

KENTUCKY ANIMAL SCIENCE RESEARCH REPORTS

JULY
1966



PROGRAM FOR 1966 ANNUAL LIVESTOCK FIELD DAY

LEXINGTON

July 13, 1966

Morning

Chairman -- C. Frank Buck

Coldstream Farm -- Conducted tours showing beef, sheep and swine research will start at regular intervals, beginning at 9 a.m. (EST). Last tour starts at 10 a.m.

Noon

Lunch

Courtesy of Bluegrass Stockyards,
Lexington

PRINCETON

July 15, 1966

Morning

Chairman -- Paul P. Appel

Livestock Farm West Kentucky Substation. Conducted tours showing beef and swine research will start at regular intervals beginning at 9 a.m. (CST). Last tour starts at 10 a.m.

Noon

Lunch

Courtesy of Field Packing Co.
and Owensboro Milling Co.,
Owensboro

Afternoon

Chairman -- W. P. Garrigus

1:15 Address -- "The Stockmen's Future"

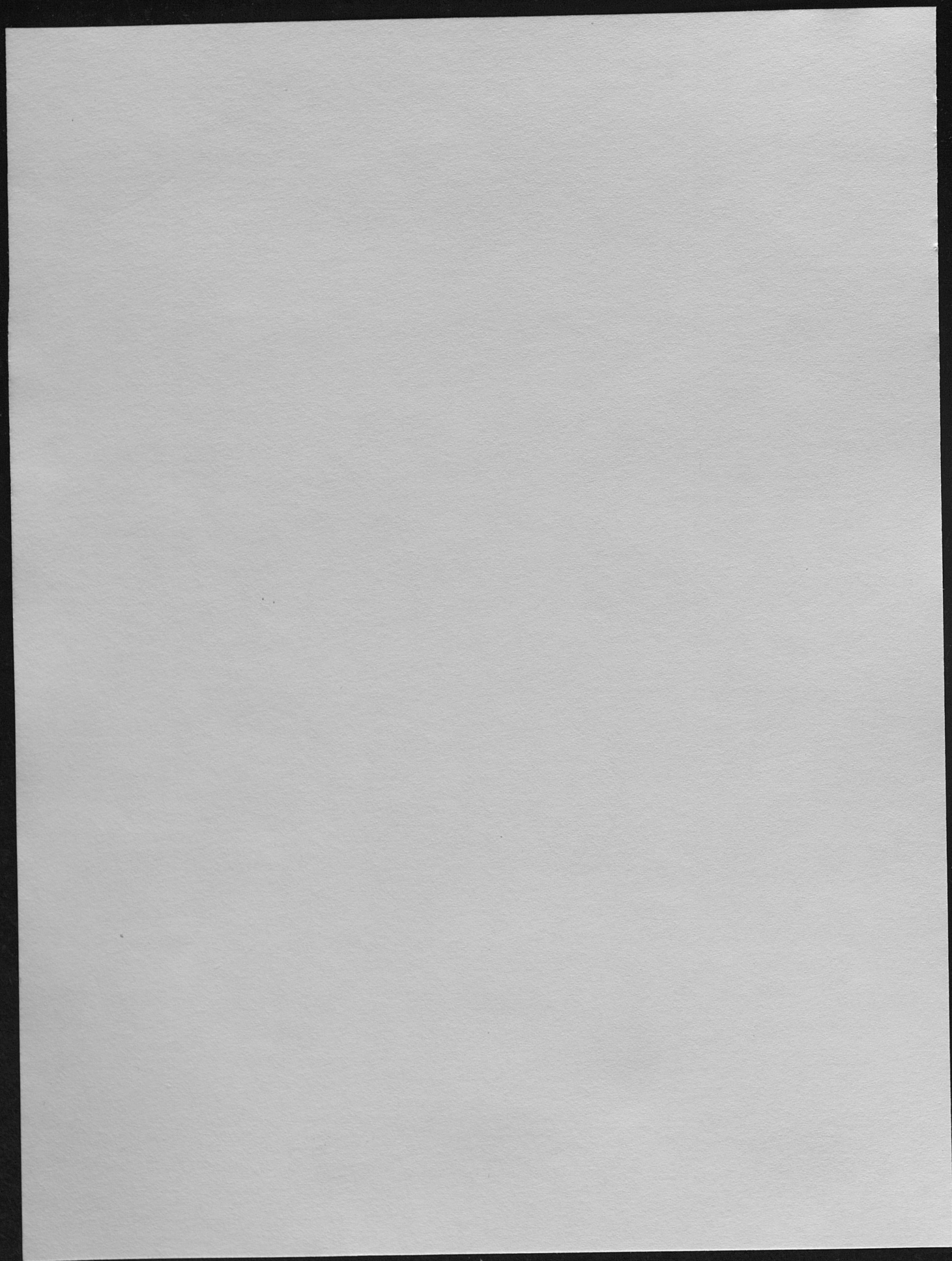
Charles S. Hobbs, Chairman
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University of Tennessee

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AGRICULTURAL EXPERIMENT STATION



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BEEF CATTLE SECTION

TYLOSIN FOR BEEF STEERS ON PASTURE WITH OBSERVATIONS ON THE PHYSICAL DECAY AND RELEASE RATE OF TYLOSIN BOLUSES

D. B. Herd, N. W. Bradley, D. E. McKechnie and D. R. Lovell

Growth responses have previously been reported (1962, 1963 and 1964) for grazing steers receiving tylosin from sustained release boluses. Boluses were expected to release the antibiotic over a 6-week period of time, but previous patterns in the gain response and a limited number of ruminal fluid tylosin assays suggested a shorter release period.

The following series of trials was conducted to (1) substantiate or disprove that tylosin does produce a growth response in grazing steers and (2) obtain more information on the physical decay rate and antibiotic release rate of tylosin boluses.

Trial 1

Seventy Angus steers were randomly divided into two groups, one group serving as a control and the other group receiving two tylosin boluses initially and also at 42-day intervals during the trial. Each bolus weighed 64 g and contained 5.6 g of tylosin per bolus as tylosin phosphate. Each steer was implanted with 12 mg of diethylstilbestrol. The steers grazed on mixed grass and legume pastures. Weights were taken every 2 weeks during the trial after a 14-hour shrink off pasture and water. Strained ruminal fluid samples were taken at 2, 4 and 6 weeks after bolusing during the last two of the three bolusing periods for tylosin assays.

Steer performance is summarized in Table 1. Steers receiving tylosin boluses gained 0.08 lb, or 13% faster than control steers. As with previous trials, a definite pattern was observed in the response of steers to tylosin boluses as shown in Table 2. Tylosin produced 0.23 lb increased in daily gain the first 2 weeks after bolusing while responses from 14 to 28 and 28 to 42 days were less pronounced.

Table 1. ---Effect of Tylosin Boluses on Average Daily Gain of Grazing Steers

	Control	Tylosin ^{a/}
Number of steers	35	35
Initial weight, lb	467	469
Final weight, lb	545	556
Total gain, lb	78	87
Total ADG, lb	0.61	0.69

^{a/} Tylosin boluses (two boluses per steer) were administered at the beginning and at 42-day intervals during the trial.

Analysis of the ruminal fluid samples (summarized in Table 3) revealed that tylosin was present in significant amounts in a majority of the steers at 2 weeks after bolusing but not at 4 or 6 weeks after bolusing.

Table 2. ---Average Daily Gain of Steers at Different Times After Bolusing

	Time After Bolusing					
	0-14 Days		14-28 Days		28-42 Days	
	Ca/	Tb/	Ca/	Tb/	Ca/	Tb/
	lb	lb	lb	lb	lb	lb
First two boluses	0.91	1.17	1.93	1.68	0.32	0.40
Second two boluses	1.57	2.02	-1.51	-1.62	1.93	2.17
Third two boluses	<u>1.11</u>	<u>1.09</u>	<u>-0.43</u>	<u>-0.43</u>	<u>-0.31</u>	<u>-0.31</u>
Average	1.20	1.43	0.00	-0.12	0.65	0.75
Difference (T-C)		+0.23		-0.12		+0.10

a/ Control.

b/ Tylosin at 42-day intervals.

Table 3. ---Concentration of Tylosin in the Ruminal Fluid at Different Times After Bolusing

	Time After Bolusing		
	2 Weeks	4 Weeks	6 Weeks
% of steers showing tylosin activity	100	9	6
Average level of tylosin, mcg/ml ^{a/}	4.3	0.6	0.4
Range of tylosin level, mcg/ml	1.3 to 8.4	0 to 2.1	0 to .6

a/ The tylosin assay was sensitive to levels of 0.2 mcg/ml or more. Anything less was considered 0. Only values from steers showing tylosin activity are included in the averages.

Trial 2

Sixty yearling Hereford steers were randomly divided into three groups. One group served as a control while groups two and three received 70 and 250 mg of tylosin per steer daily, respectively. Each steer had been implanted with 36 mg of diethylstilbestrol 2 months prior to the start of the trial. Each group of steers was group-fed one pound of finely ground shelled corn per steer daily as a carrier for the antibiotic. Tylosin was in the form of tylosin phosphate.

The steers were grazed on three 20-acre bluegrass-white clover pastures with the steers being rotated on the pastures at frequent intervals to reduce pasture effects. Initial and final weights were taken after a 14-hour shrink off pasture and water, while 14-day weights were taken with no shrink.

Strained ruminal fluid samples were taken from treated steers at 2, 4, 6, 8, 10 and 12 weeks 24 hours after tylosin feeding with no shrink. Samples were also taken at the end of the trial 24 hours after feeding but with the steers having been off pasture and water for the last 14 hours.

Steer performance is summarized in Table 4. Feeding 70 mg of tylosin per steer daily increased daily gain 8%, but feeding 250 mg decreased daily gain by 9%. These

differences were not statistically significant, and no pattern was observed in daily gain as noted in the bolus trials.

Table 4. ---Response of Hereford Steers on Pasture to a Constant Daily Level of Tylosin^{a/}

	Control	70 Mg Tylosin ^{b/}	250 Mg Tylosin ^{c/}
Number of steers	20	20	20
Initial weight, lb	524	524	522
Final weight, lb	657	668	644
Total gain, lb	133	144	122
Total ADG, lb	0.87	0.94	0.79

^{a/} Steers on each treatment were group-fed once a day 1 lb of finely ground shelled corn per steer.

^{b/} Each pound of corn contained 70 mg of tylosin.

^{c/} Each pound of corn contained 250 mg of tylosin.

Results of the ruminal fluid assays are summarized in Table 5. Few of the steers receiving 70 mg of tylosin showed any antibiotic in the ruminal fluid until the last sampling at 22 weeks. Samples may have been too diluted for tylosin detection as steers were sampled in a full condition directly off the pastures 24 hours after feeding tylosin. At 22 weeks when the steers were shrunk before sampling and ruminal contents may not have been so diluted, 75% of the steers receiving 70 mg of tylosin daily showed tylosin activity in the ruminal fluid. It may also be noted that the concentration of tylosin in the ruminal fluid and the percentage of steers showing activity on the high level of tylosin intake also increased at 22 weeks.

Table 5. ---Concentration of Tylosin in the Ruminal Fluid of Steers Receiving a Constant Daily Intake of Tylosin

Time	70 mg Tylosin ^{a/}		250 mg Tylosin ^{b/}	
	Concentration ^{c/}	% of Steers ^{d/}	Concentration ^{c/}	% of Steers ^{d/}
2 weeks	0.3	15	0.6	35
4 weeks	0.0	0	0.4	45
6 weeks	0.3	5	0.6	60
8 weeks	0.0	0	0.5	30
10 weeks	0.0	0	0.5	75
12 weeks	0.0	0	0.4	75
22 weeks	0.4	75	1.2	100

^{a/} Steers were group-fed 70 mg of tylosin per steer daily.

^{b/} Steers were group-fed 250 mg of tylosin per steer daily.

^{c/} Concentration of tylosin in mcg/ml of ruminal fluid.

^{d/} The % of steers showing tylosin activity at each time period. The assay for tylosin was sensitive to 0.2 mcg/ml of ruminal fluid and anything below this level was considered as 0.

Trial 3

Thirty Angus steers were each given two tylosin boluses on day one of the trial and were grazed on Bluegrass pastures. The steers were randomly divided, after blocking for weight, into six groups of five steers each. Bolus recoveries were made on a group of steers at 1, 2 and 3 weeks after bolusing. Strained ruminal fluid samples were taken at 1, 2, 3, 4, 5 and 6 weeks from all steers from which bolus recoveries had not been conducted. Steers were held off pasture and water for 14 hours before sampling. Boluses were recovered by rumenotomy technique at week one and week two, while the steers were killed at 3 weeks. The entire ruminal contents were suspended in cool water where even the smallest bolus pieces settled out for recovery.

Tylosin boluses remained physically stable for a period of less than 3 weeks as evidenced by the small number of boluses recovered and the low percentage of steers showing tylosin in the ruminal fluid at this time. Physical bolus decay was minimal during the first week after bolusing, but by 2 weeks complete decay was observed for some boluses and for most boluses by 3 weeks. At 2 weeks several extremely high values (10 to 12 mcg/ml) were observed in the ruminal fluid of some individual steers. Boluses may have undergone gradual physical decay up to a point where complete disintegration took place, releasing all remaining tylosin and thereby greatly elevating ruminal fluid concentrations of tylosin. Boluses released 30% of the tylosin by the end of one week and 55% by the end of 2 weeks. After 2 weeks the majority of boluses underwent complete physical decay releasing all tylosin remaining in the boluses.

Summary

Analysis of the data from all growth trials, 1962 through 1966, in which tylosin boluses were studied revealed a significant ($P < .005$) 10.4% increase in average daily gain of treated steers (1.48 lb) over control steers (1.34 lb). The response has been in addition to that provided from stilbestrol. The response has ranged from a low of 5.1% to a high increase of 21.1% in the five trials analyzed involving 211 steers. The response in daily gain from tylosin has come in all trials during the first 2 weeks after bolusing (+0.39 lb) with less pronounced effects from 14 to 28 days (-0.07 lb) and 28 to 42 days (+0.07 lb). Each steer was receiving roughly 400 to 500 mg of tylosin daily from the boluses in Trial 1 during the first 2 weeks after bolusing when growth stimulation was greatest. In trials previous to 1966 only one bolus was given per steer, and values might be expected in the range of 200 to 250 mg of tylosin per steer daily.

The gain response pattern appears to be dependent on the release rate and physical decay of the tylosin boluses. A tylosin inhibitor does not appear likely as a cause of the response pattern. Tylosin was present in the ruminal fluid 24 hours after feeding in the steers of Trial 2 which had received tylosin daily for 154 days.

The decay rate of the boluses did not seem to be hastened by the presence of two boluses in the rumen as studies with single boluses in fistulated steers indicated complete decay within 2 to 3 weeks in the majority of observations.

The depression in rate of gain observed in Trial 2, where steers received a constant 250 mg of tylosin per steer daily, is not consistent with the increased gain observed with tylosin boluses during the period of high tylosin release. The inconsistency in gain responses may be due to random variation as the depression in gain from 250 mg of tylosin in Trial 2 was not statistically significant. When a constant daily intake of tylosin was obtained, as in Trial 2, a level of 70 mg of tylosin per steer daily produced more favorable responses in daily gain. Further study may be needed on the alternate use of tylosin and the level of tylosin to provide.

Table 6. ---Effect of Time on Tylosin Boluses and Levels of Tylosin in Ruminal Fluid

	Time After Bolusing In Weeks					
	1	2	3	4	5	6
No. of steers boluses recovered from						
Total No. boluses given ^a	5	5	5	5	5	5
Total No. boluses recovered	10	10	10	10	10	10
Average weight of recovered boluses, g	10	6b/	$\frac{1}{2}$ c/	d/	—	—
Average % of tylosin remaining/bolus	60	48	29	d/	—	—
	70	45	13	d/	—	—
Number of steer ruminal sampled.						
% of steers showing tylosin activity in ruminal fluid	30	25	20	15	15	15
Average concentration of tylosin in mcg/ml of ruminal fluid in the steers showing activity. ^e	100	80	20	7	0	0
	2.2	4.8	1.4	0.4	0	0

a/ Tylosin boluses weighed 64 g and contained 5.6 g of tylosin.

b/ The six boluses were recovered from three steers. One steer had 4.1 g of bolus chips, while nothing could be recovered in one steer.

c/ In addition to the steer with the half bolus, one steer had 2.6 g and another steer had 2.7 g of bolus chips. Nothing could be recovered from the two remaining steers.

d/ Bolus recoveries were not attempted after 3 weeks.

e/ The tylosin assay was sensitive to levels of 0.2 mcg/ml or above. Anything less was considered as 0.

TWO LEVELS OF CORN AND CORN SILAGE WITH AND WITHOUT TYLOSIN FOR PRODUCING CHOICE BEEF

D. B. Herd, N. W. Bradley and D. E. McKechnie

It was reported in 1965 by the Kentucky station that choice beef could be produced when feeding ground shelled corn at levels of 1.5, 1.0 and 0.5% of the cattle's body weight with corn silage fed free choice. Surprisingly, during a 125-day feeding period, the steers receiving the low level of corn graded the same as those on the higher levels of corn. All steers graded choice.

Since the cost of gains generally decreases with increasing levels of corn silage in a ration, it seemed desirable to obtain more information on optimum levels of corn and corn silage for producing choice beef in a feeding period of from 100 to 150 days. The antibiotic tylosin was also tested in view of the small but consistent responses observed in grazing steers by this station.

One hundred and twenty yearling Angus steers in medium flesh were randomly allotted to 12 lots after blocking on the basis of weight. Each steer was initially implanted with 24 mg of diethylstilbestrol. Steers were individually weighed on and off the experiment after a 24-hour shrink off feed and water.

The following treatments were employed with two lots of steers receiving each treatment:

1. Low corn - no tylosin
2. Low corn - 20 mg of tylosin/steer daily
3. Low corn - 250 mg of tylosin/steer daily
4. High corn - no tylosin
5. High corn - 70 mg of tylosin/steer daily
6. High corn - 250 mg of tylosin/steer daily

For the low-corn rations, ground shelled corn was fed at a level of 0.75% of the cattle's body weight. For the high-corn rations, ground shelled corn was fed at a level of 1.5% of the cattle's body weight. Steers received all the corn silage they would consume in addition to the ground shelled corn.

Tylosin was supplied in the form of tylosin phosphate, and fed in the protein supplement. Soybean meal was used to balance all rations for crude protein according to recommendations of the National Research Council. All steers received 30,000 I. U. of vitamin A daily in the protein supplement and had salt, bonemeal and water before them at all times for free-choice consumption.

The data were analyzed by analysis of variance for a 2 x 3 factorial arrangement of treatments considering in addition replication and blocking.

Results and Discussion

The effect of level of corn on steer performance and carcass characteristics is summarized in Table 1. Steers receiving the high level of corn gained 0.15 lb more daily ($P < .01$) than did steers receiving the low level of corn. Air-dry feed intake was essentially the same, while efficiency of gain favored slightly the faster gaining steers. Steers fed the low level of corn put on cheaper gains but steers receiving the high level of

corn put on more gain which sold for more money. Advantages in carcass weight, dressing percent, marbling score, carcass conformation grade and carcass grade resulted in a higher selling price for steers fed the high level of corn when sold on a grade and yield basis. The low level of corn feeding produced carcasses with less kidney fat and fat over the rib but had no effect on rib eye area per cwt. of carcass.

Table 1. ---Effect of Level of Corn on Steer Performance and Carcass Qualities

	Low Corn ^{a/}	High Corn ^{b/}
Number of steers	60	60
Initial weight, lb	661	661
Final weight, lb	948	970
Total gain, lb	287	309
ADG, lb	1.87	2.02**
Feed/cwt gain, lb ^{c/}	961	935
<u>Feed consumption</u>		
Corn, lb	5.9	11.5
Corn silage, lb	29.3	17.7
Soybean meal, lb	2.05	1.69
<u>Costs and prices</u>		
Feed cost/cwt gain, \$ ^{d/}	18.02	19.80
Selling price/cwt, \$ ^{e/}	25.61	26.05
<u>Carcass Data</u>		
Cold carcass weight, lb	590	612**
Dressing %	62.2	63.1
Carcass conformation grade ^{f/}	13.7	14.3*
Carcass grade ^{f/}	12.9	13.3
Marbling ^{g/}	6.2	6.5
Maturity ^{h/}	1.6	1.8
Kidney fat, %	2.7	3.0
Fat thickness over rib, in.	0.62	0.70
Rib-eye area, sq. in.	11.81	12.13
Rib-eye/cwt carcass, sq. in.	2.01	1.98

^{a/} Ground shelled corn was fed at 0.75% of body weight and corn silage to appetite.

^{b/} Ground shelled corn was fed at 1.5% of body weight and corn silage to appetite.

^{c/} Corn silage is expressed on an air-dry basis.

^{d/} Feed costs calculated from the following: corn at \$1.25/bushel, corn silage at \$8/ton and soybean meal at \$85/ton.

^{e/} Price per cwt. of live weight on grade-yield basis.

^{f/} Grade on scale of 12 = low choice, 13 = medium choice and 14 = high choice.

^{g/} Marbling on scale of 6 = modest and 7 = moderate.

^{h/} Maturity on scale of 1 = A- and 2 = A.

** Statistical significance at $(P < .01)$

* Statistical significance at $(P < .05)$

In terms of net returns, both systems of feeding were about equal. The low-corn system produced cheaper gains, but the high-corn system produced improvements in selling price when selling on a grade and yield basis.

Probably the most significant finding was the production of choice beef on a minimum of corn with a corn silage ration. Differences in the cost and availability of feed stuffs and in future demands for lighter trimmer beef will all affect the choice of feeding systems.

The effect of tylosin on steer performance and carcass characteristics is summarized in Table 2. Both levels of tylosin feeding produced small improvements in average daily gain (5 to 7%), efficiency of gain (6 to 8%) and in the cost of gains (6 to 8%). It should be remembered that no charge was made for the tylosin. None of the carcass measures were significantly affected by tylosin feeding.

Table 2. ---Effect of Tylosin on Steer Performance and Carcass Qualities

	Control ^{a/}	70 mg Tylosin ^{a/}	250 mg Tylosin ^{a/}
Number of steers	40	40	40
Initial weight, lb	660	662	661
Final weight, lb	946	962	968
Total gain, lb	286	300	307
ADG, lb	1.87	1.96	2.00
Feed/cwt gain, lb ^{b/}	995	931	918
<u>Feed consumption</u>			
Corn, lb	8.8	8.7	8.7
Corn silage, lb	23.8	23.2	23.6
Soybean meal, lb	1.87	1.87	1.87
<u>Costs and prices</u>			
Feed cost/cwt gain, \$ ^{c/}	19.82	18.64	18.28
Selling price/cwt, \$ ^{d/}	25.80	25.82	25.86
<u>Carcass data</u>			
Cold carcass weight, lb	593	603	607
Dressing %	62.6	62.7	62.7
Carcass conformation grade ^{e/}	13.8	14.1	14.1
Carcass grade ^{e/}	13.2	13.0	13.1
Marbling ^{f/}	6.4	6.4	6.4
Maturity ^{g/}	1.6	1.8	1.8
Kidney fat, %	2.8	2.9	2.8
Fat thickness over rib, in.	0.60	0.69	0.69
Rib-eye area, sq. in.	11.84	12.03	12.03
Rib-eye/cwt carcass, sq. in.	2.00	2.00	1.99

^{a/} Tylosin was fed at a rate of 0, 70 or 250 mg per steer daily. One-half of the steers on each treatment received high-corn rations and one-half low-corn rations.

^{b/} Corn silage is expressed on an air-dry basis.

^{c/} Feed costs calculated from the following: corn at \$1.25/bushel, corn silage at \$8/ton and soybean meal at \$85/ton. No charge was made for tylosin as the product is still in the experimental stage for feeding cattle.

^{d/} Price per cwt of live weight on grade-yield basis.

^{e/} Grade on scale of 12 = low choice, 13 = medium choice, and 14 = high choice.

^{f/} Marbling on scale of 6 = modest, and 7 = moderate.

^{g/} Maturity on scale of 1 = A- and 2 = A.

UTILIZATION OF UREA AND FAT BY STEERS FED MEAL AND PELLETTED RATIONS

J. T. Thompson, N. W. Bradley and C. O. Little

Previous work at this station has indicated that the performance of fattening steers is decreased when combinations of urea and fat are fed in isocaloric feedlot rations. This experiment was designed to study further these combinations in both meal and pelleted rations. Data were also accumulated concerning the utilization of energy and nitrogen when urea, fat and fat plus urea were included in the ration.

Sixty Hereford steers averaging 740 lb each were allotted to six treatments in a 3 x 2 factorial arrangement. The factors were: ration—urea, fat and fat plus urea; and form—meal and pellet. The ration compositions and proximate analyses are given in Table 1.

During the 139-day feedlot trial ruminal samples were collected at 56 and 139 days. Volatile fatty acids (VFA), pH, total nitrogen, protein nitrogen, non-protein nitrogen, ammonia nitrogen, and non-protein non-ammonia nitrogen were determined. At the conclusion of the trial the animals were slaughtered and carcass data were collected.

A summary of the results of this experiment is given in Table 2. Steers fed the urea ration gained 1.91 lb daily, while those fed the fat ration gained 1.68 lb and steers fed fat plus urea gained 1.47 lb. Steers fed the rations in the meal form gained 1.61 lb daily and those fed the pelleted rations gained 1.79 lb. There were no differences in feed consumption due to the ration or its form. The large differences in feed efficiency were significant for both ration and form. Steers making the most rapid gains were more efficient in their feed conversion.

Steers fed the fat ration had greater dressing percentages than steers fed the urea or the fat plus urea rations. There were significant ration by form interactions affecting U.S. grade, fat over the rib-eye and marbling score. These ration by form subclass means are shown in Table 3. Steers fed the fat ration had increased carcass fat when the rations were pelleted compared with steers fed the meal rations. Steers fed the urea ration had decreased carcass fat, and steers fed the fat plus urea had about the same carcass fat percentage regardless of the ration form.

Steers fed the urea ration had a greater concentration of VFA, a lower percentage of acetate, a greater percentage of propionate, a lower percentage of iso-valerate, a lower acetate to propionate ratio and a lower ruminal pH than did steers fed either the fat ration or the fat plus urea ration. Steers fed urea had a greater percentage of normal valerate than steers fed fat plus urea. There were no differences in VFA due to the form of the ration.

The steers fed urea had greater concentrations of total nitrogen, protein nitrogen, non-protein nitrogen and non-ammonia non-protein nitrogen per gram of dry matter in their ruminal fluid than steers fed either fat or fat plus urea. Steers fed the fat ration had greater concentrations of total nitrogen and protein nitrogen than steers fed fat plus urea. Steers fed the pelleted ration had lower levels of non-protein nitrogen and ammonia nitrogen than the steers fed the meal rations.

Urea is now considered as a common nitrogen supplement for cattle and at times the use of animal fats in feedlot rations has been economical. The results of this experiment indicate that the simultaneous use of fat and urea should be avoided when there is considerable

Table 1. ---Ration Composition And Proximate Analysis of Rations

	Rations ^{a/}		
	Urea	Fat	Fat + Urea
<u>Composition</u>			
Corn cobs, %	29.3	54.0	53.9
Corn, %	57.8	18.9	27.1
Molasses, %	9.9	5.9	5.9
Urea, % ^{b/}	1.5	---	1.5
Fat, %	---	5.0	5.0
Sulfur, % ^{c/}	0.1	---	0.1
Soybean meal (44%), %	---	19.9	4.9
Salt, %	0.5	0.5	0.5
Trace mineral premix, % ^{d/}	0.05	0.05	0.05
Dicalcium phosphate, %	0.3	0.3	0.5
Limestone, %	0.5	0.5	0.5
Vitamin A premix, g ^{e/}	454	454	454
<u>Proximate analysis</u>			
Dry matter, %	89.0	89.8	89.2
Crude protein, %	9.8	9.3	9.9
Ether extract, %	3.4	5.2	6.2
Crude fiber, %	14.7	19.1	16.3
Ash, %	3.3	3.4	3.2
Nitrogen free extract, %	57.8	52.8	53.7
Gross energy, Kcal/g	4.47	4.76	4.68

^{a/} Each ration was prepared in both a meal and a pelleted form.

^{b/} Feed grade urea = 262% crude protein.

^{c/} Flowers of sulfur or sublimed sulfur.

^{d/} Trace mineral premix - calcium carbonate 42.37%; ferrous carbonate 42.70%; manganese sulfate 8.80%; copper carbonate 3.00%; zinc sulfate 1.22%; calcium iodate 0.48%; and cobalt carbonate 0.48%.

^{e/} Vitamin A potency 10,000 IU per gram or greater.

roughage in the ration. It appears that the addition of fat in isocaloric rations is detrimental to efficient urea utilization. In this experiment the isocaloric substitution of fat energy for corn energy also lowered gains and increased the feed required per unit of gain.

Although pelleting improved gains and feed efficiency, any economical appraisal of cost of gains must take into consideration the increased cost of the pelleted feed. Decreased feedlot gains were measured when the ruminal VFA concentrations were low, acetate to propionate ratio was high, and protein nitrogen in the ruminal fluid was low.

Table 2. ---Feedlot Performance, Carcass Data and Ruminal Sample Data of Steers Fed Fat and Urea in Meal and Pellet Form^{a/}

	Form		Ration		
	Meal	Pellet	Urea	Fat	Fat + Urea
<u>Feedlot Data</u>					
No. steers	30	30	20	20	20
Initial wt, lb	740	739	737	741	740
Final wt, lb	964	988	1009	976	944
ADG, lb	1.61	1.79 ^b	1.91 ^a	1.68 ^b	1.47 ^c
Feed Cons., lb	23.0	21.2	22.8	21.9	21.6
Feed/cwt gain, lb	1424 ^a	1229 ^b	1191 ^a	1336 ^b	1452 ^b
<u>Carcass Data</u>					
Carcass wt, lb	570	584	598 ^a	583 ^{ab}	550 ^b
Dressing %	61.2	61.5	61.6 ^a	62.3 ^a	60.1 ^b
U.S. grade ^{b, c}	10.7	10.6	11.2	10.6	10.2
Rib-eye area, sq. in.	10.4	10.6	10.7	10.4	10.4
Fat over rib-eye, in. ^b	0.47	0.50	0.48 ^{ab}	0.58 ^a	0.40 ^b
Kidney fat, %	2.4	2.5	2.4	2.6	2.3
Marbling score ^{b, c}	4.3	4.3	4.6 ^a	4.3 ^{ab}	4.0 ^b
<u>Ruminal Sample Data (Av 56 and 139 days)</u>					
Dry matter, %	4.50	4.33	5.18 ^a	4.20 ^b	3.87 ^c
pH	5.97	6.11	5.72 ^a	6.24 ^b	6.16 ^b
Total VFA, micromoles/ml.	80.6	73.5	95.1 ^a	71.1 ^b	75.9 ^b
C ₂ , molar %	63.9	65.5	56.6 ^a	68.2 ^b	69.4 ^b
C ₃ , molar %	23.3	23.0	30.9 ^a	19.3 ^b	19.2 ^b
C ₄ , molar %	10.2	9.0	10.0	9.9	9.0
i-C ₅ , molar %	1.7	1.4	1.2 ^a	1.8 ^a	1.7 ^b
n-C ₅ , molar %	1.0	1.0	1.4 ^a	1.0 ^{ab}	0.7 ^b
C ₂ :C ₃	2.74	2.85	1.83 ^a	3.53 ^b	3.61 ^b
mg N/g D.M.	80.7	80.3	89.9 ^a	79.8 ^b	71.8 ^c
mg protein N/g D.M.	71.2	71.6	79.9 ^a	71.3 ^b	63.0 ^c
mg NPN/g D.M.	10.3 ^a	8.7 ^b	10.0 ^a	8.4 ^b	8.8 ^b
mg ammonia N/g D.M.	7.3 ^a	5.9 ^b	6.3	6.4	7.2
mg non-ammonia NPN/g D.M.	2.0	2.8	3.7 ^a	2.0 ^b	1.6 ^b

^{a/} Means on the same line under the same major heading with different superscript letters are significantly different.

^{b/} A significant ration by form interaction was measured. For differences between subclass means see Table 3.

^{c/} 10 = av good; 11 = high good; 12 = low choice.

^{d/} 4 = slight; 5 = small.

Table 3. ---Ration by Form Subclass Means for Variables Affected by a Significant Ration by Form Interaction^{a/}

Characteristic	Meal-Urea	Pellet-Urea	Meal-Fat	Pellet-Fat	Meal-Fat + Urea	Pellet-Fat + Urea
U. S. grade ^{d/}	11.6 ^a	10.7 ^{abc}	10.0 ^b	11.2 ^{ac}	10.5 ^{bc}	10.0 ^b
Fat over rib-eye, in.	0.50 ^a	0.46 ^a	0.51 ^a	0.65 ^b	0.40 ^a	0.40 ^a
Marbling score ^{e/}	4.9 ^a	4.3 ^b	4.0 ^b	4.6 ^{ab}	4.0 ^b	4.0 ^b

^{a, b, c/} Means on the same line for the same characteristic with different superscript letters are significantly different.

^{d/} 10 = av good; 11 = high good; 12 = low choice.

^{e/} 4 = slight; 5 = small.

SOURCE OF NITROGEN FOR SUPPLEMENTING GROUND EAR CORN RATIONS - 1965

N. W. Bradley, J. Ralph Overfield and C. O. Little

Previous trials with ground ear corn rations have shown variable results from replacing one-half of the natural supplement with urea. In most cases steer gains have been somewhat depressed by using urea. Additions of trace minerals, alfalfa meal, molasses or complex supplements have not improved steer performance. Higher levels of urea are being used in refinishing rations, and it is possible that these ration additions would be more beneficial when no natural supplemental protein source is included in the ration.

One hundred and twenty yearling steers in average flesh and averaging about 800 pounds in weight were used in replicated lots of 10 steers each to evaluate the following treatments:

1. Ground ear corn + distillers dried grains with solubles (DDG/S)
2. Ground ear corn + urea
3. Ground ear corn + urea and molasses
4. Ground ear corn + urea + alfalfa meal
5. Ground ear corn + urea + DDG/S
6. Ground ear corn + urea + alfalfa meal + molasses

The urea in treatments 2 through 6 replaced all of the DDG/S of ration 1 on a protein-equivalent basis. Molasses, alfalfa meal and DDG/S (ration 5) were added to the various rations to supply 0.5 lb of the various ration additions per head daily. The complete composition of each of the rations is shown in Table 1.

All rations were fed to all lots of steers on a free-choice basis during a 124-day feeding period. Results of the feeding trial are given in Table 2.

Replacing all of the DDG/S with urea caused a reduction of 0.29 lb in average daily gain. Adding 0.5 lb of molasses per head daily to the urea ration restored 0.19 lb of the reduced rate of gain. A similar increase in rate of gain (0.14 lb/head daily) was measured when both alfalfa meal and molasses additions were made to the urea ration. However alfalfa meal alone or 0.5 lb of DDG/S per head daily had no beneficial effect when added to the urea ration.

Table 1. ---Composition of Rations (lb/ton)

Ingredient	Ration ^{a/}					
	1	2	3	4	5	6
Ground shelled corn	1,291	1,567	1,520	1,521	1,522	1,486
Ground corn cobs	323	379	379	380	381	371
DDG/S	359	---	---	---	45.4	---
Alfalfa meal	---	---	---	45.4	---	45.4
Molasses	---	---	45.4	---	---	45.4
Urea	---	27.3	28.3	26.4	24.6	25.4
Salt	20	20	20	20	20	20
Ground limestone	7.2	7.2	7.2	7.2	7.2	7.2
Trace mineral	0.5	0.5	0.5	0.5	0.5	0.5
Stabilized vitamin A	b	b	b	b	b	b

^{a/}1 - Distillers dried grains with solubles (DDG/S)

2 - Urea

3 - Urea plus molasses

4 - Urea plus alfalfa meal

5 - Urea plus DDG/S

6 - Urea plus alfalfa meal plus molasses

^{b/}Vitamin A was added to provide 30,000 IU per head per day.

It would appear that small additions of molasses to ear corn rations containing urea as the only source of supplemental nitrogen are more beneficial than when the ration contains supplemental nitrogen from a natural source. Steer performance was more severely depressed by replacing all of the nitrogen in the natural supplement with urea than in past experiments where only a part of the nitrogen in the natural supplement has been replaced with urea. The sometimes small but usual reduction in steer performance from additions of urea might warrant further examination of the economic feasibility of using urea rather than natural protein supplements in beef finishing rations.

Table 2. ---Steer Performance and Carcass Data

	Ration ^{a/}					
	1	2	3	4	5	6
<u>Feedlot Data:</u>						
No. steers	20	20	20	20	20	20
Initial wt, lb	799	798	796	800	799	800
Final wt, lb	1,107	1,070	1,092	1,071	1,078	1,090
Av. daily gain, lb	2.49	2.20	2.39	2.18	2.26	2.34
Feed/st/day, lb	25.5	26.0	27.1	25.7	25.4	27.0
Feed/100 lb gain, lb	1,025	1,184	1,137	1,176	1,127	1,157
<u>Carcass Data:</u>						
Slaughter wt, lb	1,077	1,034	1,064	1,043	1,046	1,053
Shrink in transit, lb	30	37	29	28	33	37
Cold carcass wt, lb	682	651	670	657	654	666
Cooler shrink, lb	9.7	9.5	9.2	9.6	9.7	9.9
Dressing %	63.3	63.0	63.0	63.0	62.5	63.3
Carcass grade ^{b/}	13.0	12.8	13.0	13.1	12.7	13.2
Carcass value, \$ ^{c/}	283.16	270.95	279.01	272.52	270.35	277.37

^{a/} 1 - Distillers dried grains with solubles (DDG/S)

2 - Urea

3 - Urea plus molasses

4 - Urea plus alfalfa meal

5 - Urea plus DDG/S

6 - Urea plus alfalfa meal plus molasses

^{b/} Low choice = 12; average choice = 13; high choice = 14.

^{c/} Carcass value determined on a grade and yield basis.

CONTROLLED ESTRUS IN FEEDLOT HEIFERS

A. W. Young, L. V. Cundiff and N. W. Bradley

It is generally accepted that animals showing less physical activity will gain more under feedlot conditions. One particular drawback to feeding heifers has been the occurrence of heat and consequent disturbances in the feedlot. The objectives of this experiment were to determine the minimum effective dose of MGA (17-acetoxy-6 methyl-16 methylenpregna-14, 6 diene, 3,20 dione) that would prevent estrus and to study the effect of the hormone on feedlot performance, carcass characteristics and reproductive organs.

In a randomized complete block design experiment, 80 good to choice Angus feeder heifers, averaging 625 lb, were fed 0, 0.20, 0.40 and 0.60 mg of MGA per head daily. The heifers were fed ground shelled corn at the rate of 11.7 lb per head daily and corn silage free choice. Soybean meal was fed at the rate of 1.5 lb per head daily and served as a carrier for the MGA. Vitamin A was added to give 15,000 IU per head daily. Shrunk weights were obtained both at the beginning and at the end of the 154-day feeding period. At the end of the feeding period, all heifers were slaughtered, reproductive tracts were examined, and carcass data were obtained.

The results of twice-a-day observations for heat are presented in Table 1. In this trial, the 0.40 mg level was the minimal effective dosage that successfully suppressed estrus. The 0.20 mg level was not completely effective in preventing estrus in feedlot heifers.

Table 1. ---Occurrence of Estrus in Feedlot Heifers Fed Varying Levels of MGA (154-days)

Level	Number of Heifers	Number Observed Showing Estrus			
		1 time	2 times	3 times	4 or more
0	20	19	18	16	13
0.20 mg	17	12	8	6	3
0.40 mg	20	3	0	0	0
0.60 mg	18	0	0	0	0

Feedlot performance in terms of total gain, average daily gain and feed per cwt gain was not affected significantly by treatment, as can be seen in Table 2. Heifers fed 0.20 mg per head daily of MGA showed a slight increase of 0.07 lb per head daily over the controls; however, none of the small differences in average daily gain were significant.

Fat thickness between the 12th and 13th rib was significantly increased ($P < .05$) owing to treatment. Control heifers had an average fat covering of 0.78 inch versus 0.79, 0.84 and 0.89 inch for the 0.20, 0.40 and 0.60 mg levels respectively. Other carcass data obtained, including dressing percentage, kidney fat percentage, marbling, carcass grade, rib-eye area and estimated percentage of retail cuts were not significantly affected by treatment. Although the heifers treated with MGA showed a significantly higher fat thickness over the rib, carcass conformation or grade was not significantly altered.

Significant changes were observed in the reproductive organs of the treated heifers. As can be seen in Table 2, heifers fed MGA had significantly ($P < .01$) heavier reproductive tracts. Ovarian weight was not significantly affected by treatment. Size of the largest follicle was significantly ($P < .01$) increased by MGA, with the controls having an average of 11.09 mm versus 16.63, 16.54 and 17.27 mm for the 0.20, 0.40 and 0.60 mg levels, respectively. Follicular fluid expressed as a percentage of total ovarian weight was significantly ($P < .01$) increased from 32.8% for the controls to 54.9, 51.1 and 52.2% for the 0.20, 0.40 and 0.60 mg groups, respectively.

The results of this experiment indicate that oral administration of MGA can effectively inhibit estrus and has rather profound effects on the reproductive tracts of heifers when fed throughout a 154-day feeding period. However, under the conditions of this experiment MGA did not significantly improve rate of gain, efficiency of gain or carcass merit of feedlot heifers.

Table 2. ---Summary of Results of Feeding Varying Levels of MGA to Feedlot Heifers

Item	Mg of MGA per Head Daily			
	0	0.20	0.40	0.60
<u>Performance data</u>				
Number ^{a/}	20	17	20	18
Initial wt, lb	623	626	624	627
Final wt, lb	910	926	916	912
Total gain, lb	287	300	292	285
Av daily gain, lb	1.87	1.94	1.89	1.85
Av daily ration				
Corn, lb	11.7	11.7	11.7	11.7
Corn silage, lb ^{b/}	16.9	16.9	16.9	16.9
Soybean meal, lb	1.50	1.50	1.50	1.50
Feed per cwt gain, lb ^{c/}	1023	980	1008	1030
Feed costs per cwt gain	21.03	20.07	20.66	21.10
<u>Carcass data</u>				
Wt at slaughter, lb	887	903	891	893
Cold carcass wt, lb	541	550	547	546
Dressing, %	61.1	60.9	61.4	61.1
Kidney fat, %	3.03	2.85	2.98	3.11
Marbling score ^{d/}	5.85	5.59	5.60	5.78
Conformation grade ^{e/}	12.1	12.7	12.4	11.7
Carcass grade ^{e/}	12.3	12.1	11.7	11.9
Rib-eye area, sq. in.	10.92	11.41	11.29	11.01
Fat thickness, in.	0.78	0.79	0.84	0.89
Estimated retail ^{f/} cuts, %	49.3	49.7	49.2	48.7
<u>Reproductive data</u>				
Number ^{g/}	18	14	18	18
Wt of reproductive tract, g	211	197	231	293
Wt of ovaries, g	11.8	16.7	11.6	11.8
Size of largest follicle, mm	11.09	16.63	16.54	17.27
Follicular fluid, % ^{h/}				

^{a/} Two heifers calved on test and 3 were pregnant at slaughter and are not included in the results.

^{b/} Silage as fed.

^{c/} Silage converted to 34.78% dry matter basis.

^{d/} 4 = slight; 5 = small; 6 = modest.

^{e/} 11 = high good; 12 = low choice; 13 = average choice.

^{f/} Estimated % retail cuts = 52.66 - 5.33 (av fat thickness) - 0.979 (% kidney fat) + 0.665 (rib-eye area, sq. in) - 0.0065 (carcass wt.).

^{g/} Loss of ovaries during removal caused fewer numbers.

^{h/} Follicular fluid was measured as a percent of total ovarian wt.

EFFECT OF LENGTH OF FEEDING PERIOD ON FEEDLOT EFFICIENCY AND CARCASS GRADE AND COMPOSITION OF STEERS

James E. Little, Jr., L. V. Cundiff, W. G. Moody
N. W. Bradley and J. D. Kemp

Previous reports at this station have indicated that it is possible to feed Angus steers to the choice carcass grade on relatively low-cost rations containing corn silage and lower levels of corn than previously expected. This study was initiated to determine the length of the feeding period necessary for Angus steers to grade choice when fed a high level of corn and to study the effect of length of feeding period in their efficiency of gain and carcass composition.

Forty head of good and choice Angus yearling steers were used in a randomized complete block design where blocks consisted of five initial weight groups and the treatments represented four different lengths of time on feed. Ten steers in each of lots 1, 2, 3 and 4, were slaughtered after 28, 56, 84 and 112 days on feed, respectively. All steers were fed the same ration consisting of 1.5 lb soybean oil meal per head daily, ground shelled corn at the rate of 1.5% of body weight, and corn silage free choice.

Forty-eight hours following slaughter tracings of the rib eye area and measures of fat thickness were made at the 12th rib. A federal grader scored each carcass on conformation, maturity, marbling, carcass grade and estimated percentage of kidney fat. Fat color, lean color, and texture of the meat were also evaluated.

The carcasses were aged for a period of 8 days and cut to give the retail yield of the round, loin, rib and chuck. The wholesale cuts were trimmed to 3/8 inch of exterior fat covering. All bone was removed prior to weighing except for the closely trimmed bone-in short loin.

A trained six-member taste panel evaluated the 6-7-8th rib section of each carcass for flavor, juiciness, tenderness and overall satisfaction. The rib roasts were cooked to an internal temperature of 155°F in an electric oven set at 325°F.

The feedlot performance and efficiency are summarized in Table 1. The reduced average daily gains, lower feed efficiency and higher cost per 100 pounds of gain of the steers fed for 28 days are misleading because they were affected by a change from a moist palatable silage to a dryer less palatable silage in the last 5 days of the feeding period. Because dry matter was not determined on the original silage fed, it was impossible to take this factor into account in estimating efficiency of gain. The 56-, 84- and 112-day feeding periods show the expected trend for reduced efficiency of gain and increased feed cost.

Table 2 gives the results of changes in average carcass grade. Average carcass grade improved significantly ($P < .05$) in the 28-, 56-, and 84-day feeding periods. However, there was no significant difference in average carcass grade between steers fed 84 and 112 days. The similarity in the average carcass grades of steers fed for 84 and 112 days is believed to be attributed to the random allotment of steers at the beginning of the experiment and is not associated with increased length of feeding.

Table 1. ---Steer Performance and Feed Costs for Four Groups of Steers

	Days on Feed			
	28	56	84	112
Number of animals/group	10	10	10	10
Average initial weight, lb	743	739	747	745
Average final weight, lb	794	854	915.5	962
Average total gain, lb	51.5	115.4	168.4	217.2
ADG, lb	1.84	2.06	2.00	1.94
Ration intake, lb/hd/day				
Corn silage (wet)	19.82	17.81	18.91	20.01
Corn silage (air dry)	6.89	6.19	6.58	6.96
Ground shelled corn	11.54	12.10	12.44	12.75
Soybean meal	1.45	1.47	1.48	1.49
Total air-dry feed	19.88	19.76	20.50	21.20
Feed/of gain	10.80	9.59	10.25	10.93
Feed cost/cwt of gain ^{a/}	\$21.64	\$19.43	\$20.38	\$21.87

^{a/} Feed costs were calculated on the following basis: Corn silage, \$8/ton; shelled cracked corn \$1.25/bushel; soybean oil meal supplement \$80/ton.

Table 2. ---Carcass Grades of Steers for the Four Feeding Periods

	Days on Feed			
	28	56	84	112
Carcass grade				
High choice				1
Average choice		1	3	4
Low choice		2	5	
High good	5	2	1	2
Average good	4	5	1	3
Low good	1			
Average carcass grade ^{a/}	10.4	10.9	12.0	11.8

^{a/} 9 = low good; 10 = average good; 11 = high good; 12 = low choice; 13 = average choice; 14 = high choice.

The carcass traits of the steers changed with the increasing lengths of feeding time. Table 3 indicates that dressing percentage, marbling score, rib-eye area, fat thickness, kidney fat and carcass weight increased significantly ($P < .05$) with the length of feeding period. The estimated percentage of retail cuts decreased significantly ($P < .05$) as the feeding period increased. Length of feeding did not significantly change the percentages of forequarter and hindquarter.

Table 4 summarizes the carcass composition of the four slaughter groups. The weights of the chilled right side, edible portion, roast and steak meat, lean trim, fat trim and bone increased significantly ($P < .05$) with the length of feeding time. The differences observed between the 4 slaughter groups for % edible portion, % roast and steak meat, % lean trim, % fat trim and % bone from the round, loin, rib and chuck were significant ($P < .05$).

Table 3. ---Carcass Data for Four Groups of Steers

	Days on Feed			
	28	56	84	112
Dressing %	57.83	58.91	59.82	60.49
Marbling score ^{a/}	3.8	4.1	5.1	5.0
Rib-eye area	10.44	10.75	11.01	11.78
Fat thickness	0.37	0.52	0.66	0.60
Estimated % kidney fat	1.0	1.05	2.1	1.8
Estimated % retail cuts ^{b/}	53.67	52.74	50.84	51.73
Percent forequarter	52.42	52.61	52.60	52.87
Percent hindquarter	47.58	47.39	47.40	47.13
Carcass wt, lb ^{c/}	459.58	503.39	547.86	582.25

^{a/} Marbling score: traces = 3; slight = 4; small = 5; modest = 6; moderate = 7.

^{b/} The USDA equation = 52.66 - (average fat thickness at 12th rib) - 5.33, (estimated % kidney fat) - 0.979, (loin eye area) + 0.665, (carcass weight) - 0.0065 = estimated % retail cuts.

^{c/} Carcass weight = $2\frac{1}{2}\%$ shrink removed from hot carcass weight.

Table 4. ---Carcass Composition of Four Groups of Steers

	Days on Feed			
	28	56	84	112
Chilled right side carcass wt, lb	228.5	249.1	273.3	290.0
Edible portion, lb	141.5	147.58	156.18	169.29
Roast and steak meat, lb	93.14	98.80	104.29	110.95
Lean trim, lb	48.38	48.77	51.88	58.34
Fat trim, lb	20.66	27.14	31.98	27.09
Bone, lb	24.85	24.30	25.70	28.17
Edible portion, %	61.90	59.26	57.14	58.39
Roast and steak meat, %	40.76	39.68	38.15	38.26
Lean trim, %	21.14	19.58	18.99	20.13
Fat trim, %	9.04	10.90	11.74	9.34
Bone, %	10.94	9.78	9.45	9.71

In general, as the length of the feeding period increased the percentage of muscular tissue decreased and the percentage of fat increased.

The results of the taste panel tests are summarized in Table 5. Flavor, juiciness and overall satisfaction scores of the four feeding periods were significantly different ($P < .05$). There is no pattern indicated in the data for length of feeding period to either improve or not improve flavor, juiciness and overall satisfaction. There was no significant difference in tenderness of the rib eye muscle from the 6-7-8th rib of cattle from the 4 lots when compared by the taste panel and the Warner-Bratzler shear force.

Table 5. ---Taste Panel Scores From the 6-7-8th Rib Section on Four Groups of Steers

	Days on Feed			
	28	56	84	112
Flavor ^{a/}	7.36	7.81	7.70	7.59
Juiciness ^{a/}	7.09	7.53	7.52	7.24
Tenderness ^{a/}	7.39	7.70	7.30	7.05
Overall satisfaction ^{a/}	7.28	7.83	7.52	7.28
W-B Shear Force, lb	19.28	15.53	17.47	16.64

^{a/}9 = like extremely well; 8 = like very much; 7 = like moderately; 6 = like slightly.

Feeding efficiency and average daily gain decreased with length of feeding period. A longer feeding period improved carcass grade, dressing percentage, area of the rib eye, and fat thickness at the 12th rib. In general, as the feeding time increased a larger percentage of the feed consumed was converted to fat and less to muscle.

RELATIONSHIPS AMONG ECONOMICALLY IMPORTANT TRAITS IN BULLS TESTED IN THE UNIVERSITY OF KENTUCKY PERFORMANCE TESTING PROGRAM

Ben H. Crawford, L. V. Cundiff and N. W. Bradley^{a/}

This study was concerned with the relationships between initial age and weight, feed efficiency, average daily gain, and final conformation score. Knowledge of these relationships is needed for developing sound procedures for conducting postweaning performance tests.

Data for this study were taken from bulls individually fed in the University of Kentucky postweaning performance testing program from 1955 through the spring of 1960. The ration for the tests contained 40% roughage and 60% concentrate and was balanced for protein, TDN and minerals.

Table 1 indicates the number of observations according to year and season available for the five traits considered in this study. Table 2 shows averages, standard deviations and ranges for initial age and weight, average daily gain, feed efficiency and conformation score at the end of the test. Table 3 gives the correlations computed on a within year x season basis.

Low and nonsignificant correlations indicated that initial age was not highly associated with feed efficiency, average daily gain, or final conformation score. This suggests that no correlation is needed in a postweaning test for initial age and that breeders need not be concerned with the effect of a range in the age of 2-3 months on the performance of bulls in a postweaning test. The high positive correlation of 0.62 obtained between initial weight and feed efficiency indicates that bulls with heavier initial weights required more feed per 100 pounds of gain than bulls with lighter initial weights. This was expected because heavier bulls have greater maintenance requirements and, therefore, require more feed to produce

^{a/}The authors acknowledge the services of the University of Kentucky Computing Center in analysis of the data.

additional gain. A low but significant negative correlation was observed between initial weight and average daily gain on test. Therefore, as the initial weight of the bulls placed on test increased the average daily gain was slightly reduced. A fairly high positive correlation was obtained between initial weight and final conformation score, indicating that larger cattle at the beginning of test tend to finish with a higher conformation score.

Table 1. ---Summary of Number of Animals Available for Each Trait According to Year and Season

Year	Season	Initial Age	Initial Weight	Feed/cwt Gain	Average Daily Gain	Final Conf Score ^b
1955	S	15	15	15	15	15
1955	F	15	15	15	15	0
1956	S	15	15	15	15	15
1956	F	0	15	15	15	0
1957	S	0	13	13	13	13
1957	F	0	15	15	15	15
1958	S	16	16	16	16	16
1958	F	14	14	14	14	14
1959	S	15	15	15	15	15
1959	F	16	16	16	16	16
1960	S	16	16	16	16	16

Table 2. ---Total Number of Animals, Averages and Standard Deviations for the Five Traits Studied

Item	Initial Age	Initial Weight	Feed/cwt. Gain	Average Daily Gain	Final Conf Score
Number of animals	122	165	165	165	135
Average, lb	253.6	580.2	778.1	2.44	11.69 ^{b/}
Standard deviation ^{a/} , 16	54.5	115.7	118.3	0.41	1.42 ^{b/}
Range, lb	279	620	772	2.36	7.7 ^{b/}

^{a/} Computed on a within-season-year group basis.

^{b/} 11 = high gain; 12 = low choice; 13 = average choice, etc.

Table 3. ---Correlations Among Five Traits Studied

	Initial Weight	Feed/cwt Gain	Average Daily Gain	Final Conf Score
Initial age	0.38*	0.18	0.06	0.17
Initial wt		.62*	-.25*	0.52*
Feed/cwt gain			-.69*	0.22*
Average daily gain				0.03

* (P < .05)

The highest correlation obtained in this study was that between feed efficiency and average daily gain (-.69). A regression coefficient of -.199 was obtained between feed efficiency and average daily gain showing that for each 0.1 lb increase in average daily gain, it took 19.9 lb less feed to put on 100 lb of gain. Furthermore, these results indicate that the expense and labor involved with individual feeding is not justified in a practical breeding program since by selecting faster gaining bulls one will also be selecting for feed efficiency.

The low positive correlation observed between feed efficiency and final type score indicates that on the average high grading bulls require slightly more feed per 100 lb of gain than lower gaining bulls. However, since this correlation is low it is possible to select some bulls that are high in both grade and feed efficiency. A very low and non-significant correlation was found between average daily gain and final type score. This demonstrates that fast-gaining bulls are no more likely to grade high than low or average. Thus, if improvement is desired in both gain and grade, it is necessary to select for both traits simultaneously.

MEASUREMENT AND SELECTION OF ECONOMICALLY IMPORTANT TRAITS IN BEEF CATTLE-1965

L. V. Cundiff, N. W. Bradley, J. Ralph Overfield,
J. D. Kemp and A. W. Young

The objectives of this long-range breeding project are to use rate of gain, efficiency of gain, conformation and carcass characteristics in an overall selection experiment and to develop a method of estimating a bull's transmitting ability for carcass characteristics as well as rate of gain and conformation.

The herd of Hereford cattle used in this project has increased to 372 head. During January, February and March 128 calves were born. At present 195 cows and heifers are being bred to 7 different bulls to calve in January, February and March 1967.

During the year pre- and post-weaning performance tests were conducted on 37 bull calves and 43 heifer calves born in the spring of 1965. Results of these tests are summarized according to sire in Table 1 and Table 2 for bulls and heifers, respectively. The average performance of these calves was not good. Several measures are being taken to help correct this. The fescue pastures at the Princeton sub-station have been renovated and seeded to ladino clover. Also since the number of cows in the herd is approaching 200 it will be possible to cull the lower producing cows more intensely in the future. Nine new herd sire prospects have been purchased and are being developed for progeny testing.

Also during 1965 progeny tests were completed on four sires, and the results are summarized in Tables 3 and 4. These data will be pooled with data obtained in previous and future progeny tests to estimate the heritability and genetic correlations among performance and carcass traits in beef cattle.

Table 1. ---Prewaning and Postweaning Performance of Bulls on Test in 1965

	Sire						
	181H	HP 15	PZ 8	A41	C-30	E-2	Z-6
<u>Prewaning</u>							
Number	10	10	5	4	3	3	2
Age in days	228	236	251	220	177	197	246
Weaning wt, lb	415	402	439	411	365	385	435
Av. daily gain, lb	1.50	1.42	1.47	1.66	1.66	1.60	1.50
Adj. ADG, lb	1.52	1.45	1.50	1.61	1.64	1.47	1.45
Type ^a /	11.2	11.7	11.8	12.8	12.3	12.0	10.5
Index ^b /	98.4	98.2	100	109.5	108.7	100.3	92.0
<u>Postweaning</u>							
Number	10	10	4	4	3	3	2
Age in days	419	425	437	399	353	377	430
Final wt, lb	795	733	741	801	796	728	826
Av. daily gain, lb	2.40	2.14	1.86	2.46	2.71	2.23	2.38
Wt./day of age, lb	1.89	1.73	1.70	2.06	2.27	1.96	1.92
Type ^a /	11.5	11.4	11.1	12.0	11.4	12.0	9.9
Index ^c /	127.0	117.1	113.1	133.0	138.8	125.9	122.1
Feed/cwt gain ^d /	661	760	608	630	593	608	-----

^a/11 = high good; 12 = low choice; 13 = average choice.

^b/Prewaning index = (40 x Adj. ADG) - 18 + 5 (type score).

^c/Postweaning index = $\sqrt{(20 \times \text{ADG}) + 20 \times (\text{WDA})}$ - 18 + 5 (type score).

^d/Obtained for 5 bulls by 181 H, 4 bulls by HP 15, 2 bulls by PZ 8, 2 bulls by A41, 3 bulls by C-30 and 2 bulls by E-2.

Table 2. ---Prewaning and Postweaning Performance of Heifers on Test in 1965

	Sires						
	181 H	HP 15	PZ 8	A41	C-30	E-2	Z-6
<u>Prewaning</u>							
Number	9	11	10	4	4	2	3
Age in days	251	248	250	245	206	193	253
Weaning wt, lb	398	391	397	372	347	396	403
Av. daily gain, lb	1.35	1.32	1.31	1.30	1.38	1.69	1.37
Adj ADG, lb	1.54	1.53	1.51	1.43	1.56	1.82	1.56
Type ^a /	11.9	11.5	12.0	12.0	12.2	12.5	12.3
Index ^b /	102.4	100.5	101.7	99.0	105.5	116.5	105.7

Item	Sires						
	181 H	HP 15	PZ 8	A41	C-30	E-2	Z-6
<u>Postweaning</u>							
Number	9	11	10	4	4	2	3
Age in days	414	411	413	403	348	346	416
Final wt, lb	582	555	572	552	509	575	607
Av. daily gain, lb	1.20	1.10	1.12	1.22	1.23	1.41	1.30
Wt./day of age, lb	1.40	1.35	1.38	1.38	1.47	1.66	1.46
Type ^a /	12.2	11.7	11.4	11.9	11.8	12.5	12.4
Index ^c /	95.3	89.1	89.8	93.2	95.0	105.9	99.0

^a/ 11 = high good; 12 = low choice; 13 = average choice.

^b/ Prewaning Index = (40 x Adj. ADG) - 18 + 5 (type score).

^c/ Postweaning Index = $\left[(20 \times \text{ADG}) + (20 \times \text{WDA}) \right] - 18 + 5$ (type score).

Table 3. ---Results of 1964-65 Progeny Test (Performance Data)

Item	Sire							
	181 H		P Z-8		Z-19		Z-16	
	Steers	Hfrs.	Steers	Hfrs.	Steers	Hfrs.	Steers	Hfrs.
Number								
<u>Prewaning</u>								
Weaning wt, lb	595	478	589	443	631	448	570	475
ADG, lb	1.83	1.71	1.91	1.55	1.85	1.28	1.66	1.46
Adj ADG, lb	2.04	1.97	2.09	1.80	1.97	1.45	1.76	1.65
Type	12.1	12.0	12.6	12.0	12.5	11.5	12.6	14.0
Index	123.8	120.5	128.6	114.0	122.9	97.0	115.4	117.0
<u>Postweaning</u>								
Age in days	505	460	489	465	512	517	518	498
Final wt, lb	954	757	900	681	1007	788	910	674
ADG, lb	2.17	1.72	1.84	1.31	2.07	1.76	1.90	1.33
Wt/day of age, lb	1.88	1.65	1.84	1.47	1.97	1.52	1.75	1.35
Type	12.1	12.7	11.1	11.1	11.6	11.4	11.7	12.3
Index	123.4	112.7	108.8	93.1	121.5	104.7	113.8	97.1

^a/ 11 = high good; 12 = low choice; 13 = average choice.

^b/ Prewaning Index = (40 x Adj. ADG) - 18 + 5 (type score).

^c/ Postweaning Index = (20 x ADG) + (20 x WDA) - 18 + 5 (type score).

Table 4. ---Results of 1964-65 Progeny Test (Carcass Data)

Item	Sire							
	181 H		PZ-8		Z-19		Z-16	
	Steers	Hfrs.	Steers	Hfrs.	Steers	Hfrs.	Steers	Hfrs.
Number	8	2	5	3	8	2	5	1
Age at slaughter	513	469	497	485	526	526	537	507
Wt at slaughter, lb	939	747	881	675	999	780	896	665
Cold carcass wt, lb	565	444	536	402	608	465	544	386
Dressing, %	60.0	59.4	60.7	59.7	60.8	59.6	60.6	58.0
Hide wt, lb	91	64	83	64	87	70	85	62
Conformation ^{a/}	13.1	12.0	12.8	11.3	13.6	11.5	13.2	12.0
Marbling score ^{b/}	3.8	4.5	3.2	4.0	3.5	4.5	4.4	4.0
Rib-eye area, sq in.	11.8	9.5	11.9	9.7	11.4	10.2	12.0	9.0
Fat thickness, in.	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.5
Kidney fat, %	1.1	1.8	1.0	1.5	1.6	2.0	1.5	1.5
Est % boneless retail cuts ^{c/}	52.5	51.2	52.6	52.0	51.1	51.4	52.8	50.1
Yield grade	2.2	2.8	2.2	2.5	2.9	2.8	2.1	2.8
Carcass grade ^{a/}	9.9	11.0	9.2	9.7	9.6	12.5	10.8	11.0
Color of fat	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Color of lean	4.1	4.5	4.4	5.3	4.0	4.0	4.8	7.0
9-10-11th rib separation								
% fat	29.9	38.6	30.8	33.0	32.7	40.8	30.3	37.5
% lean	55.1	48.5	53.4	50.9	52.0	46.1	54.2	47.3
% bone	14.2	12.3	15.2	15.1	14.4	12.2	15.0	13.6
Taste panel								
Flavor	7.7	7.8	7.7	7.8	7.7	7.6	7.9	7.5
Juiciness	7.2	7.8	7.2	7.4	7.1	7.4	7.8	7.5
Tenderness	7.5	7.7	7.5	7.6	7.4	7.5	7.8	8.1
Overall satisfaction	7.5	7.7	7.6	7.6	7.5	7.5	7.8	7.9

^{a/} 11 = high good; 12 = low choice; 13 = average choice.

^{b/} 3 = traces; 4 = slight; 5 = small.

^{c/} Est. % boneless retail cuts = 52.66 - 5.33 (Av. fat thickness over rib-eye, in.) - 0.979
 (% kidney fat) + 0.665 (area of rib-eye, sq. in.) - 0.0065
 (carcass weight, lb).

EVALUATING FORAGE CROPS FOR BEEF PRODUCTION^{1/}

W. C. Templeton, Jr.,^{2/} C. F. Buck, N. W. Bradley, J. L. Menzies
and D. B. Laster

A continuing experiment to study the effects of three pasture programs on steer gains and on time and amount of feed production was initiated in 1962. The trial is being conducted on Maury and Donerail silt loam soils in Woodford county.

Each of the three programs consists of 16 acres (2 replications of 8 acres each). Crops and fertilization treatments for each program are as follows:

<u>Program No.</u>	<u>Crops and Acreage</u>	<u>Annual fertilization,</u> <u>lb/A</u>
1	Kentucky bluegrass and Ladino clover, 16A	0-60-60
2	Kentucky bluegrass and Ladino clover, 8A	0-60-60
	Balbo rye, 8A	100-0-0
	Sudangrass, 4A	200-60-60
	Korean lespedeza, 4A	0-60-60
3	Kentucky bluegrass and Alfalfa, 8A	0-120-120 B
	Balbo rye, 8A	100-0-0
	Sudangrass, 4A	200-60-60
	Korean lespedeza, 4A	0-60-60

All pastures were limed in 1962 at the rate of 2 tons per acre. The heavy rates of nitrogen applied to some pastures resulted in marked reductions in pH, and variable rates of lime, depending on soil test, were applied in 1965.

The bluegrass-clover pastures are seeded with 1 1/2 to 2 lb Ladino clover per acre each spring. The bluegrass-alfalfa pastures were obtained by disking old bluegrass pastures and seeding 15 lb per acre of Narragansett alfalfa in the spring of 1962.

Lespedeza proved unsuccessful in this experiment, and its use was discontinued after 1964. Volunteer crabgrass was prevalent in the lespedeza areas in 1963 and 1964, and 100 lb nitrogen per acre was applied. Most of the grazing in those years was furnished by crabgrass rather than lespedeza.

^{1/}A cooperative project of the Department of Agronomy and Department of Animal Science.

^{2/}Department of Agronomy.

Sudangrass is seeded at the rate of 30 lb per acre in May or early June. Balbo rye is seeded at the rate of 3 bu per acre after the completion of sudangrass and lespedeza grazing.

Good-to-choice Angus steer calves weighing 350 to 450 lb each have been used to graze the pastures on a put-and-take rotational basis. Shade, fresh water, salt, ground limestone, and steamed bone meal are provided in each pasture. No supplemental feed is fed. The steers are implanted with 12 mg diethylstilbestrol immediately prior to the pasture season.

Data on days of grazing per acre, average daily gains, and liveweight gains per acre are shown in the following table:

<u>Year</u>	<u>Program 1</u>	<u>Program 2</u>	<u>Program 3</u>
	<u>Steer Days of Grazing per Acre</u>		
1962 ^{a/}	314	265	212
1963	407	425	462
1964	209	264	310
1965 ^{b/}	199	364	496
Average	282	330	370
	<u>Average Daily Gain per Steer, lb</u>		
1962 ^{a/}	1.21	1.06	1.19
1963	1.10	1.08	1.12
1964	1.38	1.54	1.53
1965 ^{b/}	1.46	1.18	1.30
Average	1.29	1.22	1.28
	<u>Liveweight Gains per Acre, lb</u>		
1962 ^{a/}	380	281	252
1963	448	459	517
1964	288	407	474
1965 ^{b/}	291	430	645
Average	352	394	472

^{a/} Rye was not available for grazing in programs 2 and 3 in 1962 as the experiment was not initiated until spring of that year.

^{b/} In 1965 sudangrass-sorghum hybrid or sudangrass was substituted for lespedeza in programs 2 and 3.

Observations and Points of Interest

1. Balbo rye has been ready for grazing 2 to 3 weeks prior to Kentucky bluegrass-Ladino clover. Rye changes from leafy, vegetative stage to the stemmy, boot or head stage relatively fast, and failure to utilize the pasture in the leafy stage results in excessive wastage. Also, it appears that a low degree of utilization of the rye is very detrimental to establishment of lespedeza seedlings. In addition, animal performance on too-mature rye is, undoubtedly, inferior to what it would be on rye grazed earlier.

2. Sudangrass made excellent growth during 1962 but in 1963, 1964, and 1965 it grew very slowly during the first month after seeding. The main cause of this is believed to be root disease(s) which may be associated with cool weather following planting and/or growing the sudangrass continuously on the same land.

3. Korean lespedeza was moderately successful in 1962 when seeded on a prepared seedbed, although the pastures were very weedy during most of the grazing season. Seeding in rye resulted in stand failures in 1963 and 1964.

4. Bluegrass-Ladino clover pastures are relatively easy to manage and provide moderate amounts of high quality feed. Wastage is quite low if the pastures are adequately stocked. Maintenance of clover in the pastures is favored by heavy grazing during spring, adequate fertilization with lime, phosphorus, and potassium, and frequent reseeding.

5. Bluegrass-alfalfa mixtures are highly productive if properly managed. When the spring growth is grazed wastage is so high that it is doubtful whether the practice is a sound one. Harvesting of the first crop for hay or silage and rotational grazing of the succeeding crops if needed for pasture appears to be a good way to utilize this mixture. Alfalfa-weevil infestation was high in 1965 and again in 1966. Three sprayings were required in 1966 to give fair control.

6. The data on average daily gains indicate that all of the crops being studied provide satisfactory pasturage for growing beef steers. Also, crabgrass was eaten readily and was reasonably productive during the summer of 1963 when precipitation was favorable for its growth.

7. No steers have been lost because of bloat on either the bluegrass-clover or bluegrass-alfalfa pastures. A very few cases of mild bloat have been observed on both mixtures.

8. The results obtained indicate that sudangrass may be a relatively expensive pasture compared with well-managed bluegrass-ladino clover or bluegrass-alfalfa pastures.

ANIMAL NUTRITION SECTION

IN VITRO STUDIES OF FACTORS AFFECTING B-VITAMIN CONCENTRATIONS IN RUMINAL FLUID

B. W. Hayes, G. E. Mitchell, Jr. and C. O. Little

Ruminal synthesis of B-vitamins provide beef cattle and sheep with important protection against deficiencies of these essential nutrients. Results reported in the 1964 and 1965 Kentucky Animal Science Research Reports showed that levels of B-vitamins in ruminal fluid from steers fed different levels and forms of hay and grain were affected significantly by the various rations studied. The present in vitro study was designed to determine possible influences of the type of substrate being fermented, pH of the rumen and extraction of B-vitamins from feed on the concentrations of B-vitamins in ruminal fluid.

Procedure

Experiment I. —Washed microbial cells from steers fed alfalfa hay (for cellulose) or an all-concentrate ration (for starch) were used to study B-vitamin synthesis during in vitro digestion of cellulose or starch. Following adjustment of pH to 6.8 or 5.5, 50 ml tubes were incubated 24 hours for cellulose or 9 hours for starch. The tubes were centrifuged; cellulose or starch was determined in the residue and the supernatant was assayed for B-vitamins by standard microbiological techniques.

Experiment II. —Ruminal fluid was obtained from fistulated steers fed 6.80 kg alfalfa hay or 1.36 kg alfalfa hay, 3.63 kg ground shelled corn and 0.68 kg soybean meal daily. Raw or autoclaved ruminal fluid was incubated with appropriate substrates with flasks containing no substrate as controls. The substrate was either ground alfalfa hay or mixture of ground alfalfa hay, ground shelled corn and soybean meal. After 8 hours' incubation, the fluid from each flask was assayed for B-vitamins by standard microbiological techniques.

Results and Discussion

Experiment I. —Table 1 shows progressive increases in both cellulose and starch digestion as length of the incubation periods increased. Starch digestion was greater after 9 hours than was cellulose digestion after 24 hours, and more of each substrate was digested when the initial pH of the inoculum was 6.8. Substrate digestion was accompanied by decreases in pH except for the cellulose inoculum with an initial pH of 5.5. In this inoculum pH increased to 6.21 after 8 hours but decreased after 16 and 24 hours' incubation.

Synthesis of riboflavin, niacin and vitamin B₁₂ was greater ($P < .05$) when starch was the substrate than when cellulose was the substrate. In fact, values for riboflavin and vitamin B₁₂ indicated little, if any, synthesis from the cellulose substrate. Niacin values were greater ($P < .05$) when the initial pH of either inoculum was 6.8 than when it was 5.5. Synthesis of thiamine, folic acid and pantothenic acid was not affected significantly by substrate or initial pH of the inoculum.

Synthesis of thiamine, niacin and pantothenic acid tended to increase with increased substrate digestion and decreased pH of the inoculum, suggesting that synthesis of these vitamins was related to total microbial activity. In a previous experiment high levels of folic acid in steer ruminal fluid were associated with low pH; however, this observation was not supported by results of the present study.

Table 1. ---Influence of Substrate and Initial pH of Inoculum on In Vitro Synthesis of B-vitamins by Washed Ruminal Microorganisms

Hours	Final pH	Percent Substrate Digested	Washed Cell Suspension (mcg./100 ml)					
			Ribo-flavin	Thia-mine	Niacin	Folic Acid	Pant Acid	B ₁₂
<u>Cellulose</u>								
Initial pH 6.8								
0	6.80	----	80	1.0	102	4.62	1.1	0.67
8	6.67	5.7	70	1.2	135	4.62	1.3	0.65
16	6.64	15.8	80	1.4	175	3.48	1.6	0.67
24	6.54	47.8	82	2.0	220	3.84	1.7	0.70
Increase in 24 hours			2	1.0	118	-0.78	0.6	0.03
Initial pH 5.5								
0	5.50	----	95	1.2	75	3.88	1.0	0.60
8	6.21	3.2	50	1.7	72	3.81	1.1	0.60
16	6.19	7.4	100	1.4	72	3.72	1.1	0.62
24	5.92	36.6	90	1.9	105	3.80	1.4	0.65
Increase in 24 hours			-5	0.7	30	-0.08	0.4	0.05
<u>Starch</u>								
Initial pH 6.8								
0	6.80	----	80	1.4	80	8.79	1.4	0.85
3	6.50	26.0	100	1.4	90	8.36	1.5	0.85
6	6.27	68.9	120	1.5	180	7.12	1.6	0.92
9	6.25	76.3	135	2.2	270	9.32	1.8	1.10
Increase in 9 hours			55	0.8	190	0.53	0.4	0.25
Initial pH 5.5								
0	5.50	----	70	1.2	82	7.61	1.2	0.82
3	5.50	15.8	130	1.0	82	7.52	1.4	0.80
6	5.00	36.9	125	1.6	158	7.20	1.4	0.85
9	4.80	45.8	180	1.8	162	8.38	1.5	0.90
Increase in 9 hours			110	0.6	80	0.77	0.3	0.08

Experiment II. —As shown in Table 2, control flasks containing autoclaved ruminal fluid had characteristically higher concentrations of B-vitamins than did unautoclaved ruminal fluid. This probably resulted from release of vitamins contained within the cells into the ruminal fluid. Flasks containing autoclaved ruminal fluid and either hay or the mixed substrate had more thiamine, folic acid, pantothenic acid and considerably more riboflavin than did control flasks, indicating that these B-vitamins were extracted from the substrates. Apparent extraction of B-vitamins from hay was greater than that from the mixed substrate except for niacin which was extracted from the mixed substrate but not from hay. Vitamin B₁₂ concentration in the fluid was not increased by the extraction procedure.

B-vitamin concentrations recovered from flasks containing substrates and unautoclaved ruminal fluid were substantially greater than amounts extracted from the substrates. The increase above extraction is considered to result from synthesis.

Table 2. ---B-vitamins in Ruminal Fluid or Autoclaved Ruminal Fluid After In Vitro Incubation with Hay or a Mixture of Hay, Corn and Soybean Meal^{a/}

B-vitamins (mcg/flask)							
	Final pH	Ribo- flavin	Thia- mine	Niacin	Folic Acid	Pant Acid	B ₁₂
Ruminal fluid from steers fed hay							
Ruminal fluid (initial pH 6.36)							
No substrate	6.43	45	1.8	105	14.0	1.5	0.9
13.5 g hay	5.50	345	7.5	480	24.4	5.2	2.8
Autoclaved ruminal fluid (initial pH 6.37)							
No substrate	6.37	225	4.4	360	16.5	3.0	2.4
13.5 g hay	6.14	300	5.7	360	20.7	3.8	2.4
Furnished by substrate ^{b/}		200	47.2	541	45.9	348.3	0.04
Ruminal fluid from steers fed mixed ration							
Ruminal fluid (initial pH 6.50)							
No substrate	6.45	225	0.8	225	9.0	3.0	1.5
Mixed substrate ^{c/}	5.30	1,125	3.8	600	16.5	6.8	3.8
Autoclaved ruminal fluid (initial pH 6.60)							
No substrate	6.50	570	1.8	345	13.0	3.8	3.2
Mixed substrate ^{c/}	6.40	600	2.7	360	14.2	4.5	3.2
Furnished by substrate ^{b/}		52	44.3	323	14.0	133.9	0.01

^{a/} Aliquots of 150 ml of ruminal fluid were incubated with appropriate substrates in 250 ml Erlenmeyer flasks at 39° C for 8 hours.

^{b/} Calculated B-vitamin values.

^{c/} Mixture of 2.7 g hay, 7.2 g corn and 0.9 g soybean meal.

VITAMIN A TURNOVER IN SHEEP FED ADEQUATE VITAMIN A

B. W. Hayes, H. B. Sewell, G. E. Mitchell, Jr. and C. O. Little

Liver vitamin A stores are widely used to evaluate the vitamin A status of animals and their ability to compensate for a dietary deficiency. An improved understanding of the processes involved in the deposition and removal of vitamin A from the liver would increase the usefulness of such evaluations. Several workers have studied changes in vitamin A stores during periods of vitamin A depletion or following vitamin A therapy; however, little attention has been given to the stability of vitamin A reserves when total vitamin A storage is not changing. This study was initiated to determine whether the liver vitamin A stores of sheep receiving adequate dietary vitamin A are static or dynamic and to estimate a half-time for vitamin A in the liver, if appropriate.

Procedure

Six crossbred ram lambs, averaging 32 kg, each received a jugular injection of tritium-labeled vitamin A acetate. Daily rations consisted of alfalfa hay fed free choice and

726 g of ground corn supplemented with 1,400 IU of vitamin A palmitate per sheep. After stores of labeled vitamin A were stabilized, liver samples were taken at 14-day intervals by aspiration biopsy. Jugular blood was sampled at the time of each liver biopsy.

Liver samples were saponified with alcoholic potassium hydroxide and these along with serum samples were extracted with petroleum ether. Vitamin A was then determined with trifluoroacetic acid, and tritium activity was determined by liquid scintillation counting.

Results and Discussion

Data given in Table 1 show that storage of tritium activity in the liver was adequate for the study of possible turnover. Apparently the levels of vitamin A in the liver are characterized by two plateaus. Reasons for this fluctuation are not evident. It may have resulted from errors inherent in sampling from a local area of the liver by biopsy or to differences in vitamin A storage in different areas of the liver. The apparently continuous decrease in tritium activity in the liver and the detection of tritium activity throughout the trial provide strong evidence for the dynamic state of vitamin A stores.

Problems in estimating turnover which result from the apparent reduction in vitamin A stores between 42 and 56 days are minimized by using specific activity units (DPM/mcg vitamin A). From the specific activity of vitamin A given in Table 2, the half-time for vitamin A in the liver is estimated to be approximately 75 days.

Ether extracts of the sheep feces did not indicate that appreciable amounts of radioactivity in the blood were being excreted via the intestinal tract. No tritium activity could be detected in ether extracts of urine samples.

Table 1. ---Vitamin A and Radioactivity in Liver and Serum of Sheep After Injection With Labeled Vitamin A

Days	Liver Vitamin A (Mcg/gm)	Liver Tritium Activity (10 ² DPM/gm)	Specific Activity of Liver Vitamin A (DPM/mcg)	Serum Tritium Activity (DPM/ml)
0	89	93	121	394
13	89	75	98	66
28	91	59	89	61
42	105	64	74	96
56	65	51	88	33
70	75	37	67	232
83	70	40	51	48
98	66	28	50	33

INFLUENCE OF DIETARY NITRATE ON PRE-INTESTINAL DESTRUCTION OF VITAMIN A BY WETHERS

G. E. Mitchell, Jr., C. O. Little and B. W. Hayes

The small intestine is the primary site of vitamin A absorption. In ruminants feed is subjected to extensive microbial action in the rumen and reticulum and to further action in the omasum and abomasum before reaching the small intestine. Previous experiments have shown that this action results in substantial destruction of vitamin A in both cattle and sheep. Contact with nitrate would be expected to result in the oxidative destruction of vitamin A. *In vitro* data collected at other stations indicates that nitrate additions enhance vitamin A destruction by ruminal fluids. However, adding 1% potassium nitrate to the ration of steers did not increase pre-intestinal vitamin A destruction. This report gives the results of a similar experiment using wethers.

Procedure

Four wethers with permanent abomasal cannulas were fed oat straw and a simple mineral mixture free choice. In addition, each wether received 114 g of ground shelled corn and 114 g of protein supplement twice daily. Supplement A consisted entirely of 44% crude protein soybean oil meal. Supplement B contained 78% soybean oil meal, 12% ground shelled corn and 10% potassium nitrate. Pairs of wethers were fed either supplement A or supplement B for a 2-week preliminary period plus a 15-day experimental period during which estimates of vitamin A destruction were made on the 1st, 8th and 15th days. The treatments were then reversed and the trial was repeated. Pre-intestinal destruction of vitamin A was estimated by administering 250,000 IU of vitamin A acetate dispersed in 5 ml of 20% aqueous Tween "80" and 5 g of chromic oxide by gelatin capsule. Twenty-four hours after dosing, abomasal contents were withdrawn through the abomasal fistula and analyzed in triplicate for vitamin A and chromic oxide. The change in the ratio of chromic oxide to vitamin A from the ratio administered was used in estimating the percentage of administered vitamin A reaching the abomasum.

Results and Discussion

Calculated recoveries of vitamin A from the abomasal fluid 24 hours after it was placed in the rumen are presented in Table 1. These results confirm previous observations of extensive ruminal destruction of vitamin A. They also agree with previous studies with steers in which it was found that adding nitrate to the diet failed to increase destruction. In both the steer trials and the sheep trials there was some indication that feeding potassium nitrate may have reduced destruction of vitamin A. This suggests that ruminal destruction of vitamin A may be a reductive rather than an oxidative process.

Table 1. ---Vitamin A Recovery from Abomasal Fluid (%)^a

Wether No.	Supplement		Average
	A	B (KNO ₃)	
92	35.4	35.3	42.3
	33.3	59.0	
	34.8	56.2	
188	31.8	23.0	44.4
	33.0	67.8	
	58.9	51.8	
114	58.7	17.8	42.6
	38.5	61.7	
	44.5	34.1	
123	50.5	56.1	60.6
	34.4	71.7	
	76.7	74.2	
Average	44.2	50.7	

^a/ Calculated from the ratio of vitamin A to chromic oxide in abomasal fluid compared with the ratio administered 24 hours earlier.

BIOLOGICAL STUDIES OF THE YELLOW PIGMENTS EXCRETED BY VITAMIN A DEPLETED SHEEP

R. E. Tucker, G. E. Mitchell, Jr. and C. O. Little

Previous work directed toward the investigation of microbial synthesis of carotenoids in the large intestine of sheep was reported in the 1965 Kentucky Animal Science Research Report. This was a carotenoid balance study that had shown vitamin A depleted sheep capable of being in an apparent negative carotenoid balance while on a low carotenoid ration. The amount of carotenoids excreted ranged from 1.6 to 3 times the total carotenoid intake and strongly suggested microbial synthesis. Spectrographic evaluation of the chromatographed fecal pigment did not indicate that the material was pure beta carotene. Two experiments were designed to determine the vitamin A potency of the excreted pigments, presumably of microbial origin, and their possible absorption and benefit to sheep.

Procedure

In the first experiment a sufficient quantity of fecal pigment from the carotenoid balance trial was obtained to conduct a biological vitamin A assay. The pigment was extracted by a 70:30 hexane-acetone mixture which was subsequently concentrated in vacuo to a convenient volume for purification. The acetone and water-soluble fraction was removed by washing with equal volumes of water. Further purification was accomplished by subjecting the remaining material to saponification with 10% potassium hydroxide for one hour at room temperature. The insoluble saponified fraction was removed by centrifugation and decanting the fat-soluble supernatant. Final preparation of the pigment for feeding was accomplished by removing the hexane in a rotary evaporator and redissolving in cottonseed oil.

To conduct the assay one-day-old chicks were fed a purified ration lacking only in vitamin A. The growth had ceased in 3 weeks and at this time the chicks were growth sensitive to vitamin A added to the ration. Four groups of chicks received the basal ration plus vitamin A palmitate at levels of 150, 300, 600 and 1200 IU per pound of feed which corresponds to 12.5, 25, 50 and 100% of the NRC (1964) vitamin A requirements for chicks. Two other groups received the basal ration plus the fecal pigment at theoretical levels of 600 and 1200 IU per pound of feed. Another group was designated the control. Each chick was weighed daily for the duration of the 10-day assay.

The second experiment was conducted to determine if carbon¹⁴ labeled beta carotene could be absorbed from the cecum or colon of sheep. Two wethers were anesthetized and a loop of the cecum and a loop of the colon were ligated in each sheep without disturbing the blood supply to the area. Each loop was injected with 66 micrograms of carbon¹⁴-labeled beta carotene, and venous blood sampled at 30-minute intervals for 2 hours. After the absorption period was terminated, the liver, kidneys and the intestinal loops were taken for determinations of radioactivity.

Results and Discussion

Results of the assay are shown in Table 1. Although the two groups consumed as much feed containing the fecal pigments as did the negative control, all three groups gradually reduced feed intake as the vitamin A deficiency became critical. The chicks on graded levels of vitamin A palmitate responded in rates of growth as shown in Table 1, while the vitamin A deficient chicks failed to show a growth response to the fecal pigments. Since the highest test level of the fecal pigment was eight times the lowest level of vitamin A palmitate and showed no growth response, the activity of the fecal pigment must have been considerably below one-eighth or 12.5% of the activity of vitamin A palmitate. This suggests that any microbial synthesis of carotenoids in the large intestine of sheep does not result in excretion of potent vitamin A precursors.

The results of the second experiment tended to confirm reports that carotene can be absorbed only from the small intestine. Radioactivity could not be detected in the blood, liver or the kidneys of the sheep with a ligated colon or cecum injected with labeled beta carotene. The intestinal loops, which had been excised at the termination of the absorption experiment, was digested with alcoholic potassium hydroxide and the recovery of the injected labeled beta carotene was determined. The average recovery of the intestinal loops was 101% which indicates that the labeled carotene was not absorbed. From these data it appears that the microbial synthesis of vitamin A precursors in sheep is not a major factor in their vitamin A nutrition.

Table 1. ---Results of Chick Assay of Fecal Pigments for Vitamin A Activity

Group Number	Basal Ration Plus--	Beginning Weight, g	Av Weight at 10 days, g	Mortality	Av Daily Gain ^a
1.	1200 I. U. /lb Vit A	107	167	0	6.01
2.	600 I. U. /lb Vit A	107	162	0	5.60
3.	300 I. U. /lb Vit A	105	156	0	5.36
4.	150 I. U. /lb Vit A	109	139	1	3.16
5.	1200 I. U. /lb Fecal Pigment ^b	110	105	4	-1.80
6.	600 I. U. /lb Fecal Pigment ^b	109	98	6	-1.90
7.	Control	105	99	7	-0.60

^a/Least significant difference between groups is 3.32 for $P < .05$.

^b/Theoretical units computed from optical density.

INFLUENCE OF VITAMIN A DEFICIENCY ON URINE VOLUME OF SHEEP

K. E. Webb, Jr., G. E. Mitchell, Jr.,
C. O. Little and G. H. Schmitt¹

Although vitamin A metabolism has been extensively studied, many aspects of vitamin A function are poorly understood. Numerous studies of vitamin A-deficient sheep have been conducted at this station. During a digestion trial, increased urine volumes were observed in vitamin A-deficient wethers. Similar observations have been made in vitamin A-deficient Holstein calves at the Connecticut station. The experiments reported here were designed to study the influence of vitamin A deficiency on urine volume under varying conditions of water intake.

Procedure

Four mature wethers each exhibiting acute vitamin A deficiency and four controls were maintained in metabolism crates and fed 908 g per day of a ration containing ground

corn cobs, ground milo, soybean meal and cerelose. In trials I, II and III the ration contained 5.0% of a complete mineral mix calculated to be adequate for a purified ration. The mineral mix for trial IV contained only salt, dicalcium phosphate, ground limestone and elemental sulfur. The depleted sheep received 220 IU vitamin A per kg of ration in trials I, II and III but no supplemental vitamin A during trial IV. The control ration contained 1100 IU vitamin A per kg. In trials I and II water was available on a free choice basis. In trial III water was limited to 1.5 liters per head per day, and in trial IV feed and water were removed for 3 days. In all trials the urine was collected and the volume recorded twice daily. In trial IV the urine was collected under toluene and samples were taken for further analysis.

Results and Discussion

In trials I and II the average daily urine volumes of the vitamin A-deficient sheep were 1894 ml and 1738 ml, while volumes for the controls averaged 969 ml and 886 ml. Thus the volume of the controls was approximately one-half that of the vitamin A-deficient wethers. The water intake was equalized in trial III, but on the seventh day the controls still excreted only 61% as much urine as did the vitamin A-deficient sheep (670 ml vs 1095 ml). Trial IV was designed to check the kidney's ability to concentrate urine. Table 1 shows the daily urine volumes for both the vitamin A-deficient and the control sheep. There was an overall decrease in urine volume from day 1 through day 3, with the volumes of the control wethers being lower than those of the vitamin A-deficient wethers. Table 2 shows the change in osmolality from day to day. The values for osmolality increased throughout the period, indicating that the kidneys of both groups of wethers were able to concentrate urine. Experiments designed to test other functions of the kidneys of vitamin A-deficient sheep are in progress.

Table 1. ---Urine Volume (ml) Trial IV

	Day 1	Day 2	Day 3
A-deficient No. 1	770	430	455
A-deficient No. 2	740	490	325
A-deficient No. 3	505	405	287
A-deficient No. 4	<u>940</u>	<u>520</u>	<u>310</u>
Average	739	461	344
Control No. 1	520	365	250
Control No. 2	475	325	279
Control No. 3	995	285	193
Control No. 4	<u>425</u>	<u>275</u>	<u>130</u>
Average	604	313	213

Table 2. ---Osmolality (mOsm/kg. H₂O), Trial IV

	Day 1	Day 2	Day 3
A-deficient No. 1	882	989	981
A-deficient No. 2	733	851	993
A-deficient No. 3	1037	1133	1160
A-deficient No. 4	773	903	1069
Average	856	969	1051
Control No. 1	1466	1181	1365
Control No. 2	1141	1270	1316
Control No. 3	668	1426	1541
Control No. 4	1528	1794	1968
Average	1201	1418	1548

INFLUENCE OF VANADIUM AND DDT ON CAROTENE DISAPPEARANCE FROM THE RAT INTESTINE

G. E. Mitchell, Jr., C. O. Little and Gertrude Skerski

Previous work at this station has shown that carotene disappears more rapidly from the intestines of nitrate-fed rats than controls. This increased disappearance apparently results from absorption without prior conversion to vitamin A. In a preliminary trial in which vanadium, molybdenum, selenium, copper and DDT were tested at dietary levels calculated to produce low-level toxicity, increases in carotene disappearance which approached significance were observed when vanadium and DDT were fed. The experiment reported here was designed to provide more detailed information on the effects of including vanadium and DDT in the diet.

Procedure

Three groups of 24 mature rats each (average weight 328 g) received (1) a ground commercial laboratory diet, (2) diet 1 plus 100 ppm of DDT, and (3) diet 1 plus 20 ppm of vanadium for two weeks. The rats were then transferred to a carotene and vitamin A-free diet without additives for 24 hours. They were then placed under ether anesthesia for ligation. The small intestine was ligated at both ends, and 300 mcg of beta carotene dispersed in 1 ml of 20% Tween 80 was injected. After a 3-hour incubation terminal chloroform anesthesia was administered, blood was taken from the posterior vena cava, and the intestine with its contents removed for carotene analysis. Serum from the blood samples was analyzed for carotene and vitamin A.

Results

The results are summarized in Table 1. Carotene disappearance and serum vitamin A values were somewhat higher than those observed in previous experiments but were not significantly influenced by treatment. Passage of intact carotene into the blood was small and was not increased by either treatment. These results do not suggest impairment of the ability of the rat intestine to convert carotene to vitamin A when either vanadium or DDT is included in the diet. Therefore it was concluded that any detrimental effect of vanadium or DDT on carotene utilization must involve larger doses, longer periods of exposure, or mechanisms other than those measured by this technique.

Table 1. ---Carotene Disappearance from the Intestine and Serum Vitamin A and Carotene of Rats Fed Vanadium and DDT

Treatment	Carotene Disappearance (%)	Serum Vitamin A (Mcg/100 ml)	Serum Carotene (Mcg/100 ml)
Control	48.9 $\pm$ 4.2 ^a	62.2 $\pm$ 5.3	9.9 $\pm$ 1.4
DDT	52.0 $\pm$ 4.1	54.7 $\pm$ 5.7	9.4 $\pm$ 1.3
Vanadium	45.0 $\pm$ 4.5	57.9 $\pm$ 3.8	8.9 $\pm$ 1.2

^a/ Standard error.

ABOMASAL ADMINISTRATION OF CORN OIL OR LARD TO WETHERS

C. O. Little and G. E. Mitchell, Jr.

Considerable research on fat additions to rations for ruminants has been reported with emphasis on animal performance and feed conversion. Low levels of added fat have been successfully used as energy sources in some rations; however, high levels of fat additions in roughage rations for ruminants have not been completely satisfactory. Rumen microbial activity seemingly is reduced by the presence of high levels of fat; thus, cellulose digestion, nitrogen utilization and other characteristic functions of the rumen are altered. Only a limited amount of information is available concerning the utilization of various fats posterior to the functional rumen and the influence of such fats on metabolism of other nutrients in ruminant animals. To understand better metabolism in the ruminant, the current work was initiated to study further the utilization of two different fats posterior to the rumen and to determine the influence of post ruminal fats on metabolism of other ration constituents.

Procedure

Four crossbred wethers, weighing approximately 36 kg each, were used in this study. Two of the wethers were fitted with permanent abomasal fistulas prior to the beginning of these experiments. Digestibilities with oral and abomasal administrations of corn oil were compared in the first experiment. Digestibilities with oral and abomasal administrations of lard were compared in the second experiment, and changes in plasma lipids following a single dose of corn oil or lard were compared in the third experiment. A basal ration consisting of ground alfalfa hay fed at the rate of 20 gm/kg body weight (720 g daily) and purified corn oil or lard given at 2 g/kg (72 g daily). The fat source was given orally to the intact wethers and directly into the abomasum to the fistulated wethers.

Feces and urine were collected during a 7-day collection period following a 7-day preliminary period. Digestions of dry matter, crude fat, cellulose, gross energy, and protein and nitrogen retention were determined. The trials in each experiment were arranged to obtain four observations for each method of fat administration.

Results

The results are summarized in Table 1. Digestibility of ration dry matter was not affected by method of administering corn oil or lard. A comparison should not be made between digestion with corn oil and digestion with lard. These were used in separate experiments.

Table 1. ---Digestibility, Nitrogen Retention and Plasma Lipids in Wethers Receiving Corn Oil or Lard Orally and into Abomasum

	Corn Oil		Lard	
	Oral	Abomasal	Oral	Abomasal
Digestibility (%)				
Dry matter	66.3	67.0	56.4	55.6
Crude fat	89.1	78.6	87.6	84.3
Cellulose	64.4	71.9	50.0	52.4
Gross energy	66.5	63.6	56.7	54.0
Crude protein	71.8	70.4	69.5	69.2
Nitrogen retention				
Grams per day	2.81	1.10	-.08	0.30
% of intake	17.9	7.0	-0.5	1.9
Total plasma lipids, mg/100 ml				
0 hour	346	360	366	373
4 hour	348	388	368	399
8 hour	350	355	368	388
Plasma lipid iodine No.				
0 hour	68	70	66	70
4 hour	74	69	67	69

Crude fat from both sources was less digestible when given into the abomasum than when given orally. This difference was larger with corn oil than with lard.

A reversal of this pattern was observed for cellulose digestion. Cellulose digestion was increased from 64.4% when corn oil was given orally to 71.9% when it was given into the abomasum. A similar trend resulted with lard, but the difference was smaller.

There were only small differences in energy digestion between the methods of administering corn oil or lard. This similarity in energy digestion is further supported by calculations of the energy values of digestible fat and cellulose. As more fat was digested with the oral administrations, less cellulose was digested. As a result, the total energy digested was only slightly affected.

Protein digestion was not affected by method of either corn oil or lard administration. While differences in nitrogen retention were small, wethers receiving corn oil directly into the abomasum retained significantly less nitrogen than did wethers receiving corn oil orally. Although there was a trend in the reverse direction with lard, the difference in nitrogen retention for wethers receiving lard by the two methods was not significant.

Total plasma lipids in blood samples taken from wethers at 0, 4 and 8 hours after the administration of single dose of these fat sources showed little change in wethers receiving either corn oil or lard orally; however, both fat sources gave similar increases in plasma lipids when administration was into the abomasum. Iodine numbers of the plasma lipids in the 0 and 4-hour samples were also determined. While the iodine number of the corn oil was 112 compared with 58 for the lard, there were no differences in iodine number of the plasma lipids.

AMINO ACIDS IN ABOMASAL FLUID AND PLASMA OF LAMBS FED ZEIN

D. G. Ely, C. O. Little, P. G. Woolfolk and G. E. Mitchell, Jr.

In many finishing rations for cattle and sheep, corn furnishes a large portion of the protein. Zein contributes almost half of the total protein in corn. Because zein has a poor amino acid balance, its biological value can be improved if it is hydrolyzed by rumen microbial activity and the nitrogen utilized for synthesis of microbial protein. This study was concerned with the synthesis of microbial protein in the rumen of lambs fed zein with different quantities of starch and cellulose. The relationship of dietary amino acids to amino acids in abomasal fluid and plasma were observed.

Procedure

Six crossbred wethers weighing approximately 40 kg and fitted with permanent abomasal fistulas were fed two purified rations in a reversal arrangement to provide six observations per treatment. Zein was the sole source of nitrogen in both rations and was fed at the level of 12.8% of the rations. The rations differed only in the ratio of cellulose to starch, 70:30 (high-cellulose) and 40:60 (high-starch). The rations were fed at the rate of 200 g twice daily. Abomasal fluid and blood plasma samples were collected at each 2-hour interval after both the a.m. and p.m. feedings and analyzed for free amino acids. Amino acid determinations were accomplished by automated ion exchange chromatography procedures.

Results and Discussion

No differences were found between concentrations of essential (for non-ruminants) amino acids in abomasal fluid of lambs fed the two rations. However, abomasal fluid values were considerably different from those found for both rations. This difference between ration and abomasal fluid amino acids indicates that microbial protein synthesis was occurring in the rumen.

The percentage of non-zein protein (microbial protein) in abomasal fluid, under the same conditions as this experiment, was determined on the basis of the solubility of zein in ethyl alcohol, and these results were reported in the 1965 Kentucky Animal Science Research Reports.

On the basis of these estimates of conversion and using amino acid compositions of zein and microbial protein, a "predicted" essential amino acid composition, except tryptophan, of abomasal fluid was calculated and compared with the actual as determined. These results are presented in Table 1. The similarity of the "predicted" and actual values suggested the possibility of using amino acid ratios in the diet, microbial protein, and abomasal fluid to estimate conversion of dietary protein to microbial protein. Since lysine is the amino acid that differed the most between zein and abomasal fluid in these results (0.1, 1.8 and 1.5 molar % in zein, high-cellulose abomasal fluid, and high-starch abomasal fluid, respectively), it was selected to test this hypothesis. Based on the ratios of lysine, the extent of conversion was estimated to be 27.9% and 23.8% for the high-cellulose and high-starch rations, respectively. These results indicate that estimates of microbial protein synthesis may be obtained when a homologous protein is fed by an amino acid analysis of abomasal fluid. Also, the nutritional status of the animal may be studied through amino acid analyses of abomasal fluid when a mixture of proteins are fed.

Table 1. ---Comparison of Actual and Predicted Essential Amino Acids in Abomasal Fluid of Lambs Fed Two Cellulose to Starch Ratios with Zein (Molar %)

Amino Acid	High-cellulose		High-starch	
	Actual	Predicted	Actual	Predicted
Threonine	3.7	3.8	3.7	4.0
Valine	5.4	5.0	5.1	4.9
Isoleucine	4.8	4.7	4.5	4.8
Leucine	16.7	17.0	18.1	16.4
Methionine	1.0	1.3	1.1	1.3
Phenylalanine	4.7	4.9	5.0	4.9
Lysine	1.8	1.8	1.5	2.1
Arginine	1.7	1.5	1.7	1.7
Histidine	1.1	1.0	1.2	1.0

Table 2 shows the molar percentage of the recovered essential amino acids in zein and plasma of lambs fed the two rations. Each of these amino acids was higher in the plasma of lambs fed the high-cellulose ration. This could have resulted from a greater conversion of dietary protein to microbial protein, indicated by lysine ratios, in the high-cellulose lambs or a more readily available energy source (starch) being present in lambs fed the high-starch ration, thus promoting greater tissue protein formation.

Table 2. ---Molar Percentage of Recovered Essential Amino Acids in Zein and Plasma of Lambs Fed Two Cellulose to Starch Ratios with Zein

Amino Acid	Zein	Plasma	
		High-cellulose	High-starch
Threonine	2.6	5.1	4.3
Valine	4.2	5.5	4.4
Isoleucine	4.1	2.1	1.8
Leucine	20.6	7.3	6.4
Methionine	1.3	0.5	0.4
Phenylalanine	5.3	2.0	1.7
Lysine	0.1	4.9	4.1
Arginine	1.0	2.9	2.5
Histidine	0.9	5.7	5.1

AMINO ACID COMBINATIONS FOR STARCH DIGESTION BY RUMEN MICROORGANISMS

C. R. Acord, G. E. Mitchell, Jr., C. O. Little
N. E. Alderson and B. W. Hayes

Developing an improved understanding of the utilization of the starch portion of high-grain rations by ruminants has been a concern of the Kentucky station for several years. A technique for studying starch digestion by rumen microorganisms cultured outside the rumen and an evaluation of selected non-protein nitrogen sources for in vitro starch digestion by rumen microorganisms have appeared in previous Animal Science Research Reports. This report summarizes recent observations concerning the suitability of selected amino acid combinations as nitrogen sources for this in vitro system.

Procedure

All two-way combinations of arginine, aspartic acid, glutamic acid, lysine, methionine, proline, serine and valine were tested as sources of nitrogen for in vitro starch digestion by rumen microorganisms. Each amino acid was added at a level which would furnish 6 mg of nitrogen per 20 ml of incubation mixture containing washed rumen microorganisms, minerals, buffers, and 100 mg of purified corn starch. Responses were compared with responses from 3 and 6 mg of nitrogen from urea. Treatments were replicated four times in each of two trials with 8-hour incubation periods.

Results and Discussion

In all experiments the addition of urea at a 3 mg or 6 mg level resulted in highly significant increases in starch digestion, demonstrating that the system does require nitrogen for effective starch digestion and that urea is an excellent source of nitrogen for this purpose.

Although two or four times as much amino acid nitrogen was added as urea nitrogen, none of the pairs of amino acids studied were as effective as urea in stimulating starch digestion. Pairs of amino acids which resulted in good starch digestion were aspartic acid and lysine, aspartic acid and valine, and serine and valine. Less stimulation of starch digestion resulted from the following pairs of amino acids: arginine and lysine, arginine and valine, valine and glutamic acid, serine and arginine, and proline and methionine. None of the other amino acid pairs tested stimulated starch digestion. These results indicate that microorganisms of the rumen can make selective use of amino acids to meet their nitrogen requirements for starch digestion. Results of studies of ammonia levels from selected pairs of amino acids after 4 hours or 8 hours of fermentation support this hypothesis that the observed differences in utilization for this purpose are related to the rate of ammonia release, with high-ammonia levels being associated with greater starch digestion. Since some evidence of synergism between certain amino acids was obtained, this area is receiving additional study.

UTILIZATION OF CARBOHYDRATES ADMINISTERED INTO THE ABOMASUM OF WETHERS

J. W. McAtee, C. O. Little, and G. E. Mitchell, Jr.

While microorganisms convert a portion of the dietary carbohydrates to short-chain fatty acids in the rumen, recent evidence has indicated that large quantities of starch may pass from the rumen unaltered. For this starch to be utilized, it must be digested and absorbed posterior to the rumen. Post ruminal digestion of carbohydrates has not been well defined. This report summarizes the results of two experiments in which oral and abomasal administrations of carbohydrates were compared.

Procedure

Four crossbred wethers, with an average weight of 45 kg, were used in this study. The wethers were fitted with permanent abomasal fistulas prior to the beginning of this work. A basal ration of ground alfalfa hay was fed at the rate of 18 g per kg body weight (810 g daily). The carbohydrate was fed or administered in a warm water slurry into the abomasum at 2 g per kg body weight (90 g daily). The treatments were arranged in a 4 x 4 Latin square design which provided 4 observations for each carbohydrate by each method of administration in an experiment.

Feces and urine were collected during a 7-day collection period following a 7-day preliminary period. Digestibility of dry matter, protein and cellulose, and nitrogen retention were determined. Blood samples were taken at the conclusion of each trial and also 0, 1/2, 1, 2, 3 and 4 hours after feeding, and blood sugar levels were determined.

In experiment 1, the carbohydrates compared were purified corn starch and purified glucose. In experiment 2, purified corn starch was compared with heated starch. The heated starch was prepared by autoclaving purified corn starch for 15 minutes at 1.05 kg/sq cm pressure in a moisture-proof container.

Results

Digestibility and nitrogen retention results are summarized in Table 1. In experiment 1, abomasal administration of starch appeared to decrease dry matter and protein digestibility, but these differences were not statistically significant. Cellulose digestion and nitrogen retention were not affected. Method of administering glucose had no significant effect on digestibility; however, nitrogen retention was improved significantly ($P < .05$) when glucose was given orally. In experiment 2, abomasal administration of starch appeared to decrease protein digestion and increase nitrogen retention (not significant). Heated starch significantly ($P < .05$) increased nitrogen retention and slightly improved digestibilities. Differences between oral and abomasal administrations of heated starch were not significant.

Blood sugar changes following the administration of the carbohydrates are summarized in Table 2. While the values tend to be inconsistent, they generally reflect higher blood sugar levels following abomasal administrations than following oral administrations. The high elevations after glucose was given into the abomasum were not equaled with starch or heated starch.

Table 1. ---Digestibility and Nitrogen Retention in Wethers Receiving Carbohydrates Orally or Into the Abomasum

Treatment	Digestibility, %			Nitrogen Retention	
	Dry Matter	Protein	Cellulose	G daily	% of Dig
<u>Experiment 1</u>					
Starch					
Oral	60.6	62.4	54.6	0.80	6.8
Abomasal	56.8	54.8	55.5	0.76	7.5
Glucose					
Oral	59.8	62.2	53.7	2.12	18.9
Abomasal	58.8	58.0	54.4	0.87	13.7
<u>Experiment 2</u>					
Starch					
Oral	63.2	67.8	58.5	0.18	-1.9
Abomasal	61.9	62.9	58.9	0.92	9.1
Heated starch					
Oral	65.2	70.6	61.0	1.50	15.1
Abomasal	66.6	68.8	65.8	2.04	17.2

Table 2. ---Blood Sugar Changes (mg/100 ml), in Wethers Following Oral and Abomasal Administration of Carbohydrates

	Time After Administration (hr)				
	$\frac{1}{2}$	1	2	3	4
<u>Experiment 1</u>					
Starch					
Oral	-3.0	4.0	5.0	12.3	6.9
Abomasal	3.7	4.0	15.2	3.0	2.3
Glucose					
Oral	-3.8	-2.0	2.4	4.9	-0.9
Abomasal	11.3	19.6	43.5	32.7	28.6
<u>Experiment 2</u>					
Starch					
Oral	-6.0	1.0	-4.0	-1.0	-3.0
Abomasal	6.8	12.5	2.0	-6.2	1.7
Heated starch					
Oral	-1.8	5.8	8.2	-9.6	-2.3
Abomasal	18.0	8.2	7.0	1.0	8.5

FACTORS IN CORN DISTILLERS DRIED SOLUBLES WHICH STIMULATE CELLULOSE DIGESTION

G. D. Potter, C. O. Little and G. E. Mitchell, Jr.

Several protein-rich feeds have been found to contain factors which enhance cellulose digestion by rumen microorganisms. Corn distillers dried solubles (DDS) is recognized as a potent source, and previous work has revealed several of the chemical and physical properties of these factors; however, their identity has not been definitely established. Several organic compounds have been related to the rumen stimulatory activity of some natural feeds. Research elsewhere has indicated that proline is responsible for a large part of the activity in yeast, casein and alfalfa extract. This report summarizes research initiated to study possible relationships between the rumen stimulatory activity in DDS and its proline content.

Procedure

Corn distillers dried solubles (DDS) was subjected to different physical and chemical fractionation procedures to concentrate and isolate the proline contained. In vitro cellulose digestion by rumen microorganisms was used to measure activity of the fractions. All fractions were compared on an equal quantitative basis, levels usually being equivalent to 2.5 mg original dry feed per ml nutrient medium. Several purified organic compounds, previously implicated by other research, were also assessed for activity.

Results

The rumen stimulatory factors in DDS were found to be completely soluble in water but not in alcohol. The major portion of the activity found in the water extract was precipitated with alcohol, and it remained after acid hydrolysis. Proline and valeric acid were the only chemical compounds of several studied which consistently gave responses in in vitro cellulose digestion. The response from proline or valeric acid was independent of that from other compounds. Maximum responses in cellulose digestion from the addition of proline, valeric acid and DDS were similar.

Proline and valeric acid analyses of several fractions of DDS were conducted in an attempt to relate the rumen stimulatory activity of these fractions to their content of these compounds. Valeric acid was not detectable in a DDS fraction containing all the activity. Proline was present in all active fractions but, based on the level of synthetic proline needed for comparable cellulose digestion, it was not present in sufficient quantities to explain the response obtained from those fractions.

The amino acids in a hydrolyzed preparation of DDS were separated into four groups by paper chromatography, and the only fraction which gave an increase in cellulose digestion was the one containing proline. While the cellulose digestion noted with this fraction was significantly more than that of the control, it was significantly less than the cellulose digestion with the original unchromatographed material.

Analyses of free proline, valeric acid, and cellulose digestion in tubes containing added proline or valeric acid after 6, 12, 18 and 24 hours of fermentation suggested that proline was converted to valeric acid during the period 0 to 12 hours when no cellulolytic response was noted. During periods of rapid cellulose digestion, there was a rapid decline in valeric acid. The results did not suggest that valeric acid was converted to free proline but indicated that valeric acid was metabolized by the cellulolytic microorganisms.

The information gained in these studies indicates that much of the rumen stimulatory activity of corn distillers dried solubles is related to proline in the protein portion of this feed. However, all of the stimulatory activity cannot be explained by the presence of proline alone. There are evidently other factors which contribute to the cellulolytic activity. Proline seems to give its cellulolytic response through increasing valeric acid production, and this probably results from the conversion of proline itself to valeric acid. Valeric acid, in turn, stimulates the activity of cellulolytic microorganisms and increases cellulose digestion.

VOLATILE FATTY ACIDS AND GLUCOSE IN EQUINE CECAL FLUID AND BLOOD

L. G. Kennedy, C. O. Little, G. E. Mitchell, Jr.
H. D. Stowe^{1/} and J. R. Rooney^{1/}

The cecum of the horse and the rumen of cattle both serve as fermentation vats for large numbers of microorganisms. In both cases volatile fatty acids are major products of carbohydrate fermentation. However, the rumen fermentation precedes gastric and intestinal digestion while cecal fermentation follows gastric and intestinal digestion. Consequently, a similar microbial activity may have considerably different nutritional significance to the horse and the ruminant because of the differences in feed or feed residues presented to the microorganisms and differences in subsequent metabolism of the products of fermentation.

Young ruminants have blood glucose levels similar to monogastric animals. As rumen function develops, blood glucose normally falls to less than half the original level. This reflects increased dependence on volatile fatty acids for energy which is in turn reflected in increased acetic acid concentrations in the blood. Although glucose may be an intermediate in the production of volatile fatty acids from carbohydrates in the rumen, significant levels of glucose are seldom found in the rumens of cattle or sheep fed practical rations. Since more of the starch reaches the small intestine, horses fed similar amounts of starch would be expected to absorb much more glucose than cattle or sheep. Some glucose resulting from starch digestion in the small intestine might be expected to reach the cecum of the horse.

The data in this report are the results of a survey of volatile fatty acids and glucose found in cecal fluid and serum of horses of different ages. The cecal fluids were obtained from necropsy samples. Serum was obtained through the cooperation of local breeders. Although the rations fed these horses were not under experimental control and very young animals were not included, it was hoped that useful data concerning similarities and differences in the energy metabolism of horses and ruminants would be obtained.

Procedure

Sixty-four serum samples from normal thoroughbreds and 26 necropsy samples of equine cecal fluid were included in the survey. Samples were divided into groups according to age -- suckling, weanling, yearling, 2-4-year-old, and aged. Volatile fatty acids were determined by gas liquid chromatography. Glucose was determined by the Folin-Wu, potassium ferricyanide and glucose oxidase procedures.

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Results and Discussion

Table 1 summarizes the data obtained from the serum samples. The only volatile fatty acid detected in serum was acetate. This is in general agreement with the observation that acetate is ordinarily the predominant volatile fatty acid found in the blood of ruminants. Relatively little attention has been given to volatile fatty acids in the blood of horses. However, the values reported here are somewhat higher than those which have been reported previously. Although the data are highly variable, no trend for increased volatile fatty acids with increasing age is evident. To the contrary, aged animals had substantially lower serum acetate levels than animals in the younger age classifications. The serum glucose values correlate well with previously reported values for plasma.

Table 1. ---Concentrations of Volatile Fatty Acids and Glucose in Equine Serum

Age Classification	No. of Animals	Acetate ^{a/} Concentration (uM/ml)	No. of Animals	Glucose Concentration (mg/100 ml)
Sucklings	16	2.29 ± 1.05 ^b	13	124.9 ± 13.8
Weanlings	19	1.97 ± 0.55	21	117.1 ± 25.8
Yearlings	8	2.34 ± 0.77	6	120.8 ± 16.7
Aged	21	0.80 ± 0.20	7	109.3 ± 20.0

^{a/}Other volatile fatty acids were not detected

^{b/}Standard deviations

Tables 2 and 3 summarize the volatile fatty acid data for cecal fluid. The total concentrations and the molar proportions of acetate, propionate and butyrate would be reasonable for ruminal fluid of cattle or sheep fed high roughage rations. The data suggest fully active cecal fermentation in weanlings. The high serum acetate levels observed in sucklings suggests further that this function is well established before weaning. Controlled observations on younger animals would be required to determine the sequence of physiological events associated with the development of cecal function.

Table 2. ---Volatile Fatty Acid Concentrations in Equine Cecal Fluid (uM/ml)

Age Classification	No. of Animals	Acetate	Propionate	Butyrate	Total
Weanlings	5	71.9 ± 25.0	24.7 ± 22.2	12.8 ± 10.7	109.4 ± 52.0
Yearlings	6	77.5 ± 19.0	16.8 ± 6.5	7.8 ± 3.6	102.1 ± 28.4
2 - 4	7	88.7 ± 30.0	19.1 ± 9.3	9.1 ± 5.2	116.9 ± 43.6
Aged (8+)	8	85.0 ± 30.8	26.3 ± 7.8	11.2 ± 4.8	122.5 ± 39.7

Although significant concentrations of glucose were detected in cecal fluid (Table 4), the concentrations were highly variable and would not make up a major portion of the total energy available to the animal.

Table 3. ---Molar Percentages of Volatile Fatty Acids in Equine Cecal Fluid

Age Classification	No. of Samples	Acetate	Propionate	Butyrate
Weanlings	5	65.7	22.6	11.7
Yearlings	6	76.0	16.5	7.6
2 - 4	7	75.8	16.3	7.8
Aged (8+)	8	69.0	21.3	9.1

Table 4. ---Glucose Concentrations in Equine Cecal Fluid

Age	No. of Samples	Glucose Concentration (mg/100 ml)
Weanlings	5	14 $\pm$ 21.6 ^a
Yearlings	6	30 $\pm$ 26.4
2 - 4	7	10 $\pm$ 13.7 ^b
Aged (8+)	8	27 $\pm$ 20.0

^a/ Excludes one value of 176 mg/100 ml

^b/ Excludes one value of 242 mg/100 ml

PHYSIOLOGICAL CHANGES IN LAMBS RECEIVING HIGH LEVELS OF ANTIBIOTICS

M. R. Karr, C. O. Little, G. E. Mitchell, Jr.,
H. A. Glimp and P. G. Woolfolk

The functioning rumen plays an important role in the nutrition of the ruminant. Through microbial activity in the rumen carbohydrates are converted to short-chain volatile fatty acids, dietary nitrogen sources are converted to microbial protein and the animal's B-vitamin requirements are met by microbial synthesis. This experiment was initiated to determine whether the development of bacterial populations in the rumen of lambs could be inhibited by continuously administering large doses of antibiotics into the rumen and to determine the effects of such treatment on the development of the ruminant stomach compartments and digestive processes.

Procedure

Four sets of twin lambs of the same sex born within a 3-day period were maintained in pens on elevated expanded metal floors. Rumen cannulae were installed in all lambs approximately 10 days after birth. One and one-half g of a mixture of equal parts neomycin, bacitracin and sulfathalidine were administered in two equal doses daily via rumen cannula to one lamb of each pair, starting when the lambs were 2 weeks old. Antibiotic levels were increased to 2.25, 3.0, 4.5, 6.0, 9.0 and 12.0 g on the 3rd, 4th, 5th, 6th, 9th and 11th week, respectively. In addition to the above antibiotic treatment, 2 g of penicillin and

streptomycin were given daily for three consecutive days of each week, beginning on the 12th and continuing through the 16th week. All lambs had free access to a corn-soybean meal ration containing 18% protein with vitamins A, D and B complex added. The lambs were housed with their dams during the first 7 weeks, and then weaned. Rumen fluid and jugular blood were sampled weekly. One pair of lambs was sacrificed at the end of the 8th, 12th, 14th and 16th weeks to observe anatomical and physiological differences in the development of the stomach compartments.

Results

Microscopic observations did not reveal bacteria in ruminal fluid of the treated lambs until the 12th week. Yeast cells were observed in abundance. Absence of bacteria was supported by the absence of volatile fatty acids (Table 1). The acetate levels in the jugular blood of the treated lambs remained low throughout the experiment, reflecting the low production in the rumen. Blood acetate levels in the control lambs dropped to a low on the 16th week, then increased rapidly with each succeeding week to a high of 0.95 micromoles per ml on the 16th week. Blood glucose concentrations in the control lambs dropped to an approximately normal adult level by the 8th week. The blood glucose of the treated lambs did not decline to this level until the 14th week.

Table 1. ---Ruminal VFA Concentrations and Ratios for Control and Antibiotic Treated Lambs

Week	Control				Treated ^{a/}	
	6	10	12	14	12	14
Concentrations ^{b/} Molar percent	53	92	76	52	24	15
Acetic	67	43	59	67	62	81
Propionic	24	38	30	24	28	17
Butyric	9	17	8	7	10	2
Valeric	0	2	3	2	0	0

^{a/} VFA were not detected in rumen fluid samples taken weekly from the 5th through the 11th week.

^{b/} Micromoles per ml rumen fluid.

The results of the various measurements made on the stomach compartments of the lambs are summarized in Table 2. Rumen capacity was not affected by the antibiotic treatment; however, the average weight of the reticulo-rumen was 2.4 times heavier in the control lambs than in the treated lambs. The papillae remained rudimentary and muscular development was retarded in the rumens of the treated lambs. Average omasal weight of the control lambs was greater than that of the treated lambs. Rate of gain for the control lambs was relatively constant for the duration of the experimental period (0.29 kg/day). The treated lambs gained equally well prior to weaning but did not gain or even maintain their body weight when milk was removed from their diet.

Table 2. ---Comparative Development of the Stomach Compartments of Control and Antibiotic Treated Lambs

Item	Control	Treated
Av lamb weight, kg	25.0	15.3
Reticulo-rumen fill, l	2.5	3.1
Capacity, l		
Reticulo-rumen	4.53	4.62
Abomasum	.94	.81
Weight, g		
Reticulo-rumen	555.0	230.0
Omasum	34.0	21.0
Abomasum	91.0	86.0
Papillae length, mm	3.2	0.0

Table 3 presents apparent digestion coefficients for dry matter, crude protein and starch as the constituents of the diet passed through the digestive tract. They were calculated from changes in chromic oxide to nutrient ratios in ingesta collected at time of sacrifice. Apparent digestion was fairly consistent for the control lambs. Approximately 57% of the dry matter was digested in the rumen and omasum, 14% in the small intestine, and 4% in the large intestine. No apparent crude protein digestion took place in the rumen. Nitrogen disappearance from the small intestine was equivalent to 46% of the ingested protein. The large intestine appeared to account for a major portion of the protein digested (27.8% of the intake). Overall starch digestion was nearly complete (98.4%), with 73.3% being digested in the rumen, 24.5% in the small intestine, and less than 1% in the large intestine.

Table 3. ---Apparent Digestion Coefficients for Control and Antibiotic Treated Lambs

	Control				Treated			
	12 ^a	14	16	Av	12	14	16	Av
<u>Dry matter</u>								
Rumen	33.8	25.2	28.6	29.2	-25.0	-20.0	2.4	-14.2
Oral to:								
Abomasum	53.0	60.3	57.7	56.8	1.3	-15.0	-57.6	-23.8
Posterior ileum	64.0	74.6	74.0	70.8	16.6	6.2	-14.0	2.9
Rectum	75.7	76.6	72.3	74.9	53.6	44.6	17.6	38.6
<u>Crude protein</u>								
Rumen	20.5	-30.0	-39.0	-16.2	45.7	-77.4	-48.0	-57.0
Oral to:								
Abomasum	-16.0	5.5	6.7	-1.3	-16.1	-25.8	-32.2	-22.7
Posterior ileum	26.2	66.9	44.8	46.0	48.0	4.7	-130.0	-26.0
Rectum	76.6	71.6	73.1	73.8	60.5	-2.5	-94.0	-12.2
<u>Starch</u>								
Rumen	77.2	75.0	69.3	73.8	-57.6	-3.0	23.6	-10.0
Oral to:								
Abomasum	76.0	72.3	71.5	73.3	22.6	-13.7	-2.4	-5.6
Posterior ileum	97.9	97.2	98.4	97.8	45.8	37.6	57.2	46.8
Rectum	97.9	99.0	98.3	98.4	84.4	94.1	92.8	90.4

^a/ Age of lambs in weeks at time of slaughter.

The apparent digestion coefficients for the treated lambs were quite variable and in many cases negative. The apparent digestion of dry matter and crude protein became lower or more negative with advancing time. Although less than for the controls, starch digestion by the treated lambs was relatively high compared with digestion of other components of the diet.

AMYLASE ACTIVITY OF PANCREAS FROM STEERS FED DIFFERENT RATIONS

J. J. Clary, G. E. Mitchell, Jr., C. O. Little
N. W. Bradley and W. B. Hayes

Starch fed to steers has been widely assumed to be converted almost entirely to volatile fatty acids in the rumen, and little significance has been attached to its post-ruminal digestion. Wide-spread use of high-concentrate rations has led to re-evaluation of this assumption and to experiments demonstrating that large amounts of starch escape rumen fermentation when high-concentrate diets are fed. A major portion of the starch digestion posterior to the rumen is accomplished by alpha amylase, an enzyme secreted by the pancreas. Consequently, secretion of this enzyme by the pancreas may be an important factor in determining how efficiently high-concentrate rations are utilized. It may also be related to adaptation of previously roughage-fed cattle to high-concentrate rations. This experiment was conducted to study the possible influence of rations varying widely in grain content on the amylase activity of steer pancreas.

Procedure

The pancreatic tissue used in this study was obtained from three groups of yearling steers fed their respective rations for at least 126 days prior to slaughter. Group A (39 steers) was self-fed all-concentrate rations averaging 73.5% ground shelled corn and 26.5% protein, mineral and vitamin supplement. Group B (48 steers) was fed a mixture of 66% ground shelled corn, 26% corn silage and 8% soybean oil meal and free-choice minerals. Group C (26 steers) received only legume-grass pasture and free-choice minerals. Samples of pancreatic tissue were taken at slaughter and immediately frozen and stored until assayed for amylase activity. The amylase activities were determined by homogenizing the tissue in a buffer solution, determining the protein content, diluting to a standard protein basis, and determining the ability of these standardized homogenates to digest a standard starch solution under controlled conditions. Amylase activity was expressed in arbitrary units based on the amount of starch digested per unit of protein.

Results and Discussion

Table 1 presents the means and standard errors of the alpha amylase determinations for each group of steers. Although considerable variability was observed, pancreatic tissue from pasture-fed steers contained less amylase activity than pancreatic tissue from steers fed grain. The greatest amylase activity was found in pancreas from steers fed all-concentrate rations. However, further analysis of the data revealed a significant run effect for the assays. Thus, direct comparisons among the activities shown in Table 1 are subject to question. Table 2 summarizes data from assays in which an equal number of pancreas from steers fed all-concentrate rations and steers only pasture were included in each assay. Heavy grain feeding apparently resulted in a highly significant ($P < .005$) increase in the amylase activity of the pancreas. These data suggest that one factor in the adaptation of ruminants to high-concentrate rations is increased production of amylase for the digestion of the larger amounts of starch reaching the small intestine.

Table 1. ---Effect of Ration on Alpha Amylase Activity of Steer Pancreas

Ration	No. of Steers	Amylase Activity ^{a/}	Standard Error
A (All-concentrate)	39	888	50
B (Mixed)	48	780	66
C (Legume-grass)	26	643	61

^{a/} Arbitrary units on an equal protein base.

Table 2. ---Comparison of Pancreatic Amylase from Steers Fed an All-concentrate Ration and Pasture

Ration	No. of Steers	Amylase Activity ^{a/}	Standard Error
A (All-concentrate)	24	827	61
C (Legume-grass)	24	588	52

^{a/} Arbitrary units on an equal protein base.

SHEEP SECTION

EFFECT OF INDUCED CRYPTORCHIDISM AT DIFFERENT WEIGHTS ON PERFORMANCE AND CARCASS TRAITS OF LAMBS

L. W. Hudson, H. A. Glimp, J. D. Kemp and P. G. Woolfolk

A growth trial with 52 lambs was conducted to study the effects of inducing cryptorchidism. The lambs were by Hampshire or Southdown rams and out of Montana ewes. They were allotted into five groups: wethers, 30-lb cryptorchids, 45-lb cryptorchids, 60-lb cryptorchids, and rams. The wethers were castrated at 15 lb with rubber bands and cryptorchidism was induced by pushing the testicles into the body cavity and cutting the scrotum off flush with the stomach with rubber bands. All the lambs ran with their dams and had free access to a simple creep ration until they were slaughtered at approximately 90 lb. The collected data were analyzed by least squares analysis, using a model that included the main effects of treatment, breed of sire and type of birth.

Results are shown in Table 1. There was no significant difference in average daily gain (ADG) owing to treatment; however, there were differences owing to breed and type of birth. Hampshires and singles gained faster than Southdowns and twins. The rams gained slightly faster than did the wethers as was expected but the 30-lb cryptorchids gained faster than the rams. This difference may be of considerable importance. There was a significant treatment difference in testicle size. The rams were different from the three cryptorchid groups, but there were no differences among the cryptorchid treatments. There was a trend for the earlier cryptorchid testes to be larger, which may indicate that they had an opportunity to adjust to the higher body temperature after being pushed up into the body cavity. The small differences due to breed and type of birth can be explained by the differences in ages of the lambs.

There were no significant differences in carcass grade or conformation owing to treatment, breed or type of birth. The wethers graded average prime in both conformation and grade, while the other treatments were prime minus in both respects. No significant differences were noted in loin-eye area or percentage of leg with respect to treatment, breed or type of birth. When the data were analyzed by analysis of variance, there was a significant difference in fat thickness over the loin and kidney and knob fat owing to treatment, but none of the means were significantly different when subjected to Duncan's new multiple range test. Wethers could be expected to be fatter than the rams, but the rams were also fatter than the cryptorchids which does not follow the hypothesis that the cryptorchids should be intermediate to rams and wethers owing to the lowered androgen production of the cryptorchid testes. The results of this trial indicates that inducing cryptorchidism may increase growth rate and decrease carcass fat content of cryptorchids when compared with castration.

Table 1. ---Results of Trial

	Treatment						Birth		Breed	
	30-lb		45-lb		60-lb		Singles	Twins	Hampshire	Southdowns
	Wether	Crypt	Crypt	Crypt	Crypt	Crypt				
Number of lambs	10	9	11	11	11	11	25	27	19	33
Birth weight (lb)	10.60	10.72	9.71	11.14	11.14	9.46	11.57	9.14	10.95	9.94
Final weight (lb)	91.00	92.00	90.09	91.77	91.77	91.72	92.66	90.04	93.84	89.83
ADG (lb) ^{a/}	0.54	0.63	0.60	0.61	0.61	0.61	0.68 ^{a/}	0.52 ^{b/}	0.67 ^{a/}	0.56 ^{b/}
Testicle weight (gm) ^{a/}	0	94.80 ^{b/}	81.60 ^{b/}	76.64 ^{b/}	76.64 ^{b/}	209.17 ^{c/}	83.37	104.08	87.34	98.03
Carcass conformation ^{b/}	14.20	13.22	13.36	13.63	13.63	13.36	13.56	13.55	13.42	13.63
Carcass grade ^{b/}	14.20	13.00	13.09	13.36	13.36	13.27	13.60	13.18	13.21	13.48
Loin-eye area (sq in)	2.31	2.09	2.29	2.26	2.26	2.22	2.27	2.20	2.31	2.19
Percent leg	27.75	28.54	28.79	29.12	29.12	28.35	28.89	28.18	28.97	28.26
Loin fat thickness (cm) ^{c/}	0.94	0.74	0.83	0.71	0.71	0.80	0.86	0.75	0.78	0.82
Kidney and knobfat (%) ^{c/}	3.40	2.61	2.79	2.66	2.66	2.82	3.04	2.89	2.87	2.84

^{a/} All means not followed by the same superscript are significantly different ($P < .05$).

^{b/} 15 = prime plus, 14 = prime average, 13 = prime minus.

^{c/} When analyzed by analysis of variance, a significant difference ($P < .05$) was shown, but none of these means were significantly different when subjected to Duncan's new multiple range test.

^{d/} One inch = 2.54 cm.

GENETICS SECTION

INFLUENCE OF THE UTERUS ON OCCURRENCE OF ESTRUS IN EWES

C. J. Falcon and R. H. Dutt

Various studies have indicated that the uterus exerts an effect on regulating the estrous cycle through its influence on the life and function of the corpus luteum. Since hysterectomy in many estrous females results in a condition similar to that observed in ewes during the anestrus season, i.e., absence of overt signs of estrus and ovulation, it is of interest to determine the effects of hysterectomy performed on estrous and anestrus ewes relative to the expression of estrus, ovulation and maintenance of corpora lutea.

In the first part of the experiment, 10 estrous ewes were hysterectomized and corpora lutea were enucleated. Ten control ewes were laparotomized and had corpora lutea enucleated, but the uterus remained intact in each of these. Ewes were checked for uterus immediately following surgery and were considered to be in estrus when they stood and allowed teaser rams to mount. The hysterectomized ewes were laparotomized 25 days later to determine whether ovulation had occurred. In July, 10 anestrus ewes were hysterectomized and checked for estrus throughout the following breeding season. Laparotomies were performed in January of the breeding season to determine if ovulation had occurred. A third part of the study was to compare the sensitivity of hysterectomized and intact ewes to 1 mg injections of estradiol benzoate relative to expression of estrus. On day 8 of the cycle ewes were selected for controls since the corpora would be at a stage of development comparable to that in hysterectomized ewes. Results are summarized in the following table.

Table 1. ---Summary of Observations on Hysterectomized Ewes

Treatment	No. of Ewes	Percent of Ewes Showing Estrus	Average Interval to Estrus, Days	Duration of Estrus, Days
Control estrous ewes, CL enucleated	10	100	2.20	1.4
Hysterectomized estrous ewes CL enucleated	10	70	2.86	1.3
Hysterectomized anestrus ewes	10	10	89.0	1.0
1 mg E.B. ^a injection 8-day control ewes	7	85.7	3.0	3.3
1 mg E.B. injection hysterectomized estrous ewes	10	10	1.0	2.0

^a/ Estradiol benzoate.

Although there was suppression in percentage of ewes showing estrus among those hysterectomized during the breeding season, differences were not significant. Laparotomies performed on the ewes indicated that all had ovulated and corpora lutea were being maintained following the one ovulation. One of 10 ewes hysterectomized during the anestrus season exhibited estrus during the fall breeding season. Laparotomies revealed the presence and

maintenance of corpora lutea in all of the anestrous ewes, indicating that ovulation had occurred but without overt estrous symptoms in 9 out of the 10 ewes. Estrogen injections into hysterectomized and control ewes indicated a significant ($P < .01$) reduction in sensitivity to estrogen. Results from these studies indicate that the uterus is involved in expression of estrous behavior in the ewe. An explanation of the mechanism through which this influence is mediated is not evident, but results of the test with injected estrogens suggest that the metabolism of estrogens by the uterus may be involved.

EFFECTS OF INJECTED PROGESTOGENS ON ESTROUS BEHAVIOR IN THE EWE

C. J. Falcon and R. H. Dutt

Experiments with the recently developed orally-effective synthetic progestins have shown them to be quite potent in their ability to control estrous. The purpose of this study was to determine the effects of these compounds injected subcutaneously on length of estrous suppression, ovarian activity and on synchronization of estrus periods in ewes. Such injections may be practical for long-term suppression of estrus, as in feedlot heifers.

Twenty cycling ewes were given one or two subcutaneous injections (microsuspension) of either 200 mg of 6-methyl-17-acetoxy-progesterone (MAP) or 100 mg of 6-chloro- Δ 6-17-acetoxypregesterone (CAP) in October and November. Twelve untreated ewes served as controls. Ewes were checked daily for estrus with teaser rams. Ewes not returning to estrus within 4 months after the single injection were laparotomized. Ewes injected twice were laparotomized 1 month after the last injection. Effects of various treatments on suppression of estrous are shown in Tables 1 and 2.

Table 1. ---Effect of Progestogen Injection on Length of Estrous Cycles

Item	Treated Ewes	Control Ewes
No. of ewes	17	12
Av cycle length, days	193.0	17.7
Range in cycle lengths, days	63-342	16.6-20.6
Standard deviation, days	116.0	1.25

Table 2. ---Interval from First Injection of MAP or CAP to Estrus

Item	Treatment ^{a/}			
	MAP-1	MAP-2	CAP-1	CAP-2
No. of ewes	5	5	5	4
Av interval, days	270	248	116	106
Standard deviations, days	89.1	90.9	110.3	12.1
Adjusted interval, days	155	150	85	106
Standard deviation, days	10.3	21.5	42.7	12.1

^{a/} 1 and 2 refers to number of injections.

The average cycle length of treated ewes was significantly ($P < .01$) larger than for controls. Average date of last estrus for control ewes was March 3, and 50% of the treated ewes did not return to estrus until the following season. The natural anestrous may have accounted for part of the long interval to estrus in many treated ewes. To overcome part of this, the last heat period observed in the controls was used as the termination of the breeding season and adjustments were made on this basis. In both adjusted and observed (unadjusted) intervals, there was a significant ($P < .05$) difference, with the MAP-treated ewes having longer anestrous intervals. Number of injections had no significant effect on interval to estrus. The treatment was not effective in producing synchronous estrus, as indicated by the large standard deviation for treated ewes.

At laparotomy, 13 treated ewes had from 6 to 2,000 ml (av 214 ml) of fluid in the uterus. Removing the fluid at time of laparotomy did not shorten the interval to estrus. Examination of histological sections of these uteri revealed hypertrophied uterine glands with degenerate epithelium.

SEMEN EVALUATION TESTS AND LAMBING PERFORMANCE OF EWES

P. R. Dame, C. J. Falcon, R. H. Dutt, and P. G. Woolfolk

Results of selecting for earlier date of lambing and for higher reproductive efficiency are being studied in a flock of Southdown sheep. Each year the flock is divided into three breeding groups, and yearling sires are used. This phase of the early lambing study is concerned with a possible relationship between semen characteristics during July and lambing results for the sire groups.

In July the yearling rams were electro-ejaculated three times at weekly intervals, and their semen was evaluated in the laboratory. Approximately 1 ml of semen was taken at each collection, and the percentage of motile cells, sperm cell concentration and percentage of abnormal cells were determined. The rams for the three breeding groups were selected on the basis of the semen evaluation. The results of the semen tests for 1965 are shown in Table 1.

Table 1. ---Semen Evaluation and Lambing Results

Characteristic	Ram		
	6409	6412	6436
Av semen volume, ml	1.10	0.80	1.10
Av semen motility, %	67.0	67.0	63.0
Av abnormal sperm, %	4.2	6.4	4.8
Sperm cell concentration, (billion/ml)	3.58	1.75	2.15
Av lambing date	March 1	February 23*	March 4
Av date of first estrous check	September 18	September 10	September 5
Av difference between first estrous check and conception	20 days	22 days	36 days

*Significantly ($P < .05$) different from other rams.

The rams were fitted with marking harnesses, and daily estrous checks were made. The crayon color was changed every 16 days so that ewes returning in estrus could easily be identified.

There was no significant difference in the semen characteristics among rams, but the ewes that had the earliest lambing date were those that had been bred to Ram 6412. Ram 6412 tended to have the lowest concentration of sperm cells and highest percentage of abnormal sperm cells.

The average lambing date of ewes bred to Ram 6412 was significantly ($P = .05$) earlier than that of ewes mated to the other rams. The average lambing date for all ewes was February 28. The average date of first estrous check for all ewes was September 11, and the average date of conception for all ewes was October 7. Conception was calculated as lambing date minus 145 days. The average difference between the first estrous check and conception for all ewes was 26 days, resulting in an average of 2.5 estrous periods per conception.

These results suggest that semen characteristics measured in July are not good predictors of potential lambing performance of ewes. It is possible that the semen characteristics of the rams could change drastically between July and September.

REPRODUCTIVE RESPONSE IN EWES AFTER SHORT-TIME EXPOSURE TO CONTINUOUS LIGHT

R. H. Dutt and C. J. Falcon

It is well-established that a change in the light-dark ratio will modify estrous activity in ewes. However, the effects of light on ovulation rate, fertility and embryo survival have not been studied under well-controlled conditions. Results of a study conducted during two breeding seasons to determine the effect of short-time exposure to continuous light on these reproductive phenomena is reported here.

Sixty ewes were placed in continuous light on the eighth day (8-day ewes) of the cycle, and 60 (full-cycle ewes) received similar treatment for one estrous cycle before breeding. Forty ewes served as controls. Yearling and 2-year-old dark-faced northwest ewes were stratified among treatments during the two breeding seasons. Ewes were checked daily with teaser rams to determine onset of estrus. All groups were pastured during the day, and at night treated groups were kept in inside pens provided with fluorescent lights. Artificial light intensity 18 inches from the floor ranged from 10 foot-candles in corners of the pen to 40 foot-candles beneath the lights. Control ewes were kept in a similar pen without artificial light. Ewes in all groups were artificially inseminated, starting October 20 each year. Half of the ewes in each group were slaughtered 3 days after breeding for ovulation and fertility data, and the remaining ewes were kept under continuous light until 20 days after breeding for data to estimate embryo loss. Ovulation rate, percent fertile ova and lambing rate for the control, 8-day and full-cycle ewes are shown in Table 1, and estimates of embryo loss and lambing rate are shown in Table 2.

Table 1. ---Ovulation and Fertility Rates

Item	Control	Continuous Light	
		8-day	Full-cycle
No. of ewes	20	30	30
Ovulation rate	1.70	1.93	2.00
Ewes having triple ovulations, %	0.0	16.7	16.7
Fertilized ova, %	85.3	83.3	91.7

Table 2. ---Embryo Loss, Lambing Rate and Birth Weight of Lambs

Item	Control	Continuous Light	
		8-day	Full-cycle
No. of ewes	20	30	30
Ewes lambing, %	80.0	80.0	83.3
Lambing rate	1.44	1.46	1.60
Embryo loss, %	20.7	22.2	26.8
Av birth wt of lambs, kg	3.89	3.98	3.81

Estimated embryo loss was not affected significantly by exposure to additional light. Ovulation rate in the full-cycle ewes was 15% higher and the lambing rate was 11% higher than for control ewes. Seventeen percent of the ewes exposed to light had triple ovulations, whereas none occurred in controls. Exposure to continuous light for one cycle had no significant effect on length of estrous cycle or duration of the estrous period.

The increase in ovulation rate in the ewes exposed to continuous light approached significance and suggests that the increased light may stimulate release or production of gonadotrophic hormone. Increased amount of light during the breeding season may have a "flushing effect" in cycling ewes.

DEVELOPMENT OF THE REPRODUCTIVE ORGANS AND GAIN IN RAM LAMBS AFTER SCROTAL ABLATION OR INJECTION WITH A PROGESTOGEN

R. H. Dutt and C. J. Falcon

It has been a general observation among certain species of livestock, i.e., beef cattle and swine, that intact males tend to outgain castrates. Such an advantage is presumably due to the presence of circulating testosterone released from the testicles in response to gonadotrophins from the pituitary. This study was undertaken to determine the effects on body growth and on accessory gland development of two treatments which would inhibit testicular growth: a progestogen to inhibit gonadotrophin release, and scrotal ablation which leaves the testicles lying against the abdominal cavity causing destruction of testicular tissue by high body temperature.

Thirty-one ram lambs ranging in age from 19 to 33 days were randomly divided into three groups of eight lambs and one group of seven lambs. Lambs in group 1 were untreated and served as controls. Lambs in group 2 were castrated. Those in group 3 were injected with 50 mg of melengestrol acetate (MGA) at the beginning of the study and 2 months later, and lambs in group 4 had a tight rubber band placed around the scrotum at the junction of the body wall after the testes had been pushed into the inguinal canal. The scrotum was then sloughed, leaving the testes lying externally against the abdominal wall. Average age, weight at slaughter, weight per day of age and weight of the reproductive organs are shown in the following table.

Table 1. ---Age, Slaughter Weight, Weight per Day of Age and Weight of Reproductive Organs of Ram Lambs

Item	Control	Wethers	Scrotal Ablation	MGA-injected
Av age at slaughter, days	139	159	159	152
Av wt at slaughter, lb	81.5	82.5	86.8	82.4
Av wt per day of age, lb	0.58	0.53	0.56	0.55
Av wt testes, g	213	--	56	96
Av wt seminal vesicles, g	5.4	0.6	5.9	1.2
Av wt bulba-urethral glands, g	2.5	0.6	2.6	1.2

MGA injections and scrotal ablation significantly reduced ($P < .01$) average weight of the testes. There were no significant effects of treatments on body weight gain. The wethers and MGA lambs had significantly ($P < .01$) lighter accessory glands. There was no significant difference between weights of accessory glands of the controls and the lambs with scrotal ablation. Even though the testes of the scrotal ablation lambs were smaller, these data indicate that such treatment did not suppress testosterone production since the accessory glands (seminal vesicles and bulbo-urethral glands) were as large as in the uncastrated rams. Treatment with MGA apparently did suppress testosterone production, as indicated by significantly ($P < .01$) smaller accessory glands.

MEATS SECTION

CARCASS EVALUATION OF LAMBS FROM SELECTED SIRES

Robert H. Smith, James D. Kemp and W. G. Moody

Carcass information from 90 prime and choice spring lambs was analyzed to determine the effect of sex, type of birth, and sire on carcass composition. These lambs were the progeny of three performance-tested Hampshire rams and western ewes. Various measurements were taken on the chilled carcass. The right side of each carcass was then cut into the wholesale cuts which were trimmed to a standard 0.2 inch of fat cover for the retail cut. The retail cuts were boned out, and any interior fat deposits were removed to obtain edible portion. The leg and rack were physically separated into lean, fat and bone. Comparisons were made between sires, singles vs. twins, and wethers vs. ewes. A summary of the results appears in the accompanying tables.

Results and Discussion

Comparison of sire groups indicates that the faster gaining lambs were leaner as indicated by the percentage of fat trim, the percentage of fat of rack, and by the fat thickness measurements. The faster gaining lambs tended to have a higher percent leg and a corresponding lower percent shoulder. Comparisons of singles and twins indicates that while singles gain faster, they tend to be slightly fatter. Wether-ewe comparisons reveal that wethers are leaner and faster gaining.

The measurements in Table 2 closely parallel the results of Table 1. Within sire groups the faster gaining lambs were leaner as indicated by the fat thickness measurements. Singles were fatter than twins, and wethers were trimmer than ewes. Correlations between measurements and composition are being determined but are not yet available.

Table 1. ---Selected Live and Carcass Traits

Characteristic	Sire 1	Sire 2	Sire 3	Singles	Twins	Wethers	Ewes	Av All Lambs
Age (days)	158.7	170.9	154.3**	151.9	172.6**	157.0	166.8**	161.6
Live weight (lb)	87.3	89.1	90.7*	89.8	88.8	90.6	88.0*	89.3
Carcass wt/day	0.28	0.29	0.32**	0.32	0.27**	0.31	0.28	0.29
of age								
Carcass grade ^a	12.10	12.71	12.44	12.77	12.11**	12.39	12.54	12.47
% leg	29.81	29.28	29.49	29.36	29.61	29.70	29.22	29.48
% loin	10.02	9.99	10.02	10.04	9.96	9.82	10.22**	10.01
% rack	7.89	8.29	7.82**	8.11	7.90	7.79	8.27**	8.02
% shoulder	24.08	24.38	24.88	24.50	24.52	24.97	23.98**	24.51
% retail yield	85.37	84.18	83.95	83.89	84.87	84.77	83.87*	84.35
% edible portion	65.96	64.38	64.25	63.82	65.65**	65.34	63.92**	64.68
% fat trim	17.54	19.22	18.67	19.35	17.75*	17.31	20.12**	18.62
% fat leg	19.76	21.96	22.04*	22.40	21.49**	21.10	21.96*	21.50
% lean leg	66.79	64.78	64.23**	64.03	66.11**	65.16	64.82	65.00
% fat rack	34.59	38.35	36.15	37.88	35.21*	34.90	38.60**	36.64
% lean rack	47.93	44.38	45.59*	44.59	46.85*	46.60	44.56*	45.65

^a/ Av choice = 11; high choice = 12; low prime = 13

* = P < .05

** = P < .01

Table 2.---Selected Carcass Measurements

Characteristic	Sire 1	Sire 2	Sire 3	Singles	Twins	Wethers	Ewes	Av All Lambs
Length leg (cm)	19.14	19.93	19.28**	19.56	19.41	19.67	19.28	19.49
Width leg (cm)	21.16	21.54	21.61	21.65	21.28	21.62	21.32	21.49
Max width rib (cm)	24.60	24.41	24.90	24.81	24.45	24.68	24.60	24.65
Max width shoulder (cm)	19.68	20.21	20.44	20.44	19.89	20.31	20.04	20.18
Min width rib (cm)	17.32	18.06	18.15*	18.20	17.62*	17.74	18.14*	17.93
Depth body (cm)	26.00	26.70	26.45	26.46	26.42	26.62	26.23	26.44
Depth fat at spinal process (mm)	7.50	8.85	8.69*	8.85	8.07	7.97	9.07**	8.49
Depth fat over rib (mm)	12.15	14.32	13.89**	14.22	13.02**	13.12	14.28**	13.67
Depth fat over rib eye (mm)	5.25	5.76	5.94	5.85	5.57	5.25	6.26**	5.72
Length body (cm)	53.80	57.14	57.73	56.25	57.06	56.28	57.03	57.13
Loin eye area (sq in)	2.04	2.07	2.00	2.06	2.00	2.07	1.99	2.04

* P < .05

** P < .01

RELATIVE CUTOUT PERCENTS, TENDERNESS, AND ORGANOLEPTIC
CHARACTERISTICS OF PORK CARCASSES FROM FIVE DIFFERENT
WEIGHT GROUPS OF HAMPSHIRE BARROW LITTERMATES

W. Ronald Usborne, William G. Moody and James D. Kemp

Relative cutout data and general carcass information were collected on four litters of Hampshire barrows from the same sire. These hogs were all fed the same ration under the same environmental conditions. One animal from each litter was slaughtered within 5 lb of 160, 190, 220, 250 and 280 lb, the viscera was weighed, and then the live weights were adjusted to standardize the amount of fill. The carcasses were chilled for 48 hours and then cut to obtain the cutout and general carcass data which appear in Table 1. In general, these cutout data support previous work done at this station with respect to lighter weight hogs having a higher percentage of lean cuts and a lower percentage of lard stock compared with hogs of heavier weights.

Table 1. ---Live Animal and Carcass Data

Characteristics	Live Weight Groups (lb)				
	160	190	220	250	280
Adjusted live weight (lb)	159.5	191.0	223.8	251.9	283.9
Carcass yield (%)	69.3	70.2	71.8	73.0	73.5
Carcass length (in.)	27.6	28.4	29.2	30.4	31.2
Average backfat thickness (in.)	1.22	1.24	1.54	1.70	1.91
Loin eye area at 10th rib (sq in)	3.13	3.86	4.14	4.65	5.03
Loin eye area/cwt Carcass (sq in)	2.84	2.88	2.58	2.53	2.41
Ham fat thickness (in)	0.94	1.04	1.31	1.38	1.58
Percent ham & loin of carcass	37.0	36.7	34.2	34.4	33.7
Percent 4 lean cuts of carcass	54.1	53.2	49.3	49.6	48.7
Percent total lard stock of carcass	16.6	18.5	21.3	20.5	22.4
Average age (days)	167.2	166.0	177.2	188.8	198.5
Average daily gain (lb/day)	0.95	1.16	1.27	1.34	1.43

Fresh meat samples were taken from the anterior portion of the Longissimus dorsi muscle for various chemical analyses. The chemical work now in progress includes quantitative analyses of the free amino acids, the sarcoplasmic protein, the fibrillar protein, and collagen. Also the proximate composition is being determined.

The rest of the loin from the right side was kept intact and was frozen for taste panel and tenderness evaluation. These loins were later cooked at an oven temperature of 325°F to an internal temperature of 170°F. Fat and bone were removed from the Longissimus dorsi muscle and then appropriate samples were taken for tenderness as measured by the Warner-Bratzler shear device, taste panel evaluation, and the previous mentioned chemical analyses. The amount of shrink, drop loss, etc. were also recorded, and a sample of the drippings from each roast was taken for free amino acid and protein determinations.

The fresh quality scores, cookery data, tenderness determinations, and taste panel evaluations for each weight group appear in Table 2. The quality of the fresh meat was acceptable in all cases except that from the 280-pound group where it approached a pale, soft, watery condition. In respect to the hogs used in this experiment, the heaviest ones

(280 lb) were the most tender as determined by the Warner-Bratzler shear device. However, the taste panel scores did not show much difference in the palatability characteristics of flavor, juiciness, tenderness, and overall characteristics.

Table 2. ---Fresh Quality, Tenderness, and Organoleptic Evaluation

Characteristics	Live Weight Groups (lb)				
	160	190	220	250	280
Fresh quality:					
Muscle color	Normal	Normal	Normal	Normal	Pale
Muscle firmness	Firm	Firm	Firm	Firm	Soft
Amount of marbling	Moderate	Moderate	Moderate	Moderate	Small
Distribution of marbling	Fine	Medium	Medium	Medium	Medium
Muscle texture	Medium	Medium	Medium	Medium	Coarse
Fresh weight of roast for cooking (lb)	4.38	5.07	5.57	6.02	7.41
Data on cooked product:					
Percent shrink	26.8	27.0	28.7	29.1	29.5
Percent drippings	11.1	9.8	10.9	7.3	10.0
Warner-Bratzler shear Scores for tenderness	11.6	11.2	10.1	10.3	8.6
Taste panel scores:*					
Flavor	7.9	7.8	7.7	7.7	7.5
Juiciness	7.5	7.0	7.2	6.9	6.8
Tenderness	8.0	8.1	7.9	7.9	7.9
Overall satisfaction	7.8	7.7	7.6	7.6	7.4

* 8.0 = Like very much.
7.0 = Like moderately.
6.0 = Like slightly.

In summary, the fastest gaining, heaviest hogs had the poorest quality but sheared the most tender. It is hoped that the chemical studies of this experiment to be reported later, will help shed some light on that result and also will help describe any changes in the free amino acid pattern and protein composition as they are related to animal growth from 160 to 280 pounds. The changes in protein composition and free amino acid content from the fresh to the cooked state will also be described.

THE EFFECT OF FRESH MUSCLE QUALITY ON AGED HAM CHARACTERISTICS

James D. Kemp and W. G. Moody

Thirty-two skinned hams of two weight groups (18-20 lb and 14-16 lb) were selected so that each weight group contained eight high quality and eight low quality hams. High quality hams were characterized by firm, well marbled lean of uniform color. Low quality hams were characterized by soft, exudative, two-toned lean with little marbling. Characteristics of the fresh hams are given in Table 1.

Table 1. ---Characteristics of Fresh Hams

	High Quality		Low Quality	
	Light Wt	Med Wt	Light Wt	Med Wt
Av initial wt, lb	14.1	18.7	14.3	18.9
Water in lean, %	73.3	72.9	73.9	73.9
Protein in lean, %	19.5	19.8	19.8	19.7
Ether extract in lean, %	4.9	5.3	4.0	4.1
Quality score*	3 - 5	3 - 5	1 - 2	1 - 2

* Based on Wisconsin quality standards.

Hams were cured 2 days per lb at 36°F, hung for 30 days at approximately 40°F for salt equalization, rinsed, smoked for approximately 24 hours at 90-100°F and aged for 5 months at 65°F.

Weight losses were recorded at monthly intervals during processing and aging. After aging the hams were cut and observed for color, firmness and aroma. Samples were taken for palatability, shear and chemical tests.

Percentage of weight loss, as shown in Table 2, increased throughout processing and aging. In every case for both weight groups for any given period the percent loss was greater ($P < .05$) for the low quality hams. Toward the end of aging the percentage of weight loss was slightly less for the medium weight hams within the same quality group.

Table 2. ---Mean Percent Weight Loss by Periods

Quality Group	Weight Group	Salt							
		Cured	Equal	Smoked	1 Mo	2 Mo	3 Mo	4 Mo	5 Mo
High	Light	2.4	9.7	12.0	18.1	21.4	23.6	25.3	27.2
High	Medium	4.0	10.9	12.0	17.1	19.5	21.5	23.5	25.2
Low	Light	4.1	12.0	14.0	20.6	24.5	27.2	29.1	31.1
Low	Medium	6.0	13.5	14.6	20.8	23.2	25.9	28.2	30.1

Color and aroma were similar and were normal in both quality and weight groups when cut for observation. A few hams that had been trimmed too closely were excessively dry and hard.

Palatability scores, made on broiled one-half inch slices are given in Table 3.

Table 3. ---Mean Palatability Panel Scores

Quality Group	Weight Group	Palatability Characteristics ^{a/}			
		Flavor	Saltiness	Tenderness	Overall Satisfaction
High	Light	6.2	7.0	5.6	6.0
High	Medium	6.5	7.0	6.1	6.3
Low	Light	6.5	6.7	6.4	6.4
Low	Medium	6.3	6.9	6.0	6.2

^{a/}Based on 9-point scale. Higher numbers are more desirable.

Analysis of variance within weight groups showed no significant differences in palatability characteristics except for tenderness in the light weight hams where the low quality hams were significantly ($P < .05$) more tender. This is in contrast to work reported in 1965, which showed high quality hams to be more tender, but agrees with the shear test in Table 4.

One-inch-thick slices were broiled, and three muscles were measured for tenderness with a Warner-Bratzler shear. Table 4 gives the results.

Table 4. ---Mean Shear Force Results^{a/}

Quality Group	Weight Group	Semi-membranosus	Muscle Semi-tendinosus	Biceps femoris
High	Light	52.6	43.6	43.6
High	Medium	45.7	38.2	35.5
Low	Light	20.9	25.6	24.6
Low	Medium	26.6	32.0	34.3

^{a/} Lb force required to shear one-inch cores.

All muscles of the low quality light weight hams were significantly more tender ($P < .01$) than those in the high quality light weight hams. This was also true of the semi-membranosus of the medium weight hams. There were no significant differences in the other muscles of the medium-weight hams. The differences again are in conflict with the results of 1965.

Free fatty acid (FFA) values were determined on outside and seam fat as shown in Table 5.

Table 5. ---Mean FFA Values

	High Quality		Low Quality	
	Light Wt	Medium Wt	Light Wt	Medium Wt
External fat	9.68	10.46	8.93	8.26
Seam fat	7.40	5.10	5.91	4.51

FFA values were significantly ($P < .05$) higher in external fat as compared with those in seam fat in both quality and weight groups except the values 9.68 vs. 7.40 in the light weight high quality group only approached significance. External FFA values were significantly higher ($P < .05$) in the high quality medium weight group as compared with the low quality medium weight group. Seam fat FFA values were higher in the high quality group with the 7.40 vs. 5.91 being significant ($P < .05$).

Lean samples were analyzed for moisture, ether extract and protein. Table 6 gives the results.

Table 6. ---Characteristics of Aged Hams

	High Quality			Low Quality		
	Light Wt	Med Wt	All	Light Wt	Med Wt	All
Water in lean, %	51.28	56.22	53.75	53.14	55.24	54.19
Protein in lean, %	30.63	29.06	29.84	31.33	31.79	31.56
Ether extract in lean, %	10.41	8.86	9.64	8.09	6.46	7.28

There was no significant difference in percentage water between quality groups in either the light weight or the medium weight group. This also was true when all high quality hams were compared with all low quality hams. There was a significant difference ($P = .01$) between moisture content of light and medium weight hams, indicating that the light hams lost more water. This agrees with the data in Table 2.

There was no significant difference due to quality in the percentage of protein within weight groups, although the differences approached significance. However, when the groups were combined, the low quality hams had significantly ($P < .05$) more protein. Weight did not affect protein values. Since there were no differences in water percentage the difference in protein may be attributed to differences in ether extract as the high quality hams had significantly more ($P < .05$) ether extract. On a weight basis the light hams had significantly ($P < .05$) more ether extract. This is in inverse relationship to the percentage of moisture.

In general, the results of 1966 compare closely with those reported in 1965 except for tenderness and free fatty acid values. High quality hams had less weight loss, and the lean contained a higher percent of ether extract, a lower percentage of protein but similar amounts of water. Free fatty acid values were higher in high quality hams, which is in reverse to the 1965 results. In 1966 tenderness was more desirable in the low quality hams, which is somewhat puzzling. Therefore, more work is underway to obtain additional data.

THE EFFECTS OF PAPAIN AND LIPASE ON THE CHARACTERISTICS OF AGED HAMS

James D. Kemp and W. G. Moody

Earlier work at the University of Kentucky (1965 Animal Science Research Reports) showed that hams treated with papain or lipase were generally adversely affected. Papain hams had numerous mushy spots, particularly near the bone. Lipase hams showed separated seam fat. Since the undesirable characteristics were mostly in the center part of the hams it was apparent that the distribution of the enzymes was not uniform. This test was designed, therefore, to evaluate again the enzymes and to evaluate methods of applying the enzymes.

Thirty-six hams were divided equally into lot 1, controls; lot 2, papain-treated and lot 3, lipase-treated. Lots 2 and 3 were further subdivided so that 6 hams were treated by stitch pumping and 6 by numerous hypodermic injections. Each treated ham received by weight 4% of a distilled water-enzyme solution so that all hams contained 4 parts per million of the respective enzyme. Hams were dry cured for 2 days per lb, hung for one month for salt equalization, smoked approximately 24 hours at 100°F and aged at 65°F for 6 months. Weight loss was recorded monthly. After aging, the hams were cut, observed for soundness, color and aroma. Two one-half inch center slices were broiled and then evaluated by a

palatability panel for flavor, saltiness, tenderness and overall satisfaction. A one-inch center slice was broiled and then evaluated for tenderness by the Warner-Bratzler shear test. Outside and seam fat was analyzed for free fatty acid values and iodine number.

Upon observation the control hams were more uniform in color, were firmer, had a more typical ham aroma, and more desirable general appearance than the others. Papain hams were variable. Most had normal color and a few appeared firm with typical aroma. Most, however, showed seam separation, and several had mushy spots, green spots and a severe seam separation with variable aroma. Lipase hams had generally good color and were firm, but most had seam separation and a few had small green spots.

Table 1 shows the weight loss by periods. None of the differences due to treatment were significant.

Table 1. ---Mean Weight Losses by Periods, %

Group	Smoked	Months Aging		
		2	4	6
Control	12.8	23.6	28.0	31.3
Papain - hypo	10.1	21.6	26.4	29.7
Papain - stitch	11.6	22.4	26.7	30.0
All papain	10.8	22.0	26.5	29.9
Lipase - hypo	11.8	22.4	27.0	30.4
Lipase - stitch	14.8	25.6	30.3	33.7
All lipase	13.2	24.0	27.6	32.1

Results of the shear test are given in Table 2.

Table 2. ---Mean Shear Force Values^{a/}

Group	Semi-membranosus	Semi-tendinosus	Biceps femoris	All Muscles
Control	44.0	38.5	41.4	41.3
Papain - hypo	38.2	31.9	38.3	
Papain - stitch	27.3	25.6	25.9	
All papain	32.8	28.7	32.1	31.2
Lipase - hypo	34.9	33.9	40.9	
Lipase - stitch	37.0	34.4	33.0	
All lipase	36.1	34.1	37.0	35.7

^{a/} Lb force required to shear 1-in. cores.

There were no significant differences in hypo and stitch groups for any muscle. The papain-treated group was significantly ($P < .05$) more tender than controls for the Biceps femoris, and all muscles ($P < .01$). The differences approached significance in the Semi-membranosus and Semitendinosus muscles. There were no significant differences in control and lipase groups for individual muscles. However, when the values for all muscles were combined, the lipase hams were significantly ($P < .05$) more tender. Although the combined papain group averaged more tender than the lipase group the difference was not significant.

Mean taste panel scores are shown in Table 3.

Table 3. ---Mean Taste Panel Scores

Group	Flavor	Saltiness	Tenderness	Overall Satisfaction
Control	6.3	7.0	5.8	6.2
Papain - hypo	6.0	7.4	6.3	5.9
Papain - stitch	6.1	7.3	6.8	6.2
All papain	6.0	7.4	6.6	6.0
Lipase - hypo	6.3	7.2	6.3	6.2
Lipase - stitch	6.4	7.0	6.0	6.4
All lipase	6.4	7.1	6.1	6.3

There were no significant differences between the hypo and stitch groups for any trait. Flavor differences approached significance when controls and papain groups were compared. The taste panel rated the papain hams as being more salty ($P < .01$). This is probably due to the relationship to flavor. Since the control hams were more desirable, they apparently were slightly less salty. The papain hams were rated as being more tender ($P < .05$), which agrees with the results of the shear test. There was no significant difference in overall satisfaction. There were no significant differences in any palatability traits between the control and the lipase hams. It should be noted that any discolored or deteriorated spot was not served to the panel. If an entire slice had been served the control hams would have, no doubt, been considered much more desirable.

Free fatty acid values and iodine numbers were determined on the external and seam fat at the end of the trial. Table 4 gives the mean values. Hypo and stitch groups are combined as there were no significant differences between them.

Table 4. ---Mean Free Fatty Acid and Iodine Values

Group	Outside Fat		Seam Fat	
	FFA	Iodine No.	FFA	Iodine No.
Control	10.6	65.0	6.2	60.9
Papain	8.3	65.0	7.3	61.1
Lipase	11.2	65.1	15.1	58.4

Outside fat from control hams showed significantly higher ($P < .05$) FFA values than did fat from papain hams, with no significant difference between the control and the lipase groups. FFA's from lipase hams were significantly greater ($P < .01$) than those from papain hams. There was no significant difference for seam fat between the control and the papain groups. However, seam fat in the lipase group was significantly higher ($P < .01$) than in either the control or the papain group. The visual appearance of the seam fat seemed to indicate considerable fat breakdown. In control hams, the FFA content was significantly higher ($P < .05$) in outside fat than seam fat; in papain hams there was no significant difference, while in lipase hams the seam fat had significantly ($P < .01$) greater FFA values. There were no significant differences in iodine numbers due to treatment. In all cases iodine numbers for outside fat were significantly higher ($P < .01$) or ($P < .05$) than for seam fat, indicating that seam fat is more saturated.

Tenderness can be improved by the use of papain. Fat degradation can be enhanced by the use of lipase. However, until a more uniform sounder product can be produced their use is not recommended.

THE EFFECTS OF ALTERNATING AGING TEMPERATURES ON CHARACTERISTICS OF AGED HAMS

James D. Kemp and W. G. Moody

Procedure

Twenty hams of similar quality and an average weight of 14.6 lb were dry-cured 2 days per lb, hung for 30 days at 40°F for salt equalization, and smoked at 90-100°F for approximately 24 hours. They were then assigned to two groups. Group 1 was aged for 5 months at a constant temperature of 65°F. Group 2 was aged at weekly intermittent temperatures of 65 and 95°F. Weight losses were determined at monthly intervals. After aging, the hams were cut and observed for color, firmness and aroma. A one-inch center slice from each ham was broiled and three muscles evaluated for tenderness by the Warner-Bratzler shear test. Two one-half inch center slices were broiled and evaluated by a palatability panel. Outside and seam fat samples were analyzed for free fatty acids.

Results and Discussion

There were no significant differences in weight loss, as shown in Table 1.

Table 1. ---Mean Weight Loss by Periods

Aging Temp, °F	Loss, %, by Months				
	1	2	3	4	5
65	19.5	22.7	25.0	27.4	28.7
65 - 95	19.5	22.7	25.2	27.2	29.2

Both groups were similar in appearance when cut. Most were typically red in color, firm and had normal ham aroma.

The greatest difference between the two groups was in tenderness, with the intermittent temperature groups being significantly ($P < .01$) more tender for all muscles. The higher temperature evidently made the proteolytic enzymes more active causing improvement in tenderness. This is shown in Table 2.

Table 2. ---Mean Shear Force Values^{a/}

Aging Temp, °F	Muscle		
	Semimembranosus	Semitendinosus	Biceps femoris
65	43.8	37.2	42.7
65 - 95	19.6	16.5	21.9

^{a/} Lb force required to shear one-inch cores.

Palatability traits were affected by aging temperatures as shown in Table 3. All values were higher for the intermittent temperatures. Tenderness and overall satisfaction scores were significantly ($P < .01$) higher for the intermittent group. The difference in flavor approached significance.

Table 3. ---Mean Palatability Panel Scores*

Aging Temp, °F	Flavor	Saltiness	Tenderness	Overall Satisfaction
65	6.2	6.3	5.8	5.8
65 - 95	6.5	6.5	7.1	6.6

* Based on a 9-point scale. Higher numbers are more desirable.

Mean free fatty acid values are given in Table 4. For seam fat the intermittent temperature group was significantly higher ($P < .01$). For outside fat the difference approached significance. This indicates that heat enhances free fatty acid development. Since free fatty acids are associated with aged flavor it is reasonable that the differences should exist.

Table 4. ---Mean Free Fatty Acid Values

Aging Temp, °F	Outside Fat	Seam Fat
65	8.56	3.61
65 - 95	9.68	6.08

Summary

The use of intermittent aging temperatures of 65 and 95°F rather than a constant temperature of 65°F had a marked effect on most traits in aged hams. Flavor, tenderness (both shear and panel) overall satisfaction were improved. Free fatty acid values were increased. There was no significant difference, however, in weight loss.

EFFECTS OF CURING AND AGING ON TRICHINELLA SPIRALIS

D. L. Gammon, James D. Kemp, J. M. Edney^{1/} and W. G. Moody

Although the incidence of trichinosis as a major disease in man has declined by about 80% since Federal Meat Inspection was begun in 1906, there are still some acute cases and a few deaths from the disease. While trichinosis is no problem in pork cooked well done, processed pork is sometimes eaten rare or without cooking. Therefore, some method of eliminating trichinae, other than cooking, is needed. U. S. Department of Agriculture regulations, based on work done in 1920, specify how dry-cured hams should be treated to kill trichinae. However, the methods prescribed are not conducive to the production of the highest quality hams. This research, therefore, was planned to determine the effects of curing, aging and salt-moisture relationships on the livability of trichinae in hams and shoulders.

^{1/} Department of Zoology.

Procedure

Hogs weighing approximately 40 lb each were dosed with approximately 20,000 trichinae larvae which had been obtained from infested rats. The hogs were slaughtered at market weight. Thirty-six hams and 36 shoulders were found by microscopic examination to contain live trichinae. These were dry-cured for 2 days per pound. After curing, samples were removed from the butt end of the hams and shoulders, which were then hung for 30 days for salt equalization. They were then washed, soaked for 30 minutes, dried at 100°F, and smoked for approximately 24 hours at 90-100°F. Cores were then taken from the center of each ham and shoulder, examined for trichinae, and analyzed for moisture and salt. The meat was placed in an aging room at 65°F and was again cored after one month, examined, and analyzed. Total count and livability were determined by digesting the samples in a solution of pepsin, HCl and water and then counting under a microscope.

Results

Preliminary results show that most of the trichinae were dead after smoking. Hams and shoulders from one hog, however, showed live, but feeble trichinae.

After one month's aging no live trichinae were found. Data on salt and moisture are being obtained but are not yet available. Additional hogs have been infected and the test with some variations is being repeated.

SWINE SECTION

SIMPLE VERSUS COMPLEX STARTER RATIONS FOR EARLY WEANED PIGS

D. G. Waddill, C. H. Chaney and R. Overfield

Experiments have been conducted at this and other stations comparing 3-week versus 6- or 8-week weaning. Results from these experiments have varied from time to time, likely because of differences in environmental factors, e.g., feeding, temperature, sanitation and overall management.

Most of the work conducted has been concerned primarily with performance of the pigs to 8 weeks of age and, in a few cases, with performance after this age. Limited effort has been made to determine the effects of early vs. late weaning on subsequent litter size and reproductive life of the sow.

A number of inquiries have been received from producers concerning the feeding of a simple corn-soybean meal ration supplemented with vitamins and minerals for pigs after three weeks of age rather than the recommended complex ration containing more expensive ingredients, e.g., dried skim milk, sugar and rolled oats.

Procedure

In this experiment a total of 20 sows and litters were randomly allotted to a 2 x 2 factorial arrangement of treatments with 5 litters on each. The variables tested were age at weaning and complex versus simple starter rations.

All pigs were fed the same creep ration from one to 3 weeks of age and were housed in 4- by 22-foot concrete pens with 10 linear feet under roof throughout the experiment. At 21 days of age, 10 litters were weaned and divided into 2 equal groups by litter. Five litters were given access to the ration shown in Table 1, and the remaining five litters were fed the ration in Table 1a. Another 10 litters were left with their dams until 6 weeks old. Five of these litters were given access to the ration in Table 1 and the other five to the ration in Table 1a from 3 to 6 weeks of age.

Table 1. ---Simple Pig Starter, Spring 1966

	%	Lb/Ton
Corn	67	1340
Soybean meal	30	600
Bone meal	2.5	50
Limestone	.5	10
Salt	.5	10
Trace mineral	.2	4
Vitamin mix No. 1	.2	4
B	.05	1
A & D	.065	1.3
Antibiotic 2 lb ^a /	.1	2.0
20% Protein		
0.87% Calcium		
0.66% Phosphorus		

^a/Supplied by 100 g of neomycin and 100 g of terramycin per ton.

Table 1a. ---Complex Pig Starter, March 1966

	%	Lb/Ton
Corn	37.05	741
Rolled oats	20.00	400
Sugar	5.00	100
Soybean meal	20.45	409
Skim milk	10.00	200
Fish meal	2.50	50
Distiller's solubles	2.50	50
Bone meal	1.00	20
Limestone	.5	10
Iodized salt	.5	10
Trace minerals	.1	4
A & D	.065	1.3
Vitamin mix No. 1	.2	4.0
B ₁₂	.05	1.0
Antibiotic ^{a/}	.1	2.0
20% Protein		
0.87% Calcium		
0.66% Phosphorus		

^{a/}Supplied by 100 g of neomycin and 100 g terramycin per ton.

The sows weaned at 3 weeks were rebred at the second postweaning estrus while those weaned at 6 weeks were rebred at the first postweaning heat ranging from 3-5 days after weaning.

Results

Feed consumed and daily gains are summarized in Table 2. As seen in this table the pigs on the more complex starter ration consumed more feed per day, and the daily gains were highest in these groups. Performance was quite similar regardless of weaning age. However, when total feed consumption is calculated for sows and litters a considerable savings of feed was realized in the early weaned group.

All sows in the group rebred on the first heat after 6 weeks settled on the first service and only one sow in the group rebred at the second heat after 3 weeks' weaning did not settle on first service. Litter size will be noted for subsequent farrowings with identical treatments.

Summary

Pigs were successfully weaned at 3 weeks of age under the conditions of this experiment. The performance of pigs weaned at 21 days was equal to that of pigs weaned at 42 days when each group was fed the same ration. The pigs on the simple ration did not perform so well as those on the more complex ration regardless of weaning age.

Table 2. ---Performance and Feed Consumption by Sows and by Pigs Weaned at 3 and 6 Weeks of Age and Fed Simple or Complex Starter Rations From 3 Weeks

Treatment	Sow Feed/ Day/ Sow, lb	No. Litters	Feed Consumed/ Day/ Pig, lb	Pigs/ Litter at 3 Weeks	Wt/ Pig at 3 Wk, lb	Pigs/ Litter at 6 Weeks	Wt/ Pig at 6 Wk, lb	Days on Test	A.D.G., lb	Sow Feed/ Sow, lb	Pig Feed/ Litter lb
(1) Weaned at 42 Days											
A - Simple Starter	16.56	5	0.17	10.2	12.88	10.2	23.23	21	0.51	348	36.4
B - Complex Starter	15.41	5	0.35	10.0	12.04	10.0	26.46	21	.69	323	73.4
(2) Weaned at 21 Days											
A - Simple Starter	6.0	5	0.73	10.0	12.12	9.8	21.55	21	.45	126	150
B - Complex Starter	6.0	5	1.03	10.2	12.96	9.2	27.46	21	.69	126	195

EFFECT OF PHOSPHORUS LEVELS ON PERFORMANCE OF BARROWS AND GILTS

C. H. Chaney, D. G. Waddill and J. R. Overfield

Research on the availability of phytin phosphorus in swine rations has been rather inconclusive. However, most results indicate that phytin phosphorus is not utilized so efficiently as the inorganic sources during the growing-finishing period. With increased use of all-plant sources of protein, which increases the phytin phosphorus level in the ration, the present NRC phosphorus recommendation may not be adequate.

Sixty Yorkshire barrows and gilts about 8 weeks of age were randomly allotted to a 2 x 3 factorial arrangement of treatments. The factors were sex and level of phosphorus. Phosphorus levels were: (1) 0.375, (2) 0.500 and (3) 0.625 %. Di-calcium phosphate was the source of supplemental phosphorus. The pigs were fed corn-soy rations throughout the experimental period. The pigs were weighed bi-weekly, and feed efficiency data were collected. The results of this trial is presented in Table 1.

Table 1.---Pig Performance

	0.375 % P		Rations 0.500 % P		0.625 % P	
	Barrows	Gilts	Barrows	Gilts	Barrows	Gilts
No. pigs	10	10	10	10	10	10
Int wt, lb	40.5	43.2	40.4	43.4	40.7	42.3
Final wt, lb	201.4	202.1	201.1	199.8	205.1	200.8
A.D.G., lb	1.46	1.26	1.67	1.57	1.74	1.65
Feed Conv, lb	3.55	3.68	3.48	3.34	3.44	3.21

The performance of the pigs improved in both rate of gain and feed conversion with each increment of phosphorus. Barrows made better rates of gain when fed these rations than did the gilts. However, feed efficiency showed greater improvement by the gilts in treatment groups 2 and 3. These data suggest that the present NRC phosphorus recommendation may be inadequate when an all-plant ration is fed.

PROTEIN SUPPLEMENTS FOR GROWING-FINISHING PIGS FED ON CONCRETE

C. H. Chaney, D. G. Waddill and J. R. Overfield

Some research indicates that self-feeding protein supplements result in excessive consumption. In this study alfalfa meal was added to reduce palatability of the supplement and, thus, to provide a more optimum intake of protein. The first trial of this experiment was reported in last year's Kentucky Animal Science Research Reports and it was found that soybean meal supplemented with vitamins and minerals was not excessively consumed. Sixty pigs were utilized in this trial to study further the use of these protein supplements. A complete mixed ration was fed all pigs until they reached 75 lb, and they were then changed to their respective rations. The protein supplements used, self-fed with shelled corn were: (1) a complete mixed supplement, (2) soybean meal, (3) soybean meal + 5% alfalfa meal, (4) soybean meal + 10% alfalfa meal, (5) soybean meal + 20% alfalfa meal and

(6) a complete mixed ration (control). Minerals and vitamins were added to the protein supplements in such quantities to meet NRC requirements. The pigs were weighed bi-weekly, and the experiment was terminated when the pen average was approximately 200 lb. The results of this trial are presented in Table 1.

Table 1. ---Results of Pig Performance Fed Different Protein Supplements

Ration	No. Pigs	Av Initial Wt, lb	Av Final Wt, lb	Av Daily Gain, lb	Feed Per 100 lb Gain, lb				Feed Cost Per 100 lb Gain ^a
					Corn	Supplement	Complete Mix	Total	
Complete supplement	10	42.3	203.6	1.61	248.9	37.4	54.9	341.1	\$10.25
Soybean meal	10	42.5	204.1	1.71	241.1	32.1	57.1	329.5	9.88
Soy + 5% alf meal	10	42.6	204.2	1.59	256.2	29.5	56.7	342.4	10.12
Soy + 10% alf meal	10	42.6	202.7	1.63	254.3	32.7	55.1	345.4	10.16
Soy + 20% alf meal	10	42.7	203.8	1.64	255.1	35.6	58.1	346.5	10.37
Complete mix	10	42.5	203.6	1.70				353.1	11.90

^a/ May 1966 feed prices.

The results of this trial are somewhat in agreement with those of the previous work. The pigs fed the complete mixed ration and those fed the shelled corn and soybean meal supplement made the best gains, 1.70 and 1.71 lb per day, respectively.

However, pigs fed the soybean meal and shelled corn were the best feed converters and made the most economical gains. It should also be noticed that again the pigs fed the soybean meal supplement did not consume an excess of protein. The total protein consumed was greater for the pigs fed the complete mixed rations (NRC recommendations) than for pigs fed these various protein supplements free choice. This explains, in part, the difference in cost of gains between these ration treatment groups.

FEED ADDITIVES FOR SWINE

C. H. Chaney and D. G. Waddill

A number of new antibiotic combinations have appeared on the market in recent years, and some are being used in high levels for pigs prior to 75-100 lb body weight.

In this experiment several combinations of antibiotics, arsenicals, sulfas, and nitrofurans were tested in pigs from 25 to 80 lb.

Eighty pigs were randomly allotted by sex and weight to eight ration treatments with two replicate lots of five pigs each. The pigs in this trial were started on test at 25 lb and were continued on the experimental rations to approximately 80 lb. They were all fed a complete 16% protein ration which was basically a corn-soybean-meat scrap mixture supplemented with the necessary vitamins and minerals. The pigs were housed in 4 x 22 feet concrete pens with 10 feed under roof. A feeder and waterer were available to the pigs at all times.

The experimental treatments for this trial were: (1) basal (no antibiotic), (2) basal plus 250 g aureo "SP" 250, (3) basal plus 100 g terramycin and 100 g neomycin sulfate, (4) basal plus 100 g terramycin, 100 g NF-180 and 90 g arsanilic acid, (5) basal plus 100 g terramycin, 50 g neomycin sulfate and 90 g arsanilic acid, (6) basal plus 100 g bacitracin MD and 90 g arsanilic acid, (7) basal plus 100 g bacitracin MD, 50 g neomycin base and 100 g sulfamethazine and (8) basal plus 100 g bacitracin MD, 68 g 3 nitro and 100 g NF-180.

The above-mentioned additions are the amounts supplemented per ton of feed.

The results of this trial are shown in Table 1.

Table 1. ---Feed Additives Trial I

Treatment	Number of Pigs	Initial Wt, lb	Final Wt, lb	A.D.G., lb	Feed/lb Gain, lb
1	10	25.6	75.8	1.42	3.00
2	10	25.1	82.0	1.56	2.84
3	10	25.3	84.1	1.57	2.65
4	10	25.1	77.4	1.48	2.92
5	10	25.2	81.0	1.50	2.94
6	10	25.4	82.0	1.48	2.80
7	10	25.3	81.9	1.57	2.67
8	10	25.0	80.3	1.44	2.58

Daily gains were improved in all treated lots. Pigs on treatments 2, 3 and 7 were the faster gaining lots. Those lots receiving arsanilic acid, nitrofurans and NF-180 in the feed gained faster than did the control lot but somewhat below those mentioned above. Feed efficiency was improved in all treated lots when compared with the controls.

CORN SILAGE, ALFALFA SILAGE AND RYE PASTURE FOR BRED SOWS

K. E. McMurray, C. H. Chaney, D. G. Waddill and C. W. Nichols

This experiment was conducted to study the performance of sows maintained during the pre-gestation and gestation periods on corn silage, alfalfa silage, rye pasture and drylot. Twenty-four Yorkshire sows were randomly allotted to the four following treatments:

Treatment I - Balbo rye pasture plus 4 lb of gestation ration daily for the first 64 days, increased to 5 lb for 14 days and then increased to 6 lb until farrowing.

Treatment II - Corn silage fed at 10 lb per head for the first 74 days and then increased to 12.5 lb per head daily until farrowing plus 1.5 lb of protein supplement (36.5% crude protein) per head daily fed through the experimental period.

Treatment III - Alfalfa silage fed at 10 lb per head daily for the first 74 days and increased to 12.5 lb per head daily until farrowing.

This was supplemented with 3 lb of gestation ration for the first 74 days, increased to 4 lb for the next 20 days and then increased to 6 lb until farrowing.

Treatment IV - Drylot consisting of spare orchard grass pasture and fed 5 lb of gestation ration for the first 94 days, then increased to 6 lb until farrowing.

Table 1. ---Sow Performance

	6	6	5	6
No. litters				
Av No. pigs farrowed	12.4	11.2	11.4	11.0
Av No. pigs farrowed alive	11.0	10.0	9.6	8.5
Av birth wt lb/pig	2.8	2.8	2.6	2.9
Av No. live pigs at 3 wk	9.8	9.0	8.0	8.0
Av pig wt at 3 wk, lb/pig	8.7	9.8	10.4	11.2

The sows performed well in each of the four ration treatments. It should be noted that only protein supplementation was needed for the sows fed corn silage. Under many farm conditions corn silage may be fed profitably to sows during the pre-gestation and gestation periods.

EFFECTS OF NITRATE AND NITRITES IN DRINKING WATER ON THE UTILIZATION OF CAROTENE IN SWINE

G. W. Garrison, R. D. Wood, C. H. Chaney and D. G. Waddill

Much research evidence has been presented which indicates that dietary nitrate and/or nitrite contribute to poor vitamin A nutrition of swine. Generally, when nitrite is included in the diet of animals vitamin A stores are reduced. Decreased conversion of dietary carotene to vitamin A in the gut wall is a possible mechanism by which nitrite reduces liver stores of vitamin A. This theory has gained support from the finding that the nitrite ion depresses thyroid activity since an active thyroid is thought to be necessary for the conversion of carotene to vitamin A. Conversion of hemoglobin to methemoglobin is a well known effect of absorbed nitrite. Methemoglobin which has lost its ability to combine with molecular oxygen causes oxygen starvation of the tissues. This experiment was conducted to study the effects of nitrates and nitrites in drinking water on the utilization of carotene by growing-finishing swine.

In trial I 40 pigs were allotted to five treatments of nitrate: (in percent) (1) 0.00; (2) 0.075; (3) 0.150; (4) 0.300 and (5) 0.300. Sources of vitamin A activity were beta-carotene (3,520 IU/kg) for treatments 1 through 4 and vitamin A palmitate (1,172 IU/kg) for treatment 5. The results of trial I are shown in Tables 1 and 2.

Table 1. ---Effect of KNO₃ in Water

Source of Vit A		Beta-Carotene			Vitamin A Palmitate
Level of NO ₃ (%)	0	0.075	0.150	0.300	0.300
No. of pigs	8	8	8	8	8
Av daily gain, lb	1.61	1.65	1.43	1.39	1.41
Av feed/gain	3.56	3.59	3.58	3.82	3.76
Av pig serum Vit A, mcg/100 ml					
0 Day	33.7	45.0	44.5	36.9	47.0
28 Day	36.9	25.6	27.9	23.7	28.3
84 Day	39.5	47.1	40.2	22.2	18.5
Av pig liver Vit A, mcg/g 84-Day	21.8	11.8	11.8	5.8 _a /	9.9

_a/ P < .05

Table 2. ---Effects of NO₃ on Hemoglobin, Methemoglobin and Hematocrit Values to 84 Days

Source of Vit A		Beta-Carotene			Vitamin A Palmitate
Level of NO ₃ (%)	0	0.075	0.150	0.300	0.300
Hb gm/100 ml	12.0	11.3	10.7	11.8	10.9
Methhb g/100 ml	0.07	0.00	0.42	0.17	0.24
Hematocrit, %	44	41	45	44	43

A design similar to that used in trial I was used in this trial to study the effects of nitrate (KNO₃) in water in carotene utilization in pigs. The nitrite levels used were: (1) 0.00; (2) 0.02; (3) 0.04; (4) 0.08 and (5) 0.08. The source and level of vitamin A activity for these treatments were the same as those in trial I. The results of trial II are summarized in Tables 3 and 4.

Table 3. ---Effects of NO₂ in Water

Source of Vit A		Beta-Carotene			Vitamin A Palmitate
Level of NO ₂ (%)	0	0.02	0.04	0.08	0.08
No. of pigs	8	8	8	8	8
Av daily gain, lb	1.61	1.21**	1.47	1.10**	1.12**
Av feed/gain	3.53	3.43	3.71	3.53	3.66
Av pig serum Vit A, mcg/100 ml					
0 Day	26.8	24.3	31.1	33.1	34.5
28 Day	35.4	30.6	26.3	16.3	20.7
84 Day	24.0	21.3	21.3	17.7	18.3
Av pig liver Vit A mcg/g 84-Day	30.9	16.2	9.6*	8.7*	9.0*

* P < .05

** P < .01

Table 4. ---Effect of NO₂ on Hemoglobin, Methemoglobin and Hematocrit to 84 Days

Source of Vit A		Beta-Carotene			Vitamin A Palmitate
Level of NO ₂ (%)	0	0.02	0.04	0.08	0.08
Hb g/100 ml	14.1	10.7	11.4	10.8	10.8
Methb g/100 ml	0.62	0.48	0.53	3.27**	2.02**
Hematocrit, %	40	35	35	36	40

** P < .01

In trial I where nitrates were fed the difference in rate of gain between treatments 3, 4 and 5 and treatments 1 (control) and 2 approached significance (P < .05) and feed efficiency was greatly reduced in treatments 4 and 5. Serum vitamin A levels were somewhat lower in treatments 3 and 4 at the 84-day bleeding. However, liver vitamin A stores were reduced in all pigs receiving the nitrate treatments with treatment 4 being significantly (P < .05) different from the control.

Rate of gain in treatments 2, 4 and 5 were significantly (P < .01) different from the controls. However, there was very little variation in feed utilization between treatments. Serum vitamin A levels were reduced as the level of nitrite was increased although there was very little difference between the carotene and performed vitamin A treatments. When nitrite was administered at the highest level, liver vitamin A levels in treatments 3, 4 and 5 were significantly (P < .05) different from the controls.

OVULATION RATE IN GILTS MAINTAINED UNDER CONSTANT LIGHT

D. G. Waddill, C. H. Chaney and R. H. Dutt

Exposure to extended hours of light has been shown to have a pronounced effect on performance of some animals, e.g., sheep and chickens. Only limited work has been reported on the effects of light on pig gains and none on reproductive performance of gilts.

This experiment was designed to study the possibility of increasing ovulation rate in gilts by maintaining them in constant light for extended periods.

Procedure

Trial 1 - In the spring of 1964 twenty Yorkshire gilts were allotted to a control or light group according to age and breeding at 7½ months of age. As the gilts were allotted to treatment they were placed in a concrete-floored building which was open in the front, and the pens were approximately one-half under roof. They were hand fed 6 lb of feed daily throughout the experimental period.

All gilts were checked daily for heat and when found to be in estrus were transferred from these pens to other pens within the same building. Gilts to be maintained in constant light were moved to a pen equipped for night lighting. The control gilts were moved to another pen within the building to equalize treatment effects. The intensity of this light was 11 foot-candles when determined in the center of the pen.

All gilts remained in these pens throughout one complete estrous cycle. They were checked daily for heat and were slaughtered 5 days after the second heat period past 7½ months of age. Therefore, the treated gilts were maintained under constant light for approximately 25-26 days depending on the length of the estrous cycle. The ovaries were removed and the corpora lutea counted to determine ovulation rate in the control and treated groups.

Trial II - The experiment was repeated in the spring of 1965, using the same procedure as outlined in trial one.

Results

The number of eggs ovulated by gilts on the various treatments is summarized in Table 1. Only slight differences occurred in eggs ovulated between the control and light groups. Light at the intensity used in this experiment did not increase the number of eggs ovulated in either trial I or trial II.

Table 1. ---Effect of Light on Ovulation Rate

Year	Treatment	No. Gilts ^{a/}	Av Eggs Ovulated
1964	Light	10	14.39
	Control	10	14.29
1965	Light	10	11.9
	Control	10	12.5

^{a/} One gilt in each group had not ovulated when slaughtered.

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