A STUDY OF THE EFFECT OF CERTAIN SUPPLEMENTS AND ADDITIVES IN STEER FATTENING RATIONS

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Bachelor of Science

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Lubbock, Texas

1955

Submitted to the faculty of the Graduate School of
the Oklahoma State University of Agriculture
and Applied Sciences
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
August, 1957

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ACKNOWLEDGEMENTS

The writer wishes to express his appreciation to Doctors L. S. Pope and Robert Totusek of the Animal Husbandry Department for guidance during the planning and execution of these studies. He also wishes to express his appreciation to Doctors V. G. Heller and Willis D. Gallup of the Department of Agricultural Chemistry for the chemical analyses of feeds and supplements used in these studies. The valuable assistance of the personnel of the Fort Reno Experiment Station and the Experimental Steer Shed is also gratefully acknowledged.

A special tribute is due the author's wife, Beverly, for inspiration and assistance during the course of these studies.

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INTRODUCTION

In comparison to poultry and swine nutrition, advancement in the nutrition of ruminant animals has been relatively slow over the past 20 or 30 years. Today's methods of feeding poultry have resulted in 50 per cent or more increase in weight in broilers at 12 weeks of age over that obtained 20 years ago. However, the problems confronting the ruminant nutritionist are comparatively complex in nature, for not only must he consider the needs of the animal, but also those of the rumen microorganisms. Because of the great importance of these microorganisms in cellulose breakdown, synthesis of protein from non-protein nitrogen, and vitamin synthesis, the trend in ruminant nutrition has been to develop better supplements to the basal feeds and roughages that will expedite the action of the rumen population and make available to the host animal more nutrients from a given quantity of feed.

Particular emphasis has been given to the use of low quality roughages and how to get the utmost feeding value from them. This problem has brought forth the development and use of various complex or special type supplements to meet the nutrient deficiencies that normally occur in roughage of poor quality. The value of complex supplements

with poor quality roughage has been demonstrated readily; however, the value of these supplements over common oilmeals when fed with roughage of average to good quality has not been established.

Together with the use of various additives, such as dehydrated alfalfa meal, molasses, trace minerals, live-cell yeast, and fermentation solubles, or combinations of these, increased use has been made of antibiotics and hormones in cattle fattening rations.

The purpose of these investigations was to evaluate some of these supplements and additives in beef cattle rations. Particular attention was given to live-cell yeast as it might affect steer performance or improve digestibility of ration components.

REVIEW OF LITERATURE

The advent of the artificial rumen technique for *in vitro* studies has enabled the researcher in animal nutrition to observe the effect of various individual nutrients, or combinations of same, on the breakdown of cellulose by rumen microorganisms. Burroughs *et al*. (1950a), using this technique in preliminary observations upon factors influencing cellulose digestion by rumen microorganisms, noted pronounced differences in the ability of these microorganisms to digest cellulose, depending upon the addition or withdrawal from the nutrient medium of such factors as a complex salt solution (containing all known essential trace elements), the ash of alfalfa, autoclaved rumen liquid, and autoclaved water extract of manure. In further artificial rumen studies, Burroughs *et al*. (1950c) tested nine feeds for their ability to stimulate rumen microorganisms, using the digestion of cellulose *in vitro* as the criterion. The following feeds were found to have the most beneficial effect: dried distillers' solubles, soybean oilmeal, and linseed oilmeal. These were followed closely by cane molasses, corn, wheat bran, and cottonseed meal. Little or no influence upon cellulose digestion was obtained from the addition of meat scraps, fish meal, liver meal, and oats.

This indicated that protein of animal origin is of no benefit in promoting increased cellulose breakdown.

In testing various energy sources and the influence of these sources upon *in vitro* urea utilization by rumen bactera, Arias *et al*. (1951) found six sources of energy; dextrose, cane molasses, sucrose, starch, cellulose, and ground corn cobs aided urea utilization provided the complex carbohydrates underwent digestion. Small amounts of readily available carbohydrate aided cellulose digestion which, in turn, increased urea utilization. However, large amounts of readily available carbohydrate inhibited cellulose digestion, possibly because the microorganisms took the path of least resistance by attacking the more readily available energy source first.

In observing the mineral influences upon urea utilization and cellulose digestion by rumen microorganisms in the artificial rumen, Burroughs *et al*. (1951) reported that the ash of molasses, immature clover hay, and mature clover hay were comparable on an equal weight basis in stimulating fermentation of cellulose. Also, they found phosphorous and iron effective in the stimulation of urea utilization and cellulose digestion by the microorganisms.

Through *in vitro* studies, the researcher can get some idea as to the various feeds or nutrients that might increase cellulose digestion by microorganisms in the rumen of the host animal and result in better utilization of the

feed or feeds being tested. However, whether the knowledge gained by *in vitro* studies is applicable *in vivo* remains to be demonstrated by practical feeding trials.

Complex Supplements in Beef Cattle Rations

Recently numerous experiments involving the use of complex supplements in beef cattle rations have been conducted. The acceptance of these special type supplements where poor quality roughages have been fed has been rather general. However, results from the use of a complex supplement with good quality roughage, such as corn silage or legume hay, have been conflicting.

Most of the experimental work on complex supplements has been done with high roughage rations fed to long-aged steers. Beeson and Perry (1952) found 3.5 pounds of Purdue Cattle Supplement A* with a full feed of corn or grass silage gave gains in excess of 2 pounds daily when fed to steer calves. Recognizing the need for a simple energy supplement rather than protein with the use of grass silage rations, Beeson *et al.* (1953) recommended supplementation with 5 to 7 pounds of corn instead of Purdue A. With high corn silage rations those workers found Purdue A produced slightly higher and more economical gains than Purdue A plus

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*Contained soybean meal, molasses feed, bone meal, salt with cobalt, and a vitamin A and D concentrate.

urea when fed to steers. Van Arsdell et al. (1953) at the Michigan station reported higher average daily gains and a slightly lower feed cost per 100 pounds gained from Purdue A as compared to soybean meal in supplementing corn silage rations for steers. However, the best results in this trial were obtained from a corn-urea mixture which gave higher daily gains at a lower feed cost per 100 pounds gained.

Perry et al. (1953a) found the addition of alfalfa meal to the original Purdue A formula gave greater and more economical gains than did Purdue A plus urea or Purdue A plus cottonseed meal, when fed with corn cobs to steer calves. These observations resulted in modification of the original formula with the addition of alfalfa meal to the previously mentioned constituents. A full feed of corn silage plus the new Purdue A cattle supplement was found by Mohler et al. (1954) to be an efficient economical ration for growing and fattening yearling steers over a 161-day period. However, no comparison was made between this special supplement and a straight oilmeal when fed under those conditions.

Using a special supplement (essentially the same as Purdue A) with a high milo ration for fattening yearling steers, Duitsman and Kessler (1956), at the Kansas station, found that 1.5 pounds of cottonseed meal was equal to 3 pounds of a special supplement in three tests. Smith et al. (1955), at the same station, noted that animals fed the

special supplement with a wintering ration gained faster, but the cost of gain was greater because of the high cost of the supplement as compared to a simple oilmeal.

There appears to be considerable evidence that, when fed on a protein-equal basis in rations containing good quality roughage, the complex supplements increase the cost of the ration without increasing gains over those obtained with a straight oilmeal.

Alfalfa Supplements to Ruminant Rations

In an attempt to determine the influence of alfalfa hay and fractions of alfalfa hay upon ground corn cob digestion by steers, Burroughs et al. (1950b) conducted a series of digestion trials with long-aged steers and reported progressive improvement of corn cob digestion with four respective additions of alfalfa hay to semi-purified diets. A water extract of dehydrated alfalfa meal, fed at a rate equivalent to 4 pounds of meal daily per steer, improved corn cob digestion markedly.

Swift et al. (1951) observed increased digestion of corn cobs by sheep from the addition of alfalfa ash. Tillman and associates (1954a,b) also working with sheep, found that the addition of alfalfa ash to rations where the roughage was prairie hay or cottonseed hulls improved apparent digestibility; a complete mineral mixture also improved the apparent digestibility of the prairie hay ration.

The use of alfalfa hay or dehydrated alfalfa meal with a poor quality roughage, such as corn cobs or cottonseed hulls, as a source of protein, and possibly more important as a source of inorganic elements, appears to have considerable value.

Snapp (1952), in reviewing work done at the Nebraska station, noted that by progressive replacement of soybean meal with dehydrated alfalfa meal in a steer fattening ration composed of ground ear corn and corn silage, the average daily gains were increased with each addition of alfalfa meal. The basal supplement was 1.5 pounds of soybean meal with 3 pounds of alfalfa meal used as the complete replacement on a protein-equal basis. In fact, the Nebraska workers got slightly higher gains from steers fed 1.5 pounds of alfalfa meal as compared to the basal protein supplement.

In summarizing the results of three trials with steers fed low quality timothy hay and corn and cob meal, Klosterman et al. (1953) found that increases in gain could be obtained by the replacement of either one-half or all of the soybean meal by dehydrated alfalfa meal. However, the cost per 100 pounds gain also was increased with each substitution of alfalfa meal for the oilmeal. This was due to the higher cost per unit of protein supplied by the alfalfa meal. By the addition of an equivalent amount of alfalfa ash, the gains were equal to those made on the alfalfa meal, indicating that minerals were an important contributing

factor to the increased performance over that obtained with the basal ration.

At the Oklahoma station, Long et al. (1952) observed that alfalfa hay would not replace satisfactorily all of the cottonseed meal as the sole source of supplemental protein in a fattening ration of corn and sorghum silage for steer calves. At this same station, Pope et al. (1954, 1955, and 1956), in three feeding trials with steer calves, found no advantage in replacing one-fourth, one-half, or all of the cottonseed meal with dehydrated alfalfa meal pellets when fed with a basal ration of milo, sorghum silage, and minerals. They found alfalfa hay to be slightly less valuable than pellets when each replaced one-fourth or one-half of the cottonseed meal.

In general, the most pronounced increases in performance from replacement of an oilmeal with dehydrated alfalfa meal or hay have been obtained in rations where ground ear corn or corn and cob meal was fed. In the trials where only good quality roughages were used, there appeared to be no significant increases in gain and little or no advantage in replacing all of the oilmeal with alfalfa meal. Apparently, a fattening ration combining a good quality roughage, grain, and an oilmeal protein supplement, plus simple minerals, can not be improved greatly by the addition of alfalfa meal. However, with corn cobs in the ration, even though in small amounts, supplementation with alfalfa appears to meet more

adequately the needs of the rumen population for certain nutrients than a straight oilmeal.

The Value of Molasses and Molasses-Urea Supplements to Cattle Rations

Molasses often is used as an appetizer; however, in vitro studies suggest that it may stimulate rumen bacterial action in cellulose breakdown.

In a comprehensive review, Snapp (1952) found that ten out of 25 experiments where not more than 5 pounds of molasses were fed daily, in rations containing corn silage, grain, hay, and a protein concentrate, the gains of calves, yearlings, and two-year-olds were no greater than the basal lots. The other 15 trials showed a slight improvement in gain from the addition of molasses, but there was not enough gain to justify its use with a high quality fattening ration. This same observation was reported by Morrison (1948) in a review of 29 trials in which 2.2 pounds of molasses per head daily were added to an excellent fattening ration for steers.

In an experiment to determine whether or not 3 pounds of molasses could be substituted for 3 pounds of milo when good quality sorgo silage was fed as the roughage, Duitsman and Kessler (1956) in three trials found the cost of gain for molasses-fed steers averaged $1.78 higher per 100 weight than for steers of the non-molasses lot. Pope et al. (1955)

also found no advantage from the addition of 1.6 pounds of molasses to a cottonseed meal-alfalfa hay supplement for fattening steer calves on sorghum silage and milo.

However, Morrison (1952) states that molasses does have value when included in a poor quality high roughage diet where additional protein is supplied, both from the palatability and its use as a cheap source of energy. Dowe et al. (1956) fed poor quality bromegrass hay plus ground shelled corn and soybean meal to steer calves and observed no increase in live weight gains from the addition of molasses. On the other hand, Klosterman et al. (1953 and 1956) found that the addition of 1 pound of cane molasses to a ration of poor quality timothy hay, ground ear corn, and soybean meal fed to fattening steer calves markedly improved the rate of gain and produced cattle with a higher degree of finish. Molasses was of no apparent benefit when included in a ration which contained trace minerals or good quality mixed hay. It also was noted by those workers that the gains of steers fed 0.75 pounds of soybean meal and 1 pound of cane molasses per head daily, plus good quality mixed clover and timothy hay, were equal to those fed 1.5 pounds of soybean meal as the supplement. This was not true when the same rations were fed without molasses. Therefore, cane molasses seemed to have a sparing effect on the protein required. Nelson et al. (1955, 1956a) stated the use of molasses in

cottonseed meal-corn pellets to be fed as supplements to poor quality hay for wintering weanling calves could be recommended.

Working with dairy cattle, Foreman and Hessman (1953) reported that the addition of 2 pounds of molasses increased the digestibility of protein of alfalfa, timothy-lespedeza, and alfalfa-brome hay fed with grain. However, an addition of 4 pounds depressed slightly protein digestion with alfalfa hay but increased protein digestion with timothy-lespedeza. With stemmy alfalfa hay, the 2 pound level increased digestibility, but the 4 pound level did not. They observed a decrease in digestibility of higher quality roughage when 1 to 2 pounds of molasses were fed. Feeding more than 2 pounds produced a pronounced decrease in digestibility.

Feeding two levels of a molasses-urea mixture (51.3 and 43.2 per cent of the protein of the ration) to steers, Tillman et al. (1951) got similar response from both levels; the gains were lower than the basal group (fed grass hay, corn, cottonseed meal, and minerals) but not significantly so. The urea did not alter the palatability of the molasses.

Bohman et al. (1954) working with dairy cattle, found that with a low quality roughage and little or no grain, molasses was not an adequate carbohydrate for the utilization of urea. However, when good quality legume hay

replaced the poor quality timothy hay, a molasses-urea supplement gave excellent gains.

The Value of Trace Minerals in Rations for Beef Cattle

By adding trace minerals to a ration of ground ear corn, poor quality timothy hay, and soybean meal fed to fattening steer calves, Klosterman et al. (1953 and 1956) reported a significant increase in gain over the basal lot. Previously cited in vitro work also indicated an increase in cellulose breakdown by the rumen microorganisms from the addition of trace minerals to the artificial rumen.

However, in a test made in three areas of Oklahoma with range beef cattle fed adequate amounts of roughage (prairie hay or native grass pasture) and supplemented with protein, salt, and phosphorus, Nelson et al. (1956b) found no apparent benefit from the inclusion of trace minerals in the above ration. Baker et al. (1955b) and Smith et al. (1956), at the Kansas Station, reported no beneficial effect from the addition of trace minerals to a wintering ration for steer calves consisting of either sorghum silage or prairie hay and 4 to 5 pounds of grain plus 1 pound of 41 per cent protein supplement. At the Nebraska station, Dowe et al. (1955 and 1956) also reported no increase in gain from the addition of trace minerals to a wintering ration of

bromegrass hay, ground shelled corn, and soybean meal fed to steer calves.

It seems that trace minerals, as well as alfalfa and molasses, are most beneficial when included in rations containing low quality roughages.

Live-Cell Yeast in Rations for Cattle

As a result of the recent emphasis on feed additives in livestock rations, an important question has been raised regarding the value of live-cell yeast suspensions in beef cattle supplements. In fact, numerous reports from the field indicate increased rate of gain, greater feed efficiency, and improved digestibility when cattle are fed live-cell yeast.

In early work, however, Voltz (1919) found that live-cell yeast was not well utilized by sheep, and he stated further that yeast in the active state should not be fed to these animals. Beeson and Perry (1952) have reported that the addition of live-cell yeast suspensions to a ration of ground corn cobs and Purdue Cattle Supplement A gave an apparent, but not statistically significant, growth response in cattle. Other research with fattening rations has failed to show that such addition increased digestibility (Baker et al. 1955; Richardson et al., 1956), although it has been reported that live-cell yeast has a stimulatory action on

cellulose digestion in the artificial rumen (Ruf et al., 1953).

A limited number of experiments concerning the effect of live-cell yeast on the digestibility of ration constituents by beef cattle have been conducted. However, there is some indication, stemming from in vitro work, that live-cell yeast fed in small amounts may influence cellulose breakdown.

Stilbestrol in Beef Cattle Rations

The value of stilbestrol in fattening rations for steers has been explored widely during the past few years, and with but few exceptions, desirable results in terms of increased gain and feed efficiency have been obtained from its use. However, there are several questions to be considered in the use of this synthetic estrogenic hormone, viz., what type ration to use it with, what age animals to feed it to, and how long should it be fed?

At the Kansas station, Richardson et al. (1955) fed a wintering ration of atlas sorgo silage, milo, and soybean meal to steers and found no significant difference in weight gains of the stilbestrol-fed group as compared to the basal. Also, there was a consistent lowering of digestibility when stilbestrol was added to the ration. Feeding the same ration to steers, Richardson et al. (1956b) noted a

tendency toward increased gains with stilbestrol; however, the difference was not great enough to offset the additional cost. No beneficial carry-over effect was obtained from feeding stilbestrol during the winter to animals going on pasture in the spring. In another wintering experiment with steer calves, Richardson et al. (1956c) observed that a low level (5 milligrams) of stilbestrol may be more desirable than a higher level (10 milligrams) when fed to younger animals. Five milligrams of stilbestrol per head daily were fed during the first 56 days, and ten milligrams per head daily were fed during the remainder of the trial. Rate and efficiency of gain were higher for the treated steers as compared with two basal lots.

In a test designed to study the effect of stilbestrol on cattle on pasture, with and without corn, Hale et al. (1955) at the Iowa station found that cattle on brome-alfalfa pasture receiving limited amounts of corn made larger average daily gains (1.82 pounds) with stilbestrol than without (1.26 pounds daily), and cattle receiving clippings in dry lot without corn made larger gains with stilbestrol than without. O'Mary and Cullison (1956), using low level implantation of stilbestrol in steers on pasture, reported significant increases in gain over non-implanted steers.

In a fattening trial with steers in a commercial feed lot, Richardson et al. (1956c) fed 10 milligrams of

stilbestrol per steer daily throughout the test to one group and 10 milligrams during the first 56 days of the test to another. The addition of stilbestrol resulted in a marked increase in rate and economy of gain; however, no advantage was observed from removing the hormone after the first 56 days of the trial. The shrink to market was greater with animals fed stilbestrol; however, within the treated steers those fed stilbestrol during the first 56 days of the trial had a lower shrink. No significant differences in dressing percentage or carcass grade were found.

By the addition of various protein supplements (soybean meal, soybean meal plus dehydrated alfalfa, and linseed meal) to a fattening ration, Matsushima et al. (1956) found the group fed a 60-40 dehydrated alfalfa-soybean meal supplement plus stilbestrol made 6 per cent higher weight gains than the group fed soybean meal plus stilbestrol as the supplement. The combination of dehydrated alfalfa meal and soybean meal did not increase gain or feed efficiency significantly when compared with the group fed linseed meal (both received stilbestrol). The steers fed the combination protein supplements had a 14 per cent increase in gain and consumed 14 per cent less corn and 13 per cent less hay per 100 pound gain than did the controls. Only slight differences were reported in rate of gain, feed efficiency, and carcass grades, regardless of whether stilbestrol was fed during the first half or the last half.

Deans et al. (1956) compared feeding stilbestrol during the entire 140-day fattening period to feeding the hormone-like drug only during the first or last 70 days of the trial. They found the fastest and cheapest gains were made by the cattle receiving stilbestrol during the entire feeding period. However, average daily gains made by the three groups were essentially the same for the 140-day period. Cost per 100 pounds gained was slightly higher in the cattle fed stilbestrol either the first or last half.

In general, where stilbestrol has been included in high energy fattening rations for steers, the results have been favorable in terms of increased gain and improved feed efficiency as compared to control groups. However, the value of stilbestrol in rations for steer calves and older cattle on high roughage rations remains to be determined.

Antibiotics in Rations for Cattle

Research with antibiotics in steer fattening rations has been relatively small; the majority has been done with young calves.

Experimenting with four pairs of identical twin calves, Pritchard et al. (1955) reported that aureomycin added to a milk diet increased growth rate and improved efficiency of feed utilization of the calves until eight weeks of age. A seven-day collection period at the end of the eight-week

period showed no significant difference in digestibility of dry matter, ash, crude protein, crude fiber, NFE, or ether extract. Also using identical twin calves (four pairs), Totusek et al. (1955) found the addition of aureomycin or a crude product containing aureomycin (fed at the level to supply 20 milligrams of aureomycin per 100 pounds body weight) to a ration of cottonseed hulls and a protein supplement, failed to increase rate of gain, feed efficiency, appetite, health, and general appearance of the calves.

Burroughs et al. (1955b) found the addition of aureomycin to a ration of corn-stalk silage and brome-alfalfa hay resulted in a substantial reduction in feed cost. A reduction in feed cost and increased gain was reported by Perry et al. (1953b) from the addition of 75 milligrams of aureomycin per steer daily to a ration of corn cobs and Purdue Cattle Supplement A. However, aureomycin had no effect of growth rate, feed efficiency, or finish when fed with a fattening ration of corn, corn cobs, and Purdue A to yearling steers.

In four fattening trials with 199 lambs full-fed a ration of corn, alfalfa hay, and soybean meal, Jordan (1952) found that the addition of 7.2, 10.8, and 14.4 milligrams of aureomycin per lamb daily did not stimulate feed consumption or feed efficiency.

The value of antibiotics in steer fattening rations remains to be elucidated. It has been postulated that

results obtained from antibiotics in livestock rations in terms of increased gain and feed efficiency are inversely proportional to the degree of sanitation or stress placed on the animal.

Other Supplements in Beef Cattle Rations

Various supplements, such as distillers' dried solubles and animal protein, have been grouped together due to the limited amount of research available. Klosterman et al. (1953) in two trials with steers found no advantage in feeding various mixtures of soybean meal, meat scraps, dehydrated alfalfa meal, and dried distillers' solubles when fed with poor quality roughage. When molasses was added to a supplement of soybean meal, meat scraps, dehydrated alfalfa meal, and dried distillers' solubles, a significant increase in gain over the same mixture without molasses was reported.

In artificial rumen studies, Burroughs et al. (1950b) found little or no favorable effect on cellulose digestion by rumen organisms from the addition of meat scraps, fish meal, or liver meal. However, those workers found fermentation solubles to be stimulatory to cellulose digestion in vitro.

Comparing a supplement of soybean meal to a soybean meal-meat scrap supplement fed with poor quality timothy hay, Klosterman et al. (1953) found no advantage in the

mixed protein supplement. Beeson et al. (1952) reported that the addition of fish meal to Purdue Cattle Supplement A and ground corn cobs for steers gave an apparent, but not statistically significant, growth stimulation. The addition of dried distillers' solubles to Purdue A and corn cobs resulted in no growth stimulation.

Although an insufficient amount of research has been done on the subject, there appears to be little benefit in normal ruminant rations from the inclusion of protein from animal sources. This also appears to be true for such products as distillers' dried solubles, even though in vitro studies have shown this feed stuff to have a stimulatory action on cellulose breakdown by rumen microbes.

EXPERIMENTAL

Objectives

Feeding trials and metabolism studies were conducted with yearling and two-year-old steers and steer calves with the following objectives:

1. To compare several complex supplements to soybean meal in high-silage rations for fattening yearling steers.
2. To determine the effect of certain feed additives, such as stilbestrol and antibiotics, in steer fattening rations.
3. To study the value of a urea-molasses mixture as a complete replacement for a cottonseed meal supplement for fattening steer calves.
4. To study the effect of live-cell yeast on nitrogen retention and digestibility of rations by steers.

PART I

SUPPLEMENTS AND ADDITIVES TO SILAGE RATIONS FOR FATTENING STEERS

A number of beef cattle supplements containing additives which are believed to supply factors stimulatory to rumen microorganisms have received much attention during the last decade. Estrogenic-like compounds, particularly diethylstilbestrol, also have been given considerable emphasis as additives to rations for growing and fattening steers.

To study the possible beneficial effect of certain of these ingredients, a series of fattening trials with beef steers was conducted from 1953 to 1956.

Experiment I

Experimental Procedure

In three fattening trials conducted during the period of 1953-56, a total of 166 good-to-choice, long-yearling Hereford steers were used. Trial I (1953-54) involved the use of 36 choice yearling steers purchased from the Barby ranch in Beaver County. In Trial II (1954-55), 60 good-to-choice yearling Hereford steers were obtained from the

Experiment Station herds at Guthrie and Coalgate. In Trial III (1955-56), 70 coming two-year-old Hereford steers were obtained from the same locations. In the last instance, the steers had been purchased the previous year from the same Osage County herd.

The steers in all trials were given approximately a week after arrival at the Ft. Reno station to recover from the effects of shipment, and then they were divided into uniform groups on the basis of weight and grade. They were allotted to treatment at random. Prior to obtaining the initial and final weights, the cattle were subjected to a 16-hour shrink in dry lot. In both Trials II and III, the steers had been purchased the previous fall and were used in certain pasture utilization studies. Thus, it was possible to use their records of gain on summer pasture in grouping them.

All of the supplements tested from 1953 to 1956 were fed on a protein-equivalent basis. Milo was adjusted to provide an equal energy intake from the concentrates fed in all lots. This allowed for an equal energy intake in all lots from the grain and supplement fed. A mineral mixture of two parts salt and one part steamed bone meal was available to all lots, free choice. The rations were fed once daily with grain and supplement poured over the silage in deep bunks. The molasses fed was poured over the feed mixture and not mixed with the soybean meal and alfalfa hay.

In Trial I, three uniform lots of 12 steers each were fed sorghum silage, a protein supplement, and limited amounts of ground milo. Lots 2 and 3 received slightly less grain due to the greater amount of the supplemental mixtures fed.

The following supplements were fed per steer daily in Trial I:

Lot 1 - 2.0 pounds of soybean meal.

Lot 2 - 2.8 pounds of Purdue Cattle Supplement A.

Lot 3 - 2.9 pounds of a 3-1-1 supplement containing three parts soybean meal, one part chopped alfalfa hay, and one part blackstrap molasses.

In this trial, milo was fed according to the following schedule (per head daily): 4 pounds for the first 50 days; 8 pounds for the next 50 days; and 12 pounds for the remaining 50 days.

The 60 steers used in Trial II were divided into six uniform groups. The feeding procedure was essentially the same as practiced in Trial 1, with the exception that drought-damaged immature corn silage was fed together with the following supplements per steer daily:

Lot 1 - 2.0 pounds of soybean meal.

Lot 2 - 2.7 pounds of Purdue Cattle Supplement A.

Lot 3 - 2.9 pounds of a 3-1-1 mixture (as described for Trial I).

Lot 4 - 4.0 pounds of a 1-1-1 supplement containing equal parts of soybean meal, chopped alfalfa, and blackstrap molasses.

Lot 5 - 1.5 pounds of soybean meal plus 1.0 pound of special supplement containing dehydrated alfalfa meal, dried molasses, condensed fish solubles, live-cell yeast, iron, copper, and cobalt.

Lot 6 - 2.0 pounds of a 2-1 mixture of soybean meal and sesame meal.

Four pounds of milo per steer daily were fed for the first 100 days. The milo then was raised gradually during the remainder of the test until the cattle were receiving approximately 22 pounds per head daily, with slight adjustments according to the energy content of the supplement fed.

In Trial III the steers were divided into seven lots of ten head each and fed sorghum silage and a limited amount of milo.

The supplements fed per head daily were as follows:

Lot 1 - 2.0 pounds of soybean meal.

Lot 2 - 4.0 pounds of the 1-1-1 supplement described for Trial II.

Lot 3 - 1.5 pounds of soybean meal and 1.0 pound of a special supplement as described for Trial II.

Lot 4 - 1.7 pounds of soybean meal plus 0.5 pound of butyl fermentation solubles.

Lot 5 - 1.95 pounds of soybean meal plus 0.05 pound of a crude product containing 90 milligrams aureomycin activity.

Lot 6 - 2.0 pounds of soybean meal containing 10 milligrams of diethylstilbestrol.

Lot 7 - 2.0 pounds of soybean meal plus 10 milligrams of diethylstilbestrol during the last 80 days of the feeding period only.

Milo was fed at the level of 4 pounds for the first 84 days and then increased until the cattle were essentially on a full-feed of grain. This was continued for the remainder of the trial (80 days). The stilbestrol was premixed with a small amount of cottonseed meal and combined with the soybean meal supplement.

At the completion of the trials, the cattle were sold on the Oklahoma City market, and data on shrink to market, yield, and carcass grade were obtained. The weight gains of the steers were subjected to analysis of variance (Snedecor, 1946).

Results and Discussion

A summary of the results of this series of fattening trials with yearling and two-year-old steers is presented in Tables 1 through 6. More complete data for individual trials are given in Appendix Tables I through VI.

Soybean Meal vs. Purdue Cattle Supplement A or 3-1-1 Supplement

In the average of two trials, shown in Table 1, the daily gains made by the steers fed Purdue Cattle Supplement A (Lot 2) and those supplemented with the 3-1-1 mixture (Lot 3) were essentially the same as the basal group (Lot 1) fed soybean meal. Although the selling price, average dressing percentage, and carcass grade were practically the same in Lots 1 and 2, the feed cost per 100 pounds gain was higher in Lot 2. The necessity of feeding a greater amount of the Purdue Cattle Supplement A in order to supply the same protein intake as Lot 1 was largely responsible for the increased feed cost.

The 3-1-1 mixture fed to Lot 3 cost slightly less than Purdue A. This lower cost, plus the slight advantage in average daily gain and a lower feed consumption, resulted in a lower feed cost per 100 pounds gain for the steers fed the 3-1-1 mixture ($23.84, $24.60, and $26.90 for Lots 1, 2, and 3, respectively). Lot 3 also had a higher average carcass grade score and a greater net return per steer than did Lots 1 and 2.

TABLE 1

AVERAGE RESULTS COMPARING PURDUE A AND A 3-1-1 MIXTURE TO SOYBEAL MEAL AS SUPPLEMENTS TO SILAGE FOR FATTENING STEERS (TWO TRIALS, 1953-54)

Lot Number	1	2	3
Supplement Fed	S.B. Meal	Purdue A[1]	3-S.B. Meal 1-Alfalfa 1-Molasses
Number of steers/lot	22	22	22
Ave. initial wt. (lb.)	711	711	712
Ave. daily gain (lb.)	1.96	1.85	1.99
Ave. daily ration (lb.)			
Milo	8.94	8.67	8.48
Supplement	2.00	2.77	2.92
Silage	44.00	42.40	42.20
Feed required/cwt. gain (lb.)			
Milo	465	468	426
Supplement	102	150	146
Silage	2248	2287	2115
Feed cost/cwt. gain (4)	24.60	26.90	23.84
Selling price/cwt. ($)[2]	20.71	20.80	21.54
Dressing %	60.0	59.2	60.8
Carcass grade score[3]	7.9	7.7	8.5

[1]Contained soybean meal, 65.05%; molasses, 14%; dehydrated alfalfa meal, 14%; steamed bone meal, 5.2%; salt (1 oz. $COSO_4$/100 lb.), 17%; and dry stabilized A (4.5 million units/lb.), 0.5%.

[2]An on-foot market value was computed from the yield, carcass grade, and current value of the carcass.

[3]Carcass grades were ave. choice = 10; ave. good = 7; and ave. commercial = 4.

These results are in general agreement with those reported by Richard et al. (1954) in which no advantage was obtained from a complex supplement as compared to soybean meal or a simple mixture of soybean meal and ground alfalfa hay when fed with a high corn silage ration to fattening yearling steers. The advantages reported by Van Arsdell et al. (1953) for Purdue Cattle Supplement A over straight soybean meal when fed with corn silage to steers were not verified under the conditions of this study.

The results indicate that a complex supplemental mixture, or the relatively simple combination of alfalfa, molasses, and soybean meal, is not superior to straight soybean meal, in terms of daily gain and feed efficiency of steers, when fed on an equal protein and energy basis.

Where poor quality roughage is fed, such as corn cobs and cottonseed hulls, supplements similar to those fed to Lots 2 and 3 might have a decided advantage over a straight oil meal supplement. The fact that dehydrated alfalfa meal and molasses contained in the complex Purdue A supplement did not stimulate weight gains does not agree with work reported by other stations. Decided increases in the average daily gains of steers were observed when part or all of an oilmeal supplement was replaced by alfalfa meal (Snapp, 1952, and Klosterman et al., 1953). However, in some instances the cost of gain also would increase with the

replacement of an oilmeal by alfalfa meal on a protein equivalent basis.

It also has been reported that molasses fed at the rate of 1 pound daily, in steer rations containing poor quality timothy hay, ground ear corn, and soybean meal, markedly improved rate of gain and finish. It is interesting to note, however, that, when those workers fed molasses in rations containing good quality mixed hay or trace minerals, it was of no apparent benefit.

Soybean Meal vs. 1-1-1 Supplement or a Special Mixture

In the comparison of the 1-1-1 supplement composed of equal parts soybean meal, chopped alfalfa hay, and blackstrap molasses (Lot 4) and the soybean meal-special mixture (Lot 5) with straight soybean meal, it was found that there were no significant differences in average daily gain between steer lots (see Table 2). Feed cost per 100 pounds gain was definitely higher for the Lot 5 steers and also higher for Lot 4 when compared to the basal group ($24.87, $25.72, and $28.10 for Lots 1, 4, and 5, respectively). Dressing percentage and carcass grades were similar for all lots; however, the selling price per 100 pounds was somewhat lower for the Lot 4 steers than either of the other lots (19.11, $19.32, and $19.35 for Lots 4, 1, and 5, respectively).

TABLE 2

AVERAGE RESULTS COMPARING A SPECIAL MIXTURE AND A 1-1-1 MIXTURE TO SOYBEAN MEAL AS SUPPLEMENTS TO SILAGE FOR FATTENING STEERS (TWO TRIALS, 1954-55)

Lot Number	1	4	5
Supplement Fed	S.B. Meal	1-S.B. Meal 1-Alfalfa 1-Molasses	S.B. Meal + Special Mix[1]
Number of steers/lot	20	20	20
Ave. initial wt. (lb.)	809	810	807
Ave. daily gain (lb.)	2.05	1.99	1.98
Ave. daily ration (lb.)			
Milo	10.82	9.74	10.64
Supplement	2.00	4.05	2.55
Silage	46.10	46.10	47.40
Feed required/cwt. gain (lb.)			
Milo	529	489	537
Supplement	98	203	129
Silage	2251	2315	2398
Feed cost/cwt. gain ($)	24.87	25.72	28.10
Selling price/cwt. ($)	19.32	19.11	19.35
Dressing %	60.72	60.29	60.99
Carcass grade score	8.3	7.9	8.0

[1]Contained (%): dehydrated alfalfa meal, 35; dried molasses, 35; condensed fish solubles, 26.5; active dry yeast (20 bil. cells/gm.), 2.5; and trace mineral premix, 1.0 (supplied 10 milligrams of iron, 1 milligram of copper, and 0.2 milligrams of cobalt per 100 pound body weight).

The poor feed conversion of the cattle fed the 1-1-1 supplement as compared to the 3-1-1 mixture (Table 1) is difficult to explain. Possibly the greater amount of molasses in the 1-1-1 supplement inhibited cellulose breakdown in the rumen. It has been reported that molasses fed at the rate of 1 to 2 pounds daily depressed digestibility of high quality roughage by dairy cattle (Foreman and Herman, 1953). It seems apparent that larger amounts of alfalfa and molasses do not improve the supplement. The trend for an increase in yield and carcass grade from feeding the 3-1-1 supplement was not observed in the lots receiving the 1-1-1 supplement containing the same feeds.

The fact that the replacement of part of the soybean meal with alfalfa hay and molasses did not increase performance of the steers over those supplemented with soybean meal alone lends further support to the results reported at the Oklahoma station where no advantage was found in replacing one-fourth, one-half, or all of the cottonseed meal with dehydrated alfalfa pellets in silage and milo rations for fattening steer calves (Pope et al., 1954, 1955, and 1956). However, the addition of either alfalfa or molasses to steer rations containing low quality roughage has been reported to markedly improve rate of gain and finish (Klosterman et al., 1953, 1956). The addition of trace minerals also was reported by those workers to stimulate weight gain increases over the control steers. Perhaps the ash fraction of

alfalfa and molasses is the main contributing factor to the better utilization of low quality roughage.

In these trials the complex special mixture containing feeds believed to be high in unidentified growth factors merely increased the feed cost without adding any factors stimulatory to weight gains. The special mixture also appeared to have no effect on appetite, yield, or carcass grade. The value of such a supplement may be inversely proportional to the quality of roughage fed.

Soybean Meal vs. a Soybean-Sesame Meal Mixture

In a single trial, the 2-1 mixture of soybean meal and sesame meal fed to Lot 6, as shown in Table 3, increased the feed cost by $2.00 per 100 pounds gain, and it resulted in no increase in gain or feed efficiency over the steers in Lot 1 fed straight soybean meal as the protein supplement. Average dressing percentage and carcass grade were similar for both lots, although the selling price per 100 weight was slightly higher for the steers supplemented with the soybean-sesame meal mixture.

TABLE 3

AVERAGE RESULTS COMPARING SOYBEAN-SESAME MEAL MIXTURE WITH SOYBEAN MEAL AS SUPPLEMENTS TO SILAGE FOR FATTENING STEERS (ONE TRIAL, 1954-55)

Lot Number	1	2
Supplement Fed	S.B. Meal	S.B. Meal + Sesame Meal[1]
Number of steers/lot	10	10
Ave. initial wt. (lb.)	739	740
Ave. daily gain (lb.)	2.09	1.99
Ave. daily ration (lb.)		
Milo	9.84	9.88
Supplement	2.00	2.02
Silage	47.60	47.90
Feed required/cwt. gain (lb.)		
Milo	471	497
Supplement	96	102
Silage	2279	2409
Feed cost/cwt. gain ($)	24.81	26.81
Selling price/cwt. ($)	21.92	22.10
Dressing %	60.6	61.1
Carcass grade score	8.4	8.4

[1]Contained two parts soybean meal to one part sesame meal.

A soybean-sesame meal mixture has been shown to contain a protein of higher biological value than soybean meal alone for chicks (Almquist, 1944). However, Loggins (1953), at the Oklahoma station, found that the average winter gains of two-year-old steers fed soybean meal were 14.5 pounds per head greater than those fed a soybean-sesame meal mixture. The steers were wintered on dry native grass.

Although sesame meal has become more plentiful in recent years, it is relatively expensive and apparently has no added value as a protein supplement for cattle, at least in high-silage rations as judged by steer performance in these trials.

The Effect of Adding Aureomycin or Fermentation Solubles to Soybean Meal

A single trial was conducted to study the value of aureomycin and dried grain and cane syrup fermentation solubles in rations for fattening steers. The data presented in Table 4 seem to indicate some apparent benefit in terms of average daily gain from the addition of aureomycin to the basal soybean meal supplement. However, the 0.14 pound increase in average daily gain over the basal group was not statistically significant. The addition of dried grain and cane syrup fermentation solubles to the basal ration greatly increased feed cost per 100 pounds gain and did not increase the performance of the steers over the basal lot.

TABLE 4

AVERAGE RESULTS COMPARING SOYBEAN MEAL + FERMENTATION SOLUBLES AND SOYBEAN MEAL + AUROFAC TO SOYBEAN MEAL AS SUPPLEMENTS TO SILAGE FOR FATTENING STEERS (ONE TRIAL, 1955-56)

Lot Number	1	4	5
Supplement Fed	S.B. Meal	S.B. Meal + Ferm. Sol.[1]	S.B. Meal + Aurofac[2]
Number of steers/lot	10	10	10
Ave. initial wt. (lb.)	879	876	877
Ave. daily gain (lb.)	2.01	1.98	2.15
Ave. daily ration (lb.)			
Milo	11.80	11.60	11.80
Supplement	2.00	2.00	2.00
Silage	44.60	47.40	43.5
Feed required/cwt. gain (lb.)			
Milo	588	583	584
Supplement	100	114	93
Silage	2223	2392	2021
Feed cost/cwt. gain ($)	24.94	26.37	23.68
Selling price/cwt. ($)	16.72	16.63	17.11
Dressing %	60.85	60.17	61.10
Carcass grade score	8.3	9.3	9.0

[1]Contained approximately 78 per cent S.B.M. and 22 per cent dried grain and cane syrup fermentation solubles.

[2]Contained 0.05 pounds of Aurofac, a crude product containing 90 milligrams of aureomycin activity.

Dressing percentages were similar for all lots. However, carcass grades were slightly higher in the lots fed aureomycin or fermentation solubles.

The beneficial effect of fermentation solubles on *in vitro* cellulose breakdown by rumen bacteria (Burroughs *et al.*, 1950c) is apparently of no great consequence in the rumen itself. It is entirely possible that fermentation solubles, due to the B-vitamin content or unidentified growth factors, stimulate an increase in cellulose breakdown *in vivo*; however, in this study no apparent benefit was observed. Beeson *et al.* (1952) also reported no growth stimulation from the addition of fermentation solubles to steer rations containing corn cobs and Purdue A.

Although the increase in weight gain over the basal group observed in the lot fed aureomycin with the soybean meal supplement is not statistically significant, the benefit from the antibiotic may be of more consequence than is immediately apparent from these data. Even though small, the reduction in feed cost per 100 pounds gain of $1.26 was noted in the aureomycin lot as compared to the basal group. This observation has been made by other workers (Burroughs *et al.*, 1955b; and Perry *et al.*, 1953b) and may be of considerable financial advantage in large feed lots.

Feeding Stilbestrol Throughout the Trial vs. Only During the Latter Half

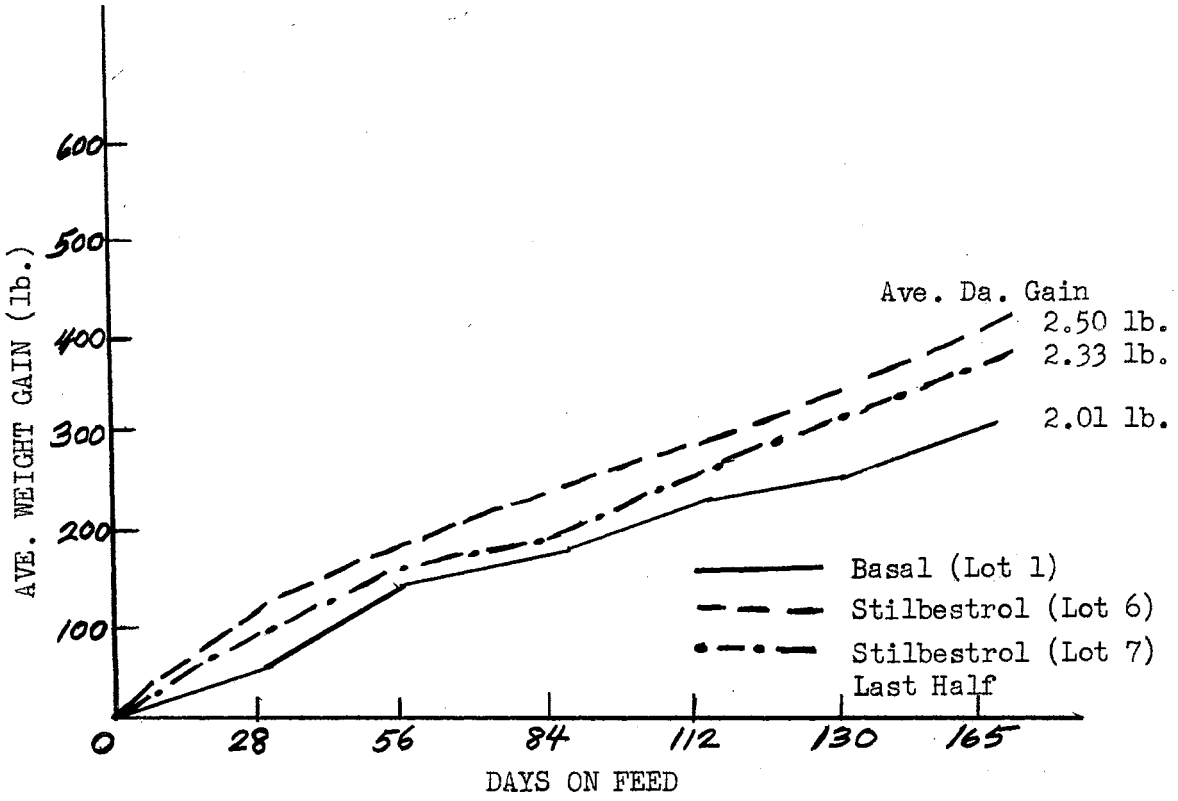
As illustrated graphically in Table 5, Lot 6 cattle fed the basal soybean meal supplement plus 10 milligrams of stilbestrol throughout the entire trial, and Lot 7 fed the same ration plus stilbestrol only during the last half of the feeding period, gained significantly more than the other groups in this test (Appendix Table VI). An increase in gain of 24 per cent above the basal lot was observed in Lot 6. A similar, though less pronounced, effect was apparent in Lot 7.

There appeared to be no advantage in feeding the drug during the last half only. This agrees with work done at other stations (Richardson et al., 1956c; Matsushima et al., 1956; and Deans et al., 1956).

In the present study, the steers in Lot 6, fed stilbestrol throughout the trial, made their maximum average daily gain during the first half of the trial. The average daily gain during the first half of the trial was approximately 2.7 pounds, whereas that for Lot 7 (stilbestrol during last half only) was only 2.2 pounds. However, during the last half of the test, the Lot 7 steers received stilbestrol in their protein supplement, and the gains of these steers markedly increased and approached those of Lot 6 as the gains of the latter group began to decline during the last half of the trial.

TABLE 5

GAINS OF STEERS FED STILBESTROL THROUGHOUT FATTENING TRIAL VS. ONLY DURING LAST 81 DAYS[1]



[1] heavy grain feeding during last 80 days of test.

Possibly a longer period of feeding during the latter phase would have resulted in equal performance of the two hormone-treated lots.

Average carcass grade, dressing percentage, and selling price were similar for all steer lots (see Table 6), and little difference was observed in shrink to market from a full weight. The cattle in Lots 6 and 7 consumed less feed than those in the basal lot and made a significantly greater weight gain, which resulted in more efficient conversion of ration nutrients to body weight.

The greatest supplemental or additive benefit, in terms of increased gain and feed efficiency, throughout the three year study was obtained from the addition of stilbestrol to the basal ration of soybean meal, silage, and milo. Significant increase in weight gains of steers fed stilbestrol also have been reported by other stations (Burroughs et al., 1955a,b; Richardson et al., 1956c; and Deans et al., 1956).

TABLE 6

AVERAGE RESULTS FEEDING STILBESTROL THROUGHOUT THE TRIAL VS. STILBESTROL FEEDING DURING LATTER HALF ONLY (ONE TRIAL, 1955-56)

Lot Number	1	6	7
Supplement Fed	S.B. Meal	S.B. Meal + Stilbestrol[1]	S.B. Meal + Stilbestrol[2] (last half)
Number of steers/lot	10	10	10
Ave. initial wt. (lb.)	879	876	878
Ave. daily gain (lb.)	2.01	2.50	2.34
Ave. daily ration (lb.)			
Milo	11.80	11.80	11.80
Supplement	2.00	2.00	2.00
Silage	44.60	49.50	47.1
Feed required/cwt. gain (lb.)			
Milo	588	471	507
Supplement	100	80	86
Silage	2223	1975	2022
Feed cost/cwt. gain ($)	24.94	21.08	22.26
Selling price/cwt. ($)	16.72	16.84	16.52
Dressing %	60.85	60.48	60.12
Carcass grade score	8.3	8.8	8.3

[1]Fed at the level of 10 milligrams/steer daily.

[2]Fed during last 80 days (10 milligrams/steer daily).

Experiment II

Experimental Procedure

Forty choice Hereford steer calves from the experimental herd and from a group purchased through the Woodward Feeder Calf sale were used in this study. The calves were grouped as evenly as possible on the basis of shrunk weight, source, and feeder grade. Four calves in each lot were distributed according to sire. The groups were assigned to treatment at random and gradually worked up to a full feed of rolled milo, with a limited amount of sorghum silage and the following supplements:

Lot 3 - 1.2 pounds of cottonseed meal plus 1.0 pound of alfalfa hay.

Lot 7 - 1.8 pounds of a urea-molasses mixture fortified with steamed bone meal and trace minerals plus 1.0 pound of alfalfa hay.

Lot 8 - 1.2 pounds of cottonseed meal and 1.0 pound of alfalfa hay plus 10 milligrams of stilbestrol.

Lot 9 - Same as Lot 8 with stilbestrol added only during the latter half of the trial.

The calves were started on grain slowly and worked up to a full-feed, with reductions in the amount of sorghum silage fed to achieve high grain intake. The urea-molasses mixture, containing 1.6 pounds of molasses and 0.188 pound of urea per steer daily, was dissolved in warm water and poured

over the silage and concentrate. The replacement of cottonseed meal by the urea-molasses mixture was made gradually over a 40-day period. A mineral mixture of two parts salt and one part steamed bone meal was available to all lots free choice. In addition, one ounce of ground limestone was added to the daily ration to insure an adequate calcium intake.

All calves were drenched with phenothiazine prior to the test for the control of internal parasites. At the conclusion of the 166-day trial, the steers were sold on the Oklahoma City yards, where marketing and slaughter data were obtained.

The weight gains of the steers were subjected to analysis of variance (Snedecor, 1956).

Results and Discussion

As shown in Table 7, the steers of Lot 7, fed the urea-molasses mixture, gained 2.14 pounds per day as compared to 2.05 pounds per day for the basal lot. Average carcass grade scores were similar for both lots; however, the average dressing percentage was somewhat higher for the basal lot. The feed cost per 100 pounds gain was slightly lower for Lot 7 ($16.84) than for the basal Lot 3 ($16.94).

TABLE 7

AVERAGE RESULTS OF STILBESTROL AND UREA-MOLASSES IN RATIONS FOR FATTENING STEER CALVES (ONE TRIAL, 1955-56)[1]

Lot Number Treatment	3 Control	7 Urea-mol.	9 Stilbestrol (10 mg.)	10 Stilbestrol (10 mg. last half)
Number of calves/lot	10	10	10	9
Ave. initial wt. (lb.)	521	519	527	520
Ave. daily gain (lb.)	2.05	2.14	2.45	2.24
Ave. daily ration (lb.)				
Milo	12.3	12.6[2]	12.8	11.7
C.S. meal	1.2	0.68[2]	1.2	1.2
Urea-molasses[3]	--	1.5	--	--
Alfalfa hay	1.0	1.0	1.0	0.9
Sorghum silage	11.5	11.6	11.7	9.9
Feed required/cwt. gain (lb.)				
Milo	600	589	524	523
C.S. meal	58	7	49	52
Urea-molasses	--	76	--	--
Alfalfa hay	46	44	39	41
Sorghum Silage	558	543	476	443

[1]Complete data are presented in Appendix Tables VII through X.

[2]Average fed during first 40 days of trial only.

[3]Mixture contained 1.6 lb. of molasses and 0.188 lb. of urea plus 0.1 lb. bone meal and 0.75 gm. trace mineral per head daily. The substitution of the urea-molasses mixture for cottonseed meal was made by a step wise replacement over a 40-day period.

TABLE 7--Continued

Lot Number Treatment	3 Control	7 Urea-mol.	9 Stilbestrol (10 mg.)	10 Stilbestrol (10 mg. last half)
Feed cost/cwt. gain ($)	16.49	16.84	14.86	14.80
Selling price/cwt. ($)	19.30	19.30	19.64	19.11
Dressing %	62.7	60.2	61.9	61.3
Carcass grade score	8.9	9.1	8.9	8.3

Apparently, molasses is a desirable substance to combine with urea for feeding cattle. In vitro studies have shown that small amounts of molasses increased cellulose digestion, which in turn increased urea utilization (Arias et al., 1951). In past experiments it has been noted that a period of adjustment appears necessary during the first part of the feeding trial when urea is included in the ration. This possibly could result from a bacterial adaptation to maximum utilization of urea. In the present study, however, the average daily gain made by the urea-molasses fed steers during the first 84 days of the test was comparable to that of the basal lot (1.96 pounds and 2.02 pounds, respectively). Perhaps this was due to the gradual replacement of the cottonseed meal with the urea-molasses supplement. Urea fed in this manner did not alter the palatability of the molasses, which is in agreement with the report of Tillman et al. (1951).

The results obtained from the use of this mixture with good quality roughage and ample amounts of grain lend further support to the previously reported observations of Bohman et al. (1954) who found that when good quality hay replaced poor quality hay, in a ration containing ample amounts of grain, a urea-molasses supplement gave excellent gains.

Feeding the urea-molasses supplement rather than a simple oilmeal protein supplement afforded no financial

saving in this particular trial. Under conditions where molasses could be purchased and handled cheaply, the mixture might have a potential value.

The stilbestrol steers in Lots 8 and 9 had significantly higher gains than those in the other two lots (See Appendix Table X). Lot 8, fed stilbestrol throughout the trial, had an average daily gain increase of 19.5 per cent over the controls. In Lot 9, receiving the drug only during the last half of the trial, there was a rate of gain increase of 9.3 per cent. Although feeding stilbestrol throughout the trial produced greater gains than feeding it only during the last half, the difference was not statistically significant. The difference in average daily gain between the two lots for the first half of the test was practically the same as the final difference.

The fact that no advantage was observed between feeding stilbestrol throughout vs. only during the last half further substantiates the results of the high-silage trials with long-aged steers and, also, is in general agreement with work done at other stations (Richardson et al., 1956c; Matsushima et al., 1956; and Deans et al., 1956). However, it generally is recommended that for maximum results, stilbestrol should be fed throughout the fattening period.

The steers fed stilbestrol (Lots 8 and 9) had a lower cost per 100 weight gain ($14.86 and $14.80) as compared to $16.94 and $16.84 for Lots 3 and 7, respectively. The

efficiency of gain as measured by feed required per 100 pounds gain was equal, although the appraised value for Lot 9 was lower than that of Lot 8. Average dressing percentage and carcass grade scores were similar.

PART II

EFFECT OF LIVE-CELL YEAST ON NITROGEN RETENTION AND DIGESTIBILITY OF RATIONS BY BEEF CATTLE*

There is some evidence that live-cell yeast has a stimulatory action on cellulose digestion *in vitro*. However, the value of yeast organisms in cattle rations has not been elucidated. An attempt has been made to resolve the problem through a study of the effect of live-cell yeast on nitrogen retention and digestibility in steers fed low-quality roughage, high quality roughage, and high-energy fattening type rations.

Experimental Procedure

Twelve grade Hereford steer calves approximately 10 months old and averaging 530 pounds were used in this series of three digestion and nitrogen balance trials. The steers were stanchioned in false-bottom metabolism stalls (Nelson *et al.*, 1954) and given a week to become accustomed to their new environment and the rations to be fed. A 10-day preliminary period preceded each 10-day collection period. The

*This research was supported in part by a grant-in-aid from Vita-Vex, Inc., Kansas City, Missouri.

steers that received yeast in each trial were selected at random. To minimize carry-over effects, a 10-day period was allowed at the end of each trial before beginning the preliminary period of the next trial. The steers remained in the stalls during this period.

Feces were collected in metal boxes and transferred at frequent intervals to covered metal containers. The feces were weighed daily, and aliquots were preserved in tightly covered glass jars under refrigeration. Thymol crystals were used to aid in preservation. Urine was collected in metal containers, diluted with water to a definite weight daily, and aliquots were acidified and stored under refrigeration. At the end of each trial, representative samples of all feeds and excreta were analyzed by accepted methods (A.O.A.C., 1950).

The low-quality roughage ration fed in Trial 1 was composed of cottonseed hulls, 2,724 grams; cottonseed meal, 908; yeast carrier grains, 227; steamed bone meal, 45.4; salt, 27; and a Vitamin A and D supplement. The high-quality roughage ration of Trial 2 contained alfalfa and prairie hay (1:1), 3,632 grams; yeast carrier grains, 227; and salt, 27. The fattening ration of Trial 3 contained cottonseed hulls, 1,589 grams; dehydrated alfalfa meal, 454; cottonseed meal, 681; milo, 2,724; yeast carrier grains, 227; and salt, 27. The yeast carrier grains consisted of a

mixture of 65 per cent wheat shorts, 30 per cent milo, and 5 per cent yellow corn. In each trial, six of the 12 steers received this grain mixture which, according to the manufacturer, contained about 40 million live-cells per gram; the other six steers received the same amount of a grain mixture of essentially the same composition (control ration) without the yeast organisms. The chemical composition of the complete rations and the amounts fed daily are shown in the first part of Table 8.

Results were treated statistically according to methods described by Snedecor (1946).

Results and Discussion

The apparent digestibility of nutrients in each ration and the nitrogen balance data are shown in Table 8.

In Trial 1, in which the low-quality roughage ration was fed, the addition of live-cell yeast had no marked effect on the digestibility of nutrients other than ether extract. The small increase in average digestibility of crude fiber, 4 per cent, did not prove to be statistically significant and was not confirmed in the other trials with different rations. The decrease in average digestibility of ether extract in the yeast ration, 81.5 per cent, as compared to 86.4 per cent in the control ration, may be of more consequence than is immediately apparent.

TABLE 8

COMPOSITION OF RATIONS AND SUMMARY OF RESULTS OF DIGESTION AND NITROGEN BALANCE STUDIES WITH STEERS FED LIVE-CELL YEAST
(Three Trials, 1956)

Trial Number	1		2		3	
Ration Type	Low-quality Roughage		High-quality Roughage		Fattening Type	
Ration Designation[1]	Control	Yeast	Control	Yeast	Control	Yeast
Dry matter intake, daily, gm.	3657	3653	3595	3623	5162	5172
Composition of dry matter, %						
Organic matter	94.6	95.0	91.5	91.6	96.2	96.4
Protein	14.8	14.8	12.1	12.2	13.7	13.8
Ether extract	2.1	2.1	2.7	2.7	3.6	3.5
Crude fiber	32.6	32.5	30.2	30.0	16.0	16.0
N-free extract	45.1	45.6	46.5	46.7	63.1	63.1
Apparent digestibility, %						
Organic matter	54.8	55.7	65.6	64.9	63.4	63.9
Protein	49.2	48.6	62.3	62.6	48.5	48.9
Ether extract	86.4	81.5	49.2	47.1	80.4	77.3
Crude fiber	45.6	47.4	61.8	60.1	32.1	31.1
N-free extract	61.7	62.6	69.5	69.2	73.5	74.9
Nitrogen balance data, gm.						
Intake	86.7	86.4	69.8	70.9	113.1	113.8
Feces	44.0	44.2	26.3	26.4	58.2	59.0
Urine	30.1	27.8	38.7	39.0	29.2	32.1
Digested	42.7	42.2	43.5	44.5	54.9	54.8
Retained						
as % of intake	14.5	16.7	6.9	7.7	22.7	19.9
as % of digested	29.5	34.1	11.0	12.3	46.8	41.4

[1]The yeast rations supplied approximately 9 billion live-yeast cells per steer daily.

Although the nutritional value of ether extract in the low-quality roughage ration may be questioned, it is, nevertheless, significant that the digestibility of this nutrient was decreased to a similar extent in the high-quality roughage ration of Trial 2, and to a lesser extent in the fattening ration of Trial 3. In the latter trial, ether extract digestibility was reduced from 80.4 per cent to 77.3 per cent. The digestibility of other nutrients was unchanged. Such effects, when considered in relation to the low fat tolerance of ruminants, particularly sheep, may provide a partial explanation of the adverse results of yeast feeding reported by Voltz (1919). Further, an examination of the data reported by Richardson et al. (1956) shows that the digestibility of ether extract alone was depressed consistently in steers fed suspensions of different strains of live-cell yeast. Observations made by those workers implicate the yeast cells in the less favorable growth response and skin condition of the animals so fed.

The nitrogen balance data of Table 8 lend support to the previously reported results of feed lot trials with steers fed high-silage rations. In the present study, nitrogen retention, expressed either as a per cent of the intake or as a per cent of the digested nitrogen, was not improved significantly by addition of the yeast cells to any of the three rations. In the feed lot trials with high-silage fattening rations, the gain made by steers fed

live-cell yeast in a complex protein supplement was no greater than that of control steers fed a supplement of straight soybean meal.

SUMMARY

Feeding trials and metabolism studies were conducted with beef steers to compare various supplements and additives to milo and silage rations for fattening steers and to study the effect of live-cell yeast on nitrogen retention and digestibility of rations by steers.

With the exception of those containing stilbestrol, neither simple nor complex supplemental mixtures increased gains or feed efficiency over soybean meal alone when compared at equal protein and energy levels. Special supplements such as Purdue A, or combinations of soybean meal with a special mixture, sesame meal, or fermentation solubles, invariably increased the feed cost without adding any factors stimulatory to steer growth. Similar results were obtained with simple combinations of soybean meal, chopped alfalfa, and molasses. An antibiotic (aureomycin) increased gains slightly, but not significantly, in one trial.

It appears that a good quality roughage, such as corn or sorghum silage, fed with grain and a straight oilmeal protein supplement adequately meets the needs of the rumen population as measured by steer performance.

The addition of 10 milligrams of stilbestrol to the basal oilmeal supplement resulted in significantly greater

gains and improved feed efficiency in both high-silage and heavy grain fattening rations. In two comparisons, feeding stilbestrol throughout the fattening period resulted in greater weight gains than feeding it only during the last half of the fattening period, although the difference was not statistically significant.

In digestion and nitrogen balance trials with steers, the addition of live-cell yeast to low-quality roughage, high-quality roughage, and fattening type rations depressed the digestibility of ether extract in each ration. The digestibility of other nutrients was unaffected. Differences in nitrogen retention, which favored yeast in the roughage rations only, were not significant. The results have a possible bearing on the problem of low fat tolerance in ruminants.

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APPENDIX

APPENDIX TABLE I

AVERAGE RESULTS OBTAINED WITH VARIOUS SUPPLEMENTS TO SORGHUM SILAGE FOR FATTENING YEARLING STEERS IN TRIAL I (1953-54, 150 Days on Test)

Lot Number Supplement Fed	1 S.B. Meal	2 Purdue A	3 3-S.B. Meal 1-Alfalfa 1-Molasses
Number of steers/lot	12	12	12
Average weights (lb.)			
Initial	683	683	683
Final	957	955	980
Total gain	274	272	297
Ave. daily gain	1.83	1.81	1.99
Average daily ration (lb.)			
Ground milo	8.05	7.76	7.60
Soybean meal	2.00	--	--
Purdue Supple. A	--	2.81	--
S.B.M.-Alfalfa-Mol.	--	--	2.94
Sorghum silage	40.5	37.3	36.1
Minerals[1]	0.14	0.16	0.13
Feed required/cwt. gain (lb.)			
Ground milo	441	428	384
Soybean meal	109	--	--
Purdue Supple. A	--	155	--
S.B.M.-Alfalfa-Mol.	--	--	148
Sorghum silage	2217	2057	1823
Feed cost/cwt. gain ($)	24.39	25.82	21.74
Financial results ($)			
Selling price/cwt.	19.50	19.50	20.50
Total value/steer (mkt. wt.)	183.11	181.16	195.78
Initial cost/steer @ $16.50	112.70	112.70	112.70
Total feed cost/steer	66.92	70.24	64.56
Total steer and feed cost[2]	181.77	185.09	179.41
Net return per steer	1.34	-3.93	16.37

APPENDIX TABLE I--Continued

Lot Number Supplement Fed	1 S.B. Meal	2 Purdue A	3 3-S.B. Meal 1-Alfalfa 1-Molasses
Marketing data			
Shrink to mkt. (%)[3]	1.9	2.7	2.6
Dressing percentage	59.3	57.7	59.4
U. S. carcass grades			
Choice	--	--	2
Low choice	2	--	1
High good	3	1	4
Ave. good	5	9	4
Low good	1	1	1
High Commercial	--	1	--
Ave. Commercial	1	--	--

[1]Minerals fed free choice; contained two parts salt + one part steamed bone meal.

[2]Includes charge of $0.30 for spraying and $1.85 for marketing, excluding trucking.

[3]Cattle were shipped immediately after obtaining shrunk weight, hence the low shrinkage enroute to market.

APPENDIX TABLE II

AVERAGE RESULTS OBTAINED WITH VARIOUS SUPPLEMENTS TO CORN SILAGE FOR FATTENING YEARLING STEERS IN TRIAL II
(1954-55, 10 Steers per Lot, 169 Days on Test)

Lot Number	1	2	3	4	5	6
Supplement Fed	S.B. Meal	Purdue A	3-S.B. Meal 1-Alfalfa 1-Molasses	1-S.B. Meal 1-Alfalfa 1-Molasses	1.5-S.B. Meal 1 -Special Mix	2-S.B. Meal 1-Sesame Meal
Ave. weights (lb.)						
Initial 10/1/54	739	740	741	743	740	740
Final 3/18/55	1092	1059	1080	1080	1074	1076
Total gain	353	319	339	337	334	336
Ave. daily gain	2.09	1.89	2.01	1.99	1.98	1.99
Ave. daily ration (lb.)						
Milo	9.84	9.59	9.37	8.78	9.65	9.88
Supplements						
Soybean meal	2.00	--	1.75	1.35	1.55	1.33
Purdue Supple. A	--	2.73	--	--	--	--
Chopped alfalfa	--	--	.58	1.35	--	--
Molasses	--	--	.58	1.35	--	--
Special mix	--	--	--	--	1.00	--
Sesame meal	--	--	--	--	--	.69
Corn silage	47.6	47.5	48.3	48.1	49.0	47.9
Mineral mix	.04	.05	.03	.07	.08	.06
Feed required/cwt. gain (lb.)						
Milo	471	508	467	440	488	497
Supplement	96	145	145	203	129	102
Silage	2279	2517	2408	2412	2479	2409

APPENDIX TABLE II--Continued

Lot Number	1	2	3	4	5	6
Supplement Fed	S.B. Meal	Purdue A	3-S.B. Meal 1-Alfalfa 1-Molasses	1-S.B. Meal 1-Alfalfa 1-Molasses	1.5-S.B. Meal 1 -Special Mix	2-S.B. Meal 1-Sesame Meal
Feed cost/cwt. gain ($)	24.81	28.08	25.94	25.95	28.57	26.81
Marketing data						
Shrink to mkt. from full wt. (%)	6.3	5.4	6.6	7.4	7.0	4.8
Dressing percentage[1]	60.6	60.7	61.2	60.1	60.1	61.1
U. S. Carcass grades[2]						
Ave. choice	1	1	3	--	--	1
Low choice	3	4	3	3	2	3
High good	5	5	4	6	4	5
Ave. good	1	--	--	--	3	1
Financial results ($)						
Mkt. value/cwt.[3]	21.92	22.10	22.59	21.60	21.35	22.10
Mkt. value/steer	233.01	229.62	238.32	226.37	219.91	234.26
Initial cost/steer	136.72	136.90	137.09	137.46	136.90	139.90
Feed cost/steer	87.59	89.58	87.94	87.46	95.42	90.07
Total steer + feed cost[4]	226.55	228.72	227.27	227.16	234.56	229.21
Net return/steer	6.46	.90	11.05	- .79	-14.65	5.05

[1]Hot carcass weight shrunk 2.5%.

[2]Two carcasses shipped before grades could be obtained; one each in Lots 4 and 5.

[3]An on-foot market value was computed from the yield, carcass grade, and current value of the carcass. No drop credit or debit was used.

[4]Includes charge of $0.30 each for spraying and $1.94 for marketing, excluding trucking.

APPENDIX TABLE III

AVERAGE RESULTS OBTAINED WITH VARIOUS SUPPLEMENTS TO SORGHUM SILAGE FOR FATTENING TWO-YEAR-OLD STEERS IN TRIAL III
(1955-56, 10 Steers per Lot, 169 Days on Test)

Lot Number	1	2	3	4	5	6	7
Supplement Fed	S.B. Meal	1-S.B.M. 1-Alfalfa 1-Mol.	1.5-S.B.M. 1-Special Mix	1.75-S.B.M. .50-Ferm. Solubles	S.B.M. + 90 mg. Aureo-mycin	S.B.M. + Stil-bestrol	S.B.M. + Stilbestrol (last half)
Ave. weights (lb.)							
Initial 7/30/55	879	878	875	876	877	876	878
Final 3/13/56	1208	1204	1199	1201	1230	1287	1260
Ave. daily gain	2.01	1.99	1.98	1.98	2.15	2.50	2.33
Ave. daily ration (lb.)							
Milo	11.8	10.7	11.6	11.6	11.8	11.8	11.8
Supplement							
Soybean meal	2.00	1.35	1.55	1.75	1.95	2.00	2.00
Alfalfa	--	1.35	--	--	--	--	--
Molasses	--	1.35	--	--	--	--	--
Special Mix	--	--	1.00	--	--	--	--
Aurofac	--	--	--	--	0.05	--	--
Fermentation solubles	--	--	--	0.50	--	--	--
Stilbestrol(mg.)	--	--	--	--	--	10	10[1]
Silage	44.6	44.1	45.8	47.4	43.5	49.5	47.1
Minerals (2-1)	0.09	0.09	0.07	0.09	0.09	0.09	0.06
Feed required/cwt. gain (lb.)							
Milo	588	538	587	583	548	471	507
Supplement	100	204	129	114	93	80	86
Silage	2223	2219	2318	2392	2021	1975	2022

APPENDIX TABLE III--Continued

Lot Number	1	2	3	4	5	6	7
Supplement Fed	S.B. Meal	1-S.B.M. 1-Alfalfa 1-Mol.	1.5-S.B.M. 1-Special Mix	1.75-S.B.M. .50-Ferm. Solubles	S.B.M. + 90 mg. Aureo-mycin	S.B.M. + Stil-bestrol	S.B.M. + Stilbestrol (last half)
Feed cost/cwt. gain ($)	24.94	25.49	27.63	26.37	23.68	21.08	22.26
Marketing data							
Shrink to mkt. from full wt. (%)	5.52	6.06	4.75	5.86	5.00	5.45	5.64
Percent yield[2]	60.85	60.48	61.88	60.17	61.10	60.48	60.12
Carcass grades							
High choice	--	--	1	--	--	--	--
Ave. choice	--	--	3	--	2	3	1
Low choice	4	4	3	6	6	3	3
High good	5	5	1	3	2	3	4
Ave. good	1	1	2	1	--	1	2
Financial results ($)							
Mkt. value/cwt.[3]	16.72	16.63	17.35	16.63	17.11	16.84	16.52
Feed cost/steer	82.05	83.09	89.52	85.70	83.59	86.64	85.03
Total steer + feed cost	244.67	245.52	251.40	247.76	245.83	248.70	247.46
Net return/ steer	-42.69	-45.29	-43.37	-48.03	-35.38	-31.97	-39.31

[1]Fed only during the last 80 days on test, or during heavy grain feeding period.

[2]Hot carcass weight shrunk 2.5%.

[3]An on-foot value computed from yield, carcass grade, and current value of carcass, and based on morning shrunk weights at Ft. Reno. No drop credit or debit was used.

APPENDIX TABLE IV

CHEMICAL COMPOSITION OF FEEDS USED IN FATTENING TRIALS WITH STEERS, 1953-56

Feed	Per cent Dry Matter	Percentage Composition of Dry Matter: Ash	Crude Protein	Fat	Crude Fiber	N.F.E.	Ca	P
Trial I (1953-54)								
Soybean meal	92.01	6.23	46.10	0.98	6.59	32.11	0.31	0.61
Purdue Supple. A	91.76	13.05	32.40	2.48	7.45	36.38	2.05	1.05
Molasses	68.90	6.59	2.63	--	--	--	0.25	0.05
Alfalfa hay	91.10	10.39	18.69	2.82	18.67	40.53	1.85	0.21
Sorghum silage	22.48	2.46	1.67	0.74	6.47	11.14	0.08	0.03
Trial II (1954-55)								
Milo	88.89	1.87	11.79	4.33	2.46	68.44	0.06	0.26
Silage	34.91	3.94	1.58	0.79	10.88	17.72	0.22	0.09
Soybean meal	89.37	6.45	47.93	2.19	5.54	27.17	--	--
Purdue Supple. A	89.55	11.29	35.02	1.42	7.80	34.02	1.55	0.68
Alfalfa hay	92.23	9.90	18.02	1.91	23.76	38.64	1.44	0.24
Molasses	67.73	8.72	3.61	--	--	--	--	--
Special Supple.	92.89	10.14	20.34	3.71	12.89	45.81	--	--
Sesame meal	92.05	12.49	45.40	5.17	6.37	22.62	2.41	0.99
Trial III (1955-56)								
Sorghum silage	35.50	1.73	1.72	0.79	6.96	14.30	--	--
Milo	88.61	1.16	10.38	3.12	1.49	72.46	0.06	0.12
Special mix	92.41	8.47	36.76	1.81	7.90	37.52	0.62	0.56
S.B. M. + Fermentation solubles	91.86	8.50	41.92	2.35	5.99	33.10	0.87	0.77
S.B.M. + Aurofac	90.77	7.30	44.59	2.52	4.21	32.15	0.34	0.74
Soybean meal	90.53	6.49	44.00	0.44	5.47	34.14	0.39	0.81

APPENDIX TABLE V

FEED PRICES PER TON USED IN FATTENING TRIALS WITH STEERS, 1953-56

Feed	Trial I (1953-54)	Trial II (1954-55)	Trial III (1955-56)
Milo	$51.40	$49.60	$41.00
Soybean meal	74.50	83.00	80.00
Purdue Supplement A	83.00	74.20	--
Molasses	48.00	44.00	40.00
Fermentation Solubles	--	--	100.00
Fish solubles	--	150.00	260.00
Omalass	--	132.00	97.50
Sesame meal	--	115.00	--
Aurofac	--	--	640.00
Soybean meal + stilbestrol	--	--	88.00
Salt	15.00	15.00	15.00
Special mix	--	126.80	98.80
Steamed bone meal	86.00	100.00	92.00
Alfalfa hay	30.00	30.00	25.00
Sorghum silage	8.00	--	8.00
Corn silage	--	8.00	--

APPENDIX TABLE VI

ANALYSIS OF VARIANCE AND ORTHOGONAL COMPARISON OF WEIGHT GAINS OF STEERS FED HIGH-SILAGE RATIONS, TRIAL III (1955-56)

Analysis of Variance		
Source	d.f.	m.s.
Total	69	
Treatment	6	11583*
Lots 6, 7, vs. 1, 2, 3, 4, 5	1	59600**
Lots 6 vs. 7	1	3871
Error	63	2827

* significant at the 5 per cent level

** significant at the 1 per cent level

APPENDIX TABLE VII

AVERAGE RESULTS FROM FEEDING A UREA-MOLASSES SUPPLEMENT AND THE EFFECT OF STILBESTROL ADDED TO THE DAILY RATION OF FATTENING STEER CALVES, 1955-56

Lot Number	3	7	8	9
Supplement Fed	Control	Urea-Molasses Mixture	10 mg. Stil-bestrol	10 mg. Stil-bestrol (last 82 days)
Number of calves/lot	10	10	9	9
Ave. weights (lb.)				
Initial 10/26/55	521	519	527	520
Final 4/9/56	862	874	933	892
Total gain	341	355	406	372
Ave. daily gain	2.05	2.14	2.45	2.24
Ave. daily ration (lb.)				
Rolled milo	12.3	12.6	12.8	11.7
Cottonseed meal	1.2	0.68	1.2	1.2
Urea-molasses	--	1.5	--	--
Alfalfa hay	0.95	0.95	0.95	0.95
Sorghum silage	11.5	11.6	11.7	9.9
Mineral mix (2-1)	0.07	0.07	0.07	0.06
Feed required/cwt. gain (lb.)				
Rolled milo	600	589	524	523
Cottonseed meal	58	7	49	52
Urea-molasses	--	76	--	--
Alfalfa hay	46	44	39	41
Sorghum silage	558	543	476	443
Marketing data				
Shrink to mkt. from shrunk wt. (%)	3.5	3.1	2.9	2.6
Per cent yield[1]	62.65	62.20	61.85	61.25
U. S. Carcass grades				
Ave. choice	6	6	4	4
Low choice	2	3	4	2
High good	1	1	1	3
Ave. good	1	--	--	--

APPENDIX TABLE VII--Continued

Lot Number Supplement Fed	3 Control	7 Urea-Molasses Mixture	8 10 mg. Stilbestrol	9 10 mg. Stilbestrol (last 82 days)
Financial Results ($)				
Feed cost/cwt. gain	16.94	16.84	14.86	14.80
Total steer + feed cost[2]	179.39	173.94	176.29	169.46
Selling price/cwt.	19.30	19.30	19.64	19.11
Total value/steer	166.37	168.68	183.24	170.46
Net return/steer	-13.02	-5.26	-6.95	1.00

[1]Hot carcass weights shrunk 2.5 per cent.

[2]Based on $22.00/cwt. as feeders. Does not include costs of transportation, marketing, labor, equipment, or parasite control.

APPENDIX TABLE VIII

CHEMICAL COMPOSITION OF FEEDS USED IN FATTENING TRIAL WITH STEER CALVES (1955-56)

Feed	Per cent Dry Matter	Percentage Composition of Dry Matter			
		Ash	Crude Protein	Fat	Crude Fiber	N.F.E.
Milo	88.76	1.67	11.56	2.91	1.95	70.58
Cottonseed meal	92.47	7.57	38.01	5.98	14.25	26.66
Alfalfa hay	94.29	10.20	15.31	2.22	28.66	37.90
Sorghum silage	28.25	1.83	1.98	0.93	6.18	17.33
Urea-molasses	59.67	6.25	31.17	--	--	22.25

APPENDIX TABLE IX

FEED PRICES PER TON USED IN FATTENING TRIAL WITH STEER CALVES (1955-56)

	Per Ton
Milo	$ 41.00
Cottonseed meal	63.00
Cottonseed meal + stilbestrol	71.00
Urea	110.00
Molasses	40.00
Salt	15.00
Steamed bone meal	92.00
Alfalfa hay	25.00
Sorghum silage	8.00

APPENDIX TABLE X

ANALYSIS OF VARIANCE AND ORTHOGONAL COMPARISON OF WEIGHT GAINS OF STEER CALVES (1955-56)

Analysis of Variance		
Source	d.f.	m.s.
Total	37	
Treatment	3	7479*
Lots 8, 9 vs. 3, 7	1	16689*
Lot 8 vs. 9	1	4835
Error	34	2468

*significant at the 5 per cent level

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