Adequacy of Synthetic Diets for Reproduction of Swine. (18173)

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Previous efforts(1-4) to prepare synthetic diets that were adequate for reproduction by swine failed. Another attempt was made by the authors after vit. B_{12} became available and the degree of success attained, though with only two sows, seems worthy of record. The experimental procedure has been described by Anderson and Hogan(4). The diet was of the synthetic type, homogenized with water to form a synthetic milk until the pigs were 10 weeks old. After that time the diet was fed as a dry mixture. The amount of casein was changed at times in order to better adapt the food mixture to the various stages of growth and reproductive activity, but in order to conserve space only the diets supplied during lactation are described in detail, see Table I. The experimental animals were two of the females described by Anderson and Hogan(5) and each bore two litters.

First litters. Each of the gilts had received injections of crystalline vit. B_{12} at 3-day intervals beginning when they were 3 and ending when they were 38 days of age. The total amount injected in that period was 50 μg for No. 113 and 200 μg for No. 171. The gilts were bred at the ages of 195 and 238 days and farrowed when 312 and 354 days old. A solution of iron, copper and manganese was applied daily during the first 3 weeks of lactation to the udders of the sows to prevent anemia in their litters. When the pigs were 3 weeks old they had continuous access to the same feed in a creep as was supplied to their dams. When the sows were 231 days old the vitamin injections were resumed and continued at intervals until well into the lactation period. The total amounts injected during this time were 442 μg for Sow 113 and 383 μg for Sow 171. There was some slight evidence that the ration of the sows was inadequate. A few of the pigs were born with kinked tails, though this abnormality gradually disappeared. Mild diarrhea was observed in both litters but this condition was never severe or prolonged. Sow 171 was observed to vomit on a few occasions just prior to feeding. The farrowing and

TABLE I. Composition of Experimental Rations.

Ration No.	358	359
Ingredient	%	%
Casein, vit. free*	25	22.5
Sucrose	55	55
Lard	5	5
Mineral mixture(6)	5	5
Wood pulp	10	10
Liver extract†	—	2.5
Vitamin supplement per 100 g of ration‡		
Thiamine-HCl	1 mg	
Riboflavin	1	
Ca-pantothenate	3	
Pyridoxine-HCl	1	
Nicotinic acid	4	
Choline chloride	100	
Biotin	0.03	
Pteroylglutamic acid	0.02	
Inositol	100	
Vit. E	4	
Vit. K	2	
Vit. A	2000 I.U.	
Vit. D	400	

* Labco, purchased from the Borden Company, New York, N. Y.

† Liver fraction primary powder purchased from Wilson Laboratories Division of Wilson and Company, Chicago, Ill.

‡ The pteroylglutamic acid was generously supplied by Dr. T. H. Jukes, Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y. All other vitamins except A and D were generously supplied by Dr. D. F. Green of Merck and Co. The source of vit. A was a concentrate supplied by Distillation Products Co. of Rochester, N. Y. Vit. D was Delesterol purchased from E. I. du Pont de Nemours and Co.

* Contribution from the Missouri Agricultural Experiment Station.

1. Ensminger, M. E., Bowland, J. P., and Cunha, T. J., *J. Animal Sci.,* 1947, v6, 409.

2. Russell, W. C., Terri, A. E., and Unna, K., *J. Nutrition,* 1948, v35, 321.

3. Hogan, A. G., and Anderson, G. C., *J. Nutrition,* 1938, v36, 437.

4. Anderson, G. C., and Hogan, A. G., *J. Animal Sci.,* 1950, v9, 163.

5. Anderson, G. C., and Hogan, A. G., *J. Nutrition,* 1950, v40, 243.

6. Richardson, L. R., and Hogan, A. G., *J. Nutrition,* 1946, v32, 459.

TABLE II. Farrowing and Litter Records.

Litter	First		Second	
Sow No.	113	171	113	171
Pigs born alive	7	8	8	9*
Avg birth wt, lb.	2.3	2.5	2.3	2.7
Creep feed consumed by litter, lbs.	n.w.†	n.w.†	132	129
No. of pigs weaned	6	6	7	7
Avg weaning wt, lbs.	20.4	25.8	35.1	47.1

* A 10th pig was smothered in the chorionic membranes.
† n.w. = not weighed.

litter records of the two sows are summarized in Table II.

Two pigs in the litter of Sow 171 were dead by the 10th day and, as it seemed probable that the sow had received insufficient vit. B_{12}, on the 11th day each pig was given an intramuscular injection of 21.5 μg of the vitamin. There were no more deaths. Each pig in the litter of Sow 113 was given an injection of 10 μg of vit. B_{12} immediately after birth. There was one death in her litter at the age of 19 days which was attributed to an intestinal obstruction. It soon became evident that the pigs would not attain normal weaning weights, and an attempt was made to accelerate the growth rate. Some of the pigs in each litter were given additional injections of vit. B_{12}, from 51.5 to 61.5 μg per pig, the others were given injections of the antipernicious anemia liver fraction,† from 80 to 95 units per pig. It was hoped that if pigs require an unrecognized nutrient it would be present in the liver extract and the existence of such nutrient could be established. The individual responses of the pigs, not shown, indicate that both vit. B_{12} and the liver fraction improved the nutritional status of the pigs, but there was no evidence that the liver extract was any more effective than was the crystalline vitamin.

Second litters. The results of the first trial indicated that the sows had either been given an insufficient quantity of vit. B_{12}, or else they require one or more unrecognized nutrients. In order to obtain additional information on these points both sows were carried through a second reproductive period. In order to determine whether sows require more vit. B_{12} than had been supplied in the first trial, Sow 171 was given 1.54 mg of vit. B_{12} during gestation and 0.84 mg during lactation, a total of 2.38. Each pig in her second litter was given an injection of 50 μg of vit. B_{12} shortly after birth. Sow 113 was used in the attempt to determine whether swine require an unrecognized nutrient. On the 59th day of gestation her ration was changed to Ration 359 which contains 2.5% of a water extract of liver.† When her litter was 6 weeks old the amount of the extract was increased to 5%. The pigs in the litter of Sow 171 were normal at all times. They were entirely free of the exudate on the body and around the eyes which previously has been so conspicuous(5,7) and they did not develop diarrhea. The litter was uniform, and the average weight at 8 weeks was 47.1 lbs., which is about 50% heavier than current growth standards for that age. It should be mentioned though that the pigs ate much more of the creep feed than they do when supplied with a mixture of the commonly used practical feed-stuffs, and this consumption of supplementary feed is probably the explanation of the unusual weaning weights. The performance of this litter would indicate that their diet contained all the vitamins that pigs require. The litter of Sow 113 did well, but its record was not spectacular. The average weight at 8 weeks was 35 lbs. However, the pigs had recurrent mild attacks of diarrhea during the first 3 weeks and they were not uniform in size. It is uncertain whether the differences between the two litters were due to their mothers or to the diets the mothers consumed. It may be that Sow 113 did not receive an adequate amount of vit. B_{12}. Consideration should also be given to the fact that the litter of Sow 113 did not receive vit. B_{12} injections. However the data are interpreted, they give no indication that the liver extract contains an unrecognized nutrient that is of importance to swine.

Our study was too limited for a precise

† We are indebted to Dr. R. A. Brown of Parke, Davis and Co., Detroit, Michigan, for this material.

7. McRoberts, V. F., and Hogan, A. G., *J. Nutrition,* 1944, v28, 165.

determination, but we have used the data obtained with Sow 171 for a tentative estimate of the amount of vit. B_{12} required by a mature brood sow. The method of calculation is the same as was used by Anderson and Hogan(5) and the original data and the estimates are shown below.

Days in period	168
Feed consumed	558 kg
Casein consumed	103
Vit. B_{12} in casein	1,755 μg
Vit. B_{12} inj.	2,380
Amt of vit. B_{12} required per kg of feed	11.7
Amt of vit. B_{12} required daily per sow:	
Orally	38.8
By injection	19.4

The estimate of the amount required per kg of feed is in reasonable agreement with an earlier estimate(5) of the amount required by a growing pig. One would expect both estimates to be revised when additional data become available.

Discussion. Rats, mice and chicks grow normally on diets that are completely synthetic. Guinea pigs and rabbits grow normally on synthetic diets but so far as we are aware normal reproduction has not been reported. Lambs and calves grow well, at least for limited periods, but have not been studied extensively. It seems probable that swine can be added to the list of animals for which synthetic diets are completely adequate. Admittedly it is desirable to have more animals but at present the cost is prohibitive for us. However, it seems that two successes more than counterbalance several failures with less complete diets. Even if it is conceded though that synthetic diets are adequate, several nutritional factors remain for further investigation. The acceleration of growth by liver residues and by antibiotics, when added to certain rations, are well known examples.

Summary. Two sows which consumed synthetic diets and were given injections of approximately 400 μg each of vit. B_{12} reared their first litters. The weights of the pigs when weaned at 8 weeks were subnormal, 20 and 26 lbs., and there were other signs of mild nutritional deficiency. One of the sows received by injection 2,380 μg of the vitamin during a second gestation and lactation and reared a litter of 7 pigs with the unusual average weaning weight of 47 lbs. The other sow consumed during her second gestation and lactation a diet that contained a water extract of liver and weaned a litter of 7 with an average weight of 35 lbs. The inclusion of a liver extract in the synthetic diet was not more effective than was the injection of vit. B_{12} and the evidence indicates that swine can complete a normal life cycle on diets that contain no unrecognized nutrients.

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Influenza Virus in Sectioned Tissues. (18174)

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As part of a broader study of how viruses develop within infected cells attempts are being made to recognize in thinly sectioned preparations the elementary particles of several viruses that have been examined in purified suspension. Photographs taken with this end in view have already been published of tobacco mosaic virus particles in infected leaves(1) and of particles of the fowl pox virus(2) in infected chorioallantoic membrane. The present paper is a preliminary record of what has been seen in influenza-diseased tissues. It illustrates particles having the

1. Black, L. M., Morgan, C. and Wyckoff, Ralph W. G., PROC. SOC. EXP. BIOL. AND MED., 1950, v73, 119.

2. Morgan, C., and Wyckoff, Ralph W. G., *J. Immunology*, 1950, v65, 285.