THE EFFECT OF ANIMAL TALLOW AND HYDROLYZED VEGETABLE AND
ANIMAL FAT ON RATION UTILIZATION AND RUMEN VOLATILE
FATTY ACID PRODUCTION WITH FATTENING STEERS

by

Grant M. Esplin

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SIGNED: Grant M. Exlin

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

William H. Hale
William H. Hale
Professor of Animal Science

August 17, 1962
Date

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INTRODUCTION

Fattening cattle are normally fed rations that contain both grain and roughage. Thus by lowering the roughage level of the ration and increasing the grain it is easy to increase the available energy of the ration. However, it appears that some roughage must be included in the ration from a management point of view as well as for maintaining a proper physical form of the ration.

On a weight basis, fat contains approximately 2.25 times as many metabolizable calories as does grain. The poultry industry has taken advantage of this fact to increase the energy content of broiler rations. The increased energy content of the broiler ration has resulted in marked improvement of performance and feed efficiency.

Since beef cattle are competing with poultry and swine for the consumers dollar and available concentrate supplies, methods of increasing performance and efficiency of gain are under investigation. The addition of fat to cattle rations offers an opportunity in this area.

Prior to 1950 the soap industry was the primary user of fats. In the early 1950's the industry largely changed to the production of detergents which caused a surplus of fats and depressed fat prices. The price of fat was depressed to the point that it was economically feasible to feed large amounts to livestock. At this time there was relatively little information available concerning the utilization of added dietary fat to animal rations.

Experimental studies have indicated good utilization of 4 to 5% added dietary animal fat provided the steer fattening ration contained at least 50% alfalfa hay. Studies with higher concentrate rations were less conclusive and suggested in many instances a depressing effect from the added fat.

Most of the experimental studies with the addition of fat to rations of fattening steers have been conducted with tallow. For the most part this fat has been a by-product of the meat packing industry and contains a mixture of beef tallow, sheep tallow and swine fat. Also available is the fat from the vegetable oil producing crops. In many instances the fat is hydrolyzed and the free fatty acids are available for feeding. The price of glycerol is such that the free fatty acids frequently sell for less than the fat.

The purpose of the experiment reported in this thesis was to study the effect of feeding tallow and hydrolyzed vegetable-animal fat to fattening steers. The effect of the fat in the following areas was determined:

1. Digestion of ration components.
2. Digestion of dietary energy.
3. Production of rumen volatile fatty acids.
4. Utilization of ration carotene.
5. Digestion of the added fat.
6. Gain and efficiency of feed conversion.

REVIEW OF LITERATURE

Nearly all reports of experimental work found on the effect of added fat in steer fattening rations relate to information on performance and feed efficiency. Only limited metabolism studies with steers on the effect of added fat were found in published literature. Several metabolism studies as well as growth studies on the effect of added fat in sheep rations have been conducted. The digestive systems of the two species are very similar, thus the studies conducted with sheep are included in this review.

In 1926, Maynard and McCay (24) demonstrated that the natural fat of feedstuffs was important as an energy component of the ration. When a dairy cow ration was benzene extracted to reduce the fat from 5.8% to 0.66%, there was a drop in milk production. When the non-extracted ration was fed, milk production returned to normal. No studies were conducted to determine the effect of additional fat in a dairy cow ration.

Swift et al (31) (32) added fat to lamb fattening rations to give a total ether extract content of 6.4% and 9.7%. The 6.4% level resulted in increased digestibility of all components while the 9.7% decreased digestibility of all components except ether extract. Swift et al (33) later showed that apparent digestibility of crude fiber was significantly increased from 43 to 53.8% by the addition of alfalfa ash to a sheep ration that contained 40% corn cobs and 5% corn oil. Total digestible nutrients were also significantly increased but dry

matter, crude protein, ether extract, nitrogen free extract and energy were not.

Tillman et al (34) fed wether lambs a ration containing 2.4% corn oil and 60% cottonseed hulls. The addition of 28 grams per head per day of alfalfa ash significantly increased digestibility of all ration components. There was a marked loss of weight of sheep on the basal ration, and this trend was reversed by the addition of alfalfa ash. Synthetic alfalfa ash promoted weight gains equal to natural alfalfa.

Brooks et al (8) found that the addition of corn oil significantly depressed in vivo cellulose digestion in sheep fed a 90% cottonseed hull ration as well as in vitro cellulose digestibility. Feeding 18 grams of alfalfa ash per head per day restored cellulose digestion at the 32 gram per head per day added fat level and partially restored digestion when 64 grams of fat were fed per head per day. Both corn oil and lard depressed cellulose digestibility. The added fat lowered the production of volatile fatty acids in the rumen. Addition of alfalfa ash restored volatile fatty acid production to normal.

Rhodes et al (27) added 1.8, 3.0 and 4.2% corn oil to rations containing from 65 to 80% cottonseed hulls and found that corn oil additions decreased digestibility of both cellulose and protein. The addition of alfalfa ash restored digestibility of these components to normal.

Summers et al (30) found that the addition of alfalfa ash to a ration containing 80% corn cobs had no effect on the digestibility

of cellulose, organic matter or crude protein. The addition of 2% corn oil to a ration containing 65% corn cobs resulted in a significant reduction in cellulose, organic matter and crude protein digestibility which was completely reversed when alfalfa ash was added to the ration.

Tillman and Brethour (35) conducted an experiment on the effect of 7.5% added corn oil on digestibility of calcium and phosphorus with sheep. The added corn oil did not effect the digestibility of phosphorus but had a significant effect on apparent and true digestibility of dietary calcium, resulting in a decrease in net retention of dietary calcium which closely paralleled the increase in the fecal excretion of calcium.

Brethour et al (7) added 15% animal fat to a sheep basal ration containing cottonseed hulls and found that the added fat significantly reduced the digestibilities of dry matter, organic matter and weight gains. The addition of alfalfa ash, sodium bicarbonate or potassium bicarbonate to the high fat ration did not improve weight gains, but the bicarbonate salts tended to depress feed intake and gain. In another experiment it was shown that the addition of 10% corn oil reduced gains regardless of whether it was absorbed by the concentrate or roughage portion of the ration.

Davison and Woods (9) conducted two digestibility trials with sheep and in vitro studies to determine the effect of corn oil and fatty acids on the digestibility of a ration containing 46% corn cobs. Five percent corn oil, 5% of a mixture of fatty acids, 1% lauric acid, 5% stearic acid and 5% oleic acid significantly decreased the digestibility of ether extract. All but lauric acid significantly decreased

the digestibility of ash. In the in vitro studies various fatty acids and glycerol were added at rates of 25 milligrams per 20 mls. of rumen fluid. Butyric acid, valeric acid and glycerol significantly increased cellulose digestion. Acetic and caproic acids had no effect at the levels used. The saturated, even number fatty acids from C₈ to C₁₈ had a significant depressing effect on cellulose digestion by rumen bacteria. The unsaturated fatty acids, oleic and linoleic acids significantly decreased cellulose digestion.

Davison and Woods (10) reported a second experiment in 1960 on the influence of minerals and fat additions on digestibility and performance of fattening lambs. They found that 0.4% calcium added to the basal ration containing 0.3% calcium as chloride or carbonate alleviated the depressing effects of 5% corn oil upon the digestibility of organic matter, protein, and cellulose. Calcium or corn oil did not alter the digestibility of a ration containing 40% alfalfa hay. The addition of 5% corn oil saved about 1 pound of feed per pound of gain in a fattening ration when it contained 40% alfalfa hay but did not result in increased efficiency of feed conversion when 40% corn cobs were used in the ration. Rate of gain, carcass grade and dressing percent were not significantly effected.

Davison and Woods (11) conducted a third trial, with lambs, on the effects of adding 5% fat and calcium on the digestibility of ration components and ration energy. They found 5% corn oil decreased digestibility of components in a ration containing corn cobs but that the addition of 1% or more of CaCO₃ to the rations containing corn oil increased digestibility of organic matter, protein and cellulose to

levels above that of the control ration. The addition of CaCO_3 increased calories digested from corn oil or starch added to corn cob rations. Energy from corn oil was not efficiently utilized when the ration contained less than 0.3% calcium. Five percent corn oil or 1% calcium did not appear to alter the digestibility of a ration containing 40% alfalfa hay. The energy of corn oil was well digested when incorporated in the alfalfa hay ration.

White et al (37) found that 5% corn oil additions to two different rations containing 65% corn cobs and 77% cottonseed hulls fed to mature wethers progressively decreased cellulose digestion the first 40 days and that it took 17 days to return to normal after the oil was removed from the ration. When 30 grams of alfalfa ash or 4.4 grams of calcium or a combination of 4.4 grams of calcium and 0.86 grams of phosphorus was added, digestibility was restored to normal. Phosphorus alone (0.86 gm.) or a mineral mixture of Cu, Mo, Mn, Co, Fe, Zn and B did not restore digestibility.

Grainger et al (16) using a ration similar to that of White et al (37), conducted a study, with wethers, to determine the effects of various rations and corn oil on fecal soap excretion and cellulose digestion. The addition of 7% corn oil to the basal ration decreased apparent digestibility of protein, cellulose, calcium and true digestibility of calcium. Increased insoluble fecal soaps were found to be associated with the decreased calcium digestibility. The addition of 4.4 grams of calcium or 6.2 grams of iron to the rations alleviated or partially alleviated the effect of corn oil on cellulose and protein digestibility.

In 1952, Willey et al (38) reported that feed utilization of fattening steers improved markedly when 5% cottonseed oil was added to rations that contained 20% alfalfa and 30% cottonseed hulls and the high fat ration produced more saturated body fat.

A series of 4 trials were conducted from 1954 to 1956 at Nebraska where various rates and types of fat were added to standard midwest feedlot steer fattening rations. In the first trial, Matsushima et al (20), added 2.67% corn oil or 2.87% tallow to a ration that contained 14% brome and 86% concentrate. The corn oil became rancid which resulted in depressed feed consumption. The average daily gain for the corn oil fed steers was 1.74 pounds compared to 2.11 pounds for the standard midwest feeding ration. Beef tallow fed at 0.67 to 0.75 pound per day resulted in an average daily gain of 2.00 pounds. No digestive disturbances or differences in carcass quality were observed.

In the second trial Matsushima et al (21) used edible and inedible tallow and found no difference between the two under conditions of the experiment. As the level of fat increased from 0.44 to 1.2 pounds per day, rate of gain was progressively depressed. Alfalfa was fed to all lots and accounted for 16 to 21% of the ration. Ground corn cobs was also fed in all rations and accounted for 11, 20 and 30%, respectively, in rations supplying 0.42, 0.85 and 1.2 pounds of added fat per day. No digestive disturbances were caused by either fat and there were no apparent differences in carcass grade, color or hardness of fat.

In the third trial Matsushima et al (22) added $\frac{1}{2}$, 1 and $1\frac{1}{2}$ pounds of tallow per steer per day to rations containing 25% alfalfa

and 75% concentrate. The average daily gains were 2.35, 2.36 and 2.23 pounds, respectively. The energy from high grade inedible tallow was utilized almost as efficiently as the energy from corn when the level of tallow did not exceed 1 pound per head daily. They assumed the total digestible nutrient value of the fat to be 202.5% ($2.25 \times 90\%$ digestibility). At this rate the pounds of total digestible nutrients consumed per 100 pounds gain was 700.4, 698.6 and 729.9 respectively for the $\frac{1}{2}$, 1 and $1\frac{1}{2}$ pounds of fat fed per day. No digestive disturbances were noted for levels of $\frac{1}{2}$ or 1 pound but scouring occurred on the $1\frac{1}{2}$ pound level.

In the fourth experiment Matsushima et al (23) found $\frac{1}{2}$ pound of inedible grease per steer per day increased gains and feed efficiency, whereas 1 pound resulted in little or no improvement in gain or efficiency. Where stilbesterol was fed neither level of fat improved performance. Stilbesterol improved gain and efficiency more on rations where no fat was added than when fat was added. Scouring by all animals receiving grease did not effect appetite. There was no difference in dressing percentage. All the rations in the experiment contained 20% alfalfa and 80% concentrate.

In 1956 Erwin et al (13) reported that the addition of 7% fat to a fattening ration containing 50% alfalfa increased rate of gain while the added fat depressed the rate of gain when the ration contained 50% straw.

Robinson et al (28) found that adding 5% corn oil to a ration of prairie hay and 1 pound of cottonseed meal per day to wintering Hereford steers increased nitrogen retention.

Ten percent corn oil was added to a steer basal ration containing 69% cottonseed hulls and 1.4% dicalcium phosphate in 1957 by Ward et al (36). Digestibility of all ration components, except fat, were significantly reduced by the addition of 10% corn oil to the basal ration. Addition of alfalfa ash partially alleviated the detrimental effect of corn oil on digestibility.

Bohman, Wade and Hunter (5) added 5 and 10% animal fat to steer fattening rations that contained about 50% alfalfa. The 5% fat significantly increased gains. The performance on the 10% fat ration was not significantly different than the control. The levels of fat decreased the amount of feed required per pound of gain by 23 and 16% for the 5 and 10% added fat.

Bohman, Wade and Torrell (6) added 0 and $\frac{1}{2}$ pound per day (about 5% animal fat to wintering rations of weaner calves. This study showed no response to added fat in terms of winter gains or feed efficiency. The animals fed fat in the winter gained faster the following summer than those that had not received fat. The added fat had no effect on liver storage of carotene but decreased the storage of vitamin A in the winter period.

Hubbert et al (17) reported two tests that were conducted in 1960 and 1961. In both of these tests 4% fat was added to low and high protein rations and compared with controls. In trial one, 4% added fat increased feed efficiency, resulted in less feed intake, but had no significant effect on gain, although gain was slightly less. Ground limestone at 0.1% level had no significant effect on gain however it showed a slight tendency to depress animal performance. High

protein and added tallow effects were additive on feed performance. In trial II, 4% added tallow and 1% dicalcium phosphate increased rate of gain at both levels of crude protein.

Page et al (25) reported less storage of hepatic vitamin A when steers were fed a ration containing 10% tallow. The basal ration contained 25% alfalfa and 40% cotton gin trash. They also reported that added tallow caused a decrease in digestibility of crude fiber, nitrogen free extract and ash. The fat increased digestibility of crude protein and ether extract.

It is now known that volatile fatty acid production in the rumen provides the major energy metabolites for the ruminant animal. As there are several excellent reviews in this area, Anonymous (1), Edwards (12) and Phillipson (26), this aspect will not be included in this review. Blaxter (4) has shown that the calorimetric efficiency in sheep for acetic acid is 32.9%, propionic acid 56.3% and 61.9% for butyric acid. Mixtures in various proportions in general increased in calorimetric efficiency as the percent of propionic acid increases with a corresponding decrease in acetic acid. Little information was found by the writer on the effect of added dietary fat upon the total production of volatile fatty acids or ratio of the various acids.

SUMMARY OF REVIEW OF LITERATURE

Work that has been conducted on the addition of fat to the ration of beef cattle has left many important questions as to feeding added fat in practical feedlot rations. No reports were found in the literature on ration component digestibility and production of volatile fatty acids in the rumen as influenced by the addition of fat to a practical feedlot ration. The investigation reported in this thesis was designed to determine the influence of added fat on ration component digestibility and production of volatile fatty acids in the rumen of fattening steers on a practical ration.

The general review of literature shows that if 40 to 50% alfalfa is included in the rations with added fat, performance will be at least equal to that with rations containing no fat. Where low quality roughage, such as corn cobs or cottonseed hulls, is used performance declines. The addition of alfalfa ash or alfalfa to low quality roughage rations containing 5% fat restored digestibility of ration components in in vivo sheep studies. Only partial restoration of digestibility was noted where 10% fat was added.

Metabolism trials with both cattle and sheep fed low quality roughage rations showed that the addition of fat depressed the digestibility of crude fiber, cellulose and nitrogen free extract more than was true for other components. Crude protein digestibility was usually depressed to a lesser extent while ether extract digestibility increased due to the high digestibility of the added fat.

EXPERIMENTAL PROCEDURE

Nine grade Hereford steer calves, purchased locally in September 1960, were placed on a vitamin A experiment until May 1961. Three additional grade yearling Hereford steers were purchased in May 1961. The 12 steers were placed on a standard steer fattening ration from May, 1961 to August 28, 1961 to allow the 9 steers that had been on the vitamin A experiment to recover from any of the effects of previous treatment. During this 82 day adjustment period the 12 steers gained an average of 2.39 pounds per head per day.

The nine steers that had been on the vitamin A experiment were randomly allotted into three treatments according to weight. The 3 steers purchased in May were randomly allotted to each of the three treatments. All animals were individually penned in concrete floored, partially covered pens providing 160 square feet of area per steer. The twelve individual stalls were divided into 4 groups so that the three treatments were represented within each of the 4 group positions throughout the research unit. The steers were full fed twice daily. Water and block salt were available ad libitum in the individual pens. Two day weights were taken at the initiation of the experiment on August 27 and 28. Single day weights were taken at 27 and 57 days. Two day weights were taken at the termination of the experiment on December 2 and 3, making a total of 97 days for the test. Daily feed records were kept for each steer.

The three experimental rations listed in Table 1 were: control, control plus 4% tallow and control plus 4% hydrolyzed vegetable-animal fat. The control ration is typical of rations fed the fattening cattle in Southwest feedlots. The dicalcium phosphate addition was made to the ration as Hubbert et al (17) had shown that additional dicalcium phosphate improves performance of fattening steers fed ratios containing 4% tallow. The fat was melted and added to the alfalfa hay just prior to grinding at the levels necessary to give the desired 4% fat level when the hay was mixed with the other ingredients of the ration. All feed was mixed at the University of Arizona experimental feed mill. The amount of feed mixed at one time was sufficient to feed for a 2 to 3 week period. Analysis of the two fats made by the Procter and Gamble Company at Cincinnati, Ohio are found in Table 2. Both fats were stabilized with an antioxidant. The tallow was a by-product of the meat packing industry and was solid at room temperature. The hydrolyzed vegetable-animal fat was a liquid at room temperature and as indicated in Table 2 contained 68% free fatty acids. The remainder of the product was largely tri-glycerides. As the product contained but little glycerol, the term hydrolyzed vegetable-animal fat may be somewhat of a misnomer but will be used in this thesis as the product is marketed by that name. This product was characterized by its high content of linoleic acid and reduced level of stearic acid when compared to the tallow.

During the 97 day feeding period two digestibility studies were conducted with each steer. Digestibility determinations were made on five day fecal collections using the total collection method.

Bags were placed on the steers seven days prior to collections to allow the steers to become accustomed to the collection bags and harness. The steers were on constant feed intake during the adjustment and collection periods. Feed refusal for each steer was weighed back at the end of the collection period and chemical determinations were made if more than 3 pounds were weighed back. Only five out of the 24 steers had sufficient weigh-back to require a chemical determination. Six steers were on collection at a time, two from each group as follows: first trial; steer numbers 7 through 12, October 1-5; steer numbers 1 through 6, October 9-13; second trial; steer numbers 7 through 12, November 5-9; steer numbers 1 through 6, November 12-16. Each day's collection of feces was thoroughly mixed and 10% aliquote samples were frozen. The samples were thawed and composited at the end of the collection period, oven-dried and ground in a wiley mill using a 40 mesh screen. Samples of each ration were collected daily during the digestion trial and composited. Chemical composition of both feed and feces were determined using AOAC (2) methods on the following components: dry matter, ether extract, crude fiber, ash, crude protein and nitrogen free extract. Percent digestibility was determined on all components by the following formula:

$$\frac{\text{intake} - \text{output in feces} \times 100}{\text{intake}}$$

Gross energy in all feed and feces samples was determined by use of the adiabatic bomb calorimeter.

Rumen samples were taken from each of the 12 steers, at four intervals during the study, by use of a stomach tube and electric

vacuum pump. One steer from each treatment was sampled on the following dates: September 19, 20, 21, 22; October 17, 18, 19, 20; November 20, 21, 22, 24; December 4, 5, 8, 12. Stomach pumping was done as near $3\frac{1}{2}$ hours after feeding as possible. Immediately following pumping, the rumen sample was strained through four thicknesses of grade 10 cheese cloth, centrifuged at 1500 RPM for three minutes and stored at 35° fahrenheit until the volatile fatty acid determination could be made. Volatile fatty acid determinations were by the method described by Keeny (19).

A liver biopsy sample was taken on each steer at the initiation of the trial for vitamin A determination. Total liver weight and a liver sample was also taken from each steer at time of slaughter. Hepatic vitamin A was determined by the method of Gallup and Hoefer (15). Ration carotene was determined twice weekly on all rations throughout the trial by AOAC (2) method.

All steers were weighed 24 hours after being taken off feed and were slaughtered 30 hours after being without feed. One steer from each treatment was slaughtered on each of the following days: December 7, 8, 13 and 14. Carcass weights were taken immediately after the animals were dressed and after 48 hours in the chill room. Dressing percentages were determined on the 48 hour chilled carcass weight.

The data were subjected to an analysis of variance as outlined by Steel and Torrie (29).

Table 1. Composition of Experimental Rations

	Control	Tallow	Hydrolyzed vegetable- animal fat
	Percent	Percent	Percent
Ground alfalfa	30.0	30.0	30.0
Molasses	7.0	7.0	7.0
Dry-rolled milo	28.5	26.0	26.0
Steam-rolled barley	28.5	26.0	26.0
Cottonseed meal	5.0	6.0	6.0
Dicalcium phosphate	1.0	1.0	1.0
Tallow	-	4.0	-
Hydrolyzed vegetable- animal fat	-	-	4.0
(Calculated analysis)			
Protein, Percent	12.17	12.11	12.11
Phosphorus, Percent	.44	.44	.44
Calcium, Percent	.82	.79	.79

Table 2. Analysis of the Tallow and Hydrolyzed Vegetable-animal Fat used in the Experimental Rations

Determination	Tallow Percent	Hydrolyzed vegetable- animal fat Percent
Total fatty acids	95.3	94.9
Free fatty acids	3.3	67.6
Moisture	0.1	0.1
Kerosene insolubles	0.0	0.2
Iodine value	49.8	100.4

Fatty Acid Composition (Vapor Phase Chromatography)

	Percent	Percent
C ₁₀	-	0.1
C ₁₂	0.1	0.2
C ₁₄	3.3	1.1
C ₁₄₋₋	1.1	-
C ₁₆	26.3	20.1
C ₁₆₋₋	4.1	1.2
C ₁₆₋₋₋	3.3	0.6
C ₁₈	19.4	6.5
C ₁₈₋₋	39.4	28.5
C ₁₈₋₋₋	3.0	41.7

RESULTS AND DISCUSSION

Performance and feed efficiency data are presented in Table 3 for the first 57 days and the total 97 day feeding period. The 57-day data are probably more reliable than the 97-day data due to the fact that steer number 10 in the treatment receiving hydrolyzed vegetable-animal fat gained only 1 pound in the last 40 days of the trial. At slaughter it was found that one of the kidneys of this steer had degenerated to the point that it was non-functional. This, no doubt, accounted for the low feed consumption and lack of gain during the last 40 days on feed. Consequently only the 57 day performance data will be discussed.

Due to the primary objectives of this experiment the numbers of animals involved are small thus the performance data can only be used as a guide. No doubt the digestion trials and rumen pumping of the steers had an effect on performance. However it is believed that the differences observed at 57 days in performance are similar to what might be expected in large group feeding trials with animals on similar rations.

For the first 57 days average daily gain was the same on all three treatments. These results are similar to those of Hubbert et al (17) trial I, and on one trial by Matsushima et al (20) although on another trial Matsushima et al (23) observed a 0.3 pound per head per day increase with $\frac{1}{2}$ pound per day of fat added and 0.12 pound per head

per day with 1 pound per day of fat added over controls where no stilbestrol was fed. During the first 57 days of this trial the tallow intake was approximately 0.8 pound per head daily while the intake for the steers on the hydrolyzed vegetable and animal fat was approximately 0.71 pound per head daily.

Table 3. Effect of tallow and hydrolyzed vegetable-animal fat on performance, feed intake, feed efficiency and dressing percent of fattening steers.

	Control	Tallow	Hydrolyzed vegetable- animal fat
FIRST 57 DAYS			
Avg. initial weight	818.6	877.2	795.6
Avg. daily gain, lb.	2.35	2.37	2.34
Avg. daily feed, lb.	19.68	19.93	17.80
Feed/lb gain, lb.	8.36	8.40	7.62
TOTAL 97 DAYS			
Avg. daily gain, lb.	1.99	2.12	1.81
Avg. daily feed, lb.	18.73	19.38	16.86
Feed/lb. of gain, lb.	9.39	9.13	9.29
Dressing percent*	61.61	62.92	62.73

*Avg. dressing percentage based on 48 hour chilled carcass weights.

Feed consumption was lower for the hydrolyzed vegetable-animal fat treatment than controls which is generally the case whenever fat is added to the ration of cattle. However, feed consumption of the tallow fed steers was similar to that of the controls.

Average feed efficiency of the hydrolyzed vegetable-animal fat treatment was higher than the control treatment, however this was non-significant due to the large variation of individual animals. Average feed efficiency of the tallow treatment was the same at 57 days as the controls.

Dressing percentages for the tallow and hydrolyzed vegetable-animal fat treatments were 1.31 and 1.12% higher than the control treatment.

A summary of the influence of tallow and hydrolyzed vegetable-animal fat on digestibility of ration dry matter is presented in Table 4. There was a non-significant increase in dry matter digestibility on the two fat treatments. This increase was due to the high digestibility of the two added fats as will be shown in later tables. (The digestibility of the dry matter in the hydrolyzed vegetable-animal fat treatment showed a slight increase over the tallow treatment.) Dry matter digestibility was significantly higher ($P < .05$) in trial I over trial II. A possible explanation for this might be that steers are able to utilize feed more efficiently during the first part of their feeding period than during the latter part. Jones et al (18) and Ward et al (36) have shown a decrease in ration dry matter digestibility due to added fats. However rations similar to those used in these studies are not available for comparison.

Digestibility of the gross energy of the ration is given in Table 5. The two fat treatments increased gross energy digestibility and is comparable to the increase in dry matter digestibility shown in Table 4. There was a significant ($P < .05$) decrease in energy

digestibility when trial II is compared to trial I. This decrease is not as apparent on the two fat treatments as in the control treatment.

Table 4. Effect of tallow and hydrolyzed vegetable-animal fat upon digestibility of ration dry matter.

TRIAL I		TRIAL II		AVERAGE OF 2 TRIALS
Steer No.	Percent Digested	Percent Digested	Percent Digested	Percent Digested
CONTROL				
1	71.88	66.16		69.02
5	69.94	67.61		68.78
8	71.60	62.50		67.05
12	<u>66.45</u>	<u>66.09</u>		<u>66.27</u>
Average	69.97	65.59		67.78
TALLOW				
3	69.33	68.08		68.71
4	71.22	69.04		70.13
9	70.40	71.55		70.96
11	<u>69.23</u>	<u>66.81</u>		<u>68.02</u>
Average	70.05	68.87		69.46
HYDROLYZED VEGETABLE-ANIMAL FAT				
2	73.94	72.02		72.98
6	68.87	64.56		66.22
7	69.65	69.40		69.52
10	<u>75.50</u>	<u>73.91</u>		<u>74.71</u>
Average	71.74	69.97		70.85
Average of 3 treatments				
	70.59*	68.14		

*($P < .05$)

Table 5. The effect of tallow and hydrolyzed vegetable-animal fat on digestibility of the gross energy of the ration.

TRIAL I			TRIAL II		AVG. OF 2 TRIALS	
Steer No.	Percent Dig.	Therms Dig./lb.D.M.	Percent Dig.	Therms Dig./lb.D.M.	Percent Dig.	Therms Dig./lb.D.M.
CONTROL						
1	71.25	1.404	65.87	1.310	68.56	1.357
5	68.81	1.356	66.91	1.331	67.86	1.344
8	71.36	1.420	60.73	1.193	66.05	1.307
12	<u>66.46</u>	<u>1.323</u>	<u>66.03</u>	<u>1.297</u>	<u>66.24</u>	<u>1.310</u>
Avg.	69.47	1.376	64.89	1.283	67.18	1.330
TALLOW						
3	69.44	1.452	68.47	1.405	68.96	1.429
4	70.98	1.485	68.44	1.404	69.71	1.445
9	68.66	1.410	71.00	1.478	69.83	1.444
11	<u>67.99</u>	<u>1.396</u>	<u>64.93</u>	<u>1.312</u>	<u>66.46</u>	<u>1.354</u>
Avg.	69.27	1.438	68.21	1.400	68.74	1.418
HYDROLYZED VEGETABLE-ANIMAL FAT						
2	73.25	1.512	70.28	1.450	71.77	1.481
6	66.96	1.382	63.03	1.301	65.00	1.342
7	69.47	1.419	68.79	1.435	69.13	1.427
10	<u>73.35</u>	<u>1.491</u>	<u>72.81</u>	<u>1.519</u>	<u>73.08</u>	<u>1.505</u>
Avg.	70.76	1.451	68.72	1.426	69.74	1.439
Average of 3 treatments						
	69.83*		67.27			

*(P<.05)

Digestibility of the gross energy of the ration as computed from TDN is shown on Table 6. There is good agreement between the digestible energy values found on this table and the values on Table 5 where digestible energy was determined from values obtained by the

use of the adiabatic bomb calorimeter.

Table 6. Effect of tallow and hydrolyzed vegetable-animal fat on digestibility of TDN of the ration.

TRIAL I			TRIAL II		AVG. OF 2 TRIALS	
Steer No.	Percent Dig.	Therms Dig./lb.D.M.	Percent Dig.	Therms Dig./lb.D.M.	Percent Dig.	Therms Dig./lb.D.M.
CONTROL						
1	69.33	1.388	66.09	1.323	67.71	1.356
5	68.23	1.366	67.82	1.358	68.03	1.362
8	70.31	1.408	62.71	1.256	66.51	1.332
12	<u>65.75</u>	<u>1.316</u>	<u>66.21</u>	<u>1.326</u>	<u>65.98</u>	<u>1.321</u>
Avg.	68.41	1.370	65.71	1.316	67.06	1.343
TALLOW						
3	69.51	1.392	72.07	1.443	70.79	1.418
4	74.33	1.488	73.03	1.462	73.68	1.475
9	73.92	1.480	72.43	1.450	73.18	1.465
11	<u>72.43</u>	<u>1.450</u>	<u>70.37</u>	<u>1.409</u>	<u>71.40</u>	<u>1.430</u>
Avg.	72.55	1.453	71.98	1.441	72.26	1.447
HYDROLYZED VEGETABLE-ANIMAL FAT						
2	76.02	1.522	76.01	1.522	76.02	1.522
6	70.02	1.402	68.68	1.375	69.35	1.389
7	71.77	1.437	72.72	1.456	72.25	1.447
10	<u>77.88</u>	<u>1.559</u>	<u>78.54</u>	<u>1.756</u>	<u>78.20</u>	<u>1.572</u>
Avg.	73.92	1.480	76.28	1.527	73.96	1.483

Digestibility of ether extract is presented in Table 7.

Page et al (25), Ward et al (36) and Jones et al (18) reported increased digestibility of ether extract where fat was added to the ration. As expected, the ether extract digestibility for the two fat

treatments were significantly ($P<.01$) larger than for the control treatment. There was no difference in the digestibility of the two fat treatments.

Table 7. The effect of tallow and hydrolyzed vegetable-animal fat on the digestibility of ration ether extract.

	TRIAL I	TRIAL II	AVG. OF 2 TRIALS
Steer No.	Percent Digested	Percent Digested	Percent Digested
CONTROL			
1	67.30	62.22	64.76
5	52.01	69.13	60.57
8	62.14	49.79	55.97
12	<u>56.23</u>	<u>60.40</u>	<u>58.31</u>
Avg.	59.44	60.39	59.90
TALLOW			
3	80.85	80.01	80.43
4	81.57	82.35	81.96
9	80.84	81.59	81.22
11	<u>77.18</u>	<u>74.25</u>	<u>75.71</u>
Avg.	80.11	79.55	79.83**
HYDROLYZED VEGETABLE-ANIMAL FAT			
2	82.70	86.17	84.44
6	78.92	76.98	77.95
7	72.46	72.97	72.71
10	<u>77.93</u>	<u>81.29</u>	<u>79.61</u>
Avg.	78.00	79.35	78.68**

**($P<.01$)

The results of calculations to determine digestibility of the fat added to the rations of steers in this experiment are shown on

Table 8. This calculation was made by assuming that the natural ether extract digestibility of the control rations and treated rations was the same. The amount of natural ether extract as determined by this method was subtracted from total ether extract fed the fat treatment steers. The natural ether extract digested was subtracted from the total ether extract digested as computed in the digestion trial. Percent digestion of added fat was then determined by dividing added fat digested by added fat fed.

The results show digestion of the hydrolyzed vegetable-animal fat to be 91.18% and the tallow to be 93.43% as compared to 59.90% for the ether extract digestibility in the control treatment.

Table 8. Digestibility of tallow and hydrolyzed vegetable-animal fat when fed in fattening rations to steers as determined by digestibility trials.

Steer No.	Trial I	Trial II	Avg. of 2 Trials
TALLOW			
3	92.41	95.82	94.12
4	93.52	100.01	96.77
9	92.88	99.75	96.32
11	<u>86.76</u>	<u>86.27</u>	<u>86.52</u>
Avg.	91.39	95.46	93.43
HYDROLYZED VEGETABLE-ANIMAL FAT			
2	94.97	104.84	99.91
6	89.16	89.41	89.29
7	81.13	83.07	82.10
10	<u>89.91</u>	<u>96.98</u>	<u>93.45</u>
Avg.	88.79	93.58	91.18

Table 9 gives the effect of tallow and hydrolyzed vegetable-animal fat on digestibility of ration nitrogen free extract. There was no significant difference in nitrogen free extract digestibility between treatments although the digestibility values for the hydrolyzed vegetable-animal fat were higher than the values for the tallow. There appears to be no difference between the two digestion trials except in the case of the controls where there was a decrease in nitrogen free extract digestion in the second trial as compared to the first trial.

Table 9. Effect of tallow and hydrolyzed vegetable-animal fat on digestibility of ration nitrogen free extract.

	TRIAL I	TRIAL II	AVG. OF 2 TRIALS
Steer No.	Percent Digested	Percent Digested	Percent Digested
CONTROL			
1	82.98	79.09	81.04
5	81.20	80.70	80.95
8	81.89	77.98	79.94
12	<u>78.48</u>	<u>76.86</u>	<u>77.67</u>
Avg.	81.14	78.66	79.90
TALLOW			
3	74.80	77.74	76.27
4	80.06	78.55	79.31
9	79.26	79.32	79.29
11	<u>79.24</u>	<u>78.92</u>	<u>79.08</u>
Avg.	78.34	78.63	78.49
HYDROLYZED VEGETABLE-ANIMAL FAT			
2	82.59	81.61	82.10
6	76.80	75.39	76.30
7	78.84	80.03	79.44
10	<u>85.21</u>	<u>86.29</u>	<u>85.75</u>
Avg.	80.86	80.83	80.90

The effect of tallow and hydrolyzed vegetable-animal fat on ration crude fiber digestibility is presented in Table 10. There was a larger variation in digestibility among animals for this ration component than any of the other components studied. This finding is not unusual and is probably due largely to the type of determination although replicate determinations on each sample agree closely. The digestibility of the crude fiber was lower in trial II than trial I for all three treatments. The crude fiber digestibility values were higher for the fat treatments than the controls. This difference was not significant, however.

Table 10. Effect of tallow and hydrolyzed vegetable-animal fat on digestibility of ration crude fiber.

Steer No.	TRIAL I Percent Digested	TRIAL II Percent Digested	AVG. OF 2 TRIALS Percent Digested
CONTROL			
1	32.62	29.14	30.88
5	30.17	28.83	29.50
8	37.41	10.07	23.74
12	<u>24.61</u>	<u>30.48</u>	<u>27.55</u>
Avg.	31.20	24.63	27.92
TALLOW			
3	20.68	29.99	25.34
4	31.72	36.28	34.00
9	42.27	36.64	39.46
11	<u>36.45</u>	<u>15.03</u>	<u>25.74</u>
Avg.	32.78	29.49	31.14
HYDROLYZED VEGETABLE-ANIMAL FAT			
2	39.59	37.41	38.50
6	27.93	25.30	26.62
7	37.85	28.50	33.18
10	<u>39.34</u>	<u>28.98</u>	<u>34.16</u>
Avg.	36.18	30.05	33.12

Table 11 gives the effect of tallow and hydrolyzed vegetable-animal fat on protein digestibility. Higher values of protein digestibility were obtained on the tallow and hydrolyzed vegetable-animal fat treatments than on the control. Protein digestibility was considerably higher for trial I than for trial II in the control group. However, in the case of the two fat treatments there was little difference between the two trials.

Table 11. Effect of tallow and hydrolyzed vegetable-animal fat on digestibility of ration protein.

Steer No.	TRIAL I Percent Digested	TRIAL II Percent Digested	AVG. OF 2 TRIALS Percent Digested
CONTROL			
1	49.23	51.41	50.32
5	62.77	53.86	58.32
8	62.93	50.90	56.92
12	68.00	60.32	64.16
Avg.	60.73	53.92	57.43
TALLOW			
3	62.40	63.60	63.00
4	64.35	58.91	61.63
9	60.16	66.94	63.55
11	58.49	61.73	60.11
Avg.	61.35	62.80	62.07
HYDROLYZED VEGETABLE-ANIMAL FAT			
2	64.88	60.69	62.79
6	60.12	55.35	57.74
7	60.41	64.62	62.51
10	68.46	73.61	71.03
Avg.	63.46	63.59	63.58

Table 12 lists the data on the production of rumen volatile fatty acids for each steer by treatment and date of sampling. Table 13 is a summary of these data. The percent acetic acid found in the rumen at time of sampling was slightly, but not significantly, higher for the two fat treatments than for the control. The percent propionic acid was somewhat higher for the tallow treatment than for either the control or hydrolyzed vegetable-animal fat treatment. Percent of butyric acid in the rumen at time of sampling was slightly, but not significantly lower, for the tallow treatment than for the other two treatments. The percent of valeric and higher acids was higher and very near significance for the control treatment than for the two fat treatments. Total volatile fatty acid production was higher, but not significantly so, for the two fat treatments than for the control treatment. This does not agree with Brooks et al (8) who reported a lower rumen volatile fatty acid production when fat was added to the ration. However, volatile fatty acid production returned to normal when alfalfa ash was added to the ration.

There are significant differences ($P < .05$) between dates of sampling for valeric and higher acids, acetate and total volatile fatty acid production. However, there is no set pattern for these differences and they are difficult to interpret.

Table 12. Effect of tallow and hydrolyzed vegetable-animal fat on total rumen production and molar percent of volatile fatty acids.

Sampling Date	Percent Acetate	Percent Pro-pionate	Percent Butyrate	Percent Valerate & higher	Total milli-moles/100 mls.
CONTROL					
Steer No. 1					
Sept. 22	42.40	27.20	23.13	7.45	396.0
Oct. 20	44.87	30.46	21.43	3.24	1041.2
Nov. 24	45.77	40.66	10.97	2.58	1191.7
Dec. 12	<u>45.19</u>	<u>23.21</u>	<u>24.10</u>	<u>7.49</u>	<u>955.9</u>
Average	44.56	30.38	19.91	5.19	896.2
Steer No. 5					
Sept. 21	50.28	17.48	25.00	7.24	535.0
Oct. 19	45.41	33.61	17.52	3.46	820.2
Nov. 22	50.40	36.11	10.06	3.44	927.2
Dec. 8	<u>49.31</u>	<u>18.51</u>	<u>23.44</u>	<u>8.75</u>	<u>818.8</u>
Average	48.79	26.43	19.01	5.72	775.3
Steer No. 8					
Sept. 20	45.94	22.73	22.70	8.64	419.5
Oct. 18	56.92	24.81	15.24	4.00	1017.8
Nov. 21	51.64	33.11	11.07	4.18	869.6
Dec. 5	<u>42.50</u>	<u>30.82</u>	<u>21.33</u>	<u>5.35</u>	<u>882.4</u>
Average	49.25	27.87	17.59	5.54	797.3
Steer No. 12					
Sept. 19	51.33	20.34	23.88	4.45	976.2
Oct. 17	44.98	22.51	21.00	11.50	331.2
Nov. 20	53.97	21.31	20.92	3.82	533.8
Dec. 4	<u>51.90</u>	<u>14.71</u>	<u>29.17</u>	<u>5.18</u>	<u>939.2</u>
Average	50.55	19.72	23.74	6.24	695.1

Table 12. Continued

Sampling Date	Percent Acetate	Percent Pro-pionate	Percent Butyrate	Percent Valerate & higher	Total milli-moles/100 mls.
TALLOW					
Steer No. 3					
Sept. 22	46.12	29.01	17.98	6.90	598.4
Oct. 20	45.25	40.75	11.34	2.67	916.5
Nov. 24	52.54	27.60	14.19	5.66	500.7
Dec. 12	<u>43.06</u>	<u>36.27</u>	<u>16.73</u>	<u>3.94</u>	<u>834.0</u>
Average	46.74	33.41	15.06	4.79	712.4
Steer No. 4					
Sept. 21	49.72	14.25	32.50	3.52	621.7
Oct. 19	52.79	15.32	29.37	2.52	1036.9
Nov. 22	56.87	13.94	26.23	2.96	839.1
Dec. 8	<u>48.94</u>	<u>24.32</u>	<u>21.71</u>	<u>5.03</u>	<u>937.4</u>
Average	52.08	16.96	27.45	3.51	858.7
Steer No. 9					
Sept. 20	47.18	30.37	17.45	4.99	1012.2
Oct. 18	42.13	39.85	15.03	2.99	1098.1
Nov. 21	51.69	29.03	15.16	4.13	686.2
Dec. 5	<u>38.84</u>	<u>39.22</u>	<u>18.52</u>	<u>3.42</u>	<u>1181.2</u>
Average	44.96	34.62	16.54	3.88	994.4
Steer No. 11					
Sept. 19	54.14	25.10	18.85	1.91	1159.6
Oct. 17	55.05	27.94	15.38	1.64	1083.5
Nov. 20	50.64	28.40	17.29	3.67	941.3
Dec. 4	<u>52.50</u>	<u>23.34</u>	<u>18.48</u>	<u>5.09</u>	<u>943.6</u>
Average	53.08	26.20	17.59	3.23	1032.0

Table 12. Continued

Sampling Date	Percent Acetate	Percent Pro- pionate	Percent Butyrate	Percent Valerate & higher	Total milli- moles/100 mls.
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HYDROLYZED VEGETABLE-ANIMAL FAT

Steer No. 2

Sept. 22	39.82	23.96	31.88	4.34	408.1
Oct. 20	53.26	22.58	21.85	2.30	1207.3
Nov. 24	50.52	22.48	23.42	3.59	691.9
Dec. 12	<u>44.44</u>	<u>33.19</u>	<u>18.56</u>	<u>3.81</u>	<u>618.7</u>
Average	47.01	25.55	23.93	3.51	731.5

Steer No. 6

Sept. 21	38.95	27.21	25.48	8.35	433.6
Oct. 19	48.51	27.72	20.81	2.97	804.5
Nov. 22	54.69	22.14	18.67	4.50	728.6
Dec. 8	<u>49.56</u>	<u>29.97</u>	<u>13.24</u>	<u>7.23</u>	<u>768.7</u>
Average	47.93	26.76	19.55	5.76	683.9

Steer No. 7

Sept. 20	49.61	21.79	23.25	5.34	600.1
Oct. 18	56.86	12.45	27.40	3.29	862.0
Nov. 21	54.18	20.94	20.92	3.96	1074.0
Dec. 5	<u>49.87</u>	<u>30.69</u>	<u>15.68</u>	<u>3.76</u>	<u>1232.8</u>
Average	52.63	21.47	21.84	4.09	942.2

Steer No. 10

Sept. 19	54.38	28.77	13.16	3.68	842.0
Oct. 17	53.72	25.39	19.06	1.82	1070.5
Nov. 20	48.54	30.95	16.80	3.71	1146.2
Dec. 4	<u>38.23</u>	<u>40.14</u>	<u>16.37</u>	<u>5.17</u>	<u>1123.6</u>
Average	48.67	31.31	16.35	3.60	1045.6

Table 13. A summary of rumen volatile fatty acid production as effected by tallow and hydrolyzed vegetable-animal fat in the ration.

	Control	Tallow	Hydrolyzed vegetable-animal fat
No. of steers	4	4	4
No. of samples	16	16	16
Acetic acid molar percent	48.3	49.2	49.1
Propionic acid molar percent	26.1	27.8	26.3
Butyric acid molar percent	20.1	19.2	20.4
Valeric acid & higher percent	5.7	3.8	4.2
Total volatile fatty acids, millimoles per 100 ml. rumen fluid	791	899	851

Table 14 contains data on liver storage of vitamin A and carotene fed. At times of slaughter liver weights were taken and expressed as percent of body weight. This value was then applied to the starting weight of the cattle as it was assumed that liver weights remained constant in relation to body weight throughout the trial. There was no effect of treatment on final liver weights. By these calculations it was possible to obtain an estimate of total liver vitamin A gain for the trial. At the termination of the experiment vitamin A per gram of liver was significantly higher ($P < .01$) for the control treatment than for the two fat treatments. Total liver storage of vitamin A was also higher in the control treatment than for the two fat treatments but this was not significant. Page et al (25) also observed less storage of liver vitamin A when fat was added to rations containing only the provitamin A carotene. There was an

extremely large variation in the amount of vitamin A stored per individual steer in all treatments. One or more steers in each treatment lost liver vitamin A even though carotene consumption was assumed adequate to meet the needs of the animal and allow for liver storage. Carotene fed was significantly higher ($P < .05$) for the control and tallow treatments than for the hydrolyzed vegetable-animal fat treatment. This was due to the lower feed intake on the hydrolyzed vegetable-animal fat treatment and the slightly lower carotene assay for the ration. The average carotene content for the entire trial for each of the three rations was: control 3.85 mg./lb; tallow 4.12 mg./lb. and hydrolyzed vegetable-animal fat 3.10 mg./lb.

Table 14. Effect of tallow and hydrolyzed vegetable-animal fat on liver storage of ration carotene.

Steer No.	Vitamin A Mcg./gm. Beginning	Vitamin A Mcg./gm. Finish	Carotene Fed gms.	Total liver Vitamin A storage mgs.
CONTROL				
1	10.16	5.25	5821	-15.23
5	10.35	16.59	7627	43.43
8	10.00	21.03	7377	67.14
12	<u>7.11</u>	<u>23.49</u>	<u>7157</u>	<u>76.33</u>
Average	9.41	16.59**	6995*	42.92
TALLOW				
3	7.78	8.29	7334	11.38
4	6.29	17.26	7078	61.72
9	7.77	6.16	9962	- 0.28
11	<u>7.21</u>	<u>5.08</u>	<u>6608</u>	<u>- 4.65</u>
Average	7.26	9.20	7745*	17.04
HYDROLYZED VEGETABLE-ANIMAL FAT				
2	9.05	17.07	5478	42.63
6	7.15	7.04	5081	5.18
7	11.55	8.33	5785	- 3.29
10	<u>12.21</u>	<u>10.59</u>	<u>3934</u>	<u>- 1.42</u>
Average	9.99	10.76	5070	10.78

**($P < .01$)

*($P < .05$)

DISCUSSION

The results of this experiment show that 4% fat can be added to practical feedlot rations without depressing digestibility of ration components, production of volatile fatty acids or performance. Feed efficiency was not significantly improved with the fat treatment but there were indications that the difference would have been significant if larger numbers of animals had been used.

There were no significant differences in digestibility of any of the ration components, except ether extract, which was significantly higher ($P < .01$) for the two added fat treatments. Apparently the 30% alfalfa and possibly the 1% dicalcium phosphate overcame the depressing effects some workers observed when fat was added to the ration. Jones et al (18) observed a significant decrease in digestibility of dry matter, energy and nitrogen free extract and a significant increase in digestibility of ether extract with added fat and corn cobs as the roughage. Ward et al (36) observed a significant decrease in all ration components except ether extract on a ration with added fat and 69% cottonseed hulls as the only roughage.

The average daily gain for all three treatments was the same for the first 57 days of the trial. Hubbert et al (17) observed an increase in gain with 4% tallow added to the ration. Matsushima et al (23) observed an increase in average daily gain when $\frac{1}{2}$ pound of fat per day was added to the ration of steers, without stilbesterol; but

in another trial Matsushima et al (20) reported a small decrease in average daily gain when $\frac{1}{2}$ pound per head per day of fat was added.

The decrease in storage of liver vitamin A even though it is not significant could mean that when fat is added to the ration of fattening steers, added precautions should be taken to insure adequate vitamin A in the ration. Page et al (25) also observed less storage of liver vitamin A with added fat in the ration under conditions of his experiment.

The observed increase in volatile fatty acid production of fat treatments over control observed in this experiment indicates an advantage of the added fat in this aspect. The true value of this is not known because rate of absorption in the rumen is not known. Brooks et al (8) observed a decrease in the total volatile fatty acids produced in the rumen of sheep on a ration containing 90% cottonseed hulls and added corn oil. This decrease returned to normal when alfalfa ash was added to the ration.

The increase in the volatile fatty acid production in the fat treatments may be due to rumen degradation of the long chain fatty acids although studies to date do not indicate that rumen bacteria are able to degrade long chain fatty acids.

The fact that the addition of fat to the ration had no significant effect on the percent of acetic and propionic acids found in the rumen rules out, under conditions of this experiment, any advantage or disadvantage the addition of fat might have on the acetate, propionate ratio.

The percentages of the volatile fatty acids as shown in Table 11 fit into what might be expected with the roughage: concentrate ration that was fed, except that butyric was higher than most other workers have observed. Balch and Rowland (3) observed the following range of percentages on various rations with cattle:

Acetate	40.6 - 73.9
Propionate	16.5 - 39.1
Butyrate	6.6 - 13.9
Higher acids	2.5 - 12.7

The low acetate, high propionate was with a ration of 2 pounds of hay and 24 pounds of concentrate. The high acetate, low propionate was on a silage ration. A ration consisting of 16 pounds of hay and 20 pounds of concentrate gave the following: acetate 57.1, propionate 23.7, butyrate 12, and higher 7.2. Eusebio et al (14) observed the following with alfalfa and corn meal rations:

	C ₂	C ₃	C ₄	C ₅	C ₆
Alfalfa and Corn meal	56.1	23.7	14.4	3.0	2.9
Corn meal	37.9	42.8	11.0	3.4	5.0

Both of these experiments show that as ration concentrate increases and roughage decreases, acetic acid decreases and propionic acid increases.

SUMMARY

The effects of adding either 4% tallow or hydrolyzed vegetable-animal fat to practical feedlot rations on ration component digestibility, rumen production of volatile fatty acids, utilization of ration carotene and performance were studied using 12 yearling Hereford steers.

It was found that the added fat did not significantly influence digestibility of protein, crude fiber, dry matter, energy or nitrogen free extract. Percent digestibility of protein, crude fiber, dry matter and energy were all slightly, but not significantly higher with the fat treatment. Ether extract digestibility was significantly higher ($P < .01$) in the two fat treatments due to higher digestibility of the added fat.

The added fat in the ration did not significantly effect percent of acetic, propionic, butyric or valeric and higher acids in the rumen. The percent of valeric and higher acids was very close to significance at the 5% level for the control treatment over the fat treatments. Total volatile fatty acid production was higher but not significantly so for the two fat treatments than for the control treatment.

At the termination of the experiment vitamin A per gram of liver was significantly higher ($P < .01$) for the control treatment than for the two fat treatments. Total liver storage of vitamin A

was also higher for the control treatment than the two fat treatments but this was not significant.

Average daily gain for the first 57 days of the trial was the same for all three treatments. There was no significant difference in feed efficiency.

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APPENDIX

Table 15. Analysis of variance and coefficient of variation of efficiency of feed conversion at 57 and 97 days and average daily gain at 97 days.

Source of variation	d.f.	Mean squares		
		F.C. (57 days)	F.C. (97 days)	ADG (97 days)
Treatment	2	0.69	0.34	0.10
Error	9	1.31	10.34	0.17
Coeff. of variation		13.9%	34.1%	20.7%

Table 16. Analysis of variance and coefficient of variation of micrograms of vitamin A per gram of liver at beginning and at end of experiment and total liver vitamin A at end of experiment.

Source of variation	d.f.	Mean squares		
		Mcg./gm. beginning	Mcg./gm. finish	Total finish
Treatment	2	8.33	61.47**	1530.82
Error	9	2.84	3.84	856.41
Coeff. of variation		19.0%	16.0%	50.1%

Table 17. Analysis of variance and coefficient of variation of percent digestibility of ether extract, crude fiber, protein, nitrogen free extract, dry matter and energy.

Source of variation	d.f.	Mean squares					
		E.E.	C.F.	C.P.	NFE	D.M.	G.E.
Replicate	1	2.06	170.61	17.05	3.27	38.21	39.24
Treatment	2	1001.25**	55.02	80.59	11.27	23.03	13.37
R X T	2	2.00	6.33	37.68	4.60	5.51	6.64
Error	18	29.39	61.09	29.41	7.82	7.13	8.00
Coeff. of variation		7.4%	25.5%	8.9%	3.5%	3.8%	4.1%

** (P<.01)

Table 18. Analysis of variation and coefficient of variation of molar percent of valerate and higher, butyrate, propionate, acetate and total volatile fatty acid production.

Source of variation	d.f.	C ₂	C ₃	C ₄	C ₅ & up	Total VFA production
Replicate	3	75.22	46.10	67.72	10.44*	196,963.24*
Treatment	2	3.88	13.92	6.90	10.46	47,185.59
R X T	6	16.08	108.38	48.30	3.27	49,614.12
Error	36	23.61	47.64	23.55	3.25	51,326.48
Coeff. of variation		10.0%	25.8%	24.4%	39.9%	26.7%

* $P < .05$

Table 19. Proximate analysis and gross energy of feed fed and feed weigh back. All analysis on a dry matter basis.

	Pct. D. M.	Pct. E. E.	Pct. C. F.	Pct. Ash	Pct. C. P.	Pct. NFE	Kcal. G. E./lb.
Oct. 1-5							
Control	91.39	2.07	10.29	6.82	13.78	67.04	1991
Tallow	91.50	5.67	10.43	5.94	13.56	64.40	2053
Hyd. veg.- an. fat	91.51	5.07	9.79	6.10	13.57	65.47	2032
Oct. 9-13							
Control	91.30	1.76	10.05	7.19	14.33	66.67	1971
Tallow	91.35	4.95	8.67	5.60	13.90	66.88	2092
Hyd. veg.- an. fat	91.31	5.03	9.67	6.26	13.77	65.27	2064
Nov. 5-9							
Control	89.47	2.62	11.93	5.98	12.57	66.90	1964
Tallow	89.74	5.75	10.36	5.92	13.54	64.43	2081
Hud. veg.- an. fat	89.34	6.01	10.56	5.94	14.08	63.41	2086
Nov. 12-16							
Control	89.65	2.58	13.21	6.03	11.54	66.64	1989
Tallow	90.02	5.86	11.33	5.80	12.34	64.67	2051
Hyd. veg.- an. fat	89.80	6.21	11.51	5.94	12.59	63.75	2064
Weigh back							
Oct. 6							
Steer No. 10	91.50	4.67	8.62	6.57	13.95	66.19	2063
Oct. 6							
Steer No. 11	91.66	5.18	8.46	6.09	13.37	66.90	2075
Oct. 14							
Steer No. 1	91.78	1.50	7.98	10.32*	16.01	64.19	1936
Nov. 10							
Steer No. 10	87.15	5.02	9.13	6.36	12.35	67.14	2069
Nov. 17							
Steer No. 6	89.05	7.15	7.97	8.64	12.26	64.01	2069

*Sand in sample

Table 20. Proximate analysis and gross energy of feces.

All analysis on a dry matter basis.							
Steer No.	Pct. D. M.	Pct. E. E.	Pct. C. F.	Pct. Ash	Pct. C. P.	Pct. NFE	Kcal. G. E./lb.
October							
Control							
1	97.59	2.17	26.14	13.38	17.46	40.85	2023
5	97.04	2.81	23.35	14.39	17.75	41.70	2046
8	96.24	2.76	22.68	13.89	17.99	42.76	2008
12	97.49	2.70	23.12	13.94	17.25	42.99	1990
Tallow							
3	98.17	3.09	22.42	11.46	17.04	45.99	2084
4	97.74	3.17	20.57	12.70	17.22	46.34	2109
9	96.77	3.67	20.34	12.75	18.25	44.99	2174
11	97.19	4.30	22.65	12.20	18.34	42.91	2127
Hydrolyzed vegetable-animal fat							
2	98.11	3.34	22.42	12.47	18.56	43.61	2120
6	97.57	3.30	21.69	10.80	17.09	47.12	2123
7	97.74	4.60	21.05	12.00	17.70	45.65	2044
10	96.81	4.66	25.02	13.72	17.29	39.31	2196
November							
Control							
1	97.18	2.88	27.66	11.72	16.57	41.17	2006
5	96.77	2.30	29.03	12.51	16.44	39.72	2032
8	94.83	3.51	28.61	12.14	16.46	39.28	2042
12	95.52	3.06	24.50	12.08	14.71	45.65	1968
Tallow							
3	95.78	3.67	24.85	12.22	14.17	45.09	2026
4	96.86	3.34	23.32	12.15	16.38	44.81	2092
9	95.68	3.72	23.07	12.58	15.73	44.90	2121
11	95.05	4.46	26.52	12.50	15.61	40.91	2136
Hydrolyzed vegetable-animal fat							
2	97.49	3.07	25.75	11.59	17.69	41.90	2192
6	96.18	3.98	24.91	10.96	15.90	44.25	2152
7	96.59	5.51	24.68	12.38	16.24	41.39	2138
10	95.98	4.44	29.45	13.38	14.56	38.17	2177