proteins of animal origin of high biological value.

Supplementary Relationships between Proteins in Buckwheat Flour, Milled Cereal Grains, and Grain Sorghum. Table III shows that the replacement of one half, one third, and one fourth of the proteins in milled wheat flour with equivalent amounts of proteins in buckwheat flour was accompanied with 270.2, 194.7, and 117.3% increased growth; and 129.3, 87.8, and 59.7% increase in protein efficiency ratios, respectively. Similar percentagewise replacements of the proteins in milled white corn meal with equivalent amounts of proteins in buckwheat flour resulted in 1323.6, 794.5, and 249.1% increased growth; and 687.0, 430.4, and 182.6% increase in protein efficiency, respectively. Replacement of one half and one third of the proteins in Arkansas grain sorghum with equivalent amounts of proteins in buckwheat flour was followed by 500.7 and 116.9% increased growth and 293.2 and 118.2% increase in protein efficiency.

Rye has considerable amounts of bran which is removed in milling leaving a flour of low protein content. The milled rye flour obtained from General Mills contained only 7.5% protein (N × 5.7) (*6*). It was, therefore, possible to introduce a maximum of only 6.0% protein in the ration. Replacement of one half, one third, and one fourth of the proteins in milled rye by equivalent amounts of proteins in buckwheat flour resulted in 279.1, 191.5, and 98.9% gains in body weight; and 145.1, 104.9, and 74.4% increase in protein efficiency, respectively.

The results of this study indicate the necessity of large expansion of the cultivation of buckwheat in various sections of the world, particularly in the Orient, Latin American countries, and Africa where there exists a marked protein deficiency associated with a low resistance to infections and low life expectancy (*2*, *5*).

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FEED FROM SEWAGE

Sewage Sludge as a Feed Ingredient for Swine and Poultry

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Dry activated sludge can be included in the diet of the baby pig up to a level of 5% without adverse effects on growth. Levels of 2 and 10% in the diet of the chick produced a growth response in excess of 8% over a control group.

Microbiological assays have indicated (*2*, *3*) that dry activated sewage sludge is a potential source of vitamin B_{12}. Schendel and others (*5*) have shown that a level of 2% sludge in the diet of the baby pig will satisfy the B_{12} requirement for growth without adverse effects. It seemed desirable to investigate higher levels of sludge as a possible source of other growth factors or toxic substances.

Crossbred baby pigs 2 to 3 days old were obtained from a commercial hatchery for use in these experiments. The pigs were kept together for 2 days to facilitate their learning to drink from bowls and then were housed individually in wire-bottomed metal cages. They were fed approximately every 8 hours an alpha-protein synthetic milk, the composition of which is given in Table I, in amounts estimated to be 100 to 200 ml. more than they would consume before the next feeding. Sewage sludge and vitamins were added at the time of feeding; control animals received 0.8 γ of vitamin B_{12} per kg. of body weight per day by weekly intramuscular injection (*4*). Microbiological assay with *Ochromonas malhamensis* indicated 4.0 γ of B_{12} activity per gram of sludge and with *E. coli* mutant 7.5 γ of B_{12} activity per gram of sludge.

The first experiment compared a basal group with a group receiving the basal diet plus dry activated sewage sludge at the rate of 10% of the dry matter of the diet. After 3 weeks it became apparent (Table II) that the 10% level was inhibiting growth and decreasing feed efficiency. At this point the sludge was lowered to a level of 5% and the experiment continued for 3 more weeks, during which the gains paralleled those of the basal and the feed efficiency improved markedly.

Table I. Basal Diet

	%
Alpha-protein	27.5
DL-Methionine	0.5
Cerelose	30.09
Lard	30.77
Minerals	11.14

These materials were made into a synthetic milk containing 13% solids according to a modification of the Clark method (*1*).

	Vitamins Added per Liter of Synthetic Milk, Mg.
Thiamine HCl	0.65
Riboflavin	1.30
Pyridoxine HCl	1.30
Nicotinic acid	2.60
Ca pantothenate	7.80
Choline chloride	130.00
Folic acid	0.052
Biotin	0.01
2-Methyl-1,4-naphthoquinone	0.26
Vitamin A	2000 I.U.
Vitamin D	200 I.U.

The second experiment involved four groups of pigs: a basal group and pigs fed 4, 6, and 8% levels of sludge. Data from the 6-week experimental period are given in Table II.

The first experiment served essentially as a pilot experiment to establish the limits within which sewage sludge either stimulated growth or became toxic. The 10% level was obviously too high, while 5% could apparently be tolerated, although this level was complicated by the initial inhibition due to the higher level. The data of experiment 1 are given in Table II and are broken down into the two 3-week periods. For the first 3 weeks the sludge was fed at the 10% level and for the last 3 weeks at the 5% level.

Results of the second experiment showed that the 6 and 8% levels of sludge depressed growth and feed efficiency, while the 4% level gave neither adverse nor stimulating effects.

A subsequent experiment of similar nature was conducted with chicks to study the use of sludge as a source of B_{12} and other growth factors. A synthetic B_{12}-deficient diet composed of Drackett protein, 24%; cerelose, 64%; corn oil, 6%; salts, 5.5%; and DL-methionine, 0.3%, with adequate vitamin supplementation was fed *ad lib* to three groups of 10 chicks each. The basal group received 50 γ of crystalline B_{12} per kg. of diet; group 2 received 2% sludge and group 3 was fed 10% sludge.

The 4-week data are given in Table III. In contrast to the pig experiments, the inclusion of both 2 and 10% activated sludge in the diet of the chick give a substantial increase in growth and efficiency of gain at 4 weeks.

These experiments indicate that dry activated sludge can be included in the diet of the baby pig up to a level of 5% without adverse effects on growth. No evidence of growth stimulation attributable to unidentified factors was obtained at levels of 4 and 5%, while higher levels markedly depressed growth and feed efficiency. Levels of 2 and 10% in the diet of the chick produced a growth response in excess of 8% over a basal group receiving a synthetic diet including vitamin B_{12} and improved feed efficiency in both instances.

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Table II. Effect of Various Levels of Sewage Sludge on Growth of Baby Pig

Experiment 1	*Basal + B_{12}*	*Basal + Sewage Sludge at 10% (1–3 Wk.), 5% (4–6 Wk.)*
No. of pigs	3	4
Av. initial wt., kg.	1.53	1.59
Av. 3-wk. wt., kg.	4.65	3.76
Av. 3-wk. gain, kg.	3.12	2.17
Feed cons./gain, kg./kg.	1.34	1.90
Av. 6-wk. wt., kg.	14.55	11.64
Av. gain, 4–6 wk., kg.	9.90	7.88
Av. total gain, kg.	13.02	11.05
Feed cons./gain, 4–6 wk., kg./kg.	1.27	1.24

Experiment 2		*Basal + 4% Sludge*	*Basal + 6% Sludge*	*Basal + 8% Sludge*
No. of pigs	4	5	5	5
Av. initial wt., kg.	1.80	1.61	1.61	1.62
Av. final 6-wk. wt., kg.	12.29	12.30	7.72	9.82
Av. gain, kg.	10.49	10.69	6.11	8.20
Feed cons./gain, kg./kg.	1.41	1.63	1.98	1.77

Table III. Effect of Sewage Sludge on Chick Growth

	Basal + B_{12}	*Basal + 2% Sludge*	*Basal + 10% Sludge*
No. of chicks	10	10	10
Av. initial wt., g.	42	42	42
Av. 4-wk. wt., g.	368	400	400
Gain/feed cons., g./g.	0.47	0.55	0.50