Reprinted from JOURNAL OF ANIMAL SCIENCE, Vol. 12, No. 2, May, 1953

EFFECT OF AUREOMYCIN AND VITAMINS ON GROWTH AND BLOOD CONSTITUENTS OF PIGS FED CORN AND BANANA RATIONS[1]

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CORN is expensive in Guatemala and is used there principally as a food for human beings. Animal-protein feedstuffs are unavailable. For these reasons, workers in nutrition in that country have stressed the importance of finding local substitutes for corn and evaluating antibiotics in combination with local vegetable proteins. Squibb and Salazar (1951) demonstrated that ripe bananas, including the skins, could replace some of the carbohydrates of corn in rations for growing and fattening pigs. They found also that addition of an APF (Animal Protein Factor) concentrate to the rations increased the rate of gain and the efficiency of feed utilization.

The object of the studies reported here was, first, to determine whether ripe bananas, including the skins, could replace *all* of the carbohydrates supplied by corn in rations for growing and fattening pigs and, second, to determine the effect of crystalline aureomycin and a vitamin concentrate on the growth of pigs and on several constituents of their blood.

Procedure

Sixty Duroc-Jersey pigs, all of which had been on pasture, were used in the two experiments reported here. They were assigned to experimental groups on the basis of age and weight, and each group of pigs was housed in a pen with a solid concrete floor and walls. Pens were washed thoroughly each day. Fresh water and the test

[1] A contribution from the Instituto Agropecuario Nacional in Guatemala, a technical agricultural organization for that country operated jointly by the Government of Guatemala and by the Office of Foreign Agricultural Relations, U. S. Department of Agriculture. United States participation in this work was carried out as part of the Point IV program, administered by the Technical Cooperation Administration, U. S. Department of State. The financial assistance of the Instituto de Fomento de la Producción of Guatemala is gratefully acknowledged.

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[3] The authors acknowledge the valuable help of Dr. M. K. Wyld and Dr. Henry Hopp in the statistical analyses of the data, and of Francisco Aguirre in making the determinations of the red-cell count, hematocrit, and hemoglobin of the pigs' blood.

rations were provided *ad libitum*. In addition to the rations, each pig was fed 0.75 pound of fresh green Kikuyu grass *(Pennisetum clandestinum)* per day as a supplemental source of carotene and other essential nutrients. All feed refused was weighed back and was not charged to feed consumption. Each pig was weighed once a week.

TABLE 1 GROWTH AND FEED UTILIZATION OF PIGS FED CORN AND BANANA RATIONS, EXPERIMENT 1

Ration [1]	Average Weight: At Start of Experiment	Average Weight: At End of Experiment	Average Daily Gain	Feed Efficiency [2]
	lb.	lb.	lb.	lb. feed per 100-lb. gain
	8 pigs in each group, on rations 140 days			
Corn	39	163	0.88	393
Bananas	40	191	1.07	509
	9 pigs in each group, on rations 91 days			
Corn	65	170	1.15	380
Bananas	65	182	1.28	451

[1] Rations were as follows:

Corn:

For pigs weighing 30–124 lb.: sesame oil meal, 40; ground yellow corn, 57; bonemeal, 1; calcium carbonate, 1; and salt, 1. (Crude protein, 15 percent.)

For pigs weighing 125–200 lb.: sesame oil meal, 23; ground yellow corn, 74; bonemeal, 1; calcium carbonate, 1; and salt, 1. (Crude protein, 15 percent.)

Bananas:

For pigs weighing 30–124 lb.. 1 part of concentrates (sesame oil meal, 45; bonemeal, 1; calcium carbonate, 1; and salt, 1) to 4 parts of bananas. (Crude protein, 21 percent.)

For pigs weighing 125–200 lb.: 1 part of concentrates to 5 parts of bananas. (Crude protein, 15 percent.)

[2] Ripe bananas were reduced to the same moisture content as the corn.

Experiment 1

In Experiment 1, duplicate groups of pigs were fed rations containing either corn or ripe bananas as the principal source of carbohydrates. The bananas, which were overripe and included the skins, were fed to replace all the carbohydrates of corn and to supply the same amount of dry matter as corn. The number of pigs, length of trials, rations fed, and the pigs' growth and efficiency of feed utilization are presented in table 1.

Experiment 2

In Experiment 2, a comparison was made of the rates of growth of pigs fed corn and banana rations with and without the addition

of (1) a vitamin concentrate, or (2) crystalline aureomycin. The number of pigs used in this study, the length of the experiment, rations fed, and the growth and efficiency of feed utilization of the pigs are presented in table 2.

In this experiment the effect of the supplements on several constituents of the blood of the pigs was also observed. Approximately 5 ml. of blood was collected from the tail of each pig at the start

TABLE 2. GROWTH AND FEED UTILIZATION OF PIGS FED CORN AND BANANA RATIONS SUPPLEMENTED WITH A VITAMIN CONCENTRATE AND WITH AUREOMYCIN, EXPERIMENT 2

Ration	Number of Pigs	Number of Days	Average Weight		Average Daily Gain	Feed Efficiency [1]
			At Start of Experiment	At End of Experiment		
			lb.	lb.	lb.	lb. feed per 100-lb. gain
			Basal rations [2]			
Corn	10	49	46	76	0.64	352
Bananas	10	49	45	85	0.82**	362
			Rations supplemented with vitamin concentrate [3]			
Corn	10	49	47	80	0.67	355
Bananas	10	49	46	87	0.83**	358
			Rations supplemented with aureomycin [4]			
Corn	10	49	47	83	0.72	304
Bananas	10	49	46	91	0.92**	305

[1] The ripe bananas were reduced to the same moisture content as the corn.

[2] Basal corn rations (protein, 24 percent) consisted of the following: sesame oil meal, 40; ground yellow corn, 57; calcium carbonate, 1; bonemeal, 1; salt, 1; and Delsterol, 3 gm. per 100 lb. of ration. Basal banana rations (protein, 24 percent) consisted of the following: sesame oil meal, 94; calcium carbonate, 2; bonemeal, 2; salt, 2; bananas, 4 parts, by weight, to 1 part of concentrates; and Delsterol, 3 gm. per 100 lb. of ration.

[3] Vita-Rich, starter grower, fed to replace 1 percent of the corn in the basal corn rations, or 1 percent of the sesame oil meal in the basal banana rations. Claimed by manufacturer, Thompson-Hayward Chemical Co., to contain (in a carrier of sardine and whey solubles, fish liver, and glandular meals, etc.), per pound, not less than 300 mg. riboflavin, 250 mg. pantothenic acid, 10,000 mg. choline, 20 mg. thiamine, 300 mg. niacin, 0.5 mg. vitamin B_{12}, 90,800 AOAC chick units of vitamin D, and 90,800 U.S.P. units of vitamin A.

[4] Aureomycin HCl (crystalline), courtesy of Dr. T. H. Jukes, Lederle Laboratories.

** Difference between pigs fed bananas and pigs fed corn significant at the 1% level.

and end of the experiment. The serum from these samples was analyzed for serum proteins (method by Lowry and Hunter, 1945), riboflavin (method by Burch *et al.*, 1948), ascorbic acid (methods by Goodland *et al.*, 1949, and Lowry *et al.*, 1945, which were modified by using a solution of copper sulfate and thiourea instead of norite), carotenoids and vitamin A (method by Bessey *et al.*, 1946), tocopherols, and alkaline phosphate.

In addition, 2 ml. of blood was taken at the end of the experiment from each of five pigs selected at random from each group,

These samples were collected in tubes containing an anticoagulant. Red-cell count, hemoglobin content, and percent of hematocrit were determined on each of these samples by standard methods (Wintrobe, 1946). The blood data are presented in table 3.

Results and Discussion

Data in both tables 1 and 2 are evidence that ripe bananas may be fed to replace corn as a source of carbohydrates in rations for growing and fattening pigs. In Experiment 1, although no significant differences appeared between the rate of gain of pigs fed bananas and the rate of those fed corn, a statistical analysis of the data indicated that, during the period when the pigs weighed less than 90 pounds, the groups fed bananas showed a highly significant increase in the rate of gain over those fed corn. This observation was confirmed by Experiment 2. The reason for this increased growth of younger pigs fed bananas was not determined.

In Experiment 2, pigs fed banana rations, whether with or without vitamin or aureomycin supplements, gained significantly faster than those fed corn with or without these supplements. Addition of the vitamin concentrate did not improve the rate of gain with either the corn or banana rations (table 2). In both rations, however, addition of crystalline aureomycin increased, though not significantly, both the rate of gain and the efficiency of feed utilization.

Two principal types of changes in the levels of blood nutrients may be expected in pigs under the conditions of these experiments: (1) those that will occur irrespective of treatment, e.g., changing from pasture to dry lot; and (2) those that will occur because of treatment. When the blood data collected in Experiment 2 (table 3) were analyzed statistically, these two conditions were taken into consideration.

The data may be summarized as follows:

Serum proteins	Showed no consistent changes, irrespective of treatment.
Riboflavin	Decreased significantly in all groups except the ones fed diets to which the vitamin concentrate had been added; these groups showed some increase.
Ascorbic acid	Was reduced in all groups, with no apparent effect from the treatments.
Carotenoids	Increased in all groups, with significant increases being noted in the group fed corn, the groups fed corn or bananas with a vitamin supplement, and the group fed bananas with aureomycin.

TABLE 3. EFFECT OF VITAMIN CONCENTRATE AND AUREOMYCIN IN CORN AND BANANA RATIONS ON SEVERAL CONSTITUENTS OF THE BLOOD OF GROWING PIGS, EXPERIMENT 2

Ration	Serum Proteins		Ribo-flavin		Ascorbic Acid		Caro-tenoids		Vitamin A		Toco-pherols		Alkaline Phosphatase		Red-Cell Count, End	Hemo-globin, End	Hemato-crit, End
	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End			
	gm.%		γ%		gm.%		γ%		γ%		mg.%		mM/l/hr.[1]		thou-sands/c.c.	gm.%	%
Basal rations																	
Corn	6.83	6.56	3.27	1.97	1.92	1.72	3.4	11.3	26.4	26.8	0.26	0.47	1.78	3.83	6648	11.5	38.0
Bananas	6.74	6.98	2.50	1.84	2.17	1.58	7.2	7.5	24.3	28.9	0.09	0.46	2.22	3.27	6248	10.8	36.6
Rations supplemented with vitamin concentrate [2]																	
Corn	6.71	6.59	2.85	3.01	2.35	1.64	8.8	12.4	27.1	31.0	0.11	0.53	1.94	2.63	7166	11.5	39.4
Bananas	6.56	6.87	2.86	3.13	2.12	2.02	6.8	11.1	25.9	29.1	0.22	0.57	1.67	2.74	6120	11.1	37.4
Rations supplemented with aureomycin [3]																	
Corn	6.96	6.57	2.67	1.78	1.92	1.79	10.0	12.6	24.9	30.7	0.11	0.46	2.14	2.47	6876	11.1	37.6
Bananas	7.04	7.14	2.60	1.44	1.77	1.72	9.0	16.7	22.7	39.2	0.07	0.66	2.58	2.10	6222	10.9	36.4
Pooled standard error of the mean (+ or —)	0.28		0.57		0.38		3.6		7.0		0.11		0.79		478	0.64	2.00
Difference due to—																	
Bananas	0.42**		0.12		0.06		—0.3		2.9		0.08**		0.27		700**	—0.43	—1.53*
Vitamins	—0.04		1.16**		0.18		2.4*		2.2		0.08*		—0.86**		195	0.2	1.1
Bananas × vitamins	—0.07		0.12		0.26**		1.2		—2.0		0.02		—0.16		—323	0.2	—0.3
Aureomycin	0.08		—0.29		0.10		5.2**		7.1**		0.10**		—1.26**		101	—0.2	—0.3
Bananas × aureomycin	0.07		—0.10		0.04		4.0**		3.2		0.10**		0.10		—127	0.2	0.1

[1] Millimoles per liter per hour.
[2] See table 2, footnote 4, for composition of vitamin concentrate.
[3] Aureomycin HCl (crystalline), courtesy of Dr. T. H. Jukes and the Lederle Laboratories.
* Significant at the 5% level.
** Significant at the 1% level.

Vitamin A	Increased in all groups, significantly so in the group fed bananas and aureomycin.
Tocopherols	Increased significantly in all groups irrespective of treatment.
Alkaline phosphatase	Increased significantly in the groups fed the corn and banana rations, whether with or without the vitamin supplement; showed no increase in the groups fed aureomycin.
Red-cell count, hemoglobin, hematocrit	Showed no significant differences among the various groups except that those fed bananas, with or without the vitamin or aureomycin supplements, had a lower red-cell count and a lower percent of hematocrit than the groups fed corn.

Data are not sufficient to explain all the changes that occurred in the various constituents of the pigs' blood in this experiment. In the groups fed corn or bananas plus the vitamin supplement, the increase of serum riboflavin, carotenoids, tocopherols, and vitamin A may be attributed to this concentrate's increasing the quantity of these vitamins in the rations. In the groups fed bananas and aureomycin, the increase of carotenoids (vitamin A-activity) and vitamin A was significant. Since similar increases did not occur in the pigs fed corn and aureomycin, it is probable that aureomycin was not directly responsible for the increase.

There are indications that aureomycin may be related to a slow increase in alkaline phosphatase (in the corn group) or an actual decrease (in the banana group). Further, there were lower red-cell counts and hematocrit values in the blood of pigs fed bananas. No explanation can be given for these phenomena.

The fact that aureomycin showed no clear-cut effects on the blood constituents of young growing pigs is in agreement with the findings for hens (Squibb *et al.*, 1951) and for human beings (according to some data collected by Scrimshaw in 1951). Whatever metabolic activity aureomycin may possess, it apparently does not influence these constituents—a conclusion that will have to be revised if the depressing effect it had on the alkaline phosphatase levels of the pigs proves constant.

Summary

The studies reported here indicated that ripe bananas, fed with their skins, satisfactorily replace corn in rations for growing and fattening

pigs, but that they are more effective during the period when the pigs weighed less than 90 pounds than for heavier, older pigs.

Aureomycin increased, though not significantly, the growth of pigs fed either corn or banana rations, and also the efficiency of their feed utilization.

Aureomycin did not have any apparent effect on serum proteins, riboflavin, ascorbic acid, carotenoids, vitamin A, tocopherols, red-cell count, hemoglobin, and hematocrit in the blood of young growing pigs.

The increase in alkaline phosphatase values observed in pigs fed either corn or bananas seemed to be depressed by the addition of aureomycin to the pigs' diet.

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