A COMPARISON OF DIFFERENT LEVELS OF PROTEIN INTAKE FOR FATTENING STEER CALVES

by

BRUCE ROSS TAYLOR

B. S. A., Kansas State College
of Agriculture and Applied Science, 1931

A THESIS

submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1934

TABLE OF CONTENTS

	Page
INTRODUCTION	2
REVIEW OF PREVIOUS WORK	3
EXPERIMENTAL	8
Experiment 1	8
The Test	8
Calves Used	9
Method of Procedure	9
Observations	10
Interpretations	13
Conclusions	13
Experiment 2	14
The Test	14
Calves Used	15
Method of Procedure	15
Observations	16
Interpretations	19
Conclusions	21
CHEMICAL ANALYSIS OF FEEDS	22
ACKNOWLEDGMENTS	22
LITERATURE CITED	24

INTRODUCTION

Protein is necessary in cattle fattening rations. It is generally recognized, however, that home-grown grains plus carbonaceous roughages do not supply an adequate amount of protein for fattening cattle. Furthermore, with the exception of a few crops such as soybeans, and even these are not grown throughout the entire cattle fattening area, it is impossible to produce protein rich concentrates on the farm. Since protein supplements are necessary, they must be purchased at prices that are frequently relatively high per pound when compared to prices paid for feeds sold by farmers.

It is important, therefore, that an adequate yet not excessive amount of protein supplement be supplied to fattening cattle. This problem has received much attention from investigators in the fields of animal nutrition and animal production but much remains to be done before it can be definitely stated what these requirements are. Furthermore, much of this investigational work was completed prior to the present tendency to market highly finished light weight beef. It is apparent, therefore, that additional information is needed.

REVIEW OF PREVIOUS WORK

By the middle of the last century chemistry had paved the way toward a more scientific approach in formulating rations for livestock. In 1859 Grouven proposed a feeding standard based on crude protein, carbohydrates, and fat. This standard was based on total instead of digestible nutrients and hence was of little value (5).

Wolff, a German scientist, presented in 1864 a feeding standard based on the digestible nutrients contained in feeds (5). It stated the amount of crude protein, carbohydrates, and fat required daily by the various classes of livestock. The importance of this standard was soon recognized and its adoption was the first step toward a more rational system of feeding farm animals. Lehman, in 1896, modified this standard into what is known as the Wolff-Lehman standard (5).

Later investigations proved the Wolff-Lehman standard inaccurate as to the amount of digestible crude protein needed. This fact prompted Morrison (5) to combine in one standard the guides that appeared most useful in formulating rations. Morrison's standard is based on numerous feeding experiments and represents the amount of each

nutrient that has proven most satisfactory under conditions in America. In addition to stating the approximate pounds of each nutrient required per 1,000 pounds live weight per day, the approximate optimum nutritive ratio for various situations is given.

Mitchell (7), using all available scientific data on the subject, made recommendations as to the minimum protein requirements of cattle. His basis is a "conventional" protein and represents a requirement of digestible crude protein possessing a biological value of 100. It is applicable to any protein mixture of which the biological value can be obtained.

Under the auspices of the National Research Council and upon the initiative of Armsby (1), a series of cooperative experiments, starting in 1917, were undertaken at eight agricultural experiment stations to determine the protein requirements of cattle. The plan called for the testing of high and low protein rations of the same net energy content. For several reasons it was found impossible to execute the plan as outlined. Then too, much of the data compiled were on dairy cattle.

Stiles and Morrison (11), from an analysis of thirty-nine experiments reported by twelve different stations

investigating the protein requirements of cattle, conclude as follows: From 2.25 to 2.75 pounds of digestible crude protein per 1,000 pounds live weight per day is the optimum level of protein intake for fattening calves, and the nutritive ratio should lie within the range of 1:6 to 1:7.3.

In a test at the Kansas Station, McCampbell and Horlacher (6) found that one pound of cottonseed cake per head daily was more efficient in balancing a calf fattening ration of corn, silage, and alfalfa hay than 0, .5, 1.45, or 1.92 pounds. The ration containing one pound of cottonseed cake furnished approximately 2.27 pounds of digestible crude protein per 1,000 pounds live weight per day and had a nutritive ratio of 1:6.8.

Blizzard (2) in a similar investigation found that much larger and more economical gains were produced on calves by adding one and one-half pounds of cottonseed meal to a daily ration of corn, prairie hay, and ground limestone. Increasing the cottonseed meal to 2.47 or 3.60 pounds did not result in greater gains, but increased the cost of gain.

Work reported by Christensen (3) shows that substituting 1.25 pounds of linseed oil meal for an equal amount of barley in a steer fattening ration resulted in larger

gains, greater finish, and carcasses of better quality. The gain was increased from 2.58 to 2.70 pounds per head daily. The steers receiving the protein supplement showed keener appetitee than those of any other lot in the test.

Rusk and Snapp (9) compared a calf fattening ration of corn, roughage, and 5 pounds of cottonseed meal per head daily with another ration of corn and roughage alone. The calves fed the ration containing the protein supplement made an average daily gain of 2.29 pounds as compared to 1.59 in the check lot. However, significant differences in rate and economy of gain were noted during only the first half of the feeding period.

In another fattening experiment with three lots of steer calves fed rations of wide, medium, and narrow nutritive ratios, Rusk and Snapp (10) report daily gains of 1.51, 2.44, and 2.57 pounds respectively. Cost of gains were lowest and profits greatest in the lot fed the ration of medium nutritive ratio.

Table I - Morrison standard for fattening young beef cattle (5).

Growing fattening steers	Per day per 1,000 pounds live weight			Nutritive ratio
	Dry Matter	Digestible Crude Protein	Total Digestible nutrients	
Weight - Pounds	Pounds	Pounds	Pounds	1:
400 - 500	24.0 - 26.0	2.1 - 2.3	15.1 - 17.1	6.4 - 6.9
500 - 600	23.0 - 25.0	2.0 - 2.2	14.7 - 16.7	6.6 - 7.1
600 - 700	22.0 - 24.0	1.9 - 2.1	14.3 - 16.3	6.7 - 7.2
700 - 800	21.0 - 23.0	1.8 - 2.0	14.0 - 16.0	6.8 - 7.3
800 - 900	20.5 - 22.5	1.7 - 1.9	13.6 - 15.6	6.9 - 7.5
900 - 1000	20.0 - 22.0	1.6 - 1.8	13.2 - 15.2	7.0 - 7.6
1000 - 1100	19.5 - 21.5	1.5 - 1.7	12.7 - 14.7	7.0 - 7.8
1100 - 1200	19.0 - 21.0	1.4 - 1.6	12.3 - 14.3	7.0 - 8.0

A study of Table I shows that older cattle require less protein in proportion to their live weight than younger cattle. On this basis, the nutritive ratio of the ration should be narrower during the fore part of the feeding period if the protein needs are to be met most adequately. However, the experimental results obtained by McCampbell and Horlacher (6) and Blizzard (2) show that if the nutritive ratio becomes too wide the efficiency of the entire ration is lowered.

EXPERIMENTAL

Two experiments were conducted in this study.

Experiment 1

The object of this experiment was to study the relative value of two levels of protein intake for fattening steer calves.

The Test.- Five pairs of steer calves were used in this experiment. Each pair of calves was considered as a unit. A basal ration of corn, atlas sorgo silage, and ground limestone was used. Both members of each pair received the same quantity of silage and concentrates per day. However, one member of each pair had 1.28 pounds of the daily allowance of corn replaced by cottonseed meal.

No attempt was made to keep all pairs receiving the same quantities of feed per day.

The paired feeding method was used because it offered the greatest opportunity to eliminate all variables except the one to be studied. By using this method equilization of food intake was made possible, the problem of food wastage was simplified, and any accidents effecting individual steers would not have effected the value of the pairs left intact. The advantages and limitations of this method of feeding small numbers of animals have been fully discussed by Mitchell (8) and by Crampton (4).

Calves Used.- Ten high grade Hereford steer calves raised by the Matador Land and Cattle Company of Texas were used in this test. They arrived at this station October 23. Silage and cottonseed meal were fed until the experiment started.

Method of Procedure.- The experiment started December 13, 1933 and closed May 8, 1934 at the end of 140 days. An average of three consecutive days' weights was taken for the initial and final weights. Check weights were taken every 28 days.

The steers were matched in pairs. The members of each pair were selected for equality in initial weight,

condition, feeder grade, and indications of probable outcome. No attempt was made to keep the different pairs alike in all the respects mentioned above. The steers were allotted individual box stalls in a well ventilated and lighted barn and the identity of each steer was maintained by a numbered neck strap. The calves were allowed the run of a small yard from the hours of 9 a.m. to 5 p.m. Water was provided from a tank in this yard.

Observations.- Substituting 1.28 pounds of cottonseed meal for an equal amount of corn in a calf fattening ration of corn, silage, and ground limestone produced the following results:

1. Increased the daily gain of the steer fed cottonseed meal over his pair mate in all five pairs.

2. Increased the average daily gain of the five steers fed cottonseed meal over their pair mates by .29 pounds.

3. Decreased the amount of feed required to produce 100 pounds gain from 537 pounds of corn and 707 pounds of silage to 383 pounds of corn and 589 pounds of silage plus 70 pounds of cottonseed meal.

4. Resulted in a saving of 221 pounds of corn and 313 pounds of silage for each 100 pounds of cottonseed meal fed.

5. Increased the daily intake of digestible crude protein from 1.18 pounds to 1.85 pounds.

6. Narrowed the nutritive ratio from 1:11.6 to 1:6.9.

7. Decreased the total digestible nutrients received per calf per day from 8.21 to 8.09 pounds. This decrease resulted from the fact that cottonseed meal is slightly lower in percentage of total digestible nutrients than corn; consequently, one would not expect to improve a grain ration by substituting more cottonseed meal for corn than was necessary to supply the optimum protein requirement.

8. Improved the condition of the hair and thus the general appearance of the steer fed cottonseed meal over his pair mate in all pairs except number 5. In this case the reverse was true.

The results of this test are given in detail in Table II.

Table II - Experimental data, experiment 1. December 12, 1933 to May 1, 1934 - 140 days.

Pair number	1		2		3		4		5	
Steer number	4	6	8	10	2	7	5	11	1	3
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Initial weight	468.33	453.33	450.00	448.33	436.67	433.33	411.67	420.00	421.67	426.67
Final weight	675.00	701.67	653.33	741.67	653.33	680.00	650.00	680.00	641.67	668.33
Gain	206.67	248.34	203.33	293.34	216.66	246.67	238.33	260.00	220.00	241.66
Average daily gain	1.48	1.77	1.45	2.10	1.55	1.76	1.70	1.86	1.57	1.73
Average daily ration:										
Ground corn	8.34	7.14	8.36	6.82	8.28	6.98	8.20	7.08	8.36	7.13
Atlas sorgo silage	10.66	10.77	11.48	11.44	11.54	11.47	9.15	9.61	10.61	10.75
Cottonseed meal	...	1.28	...	1.28	...	1.28	...	1.29	...	1.28
Ground limestone	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
*Total digestible nutrients per day	8.23	8.16	8.36	8.01	8.30	8.16	7.92	7.96	8.23	8.16
*Digestible crude protein per 1,000 pounds live weight per day	1.12	1.83	1.17	1.71	1.21	1.86	1.18	1.90	1.20	1.90
*Nutritive ratio	1:11.7	1:6.9	1:11.8	1:6.9	1:11.6	1:6.9	1:11.6	1:6.8	1:11.7	1:6.9
Feed required per 100 pounds gain:										
Corn	563.51	403.40	576.55	324.76	534.19	396.59	482.35	380.65	532.48	412.14
Silage	787.83	608.47	791.72	544.76	744.52	651.70	538.24	516.66	675.79	621.39
Cottonseed meal	....	72.32	....	60.95	....	72.73	....	69.35	....	73.99

(*) Calculated from Table III (5).

Interpretations.- "Student's" method (12) was applied to determine statistically the significance of the increase in gains of the steers receiving cottonseed meal over their pair mates. The average difference between the daily gains of the two groups is .29 pound and the standard deviation of the differences is .1845. The ratio of the mean difference to the standard deviation, the Z of "Student," is 1.62. With Z = 1.62 and N = 5 the odds are 60 to 1 that the mean difference was due to the rations fed. Odds of 30 to 1 are considered necessary to allow for chance variation. Therefore, it appears that the cottonseed meal was responsible for the difference in gains.

Conclusions.-

1. The nutritive value of a ration of corn, silage, and ground limestone is materially improved by the substitution of a protein supplement like cottonseed meal for a portion of the corn.

2. A daily intake of approximately 1.18 pounds of digestible crude protein per 1,000 pounds live weight proved to be inadequate to produce satisfactory gains in fattening steer calves when the protein is derived from corn and atlas sorgo or corn silage.

3. A ration having a nutritive ratio of 1:6.9 and providing approximately 1.85 pounds of digestible crude protein per 1,000 pounds live weight daily, is nearer the optimum level of protein intake for fattening steer calves than the ration described above which had a nutritive ratio of 1:11.7.

4. A protein supplement like cottonseed meal has a distinct value in a calf fattening ration aside from any stimulating effect it may have on the appetite.

Experiment 2

The object of this experiment was to secure information as to the advantages, if any, of varying the amount of protein fed at different stages of the feeding period.

The Test.- Three lots of ten calves each were fed daily rations as follows:

Lot 1 - Shelled corn (full fed), atlas sorgo silage (full fed), ground limestone, and 1.37 pounds of cottonseed meal per steer.

Lot 2 - Same as lot 1, except that the ratio of protein to total nutrients was wider the first third and narrower the last third of the feeding period.

Lot 3 - Same as lot 1, except that the ratio of protein to total nutrients was narrower the first third and wider the last third of the feeding period.

Calves Used.- The thirty head of steer calves used in this test were of the same shipment as those used in Experiment 1. This shipment consisted of 150 head of choice steer calves. From this group 40 of the larger, smaller, and less desirable steers were cut out. The remaining 110 head were then divided into two groups on the basis of weight. The 30 head used in this test were picked from the heavier group. The three lots were made just as alike as was possible in regard to average weight, quality, condition, and indications of probable outcome.

Method of Procedure.- This test, which covered 188 days, started November 1, 1933 and closed May 8, 1934. Individual weights were taken every 28 days.

The calves were penned in three identical lots 40 feet long by 30 feet wide with a shed 15 feet deep across the north end. All feeds were fed under this shed. The cottonseed meal and ground limestone were fed with the silage which was supplied twice daily. The shelled corn was self fed from a feeder affording 15 feet of space per lot.

The amount of cottonseed meal received by lots 2 and 3 was actually varied by 28-day periods, but to simplify the interpretation the writer has divided the 188 day period into three phases.

Observations.- Phase 1 (56 days).

1. The lot fed the ration of wide nutritive ratio (lot 2) made only 84% as much gain as lot 1 or 3 and showed the least improvement in general appearance.

2. The lot receiving the ration of narrow nutritive ratio (lot 3) made only .04 pounds more gain per steer per day than the lot receiving the constant medium level of protein intake (lot 1).

Phase 2 (56 days).

1. In this phase the level of protein intake in all three lots was above the final average level for each lot and the gains produced were more nearly equal than in any other phase of the experiment.

2. Lot 3 received the highest level of protein intake but, as in Phase 1, failed to make as much gain as lot 1 which received the medium allowance of protein.

3. Lot 2 made the largest and most economical gains on the lowest level of protein intake. This was the only case in which the lower level of protein intake produced the most gain.

Phase 3 (76 days).

1. The steers in lot 2 which had been increased to the highest level of protein intake by this phase of the experiment, failed to make as large gains as those in lot 1.

2. The steers in lot 3 received the ration of widest nutritive ratio during this phase and made the smallest gains. These steers, which previously had consumed the most feed, consumed the least during this phase of the experiment.

Entire Period.

1. The lot receiving the average allowance of protein supplement fed at a uniform rate per head per day made larger gains on less feed and showed more bloom and greater finish at the close of the experiment than either of the other lots.

2. Lots 2 and 3 produced almost identical total gains on practically equal amounts of each constituent feed. During the fore part of the feeding period lot 2 was inferior to lot 3 in sleekness of coat and apparent thrift. This difference was practically overcome by the end of the test. Lot 3, in the writer's opinion, developed slightly more finish than lot 2.

Table III - Experimental data, experiment 2. November 1, 1933 to May 8, 1934 - 188 days.

Period	Phase 1 (56 days)			Phase 2 (56 days)			Phase 3 (76 days)		
Lot number	1	2	3	1	2	3	1	2	3
Number of steers in lot	10	10	10	10	10	10	10	10	10
Initial weight per steer	401.00	398.83	399.33	515.50	493.00	515.00	651.00	638.50	651.50
Final weight per steer	515.50	493.00	516.00	651.00	638.50	651.50	840.50	807.50	811.50
Total gain per steer	114.50	94.17	116.67	135.50	145.50	135.50	189.50	169.00	160.00
Daily gain per steer	2.04	1.68	2.08	2.42	2.60	2.42	2.49	2.22	2.10
Average daily ration:									
Shelled corn	5.08	5.20	4.94	9.85	10.00	10.05	13.30	11.71	12.14
Cottonseed meal	1.30	.50	1.73	1.40	1.25	1.54	1.40	1.98	1.09
Atlas sorgo silage	20.05	20.48	19.68	12.23	11.08	9.94	9.00	9.00	9.00
Ground limestone	.10	.10	.10	.10	.10	.10	.10	.10	.10
*Total digestible nutrients per steer per day	7.81	7.37	7.81	10.76	10.62	10.79	13.16	12.31	11.97
*Digestible crude protein per 1,000 pounds live weight per day	2.27	1.50	2.42	2.21	2.17	2.30	2.02	2.18	1.79
*Nutritive ratio	1:7.5	1:10.	1:6.2	1:7.3	1:7.6	1:6.9	1:7.7	1:6.7	1:8.1
Feed per 100 pounds gain:									
Corn	248.47	309.12	237.34	405.58	384.88	415.27	533.51	517.45	578.32
Cottonseed meal	63.67	27.93	82.80	57.65	48.10	63.47	56.15	82.20	57.64
Silage	980.79	1075.74	944.80	510.24	426.12	410.48	360.94	397.67	428.57
Total feed consumed:									
Corn	284.50	291.10	276.90	551.60	560.00	562.70	1011.00	890.02	923.00
Cottonseed meal	72.90	28.00	96.60	78.40	70.00	86.00	106.40	150.40	83.00
Silage	1123.00	1146.00	1102.30	685.00	620.00	556.20	684.00	684.00	684.00

(*) Calculated from Table III (5).

Entire Period (188 days)		
1	2	3
10	10	10
401.00	398.83	399.33
840.50	807.50	811.50
439.50	408.67	412.17
2.34	2.17	2.19
9.63	9.26	9.38
1.37	1.32	1.41
13.26	13.03	12.46
.10	.10	.10
10.63	10.35	10.42
2.04	2.03	2.07
1:7.5	1:7.6	1:7.3
412.08	426.05	427.81
58.63	60.34	64.44
567.00	595.13	568.57
1811.10	1741.12	1762.60
257.70	248.40	265.60
2492.00	2450.00	2342.50

Interpretations.- These data were treated statistically to determine the significance of the differences in gains. The mean total gains and probable errors for each lot, figured by the formula used for random samples, are the basis for the calculations made.

The following table shows the comparison of each lot with the others in this experiment. In this comparison m-m' is the difference between the mean total gains of any two lots compared, P.E. m-m' is the probable error of the difference, and $\frac{m-m'}{P.E.\ m-m'}$ shows the relationship of the two measures. It is generally conceded that any difference in data based upon random samples should be at least four times its probable error to be significant.

Phase 1

Lots Compared	m-m'	P. E. m-m'	$\frac{m-m'}{P.\ E.\ m-m'}$
1 and 2	20.30	±3.94	5.17
1 and 3	2.17	±3.94	.55
2 and 3	22.50	±3.66	6.17

Phase 2

Closeness of gains shows no significant difference.

Phase 3

1 and 2	20.50	±5.40	3.79
1 and 3	29.50	±4.18	7.05
2 and 3	9.00	±5.95	1.57

Entire Period

1 and 2	30.83	±7.44	4.14
1 and 3	27.33	±9.83	2.78
2 and 3	3.50	±10.02	.35

From this analysis it is seen that in Phase 1 comparisons of lots 1 and 3 with lot 2 proved to be significant whereas lot 1 compared to lot 3 did not.

In Phase 3 the only comparison showing significant difference in gain was lot 1 with 3. However, lot 1 compared to lot 2 showed a difference that is worthy of consideration.

A composite for the entire period showed lot 1 with lot 2 to be the only comparison of significant difference.

It should be remembered that the statistical formulae used in this treatment were developed for random samples with a large population rather than small picked groups. Then too, total gain is but one of several factors; namely, cost of gain, type of gain, general appearance of the cattle, and selling price that should be considered in evaluating a ration.

Conclusions.-

1. Results of this test indicate there is no advantage in raising or lowering the level of protein intake at different stages of the feeding period from that level which is supplied by feeding approximately 1.37 pounds of cottonseed meal per head each day to calves being fattened on corn, silage, and ground limestone.

2. The daily intake of digestible crude protein per 1,000 pounds live weight furnished by the above ration appears to approach closely the optimum level for fattening steer calves. Either the rate or the economy of gain, or both, were sacrificed to some extent when the level of protein intake varied from the approximate quantity this ration supplied.

CHEMICAL ANALYSIS OF FEEDS

Determinations of total nitrogen in representative samples of feeds used in these experiments, showed the protein content to be as follows: Corn 9.81%, cottonseed meal 40.75%, atlas sorgo silage 3.73%, and corn silage 2.87%.

Corn silage was substituted for the atlas sorgo silage in both lots on March 26.

Using the above figures, and applying Henry and Morrison's table of the average digestibility of feeding stuffs (5), it was found that the ration furnished approximately .30 pounds more digestible crude protein per 1,000 pounds live weight than was calculated from Table III of the same source. This difference was caused by the high protein content of the silage, which was probably richer in grain than an average of many samples would show.

ACKNOWLEDGMENTS

The investigations herein reported were planned and conducted under the direction of Prof. A. D. Weber. For his valuable suggestions and assistance throughout the

the entire project the writer wishes to express his appreciation. Much credit is also due Dr. C. W. McCampbell and Mr. W. E. Connell for their kindly interest and helpful suggestions in the preparation of this thesis.

LITERATURE CITED

(1) Armsby, H. P.
Cooperative experiments upon the protein requirements for the growth of cattle. Bul. 12 of the Nat'l Res. Council, 11:128 p. 1921.

(2) Blizzard, W. L.
Beef cattle investigations. Okla. Agr. Exp. Sta. Press Bul. 5 p. May 1931.

(3) Christensen, F. W.
Comparative steer feeding tests. N. Dak. Agr. Exp. Sta. Cir. 5, 6 p. 1933.

(4) Crampton, E. W.
Individual feeding for the comparative feeding trial. Amer. Soc. Anim. Prod., Proc. 1930. p. 56-63.

(5) Henry, W. A. and Morrison, F. B.
Feeds and feeding. 19th ed. New York. The Henry-Morrison Co., p. 112, 722-43, 744, 747. 1928.

(6) McCampbell, C. W. and Horlacher, W. R.
Silage feeding investigations. Kans. Agr. Exp. Sta. Cir. 105, p. 1-6. 1924.

(7) Mitchell, H. H.
The minimum protein requirements of cattle. Bul. 67 of the Nat'l Res. Council. p. 69. 1929.

(8)
The paired feeding method. Amer. Soc. Anim. Prod., Proc. 1930. p. 63-67.

(9) Rusk, H. P. and Snapp, R. R.
General cattle feeding practices may be wrong. Ill. Exp. Sta. Annual Rpt. p. 59-62. 1929.

(10) Practices in fattening western calves compared. Ill. Exp. Sta. Annual Rpt. p. 105-11. 1928.

(11) Stiles, W. C. and Morrison, F. B.
The protein requirements of cattle. Amer. Soc. Anim. Prod., Proc. 1931. p. 162-67.

(12) "Student."
The probable error of the mean. Biometrika. 6:1-25. 1908.