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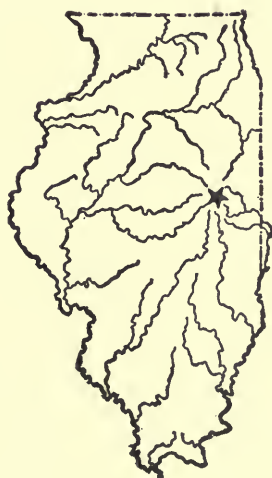
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BULLETIN No. 281

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A COMPARISON  
OF WHITE AND YELLOW CORN FOR  
GROWING AND FATTENING SWINE  
AND FOR BROOD SOWS

By J. B. RICE, H. H. MITCHELL, AND R. J. LAIBLE



URBANA, ILLINOIS, DECEMBER, 1926

## SUMMARY

The experiments reported in this bulletin were undertaken to compare the feeding value of white and yellow corn in rations for breeding sows and for weanling and fattening pigs. It was desired also to ascertain how white corn might be supplemented in order to make it as satisfactory as yellow corn for this purpose.

It was found that sows raised on normal rations could be carried thru two gestation and suckling periods on a ration of white corn, white-corn bran, and tankage without evident effect on the number of pigs farrowed or weaned or upon the growth of the pigs during the suckling period. The continued feeding of this ration, however, resulted in serious impairment of the reproductive powers of one sow, her third and fourth litters being farrowed dead. With the addition of 1 percent of cod-liver oil to the ration during the fifth gestation, this sow farrowed a litter of normal pigs.

Normal weanling pigs which were farrowed by sows carried thru their gestation periods on white corn rations were continued on a ration of white corn and tankage. They failed to thrive and ultimately developed pathological symptoms and died. Pigs farrowed by sows not on experiment and raised on normal rations to 60 or 70 pounds were eventually handicapped by white corn feeding altho they made normal gains for several weeks. At weights of 175 to 200 pounds they developed characteristic symptoms of white corn feeding and finished poorly.

Small amounts of alfalfa meal (a little more than an ounce a head daily) proved entirely effective in correcting the deficiencies of a ration of white corn and tankage fed pigs while growing and fattening from weights of 60 to 227 pounds.

Apparently it was a lack of vitamin A that caused the unfortunate results when sows and pigs were continued on the white corn ration for too long a time, for when that factor was supplied by adding small amounts of alfalfa meal or cod-liver oil the pigs developed normally and the sows farrowed normal litters. While white corn may be deficient in vitamin D as well as vitamin A, it is considered improbable that such a deficiency could have affected the results, since sunshine apparently removes the necessity for that vitamin in the feed, and all the pigs in these experiments were confined to open dry lots, allowing as great exposure to direct sunlight as the weather would permit.



# A COMPARISON OF WHITE AND YELLOW CORN FOR GROWING AND FATTENING SWINE AND FOR BROOD SOWS

BY J. B. RICE, H. H. MITCHELL, AND R. J. LAIBLE<sup>1</sup>

The experiments reported in this bulletin were undertaken with two general purposes in view: first, to compare the feeding value of white and yellow corn for pigs under various conditions, and second, to investigate the relative vitamin A requirements of pigs for growth and reproduction. It was also decided to obtain some information concerning supplements for white corn rations that would adequately take care of the known deficiency of this cereal in vitamins.

At the present time there can be little question that yellow corn under certain conditions of restricted feeding has a higher nutritive value than white corn. It is equally true, however, that from the standpoint of crop production white corn, in certain localities, is considered a more suitable crop than yellow corn. For such localities it is certainly of great practical importance to understand the possible methods of supplementing white corn so as to make it equal in value to yellow corn.

In the dry-lot feeding of pigs, rations comparatively low in vitamin A are frequently fed—rations, for example, made up largely of white corn, oats, tankage, fish meal, gluten feed, linseed meal, or skim milk. It is of considerable interest, therefore, to ascertain whether such rations are deficient in this vitamin for swine, or whether swine do not require vitamin A, or require it in such small quantities that even such rations will contain it in ample concentration.

An experiment reported by Zilva, Golding, Drummond, and Coward<sup>2</sup> indicates that the requirement of vitamin A by growing pigs is of a low order. One pig that had from birth received a ration very low in the vitamin grew well for about a month; with the cessation of growth, cream was added to the diet for 13 days, and crude casein for the following 19 days. Upon again being placed on the ration low in vitamin A, growth was continued for over three months at a rate greater than in the controls. This experiment is a striking illustration of a fact which has been discovered recently with respect to vitamin A; namely, that growing animals receiving rations rich in the vitamin are

<sup>1</sup>JOHN B. RICE, formerly Assistant Chief in Swine Husbandry; H. H. MITCHELL, Chief in Animal Nutrition; RUSSELL J. LAIBLE, formerly First Assistant in Animal Husbandry.

<sup>2</sup>Zilva, S. S., Golding, J., Drummond, J. C., and Coward, K. H. Jour. Biochem. 15, 427. 1921.

able to store such quantities of it in their bodies as to tide them over a considerable period of time on rations very greatly deficient in the vitamin.

The discovery by Steenbock and Boutwell<sup>1</sup> that white corn does not contain any demonstrable amount of vitamin A made possible the execution of large-scale experiments on swine, designed to determine whether these animals require the vitamin, and if so, to what extent. Accordingly an experiment of this character was planned as a cooperative project between the Swine and Animal Nutrition Divisions of the Department of Animal Husbandry of this Station. The experiment was started on December 4, 1920. At about that time the authors learned of some work of the same nature which had been under way at the University of Wisconsin since July of the same year.

Since then Morrison, Bohstedt, and Fargo<sup>2</sup> have reported several feeding trials with pigs started at weights of 50 to 60 pounds and carried to 200 pounds, comparing the feeding value of white and yellow corn. In all these trials the pigs were self-fed. They all showed clearly that yellow corn produces decidedly larger and more economical gains than white corn when fed to pigs in dry lot with such supplements as skim milk, whey, or linseed meal, none of which is rich in vitamin A. For pigs on excellent pasture there has been no difference in value between white and yellow corn. In the autumn, however, when the pasture became scant, the pigs on white corn soon began to fall behind those receiving the yellow corn. Later, when the two lots were taken off pasture, those fed yellow corn far outstripped the white corn lot. When fed with tankage or meat meal, yellow corn has usually proved decidedly better than white corn, tho in two tests little or no difference between the two was demonstrated. In view of the fact that tankage is probably absolutely devoid of all vitamins, owing to the high temperature to which it is exposed in the process of preparation,<sup>3</sup> the variable results obtained with this supplement are noteworthy, as are the uniformly disastrous results obtained with skim milk, which is ordinarily considered as containing appreciable amounts of the vitamin.

Comparative results with white and yellow varieties of corn similar to those reported from the Wisconsin Station have been reported also from the Nebraska Station.<sup>4</sup> More recently Lamb and Evvard<sup>5</sup> have reported experiments which indicate: first, that on a white corn ration containing no vitamin A supplement, a sow may farrow a litter and suckle it successfully, and second, that for growth and fattening

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<sup>1</sup>Steenbock, H., and Boutwell, P. W. *Jour. Biol. Chem.* 41, 81. 1920.

<sup>2</sup>Wis. Agr. Exp. Sta. *Buls.* 323 and 339. *Ann. Rpts.* 1919-20 and 1920-21.

<sup>3</sup>Bohstedt, G., Hunt, C. H., Winter, A. R., and Miller, R. C. *Proc. Amer. Soc. Anim. Prod.* 1923, 34.

<sup>4</sup>Nebr. Agr. Exp. Sta. *Ann. Rpt.* 1921. 20, 23.

<sup>5</sup>Lamb, A. R., and Evvard, J. M. *Proc. Amer. Soc. Anim. Prod.* 1923, 136

from 125 to 265 pounds, there is no difference in the nutritive value of white and yellow corn.

It has recently been shown at the Wisconsin Station in work with growing chickens that yellow corn may be superior to white in its content of vitamin D (the anti-rachitic vitamin), as well as in vitamin A. For young growing chicks, which are frequently kept indoors, this difference in vitamin D content is undoubtedly of importance, but for young growing swine it is certainly of less importance, since they are not ordinarily confined indoors except for the first week or two of life. Direct sunshine apparently can remove the necessity of supplementing rations of growing animals with respect to vitamin D. For this reason feeding tests with swine that compare the value of white and yellow corn under practical farm conditions can reasonably be interpreted with reference to vitamin A only.

### GENERAL PLAN OF THE EXPERIMENTS

Since Steenbock and Boutwell found that of the varieties of white corn tested by them, Silver Mine contained the least vitamin A, in fact no demonstrable amount, Silver Mine was used in these tests. The ration of white corn and tankage was tested thoroly with rats, to determine its relative concentration of vitamin A.

The first experiment was concerned with the relative values of white and yellow corn for brood sows. Eight sows were divided into two equal groups; one group received yellow corn, yellow-corn bran, and tankage, and the other white corn, white-corn bran, and tankage.

The sows were kept on the experimental rations from the time they were bred thru two successive gestation periods. Two of the sows fed white corn were bred a third time, and records on a third litter were obtained. One of these sows died shortly after farrowing her third litter. The other sow was bred and carried thru a fourth gestation period. To determine whether the disastrous results of this fourth gestation were due to vitamin deficiency, this sow was bred and carried thru a fifth gestation period on a ration of white corn supplemented with cod-liver oil.

An attempt was made to raise the first litters, farrowed in the spring, on the same rations as their dams during their gestation periods, except that corn bran was omitted. They were accordingly divided into two lots corresponding to the two rations under trial, and were hand-fed, so that the feed intake of the two groups was kept approximately the same per unit of weight. Otherwise, as was amply shown by the Wisconsin experiments, the lots fed yellow corn would have consumed more feed than those fed white corn, and the difference in the results secured on the two rations would have been due to a difference in the amount of feed consumed as well as to a difference in vita-

min intake. It was thought that in such case possible effects might be accentuated or obscured by effects due simply to undernutrition.

In order to test further the two rations with growing pigs, another experiment was performed using two lots of eight pigs each, farrowed from sows not on experiment and raised on normal rations in pasture lots to a weight of about 70 pounds. In this test also the rations were hand-fed and the intake was equalized as before.

In a third growth experiment four lots of twenty pigs each, with average initial weights of a little over 60 pounds, were started on the following four rations: (1) Silver Mine corn and tankage; (2) yellow corn and tankage; (3) Silver Mine corn, tankage, and alfalfa meal; and (4) White Democrat corn and tankage. The latter variety of corn is a semi-flint, pure-white corn, the growing of which is being advocated in southern Illinois because of its resistance to the chinch bug. All lots in this experiment were self-fed. This experiment furnished some information on the extent to which alfalfa meal, known to be an excellent source of vitamin A, will supplement the vitamin deficiencies of white corn.

In a final experiment two lots of ten pigs each, with initial weights averaging 50 pounds, were self-fed a ration of white corn and tankage. One of the lots received an amount of cod-liver oil equivalent to 1 percent of the ration. The results of this experiment indicated directly that the difference in food value between white and yellow corn shown in the preceding experiments was due entirely to a difference in vitamin A content.

#### PRELIMINARY FEEDING TESTS WITH RATS

In order to test the relative vitamin content of the rations used in these swine experiments, on animals thoroly standardized with respect to vitamin A, some feeding experiments were undertaken with rats. The rats weighed from 40 to 60 grams and were divided into five pairs. One rat of each pair was fed a ration containing white corn 85 percent and tankage 15 percent, while the other rat received a ration of yellow corn 85 percent and tankage 15 percent. In carrying out this test the intake of food of the rat fed yellow corn was restricted to approximately that of its pair mate receiving the white corn ration. By this means the difference in growth secured would be due entirely to the difference in the vitamin content of the rations. The results of this experiment are given in Table 1.

For each pair, after the fourth or fifth week, the rat fed yellow corn was maintained at a higher weight than the one fed white corn. The difference in condition between the rats of each pair was even more striking than the difference in weight. In two of the pairs the rat fed white corn died on the 58th day of the experiment. With all pairs the rats fed white corn developed ophthalmia (eye soreness). At the end of ten weeks the experiment was discontinued, since at that

TABLE 1.—COMPARISON OF GROWTH OF RATS ON RATIONS OF WHITE CORN AND TANKAGE AND YELLOW CORN AND TANKAGE  
(All weights in grams)

Week	Pair 1						Pair 2						Pair 3						Pair 4						Pair 5					
	Rat 101			Rat 102			Rat 103			Rat 104			Rat 105			Rat 106			Rat 107			Rat 108			Rat 109			Rat 110		
	White corn			Yellow corn			White corn			Yellow corn			White corn			Yellow corn			White corn			Yellow corn			White corn			Yellow corn		
	Weight <sup>1</sup>	Food <sup>2</sup>	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food	Weight	Food		
1.	45	64	61	65	62	69	69	54	69	53	69	57	69	58	70	54	70	58	70	54	70	50	69	53	69	50	69	53	69	
2.	59	68	68	61	76	68	70	79	70	68	76	70	77	79	80	67	80	70	80	67	80	65	80	65	80	65	80	65	79	
3.	98	60	77	61	83	51	83	83	81	84	77	87	77	87	77	87	83	86	83	86	83	80	79	84	76	80	79	84	76	
4.	84	54	88	62	102	73	80	103	80	100	79	103	80	102	82	101	82	102	82	101	82	99	116	69	119	105	69	105	69	
5.	84	71	99	70	120	75	78	120	78	114	75	123	76	120	79	116	78	120	79	116	78	116	116	69	119	105	69	105	69	
6.	88	47	110	80	127	40	40	138	40	133	54	135	54	129	59	117	59	123	59	117	59	123	52	126	32	126	32	126	32	
7.	83	27	110	80	118	49	50	131	50	119	51	133	55	128	55	119	55	107	58	114	55	107	58	113	60	107	58	113	60	
8.	58	..	98	30	115	55	55	131	55	112	..	130	50	118	55	119	55	114	40	124	40	111	45	118	45	118	45	118	45	
9.	67	28	95	40	118	50	50	132	50	118	45	118	45	106	45	109	45	111	45	111	45	111	45	111	45	111	45	111	45	111
10.	Died on 58th day	..	94	40	115	53	53	130	55	120	40	120	40	106	39	112	45	96	..	..	..	116	..	..	..	..	..	..	..	

<sup>1</sup>The weights given are those of the rats taken at the end of each week. <sup>2</sup>These amounts of food are the total weekly rations.

time the rats fed white corn were apparently on the verge of death. It is evident from this experiment that when the intake of yellow corn is kept as low as that of white corn a distinct difference in nutritive condition will still be manifested.

### WHITE CORN FEEDING FOR BROOD SOWS RAISED ON WELL-BALANCED RATIONS PROVES INFERIOR ONLY AFTER TWO GESTATIONS

Eight sows that had been raised on well-balanced rations were selected for this experiment, and were divided into groups of four each. Each group contained one sow each of the following four breeds: Duroc-Jersey, Poland China, Hampshire, and Chester White. The Chester White sow in the yellow corn group proved not to be in pig, and was replaced late in the experiment by a Duroc-Jersey sow. The previous history of these sows in so far as it relates to this experiment is contained in Table 2.

*First Gestation Period.*—The sows were started on experiment December 4, 1920. One group was fed yellow corn, yellow-corn bran, and tankage, and the other group was fed white corn, white-corn bran, and tankage. The sows had previously been bred to boars of their respective breeds so that they would farrow some time during March or the first part of April.

The yellow corn used was of the Reid Yellow Dent variety. The white corn was of the White Silver Mine variety; it was locally grown and contained only an occasional yellow grain. From December 4 to June 15 the feeds were sampled daily, and composite samples were analyzed with the results shown in Table 3.

The sows farrowed in a large, half-monitor hog house. As soon as possible after farrowing, the sows and their litters were transferred to small dry lots, each sow and her litter having a separate lot. The lots were entirely free of vegetation, and contained portable sheds and some artificial shade.

The feed consumed by the individual sows during the first gestation period and the changes in weight of the sows are shown in Table 4. Considerable variation existed among the sows in the two groups with respect to the rate and economy of gains during the first gestation period. The differences between the average figures, generally favoring the sows fed white corn, are therefore of no significance with reference to the difference in feeding. There was nothing in the appearance, health, or thrift of the sows indicating any inferiority of the white corn ration.

The sows fed white corn farrowed on an average more pigs per litter than those fed yellow corn, tho again the differences between individual sows were so great that it is impossible to say whether they bore any relation to the difference in ration. The average weight of

TABLE 2.—AGE, NUMBER OF PREVIOUS LITTERS, INITIAL WEIGHT, AND BREEDING DATA OF SOWS USED IN EXPERIMENT

Breed	Sows fed yellow corn				Sows fed white corn			
	Age	Number of previous litters	Initial weight	Date bred, 1920	Age	Number of previous litters	Initial weight	Date bred, 1920
Duroc-Jersey <sup>1</sup> , Chester White	<i>months days</i> 15 13	None	<i>pounds</i> 373	Dec. 13	<i>months days</i> 32 6	3	<i>pounds</i> 311	Dec. 11
Duroc-Jersey	14 11	None	324	Nov. 23	14 25	None	300	Nov. 19
Hampshire	26 22	3	312	Nov. 22	20 25	1	392	Dec. 20
Poland China	32 29	4	434	Nov. 17	20 13	2	365	Nov. 22

<sup>1</sup>The Chester White sow in the yellow corn group proved not to be in pig and was replaced with a Duroc-Jersey late in the first gestation period.

litters was practically the same in the two groups, but the average weight per pig was greater in the yellow corn group. This greater average weight of pigs farrowed in the yellow corn group is probably related to the smaller litters in this group rather than to the difference in feeding.<sup>1</sup>

*First Suckling Period.*—The sows were continued on the same ration thruout the suckling period. They were fed approximately the same amounts of feed daily per 100 pounds weight of sow and litter.

TABLE 3.—CHEMICAL COMPOSITION OF FEEDS USED IN EXPERIMENT  
(Samples collected from December 4 to June 15)

	Dry substance	N-free extract	Crude fiber	Crude protein	Ether extract	Ash
Yellow corn.....	87.28	71.96	2.22	9.01	2.64	1.25
White corn (Silver Mine)...	88.38	73.59	2.51	9.40	1.39	1.35
Yellow-corn bran.....	91.76	70.49	9.66	7.86	1.96	1.78
White-corn bran.....	92.32	66.91	6.55	12.12	3.61	3.10
Tankage (Swift & Co.) ...	91.43	1.29	1.23	58.51	8.58	21.71

The feed and weight records of sows and pigs during the first suckling period are contained in Table 5.

The sows fed yellow corn raised larger litters, on an average, than the sows fed white corn, tho this difference is due entirely to the poor performance of one sow (40 H) in the group fed white corn. The average weights of pigs at weaning time and the average daily gain per pig were practically the same for the two groups. The sows fed yellow corn lost more in weight on an average than the sows fed white corn, tho this difference cannot be said to be related to the difference in feeding, because of the great variation existing among the individual sows in each group.

*Second Gestation Period.*—The first litters were all weaned in May or the early part of June. The sows were kept on the same ration and were bred as soon as possible for fall litters. One sow in the group fed yellow corn failed to come in heat and was taken out of the experiment. During the second gestation period the sows were fed in two groups instead of individually, as in the first gestation period. Data comparing weights of sows and feed consumed during the second gestation period are contained in Table 6.

While the sows fed yellow corn produced on an average slightly more rapid and slightly more economical gains than those fed white corn, the differences were so small as probably to be insignificant. Both groups of sows were in good condition at farrowing time.

The litters farrowed by the sows fed yellow corn were on the average larger in number and the pigs slightly heavier in weight. However, in view of the marked differences existing among the different sows, it

<sup>1</sup>Carmichael, W. J., and Rice, J. B. Ill. Agr. Exp. Sta. Bul. 226. 1920.



TABLE 4.—FEED AND WEIGHT RECORDS FOR THE SOWS DURING THE FIRST GESTATION PERIOD  
(All weights in pounds)

	Yellow corn					White corn				
	63 D. J.	1 P. C.	30 H.	91 D. J. <sup>1</sup>	Average of 3 sows <sup>2</sup>	66 D. J.	93 P. C.	40 H.	17 C. W.	Average of 4 sows
Sow No. and breed .....										
Days on experiment.....	104	99	101	27	101	96	103	125	122	112
<i>Average weights</i>										
Initial weight.....	324	434	312	373	357	300	365	392	311	342
Final weight.....	409	498	395	419	434	395	466	451	437	437
Daily gain.....	.82	.65	.82	1.70	.76	.99	.98	.47	1.03	.87
<i>Average daily ration</i>										
Corn.....	3.82	4.14	5.05	5.00	4.33	4.20	4.99	3.31	5.17	4.41
Tankage.....	.43	.43	.43	.50	.43	.43	.43	.44	.44	.44
Corn bran.....	.42	.39	.41	1.00	.41	.38	.42	.52	.51	.46
Total.....	4.67	4.96	5.89	6.50	5.16	5.01	5.84	4.27	6.12	5.31
<i>Feed consumed daily per hundredweight.</i>										
Feed per 100 pounds gain	1.26	1.08	1.68	1.67	1.32	1.44	1.46	1.02	1.71	1.41
Corn.....	467	641	616	294	569	425	508	701	501	534
Tankage.....	53	66	52	29	56	43	44	93	43	56
Corn bran.....	52	61	49	59	53	38	43	110	49	60
Total.....	572	768	717	382	678	506	595	904	593	650

<sup>1</sup>Substituted for a Chester White sow which proved not to be in pig. <sup>2</sup>Not including Sow 91 D. J.

TABLE 5.—FEED AND WEIGHT RECORDS OF SOWS AND PIGS DURING THE FIRST SUCKLING PERIOD  
(56 days)  
(All weights in pounds)

Sow No. and breed.....	Yellow corn						White corn						
	63 D. J.	1 P. C.	30 H.	91 D. J.	Aver. of 4 sows	66 D. J.	93 P. C.	40 H.	17 C. W.	Aver. of 4 sows			
	Mar. 18	Mar. 13	Mar. 15	Apr. 8		Mar. 10	Mar. 17	Apr. 8	Apr. 5				
Date of farrowing.....													
<i>Weights of sow</i>													
Initial weight <sup>1</sup> .....	388	465	378	398	407	367	439	436	415	414			
Final weight.....	286	387	329	285	322	226	402	410	369	352			
Loss in weight.....	102	78	49	113	85	141	37	26	46	62			
<i>Pigs farrowed</i>													
Number of pigs farrowed.....	6 <sup>2</sup>	12 <sup>3</sup>	6 <sup>4</sup>	9 <sup>5</sup>	8.3	13 <sup>6</sup>	9 <sup>7</sup>	7 <sup>8</sup>	11 <sup>9</sup>	10			
Average weight of pigs at birth.....	3.47	2.74	2.77	2.38	2.78	2.18	3.01	2.20	1.99	2.32			
<i>Pigs weaned</i>													
Number of pigs weaned.....	4	8	6	7	6.3	7	6	2	7	5.5			
Average weight of weaned pigs at birth.....	3.45	2.75	2.87	2.54	2.49	2.51	2.87	2.61 <sup>10</sup>	2.06	2.47			
Average weight of pigs at weaning.....	27.9	19.3	25.7	21.7	22.9	20.0	24.8	31 <sup>10</sup>	17.3	21.4			
Average daily gain per pig.....	.40	.29	.40	.34	.35	.31	.39	.43 <sup>10</sup>	.27	.33			
<i>Feed consumed per sow and litter daily</i>													
Corn.....	6.43	8.54	8.55	6.60	7.53	6.24	8.91	5.49	7.79	7.11			
Tankage.....	.75	.73	.82	.69	.75	.76	.81	.62	.78	.74			
Corn bran.....	.60	.91	.84	.24	.65	.83	.75	.23	.35	.54			
Total.....	7.78	10.18	10.21	7.53	8.93	7.83	10.47	6.34	8.92	8.39			
<i>Feed consumed per 100 pounds of sow and litter</i>	1.97	2.00	2.36	1.79	2.04	2.11	2.16	1.38	1.97	1.90			

<sup>1</sup>Initial weight of sow was calculated by subtracting weight of litter from weight of sow previous to farrowing. <sup>2</sup>Two pigs were stolen from lot April 3. <sup>3</sup>One pig died first night. Three pigs were transferred to No. 30 Hampshire sow, March 16 and 17. <sup>4</sup>Sow lay on 3 pigs first two days; replaced by 3 from No. 1 Poland China sow. <sup>5</sup>Sow lay on 2 pigs April 11. <sup>6</sup>One pig was farrowed immaturely, weight 7 pound. Sow lay on 5 pigs the first day. <sup>7</sup>Sow lay on 2 pigs the first and second days. One pig would not stay with sow. <sup>8</sup>One pig was farrowed dead, weight 1.5 pound. Sow lay on 4 pigs by April 11. One pig starved April 16. Two Duroc-Jersey pigs were added to litter on April 16, at weights of 6.5 and 6.0 pounds. Sow lay on the latter pig May 4, weight 10.7 pounds. <sup>9</sup>Sow lay on 3 pigs April 6 and 1 pig April 14. <sup>10</sup>These figures refer to the one pig in this litter raised from birth by Sow 40 H.

is impossible to conclude that these average differences in size and weight of litters are due to the difference in feeding. The pigs from the sows fed white corn appeared to be strong and normal in every way.

*Second Suckling Period.*—The sows were continued on their rations of white or yellow corn, corn bran, and tankage thruout the

TABLE 6.—FEED AND WEIGHT RECORDS OF SOWS DURING THE SECOND GESTATION PERIOD  
(All weights in pounds)

	Yellow corn	White corn
Number of sows.....	4 <sup>1</sup>	4
Days on experiment.....	142	152
<i>Weights</i>		
Average initial weight.....	321	352
Average final weight.....	462	461
Average daily gain.....	.92	.87
<i>Average daily ration</i>		
Corn.....	3.66	3.49
Tankage.....	.46	.47
Corn bran.....	.76	.83
Total.....	4.88	4.79
<i>Feed consumed daily per hundredweight</i> .....	1.29	1.23
<i>Feed per 100 pounds gain</i>		
Corn.....	395	402
Tankage.....	50	54
Corn bran.....	82	96
Total.....	527	552

<sup>1</sup>One sow failed to come in heat and was taken from the experiment on July 30, 86 days after the experiment started.

second suckling period. Separate records were kept for each sow and her litter. In Table 7 will be found the most important data relating to this period. The number of pigs weaned by the different sows varied widely with no evident relation to the method of feeding. In other words, the mortality of the pigs seemed to be due to accidental causes or to factors incidental to the experiment. At weaning time the average weight of the pigs fed white corn was practically the same as that of the group fed yellow corn. The average daily gain of the pigs in the two groups was also practically the same. The pigs from both groups at weaning time appeared to be normal and healthy, altho they were undersized for their age.

The sows fed yellow corn lost more weight in general than those fed white corn, a fact which is probably related to the larger litters raised in the yellow corn group.

*Third Gestation Period.*—Two of the sows which had been fed thru two gestation and suckling periods on a ration of white corn, white-corn bran, and tankage, were bred and continued on the same ration for a third gestation period. The rate and economy of gains of these sows were satisfactory, as the data in Table 8 indicate.

TABLE 7.—FEED AND WEIGHT RECORDS OF SOWS AND PIGS DURING SECOND SUCKLING PERIOD  
(56 days)  
(All weights in pounds)

Sow No. and breed.....	Yellow corn				White corn				Aver. of 4 sows
	1 P. C.	30 H.	91 D. J.	Aver. of 3 sows	93 P. C.	40 H.	66 D. J.	17 C. W.	
	Sept. 6	Sept. 27	Sept. 27	Sept. 27	Sept. 10	Sept. 27	Sept. 22	Oct. 4	
Date of farrowing.....									
<i>Weights of sow</i>									
Initial weight <sup>1</sup> .....	491	456	365	437	461	502	316	488	442
Final weight.....	390	347	231	323	411	410	232	380	358
Loss in weight.....	101	109	134	114	50	92	84	108	84
<i>Pigs farrowed</i>									
Number of pigs farrowed.....	11 <sup>2</sup>	9 <sup>3</sup>	9 <sup>4</sup>	9.7	6 <sup>5</sup>	7 <sup>6</sup>	9 <sup>7</sup>	11 <sup>8</sup>	8.3
Average weight of pigs at birth.....	2.54	2.77	2.23	2.51	2.90	2.51	2.41	1.75	2.30
<i>Pigs weaned</i>									
Number of pigs weaned.....	9	6	6	7	4	3	7	6	5
Average weight of weaned pigs at birth.....	2.56	2.73	2.25	2.52	2.90	2.90	2.70	1.78	2.50
Average weight of pigs at weaning.....	16.2	17.9	18.3	17.3	22.8	19.5	15.9	15.3	17.6
Average daily gain per pig.....	.24	.27	.29	.26	.35	.30	.23	.24	.27
<i>Feed consumed per sow and litter daily</i>									
Corn.....	6.65	5.98	5.53	6.06	6.26	3.20	5.27	6.27	5.25
Tankage.....	.56	.61	.62	.59	.57	.49	.58	.63	.57
Corn bran.....	.25	.04	.11	.13	.16	.21	.05	.11	.13
Total.....	7.46	6.63	6.26	6.78	6.99	3.90	5.90	7.01	5.95
Feed consumed per 100 pounds of sow and litter.....	1.44	1.44	1.73	1.52	1.41	.80	1.77	1.53	1.34

<sup>1</sup>Initial weight of sow was calculated by subtracting weight of litter from weight of sow previous to farrowing. <sup>2</sup>Sow lay on 2 pigs September 6. <sup>3</sup>Two pigs were farrowed dead. Sow lay on 1 pig September 27. <sup>4</sup>Sow lay on 2 pigs September 27, and 1 September 29. <sup>5</sup>Two pigs were eaten September 10. <sup>6</sup>Sow lay on 4 pigs September 27. <sup>7</sup>One pig was farrowed dead and 1 immature. <sup>8</sup>Sow lay on 5 pigs October 4.

The sows appeared to be in good condition at farrowing time. However, after farrowing a normal litter of pigs, one of the sows, a Chester White, developed inflammation of the udder and later pneu-

TABLE 8.—FEED AND WEIGHT RECORDS OF SOWS FED WHITE CORN IN THE THIRD, FOURTH, AND FIFTH GESTATION PERIODS  
(All weights in pounds)

Gestation period.....	Third	Fourth	Fifth
Ration.....	White corn, tankage	White corn, tankage	White corn, tankage, cod-liver oil 1 percent
Number of sows.....	2	1	1
Days on experiment.....	118	121	118
<i>Weights</i>			
Average initial weight.....	301	342	358
Average final weight.....	430	390	454
Average daily gain.....	1.09	.40	.81
<i>Average daily ration</i>			
Corn.....	5.75	3.81	5.55
Tankage.....	.44	.41	.50
Cod-liver oil.....	.....	.....	.08
Total.....	6.19	4.22	6.05 <sup>1</sup>
Feed per 100 pounds gain.....	566	1 063	743

<sup>1</sup>Not including the cod-liver oil.

monia, and died. The other sow, a Duroc-Jersey, farrowed a litter of dead pigs. While the average weight of these pigs (Table 9) was not much below normal, they had very little hair. They were examined for goiter, but the thyroid glands appeared to be normal in size. For several weeks after farrowing, the Duroc-Jersey sow was not in very good condition.

*Fourth Gestation Period.*—The Duroc-Jersey sow surviving the third gestation period was bred as soon as possible for a fourth litter, and was continued on the ration of white corn, white-corn bran, and tankage. Small amounts of potassium iodid were added to this ration to correct a possible deficiency in iodine.

TABLE 9.—FARROWING RECORDS FOR THE THIRD, FOURTH, AND FIFTH GESTATION PERIODS

Litter.....	Third		Fourth	Fifth
Sow.....	17 C. W. <sup>1</sup>	66 D. J.	66 D. J.	66 D. J.
Gestation period, days.....	115	124	118	118
Number of pigs farrowed.....	10	8 <sup>2</sup>	5 <sup>2</sup>	6
Number of pigs farrowed dead.....	1	8	5	0
Average weight per pig.....	2.32	2.10	.. <sup>3</sup>	1.70

<sup>1</sup>Sow died from inflammation of udder and pneumonia. <sup>2</sup>Farrowed dead, little hair, otherwise normal. <sup>3</sup>No weights were taken on this litter.

After a gestation period of normal length, another litter of dead pigs was farrowed by this sow. These pigs also were thinly covered with hair, tho otherwise they appeared to be normal. The sow was in good flesh, altho she did not appear to be entirely normal during the last few days of the gestation period. This condition may have been caused by the carrying of a dead litter. The records of this period are included in Tables 8 and 9 also.

*Fifth Gestation Period: Supplementing Effect of Cod-Liver Oil Tested.*—In order to determine whether the last two litters of this sow were born dead because of a deficiency of the ration in vitamins, the sow was bred and carried thru a fifth gestation period on the same ration, to which was added 1 percent of cod-liver oil, known to be rich in fat-soluble vitamins. From the records of this period (Table 8) it is evident that the sow gained well during her fifth gestation. She also appeared to be in much better physical condition than during the fourth gestation period. A normal litter of live and fairly vigorous pigs was farrowed after a gestation period of 118 days (Table 9). The sow was restless, however, and by the fourth day had killed all her pigs. Nevertheless it seems fair to conclude that the addition of cod-liver oil to the white corn ration had greatly improved the reproductive performance of the sow.

#### WEANLING PIGS FAIL TO THRIVE ON WHITE CORN

Forty-five of the pigs farrowed by the eight sows in the preceding experiment after their first experimental gestation period were divided into two groups of 22 and 23 pigs each. One group had been farrowed by the sows fed yellow corn, yellow-corn bran, and tankage, and the other group had been farrowed by the sows fed white corn, white-corn bran, and tankage. The two groups were continued on the ration of their respective sows with the exception that the corn bran was eliminated in each case. The same amount of feed per 100 pounds of live weight was fed to each lot of pigs. Within three weeks it became evident that the pigs fed yellow corn would consume much more feed per 100 pounds live weight than those fed white corn. In the hope that the substitution of pork cracklings for tankage would induce the pigs fed white corn to consume more corn, this substitution was made. Both lots of pigs consumed the cracklings readily, but the daily consumption of corn did not increase; hence the feeding of tankage was resumed.

The feeding of these two lots of pigs was started May 5, 1921. On June 24 four pigs were taken from each lot for a supplementary feeding test which will be described later. Again on August 6 four more pigs were taken from each lot for another purpose, which also will be described later.

It was evident in a very short time after the experiment was started that the pigs on the white corn ration were not doing so well as those on the yellow corn ration. On June 5 one of the pigs in this lot was nearly dead, and was killed for post-mortem examination. It appeared to be blind in one eye, which was cloudy in appearance; it had intestinal worms; and cultures showed a condition of pneumonia complicated with botulism of Type A. In view of the finding of botulism in this pig, the remaining pigs in both lots were vaccinated against botulism on July 19. This treatment resulted in the death of a second pig in the white corn lot, which went into convulsions shortly after treatment. From this time on, deaths occurred frequently in the white corn lot. Several pigs were removed from the lot when found to be nearly dead, and were submitted to post-mortem examination by the Division of Animal Pathology and Hygiene. These examinations did not always reveal abnormal conditions. Pneumonia, however, was present in several cases.

A peculiar behavior characterized the pigs kept on this ration for several months. Convulsions, partial loss of the sense of balance, and difficulty in urination, were often observed for several days preceding death.

By December 17 all the pigs in the white corn lot that had not been removed for other purposes were dead or in such a condition that they would have died in a very short time. The heaviest pig produced on the ration weighed 76 pounds just preceding death. The other pigs attained weights of 60 to 70 pounds. The mortality of this lot and the results of the post-mortem findings are given in Table 10.

The amount of feed per 100 pounds live weight allowed the pigs on yellow corn was severely restricted in accordance with the feed consumption of the pigs on white corn; hence the pigs on yellow corn were maintained for a considerable time on what amounted to a starvation ration. The stronger pigs in the lot secured more than their share of the feed, and several of the weaker pigs were scarcely able to secure a maintenance ration. On August 2 two pigs weighing 12 and 13 pounds respectively, and apparently at the point of death because of insufficient feed, were killed and examined, but nothing positive was found. On November 11 another pig died apparently of starvation, and on December 14 two more pigs died apparently from the same cause. These three pigs on post-mortem examination showed congested lungs. On December 17, when the last pig in the white corn lot was killed, the nine pigs remaining in the yellow corn lot averaged 82 pounds in weight. These pigs appeared to be vigorous and healthy and altho stunted from lack of feed would probably have made good gains had they been given the amount of feed they could have eaten. The removals of pigs from this lot are shown in Table 11.

TABLE 10.—CAUSES FOR THE REMOVAL OF VARIOUS PIGS FROM THE LOT FED  
WHITE CORN  
(Feeding started May 5)

Date	Average weight of lot at time of last weighing	Cause of removal and post-mortem findings
June 24.....	<i>lbs.</i> 23	Four pigs taken from experiment at weights of 15, 18, 24, and 26 pounds. Fed butter in addition to previous ration (see text).
July 5.....	23	Nearly dead. Killed at weight of 14 pounds. Blind in one eye, had intestinal worms, cultures showed pneumonia and botulism Type A.
July 19.....	25	Died as a result of vaccination against botulism. Weight 32 pounds.
August 2.....	24	Four pigs nearly dead. Killed at weights of 13, 15, 13, and 17 pounds. Nothing positive found on post-mortem examination.
August 6.....	24	Four of the poorest pigs were taken from the experiment to be fed yellow corn and tankage (see text). Weights 16, 20, 20, and 24 pounds.
October 8.....	49	Died. Weight 24 pounds. Lungs congested; emaciated.
October 16 ...	49	Died. Weight 32 pounds. Urinary passage stopped just outside bladder.
October 22...	59	Nearly dead. Killed at weight of 42 pounds. Wobbly, had injured foot, worms.
October 26 ...	59	Died. Weight 53 pounds. Eyes bad, a few worms, lungs in bad condition.
November 25.	63	Died. Weight 42 pounds. Had been failing for over a month. Was one of the best pigs at one time. Had a convulsion on October 16.
December 14 .	67	Died. Weight 70 pounds. Worms, severe attack of pneumonia, had been the best pig in the lot.
December 17	59	Killed. Weight 42 pounds. Emaciated, sarcoptic mange, a few worms, stones in kidneys, lungs in fair condition.
December 17	59	Killed. Weight 76 pounds. Many worms, lungs in fair condition, had convulsions at different times during the last month, was not doing well.

The average feed and weight records for the two lots in this experiment are given in Table 12. The average rate of gain made by the pigs fed yellow corn was twice as great as that of the pigs fed white corn. The pigs on yellow corn also required only about one-half as much feed to produce 100 pounds gain as was required by the pigs on



TABLE 11.—CAUSES FOR THE REMOVAL OF VARIOUS PIGS FROM THE LOT FED YELLOW CORN  
(Feeding started May 5)

Date	Average weight of lot at time of last weighing	Cause of removal and post-mortem findings
June 24. . . . .	<i>lbs.</i> 26	Four pigs taken from experiment at weights of 24, 21, 17, and 20 pounds (see text).
August 2. . . . .	30	Two pigs nearly dead of starvation. Weights 12 and 13 pounds. No positive findings on post-mortem examination.
August 6. . . . .	30	Four best pigs were taken from the experiment to be fed white corn and tankage. Weights 43, 36, 37, and 36 pounds.
November 11.	57	Died. Weight 22 pounds. Emaciated, bad lungs.
December 15..	66	Died. Weight 20 pounds. Lungs congested, hard heart.
December 15..	66	Died. Weight 22 pounds. Worms, lungs congested, hard heart.

white corn. This difference in the rate and economy of gains occurred in spite of the fact that each group was given, as nearly as possible, the same amount of feed per 100 pounds live weight.

#### ADDITION OF VITAMIN A FAILS TO IMPROVE CONDITION OF THE PIGS ON WHITE CORN

On June 24 four pigs were taken from the white corn group and were given, in addition to the ration of white corn and tankage in as large quantities as they would consume, one-tenth pound of butter per head daily, in order to correct the deficiency of vitamin A in their ration. These pigs were group-fed. As a control on this test, on the same date four pigs were removed from the group fed yellow corn and were continued on the ration of yellow corn and tankage but received in addition one-tenth pound of lard per head daily, the lard supplying to this group the same amount of fat as the butter supplied the white corn group but adding no vitamin A to the ration. The amount of feed per 100 pounds live weight allowed this group of four pigs was the same as that consumed by the four pigs getting white corn, tankage, and butter.

The condition of the pigs receiving white corn, tankage, and butter did not improve, and at the end of 78 days the test was discontinued.

TABLE 12.—RATIONS OF WHITE AND YELLOW CORN USED FOR WEANLING PIGS  
(All weights in pounds)

Lot No.....	1	2
Ration.....	White corn, tankage	Yellow corn, tankage
Number of pigs <sup>1</sup> .....	22	23
Days on experiment.....	226	226
<i>Weights</i>		
Average initial weight.....	21	23
Average final weight.....	30	46
Average daily gain.....	.08	.17
<i>Average daily ration<sup>2</sup></i>		
Corn.....	.81	.99
Tankage.....	.14	.17
Pork cracklings.....	.01	...
Total.....	.96	1.16
<i>Total feed consumed per 100 pounds gain.....</i>	1 148	676

<sup>1</sup>The pigs in Lot 1 were taken from the litters of sows fed white corn, and those in Lot 2 from the litters of sows fed yellow corn during the gestation and suckling periods. Eight pigs were taken from each lot for other tests. Five of the pigs in Lot 2 and 14 in Lot 1 died or were killed when nearly dead. <sup>2</sup>The two lots of pigs were fed the same amounts of feed daily per hundredweight.

During this period one pig on the white corn ration was in such poor condition that it could hardly stand. It was therefore killed and post-mortem examination revealed nothing positive except a spotted condition of the liver. On September 9, the day before the test ended, another pig in this lot died. Apparently these pigs were so greatly injured by the continued feeding of white corn that the addition of vitamin A in the butter exerted no favorable effect.

The feed and weight records of this test are given in Table 13.

#### EFFECT OF REVERSING YELLOW AND WHITE CORN FEEDING

On August 6 four of the poorest pigs were taken from the lot fed white corn and four of the best pigs from the lot fed yellow corn and their rations reversed. The two groups were self-fed.

The four pigs which had been fed white corn and tankage were apparently so greatly injured by white corn feeding that recovery was impossible on a yellow corn ration. After 35 days on yellow corn and tankage it was evident that no improvement would result from this change and the group was discontinued.

The four pigs which had been fed yellow corn and tankage averaged 38 pounds in weight when changed to white corn and tankage. From August 6 until the middle of November these four pigs made an average daily gain of a little more than half a pound. After November 19 they did very poorly. One pig died on December 12 and the others would probably have died shortly had they not been removed from the experiment on December 17. During the last part of this experi-

ment all these pigs staggered as they walked, and one pig frequently had convulsions.

The feed and weight records of this test are given in Table 14.

TABLE 13.—EFFECT ON PIGS OF ADDING BUTTER TO A RATION OF  
WHITE CORN AND TANKAGE<sup>1</sup>  
(All weights in pounds)

Lot No.....	3	4
Ration.....	Yellow corn tankage, lard	White corn tankage, butter
Number of pigs.....	4	4 <sup>2</sup>
Days on experiment.....	78	78
<i>Weights</i>		
Average initial weight.....	21	21
Average final weight.....	29	22
Average daily gain.....	.10	.02
<i>Average feed consumption per pig per day</i>		
Corn.....	.30	.28
Tankage.....	.08	.07
Butter.....	...	.12
Lard.....	.11	...
Total.....	.49	.47
Feed per 100 pounds gain.....	474	2 235

<sup>1</sup>The pigs in Lot 3 were taken from Lot 2 and those in Lot 4 from Lot 1. <sup>2</sup>One pig was killed at a weight of 13 pounds, 50 days after the experiment began. It had been getting weaker and could hardly stand. On post-mortem examination the liver was found to be spotted. Another pig in this group died on the 77th day of the experiment at a weight of 28 pounds.

TABLE 14.—EFFECT OF REVERSING THE RATIONS OF FOUR PIGS TAKEN  
FROM LOT 1 AND FOUR FROM LOT 2  
(All weights in pounds)

From Lot No.....	2	1
Ration.....	Yellow corn, tankage	White corn, tankage
Number of pigs.....	4 <sup>1</sup>	4 <sup>2</sup>
Days on experiment.....	35	133
<i>Weights</i>		
Average initial weight.....	20	38
Average final weight.....	23	101
Average daily gain.....	.07	.43
<i>Average feed consumption per pig per day</i>		
Corn.....	.57	1.92
Tankage.....	.15	.39
Total.....	.72	2.31
Feed per 100 pounds gain.....	1 078	532

<sup>1</sup>One pig died at a weight of 20 pounds 29 days after the experiment started

<sup>2</sup>One pig died from pneumonia 5 days before the close of the experiment; all pigs in the lot staggered as they walked, one pig had convulsions every few days as early as the 8th week of the experiment.

## PIGS RAISED ON NORMAL RATIONS TO SIXTY TO SEVENTY POUNDS EVENTUALLY ARE HANDICAPPED BY WHITE CORN FEEDING

It is known that animals raised on rations containing an abundance of vitamin A are capable of storing considerable amounts of this vitamin, so that if they are subsequently put upon rations free from or deficient in vitamin A, they will continue to grow normally for some time. It was thought advisable, therefore, to find out whether pigs grown on good rations to weights of 60 to 70 pounds could complete their growth to market weight as economically on a ration of white corn and tankage as on a ration of yellow corn and tankage.

Sixteen pigs were taken for experiment. They had been raised to 60 to 70 pounds on good rations at the University farms and were from sows fed normal rations. They were divided into two lots of eight pigs each averaging approximately the same weight. The first lot was fed a ration of white corn and tankage, and the second lot a ration of yellow corn and tankage. As in most of the preceding experiments, the amounts of feed given the two lots per 100 pounds live weight were kept the same within narrow limits. Any differences resulting from these two methods of feeding must be due, therefore, to the quality and characteristics of the feed itself rather than to an unequal consumption of the two rations.

For some time the appetites of the two groups of pigs apparently were about equal; both lots can therefore be considered as being on full feed during the first few months of the experiment. The characteristic effect of a lack of vitamin A on the appetite of pigs did not show up until the fifth month of feeding, at which time the feed consumption of the pigs on white corn and tankage was not up to normal. As each pig reached a weight of approximately 225 pounds it was taken out of the experiment.

About six months after the experiment started characteristic pathological symptoms appeared in the pigs fed white corn, altho all the pigs except one reached a weight of 225 pounds. This pig died on the 232d day of feeding, at a weight of 178 pounds. For two weeks preceding its death it had frequent convulsions.

Even under such a restricted method of feeding as was used in this experiment (Table 15), the pigs on the yellow corn ration made considerably faster and more economical gains than those on the white corn ration. It seems probable from this experiment that the stores of vitamin A possessed by the pigs fed white corn at the start of the experiment were sufficient to enable them to gain 100 pounds in weight, or slightly more, at a normal rate.<sup>1</sup>

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<sup>1</sup>If the differences in growth and condition observed between these two groups of pigs had been due in part or entirely to a difference in the vitamin D

TABLE 15.—RESULTS FROM USING WHITE AND YELLOW CORN RATIONS FOR PIGS OF 70 POUNDS WEIGHT  
(All weights in pounds)

Ration <sup>1</sup> .....	Yellow corn, tankage	White corn, tankage
Number of pigs <sup>2</sup> .....	8	8 <sup>3</sup>
Days on experiment (average).....	183	211
<i>Weights</i>		
Average initial weight.....	69	68
Average final weight.....	230	229
Average daily gain.....	.88	.75
<i>Average daily ration</i>		
Corn.....	3.78	3.67
Tankage.....	.39	.37
Total.....	4.17	4.04
<i>Feed per 100 pounds gain</i>		
Corn.....	428	487
Tankage.....	44	50
Total.....	472	537

<sup>1</sup>The same amounts of feed were fed daily per hundredweight. <sup>2</sup>Each pig was taken from the experiment when it reached approximately 225 pounds in weight. <sup>3</sup>Pig died April 30, after 232 days on the white corn ration, at a weight of 178 pounds. It had convulsions every few days for 2 weeks preceding its death. Two other pigs staggered during the last month of experiment.

content of the rations, a defective calcium assimilation in the pigs fed white corn, manifested by a lowered calcium content of the bones, should be demonstrable. Selected bones from five of the pigs on white corn and two of the pigs on yellow corn were therefore measured and analyzed, with the following results:

	Volume of bone	Sp. gr. of bone	Moisture	Ash	Protein	Calcium	Calcium in ash
	cc.		perct.	perct.	perct.	perct.	perct.
<i>Pigs fed white corn</i>							
Humerus.....	230	1.09	26.9	42.5	25.5	15.8	37.2
.....	239	1.06	24.9	44.4	24.9	16.8	37.8
.....	140	1.34	26.6	45.4	24.6	18.3	40.3
.....	.....	.....	24.8	37.3	24.5	14.9	40.0
.....	219	1.33	22.2	42.0	23.1	16.1	38.3
.....	.....	.....	.....	.....	.....	.....	.....
Ulna-radius.....	130	1.31	24.5	44.9	27.6	17.2	38.3
.....	138	1.26	22.6	45.3	27.9	17.8	39.3
.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	23.1	40.8	25.9	16.4	40.2
.....	147	1.40	23.8	45.5	29.1	18.6	40.9
<i>Pigs fed yellow corn</i>							
Humerus.....	150	1.23	31.0	44.0	26.8	17.1	38.9
.....	184	1.32	23.1	39.8	22.6	15.9	40.0
.....	.....	.....	.....	.....	.....	.....	.....
Ulna-radius.....	98	1.25	25.6	43.5	27.9	16.8	38.6
.....	.....	.....	.....	.....	.....	.....	.....

The analysis of the humerus of a pig not taken from the experiment but slaughtered at the same time was: specific gravity 1.16, moisture 29.5, ash 43.5, protein 27.0, calcium 15.4, and calcium in ash 35.4.

There apparently is no reason for suspecting a defective calcium assimilation in the pigs fed white corn, or a deficiency of the ration in vitamin D under the conditions of this experiment.

## SMALL AMOUNTS OF ALFALFA MEAL EFFECTIVELY SUPPLEMENT WHITE CORN RATION

When the feed consumption of pigs on yellow corn rations is restricted to accord with the feed consumption of pigs on white corn rations, the differences in rate and economy of gains resulting can be due only to some nutritive deficiency in white corn. However, this plan of equalizing feed intakes cannot reveal the total effect, direct and indirect, of this deficiency. Especially in practical feeding the effect of such a deficiency on the appetite and the consumption of feed is a matter of great importance. In this experiment, therefore, the white and yellow corn rations were self-fed. This experiment involved a comparison of two varieties of white corn, namely, Silver Mine and White Democrat, and also was concerned with the supplementing effect of alfalfa meal on white corn.

The experiment was started January 14, 1922, using eighty pigs averaging about 60 pounds in weight, which were from sows fed normal rations. The pigs were divided into four equal lots and were fed the following feeds in separate compartments of the self-feeder:

- Lot 1—Yellow corn and tankage
- Lot 2—White corn (Silver Mine) and tankage
- Lot 3—White corn (Silver Mine), tankage, and ground alfalfa
- Lot 4—White corn (Democrat) and tankage

The feed and weight records of this experiment are given in Table 16.

The average rates of gain and the amounts of consumed feed per 100 pounds gain were very nearly the same in Lot 1, getting yellow corn and tankage, and Lot 3, getting white corn (Silver Mine), tankage, and ground alfalfa. No particular abnormal behavior was noted in Lot 3; which would seem to indicate that the small amount of alfalfa consumed by this group (averaging only a little over one ounce per head per day) was sufficient to correct fully the deficiency in white corn, at least until a weight of 225 pounds was reached.

Lot 2, on Silver Mine white corn and tankage, made slightly slower gains than the lots just considered, tho the economy of gains was about the same. One pig in this lot died early in the experiment from an unknown cause. Three other pigs died of cholera on May 2, the 108th day of the experiment, in spite of the fact that all pigs in the experiment had been vaccinated twice for cholera. Toward the close of the experiment two pigs in this lot showed characteristic symptoms of white corn feeding, appearing weak and staggering as they walked.

The results with the White Democrat corn are of considerable importance, since this variety of corn seems especially resistant to chinch bugs and is widely grown in those parts of the state where this

pest is frequently found. The pigs on the White Democrat corn ration did not thrive as well as those on the other rations. While the observed symptoms of white corn feeding were no more severe in this lot than in the lot getting Silver Mine corn and tankage, the food consumption was considerably less, apparently due to the fact that the pigs had some difficulty in grinding the hard, flinty kernels. Three pigs in this lot showed pathological symptoms toward the end of the experiment, and one of the three died the day before the lot was taken off experiment.

TABLE 16.—RESULTS FROM SELF-FEEDING WHITE AND YELLOW CORN RATIONS TO PIGS AVERAGING 60 POUNDS IN WEIGHT AT BEGINNING OF EXPERIMENT  
(All weights in pounds)

Lot No.....	1	2	3	4
Ration.....	Yellow corn, tankage	White corn, (Silver Mine), tankage	White corn (Silver Mine), tankage, ground alfalfa	White corn (Democrat), tankage
Number of pigs.....	20	20 <sup>1</sup>	20 <sup>2</sup>	20 <sup>3</sup>
Days on experiment.....	126	126	126	167
<i>Weights</i>				
Average initial weight...	61	62	61	61
Average final weight....	226	225	227	223
Average daily gain.....	1.31	1.22	1.30	.96
<i>Average daily ration</i>				
Corn.....	5.23	4.76	5.04	4.01
Tankage.....	.49	.51	.54	.45
Ground alfalfa.....	.....	.....	.08	.....
Total.....	5.72	5.27	5.66	4.46
<i>Feed per 100 pounds gain</i>				
Corn.....	397	388	387	418
Tankage.....	38	42	42	47
Ground alfalfa.....	.....	.....	7	.....
Total.....	435	430	436	465

<sup>1</sup>One pig died at a weight of 42 pounds 55 days after the experiment started; cause of death unknown. Three pigs died of cholera on the 108th day of the experiment, weighing 138, 183, and 197 pounds. Two pigs in this lot staggered somewhat near the end of the experiment. <sup>2</sup>One pig weighing 43 pounds was taken out on the 21st day of the experiment, and was replaced by another pig weighing 93 pounds. <sup>3</sup>One pig weighing 196 pounds died the day before the experiment closed. At the end of the experiment 3 other pigs showed characteristic indications of white corn feeding.

The most interesting result of this experiment is that very small amounts of alfalfa meal may correct the deficiency of white corn during the ordinary fattening periods of pigs in the corn belt.

#### ONE PERCENT OF COD-LIVER OIL ALSO PROVES EFFECTIVE SUPPLEMENT TO WHITE CORN RATION

While it is fair to conclude that the differences observed in the rate and economy of gains of growing pigs fed in dry lot on rations of white corn and tankage and yellow corn and tankage are in all probability due to a deficiency of vitamin A in the white corn, the results

so far do not demonstrate that point. The experiment described in this section was planned, therefore, to settle definitely the precise nature of the deficiency of white corn. For this purpose a ration of white corn and tankage was compared with a ration of white corn and tankage containing approximately 1 percent of cod-liver oil. At the time the experiment was planned, it was not known that two distinct fat-soluble vitamins are present in cod-liver oil, and that white corn is probably deficient in both. In spite of this fact the results of this experiment can probably be interpreted in terms of vitamin A only, since the effect of any deficiency in vitamin D (the anti-rachitic vitamin) was probably minimized, if not removed entirely, by the fact that the pigs in both lots received plenty of direct sunlight. Animals kept in direct sunlight apparently do not need vitamin D.

Two lots of ten pigs each, averaging about 50 pounds per pig, were used in this experiment. The rations were self-fed. Lot 2 received white corn and tankage only, while Lot 1 received cod-liver oil<sup>1</sup> to the extent of 1 percent of the corn consumed. The cod-liver oil was poured over the corn in the self-feeder in the proportion of 1 part by weight of oil to 100 of corn.

Both lots of pigs made similar gains for six weeks to two months after the experimental feeding was started. Later, however, the pigs receiving cod-liver oil consumed more of their ration and gained more rapidly in weight than the pigs receiving no cod-liver oil. At the end of 182 days of feeding, when the experiment was terminated, the pigs getting cod-liver oil averaged 238 pounds in weight. All ten pigs were alive and in excellent market condition, showing no indication of abnormal behavior of any kind.

In the lot not getting cod-liver oil the symptoms of vitamin deficiency began to appear after about two months of feeding. The appetites of the pigs declined, and in the last month of the experiment three of the pigs died, showing the typical symptoms of white corn feeding. While the other pigs after 182 days on the experiment appeared to be reasonably thrifty, their gains were not satisfactory. As Table 17 shows, the average daily gain of the pigs not getting cod-liver oil was only about one-half that of the pigs getting this supplement, and the economy of gains was correspondingly lower.

Because of the heavy losses sustained in Lot 2 after June 9, no further feed records are reported for the two lots after this date. Both lots, however, were continued on their respective rations. All ten pigs getting cod-liver oil continued to thrive until, at an average weight of 300 pounds, they were sold at market. The remaining pigs in the other lot (Lot 2) went from bad to worse, their symptoms including a lack of appetite, staggering, roughened hair coat, and staring eyes. By the middle of August all the pigs in this lot were dead except one. The

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<sup>1</sup>Squibb's best grade of cod-liver oil was used in this work.



remaining pig, altho emaciated and very weak, lived thru the summer. In the early fall dry leaves which blew into the dry lot in which the pig was kept were eaten greedily by this animal, and within two weeks its condition was much improved. It was then turned out on blue-grass pasture, and within a short time all abnormal symptoms disappeared and the pig showed a normal gain in weight.

TABLE 17.—SUPPLEMENTING EFFECT OF COD-LIVER OIL IN A RATION OF CORN AND TANKAGE SELF-FED  
(All weights in pounds)

Lot No.....	1	2
Ration.....	White corn, tankage, cod-liver oil 1 percent	White corn, tankage
Number of pigs.....	10	10 <sup>2</sup>
Days on experiment.....	182	182
<i>Weights</i>		
Average initial weight.....	49	50
Average final weight.....	238	173
Average daily gain.....	1.04	.58
<i>Average daily ration</i>		
Corn.....	4.13	2.92
Tankage.....	.34	.34
Total <sup>1</sup> .....	4.47	3.26
<i>Feed per 100 pounds gain</i>		
Corn.....	399	505
Tankage.....	33	59
Total.....	432	564

<sup>1</sup>Cod-liver oil not included in total. <sup>2</sup>Three pigs died on the 149th, 152d and 168th days of the experiment, at weights of 92, 98, and 106 pounds, respectively.

Since the differences in condition and thrift shown in the two lots of this experiment occurred in the spring and early summer, when the length of exposure to direct sunlight would appear to be adequate to protect against rickets, it is considered reasonable to explain the differences in results in Lots 1 and 2 as being due entirely to a difference in the vitamin A content of the rations.

### CONCLUSIONS

White corn is not so satisfactory as yellow corn for growing and fattening pigs under restricted dry-lot conditions such as prevail on most corn-belt farms in the winter, gains and health of pigs considered. This lower feeding value of white corn apparently is due to its deficiency in vitamin A. White Democrat corn, as well as Silvermine, is deficient in this respect.

Young pigs are much more quickly affected by white corn rations containing no source of vitamin A than are old pigs, evidences of mal-

nutrition developing much earlier in the young pigs. If pigs farrowed from sows that have been kept on such white corn rations during gestation are put on the same rations at weaning, very little if any growth will be obtained. On the other hand, if pigs are raised on normal rations containing an adequate supply of vitamin A, they may store enough of this vitamin in their bodies to carry them thru a gain of 100 to 125 pounds on white corn rations just as economically as if they were fed yellow corn. Eventually, however, malnutrition, due to lack of vitamin A, will develop.

Brood sows raised upon well-balanced rations may withstand the ill effects resulting from the deficiency of vitamin A in white corn rations for two gestation and lactation periods, tho eventually their fertility is impaired. Furthermore, pigs farrowed in the first two litters on white corn feeding may grow as rapidly during the suckling period as other pigs farrowed from sows subsisting upon yellow corn rations. Evidently enough vitamin A is stored in the sow during a protracted period of adequate feeding to supply the requirements of two litters of pigs up to weaning time.

Small amounts of alfalfa meal and cod-liver oil, which are rich in vitamin A, are effective supplements for white corn rations. They correct completely the deficiency of such rations in this important vitamin, and where pigs are kept out of doors, exposed to direct sunlight, they appear to render white corn as valuable as yellow corn for growing and fattening pigs and for brood sows.











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