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FEEDING VALUE OF FAT IN DIETS FOR FEEDLOT CATTLE

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INTRODUCTION

The feeding value of fat, as with any feedstuff, involves a consideration of much more than its energy content per se. It is also a dynamic function of acceptability or palatability, associative interactions with other ration ingredients, as well as a composite of other extra caloric effects which change in varying degrees according to the nature of the diet, level of supplementation and plane of nutrition. The objective this review is to share the results of several of our experiments evaluating the feeding value of fat for feedlot cattle.

Fat Level and Source

Concern. Intestinal digestibility of fat remains rather constant up to about 4% supplementation, averaging roughly 80%. Above 4% supplemental fat (5 to 6% total dietary fat) true digestibility of fat declines to about 56% (Palmquist and Jenkins, 1980). More dramatic reductions in digestibility occur at levels of supplementation greater than 8% (Zinn, unpublished). However, reductions in fat digestibility do not form the basis for current recommendations on safe limits for fat supplementation. The most consistent detrimental effects observed with fat supplementation are largely attributable to marked reductions in feed intake. It

has been reported for levels of supplementation as low as 3%, although the majority of cases are reported for levels greater than 5% of ration dry matter (Brethour et al., 1957; Buchanan-Smith et al., 1974; Cameron and Hogue, 1968; Cuitun et al., 1975; Dinius et al., 1975; Hatch et al., 1972; Johnson and McClure, 1972; Lofgreen, 1965; etc. Once this occurs, performance may continue to be mediocre, even after fat is removed form the diet (Hatch et al., 1972).

The basis for these effects is not understood. Indeed, it may be as much (or more) related to quality characteristics of the fat than level of supplementation, per se. Growing-finishing trials with feedlot cattle have not revealed significant (P<.05) or consistent differences between BVF, YG, tallow, cottonseed soap stock or soybean soap stock (Lofgreen, 1965; Brandt, 1988; Zinn, 1989a). However, a problem with comparing fat sources on the basis of animal performance is that supplemental fats usually comprise less than 8% of diet dry matter. The precision obtainable in such studies does not allow for detection of subtle (less than 10%) differences in the energy value of fat sources.

Three characteristics of fat source which may contribute to its feeding value are acceptability, total fatty acids (a measure of purity), proportion of total fatty acids as free fatty acids and iodine value (degree of unsaturation). Differences between common fat sources in acceptability have not been clearly demonstrated, although practical experience warrants some caution. For example, Brandt (1988) conducted two feeding trials involving various fat sources supplemented at 3.5% of diet dry matter. In the first trial YG supplementation resulted in a greater rate of weight gain and feed intake and less feed per unit gain than tallow supplementation. In the second trial the opposite was observed.

Trial (Zinn, 1989a,b). Two hundred twenty-eight crossbred steers (304 kg) were used in a 125-d comparative slaughter trial to evaluate the influence of level and source of supplemental fats on their feeding value for feedlot cattle. Dietary treatments consisted of a steam rolled barley-based finishing diet containing: 1) no supplemental fat; 2) 4% yellow grease (YG); 3) 4% blended animal-vegetable fat (BVF); 4) 8% YG; 5) 8% BVF and 6) 6% BVF and 2% crude soybean lecithin. The results of this trial are shown in Tables 1-8. Increasing level of supplemental fat in the diet resulted in linear improvements (P<.01) in weight gain, feed conversion and NE value of the diet. Estimated NE values of YG and BVF were similar and did not appear to be influenced by level of supplementation, averaging 5.78 and 4.61 Mcal/kg for maintenance and gain, respectively. Fat supplementation resulted in linear increases in empty body fat (P<.01), kidney, pelvic and heart fat (P<.01) and marbling score (P<.05). Partially replacing BVF with lecithin did not influence (P>.10) steer performance, carcass merit or estimated NE value of the diet. It was concluded that under the conditions of this trial, the comparative feeding value (in terms of both acceptability and NE value) of supplemental fats was similar and apparently not influenced by levels of supplementation as high as 8% of diet DM.

The influence of level and source of dietary fat on characteristics of digestion was evaluated using 6 crossbred steers (315 kg) with cannulae in the rumen, proximal duodenum and distal ileum (Tables 9-18). Increasing level of fat supplementation resulted in linear decreases (P<.01) in ruminal and total tract digestion of OM and ADF, and intestinal digestion of fat (P<.05). At the 4 and 8% levels of supplementation, intestinal true digestibility of fat averaged 80.1 and 69.3%, respectively. Thus, consistent with Palmquist and Jenkins (1980), intestinal digestibility of fat remains rather constant (80%) up to about 4% supplementation (5 to 6% total dietary fat) after which it declines with increasing levels of supplementation at the rate of 3.4% for each percentage increase in level of supplementation above 4%.

Ruminal molar proportions of acetate decreased, and propionate molar proportion, as well as DE and ME values of the diet increased linearly (P<.01) with level of fat supplementation. The DE and ME values for fat at the 4 and 8% levels of supplementation were 8.17 and 9.76, and 7.35 and 8.72 Mcal/kg, respectively. Yellow grease supplementation resulted in greater (P<.05) ruminal fiber digestion and greater ruminal molar proportions of propionate than BVF.

Intestinal fat digestion was similar (P>.10) for YG and BVF. Adding 25% lecithin to BVF resulted in greater ruminal fiber digestion and greater ruminal molar proportions of acetate; however, lecithin tended (P<.10) to lower the ME value of BVF.

Method of Fat Supplementation

Concern. One explanation for the detrimental effects of supplemental fat on diet digestibility is that it physically coats feed particles and thus retards digestion. Since supplemental fat has been shown to have little or no effect on the digestibility of the non-fibrous components of the diet (Robertson and Hawke, 1964; McAllan et al., 1983) it has been proposed that applying the supplemental fat directly to the grain or concentrate portion of the diet will improve its feeding value as compared to applying it to the forage component or as the last step in formulation, as is often the case. However, early studies are not supportive of this theory (Brethour et al., 1957).

Trial (Zinn, 1986a). Two hundred twenty-eight crossbred steers were used in a comparative slaughter trial to study the influence of method of fat supplementation on animal performance. Prior to initiation of the study, steers were fasted 16 hours (no feed or water). Twelve steers were selected at random for determination of initial carcass composition. The remaining 216 Steers were weighed, implanted (Synovex) and randomly assigned to 36 pens, 6 animals/pen. Three methods of fat supplementation were compared: 1) fat portion of the diet was added directly to the grain prior to adding other ration ingredients; 2) fat portion of the diet was added directly to the hay prior to adding other ration ingredients and 3) fat portion of the diet was applied as the last step in the batch mixing. Method of fat supplementation was compared at each of three levels of fat supplementation (3, 6 and 9%, table 19). Composition of experimental diets is shown in Table 19. Tallow fatty acids (acidulated tallow soap stock), a byproduct of the rendering industry, was the source of fat used. Fatty acid composition of the fat was as follows: myristate, 3.7%; palmitate, 29%; palmitoleate, 3.7%; Stearate, 19.7%; oleate, 39.9%; linoleate, 3.9%. Experimental diets were prepared weekly and stored in plywood boxes located in front of each pen. Steers were fed twice daily. The results of the trial are shown in Table 20. All three alternatives in method of fat supplementation gave similar results when the level of fat supplementation was less than 6%. At the 9% level of supplementation, adding fat directly to the hay resulted in marked reductions in gain and efficiency (P<.01).

__Calcium and Fat Utilization__

Concern. Of the macro elements that might interact with fat none have received more research attention then calcium. Numerous trials have indicated that when calcium has been increased in fat supplemented diets digestibility (usually fiber) also increases (Grainger et al., 1961; Davison and Woods, 1963; Galbraith et al., 1971; Galbraith and Miller, 1973; Jenkins and Palmquist, 1982; Drackley et al., 1985). The benefit to added calcium appears to be related in part to its influence on solubility of nonesterified fatty acids. The process of hydrolysis of esterified fatty acids is rapid. Hawke and Silcock (1970) observed that 80% of the esterified fatty acids were nonesterified within 2 h of incubation in ruminal fluid. Calcium reacts with nonesterified fatty acids to form insoluble calcium soaps (Jenkins and Palmquist, 1982; Drackley et al., 1985; Chalupa et al., 1986; Palmquist et al., 1986). Low dietary calcium levels or low calcium solubility in the rumen may reduce the rate and/or extent of soap formation, increasing ruminal concentrations of nonesterified fatty acids. Early on, it was theorized that the role of calcium in overcoming the negative effects of supplemental fats on digestion were somehow related to ruminal concentrations of nonesterified free fatty acids (Grainger et al., 1961). Subsequent work lent support to that concept. While calcium salts of long-chain fatty acids were found to be comparatively nonreactive in the rumen (Jenkins and Palmquist, 1984; Chalupa et al., 1986), nonesterified free fatty acids were found to have a marked inhibitory effect on growth of cellulolytic bacteria (Henderson, 1973; Maczulak et al., 1981). Nevertheless, addition of calcium to fat supplemented diets has not resulted in appreciable changes in soap formation (Drackely et al., 1985; Finn et al., 1986; Palmquist et al., 1986). Supplemental fat might also influence microbial growth indirectly by depressing free ruminal calcium concentrations below that necessary to maintain optimal growth of cellulolytic bacteria. However, Palmquist et al. (1986), observed that while fat supplementation did depress ruminal free calcium concentrations, the mean concentration (.60 mM) remained higher than that considered optimal for cellulolytic activity (.25 mM, Bryant et al., 1959). Furthermore, Bock et al (1991) found that increasing the level of supplemental calcium from .6 to .9% did not influence characteristics of digestion or feedlot performance of steers fed fat supplemented diets.

Trial (Zinn, 1987). A comparative slaughter trial and a metabolism trial were conducted to evaluate the influence of calcium source on utilization of a high fat diet by feedlot steers. Treatments consisted of a 90% concentrate finishing diet containing 8% yellow grease and supplemented with 1.3% limestone or .8% calcium hydroxide. Results of the trials are shown in Tables 21-25. In trial 1, involving 54 crossbred steers (225 kg) in a 162-d comparative slaughter trial, calcium hydroxide supplementation decreased feed intake 6.2% ($P<.10$). The decreased intake was reflected in a tendency for decreased weight gain and feed conversion. Net energy value of the diet was not influenced by calcium source ($P>.20$). Treatment effects on body composition and carcass merit were small ($P>.20$) with the exception of ribeye area which was 4.4% larger in steers fed the limestone supplemented diet ($P<.01$). In trial 2, ruminal digestion of OM and N was decreased 8.1% ($P<.05$) and 6.3% ($P<.10$) with calcium hydroxide substitution for limestone. Otherwise, ruminal, intestinal and total tract digestion was not effected by calcium source ($P>.20$). Calcium source did not influence ruminal pH ($P>.20$). Ruminal concentrations of ionized calcium tended to be higher throughout the feeding interval for the calcium hydroxide diet. At the 6 h sampling time ruminal ionized calcium concentrations for the calcium hydroxide supplemented diet exceeded that for the limestone diet by 226% ($P<.05$). Results of this study suggest that calcium source does influence the efficiency of utilization of high fat finishing diets by feedlot cattle. Palatability and cost should be the principal criterion when choosing a calcium source.

Fat by Ionophore Interaction

Concern. The basis for consideration of a supplemental fat by ionophore interaction is related to their analogous effects on end-products of ruminal fermentation. Its has been proposed that the effects of ionophores on efficiency of feed utilization are mediated, in part, through changes in the nature of ruminal fermentation associated with increasing molar proportions of propionate and decreasing methane production (Raun et al., 1976; Richardson et al., 1976; Fontenot et al., 1980; Bartley et al., 1979; Fuller and Johnson, 1981; Ricke et al., 1984). Supplemental fat has been found to affect similar changes (Czerkawski et al., 1975), possibly raising the base line for the drug effect. This hypothesis is supported by a feedlot growth-performance trial of Brandt et al (1991). In the abscence of supplemental fat monensin plus tylosin improved feed efficiency 7.2%. While, in the presence of supplemental fat there was no response to monensin-tylosin supplementation. Nevertheless, in a subsequent trial (Brandt, 1992) the feed efficiency response to supplemental fat and monensin plus tylosin were more nearly additive.

Trial (Zinn, 1988). Two comparative slaughter trials and a metabolism trial were conducted. Treatments consisted of: 1) 0 fat, 0 monensin; 2) 4% yellow grease, 0 monensin; 3) 0 fat, 33 mg/kg monensin and 4) 4% yellow grease, 33 mg/kg monensin. Treatments were arranged as a 2 x 2 factorial. The results of the trials are shown in Tables 26-32. Trial 1, involved 104 crossbred steers (267 kg) in a 140-d comparative slaughter trial. There were no interactions ($P>.20$) between supplemental fat and monensin on steer performance. Monensin supplementation decreased rate of weight gain ($P<.10$) and feed intake ($P<.05$), with no effect on energy value of the diet ($P>.20$). Fat supplementation increased ($P<.01$) rate of weight gain 12.5% and the NE_m and NE_g value of the diet 8.5 and 9.4%, respectively. The NE_m and NE_g value of the supplemental fat (replacement technique) was 6.40 and 4.69 mcal/kg, respectively. Fat supplementation increased ribeye area 6.5% ($P<.01$) and KPH 14% ($P<.05$). Treatment effects on components of empty body weight gain were largely the consequence of differences in rate of weight gain. Trail 2, involved 154 Holstein steers (290 kg) in a 94-d comparative slaughter trial. There were no interactions between supplemental fat and monensin (P>.20). Monensin supplementation did not effect rate or composition of gain (P>.20) but reduced (P<.05) feed intake and feed required per unit weight gain 3.6%, and an increased (P<.05) the NE_m and NE_g content of the diet 3.6 and 4.0%, respectively. Fat supplementation increased (P<.01) fat and energy gain 12.5 and 10.3%, respectively, and the NE_m and NE_g content of the diet 7.5 and 8.4%, respectively. The NE_m and NE_g value of the supplemental fat was 6.00 and 4.37 mcal/kg, respectively, in good agreement with trial 1. Fat supplementation increased (P<.05) carcass fat and KPH fat 4.3 and 11.1%, respectively. Trail 3, utilized 4 crossbred steers (220 kg) with cannulas in the rumen, proximal duodenum and distal ileum. There were no interactions between supplemental fat and monensin with respect to site of digestion (P>.20). Supplemental fat did not effect (P>.20) of OM, ADF, starch or N digestion. Intestinal digestibility of fat averaged 77.3%. Monensin increased (P<.10) intestinal digestibility of fat 7.4%. However, there were negative associative effects on ruminal acetate:propionate ratios and estimated methane production. It is concluded that the feeding value of feed fat is underestimated in current tables of feed standards and that the net effects of monensin on these estimates are additive.

<u>Fat by Urea Interaction</u>

Concern. Palatability of various feed fats has been singled out as a primary factor for explaining the occasional depressions in feedlot performance with fat supplementation. However, these effects may actually be related to protein nutrition of the animal. This is particularly evident from studies comparing urea versus natural protein in diets with supplemental fat (Jones et al., 1961; Thompson et al., 1967; Hatch et al., 1972; Buchanan-Smith et al., 1974).

Trial (Zinn, 1989). A comparative slaughter trial and a metabolism trial were conducted to evaluate the influence of N supplementation on the feeding value of yellow grease (YG). Treatments consisted of: 1) steam-flaked corn based finishing diet containing no supplemental fat, urea as source of supplemental N; 2) same as treatment 1 plus 6% YG; 3) 6% YG, urea and soybean meal (SBM) as sources of supplemental N and 4) 6% YG, urea and SBM as sources of supplemental N. Soybean meal and urea used in diets 3 and 4 replaced proportionate quantities of steam-flaked corn and urea in diet 2 so as to maintain a similar amount of ruminal available N while increasing ruminal escape N. Results of this study are shown in Tables 33-39. In trial 1, treatment effects on feedlot growth-performance were evaluated in a 149-d comparative slaughter involving 90 crossbred steers. Fat supplementation improved feed/gain (9.9%, $P<.05$) and NE value of the diet (10.3%, $P<.01$). Substituting SBM for urea resulted in a linear ($P<.05$) depression in NE value of the diet. The estimated NE value of YG averaged 5.35 and 4.30 Mcal/kg, respectively, for maintenance and gain. Trial 2 involved 4 steers (468 kg) with cannulas in the rumen and proximal duodenum. Soybean meal substitution into the diet did not increase ($P>.10$) non-ammonia N passage to the small intestine. Soybean meal substitution increased ($P<.05$) ruminal molar proportions of propionate and ADF digestion and decreased ($P<.05$) methane losses, but total tract OM digestion was decreased linearly ($P<.05$). Intestinal digestibility of yellow grease averaged 64% and was not influenced by SBM. Yellow grease supplementation increased ($P<.01$) ME, NE_m and NE_g values of the diet 3.8, 4.9 and 6.3%, respectively. It is concluded that substitution of SBM for urea in fat supplemented steam-flaked corn based diets may not improve the feeding value of the supplemental YG.

Fat Plus High-Bypass Protein

Concern. Increasing levels of protein supplementation has been found to enhance the DE value of the diet Tyrrell (1987). A primary factor which limits the feeding value of fat at higher levels of supplementation is its decreasing rate of small intestinal digestibility. Thus, it may be postulated that by simultaneously increasing the level of protein reaching the small intestine, digestibility of fat might also be enhanced.

Trial (Zinn, 1990 unpublished). A comparative slaughter trial and a metabolism trial were conducted to evaluate the influence of N supplementation using a high-bypass protein blend (HBP; 1/3 feather meal, 1/3 blood meal, 1/3 meat and bone meal) on the feeding value of yellow grease (YG). Treatments consisted of: 1) steam-flaked corn based finishing diet containing no supplemental fat, urea as source of supplemental N; 2) same as treatment 1 plus 5% YG; 3) same as 1 plus 2% HBP, and 4) same as 3 plus 5% yellow grease. The results of these trials is shown in Tables 40-49. In trial 1, treatment effects on feedlot growth-performance were evaluated in a 123-d comparative slaughter involving 68 crossbred steers. Fat supplementation improved DMI/gain (8.6%, $P<.05$) and NE value of the diet (9.6%, $P<.05$). Addition of 2% HBP did not influence ($P>.10$) feedlot performance. The estimated NE value of YG averaged 6.11 and 5.07 Mcal/kg, respectively, for maintenance and gain. Trial 2 involved 4 Holstein steers with cannulas in the rumen and proximal duodenum. The addition of 2% HBP increased ($P<.01$) the passage of feed N to the small intestine. Supplementation with HBP tended to increase the DE value of the basal (no supplemental fat) diet, apparently, by increasing intestinal digestibility of fat. This trend was consistent with the slightly greater estimated NE values for treatment 3 observed in trial 1. However, HBP supplementation did not influence ($P>.10$) the intestinal digestibility of fat in the fat supplemented diet. DE value of the diet was increased ($P<.05$) with fat supplementation. Using the replacement technique, the DE value of YG grease was 7.49 Mcal/kg. This value corresponds to a digestibility of 79% for YG. Observed digestibility of YG was 79.6%, in good agreement with DE calculations.

Fat by Grain Type Interaction

Concern. Hale (1986) noted that the general response to supplemental fat was poorer with corn-based diets as opposed to barley-, wheat- or milo-based diets. This concept is supported, in part, by the observation that positive responses to fat supplementation (Brandt, 1988; Zinn, 1988; Zinn, 1989a) were obtained with steam rolled barley- or milo-based finishing diets, while negative responses to fat supplementation (Buchanan-Smith et al., 1972; Hatch et al., 1972; Johnson and McClure, 1972) were obtained with corn-based diets. An exception to this trend is the study of Lofgreen (1965) which involved a 70% barley-based finishing diet. However, depressed performance was only noted at the 10% level of fat supplementation.

Trial (Zinn, 1992). One hundred thirty crossbred steers (324 kg) were used in a 121-d comparative slaughter trial to evaluate the comparative feeding value of yellow grease (YG) and cottonseed oil soapstock (COS) in steam-flaked corn (SFC) or wheat (SFW) based finishing diets. Dietary treatments consisted of an 88% concentrate finishing diet containing: 1) SFC, no supplemental fat; 2) SFC, 6% YG; 3) SFC, 6% COS; 4) SFW, no supplemental fat; 5) SFW, 6% YG and 6) SFW, 6% COS. The results of this trial are shown in Tables 50-56. There were no interactions (P>.10) between grain type and performance response to supplemental fat. Fat supplementation increased (P<.05) ADG 6.4% and decreased (P<.01) DM/gain 10.6%. Substituting SFW for SFC did not influence (P>.10) ADG, but tended (P>.10) to increase DM/gain and decreased (P<.05) the NE_m and NE_g of the diet 3.4 and 4.3%, respectively. It is concluded that the feeding value of supplemental fat is similar for wheat- and corn-based finishing diets. Performance response to supplemental YG and COS was similar. The NE_m and NE_g value of YG were 6.35 and 4.93 Mcal/kg, respectively, while the corresponding values for COS were 5.69 and 4.60 Mcal/kg. Differences between the two fat sources appeared to reflect the higher percentages of moisture, impurities and unsaponifiables in COS. The NE value of SFW was roughly 96% the value of SFC.

<u>Oleic Acid and Fat digestion</u>

Concern. Intestinal digestibility of palmitic and stearic acid are low compared with unsaturated fatty acids such as oleic and linoleic acid. Absorption of fatty acids is dependent on the formation of bile salt micelles. The greater the surface area of the micelles, the greater the digestibility of the fat. The surface area of the micelles is enhanced by the interaction of bile salts and insoluble-swelling amphophiles such as the unsaturated fatty acids. Consequently, swelling amphophiles such as unsaturated fatty acids are thought to be helpful in the absorption on non-swelling amphophiles such as saturated fatty acids. This concept is supported by the observation that small amounts of oleic acid has measurably improved utilization of saturated fatty acids in poultry fed diets low in phospholipids (Krogdahl, 1985). In ruminants, relatively little unsaturated fatty acids escape hydrogenation in the rumen. Thus, fat digestion may be enhanced by bypassing unsaturated fatty acids to the small intestine.

Trial (Zinn, 1990 unpublished). Three Holstein calves (209 kg) with cannulas in the abomasum, proximal duodenum and distal ileum were used in a Latin square design experiment to evaluate the influence of oleic acid infusion on intestinal digestibility of fat. All calves were fed a basal diet containing 8% tallow (DM basis). Treatments consisted of infusing 0, 68 or 160 g/d of oleic acid via the abomasal cannula. The results of the trial are shown in Table 57. Fatty acid digestion was not enhanced by increasing the proportion of oleic acid entering the small intestine. Small intestinal digestion of palmitic, stearic, oleic and linoleic acids averaged 73, 60, 90 and 92%, respectively.

Fatty-fatty esters

Concern. Can esters of long-chain fatty acids be utilized by cattle? Coconut alcohol bottoms-bottoms are a remnant from the distillation of fatty alcohols produced by the reduction and high pressure catalytic hydrogenation of coconut oil. Sometimes referred to as "stillbottoms", they contain some fatty alcohol, but are largely made up of fatty-fatty esters, which are the esters of a fatty acid and a fatty alcohol. This material has been classified as a nonfood industrial waste which may have potential as a feedstuff for livestock (NRC, 1983).

Trial (Zinn, 1989). Six crossbred steers (274 kg) with "T" cannulas in the rumen, proximal duodenum (6 cm from the pyloric sphincter) and distal ileum (20 cm from the ileal-cecal valve) were used in a crossover design experiment to evaluate the feeding value of coconut alcohol bottoms-bottoms (CABB) in a finishing diet for feedlot steers. Dietary treatments consisted of a steam-rolled barley based finishing diet supplemented with or without an additional 6% CABB. The CABB was first blended with the steam-rolled barley portion of the diet prior to incorporation of remaining dietary ingredients. Results of this trial are shown in Tables 58-61. Ruminal digestion of ADF and N was not affected (P>.10) by CABB supplementation. Ruminal OM digestion was depressed commensurate to the level of CABB supplemented. Total tract digestibility of OM, ADF, lipid and DE was decreased by 5.65 (P<.01), 29.4 (P<.05), 57.4 (P<.01) and 5.65%, respectively. Adjusting for constituent passage of the basal diet, estimated total tract digestibility of OM, DE and lipid of the supplemental CABB was 1.1, -.23 and 16.4%, respectively. It is concluded that CABB has essentially no feeding value in finishing diets for cattle.

<u>Calcium soaps of fatty acids</u>

Concern. Reacting fatty acids with calcium to form calcium soaps (CSFA) results in a "dry" fat form which facilitates handling and mixing. Furthermore, the CSFA are thought to be less reactive in the rumen (Chalupa et al., 1985), avoiding potential negative associative effects on digestive function. The objective of this study was to compare yellow grease and CSFA with respect to characteristics of ruminal and total tract digestion.

Trial (Zinn and Plascencia, 1992). Four Holstein steers (372 kg) with "T" cannulas in the rumen, proximal duodenum and distal ileum were used to evaluate the comparative effects of calcium soaps of fatty acids (CSFA) versus yellow grease (YG) on digestive function. Four dietary treatments were compared: 1) no supplemental fat; 2) 5% YG; 3) 5% MegaLac (ML) and 4) 5% RumInsol (RI). ML and RI are commercial preparations of CSFA and contain roughly 80% fat. The basal diet contained 55% concentrate and 45% alfalfa hay. Composition of experimental diets and trial results are shown in Tables 62-66. Ruminal pH was higher (P<.05) for CSFA supplemented diets than the YG diet. Ruminal propionate levels tended (P<.10) to be lower for the fat supplemented diets. Ruminal digestion of feed N was higher (P<.05) for the fat supplemented diets, reflecting the higher ruminal degradability of soybean meal which was added along with supplemental fats to maintain similar calorie:protein ratios across treatments. The addition of supplemental fat did not influence (P>.10) ruminal digestion of OM and ADF or ruminal microbial efficiency. Small intestinal digestibility of lipid was similar (P>.10) across supplemental fat sources, averaging 78.6%. Reacting fat with Ca to form calcium soaps did not prevent extensive ruminal biohydrogenation of supplemental fat. Small intestinal fatty acid digestion was similar (P>.10) across treatments, averaging 84.2%. Adjusting for fatty acid contribution of the basal diet, fatty acid digestibility of the supplemental fats averaged 84.1% (84.2, 84.0 and 84.0%, respectively, for YG, ML and RI). Based on small intestinal true digestibility of supplemental fats, the expected DE values for YG, ML and RI are 8.00, 6.28 and 6.40 Mcal/kg, respectively. It is concluded that in a 55% concentrate diet the characteristics of ruminal and total tract digestion are similar for calcium soaps of fatty acids and yellow grease.

<u>Whole cottonseed and supplemental fat</u>

Concern. From time to time, whole cottonseed has been priced competitively (on an energy basis) with corn, and presently, large amounts are being fed to feedlot cattle in the Southwestern United States and Northwestern Mexico. Moderate to high levels of supplemental fat are also used in diet formulation is these regions and there is some concern that the feeding value of WC may not be additive with concomitant fat supplementation.

Trial (Zinn and Placencia, 1992). Four Holstein steers (155 kg) with "T" cannulas in the rumen and proximal duodenum were used in a 4 x 4 Latin square design experiment to evaluate the interaction of whole cottonseed (WC) and yellow grease (YG) on digestive function. Four treatments were compared: 1) 0% YG, 0% WC; 2) 5% YG, 0% WC; 3) 0% YG, 20% WC and 4) 5% YG, 20% WC. The YG and WC were substituted for steam-flaked corn in an 80% concentrate growing-finishing diet. Composition of experimental diets and trial results are shown in Tables 67-70. Both YG and WC depressed ruminal OM digestion (P<.01). However, the effects were not additive (interaction, P<.05). When YG was added to the non-WC supplemented diet ruminal OM digestion was depressed 6.9%. In contrast, when YG was added to the WC supplemented diet the depression was 24.0%. This interaction was also apparent (P<.05) in ruminal digestion of feed N and starch. Total tract digestion of OM was depressed (P<.01) with WC and YG supplementation, although, like ruminal digestion, the effects were non-additive (P<.05). In the absence of WC, YG had little influence (.8%) on OM digestion. However, in the presence of WC, YG depressed total tract OM digestion 5.7%. This interaction was also manifest (P<.05) in total tract digestion of ADF and GE. While there was some compensation with respect to methane energy loss, the ME (Mcal/kg) of WC was 20% lower when fed in combination with YG. Degree of ruminal biohydrogenation of unsaturated fatty acids was high for both WC and YG. Postruminal digestion of lipid averaged 75.5%, tending to be increased (4.3%, P>.10) by WC and decreased (2.9%, P>.10) by YG supplementation. It is concluded that the feeding value of WC is diminished in growing-finishing diets that contain moderate levels (5%) of supplemental fat. The basis for this is not so much related to depressed digestibility of fat, per se, but rather to a more general negative associative effect on ruminal and total tract digestibility of OM. While reduced digestibility was offset, to some extent, by decreased ruminal methane energy loss, the ME of WC was 20% lower when fed in combination with YG.

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Table 1. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS

Item	Treatment					
	1	2	3	4	5	6
Ingredient composition, % of total, DM basis						
Alfalfa hay	8.00	8.00	8.00	8.00	8.00	8.00
Sudangrass hay	4.00	4.00	4.00	4.00	4.00	4.00
Steam rolled barley	58.90	58.90	58.90	58.90	58.90	58.90
Steam flaked corn	18.00	11.45	11.45	4.90	4.90	4.90
Cottonseed meal	.90	3.45	3.45	6.00	6.00	6.00
Yellow grease		4.00		8.00		
Blended fat[a]			4.00		8.00	6.00
Crude lecithin						2.00
Cane molasses	8.00	8.00	8.00	8.00	8.00	8.00
Urea	.30	.30	.30	.30	.30	.30
Trace mineral salt[b]	.50	.50	.50	.50	.50	.50
Dicalcium phosphate	.10	.10	.10	.10	.10	.10
Limestone	1.30	1.30	1.30	1.30	1.30	1.30
Vitamin A[c]	+	+	+	+	+	+

[a]Blended animal-vegetable fat.
[b]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.
[c]2,200 IU/kg diet.

Table 2. CHEMICAL ANALYSES OF SUPPLEMENTAL FAT BLENDS[a]

Item	Supplemental fat source		
	YG[b]	BVF[c]	BVFL[d]
Moisture, %	.12	.86	.90
Impurities, %	.10	.59	.53
Unsaponifiables, %	.52	4.16	3.63
Iodine value	71.02	62.45	69.40
Free fatty acids, %	9.7	52.8	49.2
Total fatty acids, %	90.7	93.7	92.1
Fatty acid profile, % total			
C12:0	.7	6.3	5.7
C14:0	1.4	3.2	3.0
C16:0	20.0	27.1	26.3
C16:1	2.2	1.0	.4
C18:0	12.1	10.2	9.7
C18:1	46.8	30.9	30.7
C18:2	16.3	20.4	23.2
C18:3	.4	.8	.9

[a]Yellow grease.
[b]Blended animal-vegetable fat.
[c]Blended animal-vegetable fat (75%) plus crude corn-soy lecithin (25%).

Table 3. INFLUENCE OF LEVEL OF FAT SUPPLEMENTATION ON GROWTH PERFORMANCE OF FEEDLOT STEERS AND NET ENERGY VALUE OF THE DIET

Item	Level of fat supplementation			
	0%	4%	8%	SD
Empty body weight, kg				
Initial	306	304	304	6
Final[a]	404	412	426	11
Empty body gain				
Weight, kg/d[a]	.83	.92	1.02	.10
Energy, Mcal/d[a]	2.93	3.45	4.30	.61
Fat, kg/d[a]	.265	.313	.399	.070
Protein, kg/d[b]	.126	.135	.141	.01
Dry matter intake, kg/d	6.19	6.18	6.42	.42
Dry matter conversion[a]	7.51	6.80	6.30	.34
Diet net energy, Mcal/kg				
Maintenance[a]	1.77	1.89	2.01	.06
Gain[a]	1.14	1.25	1.35	.05

[a]Linear effect, P<.01.
[b]Linear effect, P<.10.

Table 4. INFLUENCE OF LEVEL OF FAT SUPPLEMENTATION ON CARCASS MERIT AND COMPOSITION OF GAIN OF FEEDLOT STEERS

Item	Level of Fat Supplementation			
	0%	4%	8%	SD
Carcass weight, kg[a]	274	280	291	8
Rib eye area, cm^2	76.8	79.3	78.6	2.8
Fat thickness, cm	1.17	1.23	1.33	.23
KPH, %[ab]	2.72	3.07	3.35	.26
Marbling score, degrees[cd]	4.09	4.21	4.35	.30
Retail yield, %[e]	50.6	50.5	49.8	.7
Empty body composition, %				
Water[a]	55.0	54.5	53.2	1.3
Protein[a]	16.6	16.4	16.1	.3
Fat[a]	24.6	25.4	27.0	1.7

[a]Linear effect, $P<.01$.
[b]Kidney, pelvic and heart fat as a percentage of carcass weight.
[c]Linear effect, $P<.10$.
[d]Coded: Minimum slight = 4, minimum small = 5, etc.
[e]Linear effect, $P<.05$

Table 5. INFLUENCE OF SOURCE OF FAT SUPPLEMENTATION ON GROWTH PERFORMANCE OF FEEDLOT STEERS AND NET ENERGY VALUE OF THE DIET

Item	Source of Fat Supplementation		
	Yellow grease	Blended fat[a]	SD
Empty body weight, kg			
Initial	305	304	6
Final	422	416	11
Empty body gain			
Weight, kg/d	.996	.944	.096
Energy, Mcal/d	4.05	3.71	.61
Fat, kg/d	.373	.339	.070
Protein, kg/d	.140	.136	.017
Dry matter intake, kg/d	6.41	6.19	.42
Dry matter conversion	6.50	6.60	.34
Diet net energy, Mcal/kg			
Maintenance	1.96	1.94	.06
Gain	1.31	1.29	.05

[a]Blended animal-vegetable fat.

Table 6. INFLUENCE OF FAT SOURCE ON CARCASS MERIT AND COMPOSITION OF GAIN OF FEEDLOT STEERS

Item	Source of Fat Supplementation		
	Yellow grease	Blended fat[a]	SD
Carcass weight, kg	288	283	8
Rib eye area, cm^2	78.0	79.9	2.8
Fat thickness, cm	1.31	1.25	.23
KPH, %[b]	3.17	3.25	.26
Marbling score, degrees[c]	4.19	4.37	.30
Retail yield, %	50.0	50.4	.7
Empty body composition, %			
Water	53.6	54.1	1.3
Protein	16.2	16.3	.3
Fat	26.5	25.9	1.7

[a]Blended animal-vegetable fat.
[b]Kidney, pelvic and heart fat as a percentage of carcass weight.
[c]Coded: Minimum slight = 4, minimum small = 5, etc.

Table 7. INFLUENCE OF LECITHIN ON UTILIZATION OF A SUPPLEMENTAL VEGETABLE FAT BLEND BY STEERS: FEEDLOT CATTLE GROWTH PERFORMANCE AND NET ENERGY VALUE OF THE DIET

Item	8% Blended fat[a]: 0% Lecithin	6% Blended fat: 2% Lecithin	SD
Empty body weight, kg			
Initial	304	302	6
Final	424	420	11
Empty body gain			
Weight, kg/d	1.008	.993	.096
Energy, Mcal/d	4.22	3.85	.61
Fat, kg/d	.390	.347	.070
Protein, kg/d	.139	.145	.017
Dry matter intake, kg/d	6.33	6.22	.42
Dry matter conversion	6.31	6.29	.34
Diet net energy, Mcal/kg			
Maintenance	2.01	1.97	.06
Gain	1.36	1.32	.05

[a]Blended animal-vegetable fat.

Table 8. INFLUENCE OF LECITHIN ON UTILIZATION OF SUPPLEMENTAL VEGETABLE FAT BY STEERS: CARCASS MERIT AND COMPOSITION OF GAIN

Item	8% Blended fat[a]: 0% Lecithin	6% Blended fat: 2% Lecithin	SD
Carcass weight, kg	289	286	8
Rib eye area, cm^2	78.5	79.8	2.8
Fat thickness, cm	1.37	1.23	.23
KPH, %[b]	3.51	3.39	.26
Marbling score, degrees[c]	4.51	4.49	.30
Retail yield, %	49.7	50.3	.7
Empty body composition, %			
Water	53.3	54.1	1.3
Protein	16.1	16.3	.3
Fat	26.9	25.8	1.7

[a]Blended animal-vegetable fat.
[b]Kidney, pelvic and heart fat as a percentage of carcass weight.
[c]Coded: Minimum slight = 4, minimum small = 5, etc.

Table 9. INFLUENCE OF LEVEL OF FAT SUPPLEMENTATION ON CHARACTERISTICS OF DIGESTION OF A FINISHING DIET BY FEEDLOT STEERS

Item	Level of Fat Supplementation			
	0%	4%	8%	SD[a]
Intake, g/d				
Organic matter	5,284	5,297	5,284	
Starch	2,089	2,222	2,012	
Acid detergent fiber	625	598	636	
Lipid	64	257	429	
N	124	122	125	
Gross energy, Mcal/d	23.4	24.9	26.4	
Leaving abomasum, g/d				
Organic matter[b]	2,161	2,431	2,670	271
Starch	200	215	193	45
Acid detergent fiber[b]	453	484	593	61
Lipid[b]	166	326	481	35
Non-ammonia N	117	123	112	13
Microbial N[c]	95.6	102.6	85.7	12.7
Feed N	20.7	20.0	26.4	7.2
Ruminal digestion, %				
Organic matter[b]	59.1	54.1	49.5	5.1
Starch	90.3	90.3	90.4	2.2
Acid detergent fiber[b]	27.3	19.0	6.7	9.4
Feed N	83.2	83.5	78.9	5.8
Microbial efficiency[d]	31.0	36.3	34.0	7.3
Protein efficiency[ec]	.94	1.01	.90	.10

Table 9. Continued.

Leaving small intestine, g/d				
Organic matter[f]	1,077	1,096	1,241	151
Starch	40.8	41.9	39.2	13.0
Acid detergent fiber[g]	386	400	451	72
Lipid[b]	27.5	59.4	124.1	23.5
N	33.3	34.5	35.0	2.6
Small intestinal digestion, %				
Organic matter	50.3	54.2	52.9	5.0
Starch	77.3	80.6	78.7	6.8
Acid detergent fiber	13.7	16.5	23.0	12.2
Lipid[b]	83.4	81.4	74.1	5.8
N	71.2	71.3	68.2	3.4
Fecal excretion, g/d				
Organic matter[b]	794	862	1,013	70
Starch	13.2	14.6	17.1	5.8
Acid detergent fiber[b]	341	352	399	46
N[b]	26.6	28.5	30.1	1.1
Gross energy, Mcal/d[b]	4.01	4.53	5.58	.36
Total tract digestion, %				
Organic matter[b]	85.0	83.7	80.8	1.3
Starch	99.4	99.3	99.2	.3
Acid detergent fiber[f]	45.5	41.1	37.4	7.5
N[bh]	78.5	76.5	75.9	.9
Digestible energy, Mcal/kg[b]	3.43	3.60	3.68	.06
Metabolizable energy, Mcal/kg[b]	2.98	3.24	3.39	.07

[a]Standard deviation.
[b]Linear component to treatment response, $P<.01$.
[c]Quadratic component to treatment response, $P<.05$.
[d]Microbial N, g/kg organic matter fermented.
[e]Duodenal non-ammonia N/N intake.
[f]Linear component to treatment response, $P<.05$.
[g]Linear component to treatment response, $P<.10$.
[h]Quadratic component to treatment response, $P<.10$.

Table 10. INFLUENCE OF LEVEL OF FAT SUPPLEMENTATION ON FATTY ACID PROFILE OF CHYME ENTERING AND LEAVING THE SMALL INTESTINE

Item	Level of Fat Supplementation			
	0%	4%	8%	SD[a]
Fatty acid profile, % total				
Duodenal chyme				
Lauric[bc]	1.14	.45	.29	.22
Myristic[b]	.49	.74	.91	.20
Palmitic[b]	20.69	24.21	25.86	1.55
Palmitoleic	.02	.11	.66	.17
Stearic[b]	70.67	69.06	66.67	2.44
Oleic	5.08	3.88	4.93	1.68
Linoleic	1.92	1.56	1.26	.95
Ileal chyme				
Lauric[bc]	5.58	1.89	1.87	2.22
Myristic	1.22	2.86	2.70	1.04
Palmitic	19.63	20.84	19.21	2.57
Palmitoleic[b]	.16	.09	.02	.08
Stearic[b]	68.21	74.51	77.59	3.81
Oleic[bc]	.16	.06	.02	.03
Linoleic[b]	5.03	2.33	1.02	1.70

[a]Standard deviation.
[b]Linear component to treatment response, P<.01.
[c]Quadratic component to treatment response, P<.05.

Table 11. INFLUENCE OF LEVEL OF FAT SUPPLEMENTATION ON RUMINAL PH, VOLATILE FATTY ACID PROFILES AND METHANE PRODUCTION 4-H POSTPRANDIAL

Item	Level of Fat Supplementation			
	0%	4%	8%	SD[a]
Ruminal pH	6.34	6.29	6.20	.24
Ruminal concentration, mol/100 mol				
Acetate[b]	65.1	60.2	55.6	4.5
Propionate[b]	17.8	25.6	29.6	4.3
Butyrate[c]	17.1	14.2	14.9	3.1
Acetate/propionate[b]	3.74	2.46	2.04	.57
Methane production[bd]	.626	.541	.482	.05

[a]Standard deviation.
[b]Linear component to treatment response, P<.01.
[c]Linear component to treatment response, P<.10.
[d]Methane, mol/mol glucose equivalent fermented.

Table 12. INFLUENCE OF SOURCE OF SUPPLEMENTAL FAT ON CHARACTERISTICS OF DIGESTION OF A FINISHING DIET BY FEEDLOT STEERS

Item	Source of Fat Supplementation		
	Yellow Grease	Blended fat[a]	SD[b]
Intake, g/d			
Organic matter	5,281	5,299	
Starch	2,117	2,118	
Acid detergent fiber	626	628	
Lipid	345	340	
N	123	124	
Gross energy, Mcal/d	25.6	25.7	
Leaving abomasum, g/d			
Organic matter	2,491	2,610	271
Starch[c]	183	225	13
Acid detergent fiber	520	557	61
Lipid	400	406	35
Non-ammonia N	114	121	13
Microbial N	90.9	97.4	12.7
Feed N	23.1	23.3	7.2
Ruminal digestion, %			
Organic matter	52.8	50.7	5.1
Starch[c]	91.4	89.4	2.2
Acid detergent fiber[c]	17.2	8.6	9.4
Feed N	81.3	81.2	5.8
Microbial efficiency[d]	33.5	36.8	7.3
Protein efficiency[e]	92.7	97.8	.10
Leaving small intestine, g/d			
Organic matter	1,187	1,151	151
Starch	36.9	44.2	13.0
Acid detergent fiber	441	409	72
Lipid	95.3	88.2	23.5
N	34.8	34.7	2.6
Small intestinal digestion, %			
Organic matter[f]	51.8	55.4	5.0
Starch	79.2	80.1	6.8
Acid detergent fiber[c]	14.6	24.9	12.2
Lipid	77.1	78.4	5.8
N	68.8	70.7	3.4
Fecal excretion, g/d			
Organic matter	961	914	70
Starch	17.1	14.6	5.8
Acid detergent fiber	389	362	46
N	29.1	29.5	1.1
Gross energy, Mcal/d	5.17	4.94	.36
Total tract digestion, %			
Organic matter[f]	81.8	82.7	1.3
Starch	99.2	99.3	.3
Acid detergent fiber	37.9	40.6	7.5
N	76.3	76.2	.9
Digestible energy, Mcal/kg[c]	3.61	3.67	.06

Table 12. Continued.

Metabolizable energy, Mcal/kg	3.29	3.34	.07

[a]Blended animal-vegetable fat.
[b]Standard deviation.
[c]Treatments differ, P<.05.
[d]Microbial N, g/kg organic matter fermented.
[e]Duodenal non-ammonia N/N intake.
[f]Treatments differ, P<.10.

Table 13. INFLUENCE OF SOURCE OF SUPPLEMENTAL FAT ON FATTY ACID PROFILE OF CHYME ENTERING AND LEAVING THE SMALL INTESTINE

Item	Source of Fat Supplementation		
	Yellow Grease	Blended fat[a]	SD[b]
Fatty acid profile, % total			
Duodenal chyme			
Lauric	.36	.39	.22
Myristic[c]	.71	.94	.20
Palmitic[d]	23.06	27.01	1.55
Palmitoleic	.12	.05	.17
Stearic[d]	69.87	65.86	2.44
Oleic	4.51	4.30	1.68
Linoleic	1.38	1.44	.95
Ileal chyme			
Lauric	1.66	2.09	2.22
Myristic	1.79	3.78	1.04
Palmitic[d]	16.86	23.19	2.48
Palmitoleic	.05	.07	.07
Stearic[d]	79.45	72.64	3.70
Oleic	.03	.05	.08
Linoleic	1.75	1.61	1.70

[a]Blended animal-vegetable fat.
[b]Standard deviation.
[c]Treatments differ, P<.05.
[d]Treatments differ, P<.01.

Table 14. INFLUENCE OF SOURCE OF SUPPLEMENTAL FAT ON RUMINAL PH, VOLATILE FATTY ACID PROFILES AND METHANE PRODUCTION 4-H POSTPRANDIAL

Item	Source of Fat Supplementation		
	Yellow Grease	Blended fat[a]	SD[b]
Ruminal pH	6.20	6.28	.24
Ruminal concentration, mol/100 mol			
Acetate	56.9	58.8	4.5
Propionate[c]	29.9	25.2	4.3
Butyrate[c]	13.1	16.0	3.1
Acetate/propionate[d]	2.04	2.46	.57
Methane production[e]	.486	.537	.05

[a]Blended animal-vegetable fat.
[b]Standard deviation.
[c]Treatments differ, P<.05.
[d]Treatments differ, P<.10.
[e]Methane, mol/mol glucose equivalent fermented.

Table 15. INFLUENCE OF LECITHIN ON UTILIZATION OF SUPPLEMENTAL VEGETABLE FAT BY STEERS: CHARACTERISTICS OF DIGESTION

Item	8% Blended fat[a] 0% Lecithin	6% Blended fat 2% Lecithin	SD[b]
Intake, g/d			
Organic matter	5,293	5,285	
Starch	2,020	2,050	
Acid detergent fiber	622	623	
Lipid	427	404	
N	125	125	
Gross energy, Mcal/d	26.4	26.3	
Leaving abomasum, g/d			
Organic matter	2,740	2,540	271
Starch	222	215	13
Acid detergent fiber[c]	613	537	61
Lipid	490	461	35
Non-ammonia N	116	116	13
Microbial N	89.9	86.7	12.7
Feed N	26.1	29.1	7.2
Ruminal digestion, %			
Organic matter	48.2	51.9	5.1
Starch	89.0	89.5	2.2
Acid detergent fiber[c]	1.5	13.8	9.4
Feed N	79.1	76.6	5.8
Microbial efficiency[d]	35.8	32.1	7.3
Protein efficiency[e]	92.5	93.0	.10

Table 15. Continued.

Leaving small intestine, g/d			
Organic matter	1,183	1,169	151
Starch	38.5	44.7	13.0
Acid detergent fiber	420	428	72
Lipid	116.5	94.0	23.5
N	34.0	35.2	2.6
Small intestinal digestion, %			
Organic matter	56.6	53.0	5.0
Starch	82.3	78.5	6.8
Acid detergent fiber[f]	31.1	19.0	12.2
Lipid	75.9	79.3	5.8
N	70.4	69.2	3.4
Fecal excretion, g/d			
Organic matter	989	1,003	70
Starch	15.9	17.2	5.8
Acid detergent fiber	386	403	46
N	30.2	30.9	1.1
Gross energy, Mcal/d	5.42	5.42	.36
Total tract digestion, %			
Organic matter	81.3	81.0	1.3
Starch	99.2	99.2	.3
Acid detergent fiber	37.9	35.3	7.5
N	75.9	75.2	.9
Metabolizable energy, Mcal/kg[f]	3.41	3.33	.07
Digestible energy, Mcal/kg	3.72	3.69	.06

[a]Blended animal-vegetable fat.
[b]Standard deviation.
[c]Treatments differ, P<.05.
[d]Microbial N, g/kg organic matter fermented.
[e]Duodenal non-ammonia N/N intake.
[f]Treatments differ, P<.10.

Table 16. INFLUENCE OF LECITHIN ON FATTY ACID PROFILE OF CHYME ENTERING AND LEAVING THE SMALL INTESTINE

Item	8% Blended fat[a] 0% Lecithin	6% Blended fat 2% Lecithin	SD[b]
Fatty acid profile, % total			
Duodenal chyme			
Lauric	.31	.46	.22
Myristic	1.00	1.10	.20
Palmitic	27.21	27.24	1.55
Palmitoleic	.09	.01	.17
Stearic	65.27	65.11	2.44
Oleic	4.85	4.50	1.68
Linoleic	1.28	1.58	.95
Ileal chyme			
Lauric	2.41	1.55	2.22
Myristic	3.65	3.19	1.04
Palmitic	21.89	20.61	2.48
Palmitoleic	.03	.07	.07
Stearic	74.17	74.73	3.70
Oleic	.03	.03	.08
Linoleic	1.12	2.69	1.70

[a]Blended animal-vegetable fat.
[b]Standard deviation.

Table 17. INFLUENCE OF LECITHIN ON RUMINAL PH, VOLATILE FATTY ACID PROFILES AND METHANE PRODUCTION 4-H POSTPRANDIAL

Item	8% Blended fat[a] 0% Lecithin	6% Blended fat 2% Lecithin	SD[b]
Ruminal pH	6.30	6.44	.24
Ruminal concentration, mol/100 mol			
Acetate[c]	56.4	61.9	4.5
Propionate	26.1	24.2	4.3
Butyrate[d]	17.5	13.9	3.1
Acetate/propionate	2.27	2.76	.57
Methane production[e]	.516	.560	.05

[a]Blended animal-vegetable fat.
[b]Standard deviation.
[c]Treatments differ, P<.01.
[d]Treatments differ, P<.10.
[e]Methane, mol/mol glucose equivalent fermented.

Table 18. Influence of fat level and source on estimated net energy value of supplemental fat (Trials 1 and 2).

Item	Estimated NE Maintenance	Estimated NE Gain	DE	ME
	Mcal/kg			
Yellow grease				
4% supplementation	6.406	5.047	9.757	8.166
8% supplementation	5.655	4.537	8.720	7.354
average	6.031	4.792	9.238	7.760
Vegetable blend				
4% supplementation	5.281	4.208	11.056	9.705
8% supplementation	5.781	4.646	9.224	8.216
average	5.531	4.427	10.140	8.972
Vegetable blend plus lecithin				
8% supplementation	5.239	4.172	8.277	7.903
Average for Yellow grease and vegetable blend				
4% supplementation	5.844	4.628	10.406	8.936
8% supplementation	5.718	4.592	8.972	7.785
average	5.781	4.610	9.689	8.361

TABLE 19. RATION COMPOSITION (DRY MATTER BASIS), (TRIAL 1)

Item, %	3% fat	6% fat	9% fat
Alfalfa hay	10.00	9.67	9.34
Sudan hay	12.00	11.60	11.21
Steam rolled wheat	35.00	33.85	32.68
Steam flaked corn	30.90	29.89	28.85
Cane molasses	7.00	6.78	6.54
Fat	3.00	6.00	9.00
Limestone	.30	.29	.28
Dicalcium phosphate	.70	.73	.81
Urea	.70	.80	.92
TM salt	.40	.39	.37
Vitamin A[a]	+	+	+
Lasalocid[b]	+	+	+

a2200 IU/kg.
b30 g/T air dry feed.

Table 21. Composition of experimental diets (Trial 1 and 2)

Item	Calcium source	
	$CaCO_3$	$Ca(OH)2$
	---------- % ----------	
Alfalfa hay	8.0	8.0
Sudangrass hay	4.0	4.0
Barley, 47 lb/bu	58.9	59.4
Steam flaked corn	4.9	4.9
Cottonseed meal	6.0	6.0
Yellow grease	8.0	8.0
Cane molasses	8.0	8.0
Urea	.3	.3
Trace mineral salt[b]	.5	.5
Dicalcium phosphate	.1	.1
Limestone	1.3	--
Slaked lime	--	.8
Vitamin A[c]	+	+

[a]Dry matter basis.
[b]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.
[c]2200 IU/kg

Table 22. Influence of calcium source on steer performance and diet net energy value (Trial 1)

	Calcium source		
	$CaCO_3$	$Ca(OH)2$	SE[a]
Pen replicates	3	3	
Empty body weight, kg			
Initial	227	223	2
Final	377	359	6
Gain			
Empty body, kg/d	.93	.84	.03
Protein, kg/d[b]	.135	.117	.006
Fat, kg/d	.324	.317	.018
Energy, mcal/d	3.80	3.63	.17
Feed intake, kg/d[bc]	6.17	5.79	.12
Feed/gain	6.67	6.93	.28
Diet NE, mcal/kg			
Maintenance	1.84	1.88	.04
Gain	1.22	1.25	.03

[a]Standard error of mean.
[b]Means differ, $P<.10$.
[c]Dry matter basis.

Table 23. Influence of calcium source on body composition and carcass merit of feedlot steers fed a high fat diet (Trial 1)

	Calcium source		
	$CaCO_3$	$Ca(OH)2$	SE[a]
Empty body weight, kg	377	359	6
Empty body composition, %[b]			
Water	53.3	52.6	.5
Protein	16.1	16.0	.1
Fat	26.8	27.8	.7
Carcass weight, kg	255	241	4
Ribeye area, cm^2[cd]	75.8	72.6	.4
Fat thickness, cm	1.02	1.07	.12
KPH, % [e]	2.56	2.56	.09
Yield grade	2.39	2.48	.16
Marbling score[f]	3.97	3.80	.10

[a]Standard error of mean.
[b]Based on carcass specific gravity.
[c]Taken by direct grid reading of the eye muscle at the twelfth rib.
[d]Means differ, P<.01.
[e]Kidney, pelvic and heart fat as a percentage of carcass weight.
[f]Coded: minimum slight = 3, minimum small = 4, etc.

Table 24. Inlfuence of calcium source on ruminal pH and ionized calcium concentration

	Calcium source		
Item	$CaCO_3$	$Ca(OH)2$	SD[a]
Ruminal pH			
Time postprandial			
3 h	5.85	5.74	.10
6 h	6.05	5.99	.18
9 h	6.45	6.37	.20
12 h	6.72	6.71	.19
Avg	6.27	6.20	.12
Ionized Calcium, mM			
Time postprandial			
3 h	1.375	1.543	.586
6 h[b]	.447	1.008	.284
9 h	.147	.304	.168
12 h	.176	.217	.055
Avg	.537	.768	.181

[a]Standard deviation.
[b]Means differ, P<.05.

Table 25. Influence of calcium source on characteristics of digestion of high fat finishing diets by feedlot steers (Trial 2)

	Calcium Source		
	$CaCO_3$	$Ca(OH)_2$	SD[a]
Observations	4	4	
Intake, g/d			
Organic matter	2664	2654	
Starch	1135	1095	
Acid detergent fiber	330	334	
Lipid	185	196	
N	63	65	
Ruminal digestion, %			
Organic matter[b]	46.7	43.2	1.2
Starch	87.7	83.1	5.6
Acid detergent fiber	20.4	18.8	5.8
Feed N[c]	73.4	68.8	2.9
Microbial efficiency[d]	35.0	34.6	4.0
Small intestinal digestion, %			
Organic matter	56.7	56.9	2.7
Starch	74.0	77.2	4.1
Acid detergent fiber	33.0	31.7	5.6
Lipid	77.2	72.0	8.1
N	71.1	70.6	2.0
Total tract digestion, %			
Organic matter	79.2	78.4	2.0
Starch	98.3	97.8	.4
Acid detergent fiber	41.9	42.3	6.1
Lipid	65.0	60.2	7.9
N	73.7	73.6	1.4

[a]Standard deviation.
[b]Means differ, $P<.05$.
[c]Means differ, $P<.10$.
[d]Microbial N, g/kg organic matter fermented.

Table 26. Composition of Experimental Diets[a]

Item	Experiamental Diets,%			
	1	2	3	4
Alfalfa hay	8.00	8.00	8.00	8.00
Sudan-grass hay	4.00	4.00	4.00	4.00
Steam-rolled barley	58.90	58.90	58.90	58.90
Steam-flaked corn	18.00	11.45	18.00	11.45
Cane molasses	8.00	8.00	8.00	8.00
Yellow grease[b]		4.00		4.00
Cottonseed meal	.90	3.45	.90	3.45
Urea	.30	.30	.30	.30
Limestone	1.30	1.30	1.30	1.30
Dicalcium phosphate	.10	.10	.10	.10
Trace mineral salt c	.50	.50	.50	.50
Monensin, 33 mg/kg			+	+
Vitamin A,2200IU/kg	+	+	+	+

[a]Dry-matter basis.

[b]Fatty acid composition: lauric, 2.94%, myristic, 2.20%; palmitric, 26.98%; palmitoleic, 6.08%; stearic, 14.60%; oleic, 42.23%; linoleic, 4.97%.

[c]Contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

TABLE 27. MAIN EFFECTS OF SUPPLEMENTAL FAT AND MONENSIN ON STEER PERFORMANCE AND DIET NET ENERGY VALUE (TRIAL 1)

	Treatment main effects				
	Fat, %		Monensin,mg/kg		
Item	0	4	0	33	SE[a]
Pen replicates	8	8	8	8	
Empty body weight,kg[b]					
Initial	268	266	266	268	1
Final[c]	414	430	426	417	4
Empty body gain					
Weight,kg/d[de]	1.04	1.17	1.14	1.06	.03
Protein,kg/d[fg]	.157	.174	.169	.162	.006
Fat,kg/d[cfh]	.332	.387	.387	.333	.016
Energy,Mcal/d[cfh]	3.99	4.61	4.57	4.03	.15
Feed intake,kg/d[hi]	6.91	6.89	7.07	6.72	.11
Feed/gaind	6.66	5.92	6.21	6.37	.08
Net energy of diet,MCal/kg[i]					
Maintenanc[ed]	1.761	1.909	1.851	1.819	.033
Gain[d]	1.161	1.271	1.228	1.204	.025

[a]Standard error of mean, n = 8

[b]Based on carcass weight.

[c]Supplemental fat main effect (P<.05).

[d]Supplemental fat main effect (P<.01).

[e]Supplemental monensin main effect (P<.10).

[f]Based on carcass specific gravity of initial and final slaughter groups.

[g]Supplemental fat main effect (P<.10).

[h]Supplemental monensin main effect (P<.05).

[i]Dry-matter basis.

TABLE 28. MAIN EFFECTS OF SUPPLEMENTAL FAT AND MONENSIN ON CARCASS TRAITS OF FEEDLOT STEERS (TRIAL 1)

	Treatment main effects				
	Fat,%		Monensin,mg/kg		
Item	0	4	0	33	SE[a]
Carcass weight,kg	288	293	296	284	8
Carcass componets,%					
Water	51.2	50.8	49.8	52.3	1.3
Protein	15.2	15.1	14.8	15.6	.4
Fat	29.4	29.9	31.4	27.9	1.8
Ribeye area,cm2[b]	79.5	84.7	82.1	82.1	1.0
Fat thickness,cm	1.20	1.28	1.31	1.17	.06
KPH,%[c]	2.36	2.68	2.58	2.45	.09
Marbling score, degrees	4.96	4.86	4.96	4.86	.15
Yield,%	50.9	50.9	50.6	51.1	.2

[a]Standard error of mean, n = 8.

[b]Supplemental fat main effect (P<.01).

[c]Supplemental fat main effect (P<.05).

TABLE 29. MAIN EFFECTS OF SUPPLEMENTAL FAT AND MONENSIN ON STEER PERFORMANCE AND DIET NET ENERGY VALUE (TRIAL 2)

	Treatment main effects				
	Fat,%		Monensin, mg/kg		
Item	0	4	0	33	SE[a]
Pen replicates	12	12	12	12	
Empty body weight,kg[b]					
Initial	333	331	333	331	2
Finial	439	442	441	440	3
Empty body gain					
Weight,kg/d	1.14	1.19	1.16	1.16	.02
Protein,kg/d[c]	.148	.147	.147	.147	.004
Fat,kg/d[cd]	.498	.560	.528	.530	.015
Energy,Mcal/d[cd]	5.51	6.08	5.78	5.81	.14
Feed intake,kg/d[ef]	8.97	8.75	9.02	8.70	.09
Feed/gain[df]	7.91	7.39	7.79	7.51	.09
Net energy of diet, Mcal/kg					
Maintenanc[edf]	1.750	1.882	1.784	1.848	.020
Gain[df]	1.154	1.251	1.179	1.226	.015
Maintenance coefficient[f]	.081	.081	.084	.077	.002

[a]Standard error of mean, n = 12.
[b]Based on carcass weight.
[c]Based on carcass specific gravity of initial and final slaughter groups.
[d]Supplemental fat main effect (P<.01).
[e]Supplemental fat main effect (P<.10).
[f]Supplemental monensin main effect (P<.05).

TABLE 30. MAIN EFFECTS OF SUPPLEMENTAL FAT AND MONENSIN ON CARCASS TRAITS OF FEEDLOT STEERS (TRIAL 2)

	Treatment main effects				
	Fat,%		Monensin,mg/kg		
Item	0	4	0	33	SE[a]
Carcass weight,kg	300	302	302	301	2
Carcass components,%					
Water	53.8	53.0	53.4	53.4	.2
Protein	16.1	15.8	16.0	15.9	.1
Fat	25.7	26.8	26.2	26.3	.3
Ribeye area,cm^2	76.1	75.4	75.4	76.2	.6
Fat thickness,cm[b]	.46	.49	.46	.48	.02
KPH,%	2.28	2.54	2.41	2.41	.08
Marbling score,degrees	3.60	3.62	3.59	3.63	.07
Yield,%[c]	51.8	51.5	51.7	51.7	.1

[a]Standard error of mean, n = 12.
[b]Supplemental fat main effect (P<.05).
[c]Supplemental fat main effect (P<.10).

TABLE 20. INFLUENCE OF METHOD AND LEVEL OF FAT SUPPLEMENTATION ON ANIMAL PERFORMANCE AND NET ENERGY VALUE OF THE DIETS (TRIAL 1)

	Treatments									
	3% fat			6% fat			9% fat			
	On grain	On last	On hay	On grain	On last	On hay	On grain	On last	On hay	S.D.
Pen reps	4	4	4	4	4	4	4	4	4	
Weight, kg										
Initial	269	266	264	268	267	265	267	268	268	6.8
Final	470	472	463	458	466	461	438	441	433	13.2
Daily gain, kg	1.35	1.30	1.23	1.18	1.19	1.27	1.06	1.07	.96	.10
Daily feed, kg	7.44	7.21	7.10	6.86	6.74	7.12	6.33	6.53	6.09	.28
Feed/gain	5.52	5.54	5.79	5.83	5.69	5.64	5.99	6.21	6.43	.42
Net energy, mcal/kg										
Maintenance	1.69	1.69	1.74	1.66	1.74	1.71	1.74	1.67	1.74	.060
Gain	1.10	1.11	1.15	1.09	1.15	1.13	1.15	1.09	1.14	.050

TABLE 31. MAIN EFFECTS OF SUPPLEMENTAL FAT AND MONENSIN ON CHARACTERISTICS OF DIGESTION

	Supplemental fat[a], %		Supplemental monensin, mg/kg		
	0	4	0	33	SD[b]
Observations	8	8	8	8	
Ruminal digestion, %					
Organic matter[c]	55.5	51.2	53.4	53.3	2.8
Starch	90.3	91.3	90.7	90.9	2.7
Acid detergent fiber	16.9	14.5	18.8	12.6	10.6
Feed N	56.0	55.1	56.0	55.2	8.5
Microbial efficiency[dc]	25.1	28.0	27.5	25.6	2.7
Small intentinal digention, %					
Organic matter[c]	47.3	49.6	49.0	47.9	2.1
Starch[c]	76.8	71.3	75.3	72.8	5.3
Acid detergent fiber	3.6	9.7	4.9	8.3	10.6
N[f]	74.0	73.3	74.8	72.5	2.2
Lipid[f]	81.3	79.1	77.3	83.0	5.5
Total tract digestion, %					
Organic matter	80.8	79.3	80.3	79.9	2.2
Starch	99.1	99.0	99.1	99.0	.20
Acid detergent fiber	31.8	29.3	32.8	28.4	5.8
N	74.6	74.6	74.2	75.0	3.2
Lipid[fg]	41.4	73.6	50.6	64.5	14.3

[a]Yellow grease.
[b]Standard deviation.
[c]Fat significant ($P<.05$).
[d]Microbial N, g/kg organic matter fermented.
[e]Fat effect significant ($P<.10$).
[f]Monensin effect significant ($P<.10$).
[g]Fat effect significant ($P<.01$).

TABLE 32. MAIN EFFECTS AND INTERACTIONS OF SUPPLEMENTAL FAT AND MONENSIN ON RUMINAL pH, VFA PROFILES AND ESTIMATED METHANOGENSIS

	Main effects				
	Supplemental fat[a], %		Supplemental monensin, mg/kg		
	0	4	0	33	SD[b]
Average for feeding inteval					
Ruminal pH	5.86	6.00	5.96	5.91	.28
Ruminal concentrations, mol/100mol					
Acetate[cd]	50.9	49.6	52.0	48.5	3.0
Propionate[efg]	39.9	42.6	38.7	43.8	3.0
Butyrate	9.2	7.8	9.3	7.7	1.9
Acetate/propionate[fg]	1.35	1.17	1.40	1.12	.19
Methane[fg]	.366	.335	.383	.318	

[a]Yellow grease.
[b]Standard deviation.
[c]Significant supplemental fat by monensin interactions ($P<.10$).
[d]Significant monensin effect ($P<.01$).
[e]Significant supplemental fat effect ($P<.05$).
[f]Significant supplemental fat by monensin interactions ($P<.05$).
[g]Significant monensin effect ($P<.05$).
[h]Significant monensin effect ($P<.01$).
[i]Significant supplemental fat by monensin interactions ($P<.01$).
[j]Methane, mol/mol glucose equivalent fermented.
[k]Significant monensin effect ($P<.10$).

Table 33. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS (Trials 1 and 2)[a]

Item	Treatments 1	2	3	4
	%			
Alfalfa hay	6.38	6.00	6.00	6.00
Sudangrass hay	6.38	6.00	6.00	6.00
Steam flaked corn	76.56	71.96	69.09	65.26
Soybean meal			3.06	7.22
Yellow grease		6.00	6.00	6.00
Cane molasses	7.45	7.00	7.00	7.00
Limestone	1.64	1.54	1.54	1.54
Urea	1.06	1.00	.81	.48
Trace mineral salt[b]	.53	.50	.50	.50
Vitamin A[c]	+	+	+	+
Lasalocid[d]	+	+	+	+
Nutrient composition[e]				
Net energy, Mcal/kg				
Maintenance	2.10	2.34	2.33	2.33
Gain	1.44	1.64	1.64	1.63
Crude protein, %				
Total	13.6	12.8	13.5	14.2
Rumen degradable[f]	9.6	9.0	9.2	9.3
Rumen bypass	4.0	3.8	4.3	4.9
Ether extract, %	3.5	9.3	9.2	9.1
Calcium, %	.78	.73	.74	.76
Phosphorus, %	.29	.27	.28	.30

[a]Dry matter basis.

[b]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

[c]2200 IU/kg.

[d]32 mg/kg.

[e]Based on tabular values for individual feed ingredients (NRC, 1984) with exception of supplemental fat which was assigned NE_m and NE_g values of 6.03 and 4.79, respectively (Zinn, 1988b).

[f]Based on the following estimates for ruminal degradability of dietary crude protein: alfalfa hay, 70%; sudangrass hay, 65%; steam flaked corn, 50%; soybean meal, 60%; cane molasses, 100% and urea, 100%.

Table 34. PROFILE OF YELLOW GREASE FED TO STEERS (TRIALS 1 AND 2)

Item	
Moisture, %	.5
Impurities, %	.05
Unsaponifiables, %	1.16
Total fatty acids, %	94.7
Free fatty acids, %	13.1
Iodine value	75.5
Fatty acid profile, %	
C12	.2
C14	1.8
C15	.6
C16	23.9
C16:1	5.1
C17	.2
C18	11.1
C18:1	43.1
C18:2	14.0

Table 35. INFLUENCE OF PROTEIN SUPPLEMENTATION ON FEEDLOT GROWTH PERFORMANCE AND ESTIMATED NET ENERGY VALUE OF FAT SUPPLEMENTED DIETS FED TO STEERS (TRIAL 1)

	Treatment				
Item	1	2	3	4	SD
Empty body weight, kg					
Initial	273	274	275	272	8
Final	458	476	471	468	24
Empty body gain, kg/d	1.25	1.36	1.33	1.32	.11
Dry matter intake, kg/d	7.34	7.02	7.12	7.19	.42
Dry matter conversion[a]	5.88	5.19	5.41	5.45	.27
Diet net energy, Mcal/kg					
Maintenance[bc]	1.94	2.19	2.14	2.09	.05
Gain[bc]	1.29	1.51	1.47	1.42	.05

[a]Treatment 1 versus treatments 2, 3 and 4 (fat effect), P<.05.
[b]Treatment 1 versus treatments 2, 3 and 4 (fat effect), P<.01.
[c]Linear component for treatments 2, 3 and 4 (protein effect), P<.05.

Table 36. INFLUENCE OF PROTEIN SUPPLEMENTATION ON CARCASS MERIT AND EMPTY BODY COMPOSITION OF FEEDLOT STEERS FED FAT SUPPLEMENTED DIETS (TRIAL 1)

Item	Treatment				
	1	2	3	4	SD
Carcass weight, kg	314	328	324	321	17
Dressing percentage[a]	64.8	66.3	66.0	64.8	.9
Rib eye area, cm^2	83.8	86.1	84.6	82.0	4.5
Fat thickness, cm	.98	1.14	1.10	.97	.25
KPH, %[bc]	2.28	2.78	2.68	2.51	.33
Marbling score, degrees[d]	3.86	3.91	3.86	3.95	.23
Retail yield, %	51.2	50.6	50.7	50.8	.8
Empty body composition, %					
Water	54.0	52.6	52.6	53.1	1.4
Protein	16.3	15.9	15.9	16.1	.4
Fat	26.0	27.8	27.9	27.1	1.9

[a]Linear component for treatments 2, 3 and 4 (protein effect), P<.10.
[b]Treatment 1 versus treatments 2, 3 and 4 (fat effect), P<.10.
[c]Kidney, pelvic and heart fat as a percentage of carcass weight.
[d]Coded: Minimum slight = 3, minimum small = 4, etc.

Table 37. INFLUENCE OF PROTEIN SUPPLEMENTATION ON CHARACTERISTICS OF DIGESTION OF FAT SUPPLEMENTED DIETS FED TO STEERS (TRIAL 2)

Item	Treatment				
	1	2	3	4	SD
Intake, g/d					
DM	5,782	5,788	5,827	5,827	
OM	5,477	5,485	5,518	5,521	
Starch	2,596	2,402	2,389	2,354	
ADF	431	439	445	443	
Lipid	158	442	470	453	
N (total)	125	119	126	132	
N (non-urea)	97.3	92.6	104.6	119.7	
GE, Mcal/d	24.1	26.0	26.4	26.4	
Leaving abomasum, g/d					
OM[a]	2,544	3,224	3,132	3,283	195
Starch[b]	462	579	586	595	66
ADF[cd]	340	398	375	349	27
Lipid[aef]	217	502	562	548	14
Non-ammonia N[c]	115	123	120	132	8
Microbial N[bd]	79.9	85.1	89.2	96.7	5.0
Feed N	36.0	37.7	31.1	35.7	6.8
Ruminal digestion, % intake					
OM[a]	68.1	56.7	59.4	58.0	3.3
Starch[a]	82.2	75.9	75.5	74.7	2.8
ADF[d]	21.0	9.4	15.7	21.3	6.3
Feed N					
Total	71.1	68.3	75.3	73.0	5.2
Non-urea[d]	63.0	59.3	70.3	70.1	6.1

Table 37. continued.

Microbial efficiency[ag]	21.5	27.8	27.3	31.0	2.4
Protein efficiency[ch]	.93	1.03	.96	1.00	.06
Fecal excretion, g/d					
OM[ad]	695	841	927	950	51
Starch[c]	12.3	19.8	18.2	26.3	7.8
ADF[b]	226	242	250	257	16.5
Lipid[aij]	50.3	140.5	190.6	167.2	18.5
N[bd]	26.1	27.8	29.9	32.5	1.9
GE, Mcal/d[adk]	3.58	4.77	5.47	5.43	.31
Post-ruminal digestion, % leaving abomasum					
OM[d]	72.6	73.8	70.5	71.0	1.9
Starch	97.3	96.4	96.9	96.0	1.3
ADF[d]	32.8	39.2	33.1	26.1	5.4
Lipid[c]	77.0	72.1	66.1	69.5	5.7
N	78.6	78.3	76.4	76.6	1.3
Post-ruminal digestion, % intake					
OM[a]	33.8	43.4	40.0	42.3	3.2
Starch[a]	17.3	23.3	23.8	24.2	2.8
ADF[ad]	26.5	35.4	28.0	20.6	6.5
Lipid[aef]	105.1	81.8	79.1	84.1	2.6
N	76.6	85.2	76.8	80.6	5.7
Total tract digestion, %					
OM[ad]	87.3	84.7	83.2	82.7	.9
Starch[c]	99.5	99.2	99.2	98.9	.3
ADF	47.5	44.9	43.8	41.9	3.7
Lipid	68.3	68.2	59.4	63.1	8.4
N[a]	79.1	76.6	76.2	75.4	1.5
DE, Mcal/kg[ci]	3.55	3.67	3.60	3.60	.05
ME, Mcal/kg[ad]	3.10	3.26	3.20	3.19	.04
NE_m[ad]	2.11	2.25	2.20	2.19	.03
NE_g[ad]	1.44	1.56	1.52	1.51	.03

[a]Treatment 1 versus treatments 2, 3 and 4 (fat effect), P<.01.
[b]Treatment 1 versus treatments 2, 3 and 4 (fat effect), P<.05.
[c]Treatment 1 versus treatments 2, 3 and 4 (fat effect), P<.10.
[d]Linear component for treatments 2, 3 and 4 (protein effect), P<.05.
[e]Linear component for treatments 2, 3 and 4 (protein effect), P<.01.
[f]Quadratic component for treatments 2, 3 and 4 (protein effect), P<.01.
[g]Microbial N, g/kg OM fermented.
[h]Duodenal non-ammonia N/N intake.
[i]Linear component for treatments 2, 3 and 4 (protein effect), P<.10.
[j]Quadratic component for treatments 2, 3 and 4 (protein effect), P<.05.
[k]Quadratic component for treatments 2, 3 and 4 (protein effect), P<.10.

Table 38. INFLUENCE OF PROTEIN SUPPLEMENTATION ON RUMINAL PH, AMMONIA, VFA PROFILES AND METHANE PRODUCTION 4 H POSTPTANDIAL (TRIAL 2)

Item	Treatment 1	2	3	4	SD
Ruminal pH	6.06	6.17	6.17	6.01	.18
Ruminal ammonia, mg/dl	5.56	4.68	6.68	4.79	2.11
Ruminal VFA, mol/100 mol					
Acetate[a]	68.8	70.8	67.1	65.2	3.3
Propionate[b]	21.6	19.5	21.8	24.5	2.7
Butyrate	9.6	9.7	11.1	10.3	1.3
Methane production[bc]	.62	.65	.61	.57	.04

[a]Linear component for treatments 2, 3 and 4 (protein effect), $P<.10$.

[b]Linear component for treatments 2, 3 and 4 (protein effect), $P<.05$.

[c]Methane, mol/mol glucose equivalent fermented.

Table 39. INFLUENCE OF PROTEIN SUPPLEMENTATION ON THE ESTIMATED ENERGY VALUE OF YELLOW GREASE (TRIALS 1 AND 2)

Item	Treatment 2	3	4
Trial 1			
NE, Mcal/kg fat			
Maintenance	6.11	5.35	4.60
Gain	4.96	4.35	3.58
Trial 2			
DE, Mcal/kg fat	5.55	4.51	4.71
ME, Mcal/kg fat	5.76	4.86	4.93
NE, Mcal/kg fat			
Maintenance	4.44	3.69	3.60
Gain	3.44	2.84	2.73

Table 40. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS[a]

Item	Treatments 1	2	3	4
	%			
Alfalfa hay	6.00	6.00	6.00	6.00
Sudangrass hay	6.00	6.00	6.00	6.00
Steam flaked corn	51.43	46.43	49.43	44.43
Steam flaked wheat	20.00	20.00	20.00	20.00
Cassava pellets	10.00	10.00	10.00	10.00
Yellow grease		5.00		5.00
Blood meal			.66	.66
Feather meal			.67	.67
Meat and bone meal			.67	.67
Cane molasses	3.00	3.00	3.00	3.00
Sodium bicarbonate	.75	.75	.75	.75
Limestone	1.47	1.47	1.47	1.47
Urea	.95	.95	.95	.95
Trace mineral salt[b]	.40	.40	.40	.40
Vitamin A[c]	+	+	+	+
Nutrient composition[d]				
Net energy, Mcal/kg				
Maintenance	2.07	2.25	2.06	2.24
Gain	1.41	1.57	1.40	1.56
Crude protein, %				
Total	12.5	12.0	13.8	13.3
Rumen degradable[e]	8.8	8.6	9.2	9.0
Ether extract, %	2.7	7.5	2.8	7.6
Calcium, %	.80	.80	.88	.88
Phosphorus, %	.29	.27	.32	.31

[a]Dry matter basis.

[b]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

[c]2200 IU/kg.

[d]Based on tabular values for individual feed ingredients (NRC, 1984) with exception of supplemental fat which was assigned NE_m and NE_g values of 6.03 and 4.79, respectively (Zinn, 1988).

[e]Based on the following estimates for ruminal degradability of dietary crude protein: alfalfa hay, 70%; sudangrass hay, 65%; steam flaked corn, 50%; steam flaked wheat, 85%; cassava pellets, 77%; cane molasses, 100%; feather meal, 40%; blood meal, 17%; meat and bone meal, 37% and urea, 100%.

Table 41. COMPOSITION OF YELLOW GREASE USED IN TRIALS 1 AND 2[a]

	Yellow grease
Moisture, %	.56
Impurities, %	.50
Unsaponifiables, %	.24
Iodine value	72.0
Free fatty acids, %	8.0
Fatty acid profile, %	
C14:0	1.1
C16:0	17.8
C16:1	2.5
C18:1	58.2
C18:2	19.5
C18:3	.9

[a]Analysis provided by Baker Commodities Inc., Los Angeles, CA.

Table 42. INFLUENCE OF PROTEIN SUPPLEMENTATION ON THE COMPARATIVE FEEDING VALUE OF YELLOW GREASE IN A GROWING-FINISHING DIET FOR FEEDLOT CATTLE

Item	Treatments				SD
	1	2	3	4	
Pen replicates	4	4	4	4	
Live weight, kg					
Initial[b]	352	351	350	351	26
Final[c]	480	497	485	495	28
Weight gain, kg/d					
First 56-d	1.09	1.26	1.12	1.17	.20
Overall (123-d)	1.04	1.21	1.10	1.18	.15
DMI, kg/d					
First 56-d	6.61	6.62	6.61	6.41	.69
Overall (123-d)	6.69	6.79	6.77	6.91	.62
DMI/gain					
First 56-d	6.08	5.32	5.93	4.53	.46
Overall (123-d)	6.45	5.68	6.15	5.84	.36
Diet NE, Mcal/kg[d]					
Maintenance	1.94	2.22	2.03	2.13	.13
Gain	1.29	1.53	1.37	1.46	.12

[a]DM basis.
[b]Initial weight reduced 4% to adjust for digestive tract fill.
[c]Carcass adjusted final weight.
[d]Energy retention was based on carcass specific gravity.

Table 43. TREATMENT EFFECTS ON ON CARCASS MEASUREMENTS

Item	Treatments 1	2	3	4	SD
Carcass weight, kg	309	321	313	319	18
Carcass composition, %					
Water	51.3	49.0	50.6	49.7	1.8
Fat	29.2	32.5	30.3	31.6	2.5
Protein	15.3	14.5	15.0	14.7	.6
Dressing percentage	64.5	64.7	64.9	64.1	.8
Rib eye area, cm^2	82.7	79.2	81.9	81.0	4.0
Fat thickness, cm	1.14	1.53	1.31	1.39	.39
KPH, %[a]	2.73	2.89	2.77	2.83	.37
Marbling score, degrees[bc]	4.04	4.35	4.72	3.60	.28
Retail yield, %	50.6	49.0	50.1	49.6	1.3
Liver Abscess, %	0	0	0	0	0

[a]Kidney, pelvic and heart fat as a percentage of carcass weight.
[b]Coded: Minimum slight = 3, minimum small = 4, etc.
[c]Interaction of protein and yellow grease supplementation, P<.01.

Table 44. MAIN EFFECT OF PROTEIN SUPPLEMENTATION ON FEEDLOT PERFORMANCE OF GROWING-FINISHING STEERS

Item	High-bypass protein blend −	+	SD
Pen replicates	8	8	
Live weight, kg			
Initial[a]	351	350	26
Final[b]	488	490	28
Weight gain, kg/d			
First 56-d	1.17	1.15	.20
Overall (150-d)	1.11	1.13	.15
DMI, kg/d			
First 56-d	6.61	6.51	.69
Overall (150-d)	6.74	6.84	.62
DMI/gain			
First 56-d	5.70	5.73	.46
Overall (150-d)	6.07	6.00	.36
Diet NE, Mcal/kg[c]			
Maintenance	2.08	2.08	.14
Gain	1.41	1.41	.12

[a]Initial weight reduced 4% to adjust for digestive tract fill.
[b]Carcass adjusted final weight.
[c]Energy retention was based on carcass specific gravity.

Table 45. MAIN EFFECTS OF PROTEIN SUPPLEMENTATION ON CARCASS MEASUREMENTS

Item	High-bypass protein blend		
	-	+	SD
Carcass weight, kg	315	316	18
Carcass composition, %			
Water	50.2	50.1	1.8
Fat	30.9	30.9	2.5
Protein	14.9	14.9	.6
Dressing percentage	64.6	64.5	.8
Rib eye area, cm^2	80.9	81.4	4.0
Fat thickness, cm	1.34	1.35	.39
KPH, %[a]	2.81	2.80	.37
Retail yield, %	49.8	49.9	1.3
Liver Abscess, %	0	0	0

[d]Kidney, pelvic and heart fat as a percentage of carcass weight.

Table 46. MAIN EFFECT OF YELLOW GREASE SUPPLEMENTATION ON FEEDLOT PERFORMANCE OF GROWING-FINISHING STEERS

Item	Yellow grease, %		
	0	5	SD
Pen replicates	8	8	
Live weight, kg			
Initial[a]	351	351	26
Final[b]	481	495	28
Weight gain, kg/d			
First 56-d	1.11	1.21	.20
Overall (150-d)	1.06	1.18	.15
DMI, kg/d			
First 56-d	6.61	6.51	.69
Overall (150-d)	6.73	6.85	.62
DMI/gain			
First 56-d[c]	6.01	5.42	.46
Overall (150-d)[d]	6.37	5.82	.36
Diet NE, Mcal/kg[e]			
Maintenance[d]	1.98	2.17	.14
Gain[d]	1.33	1.50	.12

[a]Initial weight reduced 4% to adjust for digestive tract fill.
[b]Carcass adjusted final weight.
[c]Treatments differ, P<.10.
[d]Treatments differ, P<.05.
[e]Energy retention was based on carcass specific gravity.

Table 47. MAIN EFFECTS OF YELLOW GREASE SUPPLEMENTATION ON CARCASS MEASUREMENTS

Item	Yellow grease, %		
	0	5	SD
Carcass weight, kg	311	320	18
Carcass composition, %			
Water	50.9	49.3	1.8
Fat	29.8	32.0	2.5
Protein	15.1	14.6	.6
Dressing percentage	64.7	64.3	.8
Rib eye area, cm^2	82.3	80.1	4.0
Fat thickness, cm	1.22	1.46	.39
KPH, %[a]	2.75	2.86	.37
Retail yield, %	50.4	49.3	1.3
Liver Abscess, %	0	0	0

[d]Kidney, pelvic and heart fat as a percentage of carcass weight.

Table 48. INFLUENCE OF PROTEIN AND FAT SUPPLEMENTATION ON RUMINAL PH, VFA PROFILES AND METHANE PRODUCTION 4 H POSTPRANDIAL (Trial 2)

Item	Treatments				
	1	2	3	4	SD
Ruminal pH	5.90	5.90	5.81	5.95	.11
Ruminal VFA, mol/100 mol					
Acetate	55.1	60.7	60.1	60.2	3.6
Propionate	27.3	24.5	26.5	25.3	3.8
Butyrate[ab]	17.7	14.8	13.4	14.5	1.8
Methane production[c]	.50	.55	.53	.54	.05

[a]Supplemental protein main effect, P<.05.
[b]Supplemental protein by fat interaction, P<.10.
[c]Methane, mol/mol glucose equivalent fermented.

Table 49. INFLUENCE OF PROTEIN AND FAT SUPPLEMENTATION ON CHARACTERISTICS OF RUMINAL AND TOTAL TRACT DIGESTION (Trial 2)

Item	Treatments 1	2	3	4	SD
Intake, g/d					
OM	6,695	6,950	6,890	7,065	
ADF	587	461	543	636	
N	144	133	153	160	
lipid	243	564	250	590	
GE, Mcal/d	29.9	32.5	30.8	33.5	
Leaving abomasum, g/d					
OM[a]	3,108	2,930	2,998	2,469	257
ADF[b]	369	342	396	436	36
Non-ammonia N[b]	149	129	156	162	16
Microbial N	57.9	58.8	55.2	56.0	13.4
Feed N[ac]	91.5	70.3	100.6	111.4	13.5
lipid[d]	261	556	270	619	111
GE, Mcal/d[ad]	15.7	16.3	15.4	19.3	1.2
Ruminal digestion, %					
OM[ae]	62.2	66.3	64.5	58.1	2.1
ADF[a]	37.1	25.9	27.0	31.5	4.9
Feed N	36.3	47.2	34.0	30.4	8.5
GE[a]	47.7	49.7	50.1	42.5	3.5
Fecal excretion, g/d					
OM	825	839	729	895	153
ADF	266	294	249	295	47
N	35.0	30.1	30.4	34.6	5.2
Lipid[d]	83.8	135.0	65.4	145.7	26.1
GE, Mcal/d	4.3	4.6	3.8	4.9	.8
Postruminal digestion, % duodenal					
OM	73.2	71.0	75.9	74.1	3.8
ADF[b]	16.1	10.4	37.7	31.5	14.1
N	77.7	77.1	81.0	79.2	3.1
Lipid	67.7	75.4	75.7	74.8	4.6
GE	72.5	71.4	75.8	74.2	4.0
Small intestinal digestion, % intake					
OM	34.1	30.1	32.9	36.4	2.3
ADF[b]	17.5	10.3	27.1	22.1	8.3
N	83.7	78.4	86.0	83.7	9.6
Total tract digestion, %					
OM	87.7	87.9	89.4	87.3	2.2
ADF[fg]	54.6	36.2	54.2	53.6	8.8
N	75.6	77.4	80.0	78.4	3.4
GE	85.6	85.8	87.8	85.3	2.4
DE, Mcal/kg[h]	3.60	3.84	3.73	3.82	.1

[a]Supplemental protein by fat interaction, $P<.05$.
[b]Supplemental protein main effect, $P<.05$.
[c]Supplemental protein main effect, $P<.01$.
[d]Supplemental fat main effect, $P<.01$.
[e]Supplemental protein by fat interaction, $P<.01$.
[f]Supplemental fat main effect, $P<.10$.
[g]Supplemental protein by fat interaction, $P<.10$.
[h]Supplemental fat main effect, $P<.05$.

Table 50. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS (Trials 1 and 2)

Item	Treatments 1	2	3	4	5	6
Ingredient Composition, %[a]						
Alfalfa hay	8.00	8.00	8.00	8.00	8.00	8.00
Sudangrass hay	4.00	4.00	4.00	4.00	4.00	4.00
Steam flaked corn	79.24	69.54	69.54	9.70		
Steam flaked wheat				70.24	70.24	70.24
Yellow grease		6.00			6.00	
Cottonseed oil soapstock			6.00			6.00
Cottonseed meal		3.70	3.70		3.70	3.70
Cane molasses	6.00	6.00	6.00	6.00	6.00	6.00
Limestone	1.56	1.56	1.56	1.56	1.56	1.56
Urea	.70	.70	.70			
Trace mineral salt[b]	.50	.50	.50	.50	.50	.50
Vitamin A[c]	+	+	+	+	+	+
Nutrient composition[ad]						
Net energy, Mcal/kg						
Maintenance	2.13	2.33	2.33	2.01	2.21	2.21
Gain	1.47	1.64	1.64	1.36	1.53	1.53
Crude protein, %						
Total	12.0	12.7	12.7	13.1	13.8	13.8
Rumen degradable[e]	7.5	7.8	7.8	9.1	9.3	9.3
Rumen escape[e]	5.4	5.7	5.7	4.2	4.5	4.5
Ether extract, %	3.6	9.3	9.3	2.0	7.6	7.6
Calcium, %	.75	.75	.75	.77	.77	.77
Phosphorus, %	.29	.32	.32	.37	.40	.40

[a]DM basis.

[b]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

[c]2200 IU/kg.

[d]Based on tabular values for individual feed ingredients (NRC, 1984) with exception of supplemental fat which was assigned NE_m and NE_g values of 6.03 and 4.79, respectively (Zinn, 1988).

[e]Based on the following estimates for ruminal degradability of dietary crude protein: alfalfa hay, 70%; sudangrass hay, 65%; steam flaked corn, 45%; cottonseed meal, 45%; cane molasses, 100% and urea, 100%.

Table 51. CHEMICAL ANALYSES OF SUPPLEMENTAL FATS (Trials 1 and 2)

Item	Supplemental fat source: Yellow grease	Supplemental fat source: Cottonseed oil soapstock
Moisture, %	.5	1.4
Impurities, %	.05	4.9
Unsaponifiables, %	1.16	3.46
Iodine value	75.5	102.6
Free fatty acids, %	13.1	54.8
Total fatty acids, %	94.7	85.7
Fatty acid profile, % total		
C12:0	.2	.4
C14:0	1.8	.9
C16:0	24.1	21.5
C16:1	5.1	1.4
C18:0	11.2	6.0
C18:1	43.4	26.5
C18:2	14.1	40.2
C18:3	.1	3.1

Table 52. INFLUENCE OF FAT SUPPLEMENTATION ON 121-D GROWTH-PERFORMANCE OF FEEDLOT STEERS AND NET ENERGY VALUE OF THE DIET (Trial 1)

Item	Treatments[a]			SD
	No fat	6% YG	6% COS	
Pen replicates	10	10	10	
Initial weight, kg				
Live[b]	324	323	323	2
Empty body	292	292	292	2
Final weight, kg				
Live[cd]	481	492	488	13
Empty body[d]	452	462	458	11
Gain				
Live weight, kg/d[e]	1.30	1.41	1.38	.11
Empty body				
Weight, kg/d[e]	1.33	1.43	1.40	.10
Water, kg/d	.62	.63	.60	.07
Fat, kg/d, kg/d[e]	.48	.55	.56	.08
Protein, kg/d	.19	.20	.19	.02
Energy, Mcal/d[e]	5.57	6.26	6.36	.74
DM intake, kg/d[e]	7.82	7.42	7.61	.38
ME intake, Mcal/d[c]	22.4	23.1	23.4	1.2
DM conversion				
Live weight[f]	6.05	5.28	5.54	.40
Empty body weight[f]	5.91	5.23	5.47	.33
Diet NE, Mcal/kg				
Maintenance[f]	1.91	2.13	2.09	.07
Gain[f]	1.27	1.45	1.43	.07

[a]Treatment main effects for: no supplemental fat (No fat); supplemental yellow grease (6% YG) and supplemental cottonseed oil soapstock (6% COS).

[b]Live weight reduced 4% to adjust for digestive tract fill.

[c]Carcass weight/average dressing percentage.

[d]No fat versus 6% YG and 6% COS, $P<.10$.

[e]No fat versus 6% YG and 6% COS, $P<.05$.

[f]No fat versus 6% YG and 6% COS, $P<.01$.

Table 53. INFLUENCE OF FAT SUPPLEMENTATION ON CARCASS MERIT OF FEEDLOT STEERS (Trial 1)

	Treatments[a]			
	No fat	6% YG	6% COS	SD
Carcass weight, kg[b]	309	317	314	8
Carcass specific gravity[b]	1.0554	1.0530	1.0519	.0041
Carcass composition, %				
Water[b]	52.2	51.3	50.9	1.5
Protein[b]	15.5	15.2	15.1	.5
Fat[b]	28.0	29.3	29.9	2.2
Dressing percentage[c]	63.7	65.1	64.6	.9
Rib eye area, cm^2 [bd]	83.5	87.8	84.8	3.6
Fat thickness, cm	.99	1.07	1.13	.19
KPH, %[bef]	2.05	2.23	2.36	.31
Marbling score, degrees[g]	3.88	3.98	3.90	.35
Retail yield, %	51.4	51.5	51.0	.6
Abscessed liver, %	5.0	0	0	4.6

[a]Treatment main effects for: no supplemental fat (No fat); supplemental yellow grease (6% YG) and supplemental cottonseed oil soapstock (6% COS).

[b]No fat versus 6% YG and 6% COS, P<.10.

[c]No fat versus 6% YG and 6% COS, P<.01.

[d]6% YG versus 6% COS, P<.10.

[e]Interaction between grain type and supplemental fat, P<.10. With the wheat based diet %KPH averaged 2.05, 2.00 and 2.05 for the no fat, 6% YG and 6% CSS diets, respectively. With the corn based diet % KPH averaged 2.08, 2.45 and 2.68 for the no fat, 6% YG and 6% CSS diets, respectivley.

[f]Kidney, pelvic and heart fat as a percentage of carcass weight.

[g]Coded: Minimum slight = 4, minimum small = 5, etc.

Table 54. CHARACTERISTICS OF STEAM-FLAKED CORN AND WHEAT (Trial 1 and 2)

Item	Steam-flaked Corn	Steam-flaked Wheat
Dry matter, %[a]	83.0	87.0
N, % (DM basis)	1.47	2.47
Starch, % (DM basis)	72.3	65.0
Density, kg/l[ab]	.30	.36
Amyloglucosidase reactive starch, % of total starch	12.5	11.2

[a]Measurement taken on grain as it exited the rollers.
[b].30 kg/liter = 23 lb/bu, .36 kg/liter = 28 lb/bu.

Table 55. INFLUENCE OF REPLACING STEAM-FLAKED CORN WITH STEAM-FLAKED WHEAT ON 121-D GROWTH-PERFORMANCE OF FEEDLOT STEERS AND NET ENERGY VALUE OF THE DIET (Trial 1)

Item	Steam-flaked Corn	Steam-flaked Wheat	SD
Pen replicates	15	15	
Initial weight, kg			
Live[a]	323	323	2
Empty body	292	292	2
Final weight, kg			
Live[b]	489	484	13
Empty body	459	455	11
Gain			
Live weight, kg/d	1.39	1.34	.11
Empty body			
Weight, kg/d	1.40	1.36	.10
Water, kg/d	.62	.62	.07
Fat, kg/d, kg/d	.55	.51	.08
Protein, kg/d	.19	.19	.02
Energy, Mcal/d	6.26	5.87	.74
DM intake, kg/d	7.63	7.61	.38
ME intake, Mcal/d	23.3	22.6	1.2
DM conversion			
Live weight	5.53	5.72	.40
Empty body weight	5.46	5.62	.33
Diet NE, Mcal/kg			
Maintenance[c]	2.08	2.01	.07
Gain[c]	1.41	1.35	.07

[a]Live weight reduced 4% to adjust for digestive tract fill.
[b]Carcass weight/average dressing percentage.
[c]Treatments differ, P<.05.

Table 56. INFLUENCE OF REPLACING STEAM-FLAKED CORN WITH STEAM-FLAKED WHEAT ON CARCASS MERIT OF FEEDLOT STEERS (Trial 1)

Item	Steam-flaked		
	Corn	Wheat	SD
Carcass weight, kg	315	312	8
Carcass specific gravity	1.0525	1.0544	.0041
Carcass composition, %			
Water	51.2	51.8	1.5
Protein	15.2	15.4	.5
Fat	29.5	28.6	2.2
Dressing percentage	64.5	64.4	.9
Rib eye area, cm^2	84.9	85.8	3.6
Fat thickness, cm	1.08	1.05	.19
KPH, %[abc]	2.40	2.02	.31
Marbling score, degrees[d]	3.95	3.89	.35
Retail yield, %[e]	51.1	51.5	.6
Abscessed liver, %	1.6	0	4.6

[a]Treatments differ, P<.01.

[b]Interaction between grain type and supplemental fat, P<.10. With the wheat based diet %KPH averaged 2.05, 2.00 and 2.05 for the no fat, 6% YG and 6% CSS diets, respectively. With the corn based diet % KPH averaged 2.08, 2.45 and 2.68 for the no fat, 6% YG and 6% CSS diets, respectivley.

[c]Kidney, pelvic and heart fat as a percentage of carcass weight.

[d]Coded: Minimum slight = 4, minimum small = 5, etc.

[e]Treatments differ, P<.10.

Table 57. INFLUENCE OF OLEIC ACID INFUSION INTO THE ABOMASUM ON SMALL INTESTINAL DIGESTIBILITY OF LONG-CHAIN FATTY ACIDS[a]

Item	Oleic Acid Infusion, g/d			
	0%	68%	106%	SD[a]
Small intestinal digestion, %				
Total fatty acids	72.0	78.8	69.2	12.8
Myristic	88.7	90.6	83.7	10.4
Palmitic	74.9	80.6	62.6	16.1
Stearic	62.5	69.4	49.5	16.7
Oleic	89.7	88.7	92.1	10.4
Linoleic	92.5	90.5	93.1	6.2

[a]Measured in Holstein steers (209 kg) with cannulas in the abomasum, proximal duodenum and distal ileam. Dry matter intake was 4.1 kg/d.

Table 58. COMPOSITION OF EXPERIMENTAL DIETS[a]

Item	Control	Coconut Bottoms
	---------- % ----------	
Alfalfa hay	8.24	7.83
Sudangrass hay	4.02	3.82
Steam rolled barley	57.92	54.01
Steam flaked corn	18.83	17.89
Cottonseed meal	.90	.85
Coconut bottoms[b]		6.00
Cane molasses	7.44	7.07
Urea	.30	.28
Dicalcium phosphate	.10	.10
Limestone	1.30	1.23
Trace mineral salt[c]	.50	.47

[a]Dry matter basis.
[b]Coconut alcohol bottoms-bottoms.
[c]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

TABLE 59. INFLUENCE OF COCONUT ALCOHOL BOTTOMS-BOTTOMS SUPPLEMENTATION ON RUMINAL PH, VOLATILE FATTY ACID PROFILES AND ESTIMATED METHANE PRODUCTION 4-H POSTPRANDIAL

Item	Control	Coconut Bottoms	SD[a]
Ruminal pH	6.16	6.33	.22
Ruminal concentration, mol/100 mol			
Acetate	68.4	66.5	5.5
Propionate	23.0	25.3	6.0
Butyrate	8.6	8.3	2.2
Acetate/propionate	3.10	2.84	.88
Methane production[b]	.604	.572	.080

[a]Standard deviation.
[b]Methane, mol/mol glucose equivalent fermented.

TABLE 60. INFLUENCE OF COCONUT ALCOHOL BOTTOMS-BOTTOMS ON CHARACTERISTICS OF DIGESTION OF A FINISHING DIET BY FEEDLOT STEERS

Item	Control	Coconut Bottoms	SD[a]
Intake, g/d			
Organic matter	4534	4810	
Acid detergent fiber	495	498	
Lipid	71	375	
N	102	100	
Gross energy, Mcal/d	20.8	24.8	
Leaving abomasum, g/d			
Organic matter[b]	1893	2130	214
Acid detergent fiber	398	365	55
Lipid[c]	137	455	34
Non-ammonia N	101	103	15
Microbial N	67.6	73.8	14.1
Feed N	33.0	29.4	10.3
Ruminal digestion, %			
Organic matter	58.2	55.7	4.5
Acid detergent fiber	19.6	26.6	9.9
Feed N	67.6	70.5	10.3
Microbial efficiency[d]	26.0	28.1	7.0
Leaving small intestine, g/d			
Organic matter[e]	900	1139	140
Acid detergent fiber	325	351	63
Lipid[c]	24.3	280.9	26.9
N	28.3	28.8	2.7
Small intestinal digestion, %			
Organic matter	52.5	46.3	6.1
Acid detergent fiber	17.6	1.1	22.7
Lipid[c]	82.2	38.0	6.2
N	71.8	71.7	3.3
Fecal excretion, g/d			
Organic matter[c]	684	957	77
Acid detergent fiber[e]	274	341	36
Lipid[c]	28.8	283.0	34.3
N	24.8	25.4	3.0
Gross energy, Mcal/d[c]	4.50	8.01	.67
Total tract digestion, %			
Organic matter[c]	84.9	80.1	1.6
Acid detergent fiber[e]	44.6	31.5	9.7
N	75.7	74.6	3.0
Digestible energy, Mcal/kg	3.36	3.27	.13
Metabolizable energy, Mcal/kg	2.93	2.87	.13

[a]Standard deviation.
[b]Treatments differ, P<.10.
[c]Treatments differ, P<.01.
[d]Microbial N, g/kg organic matter fermented.
[e]Treatments differ, P<.05.

TABLE 61. INFLUENCE OF COCONUT ALCOHOL BOTTOMS-BOTTOMS SUPPLEMENTATION ON CHARACTERISTICS OF FATTY ACID DIGESTION IN THE SMALL INTESTINE

Item	Control	Coconut Bottoms	SD[a]
Entering the small intestine, g/d			
Total fatty acids[b]	73.26	107.51	.11
Myristic	6.15	6.67	6.11
Palmitic[c]	16.38	19.27	2.41
Palmitoleic	.04	.05	.03
Stearic[b]	43.77	77.90	12.95
Oleic[c]	5.87	2.70	2.87
Linoleic	1.03	.93	.74
Leaving the small intestine, g/d			
Total fatty acids[b]	7.66	31.27	8.07
Myristic	6.15	6.67	6.12
Palmitic[b]	1.97	5.16	1.35
Palmitoleic	.01	.03	0.01
Stearic[b]	4.45	24.29	6.55
Oleic	.50	.47	.30
Linoleic[d]	.25	.65	.24
Small intestinal digestion, %			
Total fatty acids[b]	89.5	71.2	7.1
Myristic	88.3	83.7	12.0
Palmitic[b]	87.8	73.2	6.8
Palmitoleic	63.4	41.7	21.5
Stearic[b]	89.8	68.7	8.5
Oleic	90.4	83.2	7.5
Linoleic	75.7	30.1	141.0

[a]Standard deviation.
[b]Treatments differ, P<.01.
[c]Treatments differ, P<.10.
[d]Treatments differ, P<.05.

Table 62. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS[a]

Item	Treatments			
	Control	YG	ML	RI
Ingredient composition, %				
Alfalfa hay	45.00	44.71	44.71	44.71
Dry rolled corn	40.26	31.91	31.91	31.91
Soybean meal	6.25	9.93	9.93	9.93
Yellow grease		5.00		
Megalac			5.00	
RumInsol				5.00
Cane molasses	7.00	6.96	6.96	6.96
Dicalcium phosphate	.60	.60	.60	.60
Trace mineral salt[b]	.50	.50	.50	.50
Chromic oxide	.40	.40	.40	.40

[a]Dry matter basis.

[b]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

Table 63. FATTY ACID PROFILE OF SUPPLEMENTAL FATS

Item	Supplemental fats		
	YG	ML	RI
Fatty acids, %			
C14:0	1.9	1.8	1.9
C16:0	24.3	51.2	50.8
C16:1	3.3		
C18:0	12.5	4.6	4.9
C18:1	41.6	34.7	34.5
C18:2	15.5	7.4	7.6
C18:3	.9	.3	.3

Table 64. COMPARATIVE EFFECTS OF YELLOW GREASE, MEGALAC AND RI ON CHARACTERISTICS OF DIGESTION IN CATTLE

	Treatments				
Item	Control	YG	ML	RI	SD
Intake, g/d					
OM	5,546	5,566	5,549	5,548	
ADF	988	990	993	1,007	
Lipid	83	351	294	291	
N	151	163	166	160	
Gross energy, Mcal/d	25.0	27.1	26.6	26.4	
Leaving abomasum, g/d					
OM	3,437	3,192	3,706	3,366	475
ADF	671	700	787	773	171
Lipid[a]	158	415	397	371	52
Non-ammonia N[b]	163	145	156	140	11
Microbial N	76.7	71.2	75.5	69.6	6.1
Feed N[c]	86.8	73.4	80.9	69.9	10.7
Ruminal digestion, %					
OM	51.9	55.4	46.8	51.9	7.9
ADF	32.0	29.2	20.7	23.3	17.9
Feed N[b]	42.6	54.9	51.2	56.2	6.7
Microbial efficiency[d]	26.9	23.1	30.4	24.6	6.2
Protein efficiency[ae]	1.08	.89	.94	.87	.07
Leaving small intestine, g/d					
OM[b]	1,778	1,496	1,644	1,493	130
ADF	588	509	505	539	76
Lipid[b]	44.5	90.1	75.2	82.6	18.1
N[b]	53.3	47.2	50.5	45.6	2.9
Small intestinal digestion, %					
OM[b]	47.7	53.2	55.1	55.4	4.8
ADF	11.5	26.3	32.7	29.9	19.5
Lipid[a]	71.3	78.3	80.3	77.3	9.5
N	67.2	67.3	67.7	67.3	2.9
Fecal excretion, g/d					
OM	1,570	1,492	1,479	1,424	265
ADF	568	554	446	523	83
N	52.6	48.6	48.5	51.0	6.2
Gross energy, Mcal/d	8.07	7.99	7.69	7.61	1.28
Total tract digestion, %					
OM	71.7	73.2	73.3	74.3	4.8
ADF	42.4	43.9	55.0	48.1	8.4
N[c]	65.2	70.1	70.8	68.1	3.9
DE, Mcal/kg[b]	2.82	3.16	3.12	3.13	.21
ME, Mcal/kg[b]	2.57	2.90	2.89	2.87	.18

[a]Control versus Yellow grease, Megalac and RumInsol, P<.01.
[b]Control versus Yellow grease, Megalac and RumInsol, P<.05.
[c]Control versus Yellow grease, Megalac and RumInsol, P<.10.
[d]Microbial N, g/kg OM fermented.
[e]Duodenal non-ammonia N/N intake.

Table 65. COMPARATIVE DIGESTION OF YELLOW GREASE, MEGALAC AND RI FATTY ACIDS IN THE SMALL INTESTINE OF CATTLE

Item	Treatments				
	Control	YG	ML	RI	SD
Leaving abomasum, g/d					
C16:0[ab]	34.1	83.2	117.4	118.6	13.5
C18:0[ac]	82.1	160.4	127.8	137.7	15.5
C18:1[ad]	23.7	68.6	79.6	60.1	11.2
C18:2[ef]	10.4	12.6	19.4	13.6	3.5
Total fatty acids[a]	150.4	328.2	345.1	333.8	30.8
Leaving distal ileum, g/d					
C16:0[g]	6.5	13.8	23.9	17.5	7.5
C18:0[g]	11.1	29.7	20.4	26.8	10.0
C18:1[e]	3.0	5.0	6.6	5.2	1.9
C18:2[h]	2.0	1.7	3.1	2.6	.8
Total fatty acids[g]	22.9	50.9	54.0	52.2	16.5
Small intestinal digestion, %					
C16:0	80.6	82.8	79.2	84.7	8.6
C18:0	87.6	81.9	83.0	79.5	8.1
C18:1	87.2	92.7	91.1	90.1	4.0
C18:2	79.9	86.2	82.8	78.0	8.2
Total fatty acids	85.1	84.6	83.5	83.5	6.1

[a]Control versus supplemental fat, P<.01.
[b]Yellow grease versus Megalac and RumInsol, P<.01.
[c]Yellow grease versus Megalac and RumInsol, P<.05.
[d]Megalac versus RumInsol, P<.05.
[e]Control versus supplemental fat, P<.10.
[f]Megalac versus RumInsol, P<.10.
[g]Control versus supplemental fat, P<.05.
[h]Yellow grease versus Megalac and RumInsol, P<.10.

Table 66. INFLUENCE OF LEVEL OF FAT SUPPLEMENTATION ON RUMINAL PH, VFA PROFILES AND METHANE PRODUCTION 4 H POSTPRANDIAL

Item	Treatments				SD
	Control	YG	ML	RI	
Ruminal pH[a]	6.29	6.08	6.74	6.56	.37
Ruminal VFA, mol/100 mol					
Acetate	64.1	65.4	66.1	68.3	4.1
Propionate[b]	18.6	16.0	18.1	15.9	1.6
Isobutyrate	1.4	1.4	1.6	1.4	.4
Butyrate	12.7	10.7	11.1	11.0	1.8
Isovalerate[c]	1.8	5.1	1.8	2.1	2.6
Valerate	1.4	1.3	1.3	1.3	.2
Methane production[d]	.62	.66	.64	.67	.03

[a]Yellow grease versus Megalac and RumInsol, P<.05.
[b]Control versus Yellow grease, Megalac and RumInsol, P<.10.
[c]Yellow grease versus Megalac and RumInsol, P<.10.
[d]Methane, mol/mol glucose equivalent fermented.

Table 67. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS

Item	Treatments			
	1	2	3	4
Ingredient composition, % (DM basis)				
Alfalfa hay	20.00	20.00	20.00	20.00
Steam-rolled barley	43.00	43.00	43.00	43.00
Steam flaked corn	25.00	20.00	5.00	
Whole cottonseed[a]			20.00	20.00
Yellow grease[b]		5.00		5.00
Cane molasses	10.00	10.00	10.00	10.00
Limestone	1.20	1.20	1.20	1.20
Trace mineral salt[c]	.40	.40	.40	.40
Chromic oxide	.40	.40	.40	.40

[a]Whole cottonseed contained 4.0% ash, 4.1% N, 36.6% ADF and 18.1% ether extract (DM basis).

[b]Yellow grease containe 91.5% total fatty acids, 15.0% free fatty acids, 1.1% MIU (moisture, impurities and unsaponifiables) and an iodine value of 65.1.

[c]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, .75%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 93.4%.

Table 68. INFLUENCE OF WHOLE COTTONSEED AND SUPPLEMENTAL FAT ON CHARACTERISTICS OF RUMINAL AND TOAL TRACT DIGESTION

	No Cottonseed		20% Cottonseed		Main effects				
					Cottonseed		Fat[a]		
	No Fat	5% Fat	No Fat	5% Fat	0%	20%	0%	5%	SD
Intake, g/d									
DM	3,644	3,661	3,711	3,723	3,653	3,717	3,678	3,692	
OM	3,428	3,448	3,479	3,498	3,438	3,488	3,453	3,473	
ADF	432	453	651	686	442	668	541	570	
N	64	63	85	83	64	84	74	73	
Starch	1,270	1,185	997	794	1,227	895	1,133	989	
Lipid	66	216	161	300	141	231	114	258	
GE, Mcal/d	14.9	16.0	15.8	16.7	15.4	16.3	15.3	16.3	
Leaving abomasum, g/d									
OM[bcd]	1,633	1,801	1,927	2,365	1,717	2,146	1,780	2,083	114
ADF[be]	357	403	574	683	380	629	466	543	56
Starch[bd]	154.9	147.5	95.8	125.2	151.2	110.5	125.4	136.3	16.4
Lipid[bcd]	101	220	192	349	160	271	146	284	19
N[b]	73.2	75.6	88.8	93.4	74.4	91.1	81.0	84.5	5.2
Non-ammonia N[b]	70.7	72.9	85.2	89.6	71.8	87.4	77.9	81.3	4.9
Microbial N[bfg]	44.7	45.3	56.8	48.5	45.0	52.7	50.8	46.9	3.2
Feed N[bcg]	26.0	27.7	28.4	41.0	26.8	34.7	27.2	34.4	3.6
Ruminal digestion, %									
OM[bcg]	65.4	60.9	60.9	46.3	63.2	53.6	63.2	53.6	3.4
ADF	17.2	10.9	11.7	5.1	14.1	6.1	14.5	5.7	10.0
Feed N[eg]	59.6	56.2	66.5	50.6	57.9	58.6	63.0	53.4	5.2
Starch[eg]	87.8	87.6	90.4	84.2	87.7	87.3	89.1	85.9	1.9
MN efficiency[bfh]	20.0	21.5	27.0	30.2	20.8	28.6	23.5	25.9	2.1
N efficiency[fij]	1.10	1.15	1.00	1.08	1.13	1.04	1.05	1.12	.06
Post-ruminal digestion, % leaving abomasum									
OM	54.6	57.2	54.8	56.7	55.9	55.8	54.7	57.0	3.8
ADF[f]	17.6	27.4	25.4	29.4	22.5	27.4	21.5	28.4	5.9
N	69.7	71.0	71.7	71.5	70.3	71.6	70.7	71.2	4.2
Starch	94.3	95.8	95.7	96.2	95.1	95.9	95.0	96.0	1.5
Lipid	75.6	72.4	77.8	76.5	74.0	77.2	76.7	74.5	8.1
Fecal excretion, g/d									
OM[bcg]	747	773	866	1,021	760	944	807	897	39

Table 2. Continued

ADF[beg]	295	293	421	482	294	452	358	387	14
N[k]	22.2	21.9	24.9	26.6	22.0	25.7	23.5	24.2	2.0
Starch[j]	9.4	6.7	4.3	4.6	8.0	4.4	6.8	5.6	3.0
Lipid[c]	24.1	60.8	42.0	82.9	42.4	62.4	33.0	71.8	20.0
GE, Mcal/d[bcd]	3.69	4.01	4.37	5.32	3.85	4.85	4.03	4.67	.27
Total tract digestion, %									
OM[bcg]	78.2	77.6	75.1	70.8	77.9	73.0	76.7	74.2	1.2
ADF[g]	31.6	35.3	35.2	29.8	33.5	32.5	33.4	32.6	3.2
N[k]	65.5	65.3	70.6	68.1	65.4	69.3	68.0	66.7	3.0
Starch	99.3	99.4	99.6	99.4	99.3	99.5	99.4	99.4	2.2
DE, Mcal/kg[fgj]	3.07	3.26	3.08	3.07	3.17	3.08	3.08	3.16	.08
ME, Mcal/kg[c]	2.38	2.62	2.40	2.50	2.50	2.45	2.39	2.56	.08

[a]Yellow grease.
[b]Cottonseed main effect, $P<.01$.
[c]Supplemental fat main effect, $P<.01$.
[d]Cottonseed by supplemental fat interaction, $P<.10$.
[e]Supplemental fat main effect, $P<.05$.
[f]Supplemental fat main effect, $P<.10$.
[g]Cottonseed by supplemental fat interaction, $P<.05$.
[h]Microbial N, g/kg OM fermented.
[i]Duodenal non-ammonia N/N intake.
[j]Cottonseed main effect, $P<.10$.
[k]Cottonseed main effect, $P<.05$.

Table 69. INFLUENCE OF COTTONSEED AND SUPPLEMENTAL FAT ON RUMINAL pH, VFA PROFILES AND METHANE PRODUCTION 4 HOURS POSTPRANDIAL

	No Cottonseed		20% Cottonseed		Main effects				
					Cottonseed		Fat[a]		
	No Fat	5% Fat	No Fat	5% Fat	0%	20%	0%	5%	SD
Ruminal pH[b]	6.37	6.50	6.71	7.13	6.43	6.92	6.54	6.81	.38
Ruminal VFA, mol/100 mol									
Acetate[c]	57.8	55.4	60.3	55.6	56.6	57.9	59.1	55.5	2.1
Propionate[d]	30.9	33.3	28.8	32.8	32.1	30.8	29.8	33.1	2.7
Butyrate	11.3	11.3	10.9	11.6	11.3	11.3	11.1	11.4	1.6
Acetate/protionate[c]	1.91	1.72	2.10	1.71	1.81	1.90	2.00	1.71	.21
Methane production[ce]	.48	.45	.51	.45	.47	.48	.50	.45	.03

[a]Yellow grease.
[b]Cottonseed main effect, $P<.05$.
[c]Supplemental fat main effect, $P<.05$.
[d]Supplemental fat main effect, $P<.10$.
[e]Methane, mol/mol glucose equivalent fermented.

Table 70. INFLUENCE OF COTTONSEED AND SUPPLEMENTAL FAT ON PROFILE OF FATTY ACIDS LEAVING THE ABOMASUM

	No Cottonseed		20% Cottonseed		Main effects				
					Cottonseed		Fat[a]		
	No Fat	5% Fat	No Fat	5% Fat	0%	20%	0%	5%	SD
Dietary, % total									
C14:0	13.3	4.5	6.6	2.2	8.9	4.4	9.9	3.3	
C16:0	32.5	24.5	30.6	32.9	28.5	31.8	31.5	28.7	
C18:0	5.2	10.0	3.9	8.8	7.6	6.4	4.6	9.4	
C18:1	21.1	32.6	12.2	23.6	26.9	17.9	16.7	28.1	
C18:2	27.8	27.1	46.7	31.4	27.4	39.1	37.3	29.2	
Leaving abomasum, % total									
C14:0	1.0	1.0	.8	1.0	1.0	.9	.9	1.0	.1
C16:0[bcd]	26.9	30.0	31.1	31.7	28.4	31.4	29.0	30.8	1.0
C18:0[e]	42.5	44.0	54.8	46.8	43.2	50.8	48.6	45.4	6.7
C18:1[f]	21.8	19.6	10.2	15.7	20.7	13.0	16.0	17.7	5.7
C18:2[bd]	7.8	5.0	3.1	4.5	6.4	3.8	5.4	4.8	1.2

[a]Yellow grease.
[b]Cottonseed main effect, $P<.01$.
[c]Supplemental fat main effect, $P<.01$.
[d]Cottonseed by supplemental fat interaction, $P<.05$.
[e]Cottonseed main effect, $P<.10$.
[f]Cottonseed main effect, $P<.05$.