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Studies of Factors Affecting Performance of Growing-Finishing Lambs

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SUMMARY

Seven factorially designed experiments using 670 lambs were conducted over a three-year period in studies of factors affecting feedlot performance of lambs.

Effect of varying proportions of concentrates and roughages in rations was studied in four trials conducted during different seasons. In trials I and III, conducted in summer, and VI in the spring, gains of lambs fed 60 percent concentrates were significantly ($P<.01$) higher than those of similar lambs fed 40 percent concentrates. Cascass yields were also significantly higher ($P<.05$). Feed efficiency and grades were somewhat higher. In similar tests conducted in winter and early spring (experiments IV and VI) gains, yields, grades and feed efficiency did not differ significantly. In two metabolism studies conducted at environmental temperatures of 40 degrees and 80 degrees F. apparent digestibility of crude protein, dry matter, ether extract and nitrogen free extract was significantly higher ($P<.01$) for lambs fed rations containing 60 percent than for those fed 40 percent concentrates. Differences were greater at 80 degrees F. than at a temperature of 40 degrees F. The test was somewhat complicated by a small difference in protein content of the rations compared.

Effect of dietary crude protein level was studied in six experiments in which temperature, physical makeup of ration, concentrate level, and hormone additions were also studied in a factorial design. In all of the six trials lambs made greater gains on levels of crude protein higher than recommended by the National Research Council (1957). In one test there was an apparent response to higher crude protein levels up to 17 percent of the ration.

Implanting lambs with hexestrol and stilbestrol resulted in 21.9 percent faster gains ($P<.01$) and greater feed efficiency with no apparent lowering of grades and yields compared with controls. Implants of 3 mg. stilbestrol or 6 mg. hexestrol for wethers and 9 mg. for ewes were apparently satisfactory for fattening lambs. Hormones appeared to negate response of lambs to higher protein levels. Greatest response to hormones was on high energy rations.

Effect of varying both concentrates and protein in rations was demonstrated in four trials. Fastest gains were made by lambs on rations composed of 60 percent concentrates and 14 percent crude protein, but only in one trial (trial 1) were differences in gains near statistical significance ($P<.06$).

Pelleting lamb fattening rations resulted in greater feed consumption, significantly faster gains ($P<.01$), higher carcass yields, and significantly higher carcass grades ($P<.05$) compared with lambs fed unpelleted rations.

Neither proteolytic enzymes fed at levels of 100 mg. per pound of feed nor 1-methyl 2 mercaptoimidazole (tapazol) additions of 100 to 200 mg. per lamb daily resulted in improved performance of lambs in the feedlot, but shearing lambs fed in warm temperatures resulted in significantly faster ($P<.01$) gains compared with lambs in the fleece.

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Studies of Factors Affecting Performance of Growing-Finishing Lambs

John C. Rea, C. V. Ross, W. H. Pfander

INTRODUCTION

This bulletin contains the results of a series of experiments conducted with growing-finishing lambs. These trials were designed to determine the effects of various factors on the requirements of lambs. Average daily gains, feed efficiency, and carcass yields and grades were used as criteria. The factors studied included the following:

1. The effect of estrogenic hormones on performance of lambs and their influence on protein requirement.
2. The influence of environmental temperature on optimum concentrate to roughage ratios.
3. The interaction between protein and energy levels for lambs.
4. The effect of the physical form of the ration on gains, feed efficiency, and yield of fattening lambs.
5. The value of adding enzymes and goitrogens to lamb rations.

REVIEW OF LITERATURE

Effect of Estrogenic Hormones on Lambs

The use of synthetic hormones to increase production has become an accepted practice for many livestock producers. These products which are similar to the natural estrogens secreted by various tissues in the body have made possible large increases in daily gains of fattening ruminants. Time on feed has been reduced and market animals have been fattened more efficiently and economically than ever before.

After the discovery of synthetic estrogenic hormones many experiments were conducted to determine their value in stimulating rate and economy of gains in ruminants. Several theories have been advanced to explain how these materials are utilized in the body, stimulating increased growth. Synthetic estrogenic hormones differ chemically from the natural estrogens secreted by the body, but apparently they have much the same biological action in the animal's system.

Following is a review of some of the experiments conducted with stilbestrol and hexestrol with growing and fattening lambs.

Stilbestrol Fed in the Ration for Fattening Lambs

In 1938 Dodds *et al.* synthesized a substance very similar to the ovarian steriod hormones. The first compound to be synthesized was dihydroxystilbene. Many derivatives of the compound have since been discovered, one of the main ones being diethylstilbestrol which has the common name of stilbestrol.

It was, however, not until the early 1950s that synthetic estrogens were used in lamb fattening experiments to a large extent. Then several workers conducted experiments in which stilbestrol was added to lamb fattening rations.

Gains and feed conversion improved with no lowering of grade or other side effects when stilbestrol was added to feed lot rations fed to lambs by Hale *et al.* (1953), Hale *et al.* (1955), and Light *et al.* (1956) at levels from 1.5 microgr. to 2 mg. per pound of feed daily.

Similar increases in gains and feed efficiency have been obtained by Henneman *et al.* (1957), Andrews *et al.* (1958), Hartman *et al.* (1958), Acker *et al.* (1955), Davey and Wellington (1959), and other workers with levels ranging from 0.5 to 5.0 mg. per day of stilbestrol; but in many trials undesirable side effects were noted including lower carcass grades and yields, poor pelting, and failure of lambs to break lamb joints on slaughter. Only minor differences were reported in results due to level of stilbestrol fed.

Stilbestrol Implants for Fattening Lambs

In general, response to implants of stilbestrol for fattening lambs have agreed with results from tests where lambs were fed the hormone. However, implants of 12 mg. or above, appear to result in more side effects than lower levels.

Andrews *et al.* (1949) were among the first to study the effect of stilbestrol implants on fattening lambs. In a test with 100 wether feeder lambs in three lots implanted with 0, 12, and 24 mg. stilbestrol pellets, the treated lambs gained faster and required less feed for 100 pounds of gain than control lambs. There were no significant differences in carcass grades; however, the treated lambs had a slightly lower dressing percentage.

In another test Andrews *et al.* (1949) found significant increases in gain in lambs with either 12 or 24 mg. stilbestrol implants, but the feed efficiency of the treated lambs was lower than that of controls.

Increased gains but lower grade and yields of fattening lambs was reported following 12 mg. stilbestrol implants by O'Mary *et al.* (1951) and Jordan and Bell (1952).

Klosterman *et al.* (1951), however, concluded from tests with two lots of fattening lambs that animals receiving 12 mg. of stilbestrol made faster daily gains than controls with little difference in grade or yield.

Jordan (1950) also found increased gains using a 12 mg. implant with no significant difference in carcass grades, but feed per 100 pounds of gain was reduced by 16 percent for treated lambs.

Results from a test conducted by Lamming and Broome (1957) indicated that lambs implanted with either 12 mg. of stilbestrol or hexestrol made significantly faster gains than control lambs with no difference in yield.

Bell *et al.* (1954) implanted half of a lot of 517 lambs with 15 mg. of stilbestrol at the start of a 112-day feeding period. Fifty percent of the treated lambs were given an additional 15 mg. implant at the end of 70 days on feed. They reported that the lambs with either one or two 15 mg. implants gained significantly faster than controls, but their carcass grades and yields were slightly lower. Much more serious side effects were observed in lambs that received the second 15 mg. stilbestrol implant. Twelve lambs were lost from prolapse of the rectum and showed symptoms similar to those observed in lambs afflicted with urinary calculi. Nearly all the implanted lambs had preputial swelling and some appeared to be in pain during urination. Bell proposed that rectal prolapse may be caused by excessive straining while urinating.

In another trial using 15 mg. implants of stilbestrol, Wilkenson and coworkers (1955) stated that treated lambs made faster gains than controls; but the controls were superior in yield, finish, grade, and amount of external fat.

Because many trials with high levels of stilbestrol resulted in undesirable side effects, pellets containing smaller dosages of stilbestrol were produced and tested by research workers.

In trials conducted with fattening lambs implanted with 6 mg. of stilbestrol, Jordan (1953), Erwin *et al.* (1957), and Hale *et al.* (1957) all reported significant increases in gains with no decrease in carcass yields or grades.

But some workers still have noted a slight lowering of carcass grade with fairly low levels of stilbestrol. Andrews *et al.* (1958), Jordan (1957), and Baird *et al.* (1957) using implants from 2 to 6 mg. of stilbestrol reported that lambs gained faster, but that fat covering was reduced and carcass grades somewhat lowered. Many workers have agreed, however, that implants of less than 12 mg. have stimulated gains and feed efficiency with less frequent occurrence of undesired effects.

Hexestrol for Fattening Lambs

Other estrogenic compounds have been used in lamb fattening experiments. Dihydroxystilbestrol, commonly called hexestrol, is closely related to stilbestrol. Some of the first work with it was conducted in England by Gill *et al.* (1956). They used a total of 524 lambs, half of which were implanted with fifteen mg. of hexestrol in seven separate trials. In five trials, all lambs gained poorly, and the hexestrol treatment gave no response; but in two of the trials gains were good, and the hexestrol implants stimulated a significant improvement in the rate of gain. Some udder development was observed in implanted ewe lambs.

Gee and Preston (1957) also implanted lambs with fifteen mg. of hexestrol, and after fifty days on feed repeated the treatment. Implanted lambs made 23 percent greater daily gains, and carcass yields were not affected. Carcasses from treated lambs contained more bone, flesh, and less subcutaneous fat, and a larger percent protein and moisture than control lambs. Hexestrol implantation significantly improved protein-conversion efficiency but had no effect on energy conversion.

Twelve mg. hexestrol implants in fattening lambs have successfully increased gains over control lambs, according to reports by Burgess and Lamming (1957) and Thompson and Pfander (1957).

Burgess and Lamming (1957) also stated that lambs fed hexestrol at the rate of 1.25 and 2.5 mg. per day in the ration were superior to control lambs.

Gerber and Ross (1958) used four levels of hexestrol implantation, 0, 6, 9, and 12 mg., on 28 wethers and 24 ewe lambs. They concluded that all lambs treated with hexestrol made faster gains than controls. They also made more efficient gains than controls except for the ewe lambs implanted with 12 mg. of hexestrol. Live and carcass grades were highest for control lambs and lambs on the lower levels of hexestrol. No serious side effects were noted although a few wethers on the two highest levels of hexestrol had difficulty urinating.

The foregoing citations emphasize the value of estrogenic hormones in the feeding of sheep, even though there is considerable variation in results. The differences can be attributed to a large extent to lack of information regarding optimum levels and methods of administration. There is some information presented regarding the effect of these substances on protein requirements; however, this evidence is not conclusive.

Effect of Concentrate : Roughage Ratio

Considerable disagreement remains among lamb feeders and research workers regarding optimum concentrate-to-roughage ratios for fattening lambs. A review of the literature indicates that management, type of supplement, type of concentrate and roughage, and physical form of feed may be primarily responsible for the difference of opinion.

Blakeslee and Brown (1937), (1940), (1947) have fattened lambs on varied proportions of corn and alfalfa hay. Their results in general favor a ratio of approximately 50:50 corn to alfalfa hay. Lambs on this proportion gained faster, yielded higher, and produced a fatter carcass than lambs on rations containing less corn.

An extensive series of tests was conducted to determine the optimum amount of grain to incorporate in lamb fattening rations by Cox (1948). In 7 trials lambs were fed the following 3 concentrate:roughage ratios: 35:65, 45:55, and 55:45. Two additional trials were conducted using paper pulp and wood pulp as the only roughage. Results were measured by gains, feed efficiency, and carcass data. Lambs on the 45:55 concentrate to roughage ratio gained fastest in 7 out of 9 trials and were most efficient in all trials from the standpoint of gains per 100 pounds of T.D.N. consumed. Lambs on the lowest level of concentrates made consistently lower gains and were less efficient in feed utilization. Daily feed intake was in general highest for lambs on bulky rations, but T.D.N. intake was highest for lambs on the most concentrated ration. Where carcass data were obtained, grade and yield tended to be higher for lambs on the highest level of concentrate.

Davison *et al.* (1950) attempted to establish ratios of concentrate to hay that could be recommended to the lamb feeder. Forty ewe lambs were individually fed in 5 groups twice daily all they would eat. Rations containing 5 concentrate to alfalfa hay ratios were used. These were: 2:3, 1:1, 3:2, 2:1, and 5:1. They reported that the average daily gains of lambs increased in every test as the concentrates in the ration increased. Feed efficiency and feed intake increased with higher concentrate levels.

There was no significant difference in gains in a trial conducted by Hartman *et al.* (1959) in which 698 lambs were self-fed on 71:29 and 41:59 concentrate to roughage ratios. However, lambs on the high concentrate rations required 12 percent less feed per pound of gain, shrank 0.86 percent less, and yielded 1.15 percent more.

Ross and Pavey (1959) reported that lambs fed a pelleted ration containing a 40:60 ratio of concentrate to roughage gained significantly faster ($P<.01$) than lambs fed either a pelleted or meal ration containing a 60:40 ratio of concentrate to roughage.

On the basis of a trial initiated by Phillips *et al.* (1951) it would appear that high energy rations are more efficiently utilized by sheep. They studied the efficiency of feed utilization of four yearling wethers. Corn supplied 25, 50, and 75 percent of the mixture fed. They observed that as the percent of corn in the ration was increased, the apparent digestibility of the complete ration increased for all the nutrients except crude protein in one instance and crude fiber in another.

Brown *et al.* (1958) fed sheep diets containing hay and concentrates in ratios of 4:1, 3:2, 1:3, and 1:4. They reported that the rumen concentration of total volatile fatty acids increased as the percent of concentrate in the diet increased. The molar percent of acetate decreased from 60 to 40, and the percent of propionate increased from 20 to 40 when the percent of concentrate in the diet was increased from 20 to 80.

Effect of Physical Form of Feed on Lamb Performance

Pelleting feeds is another fairly recent practice that may affect the requirements of farm animals. Research has demonstrated certain advantages in favor of pelleted feeds, and it appears that if the cost of pelleting is kept relatively low this operation will become a common practice.

Esplin (1957) stated that pelleting probably does not greatly change the nutritive value of feeds for lambs, but it does improve palatability and results in greater feed consumption.

Esplin (1955) reported that lambs fed a pelleted ration made faster gains with higher yields than lambs on similar rations in a meal form.

Neale (1953) found that lambs fed a cubed ration of coarse, low-grade alfalfa hay performed as well or better than similar lambs fed good alfalfa hay by hand.

Bell *et al.* (1955) conducted feed lot and digestion trials to determine differences in lamb performance and feed utilization when pelleted and non-pelleted rations varying in concentrates to roughage were fed. Lambs on pelleted rations generally produced larger and more efficient gains. Pelleted rations of 65:35 hay to grain gave better results than a pelleted 55:45 hay-grain ration. The coefficient of digestibility (COD) was higher for protein and fat and lower for crude fiber in the pelleted than in the unpelleted form. There was no significant difference in COD for dry matter, ether extract, crude fiber, and nitrogen-free extract. In palatability studies on this ration in a pelleted and meal form, self-fed lambs consumed 4 pounds of the pellets to 1 pound of meal.

Thomas and co-workers (1954) compared lambs fed rations of whole grain-long hay, pelleted grain-long hay, and grain and hay pellets. Lambs fed the complete pelleted ration went on feed quicker, made faster gains, and sold for higher prices than those on the other two forms.

Hartman *et al.* (1959) self-fed 698 "old crop" feeder lambs in a factorially designed test in which complete rations were compared in pelleted and meal form. Pelleting increased gains of lambs on high roughage, but decreased gains on low roughage when compared to meal rations. This was similar to work reported by Botkin *et al.* (1955). They found that lambs fed a pelleted 60 percent roughage ration gained faster and as efficiently as lambs on a pelleted 50 percent roughage ration. On unpelleted rations, however, lambs on the lower roughage ration made faster gains, Gains, yields, and carcass grades were superior for lambs on the pelleted rations.

Similar results favoring pelleted rations have been discussed by Weir *et al.* (1957), Noble and others (1953), Bowstead (1958), and Thompson (1958). Thompson (1958) also reported an increase in total volatile fatty acid production during rumen fermentation due to pelleting.

Many advantages have been attributed to pelleted feeds for livestock, some of which have not been based on adequate research data. From this review it appears that the following may be said regarding the value of pelleting feeds for fattening lambs:

1. Lambs gain faster when fed pelleted rations.
2. The stimulus in gains appears to be most pronounced when high roughage pelleted and meal rations are compared.
3. Palatability is improved.
4. Pelleting allows the proportion of individual feed ingredients to be more closely controlled.
5. Feed efficiency and carcass yields are generally higher for lambs on pelleted rations.

Protein Levels and Protein and Energy Relationships in Rations for Fattening Lambs

Henry (1898) in reviewing the development of nutrient requirements for farm animals stated that Grouven (1859) proposed the first feeding standards based on chemical analysis of feedstuffs. This standard was later found to be inadequate in meeting the requirements of farm animals. In 1864 Wolff published for the first time in Mentzel and V. Lengerke's agriculture calender feeding standards based upon the digestible nutrients of feedstuffs. In these standards the attempt was made to meet the physiological requirements of the animal by supplying sufficient protein, carbohydrate and ether extract for all the needs of the body without waste of any of the nutrients. Wolff's feeding standards were modified in 1897 by Lehmann of the Berlin Agriculture College and became known as the Wolff-Lehmann standards.

Henry (1898) established a table of feeding standards based on the work of Wolff and Lehmann. These were among the first to be published by a United States agriculture worker.

Kellner (1913) based his feeding recommendations on maintenance requirements which were estimated through the use of a respiration apparatus. He expressed his feeding recommendation in starch equivalents. A starch equivalent is "the amount of a nutrient required to give the same caloric value as a kilogram of starch."

The changes that have occurred in feeding recommendations in the past reflect the increase in the knowledge of nutrition. Even though current recommendations are widely accepted, we must bear in mind that a re-evaluation of these requirements must be made from time to time in view of changing conditions of management, available feeds, and consumer preference for the end product.

The recognition of the existence of interrelations between nutrients in recent years has opened up new areas of research and may change present-day recommendations. Interrelation between protein and energy in rations has been studied extensively with poultry. Here it has been shown that as the caloric content of the diet is increased the percent protein required is increased. This relationship has received less attention in the fattening of ruminants.

Bull and Emmett (1914) reviewed lamb fattening trials by American workers to determine the minimum amounts of protein and energy conducive to fattening gains of lambs of 0.3 pound of more per day. This review covered 265 lots and 5,127 lambs. Digestible protein and net energy values were calculated. Results were compiled and tabulated into four classes according to the average live weight of the lamb during the test. Their values for digestible protein and net energy, recommended as optimum, expressed as daily requirement per 1000 pounds of live weight, are shown in Table 1 with more recent recommendations by Morrison (1957) and the National Research Council (1957).

TABLE 1 - PROTEIN AND ENERGY REQUIREMENTS FOR FATTENING LAMBS

Body Weight lbs.	Protein			Energy		
	Bull-Emmet lbs. D.P./day 1,000 lb. wt.	Morrison lbs. D.P./day	NRC lbs. D.P./day	Bull-Emmet Therms N.E./day 1,000 lb. wt.	Morrison Therms N.E./day	NRC Therms D.E./day
60	3.20	.195	.17	18.0	1.45	3.2
70	2.80	.215	.18	18.5	1.65	3.8
80	2.65	.225	.19	19.0	1.80	4.2
90	2.50	.235	.20	18.5	1.90	4.8
100	2.30	.245	.20	18.5	2.00	5.2

The national Research Council has made 3 reports on nutrient recommendations for sheep (Pearson *et al.* 1945, 1949; Pope *et al.* (1957). The recommended protein allowances for the different classes of sheep in the 1945 and 1949 reports were based on a modification of the requirements of the steer. The protein needs of the different classes of sheep in the 1957 report were based on a modification of the protein requirement of the pregnant and lactating ewe.

A review of the more recent literature indicates that in many cases investigators are obtaining a response from fattening lambs when protein levels are higher than those currently recommended.

Griffith *et al.* (1959) fed 54 lambs from 70 to 100 pounds weight. Crude protein levels used were 10.9, 12.7, 14.7, and 16 percent. Soybean oil meal was used to regulate the level of protein. In this trial animals on a 10.9 percent protein ration were the most inefficient as measured by rate of gain and feed requirements. Lambs on the three higher protein levels made significantly greater gains and were more efficient in their feed utilization. Thre was no significant difference between lambs fed the three higher protein levels.

Similar results were recorded by Keith *et al.* (1957). They full fed growing ewe lambs a ration of equal parts concentrate and roughage in which four protein levels were used. These levels were controlled by the quantity of soybean oil meal. Levels were 7.1, 8.2, 10.8, and 12.7 percent crude protein. They observed that gains of lambs increased as the protein level of the ration increased. Feed consumption was higher and feed efficiency was superior for lambs fed the high protein levels.

Bush *et al.* (1955) also found that lambs on the highest protein level used gained best. In three feed lot trials with 99 lambs each in which protein levels were regulated by varied amounts of linseed meal, lambs fed 11.8 percent protein gained significantly faster ($P < .05$) than lambs fed either 10 or 11 percent protein rations.

Whiting *et al.* (1959) reported that weight gains of lambs increased with increasing levels of protein from 6.2 to 11.9 percent. Also on the higher protein levels apparent protein digestion was increased.

Preston and Burroughs (1958) concluded that lambs fed 13 and 17 percent crude protein fattening rations gained faster than those on a 9 percent ration. There was no advantage, however, for lambs fed the 17 percent protein versus 13 percent protein rations. Protein additions did not consistently improve feed utilization.

There have been several trials conducted showing an interrelation between the protein and energy level of lamb rations and its effect on digestibility of feed components. Head (1953) reviewed the work conducted with ruminants on the effect of quality and quantity of carbohydrate and protein on the digestibility of cellulose and other constituents of the ration. He stated that it appears that an important factor controlling the growth of the cellular organisms is the nitrogen content of the roughage on which they live at any given level of starch equivalent. His article states that many early workers recognizeed that the addition of maize starch to the ration of the ruminant depressed the digestibility of crude fiber; Zuntz (1891), Kuhn (1894), Keller (1907), Markoff (1911), Ewing and Wells (1915), and Armsby and Fries (1918). The digestion of ether extract is also reduced when maize starch is added; Ewing and Wells (1919)and Briggs *et al.* (1940).

Watson *et al.* (1947) found no effect on the digestibility of crude fiber if the level of roughage was reduced at the time of addition of cereal grain.

A decrease in the digestibility of the crude fiber of the ration has been illustrated by several workers when sugar or molasses was added; Lindsey and Smith (1910), Briggs *et al.* (1940), Hamilton (1942), and Swift *et al.* (1947).

Burroughs *et al.* (1950), however, found that the simultaneous addition of protein and maize did not depress the digestibility of cellulose as much as maize starch alone. Burroughs (1950) in *in vitro* studies also stated that the digestion of cellulose (filter paper) is stimulated by the presence of protein-rich meals.

More recently some workers have shown an interaction between protein and energy levels in feed lot trials with fattening lambs. Preston and Burroughs (1958) concluded that there was a significant ($P < .01$) interaction between protein and energy levels. They individually fed 144 lambs in a factorially designed experiment in order to evaluate lambs' response to rations varying in stilbestrol, protein, and energy. They found that lambs fed 13 or 17 percent protein made faster gains than those fed 9 percent protein. Gains of lambs on the high energy ration (665 calories ENE per pound of feed) were significantly higher than those of lambs on low energy (530 calories ENE per pound of feed) ($P < .01$). High energy-high protein rations produced the fastest gains of any combination. Increasing the level of protein stimulated gains on the high energy ration but not on the low energy ration. Feed intake decreased silghtly as the energy level increased and increased as the protein level was raised. Feed required per pound of gain decreased on the high energy level, and lambs graded one-third of a grade higher than those on low energy.

Whiting *et al.* (1959) obtained similar results from studying the influence of the amount of protein and energy in the ration of replacement ewe lambs on gains and wool production. Three trials were conducted each using three levels of protein at two levels of digestible energy. The higher protein levels were obtained by substituting linseed oil meal for an equal weight of a barley and corn mix. They reported there was less response to increases in protein on low energy levels than on higher levels. Increased energy in these rations caused an increase in the digestibility of dry matter and gross energy and a decrease in apparent digestion and retention of protein. Highest gains in all trials were on the high protein-high energy rations

Goitrogens and Enzymes for Fattening Lambs

Effect of Goitrogenic Substances on Fattening Lambs

The role of the thyroid gland in the growth and fattening of domestic animals has been the subject of much research. Characteristic symptoms of animals with low thyroxine production (hypothyroidism) are: low basal metabolic rate, low body temperature, slow heart rate and sluggishness. Animals that produce excess thyroxine, on the other hand (hyperthyroidism), tend to have a higher than normal basal metabolic rate with high feed intake, but they usually fail to fatten as well as normal animals and are inclined to nervousness.

Many workers have studied methods of regulating the amount of thyroxine secreted in an attempt to find practical ways of stimulating increased growth in some cases and increased fattening in others.

While only limited work has been conducted with ruminants, the development of isotope techniques to determine the biological activity of goitrogens in intact animals may increase interest in this area.

Andrews *et al.* (1947) used thiouracil and thiourea in a test with eight lots of 20 lambs each. They reported feed intake was reduced in all groups fed either substance, and feed required per pound of gain was not affected. The largest numbers of top grade carcasses were in groups receiving 0.175 and 0.333 grams of thiouracil daily. This approached statistical significance.

There was no significant effect on gains, feed efficiency, or carcass yields or grades, however, in a trial by Barrick (1949) with lambs. Levels used in the trial were: 0.21 and 0.39 gm. per day of thiouracil; 0.03 gm. daily of propylthiouracil; and 0.52 and 1.04 gm. per head daily of thyroprotein.

Similar results were obtained by Comfort *et al.* (1958) feeding a more potent goitrogenic substance, 1-methyl 2 mercaptoimidazole, commonly called tapazole. Treated steers had a lower feed intake and no improvement in gains or carcass grades.

Burroughs and others (1958), however, reported that cattle receiving 300 or 600 mg. of this substance daily had a 9 percent stimulation in gains and a saving per unit of gain of 8 percent.

Blair *et al.* (1958) in trials with 118 lambs, 80 lambs, and 72 steers reported that tapazole treatment did not improve carcasses of lambs, but markedly improved carcass grades of steers.

Enzyme Supplementation for Fattening Lambs

Publications concerning the effect of adding enzymes to the rations of fattening lambs were very limited at the time this study was initiated, although some preliminary testing of the materials had been carried out with cattle

Since that time a few reports have appeared describing their effect.

The value of adding a dried enzyme mixture of bacterial origin (Agrozyme) to beef cattle rations was investigated in 10 feeding experiments with 325 cattle by Burroughs *et al.* (1960). This mixture contained both amylolytic and proteolytic enzymes as well as others. The enzyme was fed at the rate of either 0.0075 or 0.015 pounds per animal daily incorporated in the protein supplement allowance. Live weight gains were increased an average of 7 percent in the 10 experiments by feeding the enzyme mixture. Little or no difference was noted in feed consumption, but feed conversion was improved in the enzyme-fed cattle by an average of 6 percent. No consistent improvement in carcass grades or yields was reported due to treatment.

Theurer and others (1960) found no improvement in feed consumption, rate of gain, feed conversion, carcass grade or yield in four feeding trials with lambs fed Agrozyme. Agrozyme was fed at the rate of 1.5, 3.0, and 6.0 gm. per lamb daily in the trials.

Ward *et al.* (1960) reported on three lots of 10 heifers each, fed fattening rations with 0, 0.567, and 1.362 gram of amolytic enzyme added per head daily. Difference in gains or feed conversion efficiency over a 215-day feeding period were not significant. Kercher (1960), in a feeding trial comparing control steers with steers receiving 4 gm. of Zymo-pabst enzyme preparation per day, also found no significant differences in gains, shrink, or live grade of treated steers over controls.

The foregoing review presents an example of the type of research upon which our present recommendations are based. It is obvious that any conclusions drawn or requirement figures quoted using these types of data will not apply equally well under all conditions and in many cases the figures simply represent an average, disregarding differences in experimental conditions.

Some generalizations can be made with some confidence, however, on certain factors quoted in the review. They include the following:

1. Both stilbestrol and hexestrol, fed orally or implanted, stimulate appetite, gains, and feed efficiency of fattening lambs.
2. Incidence of undesirable side effects from these substances appear to be less when relatively low levels are used.
3. Lambs fed pelleted rations gain faster, require less feed per pound of gain, and give higher carcass yields than those fed meal.
4. Pelleting is most beneficial if high roughage rations are to be fed.

5. Protein levels higher than current N.R.C. recommendations tend to result in increased gains.

It is apparent in other areas, too, that more research is needed before definite statements can be made. These include:

1. The effect of estrogens on the protein requirement of fattening lambs.
2. Optimum concentrate to roughage ratios for fattening lambs.
3. The influence of environmental temperature on the concentrate: roughage requirement of lambs.
4. The effect of pelleting on the requirement for roughage.
5. The effect of level of energy on protein requirements.
6. The value of supplementing goitrogenic substances or enzymes in lamb fattening rations.

GENERAL EXPERIMENTAL PROCEDURE

General Plan

Five feed lot trials, one digestion trial, and one trial comparing lambs fed at two temperatures were conducted over a two-year period. These experiments were all primarily concerned with the effect on fattening lambs of varied protein and concentrate levels and interaction between these treatments. In addition, however, most of the trials were factorially designed to permit testing of other variables. These included hormones (hexestrol[1] and stilbestrol[2]), enzymes[3], and 1-methyl 2-mercaptoimidazole.[4]

Experimental Animals

All lambs used in the study were examined and only uniform, thrifty lambs, apparently free of disease, were placed on test.

Over-all, the average initial weight of lambs at the start of tests was approximately 70 pounds.

Lambs used in Trials I, VI, and VII were white-face lambs originating in Texas. Those in Trial I were genuine spring lambs born in 1959. In Trials VI and VII the lambs were born in 1960 and marketed in 1961.

In Trial II, 54 late spring native born lambs out of Northwest ewes and Southdown rams were used. One hundred and ninety-two Arizona feeder lambs

[1]Dihydroxystilbestrol, donated by Merck, Sharp, and Dohme.

[2]Diethylstilbestrol, donated by Eli Lilly Company.

[3]Trade name: Agrozyme, donated by Merck, Sharp, and Dohme.

[4]Trade name: Tapazole, donated by Eli Lilly Company.

were used in Trial III. In Trial IV Corriedale and Corriedale x Hampshire crossbred lambs were fed, and Corriedale lambs were used in the digestion study, Trial V.

Pre-trial Management of Lambs

All lambs shipped into Columbia were handled in the following manner: Lambs were unloaded and placed in a large outside holding pen with access to shelter. Water and first cutting alfalfa or grass hay were provided the first two to three days after arrival. Lambs were allowed to consume hay free choice.

At the time lambs were put in the holding lot, they were examined, and those which were sick or unthrifty were removed to a separate pen and treated if necessary. After a few days in the holding pen all lambs were started on the light pre-test ration shown in Table 2, which was fed until the initiation of the trial.

TABLE 2 - FORMULATION OF PRE-TEST RATIONS

	%
Ground ear corn	20
Soybean oil meal	5
Cane molasses	10
Red clover hay	65

During this pre-test period of 10 to 14 days all lambs were vaccinated for sore mouth (contagious ecthyma) and enterotoxemia. Ten days after vaccination they were sheared if their fleece was over one-half inch in length. All lambs were ear tagged and individually identified with marking paint.

Native lambs were selected on the basis of uniformity, thriftiness, and general health. They were also vaccinated before initiation of the test and were fed light pre-trial rations in cases where they had not previously been on feed.

All lambs were weighed on two consecutive days to obtain an average initial weight. Lambs were divided into outcome groups based on this weight and were randomly assigned to treatment. In most of the feed lot trials lambs were fed to a weight of 105 pounds or until they were adequately finished to grade choice by the U. S. Standards in effect at time of slaughter. During the period in which these trials were conducted, there was a revision in standards of grading fat lambs.

All lambs were marketed at the Independent Packing Company at St. Louis, Mo. Carcass information was obtained on the killing floor and in the cooler.

Equipment and Feeding Facilities

The physical arrangement for Trials I, III, and VI was identical. Eight pens measuring 15 x 33 feet were divided down the center by one self feeder and a panel at each end. Feeders were divided to allow separate feeding of lambs on either side.

Water was supplied in galvanized tubs arranged so lambs on both sides of each feeder had access to it. Mineral mixtures were supplied in small boxes for each lot of lambs. Approximately one-fourth of the total area was open lot on the south side of an open shed and the remainder was covered. The arrangement in Trial IV was the same, but only four large lots were employed with five lambs on each side of the division.

In Trial II three of these 15 x 33 feet pens were utilized. Eighteen lambs were placed in each pen. Eighteen individual feeding crates were used per pen. These were constructed in three units with six stalls each. Each lamb's feed box was identified and could be removed from the crate and placed in the correct stall at time of feeding. Water and minerals were supplied in the same manner as reported earlier.

The lambs used in the metabolism study, Trial V, were housed in the climatic laboratory of the Dairy Department at the University of Missouri. The metabolism stalls used were of two types. Six stalls used were those described by Boenker (1960) and two stalls were similar to those described by Ellis (1955).

In trial VII 20 lambs were assigned, 5 to a lot, in an enclosed room with temperature regulation. These lots measured 12 x 4 feet including feed and water facilities. Flat-bottomed feeders were placed at one end of the pen.

Twenty lambs were placed in similar pens outside. Feeders were placed at one end of the pen. They were covered by 10-foot galvanized roofiing which also extended about 8 feet back over the pens. Water for both groups of lambs was provided in galvanized buckets.

Rations

Lambs in all trials were fed a complete mixed ration in either a meal or pelleted form. Rations were formulated using ground ear corn, blackstrap molasses, first-cutting alfalfa hay, and 44 percent solvent soybean oil meal in all trials except I. Ingredients in Trial I were the same except that first-cutting red clover hay was used in place of alfalfa hay.

These basic ingredients were added in quantities needed to provide the various protein and concentrate levels desired. Molasses content of all rations, however, was held at a constant level of 5 percent.

An antibiotic, Aureomycin, was added to all rations at the rate of 10 mg. per pound of feed.

All rations were ground by the Boone County Milling Service in a mobile hammer mill and mixer. In Trial I the rations were ground through a 3/16 inch screen and pelleted at the Red Comb Pioneer Feed Mill at Marshall. These pellets were 3/16 inch in diameter and approximately ¼ inch long.

In other trials rations were ground through a ⅜ inch screen and were pelleted by the Boone County MFA Exchange in Columbia. These pellets were ⅜ inch in diameter. In Trial IV an inert substance, Bentonite, was added to the rations to increase hardness and stability of the pellets.

A simple mineral mixture composed of equal parts by weight of salt and steamed bone meal was provided for lambs free choice except in the digestion trial. In this trial salt and bone meal were included in the ration.

Statistical Methods

Data obtained in these trials were treated by analysis of variance according to the methods of Snedecor (1956). The significance of the F ratios obtained was compared to probability values equal to 0.05 and 0.01. Analysis of variance tables are included in the Appendix. Treatment comparisons were made according to the method outlined by Duncan (1955).

RESPONSE OF IMPLANTED LAMBS FED RATIONS VARYING IN PROTEIN AND CONCENTRATES (TRIAL I)

Objectives of Trial I

The objectives of this feeding experiment were:

1. To determine the effect of varying levels of protein and concentrates in lamb fattening rations.
2. To compare stilbestrol and hexestrol as implants for fattening lambs.
3. To determine the effects of adding enzymes to lamb fattening rations.
4. To study procedures for satisfactory summer fattening of Texas spring lambs.
5. To observe the effect of treatment combinations.

Materials and Methods

Two hundred and eight Texas spring lambs were used in a 2 x 2 x 2 x 2 factorially designed experiment. The factors were: 11 and 14 percent crude proein rations, 66:34 versus 38:62 ratios of concentrate to roughage, stilbestrol versus hexestrol implants and controls versus 100 mg. Agrozyme per pound of feed. Gains, feed efficiency and carcass quality of lambs were the criteria used in the comparisons. Treatments are shown in Table 3.

Lambs were first allotted on June 15, 1959, with 16 lambs in each of the 16 treatments. After a few days on test, however, several lambs were obviously sick. They had red watery eyes, appeared listless, and were consuming only small amounts of feed. This condition was diagnosed as pinkeye; it spread rapidly

TABLE 3 - TREATMENT OF LAMBS (TRIAL I)

Lot	# Lambs*	Treatments
1	13	Hexestrol - 11% protein - low concentrate** - no enzymes
2	13	Stilbestrol - 11% protein - low concentrate - no enzymes
3	13	Hexestrol - 11% protein - low concentrate - enzymes***
4	13	Stilbestrol - 11% protein - low concentrate - enzymes
5	13	Hexestrol - 11% protein - high concentrate - no enzymes
6	13	Stilbestrol - 11% protein - high concentrate - no enzymes
7	13	Hexestrol - 11% protein - high concentrate - enzymes
8	13	Stilbestrol - 11% protein - high concentrate - enzymes
9	13	Hexestrol - 14% protein - low concentrate - no enzymes
10	13	Stilbestrol - 14% protein - low concentrate - no enzymes
11	13	Hexestrol - 14% protein - low concentrate - enzymes
12	13	Stilbestrol - 14% protein - low concentrate - enzymes
13	13	Hexestrol - 14% protein - high concentrate - no enzymes
14	13	Stilbestrol - 14% protein - high concentrate - no enzymes
15	13	Hexestrol - 14% protein - high concentrate - enzymes
16	13	Stilbestrol - 14% protein - high concentrate - enzymes

*Eight wethers and five ewes in each lot.
**High concentrate rations contained an average ratio of 66:34 concentrate to roughage and low concentrate rations a 38:62 ratio.
***Agrozyme was added to the ration at the rate of one hundred mg. per pound of feed.

through the group in spite of treatment with a silver nitrate solution, sulfa powder, and supplementation of rations with Vitamin A. Due to the outbreak, it was decided to regroup the lambs, selecting those that had recovered or were free from this condition and start the trial again.

On July 1, 1959, all lambs were reweighed and placed in outcome groups based on weight, sex, and thrift. Thirteen lambs were assigned randomly to each of the 16 lots.

Ewe lambs received a 9 mg. and wethers a 6 mg. hexestrol implant. All lambs receiving stilbestrol were treated with a 3 mg. pellet.

All lambs were self-fed complete mixed and pelleted rations. Ration formulation for Trial I is shown in Table 4, and chemical analyses are shown in Appendix Table 25.

The lambs were marketed in three groups based on the criteria of choice live grade or 105 pounds live weight. The three groups were slaughtered 50, 71, and 83 days after the start of the experiment.

TABLE 4 - FORMULATION OF EXPERIMENTAL RATIONS
(TRIAL I)

	11% Protein Low Concentrate	11% Protein High Concentrate	14% Protein Low Concentrate	14% Protein High Concentrate
Ground ear corn (%)	36	67.9	27.0	58.4
Soybean oil meal (%)	3.4	6.4	11.4	14.4
Blackstrap molasses(%)	5.0	5.0	5.0	5.0
1st cutting red clover hay (%)	55.6	20.7	56.6	22.2
Aureomycin (mg./lb.)	10	10	10	10

TABLE 5 - EFFECT OF LEVEL OF CONCENTRATES ON LAMB PERFORMANCE
(TRIAL I)

Treatment	Low Concentrate	High Concentrate
No. lambs	104	104
Avg. initial wt. (lbs.)	71.10	71.05
Avg. final wt. (lbs.)	95.96	98.74
Avg. days on feed	71.40	64.00
Avg. daily gain (lbs.)	.348	.433**
Avg. daily feed intake (lbs.)	3.55	3.48
Feed/lb. gain (lbs.)	10.21	8.04**
Avg. carcass yield (%)[1]	47.70	49.10**
Avg. carcass grade[2]	5.40	5.50

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]Carcass grades were assigned values as follows: low choice 7, high good 6, medium good 5, low good 4.

**$P < .01$

Results and Discussion

Results are tabulated in Tables 5, 6, 7, 8, and 9.

Lambs fed on a high concentrate ration gained significantly faster with higher carcass yields and required less feed per pound of gain than lambs on the low concentrate ration ($P<.01$). The results obtained in this trial failed to agree with data presented by the New Mexico workers or data presented by Ross and Pavey (1959). The high concentrate ration was essentially a duplication of that used by Ross and Pavey (1959); however, gains of lambs in their test were higher when a 40:60 concentrate to roughage ration was fed.

On examination of these two experiments in an attempt to determine causes for the wide disagreement in results, it appeared the major variances between the two trials were the time of year in which they were conducted and the lambs used. The earlier trial ran through November, December, and January; and this trial was conducted during the hottest months of the year, July and August. Origin of lambs used also differed, coming from Idaho in the earlier work and Texas in this trial.

Recommended nutrient allowances for farm animals have in general been presented with little regard to the season or the environmental temperature. This could be of major importance in feed lot operations where there is as yet no practical way of controlling temperature.

The influence of environmental temperature on the requirements of the fattening lamb is not clearly shown in the literature. However, workers at the Missouri station have conducted extensive studies to demonstrate the relationship between temperature and growth, feed, and water consumption and other physiological reactions in dairy cattle.

The "comfort zone" is described by Brody (1948) as "the point at which the environmental temperature is perfectly adjusted to keep the body temperature normal without resorting to the body's chemical thermo-regulative devices." It does not necessarily follow, however, that this environmental temperature is the best for highest productivity. All productive processes, whether with dairy cattle or fattening lambs, involve a heat increment which must be removed. This heat increment is difficult to remove at warm temperatures, and when feeds are provided which tend to produce a high heat increment the difficulty is increased.

This factor of heat increment and its more efficient utilization by animals fed at cool temperatures may be the basis for differences in response of lambs fed high concentrate rations during the summer and those fed out under colder temperature conditions. High roughage rations result in a larger heat increment factor than rations composed mainly of grain. High roughage, therefore, would be expected to compare more favorably in a cold than in a warm environment with a high concentrate ration.

Lambs receiving the higher protein level in this trial outgained lambs on the lower level ($P = .08$) and had significantly higher carcass yields ($P<.01$).

TABLE 6 - THE EFFECT OF PROTEIN CONTENT OF RATIONS ON LAMB PERFORMANCE (TRIAL I)

Treatment	11% Protein	14% Protein
No. lambs	104	104
Avg. initial wt. (lbs.)	71.12	71.02
Avg. final wt. (lbs.)	97.21	97.36
Avg. days on feed	69.12	66.31
Avg. daily gain (lbs.)	.377	.397[1]
Avg. daily feed intake (lbs.)	3.43	3.66
Feed/lb. gain (lbs.)	9.09	9.23
Avg. carcass yield (%)[2]	48.2	48.6**
Avg. carcass grade[3]	5.50	5.40

**P < .01

[1]P < .08

[2]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[3]Carcass grades were assigned values as follows: low choice 7, high good 6, medium good 5, low good 4.

TABLE 7 - HEXESTROL VERSUS STILBESTROL IMPLANTS FOR FATTENING LAMBS

Treatment	Hexestrol	Stilbestrol
No. lambs	104	104
Avg. initial wt. (lbs.)	71.46	70.69
Avg. final wt. (lbs.)	97.92	96.65
Avg. days on feed	67.44	68.00
Avg. daily gain (lbs.)	.392	.382
Avg. daily feed intake (lbs.)	3.56	3.51
Feed/lb. gain (lbs.)	9.07	9.18
Avg. carcass yield (%)[1]	48.5	48.3
Avg. carcass grade[2]	5.53	5.34

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2]Carcass grades were assigned as follows: low choice 7, high good 6, medium good 5, low good 4.

TABLE 8 – RESPONSE OF LAMBS TO VARIOUS PROTEIN AND CONCENTRATE COMBINATIONS (TRIAL I)

Treatment	11% Protein Low Conc.	11% Protein High Conc.	14% Protein Low Conc.	14% Protein High Conc.
No. lambs	54	54	54	54
Avg. initial wt. (lbs.)	71.05	71.20	71.15	70.90
Avg. final wt. (lbs.)	96.10	98.32	95.58	99.15
Avg. days on feed	71.52	66.72	71.30	61.32
Avg. daily gain (lbs.)	.350	.406	.340	.460[1]
Avg. daily feed intake (lbs.)	3.52	3.24	3.53	3.72
Feed/lb. Gain (lbs.)	10.06	7.99	10.37	8.09
Avg. carcass yield (%)[2]	47.5	48.8	47.9	49.3
Avg. Carcass grade[3]	5.40	5.60	5.40	5.30

[1] $P < .06$.

[2] Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[3] Carcass grades were assigned as follows: low choice 7, high good 6, medium good 5, low good 4.

TABLE 9 - EFFECT OF ADDING ENZYMES TO LAMB RATIONS
(TRIAL I)

Treatment	No Enzymes	Enzymes
No. lambs	104	104
Avg. initial wt. (lbs.)	71.14	71.01
Avg. final wt. (lbs.)	97.49	97.09
Avg. days on feed	67.00	68.44
Avg. daily gain (lbs.)	.39	.38
Avg. daily feed intake (lbs.)	3.50	3.56
Feed/lb. gain (lbs.)	8.91	9.35
Avg. carcass yield (%)[1]	48.50	48.30
Avg. carcass grade[2]	5.51	5.35

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2]Carcass grades were assigned as follows: low choice 7, high good 6, medium good 5, low good 4.

This agrees with results obtained by Griffith (1959), Keith (1957), and Preston and Burroughs (1958). There also appeared to be an interaction between protein and concentrate level. Lambs fed the high concentrate-14 percent protein ration made faster gains and had higher carcass yields than lambs on any other combination of protein and concentrate. These results approached statistical significance ($P = 0.06$) and agreed with work reported by Preston and Burroughs (1958) and Jones and Hogue (1960). Both of these groups found a significant increase in gains when high energy-high protein rations were fed. Results in this trial agree very closely with the report by Preston and Burroughs that increasing the level of protein stimulated gains on the high energy ration but not on the low energy rations.

In the work conducted by Jones and Hogue (1960), 192 Western white-faced wethers were assigned to treatment in a 2 x 2 x 2 factorially designed test. Variables were 11.2 versus 8.4 percent digestible protein, oral stilbestrol versus controls, and high energy (1.6 therms ENE per day) versus low energy (1.4 therms ENE per day). They obtained less response in gains due to higher energy levels than in the trials conducted by Preston and Burroughs; however, lambs on a high energy-high protein ration gained faster and graded higher than any other group ($P < .01$), but lambs on a low energy-high protein ration were more efficient.

Similar results were recorded by Olsen *et al.* (1960) in a trial with 217 lambs allotted to four treatments consisting of 650 and 700 calories per pound of feed and two levels of protein, 12 and 14 percent. Corn, alfalfa hay, molasses and soybean oilmeal were the basic feed ingredients. Gains of lambs were stimulated when either protein or energy levels were raised. The fastest gains were made by lambs receiving a high energy-high protein ration. Response was substantially the same in a second trial with 277 lambs.

Feed lot comparison of the estrogenic hormones, hexestrol and stilbestrol, were made and results indicate no significant differences between the two. Average daily gains, feed efficiency, yields, and grades, however, were slightly in favor of the lambs implanted with hexestrol, even though higher levels of hexestrol were used than of stilbestrol.

There was no stimulus in feed lot performance observed due to feeding enzymes at the level of 100 mg. per pound of feed. As shown in Appendix Tables I, II, and III, interaction between treatments other than concentrate and protein level did not approach statistical significance.

RESPONSE OF LAMBS FED VARYING PROTEIN LEVELS TO HORMONE IMPLANTS AND GOITROGENS (TRIAL II)

Objectives of Trial II

The objectives of the second feeding trial were:

1. To compare hexestrol implanted lambs with controls.
2. To determine the effect of varying levels of protein in lamb fattening rations.
3. To study the interrelations between hormone implants and level of protein for lambs.
4. To determine the effect of adding sufficient goitrogenic substances to lamb rations to partially block the thyroid gland.

Materials and Methods

On November 3, 1959, fifty-four late spring lambs out of Northwest ewes and Southdown rams were placed on a 2 x 3 x 3 factorially designed experiment. The factors compared were hexestrol-implanted lambs versus controls; 13, 15, and 17 percent protein in rations; and no tapazole versus 100 and 200 mg. of tapazole per lamb per day in the rations. The lambs were placed in three pens and assigned to treatment as shown in Table 10.

All lambs had been vaccinated for enterotoxemia and sore mouth during the summer. Just prior to the start of the test, all lambs were drenched for internal parasites with fine particle Phenothiazine.

All lambs were individually fed complete mixed rations in a meal form. They were given free access to feed for approximately 1 hour morning and night in individual feeding crates. The average components of the rations used in this trial are shown in Table 11. The rations were approximately equal in level of energy.

After the lambs had been on feed for 69 days they were graded alive, weighed off test, and marketed.

TABLE 10 - TREATMENT OF LAMBS
(TRIAL 11)

No. Lambs per Treatment	Treatment
27	Control
27	Hexestrol[1]
18	13% protein
18	15% protein
18	17% protein
18	No tapazole
18	100 mg. tapazole[2]
18	200 mg. tapazole[2]

[1]Wethers received six mg. and ewes nine mg. hexestrol implants.
[2]1-methyl 2-mercaptoimidazole per head daily.

TABLE 11 - FORMULATION OF EXPERIMENTAL RATIONS
(TRIAL II)

Protein (%)	13	15	17
	%	%	%
Ground ear corn	53.3	48.1	42.1
Blackstrap molasses	5.0	5.0	5.0
Alfalfa hay (first cutting)	36.9	37.1	37.1
Soybean oilmeal (44% crude protein)	4.8	9.8	15.8
Aureomycin	10 mg./lb.	10 mg./lb.	10 mg./lb

Results and Discussion

Lambs implanted with hexestrol pellets made significantly faster gains ($P < .01$) and were more efficient in their feed utilization than controls. There were only small differences between controls and implanted lambs in carcass grades and yields. These results are shown in Table 12.

No undesirable side effects were observed which could be attributed to the use of hexestrol, such as difficult pelting or udder development, or increased incidence of difficult urination by wether lambs.

Results obtained from lambs fed varying protein levels agreed in general with those reported in Chapter 4. This is shown in Table 13. There was an increase in average daily gains and a corresponding decrease in feed required per 100 pounds of gain as the protein in the ration was raised.

TABLE 12 - RESPONSE OF LAMBS TO HEXESTROL IMPLANTS (TRIAL II)

Treatment	Control	Hexestrol
No. of lambs	27	26[1]
Avg. initial wt. (lbs.)	69.8	69.6
Avg. final wt. (lbs.)	98.0	106.4
Avg. gain (lbs.)	28.2	36.8
Days on feed	69	69
Avg. daily feed intake (lbs.)	3.02	3.15
Avg. daily gain	.408	.533**
Feed per lb. gain (lbs.)	7.4	5.9
Avg. carcass yield (%)[2]	49.00	48.40
Avg. carcass grade[3]	6.26	6.23

[1]One lamb was removed from the test because of unthriftiness due to pneumonia.

[2]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[3] USDA Grades were assigned values as follows: low choice 7, high good 6, medium good 5, low good 4.

**P < .01.

TABLE 13 - RESPONSE OF FATTENING LAMBS TO DIFFERENT PROTEIN LEVELS IN THE RATION (TRIAL II)

Treatment	13% Protein	15% Protein	17% Protein
No. of lambs	17	18	18
Avg. initial wt. (lbs.)	69.6	69.8	69.8
Avg. final wt. (lbs.)	100.5	102.5	103.3
Avg. gain (lbs.)	30.9	32.7	33.5
Days on feed	69	69	69
Avg. daily feed intake (lbs.)	3.09	3.18	3.12
Avg. daily gain (lbs.)	.447	.474	.485
Feed/lb. gain (lbs.)	6.9	6.7	6.4
Avg. carcass yield (%)[1]	49	48	49
Avg. carcass grade[2]	6.1	6.2	6.3

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA Grades were assigned values as follows: low choice 7, high good 6, medium good 5, low good 4.

Gains of lambs treated with hexestrol were higher in all cases than those of controls; however, it was interesting to note that the stimulation in gains due to feeding higher protein levels was greater for control than for implanted lambs This is illustrated in Table 14. Lambs receiving no hexestrol made gains of 0.321, 0.430, and 0.442 compared to gains of 0.552, 0.517, and 0.530 for implanted lambs on protein levels of 13, 15, and 17 percent. This agrees with the work of Goodwin *et al.* (1958) with cattle. When they fed three protein levels with and without 24 mg. stilbestrol implants, the low level of protein appeared to be adequate only for implanted steers.

Preston and Burroughs (1958) and Jones and Hogue (1960) also found that the increase in gains of implanted lambs over controls was greater on low protein than on high protein rations.

Following the acceptance of estrogens by many animal husbandmen, interest in goitrogenic substances as a possible means of counteracting the incidence of low carcass grades of estrogen-treated animals has increased.

The ability of these substances to inhibit the function of the thyroid gland has been demonstrated. In this manner many workers have felt the rate of metabolism could be decreased resulting in more fat deposition and higher carcass grades. Andrews *et al.* (1947), Barrick *et al.* (1949), Burroughs *et al.* (1958) have worked with goitrogens such as thiouracil, thiourea, and tapazole in ruminant feeding. Results have been inconsistent with ruminants, possibly due to lack of information on optimum levels to employ.

As shown in Table 15 in this trial, tapazole failed to stimulate gains or improve feed efficiency, yields, or grades significantly. Lambs on the highest level of tapazole had depressed gains and lower yields than controls. Lambs on feed containing tapazole were harder to get on feed and did not consume feed as readily as controls. This is reflected in the lower daily feed consumption of lambs on tapazole treatment, especially those on the higher level. Part of the decrease in gains may, therefore, be due to palatability of the feed.

RESPONSE OF FATTENING LAMBS TO VARYING LEVELS OF CONCENTRATES, PROTEIN, HORMONES, AND ENZYMES (TRIAL III)

Objectives of Trial III

The third experiment was designed to repeat, in part, Trial I in which lambs were fattened during the summer months. The objectives were:

1. Comparison of lambs fattened on high and low concentrate rations.
2. To compare stilbestrol-implanted lambs with controls.
3. To compare lambs fed 11, 12, 13, and 14 percent protein rations.
4. Observe the effect of including enzymes added at the rate of 200 mg. per pound of feed.
5. Observe the effect of treatment interaction.

TABLE 14 - THE EFFECT OF VARYING HORMONE[1] AND PROTEIN CONTENT OF RATIONS FOR FATTENING LAMBS (TRIAL II)

Treatment	13% Protein Control	13% Protein Hex.	15% Protein Control	15% Protein Hex.	17% Protein Control	17% Protein Hex.
No. lambs	9	8	9	9	9	9
Avg. initial wt. (lbs.)	71.1	67.9	67.0	72.6	71.3	68.2
Avg. final wt. (lbs.)	93.3	106.0	96.7	108.3	101.8	104.8
Avg. gain (lbs.)	22.2	38.1	29.7	35.7	30.5	36.6
Days on feed	69	69	69	69	69	69
Avg. daily feed intake (lbs.)	2.51	3.26	3.10	3.26	3.18	3.02
Avg. daily gain (lbs.)	.321	.552	.430	.517	.442	.530
Feed/lb. gain (lbs.)	7.8	5.9	7.2	6.3	7.2	5.7
Avg. carcass yield (%)[2]	49.8	48.2	47.8	48.3	49.6	48.7
Avg. carcass grade[3]	6.2	6.1	6.0	6.3	6.4	6.2

[1]6 mg. hexestrol pellets for wether and 9 mg. pellets for ewes were implanted in the ear of each lamb.

[2]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[3]USDA grades were assigned values as follows: low choice 7, high good 6, medium good 5, low good 4.

TABLE 15 - RESPONSE OF LAMBS TO GRADED LEVELS OF TAPAZOLE IN RATIONS (TRIAL II)

Treatment	Control	100 mg. Tapazole/Day	200 mg. Tapazole/Day
No. lambs	18	18	17
Avg. initial wt. (lbs.)	71.1	68.6	69.5
Avg. final wt. (lbs.)	105.0	101.8	99.4
Avg. gain (lbs.)	33.9	33.2	29.9
Days on feed	69	69	69
Avg. daily feed intake (lbs.)	3.39	3.13	2.86
Avg. daily gain (lbs.)	.491	.481	.433
Feed/lb. gain (lbs.)	6.9	6.5	6.6
Avg. carcass yield (%)[1]	.49	.49	.48
Avg. carcass grade[2]	6.17	6.28	6.24

[1]Carcass yield = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2]USDA grades were assigned values as follows: low choice 7, high good 6, medium good 5, low good 4.

Materials and Methods

One hundred and ninety-two Arizona feeder lambs were selected from a car load of 280 lambs that arrived in Columbia April 18, 1960. These lambs were used in a 2 x 2 x 4 x 2 factorially designed experiment in which the factors compared were:

1. Fifty-seven versus 41 percent concentrate rations.
2. Three mg. stilbestrol implants verus controls.
3. Eleven, 12, 13, and 14 percent crude protein rations.
4. Enzymes added at levels of 200 mg. per pound of feed versus no enzymes.

Treatments for the lambs are shown in Table 16. Following a two-week period in which routine pre-test management was practiced, the lambs were started on experimental rations on May 2, 1960.

TABLE 16 - TREATMENT OF LAMBS (TRIAL III)

Lot	No. Lambs	Treatment
1	12	Low concentrate[2] - 11% protein[3] - no enzymes[4]
2	12	Low concentrate - 11% protein - enzymes
3	12	Low concentrate - 12% protein - no enzymes
4	12	Low concentrate - 12% protein - enzymes
5	12	Low concentrate - 13% protein - no enzymes
6	12	Low concentrate - 13% protein - enzymes
7	12	Low concentrate - 14% protein - no enzymes
8	12	Low concentrate - 14% protein - enzymes
9	12	High concentrate - 11% protein - no enzymes
10	12	High concentrate - 11% protein - enzymes
11	12	High concentrate - 12% protein - no enzymes
12	12	High concentrate - 12% protein - enzymes
13	12	High concentrate - 13% protein - no enzymes
14	12	High concentrate - 13% protein - enzymes
15	12	High concentrate - 14% protein - no enzymes
16	12	High concentrate - 14% protein - enzymes

[1]Lots composed of eight wethers and four ewes. Half the lambs in each lot were implanted with three mg. of stilbestrol.
[2]Low concentrate=41%; High concentrate=57% by weight.
[3]Crude protein.
[4]Trade names: Agrozyme, a product of Merck, Sharp, and Dohme. Added to ration at the rate of two hundred mg./lb. of feed.

Lambs were self-fed complete pelleted rations as shown in Table 17.

On May 7, 1960, half of the lambs in each lot were implanted in the ear with a 3 mg. stilbestrol pellet.

TABLE 17 - FORMULATION OF EXPERIMENTAL RATIONS
(TRIAL III)

Ration	% Ground Ear Corn	% Cane Molasses	% Alfalfa Hay	%SBOM (44%)
Low conc. 11% protein	42.5	5.0	50.1	2.4
Low conc. 12% protein	40.0	5.0	50.1	4.9
Low conc. 13% protein	36.6	5.0	50.8	7.6
Low conc. 14% protein	33.8	5.0	50.8	10.4
High conc. 11% protein	59.1	5.0	31.6	4.3
High conc. 12% protein	56.5	5.0	31.4	7.1
High conc. 13% protein	53.6	5.0	31.7	9.7
High conc. 14% protein	50.2	5.0	32.5	12.3

Lambs were graded alive at the end of six weeks on feed. All which were satisfactory in size and finish were slaughtered at that time. The rest of the lambs were slaughtered at the end of 55 days.

Results and Discussion

Lamb performances on the two levels of concentrate and roughage are shown in Table 18. In general, the results agreed with those reported in Trial I which was conducted during the summer of 1959. Lambs on the high concentrate ration made significantly faster gains ($P < .01$), had higher yields ($P < .05$), and required less feed per pound of gain than those on the low roughage ration. Average carcass grades were practically the same for both lots. Nearly all lambs graded Swift Premium with a very few as low as Swift Select. Company grades were used because at the time these lambs were marketed there had been a temporary suspension of U. S. Government grading at the St. Louis Independent Packing Company.

The effect of increasing the level of protein in lamb fattening rations did not appear to be as clearcut as it was in Trials I and II, and differences were not statistically significant. However, the lambs on the highest protein level again

TABLE 18 – EFFECT OF HIGH AND LOW CONCENTRATE RATIONS ON LAMB PERFORMANCE (TRIAL III)

Treatment	High conc.	Low conc.
No. lambs	93	95
Avg. initial wt. (lbs.)	78.15	77.95
Avg. final wt. (lbs.)	111.48	109.52
Avg. days on feed	45.80	47.20
Avg. daily gain (lbs.)	.73**	.67
Avg. daily feed intake (lbs.)	4.12	4.46
Feed/lb. gain (lbs.)	5.66	6.67
Avg. carcass yield (%)[1]	48	46
Avg. carcass grade[2]	4.94	4.96

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]Carcass grades were assigned values as follows: Swift Premium 5, Swift Select 4, U. S. Government grades were not available at time of slaughter.

*P < .05.

**P < .01.

made faster gains and required less fed per pound of gain than lambs fed less protein. This is noted in Table 19. Higher carcass yields were made by lambs fed rations with 14 percent crude protein.

TABLE 19 – EFFECT OF GRADED LEVELS OF PROTEIN IN LAMB FATTENING RATIONS (TRIAL III)

% Protein	11	12	13	14
No. lambs	48	46	46	48
Avg. initial wt. (lbs.)	78.00	78.08	77.95	78.18
Avg. final wt. (lbs.)	109.98	110.62	110.88	110.78
Avg. days on feed	46	46	47	46
Avg. daily gain (lbs.)	.69	.70	.69	.71
Avg. daily feed intake (lbs.)	4.47	4.16	4.25	4.36
Feed/lb. gain (lbs.)	6.48	5.92	6.12	6.16
Avg. carcass yield (%)[1]	47	47	48	48
Avg. carcass grade[2]	4.98	4.91	4.87	4.96

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]Grades were assigned values as follows: Swift Premium 5, Swift Select 4, U. S. Government grades were not available at time of slaughter. Swift Premium and Swift Grades correspond to U. S. choice and U. S. good grades.

Lambs which were implanted with stilbestrol gained 0.125 pounds per day faster than controls as shown in Table 20. This was statistically significant ($P<.01$).

TABLE 20 - RESPONSE OF FATTENING LAMBS TO STILBESTROL IMPLANTS (TRIAL III)

Treatment	Control	Stilbestrol
No. lambs	93	95
Avg. initial wt. (lbs.)	78.12	77.97
Avg. final wt. (lbs.)	108.07	112.93
Avg. days on feed	47.31	46.08
Avg. daily gain (lbs.)	.63	.76**
Avg. carcass yield (%)[1]	48	47
Avg. carcass grade[2]	4.97	4.92

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]Grades were assigned values as follows: Swift Premium 5, Swift Select 4, U. S. Government grades were not available at time of slaughter.

**$P< .01$.

The interaction between hormone and protein treatments is shown in Table 21. While average daily gains did not coincide exactly with those reported in Trial II, the greatest increase in gains due to hormone treatment occurred in lambs fed the lowest level of protein.

A possible explanation of these results may be found by a review of the action of stilbestrol. Several workers have shown an increase in nitrogen retention following stilbestrol administration. Other reports show increased calcium and phosphorus balance as well. There is good experimental evidence that this increase in efficiency of nitrogen utilization and retention results in true tissue growth.

Turner in his unpublished notes on the effect of estrogens on uterine tissue states that estrogens influence the various enzyme systems of the cell. "Estrogens cause a marked growth of all structural and functional components of the uterus. There is an increase in uterine capillaries and blood supply and also a marked increase in water supply to the uterus. The cells of the uterus become bathed in a rich nutrient and hormone supply and quickly show evidence of true growth."

Gee and Preston (1957) found that carcasses of lambs implanted with 15 mg. of hexestrol had more bone, flesh, less subcutaneous fat, and a greater percent of moisture than controls. Hexestrol implantation significantly improved protein-conversion efficiency. The improvement in protein-conversion efficiency may explain the greater stimulus in gains of implanted lambs over controls on low protein rations than on higher levels of protein. It is possible that the lower levels of protein used in these trials are below the needs of the non-implanted

TABLE 21 - EFFECT OF STILBESTROL IMPLANTS[1] ON LAMBS FED GRADED LEVELS OF CRUDE PROTEIN (TRIAL III)

Treatment	No. Lambs	Avg. Inital Wt. (lbs.)	Avg. Final Wt. (lbs.)	Days on Feed	Avg. Daily Gain (lbs.)	Carcass Yield (%)[3]	Carcass Grade[2]
11% protein Control	24	78.33	107.38	47.96	.606	48.0	4.92
11% protein Stilbestrol	24	77.67	112.54	45.25	.771	46.9	5.04
12% protein Control	23	77.25	107.83	45.39	.668	47.5	4.96
12% protein Stilbestrol	23	78.65	113.48	47.08	.740	46.5	4.91
13% protein Control	22	78.36	108.68	48.50	.625	47.8	4.95
13% protein Stilbestrol	24	77.50	112.75	46.33	.760	47.6	4.88
14% protein Control	24	78.25	108.42	47.42	.636	48.3	5.04
14% protein Stilbestrol	24	78.08	112.96	44.71	.780	47.9	4.88

[1]3 mg. stilbestrol pellets implanted in the ear of each lamb.

[2]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[3]Grades were assigned values as follows: Swift Premium 5, Swift Select 4, U. S. Government grades were not available at time of slaughter.

lambs but adequate for implanted lambs due to better utilization. The higher protein levels, however, may meet the requirements of control lambs adequately, and the excess protein available to implanted lambs through better utilization may be used as an energy source rather than a protein source.

The relationship between stilbestrol treatment and protein requirement may be affected by levels of energy in fattening rations. As shown in Table 22 the stilbestrol treatment appeared to have a greater influence on gains of lambs on high concentrate than on low concentrate rations. Preston and Burroughs (1960) reported that a greater gain stimulation of fattening lambs due to stilbestrol treatment occurred on high protein levels in combination with high energy levels, whereas the reverse appeared to be true on low energy levels. Taking the differences in yield into account, gains of lambs in this trial show a similar trend. These results may indicate the value of high concentrate rations fed in conjunction with high protein levels when lambs are treated with estrogens. Feeding high concentrate rations should insure the presence of adequate energy for maximum protein conversion.

TABLE 22 - EFFECT OF VARYING DIETARY LEVELS OF PROTEIN AND ENERGY ON GAINS AND CARCASS YIELDS OF CONTROL AND STILBESTROL-IMPLANTED LAMBS

Concentrate Level	% Protein Level	Hormone	Avg. Daily Gain (lbs.)	Carcass Yield (%)
Low	11	Control	.60	47.7
		Stilbestrol	.74	46.7
	12	Control	.64	46.6
		Stilbestrol	.68	46.5
	13	Control	.63	47.3
		Stilbestrol	.74	47.0
	14	Control	.64	47.8
		Stilbestrol	.77	47.0
High	11	Control	.64	48.2
		Stilbestrol	.82	46.7
	12	Control	.72	48.2
		Stilbestrol	.82	46.5
	13	Control	.62	48.4
		Stilbestrol	.81	48.3
	14	Control	.65	48.8
		Stilbestrol	.79	48.5

The interaction between protein and concentrate levels is shown in Table 23. Lambs on the 12 percent-high concentrate ration made the fastest gains; however, they yielded 1 percent less than lambs on the 14 percent protein-high concentrate ration. Those on high concentrate rations at all protein levels yielded higher except on the 11 percent protein rations. Then they were equal.

The data in Table 24 indicate little if any advantage from the addition of Agrozyme to rations at the rate of 200 mg. per pound of feed. Since statistical analysis of this data showed no differences in gains, feed efficiency, carcass yields, or grades due to enzyme treatment, all lambs fed enzymes were combined with controls for analysis of the other factors in this trial.

THE EFFECT OF VARYING THE CONCENTRATES, PROTEIN, AND PHYSICAL FORM OF RATIONS FOR FATTENING LAMBS (TRIAL IV)

Objectives of Trial IV

The objectives were:

1. To observe the effect of level of concentrates on gains, feed efficiency, and carcass characteristics of fattening lambs fed during the winter.
2. To compare the effect of two protein levels in fattening rations.
3. To determine protein and energy interaction in fattening rations.
4. To compare pelleted versus meal rations varying in protein and concentrate levels.
5. To observe the effect of various treatment combinations on lamb performance.

Materials and Methods

Forty late spring lambs which were raised on farms at the University of Missouri were used in the trial. They were primarily Corriedales with a few Corriedale-Hampshire crosses. The lambs had been carried on pasture through the summer and early fall prior to the initiation of the trial.

The lambs were placed in outcome groups by weight and randomly assigned to a 2 x 2 x 2 factorially designed experiment and subjected to treatments shown in Table 25. All lambs were implanted with a 3 mg. stilbestrol pellet at the start of the trial. They were self-fed complete mixed rations in a meal or pelleted form starting November 9, 1960. Average ration composition used is shown in Table 26.

Following a 50-day feeding period, the lambs were graded alive, weighed off test, and marketed.

Results and Discussion

Results of the comparison of the two concentrate levels are shown in Table 27. There were only small differences in average daily gains of lambs on the

TABLE 23 - THE EFFECT OF FEEDING VARIED COMBINATIONS OF PROTEIN AND CONCENTRATE TO FATTENING LAMBS (TRIAL III)

Protein Concentrate	11 Low	11 High	12 Low	12 High	13 Low	13 High	14 Low	14 High
No. lambs	24	24	23	23	24	22	24	24
Avg. initial wt. (lbs.)	77.95	78.05	78.10	78.07	77.70	78.20	78.05	78.30
Avg. final wt. (lbs.)	109.50	110.45	109.17	112.17	109.75	111.97	109.70	111.35
Avg. days on feed	47.95	44.70	47.97	44.82	47.42	47.32	45.79	46.33
Avg. daily gain (lbs.)	.66	.72	.65	.76	.68	.71	.69	.71
Avg. daily feed intake (lbs.)	4.78	4.13	4.19	4.09	4.45	4.01	4.42	4.23
Feed/lb. gain (lbs.)	7.26	5.70	6.46	5.38	6.58	5.61	6.39	5.93
Avg. carcass yield (%)[1]	47.20	47.20	46.60	47.40	47.10	48.40	47.40	48.70
Avg. carcass grade[2]	5.04	4.91	5.00	4.86	4.67	4.95	4.91	5.00

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2]Grades were assigned values as follows: Swift Premium 5, Swift Select 4, U. S. Government grades were not available at time of slaughter.

TABLE 24 - RESPONSE OF FATTENING LAMBS TO ENZYMES IN RATIONS (TRIAL III)

Enzymes Mg./lb.[1] of Ration	None	200
No. lambs	94	94
Avg. initial wt. (lbs.)	78.18	77.91
Avg. final wt. (lbs.)	110.89	110.08
Avg. days on feed	47.25	45.73
Avg. daily gain (lbs.)	.69	.70
Avg. daily feed intake (lbs.)	4.32	4.27
Feed/lb. gain (lbs.)	6.25	6.07
Avg. carcass yield (%)[2]	47.6	47.5
Avg. carcass grade[3]	4.95	4.94

[1]Trade name: Agrozyme. A dried enzyme mixture of bacterial origin containing both amylolytic and proteolytic enzymes, a product of Merck, Sharp, and Dohme.

[2]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[3]Grades were assigned values as follows: Swift Premium 5, Swift Select 4, U. S. Government grades were not available at time of slaughter.

TABLE 25 - EXPERIMENTAL TREATMENT OF LAMBS (TRIAL IV)

Lot	No. Lambs	Protein (%)	Treatment Conc:Roughage Ratios	Physical Form
1	5	11	65:35	Meal
2	5	11	65:35	Pellets
3	5	14	65:35	Meal
4	5	14	65:35	Pellets
5	5	11	45:55	Meal
6	5	11	45:55	Pellets
7	5	14	45:55	Meal
8	5	14	45:55	Pellets

TABLE 26 - FORMULATION OF EXPERIMENTAL RATIONS
(TRIAL IV)

Ration	Ground Ear Corn %	Molasses %	Alfalfa Hay %	Soybean Oil Meal %
11% crude protein High concentrate	68.0	5.0	21.0	6.0
11% crude protein Med. concentrate	47.0	5.0	46.0	2.0
14% crude protein High concentrate	57.5	5.0	24.0	13.5
14% crude protein Med. concentrate	39.0	5.0	47.0	9.0

two concentrate to roughage ratios. The results did not agree with those obtained in Trials I and III where there appeared to be a fairly large stimulus in gains of lambs fed a high concentrate ration. These results compare favorably with reports by Cox (1948) who concluded that the optimum performance with fattening lambs was obtained when a ration containing 45 parts concentrate and 55 parts roughage was fed.

TABLE 27 - THE EFFECT OF VARYING THE PROPORTION OF CONCENTRATE TO ROUGHAGE FOR FATTENING LAMBS
(TRIAL IV)

Concentrate:Roughage	65:35	45:55
No. lambs	20	20
Avg. initial wt. (lbs.)	76	75
Avg. final wt. (lbs.)	111.25	111.70
Days on feed	50	50
Avg. daily gain (lbs.)	.70	.73
Avg. daily feed intake (lbs.)	4.67	4.49
Feed/lb. gain (lbs.)	6.62	6.12
Avg. carcass yield (%)[1]	44.7	43.4
Avg. carcass grade[2]	8.4**	7.2

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$

[2]USDA Carcass grades were assigned values as follows: high choice 9, medium choice 8, low choice 7, High good 6.

**P < .01.

The results also appear to be similar to those obtained by Ross and Pavey during the winter of 1959; however, differences were not as great.

A comparison of carcass yields and U. S. Government grades indicates that part of the increase of gains of lambs on the low concentrate ration was due to fill. Lambs on the 65:35 ratio yielded 1.3 percent higher than lambs on the 45:55 ratio of concentrates to roughage. This approached statistical significance ($P < .01$). Their average of one-third grade higher indicated higher finish.

These results tend to support the idea that lamb requirements may be affected by season of the year or the environmental temperature. The trial was conducted during November and December of 1960, and lambs were slaughtered December 29. Thus the time of year appears to be one of the major variables between this trial and Trials I and III.

If the season of the year should strongly influence utilization of concentrates or roughage by fattening lambs, it may explain to some extent the variation in results found by many investigators.

It has been shown with sheep that the heat increment of acetic acid is greater than propionic and butyric, Armstrong *et al.* (1957). The ratio between these acids appears, however, to have a large influence on the heat increment produced. The presence of propionic and butyric acids tends to decrease the heat increment of acetic acid. The ratio of acetic acid to propionic acid has been shown to be lower when rations are high in concentrates.

It is possible that the value of high roughage rations fed during the winter months results from greater production of acetic acid and, therefore, a higher heat increment. An increased heat increment should be beneficial under cold temperature conditions; whereas in Trials I and III conducted under warm environmental conditions, it could have been detrimental due to the necessity of dissipating the heat produced. If this should be true, it would agree with a conclusion reached by Andrews (1957) regarding his work with cattle. "Feeding animals straw in winter to keep them warm through the increment of heat is well known, and by the same token a roughage diet during the summer can generate a lot of waste heat, which interferes with beef production."

The results also agree with research conducted by Rupel and Leighton (1957) working with dairy cattle. During periods of mild weather there was little difference in milk production but, during periods of high temperature, milk production and body weight were more satisfactory on low fiber rations.

The effect of protein levels is shown in Table 28. Lambs on a 14 percent crude protein ration made faster gains and had slightly higher yields and carcass grades than lambs which received 11 percent crude protein. While this difference was not significant, it follows the trend reported in earlier trials which favored the higher percent of protein.

Interaction between protein and concentrate levels is shown in Table 29. No significant difference was found by analysis of variance in this interaction as shown in Appendix Table X. It does not indicate a trend favoring the high concentrate-high protein combination, however, as was found in Trial I and in data reported by Preston and Burroughs (1958) and Jones and Hogue (1960).

TABLE 28 - A COMPARISON OF 11 AND 14 PERCENT CRUDE PROTEIN IN LAMB FATTENING RATIONS (TRIAL IV)

Crude Protein (%)	11	14
No. lambs	20	20
Avg. initial wt. (lbs.)	74.4	76.6
Avg. final weight (lbs.)	109.95	113.0
Days on feed	50	50
Avg. daily gain (lbs.)	.71	.73
Avg. daily feed intake (lbs.)	4.32	4.56
Feed/lb. gain (lbs.)	6.08	6.27
Avg. carcass yield (%)[1]	43.7	44.4
Avg. carcass grade[2]	7.4	7.9

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA carcass grades were assigned values as follows: high choice 9, medium choice 8, low choice 7, high good 6.

TABLE 29 - EFFECT OF VARYING PROPORTION OF PROTEIN, CONCENTRATES, AND ROUGHAGE IN LAMB FATTENING RATIONS (TRIAL IV)

Crude Protein (%) Concentrate:Roughage	11 65:35	11 45:55	14 65:35	14 45:55
No. lambs	10	10	10	10
Avg. initial wt. (lbs.)	76.30	72.50	75.70	77.50
Avg. final wt. (lbs.)	109.70	110.20	112.80	113.20
Days on feed	50.00	50.00	50.00	50.00
Avg. daily gain (lbs.)	.67	.75	.74	.71
Avg. daily feed intake (lbs.)	4.76	4.40	4.54	4.58
Feed/lb. gain (lbs.)	7.12	5.84	6.12	6.42
Avg. carcass yield (%)[1]	44.65	43.85	44.80	44.05
Avg. carcass grade[2]	8.4	7.0	8.5	7.3

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA carcass grades were assigned values as follows: high choice 9, medium choice 7, low choice 7, high good 6.

The effect of the physical form of feed on lamb performance is shown in Table 30. Lambs on pelleted rations made faster gains, had slightly higher carcass yields and graded significantly higher ($P < .05$) than lambs fed similar rations in a meal form. This agrees with work conducted by Thomas *et al.* (1945), Esplin (1955), and Bowstead (1958).

TABLE 30 - EFFECT OF PHYSICAL FORM OF FEED ON LAMBS
(TRIAL IV)

Physical Form of Ration	Meal	Pellets
No. lambs	20	20
Avg. initial wt. (lbs.)	75.50	75.50
Avg. final wt. (lbs.)	109.65	115.30
Days on feed	50.00	50.00
Avg. daily gain (lbs.)	.68	.76
Avg. daily feed intake (lbs.)	4.22	4.96
Feed/lb. gain (lbs.)	6.18	6.56
Avg. carcass yield (%)[1]	43.98	44.20
Avg. carcass grade[2]	7.4	8.2*

[1] Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2] USDA carcass grades were assigned values as follows: high choice 9, medium choice 8, low choice 7, high good 6.
*$P < .05$.

As seen in Table 31, pelleting apparently had the most effect on gains of lambs on the lower concentrate ration, but the differences were not statistically significant. This tends to agree with reports by Botkin (1955) and Hartman (1959).

Pelleting both the medium and high concentrate rations resulted in greater daily feed intake, but did not significantly improve the efficiency of feed conversion.

EFFECT OF TEMPERATURE AND CONCENTRATE LEVELS ON DIGESTIBILITY OF FEEDS FOR FATTENING LAMBS (TRIAL V)

Objectives of Trial V

1. To study the effect of environmental temperature on the digestibility by lambs of dry matter, protein, nitrogen free extract, ether extract, fiber, and ash.
2. To observe the effect on digestibility of rations varying in percent concentrate at a low and high environmental temperature.

TABLE 31 - INTERACTION BETWEEN PHYSICAL FORM OF RATION AND CONCENTRATE:ROUGHAGE RATIOS (TRIAL IV)

Concentrate:Roughage Physical Form of Ration	65:35 Meal	65:35 Pellet	45:55 Meal	45:55 Pellet
No. lambs	10	10	10	10
Avg. initial wt. (lbs.)	74.7	77.3	76.3	73.7
Avg. final wt. (lbs.)	108.6	113.9	110.7	112.7
Days on feed	50.0	50.0	50.0	50.0
Avg. daily gain (lbs.)	.68	.73	.69	.78
Avg. daily feed intake (lbs.)	4.28	5.07	4.16	4.76
Feed/lb. gain (lbs.)	6.32	6.92	6.04	6.10
Avg. carcass yield (%)[1]	44.45	45.00	43.50	43.40
Avg. carcass grade[2]	8.0	8.9	6.9	7.4

[1] $\text{Carcass yield (\%)} = \frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2] USDA carcass grades were assigned values as follows: high choice 9, medium choice 8, low choice 7, high good 6.

3. To observe the effect of environmental temperature on body temperatures of fattening lambs.

Materials and Methods

A metabolism study using eight Corriedale wether lambs was made in the climatic laboratory at the University of Missouri.[1] All lambs were sheared at the start of the trial. After a seven-day preliminary period, collections were made on lambs for seven days at both 80 and 40 degrees Fahrenheit. Daily rectal temperature readings were taken for each lamb.

Initially four lambs were fed on a high concentrate[2] and four on a low concentrate ration in a chamber with the temperature controlled at 80 degrees F. Following the seven-day preliminary and a seven-day collection period, the temperature in the chamber was lowered to 40 degrees F. Lambs were allowed seven days to become accustomed to the lower temperature before starting another seven-day collection period.

Total urine and feces were collected daily. Fecal collections were weighed and a 10 percent aliquot was dried at 80 degrees F. for 24 hours. Total urine collections were made under 10 milliliters of toluene which acted as a preservative. A 10 percent sample of urine was taken and stored at minus 14 degrees F.

[1] In cooperation with the Dairy Department, Missouri Agriculture Experiment Station, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture.

[2] High concentrate rations contained approximately 60 percent and low concentrate rations 40 percent concentrate.

Fecal and urine samples were composited daily for each lamb. Fecal samples were allowed to equilibrate with the air for 24 hours or longer before an air dry weight was taken. Samples were then ground and mixed for analysis.

Urinary nitrogen was determined and feed and fecal samples were analyzed quantitatively for nitrogen, ether extract, moisture, crude fiber, and ash using methods of the Association of Official Agricultural Chemists (1955).

Lambs were hand fed complete mixed and pelleted rations shown in Table 32. Lambs were fed each morning all the feed they would consume in a 24-hour period.

TABLE 32 - RATION COMPONENTS FOR LAMBS IN DIGESTION TRIALS

Components	Concentrate:Roughage 60:40	Concentrate:Roughage 40:60
	%	%
Alfalfa hay	27.5	51.0
Ground ear corn	61.3	41.9
Soybean oil meal (44%)	5.7	1.6
Blackstrap molasses	5.0	5.0
Salt	.5	.5

Results and Discussion

Average chemical compositions of the two rations used are given in Table 33.

The effect of the two rations upon apparent digestibility at both a high and a low temperature are shown in Table 34. Detailed data concerning digestibility determinations are shown in Appendix Table 29.

When data from the two trials were combined, the coefficient of digestibility for protein, dry matter, ether extract, and nitrogen free extract was significantly greater ($P<.01$) for lambs fed high concentrate rations.

TABLE 33 - CHEMICAL COMPOSITION OF RATIONS USED IN THE METABOLISM STUDY

Components	Concentrate:Roughage 60:40	Concentrate:Roughage 40:60
Crude protein	12.38	10.19
Moisture	5.81	5.78
Crude fiber	15.44	20.67
Ash	5.57	5.72
Ether extract	3.04	2.51
NFE	57.76	55.13

TABLE 34 - AVERAGE APPARENT DIGESTIBILITY OF EXPERIMENTAL RATIONS (TRIAL V)

Ration Component	Crude Protein	DM	EE	Fiber	Ash	NFE
	%	%	%	%	%	%
Low concentrate	51.84	59.16	74.50	34.95	48.22	69.42
High concentrate	58.08**	62.84**	82.18**	33.08	49.06	72.13**
80°F.	55.74	61.20	78.00	33.86	46.63	71.34
40°F.	54.17	60.80	78.68	34.18	50.64	70.22
Low concentrate, 80°F.	52.27	59.05	74.55	35.80	45.70	69.49
High concentrate, 80°F.	59.21	63.34	81.46	31.92	47.56	73.18
Low concentrate, 40°F.	51.40	59.26	74.45	34.11	50.73	69.36
High concentrate, 40°F.	56.94	62.34	82.90	34.25	50.56	71.08

$^{**}P < .01$.

The greater apparent digestibility of crude protein agrees with research reported on by Glover and Duthie (1958) who found that as the level of crude fiber in the ration was decreased the apparent digestibility of crude protein increased. The total amount of protein digested was also greater for lambs on the high concentrate rations even though daily feed intake was slightly higher for lambs on the low concentrate rations. It also agrees with that of Elliot and Loosli (1959). In their work apparent digestion coefficients increased for dry matter, ether extract, and nitrogen free extract as the proportion of concentrate was increased in rations for dairy cattle. However, in their trial crude protein digestibility was not significantly affected by concentrate level.

Both the high and low concentrate rations were formulated to contain equal amounts of crude protein; however, the chemical analysis of the rations indicates that the high concentrate ration was also higher in crude protein content and this difference must be considered in comparing digestibility figures of the two rations. Apparent digestibility of crude protein, dry matter, and organic matter has been increased by increasing the nitrogen percent in rations according to Briggs *et al.* (1946) and Woods *et al.* (1956). White (1960) also reported that apparent digestibility of crude protein, dry matter, and organic matter increased as the nitrogen content of rations for lambs was raised.

Because of the effect on digestion of increased protein levels that these workers have shown, it is not possible to say conclusively what amount of the improvement in digestion was due to concentrate level.

While the difference in the coefficient of digestion of fiber between levels of concentrates was not significant, there was a larger amount of fiber digested by lambs fed low concentrate rations. This agrees with work by Swift *et al.* (1947) who found that adding oat straw to basal rations of mixed hay, corn meal, and linseed oil meal for ruminants resulted in larger actual amounts of dry matter and crude fiber digestion, but a decrease in the actual amount of protein and ether extract digestion.

There were no large differences in digestibility coefficients at the high and low temperatures when lambs on both low and high concentrate rations were combined. There was a slight decrease in fiber digestibility at an environmental temperature of 80 degrees F., but the individual data indicate that the decrease was nearly all due to one animal. It is possible that the test periods at each temperature were too short for the adverse effect of high temperature to exert its full effect on all animals.

As shown in Appendix Table 29 fiber digestion by individual lambs varied widely. There were no significant differences statistically in fiber digestion in any combination of concentrate and temperature treatment.

Feed intake was higher during the second trial conducted at 40 degrees F. They averaged 4.4 pounds per day per lamb compared to 2.5 pounds during the first trial. Part of the increase was probably due to the animals becoming more accustomed to the metabolism crates.

The advantages obtained from high concentrate rations in the feed lot trials conducted during summer months may be due to an increase in digestibility. Data in Table 34 indicate that the coefficients of digestibility tend to be higher at both temperatures for high concentrate rations. The difference in favor of the high concentrate ration was greater at 80 degrees for protein, dry matter, fiber, ash, and nitrogen free extract than at 40 degrees F. temperature. However, none of the differences were statistically significant.

There were no noticeable differences in digestibility results due to the type of metabolism crate employed.

Individual rectal temperatures were taken daily and averaged for each digestion trial. They averaged 103.5 degrees F. during the trial at 80 degrees F. and 102.7 degrees at 40 degrees F. environmental temperature. There was little difference in body temperature noted due to level of concentrate fed.

FEEDING TRIALS WITH TEXAS SPRING LAMBS (TRIALS VI AND VII)

On February 23, 1961, 220 lambs arrived in Columbia from San Angelo, Texas. They were used in two feeding trials.

Trial VI—Effect of Crude Protein Levels, Proportion of Concentrates and Roughage, and Pelleting Rations on Fattening Lambs

Objectives of Trial VI

1. To compare high and low concentrate rations for fattening lambs.
2. To study the effect of graded levels of crude protein in fattening rations.
3. To study the effect of pelleting high and low concentrate rations on performance of fattening lambs.
4. To observe the effect of environmental temperature on gains of lambs fed high and low concentrate rations.
5. To study effects of main treatment combinations on lambs.

Materials and Methods

One hundred twenty-eight uniform lambs were selected from the car load of feeders. They were assigned to a 2 x 4 x 2 factorially designed experiment. Factors compared were: ratios of 35:65 versus 56:44 concentrate to roughage; 10, 12, 14, and 16 percent crude protein levels; and meal versus pelleted rations. Treatments are shown in Table 35.

The lambs were self-fed the complete mixed rations in dry lot. Average ration composition is shown in Table 36. Lambs were started on the test March 6, 1961, and were slaughtered when they would grade choice alive or weigh 105 pounds. The first group was killed at the end of 55 days and a second at 77 days after the start of the test.

TABLE 35 - EXPERIMENTAL DESIGN OF TRIAL VI

Concentrate:Roughage	Crude Protein Level %	Physical Form	Number Lambs
35:65	10	Pellet	8
		Meal	8
	12	Pellet	8
		Meal	8
	14	Pellet	8
		Meal	8
	16	Pellet	8
		Meal	8
56:44	10	Pellet	8
		Meal	8
	12	Pellet	8
		Meal	8
	14	Pellet	8
		Meal	8
	16	Pellet	8
		Meal	8

Results and Discussion

A comparison of gains of lambs fed low and high concentrate rations was made after four weeks on test to determine differences in performance during this period of relatively cool temperatures and the remainder of the trial. During this period the lambs on low concentrate rations outgained those receiving more concentrates. This is shown in Table 37. Part of the difference could be due to fill since it appeared on observation that possibly the lambs on the low concentrate rations were fuller when they were weighed at the end of 29 days. Since no carcass yield data was available at this time this factor could not be accurately compared.

TABLE 36 - FORMULATION OF EXPERIMENTAL RATIONS (TRIAL VI)

Crude Protein (%)	Alfalfa Hay (%)	Black-strap Molasses (%)	Ground Ear Corn (%)	44% Soybean Oil Meal (%)	Alfalfa Hay (%)	Black-strap Molasses (%)	Ground Ear Corn (%)	44% Soybean Oil Meal (%)
10	57.0	5.0	36.5	1.5	32.61	5.0	57.13	5.26
12	58.0	5.0	30.5	6.5	33.84	5.0	50.90	10.26
14	60.0	5.0	23.5	11.5	35.03	5.0	44.71	15.26
16	60.5	5.0	17.5	17.0	35.76	5.0	38.75	20.49

[1]Include average of rations used getting lambs on full feed.

TABLE 37 - EFFECT OF LEVELS OF CONCENTRATES AND CRUDE PROTEIN ON LAMB GAINS DURING THE FIRST PART OF TRIAL VI

Treatment	No. Lambs	Avg. Init. Wt. (lbs.)	29-day Wt. (lbs.)	Avg. Daily Gain (lbs.)
Low concentrate	64	72.64	92.42	.68
High concentrate	64	72.52	90.36	.61
10% protein	32	72.38	90.38	.62
12% protein	32	72.94	91.09	.62
14% protein	32	72.40	91.97	.67
16% protein	32	72.56	92.75	.70

However, even taking a difference of fill into account it is apparent that there would be little if any differences in gains in favor of lambs fed high concentrate rations during the early part of the test. Gain data during this period agree closely with those reported in Trial IV in which lambs were fed during the winter months, and no differences were observed in gains due to level of concentrates. It appears that the relatively low environmental temperatures during the early part of the trial may have caused an increase in utilization of the low concentrate ration. Temperatures during this period averaged 42.8 degrees Fahrenheit.

From the thirtieth day to the end of the trial the picture changed completely. During that period the lambs on the high concentrate rations gained significantly faster ($P < .01$) than those fed low concentrate rations, and average daily gains for the entire period were in their favor as shown in Table 38. They were also more efficient in feed utilization although lambs on low concentrates had slightly higher feed intake. Lambs fed the high concentrate rations also had significantly higher carcass yields and grades ($P < .01$).

TABLE 38 - COMPARISON OF HIGH AND LOW CONCENTRATE RATIONS FOR FATTENING LAMBS (TRIAL VI)

Treatment	High Conc.	Low Conc.
No. lambs	64	64
Avg. initial wt. (lbs.)	72.52	72.64
Avg. final wt. (lbs.)	102.56	101.67
Avg. days on feed	62.91	70.12
Avg. daily gain (lbs.)	.48	.41
Avg. daily feed intake (lbs.)	3.89	4.05
Feed/lb. gain (lbs.)	8.14	9.79
Avg. carcass yield (%)[1]	45.78**	43.95
Avg. carcass grade[2]	7.64**	6.55

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA carcass grades were assigned values as follows: medium choice 8, low choice 7, high good 6, medium good 5.

**$P < .01$.

It is evident that the lambs fed the high concentrate ration were decidedly superior during the last part of this trial as evidenced by their gains and carcass characteristics. Temperatures averaged approximately 55 degrees F. during the period and may partly explain the greater difference in performance of lambs fed low and high concentate rations in the last portion compared to the first 29 days.

There appeared to be a definite protein effect since rate of gain tended to increase for each level of protein fed (Tables 38 and 39). This is in agreement with findings in earlier trials and the work of several investigators cited in the literature review. Gains of lambs fed 14 and 16 percent protein were significantly higher than those fed 10 and 12 percent crude protein rations ($P < .05$). There was no significant difference between the two higher protein rations. Lambs on the 14 percent protein ration gained slightly faster than those fed 16 percent.

TABLE 39 - EFFECT OF LEVEL OF CRUDE PROTEIN IN RATIONS FOR FATTENING LAMBS (TRIAL VI)

Crude Protein (%)	10	12	14	16
No. lambs	32	32	32	32
Avg. initial wt. (lbs.)	72.38	72.94	72.40	72.56
Avg. final wt. (lbs.)	99.87	101.31	103.37	103.90
Avg. days on feed	68.06	66.69	64.62	66.69
Avg. daily gain (lbs.)	.40	.42	.48	.47
Avg. daily feed intake (lbs.)	4.00	3.84	4.23	3.92
Feed/lb. gain (lbs.)	9.90	9.05	8.84	8.33
Avg. carcass yield (%)[1]	45.28	44.99	44.58	44.63
Avg. carcass grade[2]	7.00	7.16	7.25	6.98

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA carcass grades were assigned values as follows: medium choice 8, low choice 7, high good 6, medium good 5, low good 4.

*$P < .05$.

For optimum gains using this type of complete mixed rations, it appears that levels of crude protein should be slightly higher than the 11 percent figure recommended by the National Research Council for Sheep (1957). Apparently the higher protein levels do not significantly affect either carcass yields or grades.

The effect of various combinations of levels of concentrate and protein is shown in Table 40. Best gains and feed efficiency were made on high concentrate-high protein combinations which agrees with the earlier work reported. This again suggests that a high level of energy may be required for maximum utilization of high protein rations as measured by daily gains of lambs. There was quite a lot of variation in gains which may account for these differences being non-significant statistically. Lambs fed the 16 percent crude protein in combination with the high concentrate ration made faster and more efficient gains than lambs on any other treatment.

The value of pelleting lamb rations is shown in Tables 41 and 42. These results agree with reports cited in the literature as well as those obtained in

TABLE 40 – INTERACTION BETWEEN PROTEIN AND CONCENTRATE LEVELS FOR FATTENING LAMBS (TRIAL VI)

Crude Protein (%) Concentrate	10 Low	10 High	12 Low	12 High	14 Low	14 High	16 Low	16 High
No. lambs	16	16	16	16	16	16	16	16
Avg. initial wt. (lbs.)	72.31	72.44	72.94	72.00	72.38	72.44	72.94	72.18
Avg. final wt. (lbs.)	99.81	99.94	100.44	102.18	103.18	103.56	103.25	104.56
Avg. days on feed	71.50	64.62	71.50	61.88	67.38	61.88	70.12	63.25
Avg. daily gain (lbs.)	.38	.43	.38	.47	.46	.50	.43	.51
Avg. daily feed intake (lbs.)	4.19	3.80	3.74	3.96	4.25	4.22	4.00	3.79
Feed/lb. gain (lbs.)	10.89	8.92	9.71	8.38	9.30	8.38	9.27	7.40
Avg. carcass yield (%)[1]	44.41	45.95	44.23	45.73	43.10	46.06	44.06	45.20
Avg. carcass grade[2]	6.82	7.50	6.56	7.75	6.82	7.69	6.00	7.95

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2]USDA carcass grades were assigned values as follows: medium choice 8, low choice 7, high good 6, medium good 5, low good 4.

TABLE 41 - EFFECT OF PELLETING FEED FOR FATTENING LAMBS (TRIAL VI)

	Pellets	Meal
No. lambs	64	64
Avg. initial wt. (lbs.)	72.38	72.78
Avg. final wt. (lbs.)	104.15	100.09
Avg. days on feed	64.28	68.75
Avg. daily gain (lbs.)	.49**	.40
Avg. daily feed intake (lbs.)	4.29	3.72
Feed/lb. gain (lbs.)	8.69	9.37
Avg. carcass yield (%)[1]	44.90	44.85
Avg. carcass grade[2]	7.39*	6.80

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA carcass grades were assigned values as follows: medium choice 8, low choice 7, high good 6, medium good 5, low good 4.

**$P < .01$.

*$P < .05$.

TABLE 42 - INTERACTION BETWEEN LEVEL OF CONCENTRATES AND FORM OF RATION FED IN TRIAL VI

Physical Form Concentrate Level	Pellets High	Pellets Low	Meal High	Meal Low
No. lambs	32	32	32	32
Avg. initial wt. (lbs.)	72.31	72.44	72.72	72.84
Avg. final wt. (lbs.)	104.34	103.94	100.78	99.40
Avg. days on feed	61.88	66.69	63.94	73.56
Avg. daily gain (lbs.)	.52	.47	.44	.36
Avg. daily feed intake (lbs.)	4.16	4.42	3.73	3.71
Feed/lb. gain (lbs.)	8.02	9.36	8.51	10.27
Avg. carcass yield (%)[1]	45.53	44.26	46.06	43.64
Avg. carcass grade2	7.66	7.12	7.63	5.97*

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]USDA carcass grades were assigned values as follows: medium choice 8, low choice 7, high good 6, medium good 5, low good 4.

Trial IV. Lambs fed pelleted rations made significantly faster gains ($P<.01$) than those fed meal. There was no difference in carcass yields, but carcass grades of lambs were significantly higher ($P<.05$). Feed intake was higher for lambs fed pelleted rations in this trial, as in Trial IV.

The advantage of pelleted rations over a meal form again was slightly greater among low concentrate rations than among high concentrate rations on the basis of gain. The effect on carcass grades was even greater. Lambs fed a low concentrate ration in a meal form had significantly lower grades ($P<.05$) than any other group.

Due to their ability to gain faster and fatten more quickly, lambs fed pelleted rations also required less time on feed before being marketed.

Trial VII—Effect of Environmental Temperature on Lambs Fed High and Low Concentrate Rations

Objectives of Trial VII

1. To compare lambs fattened in cool and warm temperatures.
2. To determine the effect of shearing on gains of lambs fed at two temperature levels.
3. To observe the effect of a high and low concentrate ration on lambs fed at two different environmental temperatures.

Materials and Methods

Forty uniform Texas feeder lambs were selected for the test. They were assigned at random to a 2 x 2 x 2 factorially designed experiment. Factors compared were 60 percent versus 35 percent concentrate rations, shorn versus wooled lambs, and cool versus a warmer controlled temperature.

Twenty lambs were placed inside, five lambs to a lot, and 20 were placed in similar sized pens outside. Feeding and watering facilities as well as available space were similar for both groups of lambs. Lambs were started on feed March 24, 1961, and fed for 80 days. Two lots inside and two lots outside were sheared March 28, 1961.

The mean environmental temperature of the quarters occupied by lambs fed outside was 45.1 degrees F. Fluctuation of temperature for the period ranged from 54.5 to 35.6 degrees F. The inside quarters were heated by steam and averaged 73.8 degrees F. Temperatures inside were not constant, however, and would vary approximately 20 degrees F. in a 24-hour period.

Half of the lambs were fed on a ration containing approximately 60 parts concentrate to 40 parts roughage and the remainder on a 35:65 concentrate to roughage ratio. Composition of the rations are shown in Table 43.

Results and Discussion

As shown in Table 44 there was very little difference between lambs fed at the two temperature levels. A comparison of lambs on different temperature and

TABLE 43 - FORMULATION OF EXPERIMENTAL RATIONS
(TRIAL VII)

	High Concentrate[1] %	Low Concentrate[1] %
1st cutting alfalfa hay	28	57
Blackstrap molasses	5	5
Ground ear corn	61	36.5
44% soybean oil meal	6	1.5

[1]Both rations were pelleted.

TABLE 44 - EFFECT OF ENVIRONMENTAL TEMPERATURE ON FATTENING LAMBS
(TRIAL VII)

Temperature	Warm	Cool
No. lambs	20	20
Avg. initial wt. (lbs.)	76.4	77.0
Avg. final wt. (lbs.)	102.4	103.0
Days on feed	80	80
Avg. daily gain (lbs.)	.32	.32
Avg. daily feed intake (lbs.)	3.74	3.67
Feed/lb. gain (lbs.)	11.5	11.3
Avg. carcass yield (%)[1]	42.2	42.9
Avg. carcass grade[2]	5.6	5.3

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]Carcass grades were assigned values as follows: Swift Premium 6, Swift Select 5.

concentrate combinations is made in Table 45. Gains of lambs fed a high concentrate ration compared favorably with those fed a low concentrate ration in warm temperatures, and they yielded 6.6 percent higher. On an equal yield basis the performance of lambs fed the high concentrate ration tended to be superior to those fed high roughage rations. The trend was in the same direction of earlier trials conducted during the summer months where lambs fed high concentrate rations were superior.

There were no significant differences in performance of lambs fed high or low concentrate rations at a cool environmental temperature; however, lambs fed the high concentrate ration were slightly superior. If difference in temperature between lots could have been decreased, it is possible that a more valid comparison could have been made.

TABLE 45 - EFFECT OF LEVEL OF CONCENTRATES AND ENVIRONMENTAL TEMPERATURE ON FATTENING LAMBS (TRIAL VII)

Concentrate Temperature	High Warm	High Cool	Low Warm	Low Cool
No. lambs	10	10	10	10
Avg. initial wt. (lbs.)	76.5	77.9	76.2	76.2
Avg. final wt. (lbs.)	101.6	106.0	103.1	102.0
Days on feed	80	80	80	80
Avg. daily gain (lbs.)	.31	.35	.34	.32
Avg. daily feed intake (lbs.)	3.69	3.75	3.76	3.83
Feed/lb. gain (lbs.)	11.8	10.7	11.2	11.9
Avg. carcass yield (%)[1]	43.5	43.2	40.8	42.6
Avg. carcass grade[2]	5.8	5.4	5.3	5.2

[1] Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2] USDA carcass grades were assigned values as follows: Swift Premium 6, Swift Select 5.

The principal advantage of feeding high concentrate rations under the two levels of temperature used in this trial was higher carcass yields. The average yield of all lambs fed the high concentrate ration was 43.4 percent compared to an average of 41.7 percent for lambs fed low concentrate rations. This was statistically significant ($P<.05$). As shown in Table 46 lambs on the high concentrate ration also gained slightly faster and more efficiently.

Shearing lambs appeared to increase average daily gains and improve feed efficiency as shown in Table 47; however, all of this advantage was due to shearing lambs in the high temperature lots (Table 48).

Shorn lambs subjected to cool temperatures failed to gain as fast and were less efficient in converting their feed than wooled lambs. These lambs were observed to shiver and appeared cold especially during the first part of the trial.

Temperatures during the early part of the trial averaged approximately 44 degrees F. which was below "critical temperatures" for sheep as reported by Graham *et al.* (1959). They found that the "critical temperature" for sheep was 39 to 40 degrees Centigrade, 33 degrees Centigrade, and 24 to 27 degrees Centigrade for closely clipped sheep fed 600, 1,200, and 1,800 grams of dried grass cubes per day respectively. Below these temperatures the source of additional heat was entirely increased fat catabolism.

Blaxter *et al.* (1959) observed that closely clipped sheep shivered below temperatures of 23 degrees Centigrade. They found that sheep with fleeces, in contrast to closely clipped sheep, had very wide thermo neutral zones. It was shown that a heavy fleece both depresses the critical temperature and minimizes the effect of reducing environmental temperature below the critical. The wooled

TABLE 46 - EFFECT OF LEVEL OF CONCENTRATES IN RATIONS OF FATTENING LAMBS (TRIAL VII)

Concentrate Level	High	Low
No. lambs	20	20
Avg. initial wt. (lbs.)	77.2	76.2
Avg. final wt. (lbs.)	103.8	102.6
Days on feed	80	80
Avg. daily gain (lbs.)	.33	.33
Avg. daily feed intake (lbs.)	3.72	3.80
Feed/lb. gain (lbs.)	11.2	11.5
Avg. carcass yield (%)[1]	43.4*	41.7
Avg. carcass grade[2]	5.6	5.2

[1] $\text{Carcass yield (\%)} = \frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2] Carcass grades were assigned values as follows: Swift Premium 6, Swift Select 5.

*$P < .05$.

TABLE 47 - EFFECT OF SHEARING FATTENING LAMBS (TRIAL VII)

	Shorn	Wooled
No. lambs	20	20
Avg. initial wt. (lbs.)	76.8	76.6
Avg. final wt. (lbs.)	104.4	101.9
Days on feed	80	80
Avg. daily gain (lbs.)	.34**	.32
Avg. daily feed intake (lbs.)	3.76	3.73
Feed/lb. gain (lbs.)	10.9	11.8
Avg. carcass yield (%)[1]	42.7	42.4
Avg. carcass grade[2]	5.4	5.5

[1] $\text{Carcass yield} = \frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2] Carcass grades were assigned values as follows: Swift Premium 6, Swift Select 5.

**$P < .01$.

TABLE 48
INTERACTION BETWEEN SHEARING AND ENVIRONMENTAL TEMPERATURE ON FATTENING LAMBS
(TRIAL VII)

	High Temp.		Low Temp.	
	Shorn	Wooled	Shorn	Wooled
No. lambs	10	10	10	10
Avg. initial wt. (lbs.)	76.6	76.1	77.1	77.0
Avg. final wt. (lbs.)	106.5	98.2	102.4	105.6
Days on feed	80	80	80	80
Avg. daily gain (lbs.)	.37	.28	.32	.36
Avg. daily feed intake (lbs.)	3.73	3.59	3.76	3.82
Feed/lb. gain (lbs.)	10.0	13.0	11.9	10.7
Avg. carcass yield (%)[1]	42.4	41.9	43.0	42.8
Avg. carcass grade[2]	5.6	5.5	5.1	5.5

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100$.

[2]Carcass grades were assigned values as follows: Swift Premium 6, Swift Select 5.

lambs when fed in warm temperatures were more affected by the heat than shorn lambs; and while there was little difference in feed intake, they were less efficient in feed utilization. Results by lots are shown in Table 49.

The average daily gain figures indicate that the amount of fleece on fattening lambs may be important, depending on the temperatures. Wooled lambs made lowest gains in warm temperatures, and shorn lambs in cool environmental temperatures. Differences in amounts of fleece would be expected to modify or emphasize the effect of temperature on performance of lambs. On the other hand, differences in environmental temperature would certainly influence results which have been reported regarding the value of shearing fattening lambs.

TABLE 49 - PERFORMANCE OF LAMBS BY LOTS IN TRIAL VII

	Cool Temperature				Warm Temperature			
Treatment	High Conc. Wool	High Conc. Shorn	Low Conc. Wool	Low Conc. Shorn	High Conc. Wool	High Conc. Shorn	Low Conc. Wool	Low Conc. Shorn
No. lambs	5	5	5	5	5	5	5	5
Avg. initial wt. (lbs.)	75.8	80.0	78.2	74.2	74.6	78.4	77.6	74.8
Avg. final wt. (lbs.)	104.2	107.8	107.0	97	94.6	108.4	101.6	104.6
Days on feed	80	80	80	80	80	80	80	80
Avg. daily gain (lbs.)	.36	.35	.36	.28	.25	.38	.30	.37
Avg. daily feed intake (lbs.)	3.80	3.71	3.85	3.73	3.50	3.64	3.63	3.79
Feed/lb. gain (lbs.)	10.7	10.7	10.7	13.1	13.9	9.7	12.1	10.2
Avg. carcass yield (%)[1]	42.9	43.6	42.4	42.8	43.1	43.9	40.7	41.0
Avg. carcass grade[2]	5.4	5.4	4.8	5.6	5.8	5.8	5.2	5.4

[1]Carcass yield (%) = $\frac{\text{chilled carcass weight}}{\text{weight out of feed lot}} \times 100.$

[2]Carcass grades were assigned values as follows: Swift Premium 6, Swift Select 5.

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