1965

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A.S. Series 65-22

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Traditionally, swine diets have been developed by including the essential nutrients (carbohydrates, fats, proteins, minerals and vitamins) and growth-supporting additives in the dry diet. Completely mixed diets have been widely accepted by the modern swine producer because they support excellent gains and feed utilization by the animals. It has been convenient and advantageous to feed these completely mixed balanced diets; however, there are some disadvantages. Cost of the diets rises as more and more mixing of ingredients is required. The additional expense is due to the equipment and labor involved in mixing the nutrients used in small quantities, called micronutrients, into premixes and then adding to grain and extensively mixing again with the macro-ingredients. Another disadvantage is that once the diet is mixed, it is difficult to change. There are times, such as in scouring and with certain diseases, when an immediate change in the diet is desirable.

The method of providing needed nutrients to swine other than the traditional air-dry diet is presently being explored. The idea is suggested that daily nutrients might be successfully added to water and eliminate some of the disadvantages of the completely mixed diet. If animals perform satisfactorily by providing their nutrients in water, then another possible method of feeding would be available. This new nutritious water method should be evaluated by comparing it with the feeding methods presently generally accepted. Some of the advantages of the nutritious water method of feeding seem to be: (1) Part of the extensive mixing required in the usual method of diet preparation may be eliminated by mixing all of the micronutrients together and adding them in the water. Trace minerals used in micro amounts can be added with salt along with the grains and soybean meal and mixed in the dry diet. (2) One of the greatest advantages to this feeding program may be the possible flexibility of nutrients which are to be fed to animals. A decrease in feed intake usually occurs during the extremely hot or cold weather, poor health conditions or scouring due to bacterial organisms, yet animals seldom refuse to drink water under such conditions. In fact, water consumption increases in some instances. By having nutrients present in their water, animals that go off feed or reduce their feed intake would continue to receive needed nutrients and could be treated for the stress condition when necessary. (3) Clean, fresh water is important for animals, but there is little information to show how much influence this has on animal performance. Most water provided for animals is contaminated to some extent with bacteria due to the unsanitary conditions in and around the waterer. The addition of antibiotics and antibacterial agents in the water can act as a growth promoter and check the organisms in the water, destroying some harmful bacteria before they reach the gastrointestinal tract of the animal.

In spite of these apparent advantages, it must be made clear that this idea is based on an untried hypothesis and extensive research must be completed before an accurate evaluation can be made. A research program is seeking the needed information for an accurate evaluation of the nutritious water method.

The quantities of nutrients needed per gallon of water are not well established at this time. Animal weights and weather conditions may require the levels of nutrients to be varied. However, our research to date indicates these changes will not be extensive, if needed at all.

Nutrients must be added to the water frequently due to the instability of some vitamins in the water. Most of the B vitamins appear to be relatively stable in solution; however, fat soluble vitamins added in water dispersible form, such as vitamin A, may be destroyed after several hours. This may appear to be a rather critical problem, but this author is optimistic that the storage of vitamin A in the liver is adequate to provide nourishment to the tissue cells until the next addition of the nutrient to the water. Preliminary analyses of liver samples for vitamin A content indicated vitamin A storage is adequate for normal growth and health. The results of the trials reported in this article were with treated water lasting three or four days, which indicates this was not a serious problem in these trials.

Metering the proper dosage of nutritious water into an automatic water line requires special equipment, but this can be done without difficulty. Avoiding wastage of water containing the expensive nutrients would become an important factor with the new method.

Baby Pig Experiments

In trial 1, each group of twelve pigs were weaned at two weeks of age and fed 18 pounds of a commercial pre-starter, followed by 10 pounds of a commercial starter ration, and finally a 16% crude protein grower ration to the end of the four week test period. All diets were considered adequate in vitamin and antibiotic content for good daily gains. Group 1 received unfortified water (control animals), group 2 received additional vitamins in the water, group 3 received tylosin in the water, and group 4 received vitamins and tylosin in the water.

A summary of this research is shown in table 1. Pigs fed the vitamins, antibiotic or combination of vitamins and antibiotic fortified water gained 2.6, 3.3 and 2.3 pounds per pig, respectively, more than the control pigs for the four-week period. The faster daily gains of pigs fed the water-fortified diets were somewhat associated with greater feed and water intake, although there was some variation within and between trials. In trial 1, a coagulant formed in the water containing both vitamins and antibiotic. Coagulation was due to a fungus and probably affected the palatability of the water. The coagulation did not form in trial 2, and the water consumption was normal. Pigs fed the supplemental vitamins or tylosin separately required 14% less feed per pound of gain than the control pigs. Feed efficiency of pigs given the combination of vitamins and tylosin was only slightly better than the control pigs in trial 1 and essentially the same as the control pigs in the second trial.

Four experiments with baby pigs compared the effects of no vitamin addition to the feed or water (negative control group) and adding a low, medium, or high level of vitamins in the water. The low level provided 2375 I.U. of vitamin A, 1430 I.U. of vitamin D, 8 mg. of riboflavin, 2 mg. of thiamine, 17 mg. of pantothenic acid, 37 mg. of niacin, 2 mg. of pyridoxine, 21 mcg. vitamin B_{12} and 125 mg. choline chloride per gallon of water. The medium level provided twice, and the high level four times, the amount of vitamins in the low level. Based on expected water consumption, the low level would provide approximately one-half the daily requirement, the medium level would meet the daily requirement, and the

Table 1. Supplemental Vitamins and Antibiotic for Early Weaned Pigs

Item	Trial	Added to water			
		None	Vitamins[b]	Tylosin[c]	Vitamins and tylosin
Group number[a]		1	2	3	4
Av. total gain, lb.	1	11.2	15.9	17.6	14.4
	2	13.9	14.7	14.3	15.7
	Av.	12.7	15.3	16.0	15.0
Feed/lb. gain, lb.	1	1.62	1.46	1.46	1.51
	2	1.80	1.50	1.52	1.83
	Av.	1.73	1.48	1.49	1.66

[a] Six pigs were allotted to each treatment in each trial.
[b] Vitamins were added to provide 48,000 I.U. of vitamin A, 48,000 I.U. of vitamin D, 25.6 I.U. of vitamin E, 2 mg. of thiamine hydrochloride, 4 mg. of riboflavin, 32 mg. of niacin, 2.4 mg. of pyridoxine hydrochloride, 20 mg. of calcium pantothenate, 1.6 gm. choline chloride and 36 mcg. of vitamin B_{12} per gallon of water.
[c] Tylosin was added to provide 340 mg. of tylosin per gallon of water.

higher level was twice the current recommended daily needs of the pigs. These pigs were weaned at three weeks of age and fed on test for seven weeks. The summary is shown in table 2.

Average daily gain was highest in the group given the high level of vitamins in the water--they gained about 10% faster than the other treatment groups. We have been surprised that pigs fed diets without supplemental vitamins have done so well in all of the trials. No deficiency symptoms were observed and the pigs appeared healthy. Feed efficiency was the same for all groups.

Table 2. Summary of Four Baby Pig Trials

Item	Level of Vitamins in Water			
	None	Low	Medium	High
Group number	1	2	3	4
Number of pigs	26	26	26	24
Av. daily gain, lb.	.77	.80	.78	.86
Feed per lb. gain, lb.	1.91	1.96	1.94	1.91
Av. daily water, lb.	3.14	3.29	3.27	3.67

The same four treatments plus another--a normal diet with vitamins in the dry feed (positive control)--have been used in three experiments (table 3). See the footnotes of the table for vitamin supplementation in the diet for the positive control pigs. In these studies, the positive control group and the group fed the high level of vitamins in the water had the best gains. The negative control group had the slowest gains. Again, feed utilization was not influenced by treatment in these trials.

Growing-Finishing Pig Experiments

Preliminary experiments with growing-finishing pigs (1964 South Dakota Swine Day Report 64-19) showed that performance was essentially the same for pigs fed completely mixed air-dry diets and pigs fed diets without vitamins and antibiotic but the drinking water fortified with vitamins and antibiotic. Two recent experiments with the same experimental design as used in the baby pig experiments are shown in table 4. The low level of vitamins in the water was 1280 I.U. of vitamin A, 280 I.U. of vitamin D, 3.8 mg. of riboflavin, 1.6 mg. of thiamine, 19 mg. of niacin, 16 mg. of pantothenic acid, 16 mcg. vitamin B_{12} and 400 mg. choline chloride per gallon of water. The medium level was twice that quantity and the high level was four times that quantity per gallon of water. In these studies all pigs gained rapidly and the vitamin treated animals gained only slightly faster than the negative control pigs. However, feed efficiency was improved when vitamins were added to the water.

In two other experiments (table 5) with a positive control group included (diet with normal vitamin fortification) pigs fed the medium level of vitamins gained about 4% faster than the other pigs, but all other pigs gained about the same, including the positive and negative control groups. Vitamin fortification improved feed utilization with both the dry ration and water fortified diets in comparison to the group fed the unfortified diet.

Discussion

The results of these trials show that the performance of early-weaned and growing-finishing pigs when properly fed supplemental vitamins in drinking water is at least equivalent to pigs fed completely mixed dry diets. Proper fortification of each nutrient in water is not well established and extensive research is needed to determine proper levels. Since individual nutrient levels needed by this method of feeding are not known, there is little need in attempting to determine the cost of production at this time. However, the vitamin intake per pig in the finishing trials for the medium level of fortification group was less than the positive control group, thus the cost is not expected to be greater.

Since the microingredients were dispersed in the water, there was no problem of thoroughly mixing these ingredients into the complete diet. The pure, undiluted vitamins can be added to the water, whereas their addition in the dry diets required premixing and then extensive mixing in the complete diet. The dispersion and stability of products in water needs extensive research. The B vitamins are theoretically soluble in water and should become dispersed in the solution. Vitamins A and D, which are added to diets, are not soluble in water; however, water dispersible vitamins A and D were used in these experiments. Analyses of water samples are in progress to determine the degree of separation, if any, of the nutrients in solution. Also, the shelf life of these products in solution is being determined. Results of the experiments do not suggest a problem in physical separation or breakdown of the nutrients in solution, but chemical and biological assays will be used as the most informative tests.

Table 3. Vitamins in Water for Early Weaned Pigs

Item	Trial	No vitamins added	Vitamins added in diet[a]	Level of vitamins in water		
				Low	Medium	High
Lot number		1	2	3	4	5
No. pigs	1	6	6	6	6	5
	2	8	8	8	8	8
	3	5	5	5	5	5
Av. initial wt., lb.	1	12.4	12.4	13.1	12.3	12.3
	2	13.4	12.9	13.7	12.9	12.8
	3	14.2	13.2	12.6	13.6	12.2
	Av.	13.3	12.8	13.2	12.8	12.5
Av. final wt., lb.	1	43.5	52.7	54.2	51.2	55.6
	2	52.8	58.9	55.1	53.4	56.8
	3	62.8	67.6	62.8	67.6	68.6
	Av.	53.1	59.2	56.8	56.4	59.7
Av. total gain, lb.	1	33.0	40.3	41.2	38.8	43.2
	2	39.3	46.0	41.3	40.5	44.0
	3	48.6	54.4	50.2	54.0	56.4
	Av.	39.7	46.4	43.6	43.5	47.2
Av. total feed cons., lb.	1	66.0	82.3	84.0	77.5	86.6
	2	76.0	90.6	78.8	76.0	84.8
	3	86.2	104.6	97.6	106.4	109.4
	Av.	75.5	91.6	85.4	84.4	92.2
Av. total water cons., lb.	1	168.5	174.2	207.8	171.1	219.4
	2	135.5	182.5	112.5	144.2	180.5
	3	228.0	272.8	224.0	297.6	256.0
	Av.	170.3	203.6	171.9	193.1	212.3
Feed/lb. gain, lb.	1	2.00	2.04	2.04	2.00	2.00
	2	1.94	1.97	1.91	1.88	1.93
	3	1.77	1.92	1.94	1.97	1.94
	Av.	1.90	1.97	1.95	1.94	1.95

[a] 1135 I.U. of vitamin A, 681 I.U. of vitamin D, 4 mg. of riboflavin, 8 mg. of calcium pantothenate, 18 mg. of niacin, 60 mg. of choline chloride, 10 mcg. of vitamin B_{12}, 1 mg. of thiamine hydrochloride, and 1 mg. of pyridoxine is provided per pound of diet.

Table 4. Summary of Two Growing-Finishing Trials

Item	Level of vitamins in water			
	None	Low	Medium	High
Group number	1	2	3	4
Number of pigs	11	12	12	12
Av. daily gain, lb.	1.71	1.66	1.79	1.73
Feed per lb. gain, lb.	3.41	3.26	3.15	3.31
Av. daily water, lb.	9.22	8.84	8.83	8.93

The practicality of the nutritious water method of feeding is speculative at this time. Acceptance or rejection will depend on the advantages or disadvantages provided to the swine producer--it must compete with current methods of feeding in terms of maximum daily gain, feed utilization and economy of gain.

Table 5. Vitamins in Water for Growing-Finishing Pigs

Item	Trial	No vitamins added	Vitamins added in diet[a]	Level of vitamins in water		
				Low	Medium	High
Lot number		1	2	3	4	5
No. pigs	1	7	8	8	8	8
	2	8	8	8	8	8
Av. initial wt., lb.	1	43.0	42.7	42.6	43.5	43.5
	2	52.8	58.9	55.0	53.4	56.8
	Av.	47.9	50.5	48.8	48.4	50.1
Av. final wt., lb.	1	203.0	202.5	202.5	203.0	202.3
	2	200.5	201.0	200.0	201.0	200.0
	Av.	202.5	201.5	201.5	202.0	201.1
Av. daily gain, lb.	1	1.69	1.68	1.68	1.80	1.71
	2	1.64	1.61	1.64	1.64	1.63
	Av.	1.66	1.64	1.66	1.72	1.67
Av. daily feed cons., lb.	1	5.77	5.47	5.58	5.59	5.74
	2	5.37	5.23	5.14	5.11	5.26
	Av.	5.55	5.35	5.36	5.35	5.50
Feed/lb. gain, lb.	1	3.45	3.26	3.32	3.11	3.36
	2	3.27	3.24	3.13	3.12	3.23
	Av.	3.36	3.25	3.22	3.11	3.29

[a] Provided 1135 I.U. of vitamin A, 340 I.U. of vitamin D, 2 mg. of riboflavin, 4 mg. of calcium pantothenate, 9 mg. of niacin, 10 mg. of choline chloride, and 5 mcg. of vitamin B_{12} per pound of diet.