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Various Forms of Dehydrated Alfalfa in High-concentrate Cattle Finishing Diets

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VARIOUS FORMS OF DEHYDRATED ALFALFA IN HIGH-CONCENTRATE CATTLE FINISHING DIETS

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

Even though growing and finishing beef cattle have been fed satisfactorily on all-concentrate diets, in many instances weight gains have been improved and management problems reduced by including some conventional form of roughage in the diet. The most efficient level of roughage will likely be a variable factor depending upon a number of things including weight and condition of the cattle and nature of the roughages and concentrates.

It is a well established fact that as the energy content of the diet increases the rate of gain increases and the feed required per unit of gain decreases. In addition to rate and efficiency of gain, a feedlot operator must also consider the cost of the gain. A diet that produces the most rapid gain does not necessarily produce the most economical gain. Less cost may result from feeding of lower energy feeds which may not only cost less per unit of weight but also less per unit of energy as compared to higher energy feeds.

Energy consumption depends on the amounts and kinds of feeds consumed, or generally in the case of ruminants, the ratio of concentrates to roughage. Ratios of concentrates to roughage in diets for finishing beef cattle has been the subject of considerable research in the past. Renewed interest in this area has resulted from changes in feed preparation methods, feeding practices and type of diets fed. These factors have been shown to influence the relative value of concentrates and roughages when fed in varying proportions.

In a previous experiment at the South Dakota Experiment Station (Larson, 1969), weight gains were improved by adding chopped alfalfa hay to an all-concentrate diet composed of corn and supplements. There were essentially no differences in weight gains between levels of hay at 3, 10 or 20% of the diet. However, total feed intake increased with increasing levels of hay resulting in a decrease in concentrates saved per unit of hay as the level was increased. The lower level of hay resulted in a more favorable response than did an equal weight of oyster shells.

Research with low levels of roughage and with roughage substitutes in cattle diets raises some questions regarding the role performed by the roughage and the importance of its physical form when making up only a small percentage of the diet. The experiment reported here was designed to compare the value of a low level of alfalfa fed in various forms in a corn diet supplemented with protein, minerals, chlortetracycline and vitamin A.

REVIEW OF LITERATURE

A major portion of the expense incurred in producing red meat for the consumer is the feed cost. Therefore, a large part of research should be, and is, involved in selecting the proper energy level in diets at various stages of growing and finishing which will result in the most economical gain with the desired weight and finish at time of slaughter. Interrelated with this problem is the selection of the proper method of processing the total diet, or various parts, to obtain the greatest economic efficiency. Both factors should be considered in order to obtain the most efficient utilization of feeds and the most economical production in growing and finishing feedlot cattle.

Levels of Concentrates and Roughage in Cattle Diets

A great deal of research has been reported in the literature when feeding diets devoid of roughage. However, early attempts to rear calves on roughage-free diets were unsuccessful. Davenport (1897) attempted to raise calves on a diet of milk and grain. He observed that normal rumination did not occur and the calves appeared to lose their appetite after a short period of time. A normal appetite was restored when a fibrous feedstuff such as hay was supplied in the diet. Essentially the same results were obtained by McCandlish (1923) and Bechdel, Eckles and Palmer (1926). These workers concluded that the difficulty was perhaps due to a lack of bulk or roughage in the diet or to mineral or vitamin deficiencies.

On the other hand, research by Huffman (1928) indicated that the beneficial effects of roughage must be something other than bulk or crude fiber. In these investigations, he fed coarse feeds in the form of corn cobs, oat hulls and wood shavings without beneficial results.

Meade and Regan (1931) were two of the earlier workers to prove that roughage or bulk per se was not necessary in the diet of calves. They successfully reared calves to 19 months of age, and normal growth was obtained on a basal ration containing barley, oats, wheat, bran and linseed meal with no roughage provided cod liver oil and alfalfa ash were supplied in sufficient amounts. They considered a lack of vitamin A and inadequate mineral supplementation to be the limiting factors in earlier research in this area.

Many of the earlier experiments involved research with various types of roughages as well as levels of concentrates and roughage. Haynes et al. (1955) conducted digestibility studies with steers and cows fed diets consisting of 100, 75, 50 or 35% alfalfa hay. The concentrate portion of the diet consisted of ground corn and distillers grains with solubles. There was a highly significant ($P < .01$) difference in digestibility between cows and steers. The difference appeared to be due to lower digestibility of crude fiber and ether extract by the steers. Digestibility of all other constituents was similar for each group of animals. The percentages of TDN in the diets with four levels of alfalfa hay, respectively, were 53.8, 62.0, 65.0 and 67.8% for cows and 46.1, 52.8, 60.9 and 62.7% for steers. These results show an increase, although not in a

uniform manner, in percent TDN in the diets for both cows and steers as the amount of hay was decreased and concentrates increased, but with cows giving a higher value in each instance.

Richardson et al. (1961) conducted three feeding trials with heifers averaging about 625 lb. at the beginning of each trial. Roughage to concentrates ratios were 1:1, 1:3 and 1:5 and a changing one produced by increasing the concentrate portion each 28 days. Lengths of the first, second and third feeding trials were 91, 154 and 125 days, respectively. The roughage was good quality alfalfa hay and the concentrate was sorghum or corn grain. All animals were started on feed with the 1:1 ratio, and then the concentrate portion was increased as fast as advisable until the respective test level was reached. Highest average gain was obtained with the 1:5 ratio ($P<.05$) and lowest with the 1:1 ratio. Carcass grades and marbling scores obtained with the 1:3 and 1:5 ratios were not statistically different. Both ratios produced higher grading carcasses than either the 1:1 or the changing ratio. This would be indicative of a positive relationship existing between rate of gain and carcass grade, especially when fed the same number of days.

Richardson et al. (1961) also used digestion trials with 11 Hereford steers to study the same roughage to concentrates ratios as used in the feedlot trials, except the changing ratio was omitted. A highly significant increase in TDN was obtained with the 1:3 and 1:5 ratios of roughage to concentrates over the 1:1 ratio. Crude fiber digestion was highest with the 1:3 ratio ($P<.01$). Digestibilities

of nitrogen-free extract and ether extract were lowest with the 1:1 ratio ($P < .05$ and $P < .01$, respectively). Protein digestion was not affected by changes in the roughage to concentrates ratio.

McCroskey et al. (1959) conducted three trials involving 236 steer and heifer calves to investigate the effects of widely varying concentrates to roughage ratios on feedlot performance and carcass grade. In two trials, concentrates to roughage ratios of 35:65, 50:50, 65:35 and 80:20 were tested. Ground milo, cottonseed meal and molasses were the concentrates fed and the roughage portion consisted of a mixture of equal parts of chopped alfalfa hay and cottonseed hulls. Digestible protein, calcium and phosphorus contents were equalized in all diets. The cattle were removed from test individually at a grade of high Good to low Choice. No significant difference in average daily gains of steers was observed. Heifers consistently made the most rapid gain on the 50:50 ratio, although the difference was significant ($P < .05$) in only one trial. Daily feed intake declined as percentage of concentrates in the diets increased, thus tending to equalize TDN intake.

Dowe, Matsushima and Orthand (1955) reported results taken from 28 digestion trials in which cattle were fed corn to alfalfa hay ratios ranging from 1:1 to 5:1. Dry matter, crude protein and nitrogen-free extract in the feces increased as the corn in the diets was increased. The apparent digestibility of dry matter and ether extract also increased as the amount of corn was increased. When

the coefficients of apparent digestibility for the nutrients studied were analyzed statistically, the difference in apparent digestibility of the nutrients between ratios was not significant.

A series of five trials, utilizing 124 cattle of varying weights, was conducted to determine the performance when fed high-concentrate diets and to study the effects of various levels of crude fiber (Davis, Oltjen and Bond, 1963). In general, cattle fed ground shelled corn consumed significantly less feed than those fed a corn and cob diet. Daily gains, feed efficiency and carcass data were not different when analyzed statistically. In one trial, diets with 2.6 or 7.0% crude fiber rations were compared. Cattle fed the diet with 7.0% crude fiber ate 27% more feed than those fed the one with 2.6% fiber. This difference was significant at the 1% level. However, there were no significant differences noted in daily gains or feed efficiency.

At a low level of roughage, cattle generally consume as much grain as those fed only grain. This suggests that the actual energy concentration is not the sole reason for the greater fluctuation in feed intake. When a small amount of roughage is fed, a different bacteria:protozoa ratio and a different concentration of volatile fatty acids (VFA) are present in the rumen compared to an all-concentrate diet (Balch and Rowland, 1957; Oltjen, Rumsey and Putnam, 1971). It is well established that total concentrations and amounts of VFA present in the rumen are dependent upon the diet. Diets rich in starch or sucrose favor propionic acid production, and, in

general, feedstuffs which are rapidly fermented in the rumen give rise to less acetic acid. Balch and Rowland (1957) suggested that a decrease in the ratio of hay to concentrates encouraged starch digesting organisms at the expense of those digesting fibrous carbohydrates. Changes in ruminal microbial population cause changes in molar proportions of rumen VFA (Eusebio et al., 1959). Shaw et al. (1960) reported that a decreased acetate:propionate ratio results in increased gain and feed efficiency.

Oltjen and Davis (1965) reported approximately equal concentrations of acetate and propionate in rumen fluid of steers receiving all-concentrate diets. Luther and Trenkle (1963) studied diets with concentrates to roughage ratios of 20:80 and 80:20. The rumen fluids of the lambs fed the diet with 80% concentrate had a lower pH, less VFA and a narrower acetate:propionate ratio than lambs fed the one with 20% concentrates.

Larson (1969) reported a wide acetate to propionate ratio when comparing an all-concentrate diet to a diet containing 3% hay. The addition of higher levels of hay (10 and 20%) resulted in even greater differences when compared to the all-concentrate diet. Inclusion of hay resulted in about 15.4% faster gain, with essentially no differences between levels of hay when compared to the all-concentrate diet.

There appears to be no definite concentrates to roughage ratio superior for all the variables that are present. Some of these variables include type and size of animal, physical form and type of

concentrates and roughages and rate of gain desired. Generally, feeding high-concentrate diets to cattle produces a faster rate of gain with a smaller amount of total feed than do high-roughage diets.

Problems Associated With All-Concentrate Diets

It has been amply demonstrated that under good management and proper nutrition all-concentrate diets can be fed safely. However, when ruminants are fed a high-energy diet, there is a high incidence of rumen parakeratosis (Ward, 1962; McGinty, 1963; Haskins et al., 1967; Harvey et al., 1968). This rumen parakeratosis, also called rumen epithelial lesions, is characterized by clumping and sloughing of rumen papillae and hair accumulation in the mucosa.

A problem associated with lesions of the digestive tract also occurs in swine fed a finely ground diet. Esophagogastric ulcers generally decrease in severity as the particle size of feed ingredients is increased. Maxson et al. (1968) included 9% oat hulls in the diet and observed a decrease in the severity of the lesions. Blasting sand included at a 5 or 10% level had no effect on the severity of the lesions.

It was observed by Maxwell et al. (1970) while working with swine that as the particle size of the corn decreased the acidity of the gastric contents increased. It was suggested that the incidence of esophagogastric ulcers when fine corn is fed is mediated by increased acidity or increased pepsin activity, or both, in the relatively unprotected esophageal region of the stomach. These effects

are probably brought about by more mixing of gastric content as a result of a greater fluidity.

In cattle there appears to be a high correlation between the presence of ruminal parakeratosis and liver abscesses (Jensen et al., 1954b). Harvey et al. (1968) also observed that liver lesions were apparently formed secondarily to the rumen lesions. The cause of rumen parakeratosis which would favor the entry of an organism into the portal systems is not known. Normal rumen mucosa is highly resistant to penetration by most organisms. When roughage is deleted from the ration, there is a lowering of pH with an increase in the amount of lactic acid in the rumen (Ryan, 1964). The gram negative bacteria and the protozoa in the rumen when some roughage is fed are highly susceptible to any drastic pH changes. When pH drops, the cellulolytic bacteria decreases in number. One organism, Streptococcus bovis, which is an acid producer increases in number. Increases in this gram positive organism makes the rumen more acid. Jensen, Connell and Deem (1954a) suggested that it is this acidic condition which causes damage to the rumen wall and thus allows entry of organisms into the portal system resulting in abscessed liver. Powell, Durham and Gann (1968) presented data indicating that liver abscesses in feedlot heifers significantly depress total average gain (0.24 lb.), marbling score (0.22 score) and carcass average daily gain (0.23 lb.).

Not only are abscessed livers a loss to the producer but also a loss to the whole beef industry. In 1967, there were over 2.5 million

cattle livers condemned for abscesses by the Federal meat inspectors. This represents about 9.6% of all cattle slaughtered at inspected plants having livers condemned from abscesses (U.S.D.A., 1968). On the other hand, cattle fed high-energy diets generally have a much higher incidence of abscessed livers. McGinty (1963) reported a high of 74% of steers receiving an all-concentrate diet had abscessed livers. Harvey, Wise and Barrick (1965) reported that 40% of steers fed a high-energy diet had abscessed livers. Feeding about 70 mg. per head daily of chlortetracycline or zinc bacitracin has been effective in reducing liver abscesses with high-energy diets (Jensen, 1960; Harvey et al., 1968; Dinusson et al., 1964). Harvey et al. (1968) also reported a slight but nonsignificant improvement in gains and feed efficiency when feeding a low level of chlortetracycline in an all-concentrate diet.

When some roughage is included in the diet, the integrity of the rumen papillae appears to be more normal than when no roughage is fed (Jensen et al., 1954a; Haskins et al., 1969). It has been suggested that roughage by some mechanism "cleans" the rumen wall. This would allow for a greater absorption area in the rumen and perhaps permit the animal to be more efficient. Haskins et al. (1969) found that a low level of hay in a basal all-concentrate diet provided protection against rumen parakeratosis and liver abscesses when compared to the basal diet without hay.

Decreasing levels of roughage in a diet would also decrease the amount of rumination which may also lead to a decrease in

salivary flow. McDougall (1948) determined that the buffering capacity of the rumen is dependent upon the amount of saliva produced. High-grain diets decrease the amount of saliva produced and generally increases the total amount of VFA, resulting in a more acidic condition in the rumen. Oltjen and Davis (1965) have reported pH values ranging from 5.2 to 6.0 in rumen fluid of steers fed all-concentrate diets. Woods and Luther (1962) reported pH values of 6.7 to 6.8 for all-hay diets.

Buffering agents have been used in attempts to counteract the increased acidity in diets devoid of roughage. Various salts of carbonate, bicarbonate and propionate have been tried up to a level 9% of the diet with generally no increase in animal performance (Nicholson and Cunningham, 1961; Nicholson, Cunningham and Friend, 1962; Oltjen and Davis, 1965). Wise et al. (1961) found that the buffering capacity of the rumen is adequate on a diet devoid of roughage if otherwise nutritionally balanced.

When roughage is deleted from a ruminant diet, a more critical look at the required nutrients may be needed. The average daily gain generally increases as the roughage is removed from the diet. This increased production may increase the total nutritional requirements of the animal due to increased growth. Generally, a diet containing between 20 to 50% good quality forage needs little or no mineral supplementation except what could be provided by trace mineral salt. However, when forage is decreased, calcium supplementation may become necessary. Also, some of the micro-minerals

may also need to be added. Harper et al. (1962) added a trace mineral mixture composed of iron, copper, cobalt, manganese, zinc and iodine to an all-barley diet and significantly improved gains, but cobalt or cobalt, copper and iron gave only partial response. Oltjen et al. (1959) added the same trace minerals to a high-sorghum grain or a high corn grain diet. The added trace minerals were without effect with the sorghum grain but increased gain significantly with the corn.

Cattle eating good quality hay can satisfy their vitamin requirements by the forage they consume. However, when the forage is reduced in the diet, some vitamins may have to be added to the diet. Burroughs et al. (1963) reported a response to vitamin E and K supplementation in performance by beef steers receiving a ground ear corn diet. In another trial with similar diets, about the same response was obtained from supplemental selenium as from the supplemental vitamins. In contrast, Woods and LaToush (1968) and Wise, Blumer and Barrick (1964) showed no response to supplemental vitamin E and choline in high-concentrate diets.

Haskins et al. (1967) and Woods and Tolman (1968) reported performance of steers was improved by increasing the protein content of an all-concentrate diet from 11% to 14%. However, the latter group reported no benefits from the higher level of protein when the diet contained 15% roughage.

Additions of Roughage and Roughage Substitutes to High-Grain Diets

With the increased use of mechanization in cattle feeding operations across the country, there has been an increased interest in trying to find a roughage substitute or replacer. Feeding roughage is a problem in both the large and small feedlots. Mechanized handling is difficult or expensive and nutrient losses are high in many types of storage and handling facilities. Roughage has been included in finishing diets to furnish required nutrients and also to lessen management problems associated with high-energy diets. However, the cost and difficulties of using roughage has led the industry to look for a roughage substitute that will perform the same functions as roughage but without the disadvantages associated with roughage. Oyster shells has probably received the most attention in this respect. However, blasting sand, sawdust, ground polyethylene, cottonseed hulls and others have also been tried.

Perry et al. (1968) compared 17% ground corn cobs and 2.5% oyster shells in a finishing diet based on ground shelled corn. There was about an 8% increase in gain for the ground corn cobs compared to the oyster shells. A higher incidence of rumen wall damage was observed with the cattle receiving the diet containing 2.5% oyster shells. More livers were also condemned from the cattle receiving this diet. Williams et al. (1970) also reported that oyster shells were harmful to the rumen tissue and that average daily gain was not improved by their addition. The authors indicated

that bloat may also be a problem when oyster shells are used to replace all or a major portion of the roughage in the diet.

Small additions of sand (2%) improved performance of completely mixed high-concentrate diets fed to yearling beef cattle during three feeding trials according to Cooley and Burroughs (1962). The degree of improvement was small, averaging about 5% as measured by live weight gains and feed conversion. The authors assumed that sand in high-concentrate diets provided some undefined physical property contributed by roughage.

Dinius et al. (1970) reported results from experiments using various roughage substitutes in comparison to a basal diet based on cracked shelled corn, rolled barley and soybean meal. They used various types of wood products and clay as the roughage substitutes. They concluded that the feeding of any of these roughage substitutes decreased the rate of passage of food material through the digestive tract. They also presented data that suggested a variety of roughage substitutes may be incorporated into complete feeds without adversely affecting digestible energy intake and that the presence of the roughage substitutes tended to increase the digestibility of the concentrate fraction of the diets.

Haskins et al. (1969) fed a variety of roughage substitutes to 620 lb. steers. Feeding about 15% hay or 2% oyster shell with the all-concentrate diets slightly increased gains. However, feeding 5% cottonseed hulls, 5% ground corn cobs, 4% oyster shell, 2% sand or 5% ground polyethylene slightly decreased gain when compared to the

basal all-concentrate diet. The addition of hay at 3 lb. per head daily provided protection against rumen parakeratosis and liver abscesses. They concluded that apparently some physical factor, or factors, present in hay prevents rumen parakeratosis. This factor, or factors, either is not present in the other roughages or roughage substitutes used in this study or is not present in sufficient quantity.

Larson (1969) conducted experiments involving yearling beef cattle to determine the effects of adding 3% oyster shells or various levels of hay to an all-corn grain diet. Adding 3% oyster shells resulted in only small effects on daily gain. Alfalfa hay was incorporated into the all-corn diet at levels of 3, 10 or 20%. The addition of alfalfa resulted in a 15.4% improvement in gain with essentially no difference between levels of hay.

Wood and wood-waste products have also received considerable attention in the area of roughage substitutes. These products contain considerable amounts of cellulose which is digestible to a high degree by the ruminant animal. However, the low digestibility of wood is generally attributed to a high content of lignin. Anthony and Cunningham (1968) incorporated 2.5 or 10.0% hardwood sawdust into an all-concentrate diet fed to steers and lambs. Highest rates of gain were obtained with the 2.5% level of sawdust, and the 10.0% level was equal to the basal diet containing no sawdust. No deleterious effects were observed from feeding these levels. Dinius et al. (1968) found that a 10% level of sawdust was without effect on digestible energy

intake by sheep when compared to an all-concentrate or 10% corn cob diet. Neither group of researchers compared wood-waste products with more conventional forms of roughage such as hay.

It appears from the work presented heretofore that the addition of a source of roughness in a high-concentrate diet will be of small benefit. These roughage substitutes generally contribute very little in the way of energy or other nutrients. Hay which shows the greatest response furnished the roughness that may be necessary for a well functioning rumen plus energy and some nutrients that may be limiting when the animal is fed a high-concentrate diet and growing rapidly. A small addition of hay has also been shown to have a pronounced effect upon VFA production, microbial population, ruminal pH and various other intraruminal chemical characteristics.

Effect of Roughage Preparation When Fed in Small Amounts in a High-Concentrate Cattle Diet

Processing of feedstuffs for cattle may be justified both from the standpoint of increasing the efficiency of handling or by economically increasing the efficiency of converting that feed to beef. In general, the feed handling characteristics of the common grains are excellent. In most cases the natural form of the grain is easier to handle than in any other form. However, roughages are rather bulky and not as easily handled without some processing, especially in mechanized situations.

Feedstuffs vary tremendously in the amount of energy and fiber they contain. There are some grains which contain nearly as much

fiber as do roughages and some roughages contain about the same energy as certain grains. Therefore, in the formulation of a diet for finishing beef cattle, the type of grain and roughage needs to be defined as nearly as possible. Grinding, pelleting, flaking and other processing methods affect digestibility of the fiber and also digestibility of the energy or starch content of the feedstuffs (Arnett and Bradley, 1961).

Some people assume that animals will eat to capacity no matter what is contained in the particular diet and regardless of how it is prepared. However, Ray and Drake (1959) studied the effects of grain preparation on preference shown by beef cattle. They found that finely ground grains were consumed in smaller quantities than whole or coarsely ground preparations. Also, when the animal was given a choice, the method of preparation of the diet made more difference than the actual type of diet.

Pelleting diets which contain higher levels of roughage have been shown to be advantageous. However, as the roughage level is reduced, benefits received from pelleting decrease. McCroskey et al. (1959) studied the effects of pelleting diets containing 1:4 and 4:1 concentrates to roughage ratios when fed to steers. Ground milo, cottonseed meal and molasses were the concentrates and chopped alfalfa hay and cottonseed hulls comprised the roughages. In two trials, rate and efficiency of gain were increased by pelleting the 1:4 diet. However, gains were either lower or not affected when the 4:1 mixture was pelleted. Beardsley, McCormick and Southwell (1959) obtained

similar results when they fed mixtures with concentrates to roughage ratios of 70:30, 55:45 and 40:60. These mixtures were fed either finely ground and pelleted or coarsely ground and unpelleted. Gains of steers on unpelleted diets decreased and on pelleted diets increased as the level of roughage was increased.

Pelleted or meal rations containing 0, 30 and 60% concentrates were compared for fattening steers by Weir et al. (1959). Steers fed the 60% concentrate diet consumed less feed and gained at a lower rate than those fed the same diet in meal form. The steers fed the all-roughage diet had increased consumption when fed pellets, but at the 30% level there was no difference in feed consumption.

Meyer et al. (1959) mixed water with reground pellets on a diet composed of all alfalfa hay and obtained similar results as when the diet was pelleted. The authors suggested that fine grinding is probably the major factor causing the increased feed consumption of pelleted hay and that pelleting merely puts the fine dusty feed into a more palatable form. McClure et al. (1960) demonstrated that pelleting appears to be more beneficial with lower levels of roughage when of low quality.

Wise et al. (1961) fed 2.5 lb. of Coastal Bermuda grass either in ground or long form in an otherwise all-concentrate diet. They found only small differences in feedlot performance or carcass characteristics between the two forms of hay. However, Thompson, Bradley and Little (1965) reported research indicating about 0.2 lb.

improvement in daily gain when 4 lb. of ground hay were fed when compared to an equal amount of long hay.

There appears to be no definite level of roughage or type of preparation for roughage for consistent optimum results. However, it is generally accepted that a small amount of hay or other conventional roughage will be beneficial in terms of feedlot performance, although it usually takes more total feed per unit of gain. When the roughage level is over 15 to 20% of the total diet, its value decreases. This indicates that either a relatively small or large percentage of the diet should be composed of roughage. Some processing of roughage may be desirable for ease of handling and to reduce waste of the unprocessed bulky material. These would be benefits in addition to those which might result from changes in utilization of the product.

PROCEDURES

One hundred five Hereford yearling steers averaging about 820 lb. were used in the experiment. Prior to the start of the trial the cattle received 12 lb. of rolled shelled corn per head daily plus a full feed of alfalfa-bromegrass haylage. The cattle were weighed for an initial filled weight and allotted at random after stratifying on basis of this weight. Initial shrunk weights were taken after withholding feed and water for about 18 hours. Steers were then sorted into their respective pens. They were allotted into 15 pens of 7 each for 5 triplicated treatments consisting of an all-concentrate control and the control diet with 2 lb. of dehydrated alfalfa added in various forms. This level of alfalfa was selected as being a desirable amount to test effects of physical form of the hay when fed at relatively low levels in high-energy diets. The alfalfa was fed as whole plant chopped hay, whole plant coarsely ground and processed into 3/4 inch cubes and wafers, whole plant finely ground and processed into 1/4 inch pellets (regular dehydrated pellet) and a coarse fraction obtained by air separation of the whole plant into fine and coarse fractions and processed into the large cubes and wafers.

Chemical analyses for dehydrated alfalfa products are shown in table 1. Chopped refers to the unpelleted form with a major portion of the stems having a length about 3/4 inch and with a considerable amount of fine material. The fine pellets and the coarse cubes were from the same material, differing only in fineness of material and size of the cube or pellet. All of the alfalfa was from the same

TABLE 1. NUTRIENT CONTENT OF THE DEHYDRATED ALFALFA PRODUCTS (MOISTURE-FREE BASIS)[a]

Product	Protein	Fiber	Ether extract	Ash	Carotene
	%	%	%	%	mg./lb.
Chopped	17.08	32.83	2.97	10.08	82.2
Fine 1/4 inch pellet	18.72	31.52	3.63	11.01	92.5
Coarse cube	18.89	29.68	3.58	11.56	99.1
Coarse fraction cube	17.03	33.55	3.07	9.87	89.0

[a] Analysis at harvest courtesy of U.S.D.A., A.R.S., Western Utilization Research and Development Division, Albany, California.

field and harvested on the same day. Analyses shown for the unpelleted chopped material likely represent some sampling error since a uniform sample was difficult to obtain with this material. However, this product should be expected to be some lower in protein and higher in fiber as fed than the pelleted material because of the losses of the finer particles in handling and feeding. The coarse fraction material was expected to be about a 15% protein product. As can be noted in the table, it was higher than this but did contain less protein and more fiber than the whole plant cube or fine pellet.

Protein contents of the diets were approximately equalized by feeding 2 lb. of a 36% protein supplement with the all-concentrate diet and 1 lb. of the supplement in diets which contained the alfalfa. The supplement was composed of corn, soybean meal, limestone, trace mineral salt and 7% urea. Chlortetracycline and diethylstilbestrol were added to furnish 70 mg. and 10 mg. of these additives per head daily. Trace mineral salt, dicalcium phosphate and limestone were

offered separately on a free-choice basis. Vitamin A was supplemented at 15,000 and 30,000 I.U. per head daily for cattle with and without alfalfa in the diet.

In addition to protein supplement and 2 lb. of the appropriate dehydrated alfalfa product, the cattle were fed 8 lb. of rolled shelled corn at the beginning of the experiment. Those fed the all-concentrate diet were fed 12 lb. of alfalfa-bromegrass haylage and the others received 10 lb. of the haylage. Corn grain was increased by 1.0 lb. per head daily for 6 days and then by 0.5 lb. until the cattle were on full feed. Haylage was decreased by 1.0 lb. daily per head until eliminated from the diet. Feeding was once daily in outside paved pens without shelter. Feed was fed in fenceline bunks and water was provided from an automatic watering cup connected to a continuous circulating system.

Final shrunk weight was taken after feed and water were withheld for about 18 hours. Weight gains for the experiment were calculated on basis of initial and final shrunk weights. Carcass data were collected about 20 hours after slaughter. A government grader placed the conformation, quality and overall carcass grade on each animal along with the marbling score, maturity, color score, firmness score and estimated percent kidney fat. The hot carcass weight was obtained and cold carcass weight was calculated from this figure by multiplying by 0.9825. The cold carcass weight was then used in calculating dressing percent. Tracings were made of the rib-eye area for measurements of the area of lean and fat thickness.

RESULTS AND DISCUSSION

Results of the feedlot performance are presented in table 2. Steers fed the dehydrated alfalfa products gained at a faster rate than those fed the all-concentrate diet. While differences in rate of gain were not statistically significant, the advantage for the coarse fraction cube amounted to 7.9% over the all-concentrate diet. There were only slight differences between cattle fed the three pelleted or cubed forms of the alfalfa. Rate of gain for the chopped, unpelleted hay was less than for the other forms of dehydrated alfalfa. In this case, weight gain was only 3.1% greater than for the all-concentrate diet. This product contained a considerable amount of fine, dusty material. There was some loss in handling and feeding and some further wind loss in the feed bunk. It was not consumed as readily by the steers as the pelleted or cubed products. However, it is unlikely that alfalfa would be dehydrated and fed to cattle in this form. It was included in the treatments for an additional comparison of forms of the alfalfa when fed at a low level in diets for finishing cattle.

The uniformity of the apparent beneficial response from the pelleted or cubed products indicates an advantage for including a small amount of alfalfa in comparison to all-concentrate diets. This improvement is in agreement with earlier findings by Wise, Blumer and Barrick (1963), Haskins et al. (1969) and Larson (1969). Haskins and associates studied the effects of sources and levels of roughage and roughage substitutes. Hay or cottonseed hulls produced more rapid

TABLE 2. DEHYDRATED ALFALFA PRODUCTS IN HIGH-CONCENTRATE CATTLE FINISHING DIETS
(AUG. 14 TO DEC. 3, 1968 - 110 DAYS)

Item	All concentrate	Dehydrated alfalfa (2 lb. per day)			
		Chopped	Fine 1/4 inch pellet	Coarse cube	Coarse fraction cube
Number of steers	21	21	21	21	21
Initial shrunk wt., lb.	817	822	822	825	821
Final shrunk wt., lb.	1138	1152	1166	1165	1166
Av. daily gain, lb.	2.91	3.00	3.13	3.09	3.14
Av. daily feed, air-dry, lb.					
Corn grain	18.17	19.06	19.67	19.08	19.42
Protein supplement	1.98	0.97	0.97	0.97	0.97
Alfalfa	---	2.02	2.02	2.02	2.02
Total	20.15	22.05	22.66	22.07	22.41
Feed per 100 lb. gain, air-dry, lb.	692	737	727	716	717
Corn and supplement replaced per unit of hay	---	0.34	0.46	0.64	0.62

gains than did corn cobs, oyster shells, sand or ground polyethylene. Larson (1969) reported that chopped alfalfa-bromegrass hay at 3% of the diet offered considerably more improvement in weight gain over an all-concentrate than did 3% oyster shells. About the same rate of gain was obtained by increasing the level of hay up to 20% as with the 3% hay diet.

Physical form, ground or ground and pelleted, of alfalfa hay had no significant effect on cattle performance when fed with high levels of corn according to Clanton and Woods (1966). However, Harvey et al. (1968) reported a slight advantage for a coarser roughage when fed at low levels with high levels of corn. Improvement in gain from 3, 10 or 20% coarsely chopped alfalfa hay in comparison to an all-concentrate diet reported by Larson (1969) was considerably greater than obtained from the various alfalfa products in the experiment reported herein. In addition to a coarser and unpelleted material used by Larson, the hay, grain and supplements were fed in a complete mixture. This perhaps resulted in a more uniform intake of roughage and concentrates each time feed was consumed. In the author's experiment, the various alfalfa products were fed on top of the corn and supplement. The allotted amount of the pelleted or cubed alfalfa was consumed readily leaving only corn and supplement available for a large part of the day.

The cattle fed the alfalfa consumed significantly ($P<.01$) more feed than those fed the all-concentrate diet. The increase amounted to approximately the 2 lb. of alfalfa fed per head daily.

A higher feed consumption by cattle fed mixed concentrates and roughage in comparison to all-concentrate diets has been reported by others (Embry et al., 1967; Wise et al., 1968; Parrot et al., 1968; Larson, 1969). Various explanations have been offered for the regulation of voluntary feed intake in ruminants. It has been reported that rumen fill controls dry matter with high-roughage diets and that metabolic products of feed digestion and assimilation are involved in control of intake with high-concentrate diets (Blaxter, Wainman and Wilson, 1961; Montgomery and Baumgardt, 1965).

Total feed required per unit of gain was increased by including alfalfa in the diets. Advantage was taken of the protein contained in alfalfa by feeding less protein supplement. The main effect of the alfalfa on feed intake appeared to be an increase in total intake but less protein supplement. On basis of feed required per unit of gain, approximately one pound of the dehydrated alfalfa saved one-half pound of the protein supplement. This is about the value to be expected on basis of protein and energy contents of the alfalfa. The whole plant and coarse fraction cubes had slightly higher replacement values in terms of corn and supplement than did the finely ground small pellet.

The response obtained as measured by rate of gain and the concentrates saved by feeding the alfalfa is not as large as reported by Haskins et al. (1969) and Larson (1969). In the research by Larson, coarsely chopped hay fed at 3, 10 or 20% of the diet had a concentrate replacement value of 3.2, 1.0 and 0.5 lb., respectively,

per pound of the hay on basis of feed required per unit of gain. The cattle were of higher initial weight and were fed for a longer time than in the experiment reported herein. Older and heavier cattle, fed for a shorter period of time, have been reported to perform more satisfactorily on all-concentrate diets (McGillick, 1964; Miller et al., 1966; Embry et al., 1967). This along with the differences in method of feeding described may account for the less apparent benefits obtained from roughage in comparison to benefits reported by others. Less management problems frequently reported by including some roughage in diets would be another benefit in addition to the faster gain and some saving in concentrates, principally as protein supplement, from the alfalfa.

Data pertaining to the various carcass characteristics are presented in table 3. Cattle fed the all-concentrate diet had less marbling and were graded lower than those fed small amounts of the dehydrated alfalfa products. However, they gained at a lower rate and were lighter in weight when slaughtered. Other differences in carcass characteristics were small and do not appear to have been affected by dietary treatments.

Only two cattle had abscessed livers with one of these being fed the all-concentrate diet. Considerably higher incidence has frequently been reported with all-concentrate diets but with a small amount of roughage being effective in reducing the problem. Haskins et al. (1969) reported that hay was more protective than cottonseed hulls, corn cobs, oyster shells, sand or ground polyethylene. Number

TABLE 3. CARCASS CHARACTERISTICS OF CATTLE FED HIGH-CONCENTRATE FINISHING DIETS

Item	All concentrate	Dehydrated alfalfa (2 lb. per day)			
		Chopped	Fine 1/4 inch pellet	Coarse cube	Coarse fraction cube
Dressing percent	59.8	59.8	60.1	60.4	59.9
Marbling[a]	5.7	6.2	6.2	6.0	6.6
Carcass grade[b]	19.6	20.2	20.2	20.0	20.6
Fat covering, inches	0.57	0.69	0.74	0.63	0.79
Rib-eye area, square inches	11.74	12.14	12.10	12.01	11.74

[a] Modest, 6; Small, 5.
[b] Choice, 20; Low Choice, 19.

of abscessed livers from 24 cattle per treatment groups amounted to 12, 16 and 4, respectively, for an all-concentrate, 3% oyster shells and 3% hay diets according to Larson (1969).

According to Haskins et al. (1969) there is apparently some physical factor, or factors, present in hay and not present in most roughage substitutes which gives protection against rumen parakeratosis. This could indirectly reduce incidence of abscessed livers (Jensen et al., 1954b). There were no problems encountered in this experiment with any treatments from cattle going off feed. Also, the relatively high level of grain consumed before the experiment started and the relatively long period to get the cattle to full feed resulting in a gradual adaptation to the diets could partially explain the low level of liver abscesses. It has been suggested by Tremere, Merril and Loosli (1968) and Jensen et al. (1954a) that the level of concentrates be increased slowly to prevent rumen parakeratosis. However, the incidence of abscessed livers was considerably lower than frequently encountered with high-concentrate diets in past experiments at the South Dakota Station even when an antibiotic was fed as in this experiment.

SUMMARY

One hundred five Hereford yearling steers were used in a 110 day experiment to compare the value of a low level of alfalfa fed in various forms in a corn diet supplemented with protein, minerals and vitamin A. The results of this experiment show that the addition of 2 lb. (approximately 9% of the total diet) of dehydrated alfalfa improved weight gains of finishing steers. The improvement for the coarse fraction cube over the all-concentrate amounted to about 7.9%. The other pelleted forms were very similar, but the chopped, unpelleted material improved gains 3.1% over the all-concentrate diet. However, it is unlikely that alfalfa would be dehydrated and not processed into a pellet or wafer. Dehydrated alfalfa fed in the unpelleted chopped form resulted in more waste and appeared less palatable in comparison to the pelleted forms. Other workers have reported a greater response with the addition of a small amount of hay to an all-concentrate diet. In this experiment, heavier cattle and a shorter feeding period may have lessened the benefits derived from the alfalfa products.

Cattle fed the alfalfa consumed more total feed than those fed the all-concentrate diet. This increase amounted to approximately the 2 lb. of alfalfa fed per head daily. Total feed required per unit of gain was increased by including alfalfa in the diets. On basis of feed required per unit of gain one unit of dehydrated alfalfa products saved about one-half unit of a 36% protein supplement. This is about the value to be expected on basis of protein

and energy content of the alfalfa. The higher rates of gain and the possibility of less management problems would give additional values above that for the protein and energy content of the alfalfa products. However, in this experiment no problems were encountered with the all-concentrate diet.

Only two cattle had abscessed livers with one of these being fed the all-concentrate diet. This is considerably lower than frequently reported when a high-concentrate diet is fed. Gradual adaptation to the high-concentrate diet and the use of an antibiotic, as utilized in this experiment, would lessen the incidence of liver abscesses.

Cattle fed the all-concentrate diet had less marbling and were graded lower than those fed the alfalfa. However, they gained at a lower rate and were lighter in weight when slaughtered.

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