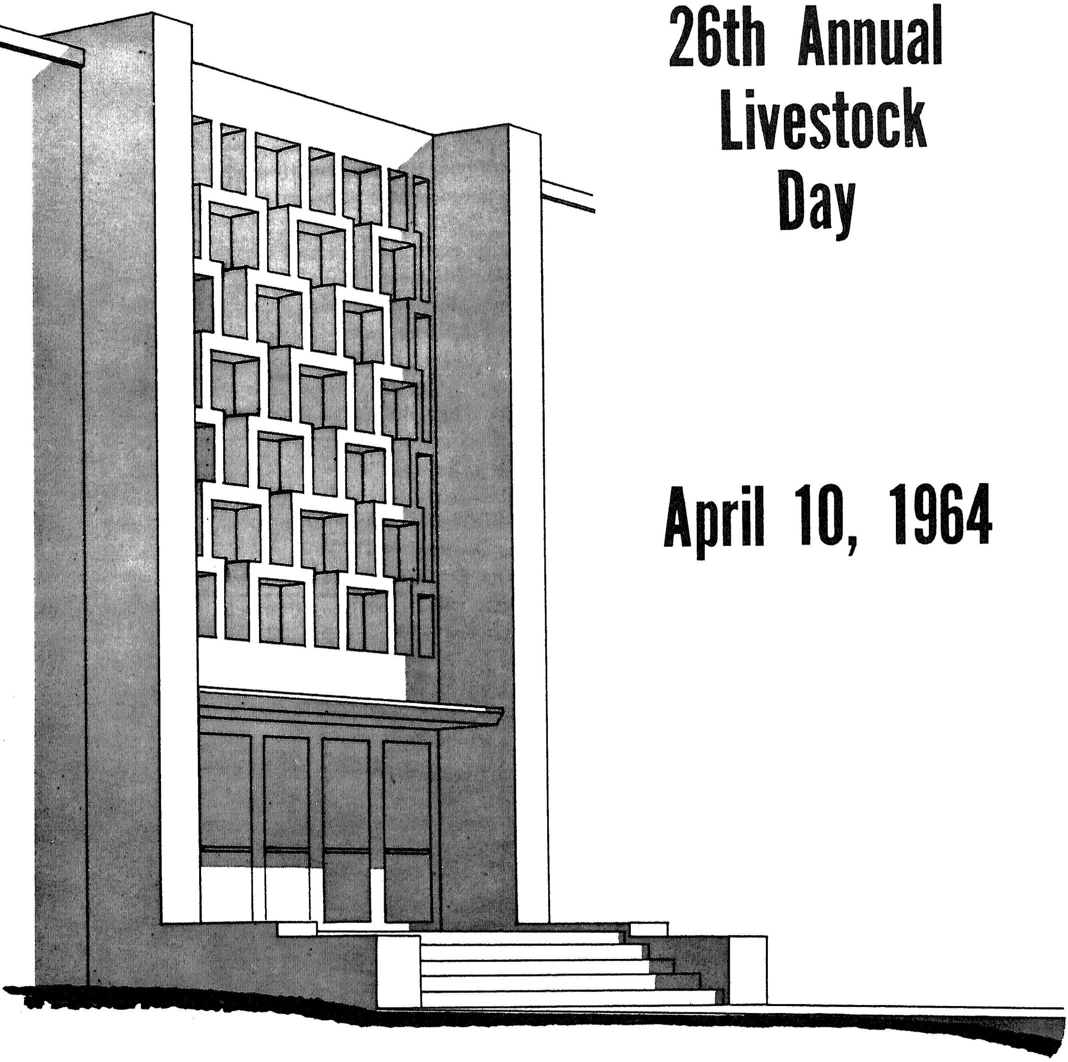
STUDIES WITH BEEF CATTLE, SHEEP AND SWINE



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UNIVERSITY OF MISSOURI

AGRICULTURAL EXPERIMENT STATION

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Project 493

CHRONIC NITRATE - NITRITE TOXICITY FROM FEED AND WATER

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Summary and Recommendations

This report summarizes work done by the Animal Husbandry Department in cooperation with other groups over the past 10 years on problems related to nitrate or nitrite in feed and water. Under some but by no means all dietary and environmental conditions, ill effects "chronic toxicity" can be produced when either nitrate or nitrite is present at less-than-deadly "subacute" levels in the water or feed supply of beef cattle, dairy cattle, sheep, swine, and rats. Disturbances observed include: abortion, lowering of milk production, reduced gain, and unthriftiness. Reduced levels of vitamin A stores in the liver are common and lowered vitamin A in blood is sometimes observed.

Certain factors are known to destroy vitamin A and carotene. Both nitrate and nitrite are strong oxidizing agents and may reduce the vitamin activity present in a feedstuff and interfere with its utilization within the animal.

The thyroid gland is believed to influence absorption of carotene. The iodine level of the diet is an important factor in counteracting nitrate toxicity associated with hypothyroidism. Part of this effect is assumed to be on the conversion of carotene to vitamin A.

Based on the experimental evidence cited, the following recommendations are now advisable for Missouri conditions.

(1) Spot check all feed and water supplies for the presence of nitrate and nitrite. If results are positive obtain a quantitative test.

(2) If the water contains more than 5 parts per million (ppm) NO^-_2 or 45 ppm NO^-_3 (nitrate) or if the feed contains more than 0.25% NO^-_3, some precautions are needed.

We recommend the following:

a. close observation of animals at all times for evidence of rough hair coat, excess watering of eyes, lameness, and failure to perform well,

b. the addition of extra energy to the ration, preferably black strap molasses. Add 1 pound per cow or steer per day if NO^-_3 is over 0.25% and 2 pounds if over 0.4%. The molasses will not be needed in high grain rations.

c. feed iodized salt.

d. add 3000 IU of stabilized vitamin A daily per 100 pounds of live weight of animal. Try to keep the vitamin A away from trace mineralized salt.

e. breeding animals should be observed carefully for evidence of poor conception rate and early abortion. They may require extra vitamin A and a better balanced diet.

(3) If the feed is unusally low in fat, the addition of 1% of fat to the ration can be expected to improve the absorption and utilization of fat soluble nutrients. Vitamin E and certain antioxidants may be considered.

(4) If feeds high in nitrate are made into silage, consider the addition of blackstrap molasses at the rate 50 lb/ton for low levels (0.25% NO^{-}_{3}) up to 200 lb/ton for high levels (1% NO^{-}_{3}).

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(5) The feeding of silage from high nitrate crops should be delayed for 3 months after silos are filled and sometimes until the second year after it has been harvested.

(6) Always run blower for 20-30 minutes before entering a silo and test silage before feeding.

A Relatively New Problem

Interest in this problem started in 1954 when large numbers of cattle died from the rapid ingestion of drouth corn. Plants under certain conditions can accumulate as high as 18% of potassium nitrate (KNO_3) on a dry weight basis. The nitrate (NO^{-}_{3}) which is accumulated can be reduced to nitrite (NO^{-}_{2}) by plant tissues or by bacteria living on the plant or in the rumen of animals.

Death may follow the sudden intake of 1 to 2 percent of potassium nitrate, or about 1/10 this amount of potassium nitrite. But many animals can resist these toxic doses and in fact tolerate even greater amounts. However, it soon became apparent that more than a problem of deadly poisonous levels was involved. Observations made over the past 10 years indicate that long term ingestion of sub-lethal amounts yields a far greater loss to the livestock industry than do the fatal doses associated with the sudden ingestion of toxic levels.

Some Test Observations

In 1954-55 silage was prepared from drouth corn. It was evaluated for total digestible nutrients (TDN) with sheep and cattle and was fed as the main ration to wintering calves and to pregnant ewes. The corn contained 19.2% TDN and 2.2% digestible protein. It supported an average daily gain of 1.0 lb. in calves when supplemented with 2 pounds of corn + 1 pound cottonseed meal. When pregnant beef cows received drouth corn silage as the major feed, they suffered from a reduced feed intake, showed difficulty in urinating, and 4 of the cows produced dead calves. When 2 pounds of blackstrap molasses was added to the ration, the cows recovered and no further difficulty was observed. The results with bred ewes are shown in Table 1.

TABLE 1 - COMPARISON OF FEEDING HIGH AND LOW NITROGEN SILAGE TO BRED EWES

Group I : 2 lbs. Oat Hay + 5 lbs. Drouth Corn Silage (1.4% KNO_3)
Group II: 2 lbs. Oat Hay + 5 lbs. Wheat Silage (0% KNO_3)

	I	II
No. ewes bred	35	35
No. ewes lambing	29	33
No. live lambs	45	49
Birth Weight lambs, lb.	10.5	10.7
Fleece Weight, lb.	8.2	8.7
Urinary NO_3 after:		
1 month	33%+	0+
6 weeks*	0	0

*KNO_3 of silage was reduced to about 0.7 %

About 1/3 of the ewes fed on the corn silage had positive nitrate in their urine and ewes on corn silage produced less wool than those that received wheat silage. This was probably primarily an effect of nitrate on energy utilization of the ration.

Pasture studies with high nitrate fertilizer have produced variable results. In the spring of 1955 wheat-lespedeza pasture which had received 250 pounds of 8-8-8 starter and 124 pounds of nitrogen per acre from ammonium nitrate on April 1 was grazed by ewes and their lambs after April 16 with no ill effects. The ewes gained 9 pounds per head and the lambs, 13 pounds per head in the next four weeks. However, in the summer, lambs grazing on orchard grass pasture which had been heavily treated with nitrogen and irrigated showed no gains while control animals on a check lot gained at a rate of 0.35 pound per day. Apparently certain green forages sometimes contain unknown agents which offer good protection against nitrate content but at other times the protective substance is missing. Here is an area for additional research not only in animal physiology, but also in plant breeding and harvest methods.

Tables 2, 4, and 5 show the results of experimental studies indicating that sheep can use small amounts of nitrate as a nitrogen source provided there is adequate energy present in the diet. On this ration (Table 2) which contained 3000 IU vitamin A per day, several lambs died with no detectable vitamin A in the liver. This was evidence that nitrate was influencing something other than just the energy utilization.

On 20% molasses low protein diet (Table 2), 0.5% KNO_3 supported an increased nitrogen balance, but 1% KNO_3 depressed nitrogen balance in young lambs.

The ration shown in Table 3 contained less molasses and was fed to larger sheep. In tests reported in Table 4 1.5% KNO_3 (potassium nitrate) or an equivalent amount of NO_3^- as Na (sodium) or NH_4^+ (ammonium) improved nitrogen balance. The NH_4NO_3 appeared to lower blood vitamin A.

TABLE 2 - EFFECTS FROM ADDING POTASSIUM NITRATE TO AN OAT HAY-MOLASSES RATION* FOR LAMBS; 1956

Treatment	Weight Change**	Blood NO_3	COD N	N Bal.
1. Control	-1 lb.	0.2 mg.	54	0.05 gm.
2. +0.5% KNO_3	0	0.3	60	1.56
3. +1.0% KNO_3	-2	0.3	63	-0.11

* Daily ration 500 gms. 20% molasses.
** Initial weight 44 lbs.

TABLE 3 - BASAL RATION FOR STUDIES IN 1956-57

	lb/cwt
Grass Hay, Ground 1/2 inch screen	67.5
Blackstrap molasses	10.2
Ground Yellow corn	20.3
Salt	1.0
Dicalcium phosphate	1.0

The several batches of this ration contained between 5.8 and 6.5 per cent crude protein.

TABLE 4.- CHRONIC NITRATE FEEDING TO WETHER LAMBS, 1956

	N		Blood	
Treatment	COD	Bal.	NO_3 Mg%	Vit. A IU/100 Ml.
1. Controls	52.5	1.91	0.1	60
2. +0.5% KNO_3	46.9	0.99	0.3	94
3. +1.5% KNO_3	55.9	2.49	2.2	67
4. 3+BHA	59.6	3.36	0.7	58
5. NH_4NO_3*	65.0	3.24	1.0	49
6. $NaNO_3$*	58.7	3.49	2.4	68

Basal ration, 740 gm/day
Initial Weight, 58 lbs.; 174 day gain 3 lb.

*Furnished the same amount of NO_3 as 1.5% KNO_3

TABLE 5 - CHRONIC NITRATE FEEDING TO MATURE WETHERS, 1956-57

Treatment	Gain** lb.	N		Blood	
		COD	Bal.	NO_3	Vit. A
1. Controls*	3	45.8	3.14	0.4	63
2. 1.75% KNO_3	10	56.0	-3.78	Lost	53
3. Two + Metabisulfite		60.0	4.06	3.8	82

* 1225 gms. ration/day.
** Initial weight 100 lbs. 83 day gains.

With mature wethers limited evidence was obtained that certain reducing substances (metabisulfite) might give protection but results were not conclusive (Table 5).

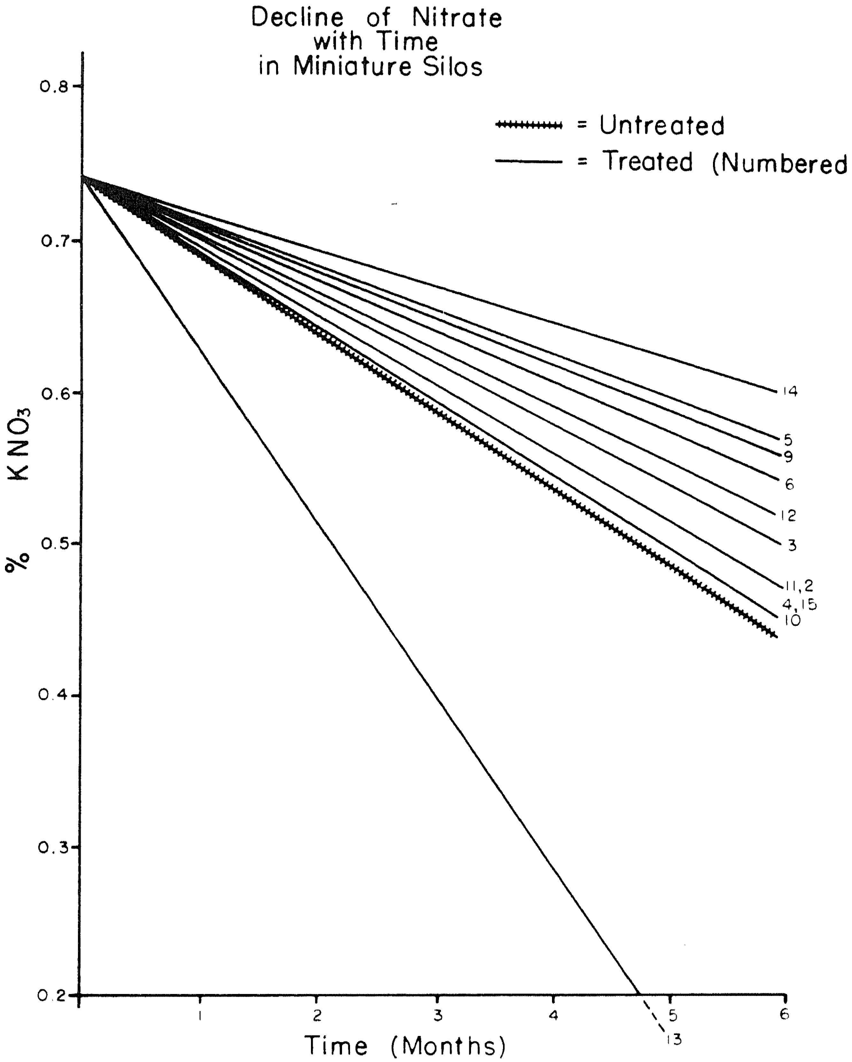
Fifty-five gallon plastic lined drums were filled with silage from a field of corn that made about 50 bu. per acre. The corn contained about 0.75% KNO_3 when ensiled. A number of silage preservatives and other additives were placed in these silos to see if they would speed the destruction of nitrate from the silo. Of the materials tested, only molasses was effective in speeding the removal of nitrate from the silage (treatment 13, Figure 1).

The results of feeding some of these silages to sheep are shown in Table 6.

TABLE 6 - EFFECT OF ADDED NITRATE ON BLOOD VITAMIN A AND THE DIGESTIBILITY OF NITROGEN (N) AND ORGANIC MATTER (OM) IN CORN SILAGE

Treatment	Vit. A	Digestibility	
		N	OM
1. Basal	77	66 ± 2.3	74 ± 1.3
2. Basal + 15 gm KNO_3	52	75 ± 0.4	71 ± 0.7
3. Two, after adding "4000 IU" of carotene	88	74 ± 0.2	66 ± 0.4
4. All preservatives	133	75 ± 0.7	78 ± 1.8
5. Corn	92	63 ± 0.9	71 ± 0.3
6. Corn + Urea	73	74 ± 1.6	77 ± 0.7

Some preservatives either increased the vitamin A activity or decreased its loss from nitrate. The addition of 4000 IU of vitamin A as carotene was not effective in maintaining blood vitamin A in the presence of nitrate in sheep. However, blood vitamin A levels may not be a good criteria of liver A stores as shown in Table 7.



Decline of Nitrate
with Time
in Miniature Silos
= Untreated
= Treated (Numbered)
% KNO3
0.8
0.7
0.6
0.5
0.4
0.3
0.2
14
5
9
6
12
3
11,2
4,15
10
13
1
2
3
4
5
6
Time (Months)

Figure 1.

TABLE 7 - Observations on Vitamin A Status

Farm	Animal	Blood Plasma		Liver	
		A	Carotene	A	Carotene
Gamm	Steer[1]	250 IU/ 100 ml	ND	12.4 IU/ gm	ND
Ketchum	Wether[2]	50 IU	10	Nil	ND
Dungan	Sheep[3]				
No problem		75-100			
Stiff		<35	ND		

[1]This animal had received daily enough vitamin A to meet NRC requirements and his ration was calculated to contain over 30,000 IU of carotene. He had received 200,000 IU via intramuscular injection 2 weeks before slaughter.
[2]Animal had received 3000 IU vitamin A in feed for previous 180 days.
[3]Animals were on corn silage ration.
ND = Not determined.

Studies were made on the addition of nitrite to sheep rations (Table 8). This substance is extremely unstable when added to mixed rations in the presence of trace minerals. It is not possible to maintain the added levels even in cold storage and the amounts actually consumed by the animals are uncertain. We believe that we were able to get more than 0.7% nitrite into our experimental animals at the end of the period. Under these conditions they could reduce the entire load of nitrite within 15 minutes. In spite of this, the animals receiving nitrite had reduced storage of vitamin A in the liver and most of the vitamin was removed from the blood.

TABLE 8 - THE EFFECT OF PROLONGED NITRITE FEEDING TO WETHER LAMBS

Treatment	Gain per Day	Liver Vit. A IU/gm	Serum Vit. A IU/100/ml
1. Control (A & D)	0.23	324	93
2. Vitamin D + Nitrite	0.13	17	36
3. Vitamin A & D + Nitrite	0.19	278	110
4. As 2. + 3% fat	0.16	9	49
5. As 3. + 3% fat	0.23	322	118

If nitrite enters the blood of an animal, it combines with hemoglobin to form methemoglobin, a substance which cannot carry oxygen. Methemoglobin was not present in the blood of sheep fed nitrate or nitrite in the experiments reported above.

In contrast to these experimental results is the observation that ewes fed silage containing only 0.2 percent KNO_3 showed methemoglobin in the spring of 1958. The strong ewes may have eaten the leaves and the weaker ewes, the pith, which had a higher concentration of NO_3.

To our knowledge this is the lowest level of potassium nitrate which has been implicated in producing methemoglobin under field conditions and suggests that factors present in silage other than nitrate may have been involved.

Species of animals other than ruminants are also endangered by nitrates. Several sows aborted when they were running on a rape and oats pasture (approximately 2.4% NO_3^-). One sow died after drinking the runoff containing nitrite from a silo and the runoff from a pit silo killed fish in a pond below the silo.

Many field observations in Missouri indicate that cattle being fed forages containing sub-lethal levels of nitrate (.5 to 1.5%) have reproduction and lactation abnormalities. Abortions, in apparently disease-free cattle, and decreased milk production have been observed when the animals' forages contained the equivalent of about 1% KNO_3. A marked drop in milk production in a Jersey cow resulted from the addition of 1.25% KNO_3 to her ration. Another animal on 0.75% KNO_3 showed a similar but less marked drop in milk production. The effect of the lower level of nitrate could be partially reversed by the addition of extra energy in the form of molasses to the diet.

Of increasing concern now is the effect of nitrate-nitrite in water supplies. We now have in our files over 100 case histories of producers who have reported poor production which is related in some way to high nitrate or nitrite in water. It should be emphasized that the effects of nitrate and nitrite are not confined to their role in interfering with vitamin A utilization. Nitrites at 5 ppm have been toxic to infants and at 10 ppm can cause trouble in any species. Also, it should be emphasized that the nitrate-nitrite effects are probably more severe during the winter than they are during the summer.

Since water becomes a more scarce item each year, every possible effort should be made to protect it from contamination from feed lots or runoff from recently fertilized areas.

We observed that water containing 120 ppm nitrate depressed thyroid function by reducing iodine utilization and that this effect could be reversed by adding iodized salt to the ration. This condition is more apt to occur in very cold weather.

Figures 2 and 3 show animals affected by excess nitrate in their water.

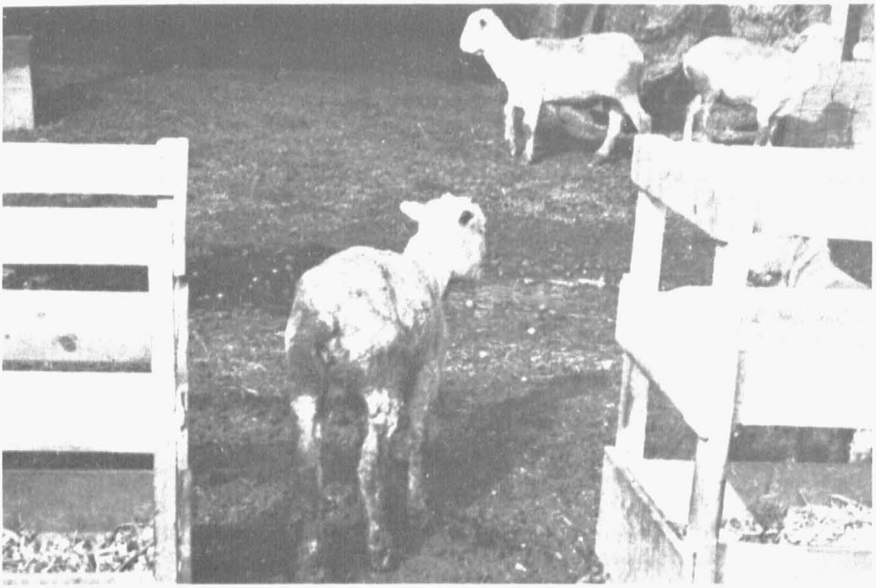


Figure 2 - Group of sheep receiving 120 PPM KNO_3 in water

Figure 3 - Cattle receiving 20 PPM KNO_2 in water. Note eye trouble.

An animal receiving a sub-toxic dose of nitrate suffers other metabolic disturbances as shown in Table 9.

TABLE 9 - RUMINAL AND BLOOD RESPONSE OF A SHEEP TREATED WITH 40 GRAMS OF KNO_3 INSERTED DIRECTLY INTO THE RUMEN

	Time in Hours				
	0.0	2.5	5.0	7.5	24
Measurements					
Rumen pH	6.8	6.3	6.3	6.4	7.0
Rumen EH (2)	---	-280	-260	-180	-120
Motility, rumen fluid	+++	+++	0	+	0(2)
Packed Cell Vol.	37.5	40.0	31.0	33.5	35.0
Methemoglobin	0.69	0.54	1.08	2.22	7.50

(1)EH reported as millivolts.

(2)Slight motility noted after 36 hours, appetite began to return in 48 hours. Another sheep died 9.0 hours after dosing.

Project 248

MEETING PHOSPHORUS REQUIREMENTS OF RUMINANTS[1]

R. L. Preston and W. H. Pfander

Phosphorus is one of the major minerals required by all animals. Currently it costs approximately one cent per head per day to supply the required amount of phosphorus in a finishing ration for a steer. Research has been conducted around the world to determine the "requirement" used in various feeding standards and requirement tables. This, however, does not mean that all is known about supplying adequate phosphorus in livestock rations.

One unknown item is the availability of the phosphorus in rations to the animal. How much of the phosphorus supplied in the ration does the animal digest and absorb?

Radioactive isotopes can be used to answer this question because they make certain determinations relatively easy which were formerly impossible. Radioactive phosphorus can be used to determine what percent of the phosphorus in feeds is actually digested, absorbed, and utilized for body function.

Such an experiment was conducted with lambs which were fed three levels of phosphorus. The results of this work showed that the daily phosphorus requirement of lambs could be expressed by the equation

[1]This work was supported in part by the Atomic Energy Commission.

$$P_T = .0088W(1 + 7.75G)$$

where P_T is the total amount of phosphorus required daily in grams, W is the body weight in pounds and G is the daily gain in pounds. For example, 80-pound lambs gaining 0.4 pound per day would require $(.0088)\ (80)\ [1+(7.75)\ (0.4)] = 2.88$ gm of phosphorus per head per day. This compares with an estimated requirement of 2.7 gm as published in the NRC requirement tables.

Since radioactive phosphorus was used in this experiment, it is possible to determine the available phosphorus requirement as follows:

$$P_A = .0071\ W(1 + 8.48G)$$

Where P_A is the available phosphorus required daily in grams. Thus, using the example above, the daily available phosphorus requirement would be:

$$(.0071)\ (80) \left[1+(8.48)\ (0.4 \right] = 2.50 \text{ gm per head per day.}$$

Furthermore, it was found that the available phosphorus requirement could be conveniently expressed in relation to the digestible energy requirement. Thus, approximately 0.63 mg available phosphorus is required per kcal of digestible energy.

Meeting Available Phosphorus Requirements of Ruminants

As a result of this work, the following available phosphorus requirements are set forth.

Beef Cattle	Weight (lb)	Grams Available Phosphorus per Day
Wintering calves	400-600	8
Finishing calves	400-600	12
Wintering yearlings	600-800	10
Finishing yearlings	600-800	16
Finishing yearlings	800-1000	18
Growing heifers and bulls	400-600	9
Growing heifers	600-800	12
Growing heifers	800-1000	13
Growing bulls	600-1000	14
Pregnant cows	1000-1200	12
Lactating cows	900-1100	21
Sheep		
Finishing lambs	60-80	2.4
Finishing lambs	80-100	3.0
Replacement ewe lambs	60-100	2.1
Replacement rams	80-120	2.6
Replacement rams	120-160	3.0
Pregnant ewes (1st 15 wks of pregnancy)	120-140	2.0
Pregnant ewes (last 6 wks of pregnancy)	120-150	2.8
Lactating ewes	100-140	3.7

As mentioned earlier, one problem in figuring the amount of total phosphorus to be supplied is how much will the animal digest and absorb from the feeds which are supplied. Below is a list of several common feedstuffs and the available phosphorus content of these feeds as determined from published material. It has been assumed that approximately 70% of the phosphorus in concentrates and 90% of the phosphorus in roughages is available to the ruminant.

Feed	% available P
Roughages:	
Legume hays	.22
Grass hays	.20
Corn silage	.05
Straws	.07
Grains:	
Corn (shelled)	.19
Corn (ear)	.15
Sorghum grain (milo)	.20
Barley	.25
Oats	.24
Protein Feeds:	
Soybean meal	.45
Cottonseed meal	.80
Linseed meal	.60
Mineral Supplements:	
Bone meal (steamed)	11.2
Dicalcium phosphate	16.9
Defluorinated (rock) phosphate	14.0
Phosphoric acid	21.7
Curacao Island phosphate	11.5
Soft phosphate (colloidal clay)	2.3

The following example is shown as a guide in use of the preceding information: 700-pound finishing yearlings require 16 gm available P daily.

Daily ration	(amt)	x	(avail P/lb)	x	(454 gm/lb)	=	avail P intake
Corn silage	(12 lb)	x	(.0005)	x	(454)	=	2.7 gm
Grass hay	(2 lb)	x	(.0020)	x	(454)	=	1.8 "
Shelled corn	(11 lb)	x	(.0019)	x	(454)	=	9.5 "
Soybean meal	(1.5 lb)	x	(.0045)	x	(454)	=	3.1 "
Limestone	(1.0 oz)	x	(none)				0
			Total available P intake = 17.1 gm				
			Total available P required = 16.5 gm				

This ration contains adequate available phosphorus. If additional available phosphorus is required in a ration, the amount required can be calculated as follows: (available P deficient in the ration) ÷ (available P/lb mineral supplement)

Available calcium requirements have not been studied extensively. Until further information is available, the total calcium to available phosphorus ratio of most rations should be maintained at two parts calcium to one part available phosphorus.

Project 513

ANTIBIOTICS FOR SWINE - A NEW LOOK

L. F. Tribble, G. L. Holck, and F. L. Zellmer

Summary

1. Tylosin proved to be an effective antibiotic in two trials with growing-finishing hogs.
2. Oxytetracycline and chlortetracycline were used in the basal ration as their effectiveness is well established from previous research.
3. A combination of penicillin and streptomycin was an effective antibiotic in one trial for growing-finishing hogs.
4. Zinc Bacitracin was not as effective as tylosin or chlortetracycline in one trial.

Research work has been conducted on the value of antibiotics for swine for approximately 15 years. The present series of tests was designed to evaluate the effectiveness of some of the newer antibiotics as well as those which had not been fed recently at the Swine Research Farm.

The data for three trials on the value of antibiotics for growing-finishing hog are shown in Table 1. The ration used in these trials was composed of corn 79%, soybean oil meal 15%, meat and bone scraps 5%, minerals and vitamins 1% and the various antibiotics tested. The ration was modified in trials 1 and 2 to reduce the protein to approximately 12% when pigs weighed 125 pounds.

In trial 1 pigs fed a ration containing a combination of penicillin and streptomycin gained 0.1 pounds per head per day faster and required 25 pounds less feed per 100 pounds gain than pigs fed a ration containing oxytetracyline. Pigs fed a ration containing tylosin in trial 2 gained 0.15 pounds per head per day faster and required 40 pounds less feed per 100 pounds of gain, compared to pigs fed a ration containing oxytetracycline. The effectiveness of these antibiotics, tylosin and penicillin-streptomycin combination, is well demonstrated by the above data. The magnitude of the difference could be due to the use of different antibiotics in rations in place of one of the tetracyclines. The tetracyclines have been used almost exclusively in this herd for over 10 years.

Three antibiotics were compared in trial 3. Pigs fed chlortetracycline made faster and more efficient gains than those receiving either of the other antibiotics. Feed effeciency was good for all pigs but the rate of gain for the pigs receiving zinc bacitracin was not satisfactory.

TABLE 1 - VALUE OF VARIOUS ANTIBIOTICS IN RATIONS FOR GROWING-FINISHING SWINE

	TRIAL						
	1		2		3		
Antibiotic*	Te	P.S.	Te	Ty	Ty	ZB	Au
No. of Pigs	22	24	40	40	32	32	32
Initial Wt.	44.5	44.5	39.8	39.9	46.6	44.8	46.4
Final Wt.	184	194	193	206	129	120	134
Av. Daily Gain	1.3	1.4	1.55	1.7	1.35	1.21	1.44
Feed/Lb Gain	3.82	3.57	3.14	2.74	3.04	3.05	2.96

*Te - Oxytetracycline, 10 gms/ton in trial 1 and 20 gms/ton in trial 2.
P.S. - Penicillin-Streptomycin, 5 and 15 gms/ton respectively.
Ty - Tylosin, 20 gms/ton.
Au - Chlortetracycline, 20 gms/ton.
ZB - Zinc Bacitracin, 20 gms/ton.

Project 513

LIMITED FEEDING FOR GROWING-FINISHING SWINE

K. L. McFate* and L. F. Tribble

Summary

1. Pigs fed a limited amount of feed 4 times per day from approximately 100 to 200 pounds had slower gains (18%) and required slightly more feed (4%) per pound of gain than pigs self-fed.

* Agriculture Engineering Department.

2. There was no difference in the performance of pigs limited fed coarse rolled corn and those fed fine ground corn in complete mixed rations.

3. The gains of the limited fed pigs were more variable than those of self-fed pigs.

4. Pigs limited-fed had 0.1 inch less backfat as determined by the probe than full fed pigs.

5. Limited fed pigs were fed an average of 4.7 pounds/head/day on the average, while those self-fed ate 5.54 pounds per head per day.

6. Prior to the beginning of the limited feeding phase of the trial an attempt was made to full feed pigs on the floor 4 times per day as compared to self-feeding. By feeding 4 times per day on the floor an amount the pigs would clean up between feedings, we were unable to obtain gains and feed consumption equal to those of pigs on the self-feeder.

Description of Tests

Phase I.

During the period from 60 to 100 pounds, pigs were fed by dumping the feed automatically on the floor four times per day at six-hour intervals. This method was compared with feeding pigs from a self-feeder. The level of feeding was adjusted to an amount the pigs would clean up between feedings. The objective was to duplicate the performance of the pigs on the self-feeder. Fine grinding of corn was compared with coarse rolling for pigs fed on the floor. The self-fed ration was from fine ground corn.

Phase II.

When the pigs reached approximately 100 pounds, they were to be limited to 5 pounds per head per day for the remainder of the trial. However, adjustments had to be made in the feeding level as pigs were not eating 5 pounds when they weighed 100 pounds. The feeding level was increased as the trial progressed.

Pigs were removed from test at approximately 200 pounds and backfat probes were obtained on a large sample of the pigs in each lot.

Pigs were started on a 16 percent protein ration composed of corn, soybean oil meal, meat and bone scraps, mineral, vitamins and an antibiotic. The ration was adjusted to a 12 percent protein ration when the pigs were started on phase II. Two pens of 14 pigs each were in each treatment group. The pens were approximately 10 x 20 feet.

The results of phase I are shown in Table 1. Pigs fed all that they would eat between feedings spaced six hours apart gained slower, ate less feed, and were less efficient than pigs eating from a self-feeder. On hot days pigs would not clean up the morning and noon feedings and some feed was wasted. The pigs voided urine and feces over the entire pen including the feeding area. This condition existed during phase II although not as bad as during phase I. This may in part explain the cause of feed wastage by the pigs fed on the concrete floor, although pens were cleaned daily.

The data for phase II are shown in Table 2. As expected, gains were slower for pigs limit-fed by the automatic feeder than pigs fed from a self-feeder. Limit-fed pigs required 23 days more on the average to reach 200 pounds than pigs on the self-feeder. There was more variation in the gains of the pigs on the automatic feeder than in gains of the ones on the self-feeder.

Feed consumption of the limit-fed pigs averaged less than 5 pounds per head per day as pigs were eating only 4 pounds per head per day at the start (100 lbs. average weight). Pigs on the self-feeder consumed less feed per head per day than normally would be expected.

TABLE 1 - RESULTS OF PHASE I
60 to 100 pounds
(June 24 to July 25, 1963)

	Feeding Method		
	Automatic 4 times per day		Self-fed
	Fine Ground	Coarse Rolled	Fine Ground
Pigs per lot	28	28	28
Av. Daily Gain lbs.	1.09	1.21	1.50
Feed/head/day lbs.	3.6	3.4	4.1
Feed/lb. gain lbs.	3.3	2.8	2.7

TABLE 2 - RESULTS OF PHASE II
100 to 200 pounds

	Feeding Method		
	Automatic 4 times per day		Self-fed
	Fine Ground	Coarse Rolled	Fine Ground
Pigs per lot	28	28	28
Av. Daily Gain lbs.	1.25	1.20	1.51
Feed/head/day lbs.	4.7	4.6	5.5
Feed/lb. gain lbs.	3.8	3.8	3.7
B. F. Probe in.	1.06	1.01	1.14

Feed required per pound of gain was slightly greater for the limit fed pigs than for pigs on the self-feeder.

Average backfat probes taken on a sample from each lot indicated a slight reduction in fatness but since the full fed pigs had little fat the reduction in backfat would not have improved carcass grade and might have been detrimental.

There were no differences in performance between the pigs limit fed rolled or ground corn.

Project 237

EFFECT OF LEVEL OF NUTRITION ON REPRODUCTION IN BEEF HEIFERS

James E. Blakely, G. B. Thompson, C. E. Stufflebeam, J. R. Brooks and J. F. Lasley

Summary

Restricting total feed intake seriously affected reproductive efficiency in beef heifers. Some of the effects were slow growth and development, irregular or no heat periods, "quiet ovulation" and improper thyroid function. All heifers fed the restricted energy level (4.25 pounds TDN per head daily) for 4 months prior to breeding failed to reproduce. The cause of a failure to reproduce may involve various hormones from the pituitary or "master gland" of the body located at the base of the brain. Biological assays indicated no differences in follicle stimulating hormone (FSH) and leutenizing hormone (LH) levels of the pituitaries of heifers fed the different energy levels.

Procedure

Three groups of Hereford heifers (16 heifers per group) were wintered at three planes of nutrition from October 15, 1962, to May 27, 1963 (224 days). The rations were adequate in protein and high (12.65 pounds TDN), medium (9.66 pounds TDN) and low (4.24 pounds TDN) in energy. The heifers were bred by natural service after 4 months on the experiment. Observations were made on heat periods and number of services per heifer. Pregnancy was determined by rectal palpation.

Thyroid secretion rates (TSR) and various blood components were determined at three intervals during the experiment. Half of each group was sacrificed at the end of the trial and slaughter data were obtained. The pituitary or "master gland" was assayed for follicle stimulating hormone (FSH) and leutenizing hormone (LH) which are believed to be responsible for development and ovulation of the egg.

Results

Average daily rates of gain for high and medium TDN level heifers were 1.50 and 0.73 pounds respectively. The low plane heifers lost 0.29 pound per day.

Table 1 illustrates the feed consumption and estimated cost of wintering heifers in this manner. Although feed costs can be reduced considerably by the low level of feeding, the results in Table 2 show the disastrous results. Though all heifers were showing evidence of heat cycles at the beginning of the trial, most of the heifers on the low level gradually ceased to have a cycle. Two heifers did not show signs of heat at the time of breeding but did accept the bull. However, only one of the heifers became pregnant. No advantage in reproduction could be attributed to the high level of nutrition compared with the medium and costs were 10¢ per head per day higher than in the medium group.

TABLE 1 - FEED INTAKE AND ESTIMATED COST/DAY

	High	Medium	Low
Ground Ear Corn (lb.)	6.40	4.99	---
Soybean Meal (lb.)	1.49	1.50	1.50
Corn Silage (lb.)	38.89	---	---
Timothy Hay (lb.)	.50	10.95	7.00
Total (Air Dry) Feed	21.35	17.44	8.50
Cost/Head/Day (cents)	31.3	22.6	10.9

Estimated cost used for these calculations were:

Corn $1.00/bu
Soybean meal $4.00 cwt.
Corn Silage $7.00/TON
Hay $14.00/TON

TABLE 2 - BREEDING AND CONCEPTION

	High	Medium	Low
No. of Heifers	16	16	16
No. bred	16	15	2
No. conceived	15	14	1
Avg. Service Per conception	1.18	1.20	1.0

Thyroid secretion rates were affected significantly by feed intake during the trial which may indicate that it plays a part in reproductive failure. Table 3 shows the thyroid secretion rates for November, February, and May.

The major effect of the level of feeding on blood constituents was on cholsterol. High intake caused higher cholesterol levels and low intake cause lower cholesterol levels, compared to the medium intake.

Reproductive tract and ovary weights of heifers indicated no real differences between the high and medium groups. The low group had very small reproductive tracts and ovaries. The pituitaries were assayed for FSH and IH; results showed no difference in absolute concentration (when adjusted for size of gland). A possible explanation for a failure of most low level heifers to reproduce is found in the theory that the two hormones, FSH and LH, are stored in the pituitary but are not released. It is possible that the release mechanism is involved with secretions from other endocrine glands such as the ovary and thyroid.

TABLE 3 - AVERAGE THYROID SECRETION RATES
(Milligrams Thyroxine/100 lb. Body Weight)

	High	Medium	Low
November	.22	.20	.12
February	.23	.19	.18
May	.23	.23	.22

Project 237

EFFECTS OF ENERGY LEVELS IN WINTERING AND FINISHING BEEF RATIONS WITH EMPHASIS ON CARCASS DESIRABILITY

G. B. Thompson, H. B. Hedrick, R. L. Preston, R. R. Freitag and A. J. Dyer

Summary

Various systems of management were employed to produce 1000 pound slaughter cattle beginning with forty-eight 400 pound good and choice Hereford calves. The feeding plan during the wintering phase compared a full feed of corn silage (low energy level), a full feed of corn silage plus 5 pounds of grain (medium energy level), and a full feed of grain plus 12 pounds of corn silage (high energy level).

The feeding plan during the finishing phase was to feed half of the steers from each wintering treatment a full feed of grain and the other half 80 percent of a full feed of grain.

Under the conditions of this experiment the following was concluded:

1. All management systems employed produced desirable carcasses economically.

2. Full feeding corn silage for 151 days followed by a 116 day finishing period produced carcasses with a higher yield of retail cuts than more liberal winter feeding.

3. Addition of five pounds of grain per head daily to steers full fed corn silage increased carcass grades slightly but did not improve feed efficiency.

4. Full feeding grain immediately to finish 400 pound steer calves produced higher grading carcasses with less time on feed and required less TDN per pound of gain to produce choice 1000 pound steers than did the deferred systems. However, this system also resulted in greatest external finish and lowest retail yield.

5. Limiting grain fed to approximately 80% of a full feed during the finishing period increased feed required per unit gain, decreased carcass grades and increased retail yield.

6. With feed costs used in calculating these results, the management system producing the gains at least cost was a full feed of corn silage during the 151 day winter period followed by a 116 day full feed of grain.

Previous work at the University of Missouri has emphasized the importance of wintering level of nutrition on feedlot performance and carcass desirability in beef feeding programs. Most beef feeders have adopted a wintering ration containing corn silage as the chief source of energy. Since both stalk and grain provide sources of energy in corn silage, the economy in employing such programs is well recognized by most feeders. To increase daily gain, some feeders add more corn to their corn silage rations.

Procedure

Forty-eight Good and Choice 400 pound Hereford steer calves were divided into 3 groups and fed one of the following wintering rations:

1. Full fed high moisture corn, 12 pounds of corn silage, and 1.5 pounds of soybean meal.

2. Five pounds of high moisture corn, full fed corn silage, and 1.5 pounds of soybean meal.

3. Full fed corn silage and 1.5 pounds of soybean meal.

Following the 151 day wintering period, all steers were implanted with 30 mg. of stilbestrol and started on a finishing ration. The finishing ration consisted of corn and cob meal, 1.5 pounds of soybean meal, and orchard grass hay. Each winter group was divided into two lots of 8 steers each. The feeding plan was to feed one group of 8 steers from each wintering treatment a full feed of corn and cob meal and the other group a limited amount of grain. Limit-fed cattle received approximately 80% of a full feed of grain.

During both periods, the steers had free access to a mineral mixture of steam bone meal and salt. Vitamin A supplement was incorporated in the soybean meal at the rate of 10,000 IU per pound.

After each steer gained a total of 550 pounds during the combined wintering and finishing periods, it was slaughtered at the University of Missouri slaughtering plant and detailed carcass data were obtained.

TABLE 1 - PERFORMANCE OF STEERS DURING THE WINTERING PERIOD (151 DAYS)

	Treatment During Winter Phase		
	High	Medium	Low
Number of Steers	16	16	16
Avg. Initial Weight (lbs.)	393	406	395
Avg. Final Weight (lbs.)	743	685	601
Avg. Daily Gain (lbs.)	2.30	1.84	1.40
Daily Ration Consumed (lbs.)			
High Moisture Shelled Corn	11.1	4.8	---
Corn Silage	11.8	25.6	32.5
SBM	1.5	1.5	1.5
Feed per 100 pounds gain (lbs.)			
High Moisture Shelled Corn	482(434)	256(230)	---
Corn Silage	513(176)	1391(480)	2314(798)
SBM	65	82	107
Total Feed per 100 Pound Gain (lbs.)*	675	792	904
TDN per pound of Gain	4.3	4.6	4.8

* Figured on an 87% dry matter basis - figures in parenthesis refer to the weight on 87% dry matter basis.

TABLE 2 - PERFORMANCE OF STEERS DURING FINISHING PHASE

	Treatment*					
	HF	HL	MF	ML	LF	LL
Number of Steers	8	8	8	8	8	8
Avg. Days on Feed	80	97	113	115	116	147
Avg. Daily Gains (lbs.)	2.70	2.41	2.75	2.40	3.14	2.45
Daily Ration Consumed (lbs.)						
Ground Ear Corn	17.5	14.6	18.2	14.0	19.6	14.2
Soybean Meal	1.5	1.5	1.5	1.5	1.5	1.5
Hay - Orchard Grass	1.4	3.7	1.4	5.2	1.6	5.0
Feed Per 100 Pound Gain						
Ground Ear Corn	648.0	608.8	660.7	582.4	623.3	579.36
Soybean Meal	55.5	62.6	54.4	62.4	47.7	61.2
Hay - Orchard Grass	51.84	154.3	50.8	216.3	50.9	204.0
Total Feed/100 Pounds Gain	755.3	825.7	765.9	861.1	721.6	844.6
TDN Per Pound of Gain (lbs.) (Finishing)	5.5	5.7	5.5	5.8	5.3	5.8
TDN Per Pound of Gain (lbs.) (Wintering and Finishing)	4.8	5.0	5.3	5.2	5.2	5.6

* Treatment: H -- high energy (winter), M -- medium energy (winter), L -- low energy (winter), F -- full fed (finishing), L -- limited fed (finishing).

TABLE 3 - STEER CARCASS EVALUATION BY TREATMENTS

	Treatment*					
	HF	HL	MF	ML	LF	LL
Number of Carcasses	8	7	8	8	8	8
Chilled Carcass Weight	574	556	569	540	528	535
Dressing Percentage	59.7	59.0	58.2	57.0	56.0	56.3
Marbling Score**	6.0	5.75	5.00	4.5	4.6	3.9
Conformation Score†	19.3	18.9	19.3	19.4	19.0	19.0
Final Grade	20.0	19.4	18.6	18.4	18.1	16.9
Ribeye Area (sq. in.)	9.44	9.48	10.25	9.93	8.84	9.22
Ribeye Area/cwt. carcass (sq. in.)	1.64	1.70	1.80	1.84	1.67	1.72
Percent Ether Extract	6.14	5.69	4.53	3.80	4.12	3.26
Percent Retail Yield of Carcass	68.9	70.8	72.9	74.2	73.0	74.8

*Treatment: H -- high energy (winter), M -- medium energy (winter), L - low energy (winter), F -- full fed (finishing), L -- limited fed (finishing).
**Marbling Score: 3 - traces, 4 - slight, 5 - small, 6 - modest, 7 - moderate.
†Conformation Score and Carcass Grade: 20 -- Average Choice, 19 -- Low Choice, 18 -- High Good, 17 -- Average Good, 16 -- Low Good.

Costs of gains:

Costs of gains were calculated using the following feed prices:

Corn Silage	$ 8.00 per ton
Soybean meal	$95.00 per ton
Corn	1.20 per bushel
Hay	16.00 per ton
Grinding	4.00 per ton

FEED COST PER 100 POUND GAIN

	Treatments*					
	HF	HL	MF	ML	LF	LL
Winter Phase	$15.39		$14.89		$14.34	
Finishing Phase	15.10	15.53	15.28	15.54	14.30	15.35
Combined	15.28	15.45	15.10	15.21	14.31	14.98

*Treatment: H -- high energy (winter), M -- medium energy (winter), L - low energy (winter), F -- full fed (finishing), L -- limited fed (finishing).

Project 237

SUPPLYING VITAMIN A TO BEEF CATTLE IN SALT

G. B. Thompson and Wayne Loch

Eighteen 530-pound beef calves were fed a finishing ration low in carotene for 120 days to evaluate a technique of feeding vitamin A in salt. Half of the calves received 15,000 IU of stabilized gelatinized vitamin A palmitate per head daily in protein supplement. The other calves received a salt mixture containing 15,000 IU of vitamin A per ounce of salt.

Gain, feed efficiency, and carcass grades were similar for the two lots. Liver vitamin A values taken at the end of the feeding period were slightly higher for the calves receiving vitamin A in the supplement. This difference was not significant.

No symptoms of vitamin A deficiency were observed in any animals during the trial. Although fairly rapid loss of vitamin A activity (25% in 7 days) occurred in the salt mixture, the results indicate salt vitamin A mixture may be used to supply vitamin A to beef cattle. Care should be taken to protect the mixture from weather and a fresh mixture of the vitamin A salt mixture should be supplied weekly.

The thirteen heifer and five steer calves were divided into two groups and fed the finishing ration for 120 days (January 11, 1963 to May 11, 1964). The vitamin A salt mixture fed to half of the calves contained 15,000 IU of vitamin A per ounce of loose salt. Calcium sterate (0.25%) was added to the salt to reduce moisture build-up. A fresh supply of the salt vitamin A mixture was added weekly. In the other lot, the protein supplement was mixed to provide 15,000 IU of vitamin A per head daily. The same gelatinized stabilized vitamin A palmitate was used in both mixtures.

Results of the feeding trial are summarized in the following table.

	Lot I Vitamin A in Supplement	Lot II Vitamin A in Salt
No. head	9	9
Initial wt. (lbs.)	533	529
Final wt. (lbs.)	795	795
Gain per steers (lbs.)	262	266
ADG	2.19	2.21
Feed per cent gain	888	865
Carotene intake mg. per head daily (1)	13.0	12.9
Vitamin A intake per head daily (IU)	15,000	10,000
Daily Ration (lbs.)		
Ground Ear Corn	17.1	16.8
Supplement	1.5	1.5
Grass Hay	0.81	0.76
Salt	0.023	---
Salt and Vitamin A	---	0.5
Liver Vitamin A IU/gm. fresh liver		
average	78.6	49.3
range	14-174	8-95
Carcass grades		
Choice	6	5
Good	3	2
Std.	---	2

(1) Calculation based on analysis of feedstuffs as fed.

The retention of vitamin A activity in the salt mixtures was determined by taking weekly samples from an all weather mineral box placed out side. Cattle were not permitted access to this mixture. The results were as follows.

Week	Vitamin A IU/oz. salt	Moisture %	% activity retained
0	15,000	--	--
1	11,000	0.4	73.3
2	7,800	1.1	52.0
3	6,000	0.1	40.0
4	3,850	0.34	25.6

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2. Hardy Salt Company, St. Louis, Mo., for salt.