268 kJ/min per kg body-weight. Expressing these values for heat output on a metabolic body size (body-weight$^{0·75}$) basis gives 0·555, 0·529 and 0·601 kJ/min per kg body-weight$^{0·75}$ for values given by Nielson (1970), Gray & McCracken (1974) and Thorbek (1975) respectively, which are higher than the value of 0·481 found in the present experiment, presumably because of the low food intake of the pigs in the present study whilst they were in the chambers.

The determined recoveries of the label as $^{14}CO_2$ from the tracer dose of lysine (Fig. 3) indicated the complex relationship with dietary lysine level. However, adjusting these recoveries for the lysine concentration in the plasma as described by Chavez & Bayley (1976), gave a considerably simpler relationship: for the first four increments of dietary lysine there was a linear decrease in the amount of ^{14}C recovered in CO_2, with a marked increase for the highest level of dietary lysine. These adjusted values supported the conclusion that the Yorkshire piglets in this study had a requirement for lysine of between 13 and 15 g/kg diet. The 6–7-week-old suckled piglet has a lysine intake of approximately 4 g/d (Jones, 1969) from the sow's milk which contains 64 g crude protein with a lysine content of 72·5 g/kg protein (Bowland, 1966). The requirement of 14 g lysine/kg diet reported here is equivalent to an intake of 3·9 g lysine/d, with the pigs consuming 0·278 kg diet.

Thus the requirement for lysine estimated by this method agrees closely with the requirement estimated from the determination of growth rate and plasma concentra-

tion, providing some empirical justification for the procedure. Neale & Waterlow (1974) criticized the study of amino acid oxidation as a means of estimating dietary requirements because of the difficulties of defining the metabolic pool into which the dose was diluted. However, the lysine requirement estimated by Brookes *et al.* (1972) for the rat agreed well with their estimates based upon other procedures.

Estimates of dietary requirements for the young pig are usually made by using growth rate as a response measurement, and in most instances growth rates on experimental diets are lower than when the piglets receive sow's milk. In the present studies the metabolism of lysine has been studied in an attempt to assess the dietary level which minimizes the catabolism of a tracer dose of the amino acid. The level which achieves this may not be the level which results in maximum growth, and although there are no other direct studies of amino acid metabolism in the young pig, Cooke, Lodge & Lewis (1972) using pigs growing from 23 to 59 kg found maximum growth rate on a diet containing 174 g crude protein, 10·5 g lysine and 8·1 g methionine plus cystine/kg; higher crude protein levels reduced growth rate. However, they found a linear increase in the dissectable lean content of the carcasses up to the highest level of dietary crude protein used in the experiment. This diet contained 275 g crude protein, 15·9 g lysine, and 12·4 g methionine plus cystine/kg diet. Since lean deposition is more closely associated with protein synthesis than is the total increase in weight of the pig, these findings are in agreement with the results of the present experiment, that the levels of amino acid needed to maximize growth rates are not necessarily equal to those which result in marked increases in amino acid catabolism.

Although the effects of compensatory growth (Duckworth, 1965) may mean that imprecision in balancing the nutrient levels in the diet on the over-all development of the pig may be of little practical consequence, the theoretical basis of the system used to define the piglets' dietary requirements should be amenable to precise description.

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