Reprod. Nutr. Dévelop., 1986, **26** (3), 849-861.

Protein synthesis and retention in some tissues of the young pig as influenced by dietary protein intake after early-weaning. Possible connection to the energy metabolism

B. SÈVE**, P. J. REEDS*, M. F. FULLER*, A. CADENHEAD*, Susan M. HAY*.

(*) *The Rowett Research Institute, Greenburn Road, Bucksburn, Aberdeen AB2 9SB (U. K.).*
(**) *Station de Recherches Porcines, I.N.R.A. St-Gilles 35590 L'Hermitage (F).*

Summary. Changes in fractional protein synthesis rates (FSR) of 4 tissues (muscle, liver, intestine and bone) were assessed in 2 groups of young pigs from weaning, 10 days post-partum, to one week later, after feeding equal amounts of dry diets at 2 levels of protein (15 and 30 %). In the meantime, protein and energy balance measurements were performed on the whole body partitioned into 4 components (carcass, liver, digestive organs, other organs + blood). Whole body energy balances were strongly negative in both groups as a result of low metabolisable energy (ME) intakes and fat mobilization. Protein balance improved, with the increase in dietary protein, at the expense of additional body fat loss. Parallel to that, an increase in the efficiency of ME for protein deposition was noticed. With the lower protein intake, protein deposition remained significantly positive in digestive tissues but not in liver and carcass. Muscle and liver RNA : protein ratios decreased after weaning at rates consistent with the normal age-dependent variations regardless of diet. FSRs were directly related to protein intake and the high supply allowed these tissues to match the preweaning values. In contrast, intestine RNA : protein ratio did not change after weaning and FSR was increased in both groups, with a trend to a higher value with the lower protein supply. Bone RNA : protein ratio and FSR both decreased after weaning on the low-protein diet ; the effect of increasing dietary nitrogen could not be assessed in this tissue. The most typical effect of underfeeding associated with early-weaning seems to be an exaggeration of the normal age-dependent increase in protein synthesis per unit of RNA, provided that an adequate protein diet is fed. The relevance of these findings to the variations in the ME efficiency for protein deposition needs further investigations.

Introduction

In growing pigs, protein deposition is closely related to protein synthesis (Reeds *et al.*, 1980). This relationship has been established in studies at stages when muscle is the main tissue involved in growth. In younger animals, viscera and bones contribute a larger proportion of whole body protein deposition and

synthesis than muscle. The importance of the essential tissues is likely to be further increased at critical times such as at weaning when piglets are severely underfed. It is now well known that some of these tissues do not respond to nutrient supply variations in the same way as muscle, as far as protein synthesis is concerned (Arnal, Fauconneau and Pech, 1972). Previous work has shown that piglets weaned at 10 d instead of 35 d of age experienced a check followed by an acceleration of growth rate associated with an alteration in the pattern of energy utilization, *i.e.* higher maintenance requirement and efficiency of energy for growth (Sève, 1982).

It was shown that the acceleration of growth was dependent on the amount of protein supplied during a short period after weaning, when energy intake did not exceed the maintenance requirement (Sève, 1979). At the same time, protein deficiency was associated with the preservation of protein deposition in the digestive organs and more generally in all the essential tissues, but this was obtained with a low efficiency of energy for protein deposition. On the other hand, the high protein supply promoted muscle growth and improved the efficiency of energy for protein deposition. The purpose of the present experiment was to relate protein retention and energy balance to protein synthesis in different tissues of piglets given two levels of dietary protein one week after weaning at 10 d of age. This is the first attempt to assess protein synthesis in the pig with the injection of a large dose of a labelled amino acid, a method developed and extensively applied in laboratory animals (Garlick *et al.*, 1980).

Material and methods

Five litters were born from sows of the Rowett Research Institute's herd, weaned at 10 days of age, and each partitioned in 2 groups of three piglets on the basis of weight : one control pig was slaughtered 1 hour after the last suck and 2 pigs were offered the experimental diet and were slaughtered seven days later, 2 hours after feeding. In the meantime, these animals were kept individually in wire-floored cages at constant room temperature (28 °C). They were fed twice daily in gradually increasing amounts of pellets according to a common scale close to the actual volontary feed intake of newly-weaned pigs of this age (from 50 g/d at weaning to 170 g/d on day 7). Drinking water was available *ad libitum.* During this period feed refusals were carefully collected as well as faeces and urine in acid. Diets 1 and 2 differed in protein content, 15 and 30 % respectively (table 1). The proportion of a protein mixture (2 : 3 milk ; 1 : 3 fish) was increased from diet 1 to diet 2 at the expense of carbohydrate ingredients (maltodextrin and starch) and fat supply remained constant.

Two days before weaning, catheters were implanted in one of the internal jugular veins and led under the skin to emerge inside the ear. On slaughter day a flooding dose of unlabelled L-phenylalanine (20 ml of a 150 mM solution) combined with 3.7-5.5 MBq of L-(Ring-2, 3, 4, 5, 6^{-3}H)-phenylalanine (New-England Nuclear, Boston, Massachussets, USA) was injected through this catheter into the circulating blood. A preliminary experiment had shown that

TABLE 1

Composition and analysis (g/kg) *of the diets.*

Diet Protein supply	1 Low	2 High
— Calf milk replacer ([1])	400.00	400.00
— Skimmilk	—	286.00
— Soluble F.P.C. ([2])	57.00	114.00
— Maltodextrin ([3])	223.60	60.27
— Maize starch	223.63	60.30
— Maize oil	40.00	40.00
— Dicalcium phosphate	45.00	27.00
— Limestone	5.00	6.00
— Trace minerals and vitamins	5.76	6.43
— L. Tryptophan	0.17	0.33
— D. L. Methionine	0.50	1.00
Total	1 000.66	1 001.33
Analysis %		
— Dry matter	93.70	93.29
— Nitrogen	2.49	4.73
— Energy, kJ/kg	17.84	18.81
— Fat	11.37	11.85

([1]) 60 % Skimmilk, 20 % oil, Volac Orwell Royston-Herts SG8 5QX (G.B.).
([2]) Fish protein concentrate : CPSP 80, CTPP 62480 Le Portel (France).
([3]) Roquette Frères — 62136 Lestrem (France).

plasma phenylalanine specific radioactivity (SRA) decreased slowly during the first 15 min following the injection despite a significant increase in tyrosine SRA (fig. 1). Therefore ten min after the mid-point of the injection (15 to 20 s) piglets were killed with a lethal dose of pentobarbital and immediately bleeded. Samples of liver, upper small intestine *(duodenum),* hindleg muscle *(semitendinosus)* and bone *(femur)* were collected within 2 min and frozen in liquid nitrogen. Bodies were then partitioned into four components : 1. Carcass, 2. Empty digestive tract including intestine mesenteric tissues and pancreas, 3. Liver and 4. Other organs plus blood frozen and kept at − 18 °C.

Free and bound phenylalanine specific radioactivities (phe-SRA), protein and RNA tissue contents were assessed according to procedures described by Garlick *et al.* (1980). However 1 g of each tissue at least was used in order to collect measurable amounts of label namely from the muscle protein. Bone protein was partitioned into an alkali-soluble fraction (ASB) after 1 hour of incubation at 37 °C in 0.3 M NaOH and an alkali-insoluble fraction (AIB) which was incubated for 4 days more. For all tissues an additional stage of purification of the hydrolysates on Dowex 50 × 8 resin was necessary to remove heavy cations responsible for inhibitory effects on tyrosine decarboxylase. Radioactivity was measured by liquid scintillation counting with NE 265 Scintillator (Nuclear Entreprises, Edinburgh, Scotland U.K.) and a Packard 460 CD Counter. Fractional rates of protein synthesis (percentage of the protein mass synthesized per day) were calculated as

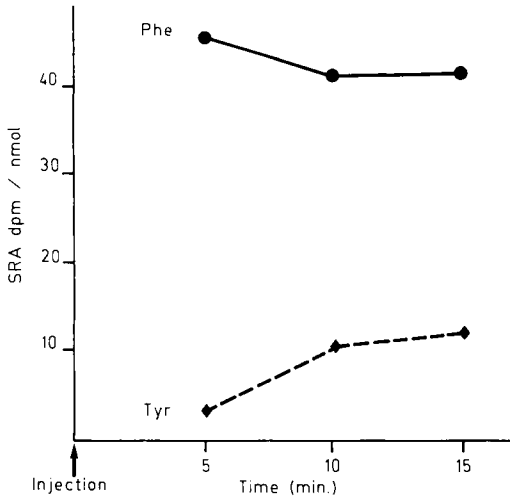

FIG. 1. — *Blood simultaneous slight increase in free tyrosine* (Tyr) *and decrease in free phenylalanine* (Phe) *specific radioactivities* (SRA) *15 min after the injection of a flooding dose of L-^{3}H-Phe* (in a preliminary trial on one animal).

FSR = $[S_B/(S_A \times t)] \times 100$ where S_B is the protein phe-SRA, S_A the free pool phe-SRA and t the labelling time in days including the time elapsed between slaughter and freezing the samples.

The mixed contents of the digestive tract added to faeces and urine (MDFU) and the various body components were ground, homogenized, freeze-dried and analyzed for nitrogen and energy. Fat determination was performed on carcass samples. Metabolisable energy (ME) intake was calculated by substracting MDFU energy from total intake. Initial components and total body composition were estimated from regression equations on live weight established with control animals (table 2). Protein, fat and energy retentions during the 7-day experimental period were obtained by difference from the final composition.

Results

Balance data

Three pigs in litter 2 failed to eat properly during the experimental period. Balance results were calculated on 4 litters *i.e.* 8 pigs per diet. Energy balances were strongly negative with both diets, the daily loss per metabolic weight ($W^{0.75}$) representing about half the ME intake (table 3). In contrast, protein balance was not significantly different from zero with diet 1 (low protein intake) and clearly positive with diet 2 (high protein intake). At the same time, fat loss was higher with diet 2 than with diet 1 ($P < 0.05$) without any significant difference in heat production. Most of the effect of dietary protein on whole-body nitrogen balance

TABLE 2

Within litter regression of chemical content (y) *in body components of the 10 d. old control piglets on body weight* (× in kg).

y [1] :		Protein (g)	Fat (g)	Energy (MJ)
Carcass :	a	− 68.4	− 110.7	− 1.81
	b	138.4	127.7	7.12
	R^2 (cv)	0.97 (2.9)	0.84 (7.7)	0.97 (2.8)
Digestive tract :	a	− 5.16	—	− 0.449
	b	8.58	—	− 0.363
	R^2 (cv)	0.94 (4.1)	—	0.96 (4.4)
Liver :	a	4.91	—	0.107
	b	3.85	—	0.237
	R^2 (cv)	0.73 (6.3)	—	0.56 (8.6)
Other viscera + blood :	a	− 17.01	—	0.306
	b	6.31	—	0.215
	R^2 (cv)	0.44 (9.2)	—	0.56 (8.9)
Total [2] :	a	− 51.6	− 117.7	− 1.72
	b	157.1	132.7	7.81
	R^2 (cv)	0.96 (3.1)	0.86 (7.3)	0.96 (3.0)

([1]) $y = a + bx$, R^2 = squared correlation, cv : coefficient of variation *i.e.* residual standard deviation (RSD) as a percentage of $\bar{y}$, the mean estimate. ($\bar{x}$ = 3.66 kg, RSD = 0.47).

([2]) Fat in the non-carcass body components (f_{nc}) has been estimated from total energy (e in kj), dry matter (dm in g) protein (p in g) and ash (a in g) contents as :

$f_{nc} = 21.76\ [(e - 23.85\ p - 17.15\ (dm - p - a)]$

was due to differences in rates of carcass protein deposition (table 4). The effect of dietary protein on nitrogen deposition in the liver was smaller but highly significant.

Protein deposition in the digestive tract was significantly different from zero with diet 1 and the superiority of diet 2 (+ 30 %, $P < 0.10$) was not in proportion to the additional protein supply (+ 85 %). Deposition rates calculated for « other organs and blood » were not as reliable as the others, probably as a result of lack of accuracy in the calculations of initial compositions (table 2).

Metabolism data

Compared with the injected solution, the free pool phe-SRA decreased more rapidly in the liver and the intestine than in the muscle (fig. 2). For this reason, Mc Nurlan, Tomkins and Garlick (1979) and Goldspink, Lewis and Kelly (1984) slaughtered groups of rats 2 min after the injection in order to calculate a mean free pool SRA during the labelling time. Using the 10 min value, *i.e.* the tissue free pool SRA at slaughter, may have resulted in an overestimation of the fractional protein synthesis rate in the intestine. But it may be argued that using the 10 min free pool phe-SRA takes into account the fact that the rise to the plateau SRA is not instantaneous.

TABLE 3

Energy balance (kj/kg live weight $^{0.75}$ per d). *Partition into fat and protein.*

Diet	1	2	SEM ([1])	Statistical
Protein supply	Low	High		significance
Number of animals	8	8		
Live weight, kg				
at weaning	3.71	3.68	0.07	NS
at slaughter	3.93	4.01	0.10	NS
ME intake ([2])	454	471	28.3	NS
digestible protein ([3]) ([4])	99	183	6.3	***
digestible fat ([3]) ([4])	101	102	4.5	NS
Energy retained ([2])	− 233	− 235	35.2	NS
as protein + fat ([3])	− 256	− 262	31.5	NS
as protein ([3])	17	89	16.9	*
as fat	− 272	− 351	22.4	*
Heat production ([2])	688	707	23.4	NS
as ME - retained protein + fat	710	733	29.2	NS
from protein ([5])	66	76	10.0	NS
from fat	373	452	22.2	*

([1]) *** : $P < 0.001$; ** : $P < 0.01$; * : $P < 0.05$; + : $P < 0.10$; NS : $P > 0.1$.
SEM : standard error of a mean calculated from the residual mean square.

([2]) From bomb calorimeter measurements.

([3]) Assuming 23.85 kJ/g protein and 38.91 kJ/g fat.

([4]) Digestibility has been estimated from previous experiments with the same dietary protein and fat (Sève *et al.*, 1985).

([5]) The urinary loss of energy is estimated at 28.33 kJ/g urinary nitrogen according to Diggs *et al.*, 1965.

TABLE 4

Protein (N × 6.25) *balance,* g/kg live weight $^{0.75}$ per d.

Diet	1	2		
Protein supply	Low	High		
Number of animals	8	8	SEM ([1])	Statistical significance
Digestible protein intake	4.15	7.67	0.26	***
Retention of protein in :				
— carcass	0.19	2.84	0.70	*
— empty digestive tract	0.32	0.42	0.03	*
— liver	− 0.01	+ 0.08	0.02	*
— other viscera and blood	0.20	0.39	0.10	NS
— total body	0.70	3.73	0.71	*

([1]) See table 3.

The effect of weaning with the low protein diet on protein metabolism could be studied using 9 replicates for the first 3 tissues (muscle, liver and intestine) and 8 replicates for the bone (missing samples in litter 3). (table 5). No radioactivity was detected in the AIB fraction and the data refer to the ASB fraction which represented 43.7 % and 40.7 % of total bone protein in suckled and weaned pigs respectively (SEM = 1.5). One of the control animals (in litter 5) failed to suck properly after surgery and consequently gave aberrant data so that missing values were calculated according to Cochran and Cox (1957). Three pigs on diet 2 ate only

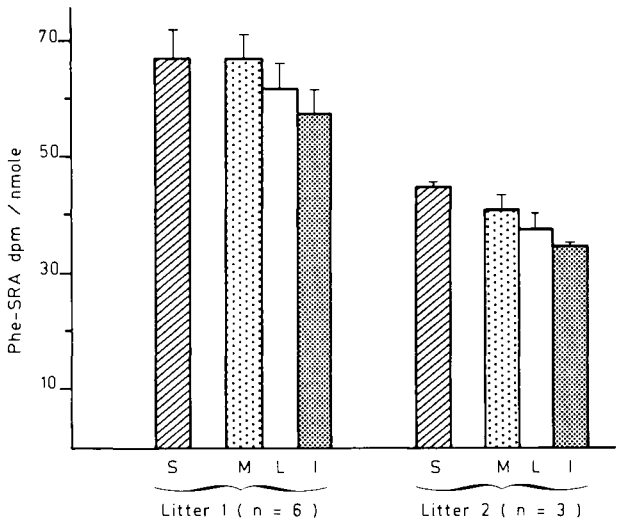

FIG. 2. — *Specific radioactivity of phenylalanine* (Phe-SRA) *in the free pools of muscle* (M), *liver* (L) *and intestine* (I) *as compared to that in the injected solution* (S) *when it had been checked* (Litters n° 1 and 2).

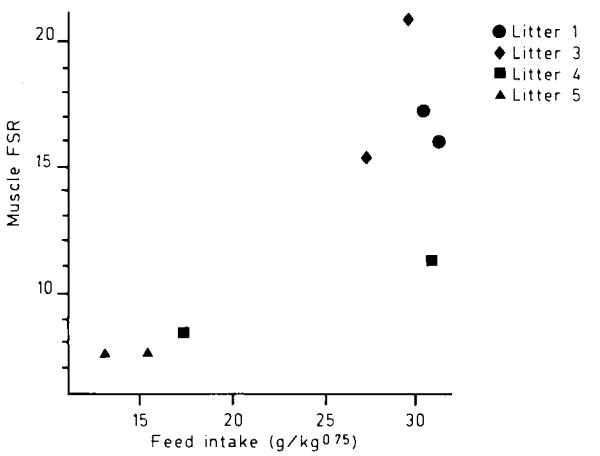

FIG. 3. — *Effect of the level of feed intake on the day of injection on muscle fractional protein synthesis rate* (FSR) *in piglets fed diet 2.*

half their meal on the day of slaughter. This decreased substantially the rate of muscle protein synthesis as shown in figure 3. The effect of dietary protein could be reliably assessed within litters 1 and 3 (4 replicates) for muscle liver and intestine but not for bone.

In pigs given the low protein diet, fractional rate of protein synthesis (FSR) decreased significantly after weaning in muscle ($P < 0.05$), liver ($P < 0.01$) and bone (ASB) ($P < 0.10$) (table 5). RNA : protein ratios decreased nearly in the same proportion (table 6) so that rates of protein synthesis per unit of RNA were

TABLE 5

Effect of weaning and dietary protein on fractional protein synthesis rates in four tissues.

		Suckled pigs (10 d. old)	Weaned pigs (17 d. old)		
Diet Protein supply	n [2] n [3]	Sow's milk —	1 Low	2 High	SEM [1]
Muscle	4	18.2[a]	13.9[b]	17.4[a]	1.16 +
	9	16.4[a]	12.7[b]	—	0.95*
Liver	4	70.4[a]	59.4[b]	68.7[a]	1.56**
	9	84.6[a]	69.7[b]	—	2.55**
Intestine	4	51.0	78.8	66.8	8.13 NS
	9	59.0[a]	79.4[b]	—	5.48*
Bone	8	79.7[a]	64.8[b]	—	4.49 +

[1] See table 3. Means in the same row with different superscripts differ significantly at probability levels indicated in the SEM columns.
[2] Number of replicates for within litter comparisons of the three treatments (litters 1 and 3).
[3] Number of replicates for within litter comparison of control and diet 1 treatments (all litters).

TABLE 6

Effect of weaning and dietary protein on RNA : protein ratios in four tissues.

		Suckled pigs (10 d. old)	Weaned pigs (17 d. old)		
Diet Protein supply	n [2] n [3]	Sow's milk —	1 Low	2 High	SEM [1]
Muscle	4	13.7[a]	10.4[b]	9.5[b]	0.80*
	9	13.8[a]	10.6[b]	—	0.42**
Liver	4	53.9	41.1	42.7	4.47 NS
	9	53.3[a]	43.5[b]	—	2.86 +
Intestine	4	41.4	47.1	44.7	3.67 NS
	9	44.8	48.6	—	2.90 NS
Bone	8	48.2[a]	37.2[b]	—	1.61**

[1] [2] [3] See table 5.

maintained at the same level (table 7). An opposite trend was noticed in the intestine where the fractional protein synthesis rate was accelerated after weaning while RNA : protein did not change so that the rate of protein synthesis per unit of RNA increased significantly.

The statistical analysis of the effect of weaning with the low protein diet showed the same trends with 4 as with 9 replicates although the accuracy of the comparison was lower ; the average values were slightly different due to litter effects which were highly significant in the cases of fractional rate of liver protein synthesis and muscle RNA : protein ratio.

Increasing dietary protein induced higher rates of protein synthesis, matching the preweaning levels, in muscle ($P < 0.10$) and liver ($P < 0.01$). (table 5). There was no parallel variation in RNA : protein ratios (table 6) and, as a consequence, protein synthesis per unit of RNA was increased with the higher protein intake (table 7). This effect was significant in the case of muscle but not liver due to higher variability in RNA contents. Again, intestine did not behave in the same way : in this tissue, protein synthesis and RNA : protein ratio were not dependent on dietary protein supply. With both diets there was a significant increase in intestine protein synthesis per unit of RNA after weaning ($P < 0.05$).

TABLE 7

Effect of weaning and dietary protein on protein synthesis per unit of RNA in four tissues.

		Suckled pigs (10 d. old)	Weaned pigs (17 d. old)		
Diet Protein supply	n [2] n [3]	Sow's milk –	1 Low	2 High	SEM [1]
Muscle	4	13.5[a]	14.7[a]	18.4[b]	1.35 +
	9	11.7	13.5	–	0.96
Liver	4	13.5	14.7	16.6	1.33 NS
	9	15.6	16.0	–	0.95 NS
Intestine	4	12.4[a]	16.4[b]	14.9[b]	0.91 +
	9	13.2[a]	16.1[b]	–	0.64*
Bone	8	16.5	17.1	–	0.86 NS

[1] [2] [3] See table 5.

Discussion

The negative energy balance suggests that the energy intake is below the maintenance requirement, which is roughly in agreement with the data reviewed by Close and Stanier (1984). A striking result is the shift of the energy metabolism towards protein accretion at the expense of body fat as dietary protein is increased. Prokop (1976) reported similar results on piglets given either a protein-free or a protein adequate diet at low energy intakes. The extrapolation of Campbell and Dunkin's data (1983) to low energy intakes would provide the same

conclusion. Evidently, in piglets fed diet 2 the substitution of protein for carbohydrate induces an energy deficit which, as ME intake does not increase, has to be compensated by the enhancement of fat oxidation over the values found in piglets fed diet 1. On the other hand, regression calculations show that, within each diet, protein accretion (P) is the primary factor related to metabolisable energy, while the contribution of fat mobilization is insignificant (diet 1 : ME = 422 + 1.88 P, R^2 = 0.88, RSD = 9.5 ; diet 2 : ME = 368 + 1.13 P, R^2 = 0.84, RSD = 6.8). These equations would indicate that increasing dietary protein content tends to improve ME utilization for maintenance or protein deposition in agreement with Campbell and Dunkin's data (1983).

At 10 days of age the digestive tract contains about 5 % of the total body protein content. Protein deposition in this component is a much higher proportion of whole-body retention with diet 1 than with diet 2 (46 % vs 11.5 %). The same pattern has been observed one week later in lighter piglets (21 % vs 14 %) but in heavier piglets there was no effect of the dietary protein on these ratios (12 % in both weight groups ; Sève and Julien, unpublished data). In rats, the contribution of the small and large intestine to whole body growth was of comparable magnitude (11 %) from birth to weaning (Goldspink, Lewis and Kelly, 1984). The superiority of the data related to a low protein supply is the expression of the priority ot digestive organs for nutrients over other parts of the body, in agreement with Lenkeit *et al.* (1963). These authors also reported an opposite response of the liver and the digestive tract to protein deficiency. In the present experiment, this occurs before the beginning of the stage of positive allometric growth of the main digestive organs reported in suckled piglets (Kidder and Manners, 1978). Consequently, we may hypothesize that weaning in itself is responsible for the stimulation of digestive development.

The rate of muscle protein synthesis is only slightly higher than the value reported in the actomyosin of the hindlimb muscles in suckled piglets of the same age (Perry, 1974). Lower figures (7.6 % per d) were obtained in the *gastrocnemius* muscle of 20-30 kg pigs (Edmunds, Buttery and Fisher, 1978 ; Simon *et al.,* 1978) or in the leg muscles of 70 kg pigs (Garlick, Burk and Swick, 1976). An important decrease (16.2 to 10.2 %) has been shown recently in rats from 21 to 60 days post-partum (Kelly *et al.,* 1984). In the lamb, from higher values at 1 week of age, a similar fall was found 4 weeks later (Arnal *et al.,* 1977). The rate of liver protein synthesis (70.6-84.6 per d) is quite high as compared to the values of 36.9 and 23.3 % reported by Edmunds, Buttery and Fisher (1978) and Garlick, Burk and Swick (1976), respectively. As in the muscle, this difference is probably the result of a decline in FSR with age, always reported in other species (Goldspink and Kelly, 1984 ; Arnal *et al.,* 1977). Similarly, the rate of protein synthesis in the small intestine is higher in our suckled piglets (59 % per d) than in the 25 kg pigs (23 % according to Edmunds, Buttery and Fisher, 1978). In the rat, intestine FSR remained at the same high level from 20 days of foetal age to 21 days post-partum and then continuously decreased after weaning (Goldspink, Lewis and Kelly, 1984). The rate of protein synthesis in the ASB fraction of the *femur* is comparable to the high values reported in the whole *tibia* of immature rats by Preedy, Mc Nurlan and Garlick (1983). However, taking into

account the AIB component would provide lower whole-bone FSRs, 34.8 % and 26 % per d in suckled and weaned piglets respectively, although such values are still much higher than the muscle ones.

In our experiment weaned piglets were slaughtered one week later than the suckled ones. Even within this short period, developmental processes such as a decrease in RNA : protein ratio (Durand, Fauconneau and Penot, 1967), may have been superimposed on weaning effects. It is possible, but has to be confirmed using control suckled piglets of the same age, that early-weaning exaggerates the normal age-dependent increase in muscle and liver protein synthesis per unit of RNA, shown in the rat by the data of Kelly *et al.* (1984). This is suggested by the fact that, if an adequate protein diet is fed, FSR remains at its preweaning level instead of decreasing with age as in well-fed rats. Compared to the other tissues, the intestine is peculiar because the post-weaning increase in protein synthesis is not associated with a decrease in RNA : protein ratio and does not depend on a high protein supply. However, as far as intestine FSR is concerned, a similar effect of weaning has been reported in the lamb (Combe, Attaix and Arnal, 1979) and in the normal Zucker rat (Reeds *et al.*, 1982). According to the data of Goldspink, Kelly and Lewis (1984) this effect would already appear on the day of weaning in terms of protein synthesis per unit of RNA. Such an observation would suggest that the preserved development of the digestive tissues is not related to the weaning diet but merely to the undernutrition, already present in 21 day-old suckled rats just before weaning.

The positive effects of dietary protein on muscle and, to a lesser extent, liver's FSR are consistent with the elevated whole body protein synthesis rate produced through additional protein supply (Reeds *et al.*, 1981). In the same dietary conditions, the trend to a decrease in intestinal FSR, associated with an increased protein deposition in digestive tissues, implies a reduction in protein degradation. This last result would be consistent with an improvement in the efficiency of energy for maintenance or protein deposition, if it reflected the response of the whole body. Further investigations including protein synthesis measurements in other essential tissues (bone, skin, thoracic organs) are clearly needed to support this hypothesis.

Reçu en octobre 1985.
Accepté en mars 1986.

Acknowledgements. — This work has been performed during the sabbatical year of B. Sève at the Rowett Research Institute. The author is grateful to prof. W.P.T. James, Director, A.S. Jones, Deputy-director for welcoming him and acknowledges the helpful assistance of the staff of the applied nutrition and protein biochemistry departments namely R. M. Palmer and W. S. Mackie.

Résumé. *Synthèse protéique dans quelques tissus du porcelet sevré précocement et soumis à une variation de l'apport azoté alimentaire. Relation avec le métabolisme énergétique.*

L'évolution de la synthèse protéique (en % par jour) est mesurée dans 4 tissus (muscle, foie, intestin et os) au cours de la semaine suivant un sevrage à 10 jours d'âge dans deux groupes de porcelets recevant individuellement des quantités égales d'aliments secs à

15 ou 30 % de protéines. Parallèlement, on effectue des bilans corporels d'énergie et d'azote en distinguant 4 compartiments (carcasse, foie, organes digestifs, autres organes + sang). Les bilans énergétiques se révèlent fortement négatifs dans les deux groupes du fait des faibles quantités d'énergie ingérées et de l'importante mobilisation des réserves lipidiques corporelles. L'augmentation de l'apport azoté alimentaire s'accompagne d'une amélioration du bilan protéique et d'une mobilisation supplémentaire de lipides. Avec le régime à basse teneur en protéines, la rétention azotée reste significative dans les organes digestifs mais pas dans le foie ni la carcasse. Les rapports ARN : protéines du muscle et du foie décroissent après sevrage selon un rythme compatible avec les variations normalement associées à l'âge, quel que soit le régime. La synthèse protéique augmente avec les apports azotés dont le plus élevé permet aux animaux de maintenir leur niveau d'avant le sevrage. Dans l'intestin, en revanche, le rapport ARN : protéines ne change pas après sevrage et la synthèse protéique est augmentée quel que soit le taux de protéines de l'aliment. Dans l'os, le rapport ARN : protéines et la synthèse protéique, décroissent tous deux après sevrage lorsque le régime hypo-azoté est offert ; l'effet de l'apport de protéines n'a pu être mesuré dans ce tissu. Un effet du sevrage précoce commun à tous les tissus pourraît être d'augmenter l'activité de synthèse protéique par unité d'ARN au-delà des valeurs normalement observées à cet âge.

References

ARNAL M., FAUCONNEAU G., PECH R., 1972. Synthèses protéiques *in vivo* dans divers tissus du Rat en croissance soumis à une réduction de l'apport énergétique de la ration. *Ann. Biol. anim. Bioch. Biophys.*, **12**, 91-108.

ARNAL M., FERRARA M., FEBVAY G., FAUCONNEAU G., 1977. Aspect dynamique du métabolisme protéique dans quelques tissus de l'agneau au cours du développement. *Bull. Tech. C.R.Z.V. Theix, I.N.R.A.*, **30**, 17-22.

CAMPBELL R. G., DUNKIN A. C., 1983. The effects of energy intake and dietary protein on nitrogen retention, growth performance, body composition and some aspects of energy metabolism of baby pigs. *Br. J. Nutr.*, **49**, 221-230.

CLOSE W. H., STANIER M. W., 1984. Effects of plane of nutrition and environmental temperature on the growth and development of the early-weaned piglet. 2. Energy metabolism. *Anim. Prod.*, **38**, 221-231.

COCHRAN W. G., COX G. M., 1957. *Experimental designs,* 2nd Ed. J. Wiley and sons ed., New York, 611 p.

COMBE E., ATTAIX D., ARNAL M., 1979. Protein turnover in the digestive tissues of the lamb throughout development. *Ann. Rech. vét.* **10**, 436-439.

DIGGS B. G., BECKER D. E., JENSEN A. H., NORTON H. W., 1965. Energy value of various feeds for the young pig. *J. anim. Sci.*, **24**, 555-558.

DURAND G., FAUCONNEAU G., PENOT E., 1967a. Evolution de la teneur en acides nucléiques et en protéines du muscle chez le Porc au cours de la croissance post-natale. *C.R. Acad. Sci. Paris,* **264**, 1640-1643.

DURAND G., FAUCONNEAU G., PENOT E., 1967b. Evolution des teneurs en acides nucléiques et en protéines du foie du porc au cours de la croissance post-natale. *Bull. Soc. Chim. biol.* **49**, 361-370.

EDMUNDS B. K., BUTTERY P. J., FISHER C., 1978. Protein turnover and whole body nitrogen metabolism in the growing pig. *Proc. Nutr. Soc.* **37**, 32A.

GARLICK P. J., BURK T. L., SWICK R. W., 1976. Protein synthesis and RNA in tissues of the pig. *Amer. J. Physiol.*, **230**, 1108-1112.

GARLICK P. J., Mc NURLAN M. A., PREEDY V. R., 1980. A rapid and convenient technique for measuring the rate of protein synthesis in tissues by injection of (^{3}H)-phenylalanine. *Biochem. J.*, **192**, 719-723.

GOLDSPINK D. F., KELLY F. J., 1984. Protein turnover and growth in the whole body, liver, and kidney of the rat from the foetus to senility. *Biochem. J.,* **217,** 506-516.

GOLDSPINK D. F., LEWIS S. E. M., KELLY F. J., 1984. Protein synthesis during the developmental growth of the small and large intestine of the rat. *Biochem. J.,* **217,** 527-534.

KELLY F. J., LEWIS S. E. M., ANDERSON P., GOLDSPINK D. F., 1984. Pre and post-natal growth and protein turnover in four muscles of the rat. *Muscle and Nerve,* **7,** 235-242.

KIDDER D. E., MANNERS M. J., 1978. *Digestion in the pig.* Scientechnica Ed., Bristol, 201 pp.

LENKEIT W., STRUNZ K., KEMME J., SPAARMANN W., 1963. Die Stickstoff- und Nucleinsäure-Verteilung im Ferkelkörper unter dem Einfluss der Proteinzufuhr (Vorläufige Ergebnisse). *Z. Tierphysiol. Tierern. Futtermittelkde,* **18,** 227-239.

Mc NURLAN M. A., TOMKINS A. M., GARLICK P. J., 1979. The effect of starvation on the rate of protein synthesis in rat liver and small intestine. Biochem. J., **178,** 373-379.

PERRY B. N., 1974. Protein turnover in skeletal muscle of piglets. *Br. J. Nutr.,* **31,** 35-45.

PREEDY V. R., Mc NURLAN M. A., GARLICK P. J., 1983. Protein synthesis in skin and bone of the young rat. *Br. J. Nutr.,* **49,** 517-523.

PROKOP V., 1976. A complete nitrogen balance in piglets determined by the method of analysis of bodies. (Czech). *Zivocisna Vyroba,* **21,** 375-381.

REEDS P. J., CADENHEAD A., FULLER M. F., LOBLEY G. E., Mc DONALD J. D., 1980. Protein turnover in growing pigs. Effects of age and food intake. *Br. J. Nutr.,* **43,** 445-455.

REEDS P. J., FULLER M. F., CADENHEAD A., LOBLEY G. E., Mc DONALD J. D., 1981. Effects of changes in the intakes of protein and non-protein energy on whole-body protein turnover in growing pigs. *Br. J. Nutr.,* **45,** 539-546.

REEDS P. J., HAGGARTY P., WAHLE K. W. J., FLETCHER J. M., 1982. Tissue and whole body protein synthesis in immature Zucker rats and their relationship to protein deposition. *Biochem. J.,* **204,** 393-398.

SÈVE B., 1979. Bien concevoir les aliments du porcelet. *Elev. Porc.,* **82,** 19-29.

SÈVE B., 1982. Age at weaning, development of chemical body components and energy utilization in piglets from 3 to 25 kg live-weight. *Livestock Prod. Sci.,* **9,** 603-617.

SÈVE B., AUMAITRE A., BOUCHEZ P., 1985. Effet d'un traitement technologique sur la valeur nutritionnelle du pois pour le jeune porcelet. *Sci. Aliments,* **5,** n° hs V, 119-126.

SIMON O., MUNCHMEYER R., BERGNER H., ZEBROWSKA T., BURACZEWSKA L., 1978. Estimation of rate of protein synthesis by constant infusion of labelled amino acids in pigs. *Br. J. Nutr.,* **40,** 243-252.