AN ABSTRACT OF THE THESIS OF

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Abstract approved:_____

Timothy DelCurto

Three experiments were conducted to evaluate the influence of quality of supplemental alfalfa quality on beef cattle consuming low-quality meadow grass (MG) roughages. Fifteen steers (250 kg) were assigned randomly to one of three treatments: 1) meadow grass (5.2% CP), no supplement (MNS); 2) meadow grass plus high quality alfalfa hay (AHS) (18.8% CP); and 3) meadow grass plus low quality alfalfa hay (ALS) (15.2% CP). Supplements were fed at 0.45% BW and 0.55 % BW respectively. Total DM intake was greater ($P < .01$) for alfalfa supplemented steers. Likewise intake of digestible DM, DM digestibility and ruminal ammonia levels were greater for alfalfa supplemented steers ($P < .01$). In Exp. 2; 96 gestating Hereford x Simmental cows (537 kg; body condition 4.86) were assigned to the same treatments as in Exp. 1. For d-0 to d-42 cows grazed on 19.1 ha of stockpiled MG (4539 kg/ha; 6.8% CP) whereas d-43 to d-84, cows received MG hay (5.2% CP). Results for the 84-d study indicated that supplemented cows gained more BW ($P < .01$), body condition ($P < .01$) and had heavier ($P < .01$) calf birth weights than MNS cows. In the first 42-d period supplemented cows gained 16.2 kg more BW than MNS cows ($P < .01$). Likewise, supplemented cows increased .24 BC more ($P <$

.01) than MNS cows. The same trend was observed from d-42 to d-84, though ALS cows lost more BC ($P < .01$) than the AHS cows. In Exp. 3; 90 gestating Angus x Hereford cows (475 kg; body condition 4.59) were assigned to one of three supplemental treatments: 1) 16.1% CP alfalfa; 2) 17.8% CP alfalfa; 3) 20.0% CP alfalfa. The level of supplementation was 0.63%, 0.55%, and 0.50% of BW, respectively. The basal diet was baled MG hay (5.6% CP). Weight gain and BC change for the 84-d study displayed a quadratic response ($P < .10$). In conclusion, alfalfa hay is an effective way of increasing low-quality roughage DM intake and digestibility. However, alfalfa hay quality did not appear to dramatically effect BW, BC, and (or) calf birth weights, when fed on a isonitrogenous basis.

(**KEY WORDS:** Beef cattle, Supplementation, Meadow Hay, Alfalfa Hay)

The Influence of Supplemental Alfalfa Quality on the Intake and Utilization of Low-Quality Roughages by Beef Cattle

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I understand that my thesis will become part of the permanent collection of Oregon State University Libraries. My signature below authorizes release of my thesis to any reader upon request.

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Dedication

I would like to dedicate this thesis to three important ideas or people in my life. First to my family and parents; Ivo and Irma for without their support I would never have had the courage to finish this undertaking. They instilled upon me a good work ethic, with the idea that anything can be done, through hard work and determination. This Masters Thesis has also made me realize that, just how good home really is.

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The Influence Of Supplemental Alfalfa Quality on The Intake and Utilization of Low-Quality Roughages by Beef Cattle

Introduction: Supplementation of Low-quality Roughages for Optimal Beef Cattle Production

For centuries livestock production has served man in countless ways. Through animal production mankind has been able to feed populations, settle the west, and develop life-saving drugs from animal byproducts. In fact, livestock production supplies nearly three-quarters of the protein, one-third of the energy, most of the calcium, phosphorus and essential microminerals and vitamins required for proper human nutrition (Pond et al., 1980). Increasing world population has further increased demands on livestock production. Thus, an adequate supply of feed for livestock production is a critical concern and a constraint to meeting the ever increasing demands for livestock products.

Over the last forty years, cereal grains have been increasingly used to obtain improvements in meat and milk production. However, using grains for feeding livestock instead of directly for human consumption is becoming harder to justify. Consequently, livestock producers must promote the greater use of noncompetitive feed stuffs and develop a higher use of roughages to supply the nutritive needs of livestock. The ruminant is well equipped to exploit this inevitable shift in livestock production. Unlike simple stomached species, the ruminant can effectively utilize coarse, fibrous plant materials, human food wastes and by-products, and nonprotein nitrogen (NPN).

In the U.S., there are more than 405 million nontillable hectares adapted to range and pasture grazing systems, which could be used for some kind of livestock production system (Pond et al., 1980). Combine that with the millions of hectares of crops which

produce crop residues and we could dramatically alter the way livestock are reared in the U.S. By utilizing these other feed resources, there would be more land available for raising food crops. However, poor nutritive values are a problem when using high-fiber low-quality roughages in the diets of ruminants. This is especially true with the use of crop residues and dormant stockpiled roughages. At these late stages in plant growth some feeding modification must be implemented to adequately maintain animal production and effectively utilize these roughage resources.

Numerous approaches have been taken to improve utilization of high-fiber, low-quality roughages. Physical modification processes such as grinding and pelting (Nicholson, 1981) and high pressure steam (Satter, 1983) have been effective in improving the intake and utilization of low-quality roughages. These physical modification procedures; however, are expensive and do not appear to be cost effective (Fahey and Berger, 1986).

Chemical modification such as the use of anhydrous ammonia (Ward and Ward, 1987), urea (Chestnut et al., 1988), and alkaline hydrogen peroxide (Kerley et al., 1985) has shown considerable promise as a tool to increase both the intake and utilization of crop residues and poor quality hays. However, chemical modification usually requires special handling of feeds and additives and as a result has not been widely accepted by beef producers. Application is also limited to harvested forages and would be impossible to use in situations where low-quality stockpiled forages are being utilized.

Supplementation is the most easily implemented nutritional strategy in utilizing high-fiber, low-quality range roughages. Supplements work two-fold. First,

supplementation provides additional nutrients that are not provided in sufficient quantity or proportions in the forage to allow the animal to meet a desired level of performance. In addition to complimenting the nutritive content of ruminant diets, supplementation can be an effective tool in enhancing the intake and utilization of low-quality roughages. Therefore, the ideal goal of supplementation would be to maximize utilization, while maintaining desired performance levels. When referring to supplementation of low-quality roughages, energy and protein supplements generally come to mind. However, supplementation of low-quality roughages more often than not, generally refers to protein supplements.

Problem Definition:

Beef producers across the Western United States and Canada have to contend with dynamic forage resources which vary in quality as well as quantity throughout the year. In many cases the forages these ranches depend on become inadequate in meeting the demands of cattle during critical production periods. During the winter season the most critical grass species become dormant, and with the combination of weathering, these grasses are typically low in protein and less digestible. During late summer and early fall, plants translocate their soluble carbohydrates towards their base and roots. These reserves are used to maintain the root structure throughout the winter period and help reinitiate spring growth.

A beef producer's primary goal is to make money, while at the same time, maintain adequate animal health that ensures optimal beef cow production. However, because most

ranges will not adequately meet the nutritional needs of beef cattle, producers are forced to supplement or entirely replace their forage base with hay. Relative to other parts of the U.S. and the world the producer in the western U.S. and Canada has an economic disadvantage.

One way to lower feed costs is through utilization of stockpiled roughages. A common misconception relative to stockpiled forages is that these forages do not serve well as feed sources during the winter months. However, research has proven that supplementing with a feed source that has adequate levels of protein can dramatically increase intake and digestion of lower quality roughages.

There are several types of supplements that can be used, such as soybean meal to non-protein nitrogen such as urea. However, these supplements can be expensive and many times do not serve as well nutritionally as other supplements. A readily available supplement much used in the western ranching community is alfalfa hay. Alfalfa hay has many benefits and in most cases is also economically favorable when evaluated on a crude protein (CP) basis. However, the majority of alfalfa that has been used by beef producers is of a lower quality and unsuitable for "dairy-quality" markets.

Dairy-quality alfalfa can be described as, "The best of the best alfalfa.". Harvested typically at the prebud or prebloom stage, this alfalfa has a high CP content and low levels of ADF and NDF. Consequently prices for this supplement are very high. On the other hand, feeder-quality alfalfa is usually alfalfa which can not be sold in the dairy market. It is harvested at later stages in plant growth and has lower CP levels and higher levels of ADF

and NDF. For these reasons, feeder-quality alfalfa can often be purchased at discounted prices and used as a protein source in the western ranching community.

Statement of Purpose:

The purpose of this project was to evaluate alfalfa supplementation and differing maturities of alfalfa, as a protein source for beef cattle grazing stockpiled and (or) receiving baled meadow grass hay. The effects of these alfalfa supplements, were compared with each other and against a nonsupplement group in both a digestion and two cow performance trials. The digestion trial was done to understand the physiology behind supplements. While the cow performance trials were done to understand the practical usages of alfalfa supplements; they also helped describe changes in cow body condition (BC) and body weight (BW) on cattle during the last trimester of pregnancy. Further evaluation will also describe supplementation effects on calf birth weights and subsequent weight gains of cows and calves and conception rates.

Forage Quality and The Ruminant:

Forage quality is best defined in terms of animal performance such as body weight gain and (or) milk production. All ruminants are largely reliant on forages to supply energy, proteins, minerals and vitamins for their growth and maintenance. However, as forages mature, these nutrients progressively become less digestible and therefore less will be utilized by the ruminant. Among the nutrients most lacking in dormant mature grasses is CP, which is needed for tissue maintenance, growth, products of conception, and for

milk protein synthesis (Øroskov, 1982). Adequate levels of protein also are required for proper rumen fermentation. Consequently, some form of supplementary protein is required to obtain positive performance when forage CP levels are inadequate.

Protein supplementation works in two ways. First, supplementation helps supply protein that may be missing in low-quality forage. Secondly, it has been shown that supplementation with feedstuffs high in protein concentration enhances low-quality forage intake. It is likely due to associated effects on fill, rate of passage, and fiber digestion. Increasing forage intake increases intake of energy and other nutrients which ultimately enhance performance (Peterson, 1987; McCollum and Horn, 1989; Owens et. al., 1991).

Control of Voluntary Forage Intake:

An understanding of forage quality factors is essential to understanding the factors which control forage intake. Such factors include forage or vegetation selection, chemical and physical composition of forages consumed and (or) animal factors such as rumen capacity. Typically, diets lower than 6-8% CP are known to be associated with depressed forage intakes and under such circumstances animals are frequently fed protein supplements to enhance performance (Campling, 1970; Kartchner, 1981).

The actual mechanism by which supplemental protein effects forage intake is difficult to establish and, in all likelihood, may be due to many interrelated factors (Forbes, 1986). Limited forage intake, due to protein deficiency is suspected to be either a host tissue-level nutrient deficiency, and (or) a nitrogen (N) deficiency in the rumen microbial environment (Van Soest, 1982). Ruminants fed diets deficient in CP typically display low

intakes and gut fill (Thornton and Minson, 1973). In this situation, the physical limitation of fill in the reticulo-rumen does not seem to be involved in the control of feed intake.

The rate at which protein is degraded relative to carbohydrates in the rumen is also thought to be critical. Some have even suggested that carbohydrate digestion is improved when N is liberated at a rate synchronous with the carbohydrate (Doyle, 1987). However, little data exists that supports this hypothesis.

On the other hand, in a study by Brandyberry et al., (1992), where form and frequency of alfalfa supplementation were compared; no differences in digestibility and forage DM intake were observed between cows fed alfalfa supplement daily versus every other day. Hunt et al., (1989) observed similar results when cottonseed meal was supplemented to low-quality fescue hay to evaluate the effects of supplementation time interval on total DM intake and DM digestibility. In another study (Song and Kennelly, 1990), NPN was infused into cows once per week. No important differences in DM intake and DM digestibility were observed when compared with cows that were infused daily. Clearly these experiments show that ammonia found in the rumen does not necessarily have to come from degradation of dietary protein and (or) NPN, but that ammonia can also come from the hydrolysis of urea recycled to the rumen.

Absorption of ammonia across the rumen wall increases with concentration, and microbial uptake can be expected to increase as the protein to energy ratio declines (Horney 1992). Changes in ruminal ammonia concentration are generally attributed to the dynamic competition which occurs between modes of protein degradation and removal (Church, 1988).

Ruminal Fill and Rate of Passage:

Ruminal fill and (or) gut capacity are important factors in determing the intake of ruminants. Van Soest (1982) attributes changes in reticulo-rumen "fill" (weight/volume of digesta) to rumen stretch factors. The rumen can expand and contract somewhat to accommodate varying amounts of digesta. He suggested that the animal's tolerance for degrees of such expansion depends upon its appetite, which changes according to how near circulating levels of certain nutrients are to meeting nutritional requirements. In a study by Egan (1970) reticulo-rumen fills were greater in sheep fed alfalfa hay than those fed oat or wheat straw. Similarly in a study by Krysl et al., (1987), mature ewes on a prairie hay diet (6.3% CP) were found to increase their reticulo-rumen fills upon supplementation with cottonseed meal. While the mechanisms behind this phenomenon have not been adequately described, it seems likely that host tissue N status is an important factor. This is particularly important for low-quality forage diets, where ruminal microbes may utilize most of the N which is liberated before it escapes to the lower tract.

Another factor determining DM forage intake may be related to the rate at which the reticulo-rumen is emptied. Forage diets that have an abundance of indigestible constituents generally decrease intake, since more digesta has to be emptied through lower tract passage and rumen digestion is usually slowed down because of higher levels of indigestible constituents. By increasing the digestible proportion of the diet through protein supplementation, increased passage rates can be achieved.

In a study by Judkins et al., (1985), alfalfa supplemented steers tended to have elevated passage rates (%/h) and performance compared to steers that consumed only dormant blue-gramma winter range. Guthrie and Wagner (1988) and Stokes et al., (1988) separately reported linear increases in rates of passage with increasing levels of soybean meal. Similarly, DelCurto et al., (1990a) described a quadratic response in ruminal indigestible acid detergent fiber (IADF) passage to graded levels of protein supplementation. Results from these studies all suggest that one of the benefits to protein supplementation is increased passage which, in turn, may facilitate greater intake.

Ruminal Fermentation:

Ammonia: Generally speaking the speed of fermentation is a function of nutrient quality, quantity, and solubility, as well as the population size and activity of resident cellulolytic microbes. However, ruminal N has a major impact on digestion. Ruminal N depends on the availability of dietary protein, the degradability of dietary protein, and the availability of recycled N (Owens, 1991). Ruminal N is necessary for microbial protein synthesis and ultimately for efficient dietary utilization of low-quality roughages (Broderick, 1991). Supplementation increases the supply of N available for promoting microbial synthesis, for direct use by the host, and for recycling. As a result, NH_3 - N concentration typically increases in response to protein supplementation of low-quality forages. For example, in a study by Hannah et al., (1991) higher ruminal ammonia levels were observed for steers receiving dehydrated alfalfa as a supplement to their basal diet of bluestem-range than non-supplemented animals. In another study by Caton et al., (1988),

higher ammonia was observed in steers that were supplemented with cottonseed meal than unsupplemented steers.

The proper level of ruminal ammonia (NH_3) to optimize ruminal fermentation is the subject of much debate. Schaefer et al., (1980) reported that no more than 5 mg/dl of ammonia is required for maximal microbial growth. On the other hand, Erdman et al., (1986) reported that maximal microbial growth is obtained when ammonia levels are in excess of 20 mg/dl. Generally the level of ammonia needed to maximize microbial growth will depend on the physiological state of the ruminant and the type and quality of feed that the ruminant is consuming. While not confirmed, 5 mg /dl is considered to be adequate amount for ruminal fermentation, whereas 10 mg /dl may maximize microbial growth on low-quality roughage diets.

VFAs': Three volatile fatty acids (VFA) make up the greatest proportion of total VFA production: acetate, propionate, and butyrate. Acetate is produced in the greatest amounts. As much as 70% of the total VFA in forage diets is acetate (Church, 1988). Research has shown increased total volatile fatty acid (TVFA) concentration in response to supplementation of low-quality forages. DelCurto et al., (1990b) and Hannah et al., (1991) reported increased TVFA concentration with supplemented steers compared with nonsupplemented steers. Further research has shown that alfalfa supplementation also has an effect on the proportions and ratios of certain types of volatile fatty acids (VFA). Judkins et al., (1987) observed that acetate proportions were lowest for supplemented treatments, while propionate proportions were highest for supplemented treatments. Research by DelCurto et al., (1990b) observed the same pattern when steers were

supplemented with alfalfa compared with those consuming only dormant, tall grass prairie range. Research concerning butyrate proportions has been mixed. Some research indicates butyrate levels are increased with alfalfa supplementation (DelCurto et al., 1990b; Hannah et al., 1991). In contrast, Judkins et al., (1987) saw no alteration in butyrate levels when alfalfa was offered as a supplement to blue-gramma range. However, the blue-gramma range in this study was in excess of 10.2% CP. This may explain why there was no alteration in butyrate levels.

Alfalfa supplementation of low-quality forages has also been shown to increase the molar proportions of branched-chain VFA's (isobutyrate, isovalerate and valerate). Vanzant and Cochran (1994) observed linear increases in molar proportions with increased levels of alfalfa supplementation. DelCurto et al.,(1990b) also observed increased levels of isobutyrate and isovalerate with alfalfa hay and SBM/Sorghum supplementation on dormant tall-grass range type. However, the levels of these branched-chain VFA's were lower in dehydrated alfalfa.

Enhanced fermentative activity and associated increases in TVFA concentration in response to supplementation is likely the result of providing ruminal microorganisms with more available N, some additional energy substrates, as well as the provision of additional microbial growth factors (i.e., branched-chain VFA from branched-chain amino acids).

Rumen pH: Ruminal pH is closely linked to microbial activity and VFA absorption. The VFA generated as end-products of microbial metabolism tend to shift the pH down as they accumulate. The pKa value for most VFAs are near 4.1, therefore the pH should lower as VFA increases in concentration.

Exactly how much influence VFA's have on the rumen pH is the focus of much debate. Several studies demonstrated that supplementation does not consistently lower ruminal pH. (McCollum and Galyean (1985); Caton et al., (1988); DelCurto et al., (1990b). Supplementation may increase the passage rate and thereby not allow accumulation of rumen VFAs sufficient to alter pH.

However, research by DelCurto et al., (1990c) tended to suggest that soybean meal, alfalfa hay and alfalfa pellets lowered rumen pH when fed as a supplement to tall-grass prairie hay. Lowering of the ruminal pH was attributed to a 40% increase in VFA concentration, when compared to non-supplemented steers in this study. Stokes et al., (1988) also observed a linear decrease in ruminal pH as levels of soybean meal supplementation increased. At the same time there was a linear increase in VFA production, which was apparently contributing to the decrease in pH.

Bypass Protein & the Lower Digestive Tract:

Dietary protein is digested in the rumen to a variable degree depending on feed, ruminal micro-organisms, animal, and time constraints. The balance of the dietary protein that escapes metabolism in the rumen and continues on through the omasum, abomasum and small intestine is commonly referred to as 'bypass protein' or escape protein. Protein escaping or bypassing ruminal destruction is either digested post-ruminally or excreted in the feces. Typically protein sources derived from animal by-products, such as blood and fish meal are known to be supplements with high bypass protein constituents. These supplements generally have greater than 60% bypass CP (NRC, 1984). Physical form and

(or) heat processing of the feed can also play an important factor in how much dietary protein can bypass digestion in the rumen. So what is the importance of bypass protein?

Under most circumstances when animals have an adequate level of CP intake, bacterial rumen fermentation can derive the 26 essential amino acids necessary for proper body function. However, under certain high production animal systems (dairy operations), certain amino acids, such as lysine and methionine, are required more than others for optimal production. To meet production goals in these animals, amino acids must be supplied that can pass through the rumen without being digested; in order for them to be absorbed in the small intestine. The first way to increase bypass protein, is by supplementing with a protein source high in bypass constituents, such as meat and bone meal or feather meal. Protein flow to the small intestine (bypass protein) may increase as ruminal passage rate increases and (or) ruminal protein degradability decreases (Broderick et al., 1991).

Typically, bypass protein supplementation in mature beef cow is not of great concern (DelCurto, 1996; pers. comm.). Research has indicated that quantity and quality of amino acids furnished from ruminal sources are adequate for maintenance of mature gestating beef cattle during the winter feeding period. On the other hand, supplementation of protein sources high in bypass constituents has resulted in increased performance of growing beef cattle (Fernandez-Rivera et al., 1989). This is particularly the case when growing beef cattle are decreasing in body weight during winter grazing (Gutierrez-Ornelas and Klopfenstein, 1991).

Protein Supplementation & Livestock Performance:

Protein supplementation of low quality roughages increases forage intake and utilization (Clanton, 1982; DelCurto et al., 1990b; Vanzant and Cochran, 1994). Increasing the protein proportion in the diet consequently leads to increased levels of ruminal NH_3, which in turn, enhances microbial growth (Song and Kennelly, 1989). With increased intake and increased microbial action, an increase in ruminal digesta turnover can also be observed (Corbett, 1981). With the increased microbial activity, maximum ruminal roughage digestion will occur.

Alteration of the rate of passage and (or) digestion may alleviate the problem of gut fill which is the most limiting in situations where low-quality roughages are being fed (Campling, 1970; Freer, 1981)

Improved maintenance of beef cattle weight and body condition with protein supplementation has been reported by numerous researchers. In a study by Clanton and Zimmerman (1965) which took place over five concurrent winter periods, supplemented cows maintained their weight and body condition better than unsupplemented cows that received only low-quality roughages. Further evaluation of subsequent calf birth weights, weaning weights and total calf crops (% calf crop weaned vs. cows exposed) were significantly higher for supplemented cows versus the nonsupplemented cows. Days to first estrus after calving were 10 days shorter for supplemented cows than for the nonsupplemented group. Nonsupplemented cows were reported to be the same weight the following fall, due to high compensatory gains. However, the poorer conception rates and lower calf crops for the nonsupplemented cows was a very high economic cost. In a more

recent study by DelCurto et al., (1990c) adequate maintenance of the cow body weight and condition during the winter feeding period tended to promote greater reproductive efficiency and calf weaning weights.

In a study by Vanzant and Cochran (1994), cows that received increasing amounts of alfalfa conceived sooner than those that received less. This is in agreement with a study conducted by Richards et al., (1986) in which postpartum interval to conception was shorter in cows in moderate body condition compared to thinner cows.

However, responses to supplementation are not always consistent. Rittenhouse et al., (1970) and Kartchner (1981) reported that response to supplemental protein under grazing conditions may be dependent on forage availability, forage quality and climatic fluctuations. In the first trial, of that study there was no distinctive advantage to protein supplementation. They suggested that the lack of supplementation response could be explained by the mild winter weather and high forage availability during the trial. In the second trial, the following year, there was a significant advantage to supplementation. In that year the DMI and DMD were limited, and protein supplementation increased intake of cows by 27.5%.

Energy Supplementation and Low-Quality Forages:

In contrast to protein supplements, research on energy supplements has shown little influence on increasing the DMI and DMD. In fact some research has indicated that energy supplementation may depress DMI and DMD of low-quality roughages. In a study by Sanson et al., (1989), where corn was supplemented from .26% to .52% of BW, a 17% decrease in intake and a 21% decrease in the digestibility was observed at the higher level of corn supplementation. Likewise Kartchner (1981), found that when protein and energy supplementation were compared DMI of the energy supplemented cows tended to be lower than the control cows. In fact, when comparing energy supplemented cows to the protein supplemented cows, DMI was 27.5% less. Dry matter digestibility for the energy supplemented cows was 34.3% lower than control cows and 43.6% lower than protein supplemented cows. Energy supplements tend to replace or substitute for the intake of low-quality roughages and often exert little or no influence on beef cow performance. Energy supplementation should be considered only when the quantity of low-quality forage is limited and there is a need to get higher energy levels into the ruminant. Other reasons for supplementation with an energy source may also be to increase and (or) induce beef cow estrus before breeding.

Alfalfa Supplements:

Alfalfa is an important forage in ruminant diets worldwide. It is useful because of its desirable agronomic characteristics, high protein content (relative to other forages) and

its overall high nutritive value. Alfalfa produces more protein on a single hectare than any grain or oilseed crop (Heath et al., 1985). Aside from the high protein content, alfalfa also has exceptionally high levels of calcium and other minerals like magnesium and manganese. All these minerals are required in high amounts during late pregnancy and early lactation. Since alfalfa supplementation supplies not only N to the ruminal bacteria, but also trace minerals, alfalfa can serve as both a protein and mineral supplement. The nitrogen content in alfalfa is estimated to be 70% degradable in the rumen (Atwell et al., 1991), and is often less expensive than conventional CP supplements.

Although alfalfa has a relatively high nutritive value, the fiber proportion is often characterized as being poorly digested (Titgemeyer et al., 1992). Alfalfa contains soluble sugars which provide a readily available energy substrate which stimulates microbial growth and ultimately enhances forage degradation. The ruminal degradable protein in alfalfa is broken down into peptides, amino acids and ammonia. Because of the relatively high concentration of N in alfalfa and its ready availability, alfalfa is a good source of nitrogen for fibrolytic bacteria. As mentioned previously, ammonia is critical for the metabolic activities of cellulolytic bacteria which populate the floating fiber mat in the rumen. However, much of the free ammonia found in the rumen is in the liquid fraction below the fiber mat. For this reason there may be advantages to feeding proteinaceous forages rather than concentrates as supplements. These supplemental forages will join the fiber of the basal forage in the fiber mat, bringing their additional nitrogen with them, thereby providing a ready supply for the local microbes (Owens et al., 1991).

Finally, another reason why alfalfa is perceived as a superior supplement is the fact that it does not have to be mixed with any other feed source in order to get intake into ruminants. Many other protein supplements, especially concentrate supplements, are higher in protein content than alfalfa; however, palatability and preference are very low. Examples of such supplements include feather meal, canola meal or urea. In order to get proper intake, these supplements must be mixed with another more palatable feed source. By the time sufficient intake is achieved, the costs of many protein supplements can be even higher due to additives, processing and mixing costs.

Concentrate Supplements:

Concentrates are another category of protein supplements. This family of supplements is usually derived from oilseed by-products and include supplements such as canola meal, cottonseed meal, and soybean meal. Unlike alfalfa, most of these supplements have levels of CP greater than 35% (NRC, 1984). This type of supplement is also very digestible and usually are less than 40% bypass protein (NRC, 1984). Thus the majority of CP would be available to the rumen microflora, and less physical DM supplement would have to be fed in order to achieve a similar protein effect as with supplementing with alfalfa. However, one problem with this type of supplement is that when concentrates are evaluated on a $ / kg of CP (Table 1.1) they are frequently more expensive than alfalfa. In addition, they usually need to be mixed with other feeds in order to get proper ruminant intake.

Table 1.1 Comparison of Supplemental CP Sources and Comparative Costs [a]

Protein Source	*% CP*	*Cost $ / 1000 kg*	*$ / kg of CP*
Alfalfa hay, prebloom	20.0	$132	$0.66
Alfalfa hay, early bloom	18.0	$88	$0.49
Alfalfa hay, full bloom	14.0	$74	$0.53
Anipro	14.0	$308	$2.20
Beef Grow, PGG	38.0	$286	$0.75
Canola meal	35.0	$209	$0.59
Cottonseed meal	44.3	$280	$0.63
Feather meal	82.0	$418	$0.51
Meat and bone meal	50.0	$299	$0.60
Soybean meal	47.5	$297	$0.63
Urea	287.0	$297	$0.10

[a] Prices courtesy of Pendelton Grain Growers, March 8, 1996.

Judkins et al., (1987) evaluated protein supplementation on dormant range in south-central New Mexico. Yearling heifers that were equally supplemented with alfalfa or cottonseed cake displayed similar rates of gain. Cochran et al., (1986) found no differences in cow performance between alfalfa cubes and cottonseed meal-barley cake when fed as supplements to gestating beef cows, grazing eastern Montana dormant winter range. Finally, DelCurto et al., (1990c) reported that sun-cured alfalfa pellets promoted higher intake and better maintenance of mature cow weight and body condition compared to long-stem alfalfa hay or soybean meal/sorghum grain supplements.

NPN Supplementation:

As mentioned previously, ruminants have the unique ability to assimilate nonprotein nitrogen (NPN) into microbial cell protein. This means that N does not have to

come from natural protein sources rather they can come from man made substrates. The most common forms of NPN used as N sources are urea and feed-grade biuret. These sources of NPN are readily available and the $ / kg CP (Table 1.1), is also very low. Based on these attributes NPNs would seem the ideal supplement, as an alternative to natural protein supplementation of low-quality roughages, especially when the CP content is 287%.

However, NPN has not been as effective as natural protein sources when supplemented to cattle consuming low-quality roughages. A study reported by Clanton et al., (1978), decreased performances were observed for supplements containing greater than 3% urea or 6% biuret as compared to cattle that were receiving natural protein supplements. In another study by Rush and Totusek (1976), cows fed natural protein supplements lost less weight than cows fed NPN supplements. Numerous other researchers have also observed the same results, when NPN is substituted for a part of the natural protein supplement.

Addition of NPN to ruminant diets is useful only when the ruminal concentrations of ammonia are inadequate for optimal bacteria action, or when animals are on high-energy-concentrate diets. High-energy diets generally lower ruminal pH, which slows down ammonia hydrolyzation, thereby also decreasing the likelihood of rapid ammonia build up.

Rapid build up of ammonia in the rumen can lead to excessive amounts of urea absorbed into the blood stream, which can prove toxic to the animal. Levels of urea

considered toxic to ruminants are between 0.3 to 0.8 g of urea per kilogram of body weight (NRC, 1984).

Minimizing toxicity can be done by ensuring urea constitutes no more than one percent of the dry matter intake or one third of the total protein intake (NRC, 1984). Slowly degraded sources of NPN also help avoid ammonia intoxication. Secondly, because urea is so rapidly hydrolyzed it creates a positive gradient along the rumen wall. Ammonia is absorbed directly into the blood stream, transported to the liver, reconverted to urea and then filtered by the kidney and excreted before it has time to be used by the rumen microflora. In this case, the NPN supplement does not stay in the rumen long enough to be a benefit to rumen microflora. Finally, when NPN is substituted for protein in a diet, special care in mineral supplementation must be exercised since most forms of proteins provide substantial amounts of sulfur, potassium and phosphorus which are absent in NPN sources (NRC, 1984).

Optimal Supplementation Levels:

The optimal level of supplementation is the subject of much debate. Numerous research trials have concluded that the optimal supplementation level will depend on the basal diet, type and quality of supplement and the physiological status of the animal. Vanzant and Cochran, (1994) reported that total DMI and basal DMI was optimized when alfalfa (16.8% CP) was fed to steers at .70% BW. This equated to 1.47 g CP/kg of BW. In another study by Hunt et al., (1985), maximum in vitro dry matter and neutral detergent fiber digestion occurred with a forage combination of 25% alfalfa. Paterson et al., (1982)

found maximum DM digestion and steer performance occurred with rations containing 50% alfalfa - 50% corn cob diets, compared with either 100% alfalfa or 100% corn cob diets. Sunvold et al., (1991) reported that forage DMI and IADF passage rates increased quadratically with increasing CP concentration. They concluded that supplements containing at least a moderate concentration of CP ($\geq$ 20% CP) provided the best opportunity for increasing DMI. Both Sunvold et al., (1991) and DelCurto et al., (1990b) agreed that optimal protein supplementation occurred at a point in which a balance between CP and energy is achieved and forage intake will be near maximal as long as an appropriate total quantity of protein is offered.

Hand Feeding vs. Self Feeding

The disadvantage of feeding alfalfa, as well as other protein supplements is that it requires the producer to physically hand feed the supplement. A common argument with forage supplements is that it increases labor costs and (or) may alter grazing behavior if the animals are grazing stockpiled forages. On the other hand, commercially available self feeding lick and block protein supplements are cheaper because they do not have to be distributed on a daily basis. Often these supplements cost four times the value of the actual CP, by weight, supplied by forage protein like alfalfa (Table 1.1). Usually these commercially available protein supplements also contain a high percentage of NPN. With that in mind the extra labor required to hand feed forage supplements would certainly be offset by the savings in supplement cost. Further research by Brandyberry et al., (1992) has also indicated that there is no difference in average daily gain and body condition

between cows that were supplemented daily or every other day. Hunt et al., (1989) reported no difference in DMI and NDF digestibility with steers supplemented with cottonseed meal at 12, 24 and 48 hour time intervals. Unsupplemented steers had significantly lower DMI and NDF digestibility of the low-quality meadow grass. Therefore, it should be possible to supplement every other day or twice a week and get the same results as with every day protein supplementation. In addition, intake of self feeding supplements can vary a great deal between animals. In a study by Bowman et al., (1995), intake of a commercial lick supplement (28.5% CP as-fed) varied from .002 to 2.54 kg/d. If animals are consuming a low-quality basal roughage, this would mean that some of the animals would receive more CP than they need, while other animals will be severely deficient. With hand feeding, there will be a better opportunity to monitor animals and ensure that all are getting an adequate intake.

Conclusion:

Supplying supplemental protein to ruminants consuming low-quality roughages has proven to be an effective means of increasing performance, dry matter intake, digestion rates, and passage rates. Subsequent cow performance trials have documented increased cow BW gain, body condition, and reproductive efficiency. All of which are important for maximizing beef cow productivity. As we move into a new era of beef cattle management in North America, it will be even more important that we understand how to maximize the use of low-quality roughages. Research has shown that protein supplementation is an effective method to improve utilization of roughages. However, some traditional

supplements, like soybean and cottonseed meal have been studied more than others. Forage supplements like alfalfa are also reliable protein sources; however, little information on the effect of quality exists; this was the reason for undertaking this project. It is important that we understand the digestion fundamentals, and how, quality of supplement can affect the intake and utilization of low-quality roughages.

In the next chapter, a research program that critically evaluates the influence of supplemental alfalfa quality and subsequent influences on intake and use of low-quality roughages by beef cattle is described. It is desired that this research aids ruminant animal agriculture by providing information which: 1) allows for economical nutritional management and, 2) encourages optimal use of low-quality roughages in beef cattle production systems.

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Chapter 2

The Influence Of Supplemental Alfalfa Quality On The Intake and Utilization Of Low-Quality Roughages By Beef Cattle:

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The Influence of Supplemental Alfalfa Quality on the Intake and Utilization of Low-Quality Roughages by Beef Cattle

Abstract:

Three experiments evaluated the influence of supplemental alfalfa quality on beef cattle consuming low-quality meadow grass roughages (MG). In Exp. 1, fifteen steers (250 kg) were assigned to three treatments: 1) MG (5.2% CP), no supplement; 2) MG plus high-quality alfalfa (18.8% CP); and 3) MG plus low-quality alfalfa (15.2% CP). Supplements were fed at 0.45% and 0.55 % BW. Total DM intake was greater ($P < .01$) for alfalfa supplemented steers. Likewise intake of digestible DM, DM digestibility, and ruminal ammonia levels were also greater ($P < .01$) for supplemented steers. In Exp. 2; 96 gestating Hereford x Simmental cows (537 kg; body condition 4.86), were assigned to the same treatments as in Exp. 1. For d 0 to 42, cows grazed on 19.1 ha of stockpiled MG (4539 kg/ha; 6.8% CP) whereas, on d 43 to 84, cows received MG hay (5.2% CP). Supplemented cows gained more BW ($P < .01$), BC ($P < .01$) and had heavier calf birth weights ($P < .01$) than nonsupplemented cows. In Exp. 3, 90 gestating Angus x Hereford cows (475 kg; BC score 4.59) were assigned to three supplemental treatments: 1) 16.1% CP alfalfa; 2) 17.8% CP alfalfa; 3) 20.0% CP alfalfa. Supplements were fed at 0.63%, 0.55%, and 0.50% of BW. Weight gain and BC for the 84-d study displayed a quadratic response ($P < .10$). In conclusion, alfalfa hay was effective in increasing DM intake and digestibility. However, alfalfa hay quality did not effect BW, BC, and (or) calf birth weights, when fed on an isonitrogenous basis.

KEY WORDS: Beef Cattle, Supplementation, Alfalfa Hay, Low-Quality Roughages

Introduction:

Protein supplementation of low-quality roughages is a routine practice in the beef cattle industry, particularly with cattle that are grazing or those being fed low-quality roughages. Supplementation improves cattle performance by stimulation of voluntary intake (Kartchner, 1980; DelCurto et al., 1990b; Horney et al., 1992). Improvements in voluntary intake are attributed to increased rates of forage digestion and low-quality roughage passage rates (Church and Santos, 1981). Improved intake and utilization of low-quality roughages in turn, promote improved beef cow BW gain, body condition, reproductive efficiency and weaning weights of calves (Clanton, 1982; Cochran et al., 1986b; DelCurto et al., 1990c).

Most research on protein supplementation of beef cows has focused on oilseed meals (soybean, cottonseed and canola meal), nonprotein nitrogen (NPN) or strategies of supplementation such as timing, frequency and amounts. Although positive benefits of these supplements are well established, there is limited information on the role of alfalfa and alfalfa quality, when used as a supplement to low-quality roughages. The alfalfa traditionally used as a supplement in the beef cattle industry is lower quality alfalfa, which is unsuitable for the high-quality alfalfa markets. The objective of this study, was to harvest a high-quality and a low-quality alfalfa and to compare the effects on intake, digestion, and subsequent performance of beef cattle consuming a low-quality roughage.

Materials and Methods:

Alfalfa Supplements.

Two maturities of second cutting alfalfa (*Medicago sativa*) were obtained for Exp. 1 and 2. The maturity stages were early boot (high-quality) and late bloom (low-quality). The field was divided into two blocks and, within the two blocks, two maturities were randomly obtained by evaluating the phenology of the plant to the time of harvesting (Tables 2.1& 2.2). In Exp. 3, three stages of second cutting alfalfa were obtained from the same field. In this case the stages were early boot (high-quality), early bloom (mid-quality) and late bloom (low-quality; Table 2.3). This field was divided into four blocks, and within the four blocks, three maturities were randomly obtained by evaluating the phenology of the plant to harvest time. All alfalfa supplements were obtained from the same 22 ha field. Treatment maturities of alfalfa were then baled into rectangular bales (55 kg) and randomly mixed during feeding of the supplements. Ground level clippings were taken prior to both cuttings, to determine total above-ground biomass. Feed samples were then taken from the baled hay and the samples were analyzed for DM, CP, ADIN, ADF, NDF, and IVDMD (Tables 2.1, 2.2, & 2.3).

Meadow Hay:

Low-quality meadow grass hay (MG) was utilized as the basal diet in both trials. The hay for Exp. 1 and 2 was obtained from a 12.7 ha field, at the Eastern Oregon Agriculture Experiment Center in Union, Oregon (Table 2.1). While the meadow grass

hay for Exp., 3 was obtained from the Eastern Oregon Agriculture Experiment Center in Burns, Oregon (Table 2.3), both hays were at a late maturity at the time of cutting. The low-quality meadow grass hay was dominated by tall fescue (*Festuca arundinacea)*, reed canary grass (*Phalaris arundinacea*), orchard grass (*Dactylis glomerta*), Kentucky blue grass (*Poa pratensis*), and downy brome (*Bromus tectorum*). Feed samples were taken from the baled hay and analyzed for DM, CP, ADIN, ADF, NDF, and IVDMD (Tables 2.1, 2.2 and 2.3).

Experimental Procedures:

Experiment 1 - Digestion Study:

Fifteen ruminally cannulated Simmental x Hereford x Angus steers (avg. initial BW = 250 kg) were used to assess the influence of supplemental alfalfa quality on the intake, digestibility and fermentation characteristics of low-quality meadow hay. Procedures and techniques were approved by the Institutional Animal Care and Use Committee of Oregon State University. Steers were blocked by weight and then randomly assigned to one of three treatments: 1) meadow hay - control; 2) meadow hay and low-quality alfalfa (15.5% CP) supplement; 3) meadow hay and high-quality alfalfa (19.2% CP) supplement. Alfalfa supplements were fed at (DM basis) 0.55% BW and 0.45% BW steer $^{-1} \cdot$ d $^{-1}$ respectively. Steers were housed in individual pens (3 m x 3 m). Alfalfa hay supplement was provided at 0730 h daily. Following supplement feeding, steers were offered meadow grass hay (Table 2.1) at 125% of their previous 5-d average intake to

allow ad libitum access. All forages were coarsely chopped (2 cm - 6 cm length) prior to feeding to facilitate feeding and weighing. Steers had ad libitum access to water and trace-mineralized salt blocks[1] throughout the experiment. Refused hay was removed prior to feeding alfalfa supplements, weighed and discarded. The 28-d digestion study consisted of a 14 d adaptation, a 6 d intake, and a 6 d fecal collection period, with a rumen profile on d 27 and rumen evacuation on d 28.

Feed offered and refused was measured daily throughout the study, and feed and ort samples were collected on d 15 through 26. On d 21 through d 26 feed subsamples and 10% of each days orts were reserved for compositing and analysis. Orts were weighed, dried, reweighed, composited by steer, ground, and analyzed for DM, NDF, and indigestible ADF. Feeds were handled similarly with 100 gm samples taken daily during the intake and fecal collection period. These samples were ground, and analyzed for DM, CP, NDF, ADF, ADIN and indigestible ADF. On d 20, steers were fitted with fecal harnesses and bags. Bags were emptied and weighed once daily, and 5.0% subsamples were taken from each collection, weighed, dried, reweighed for DM, and composited by steer. On d 27, at 0700 h (0 h.) 19 nylon bags (10.0 X 5.0 cm, pore size 53+.10 μm) containing 1 g samples of ground alfalfa hay (2 mm length) were placed in the rumen of the supplemented steers within a weighted garment bag. At the same time each steer was dosed intraruminally with 1.0 g of Cr (prepared as Cr EDTA) in 100 ml of aqueous solution as a liquid dilution marker. Bags for 0 h were rinsed in water and subsequent bags removed at 3, 6, 9, 12, 18, and 24 h post feeding. Upon removal, all bags were

[1] Trace-mineralized salt contained not less than .35% Zn, .34% Fe, .2% Mn, .033% Cu, .007% I, and .005% Co.

immediately rinsed and frozen until analysis could be conducted. In situ rates of digestion and digestion lag times were calculated as described by Ørskov and McDonald (1979). Data was entered as a fraction of nutrient remaining versus time of incubation. Alfalfa supplement In Situ analysis was evaluated using a proc NLIN procedure and marquard model fit approach (SAS, 1991). Ruminal fluid was sampled on d 27 through the ruminal fistula by suction strainer just before dosing (0 h) and at 3, 6, 9, 12, 18, and 24 h after dosing. Approximately 10-ml portions of ruminal fluid from all sampling hours were frozen for subsequent CrEDTA analysis. The 0- through 24-h samples were analyzed immediately for pH using a portable pH meter with a combination electrode (Orion Research, Boston, MA), and proportions of ruminal fluid were acidified and frozen for VFA analysis (8 ml of ruminal fluid added to 2 ml of 25% metaphosphoric acid) and NH_3-N analysis (5 ml ruminal fluid added to 5 ml of .1 *N* HCL). On d 28 reticulo-rumen contents were evacuated manually and weighed 6 h post-feeding. Triplicate subsamples of mixed rumen contents were taken, weighed, dried and reweighed to calculate DM and liquid fill, composited by steer and analyzed for indigestible ADF (IADF).

Samples of alfalfa, meadow grass hay, orts, feces, and ruminal contents were dried at 60°C in a forced-air oven and ground to pass a 1-mm screen with a Wiley sample mill. Feed samples (alfalfa and meadow hay) collected during the fecal collection period were compiled across days. Orts and fecal samples were compiled across days for each steer. Ruminal digesta samples, previously collected in triplicate, were combined into a single sample for each steer.

Samples of the ground feed, orts, feces, and ruminal digesta were dried at 100°C for 24 h in a convection oven for DM determination and ashed at 500°C for 8 h in a muffle furnace for determination of OM concentration. Ground alfalfa and meadow hay were analyzed for DM and Kjeldahl N (AOAC, 1984). Acid detergent fiber and lignin were determined for diet samples and NDF for diet samples and feces using the procedures outlined by Goering and Van Soest, (1970). Acid detergent insoluble N (ADIN) was calculated by Kjeldahl N on the ADF residue (Goering and Van Soest, 1970). Indigestible acid detergent fiber (IADF) was determined (Cochran et al., 1986a) using a 144 h in vitro digestion to determine the indigestible component of all diets.

Ruminal fluid preserved for analysis of Cr, VFA, and NH_3-N was thawed and centrifuged at 10,000 x *g* for 15 min. before analyses. Ammonia N concentrations were determined using a combination electrode. Ruminal VFA analysis was performed using a fused silica capillary column (Alltech Associates, Inc., Deerfield, IL.) in a gas chromatography; Hewlett Packard Co[2] ., Analytical group, San Fernando, (CA). Cr EDTA analysis was analyzed using an atomic absorption spectrophotometer.

All data was analyzed by using the GLM program of SAS (1991). Intake, digestibility, in situ digestion, liquid and particulate kinetics were analyzed as a randomized complete block design with effects partitioned for treatment and block. Data collected at different times for each steer (fermentation characteristics) were analyzed as a split-plot design (Steel and Torrie, 1980). Because animals were fed individually, a steer was considered the experimental unit. Differences among treatments were evaluated using

[2] Mention of a trade name does not indicate endorsement by USDA or Oregon State University.

preplanned contrasts for 1) the control diets vs. supplemented diets and 2) low-quality alfalfa hay vs. high-quality alfalfa hay supplementation.

Experiment 2 - Cow performance trial:

Ninety-six gestating Hereford X Simmental cows (average initial BW = 546 kg; average initial body condition = 4.84 on a 1-to-9 scale) were stratified by age and body condition. Within stratum they were randomly assigned among four replicates of the three treatments in Exp. 1. Actual amounts of long stem alfalfa hay fed daily (DM basis) were 1) control, no supplement; 2) .45% BW; and 3) .55% BW. cow $^{-1} \cdot$ d $^{-1}$, respectively. Alfalfa hay supplements were weighed daily prior to feeding, and sampled weekly for feed analysis. Feed analysis was done using the daily feed samples. All cows shared one common pasture and were sorted into assigned treatment groups at 0900 h to be bunk fed their daily allotted supplement. Treatments were fed for an 84- d period from November 22, 1995 to February 14, 1996. Supplemented cows had to be group fed for a three day period from February 2 to February 5 due to excessive snow build up in the feeding pens. Alfalfa supplemented cows were group-fed in pens of 8 according to treatment. For the first 42 d period cows grazed on a 19.1 ha stock piled pasture (avg. prod. 4536 kg/ha). The meadow was dominated by tall fescue (*Festuca arundinacea)*, reed canary grass (*Phalaris arundinacea*), orchard grass (*Dactylis glomerta*), Kentucky blue grass (*Poa pratensis*), and downy brome (*Bromus tectorum*). Stocking rate during the 42-d period was 0.20 ha/cow. This would be considered a high stocking rate; however, forage availability was considered more than adequate. During the second 42-d period, cows had

Ad Libitum access to baled meadow grass hay, which was fed between 1500 and 1700 h, daily. This was the same source of low-quality meadow hay which was used in Exp. 1 (5.2% CP). Meadow hay was baled into round bales and core samples were taken weekly, composited and later analyzed for nutritive value. Cows had Ad Libitum access to trace-mineralized salt and water throughout the winter feeding period. Cows were weighed and scored for body condition (1-to-9 scale; Lemenager et al., 1991) independently by three observers on d 0, 42, and 84 of the feeding period. At 1600 h the day before each weigh/score date, the cows were gathered and placed in a corral away from feed and water overnight. The cows were then weighed and body condition scored at 1000 h the next day. Calving began February 13, 1996 and calves were weighed within 24 h of birth. Subsequent cow and calf weights were taken at the time of breeding and weaning. Cow conception rates were determined by rectal palpation.

Weight change, condition change, calving interval and calf birth weights were analyzed using the SAS (1991) GLM program. A randomized complete block design was used for analysis with feeding group as the experimental unit. Differences among treatments were evaluated using preplanned contrasts for 1) control diets vs. supplemented diets and 2) low-quality alfalfa vs. high-quality alfalfa supplementation. Experimental data for three cows were removed due to reasons deemed unrelated to experimental treatments (One cow with twins, one cow confirmed open and one cow with severe health problems).

Experiment 3 - Cow performance trial:

Ninety gestating Angus X Hereford cows (average BW = 475 kg; average initial body condition = 4.59) were stratified by age and body condition. Within stratum each was assigned to one of three supplemental treatments: 1) 16.1% CP alfalfa; 2) 17.8% CP alfalfa; 3) 20.0% CP alfalfa. The level of long stem alfalfa supplementation (DM basis) was .63%, .55% and .50% of BW. cow $^{-1} \cdot d^{-1}$, respectively, which provided isonitrogenous supplemental inputs. All cows shared one common pasture, and were sorted according to their assigned treatment daily between 0700 and 1000 h. Corresponding supplements were fed and adequate time allotted for complete consumption. Cows were then returned to the same pasture and offered Ad Libitum access to baled meadow grass hay (5.6% CP). Core samples from the alfalfa supplements and basal diets were later composited according to feed type, and used for feed analysis. Cows had Ad Libitum access to water and trace mineralized salt throughout the study. Treatment supplements were fed for an 84-d period from December 2, 1993 to February 24, 1994. Cows were weighed and scored for body condition independently by two observers on d 0, 42, and 84 of the feeding period. Feed and water were withheld for 18 h prior to each weigh/score date.

Weight change, condition change, calving interval and calf birth weights were analyzed using the SAS (1991) GLM program. A completely randomized design was used for analysis, with individual cow as the experimental unit. Differences among treatments

were evaluated using linear and quadratic orthogonal contrasts. Pregnancy rate was analyzed using CATMOD procedures of SAS (1991).

Results and Discussion:

Experiment 1 - Digestion Study:

Intake and Digestibility. Total DMI increased by 18 and 30 % ($P < .01$) for low and high-quality alfalfa supplemented steers, compared to controls (Table 2.4). However, there was no difference ($P > .10$) in DMI between steers receiving 18.8% CP high-quality alfalfa supplement (AHS) versus steers receiving 15.2% CP low-quality alfalfa supplement (ALS). Intake of meadow grass hay did not differ ($P > .10$) between treatments. Dry matter digestibility was 5 to 9% greater for supplemented steers than for the steers receiving only low-quality meadow hay ($P < .01$, Table 2.4). However, there was again no difference in DMD between steers receiving AHS and ALS supplements ($P > .10$). Likewise intake of total digestible nutrients (TDN) was 30% to 38% greater ($P < .01$) in favor of alfalfa supplemented steers. In Situ extent of alfalfa digestion was 3% greater ($P < .01$) for high-quality alfalfa (18.8% CP) than for low-quality alfalfa (15.2% CP, Table 2.4). However, this difference is statistically negligible and there was no difference ($P > .10$) in digestion lag time and 18-h extent of digestion. There was also no overall difference ($P > .10$), in NDF digestibility between supplemented and nonsupplemented treatments. However, when alfalfa supplements were compared, AHS had higher ($P < .05$) NDF digestibility than ALS.

The increase in total DMI is in agreement with numerous other researchers who have observed similar results with protein supplementation of low-quality roughages. DelCurto et al., (1990c) noted a twofold increase in total DMI when steers were supplemented with alfalfa or soybean-meal/sorghum grain based protein sources. Horney et al., (1992) noted a 13% increase in the DMI of steers fed tall fescue straw (4.1% CP) with alfalfa (20% CP). Comparable results to our study in TDN, were observed by Caton et al., (1988) when steers were supplemented with cottonseed meal while grazing dormant blue-gramma rangeland. Unlike our study where no difference in overall NDF digestibility was observed, research by Caton et al., (1988) reported that supplemented animals had higher NDF digestibility of the basal diet. However, Sunvold et al., (1991) reported no increase in NDF digestibility with protein supplementation on wheat middlings.

The improvements in DM intake and total diet digestion seem to be a function of digestibility, palatability and quantity of supplement fed. The lower levels of ADF and IADF for the alfalfa supplements suggest that alfalfa was less fibrous and more digestible than the meadow grass hay. Therefore when the alfalfa component was factored in at 20 - 25% of the daily roughage component a larger proportion would be found digestible, rather than meadow grass hay by itself. Improved palatability of the alfalfa supplements may also have stimulated increased intakes, which resulted in an additive effect on the meadow hay consumption.

Digesta Kinetics. There were no differences ($P > .10$) between treatments in ruminal DM and IADF fill at 6-h post feeding (Table 2.5). Liquid fill, liquid dilution and liquid flow

showed no difference (P > .10) between all treatments. However, outflow and passage rates of IADF tended to be faster (P < .10) for alfalfa supplemented steers as compared to control steers.

Previous research has indicated that protein supplementation of low-quality roughages increases rumen DM and IADF fill. DelCurto et al., (1990c) reported that protein supplemented steers displayed at least a 75% increase in these two components when compared to nonsupplemented steers receiving only low-quality tall grass prairie hay. DelCurto et al., (1990c) also reported ruminal volume was significantly increased with protein supplementation. McCollum and Galyean (1985) reported that cottonseed meal supplementation increased ruminal fluid passage in beef steers fed low-quality prairie hay. Such increases suggest that factors other than distention per se may play an important role in regulating the intake of very deficient forages. The increases noted in this experiment in IADF passage and outflow with protein supplementation are substantiated by previous research (Krysl et al., 1987; Sunvold et al., 1991). In the present study, little increase in ruminal volume DM and IADF fill were noted; however, this may be due to the higher quality of the basal diet used in our study when compared to basal diets used in previous studies (Sunvold et al., 1991; Vanzant and Cochran, 1994). Increases in IADF outflow and passage rates are most likely the result of decreased concentrations of IADF constituents in the diets of the supplemented steers.

Rumen Fermentation Characteristics. There was no sampling time x treatment interactions for ruminal pH (Table 2.6). However, pH tended (P < .10) to be lower in the

control steers as compared to the alfalfa supplemented steers. Supplementation of alfalfa had no affect ($P > .10$) on total VFA production (Table 6). Volatile fatty acid proportions displayed ($P < .01$) sampling time x treatment interaction for isobutyrate, isovalerate, and butyrate. However, the nature of the interaction did not preclude evaluating treatment x time due to significance of the main effects model. No treatment or sampling time x treatment interaction ($P > .10$) for acetate, propionate, and valerate was detected. Molar proportions of acetate, propionate, and (or) acetate:propionate were not affected by treatment ($P > .10$). Ruminal ammonia concentrations showed significant ($P < .01$) differences between supplemented and unsupplemented steers (Figure). Likewise there was a strong treatment x time interaction ($P < .01$). Ruminal ammonia levels between AHS and ALS were similar except at h 3 and 9 when there was a slight difference ($P < .10$). At 0 h supplemented steers had an average of 4.38 mg/dl of ammonia compared to .29 mg/dl with control steers ($P < .001$). Ammonia levels peaked 3 h post feeding, with supplemented steers having an average of 11.23 mg/dl of ammonia compared to 1.18 mg/dl with control steers. Supplemented steers maintained ($P < .01$) higher levels of ruminal ammonia throughout h 6, 9, 12, and 18.

The results in this study are contrary to many previous studies (Sunvold et al., 1991; Stokes et al., 1988) in which supplemented animals tended to have a lower average pH due to increased total VFA production. However, similar to our research, McCollum and Galyean (1985) and Hunt et al., (1988) showed that supplementation did not increase VFA production and (or) decrease ruminal pH. This may explain why we did not see a drop in the pH like, DelCurto et al., (1990c) and Sunvold et al., (1991) who both noted a

slight lowering of pH in protein supplemented steers. DelCurto et al., (1990c) attributed the lower pH to VFA production that was as much as 40% higher in supplemented compared to unsupplemented steers. Similar VFA results were observed by Vanzant and Cochran (1994). The increases in VFA production may be attributed to alfalfa supplements providing more substrate (proteins and amino acids) for production of branch-chain VFA (Sunvold et al., 1991). Ammonia concentrations in this study were similar to those reported by Guthrie and Wagner (1988) and Stokes et al., (1988). The higher ammonia concentrations may have raised ruminal pH, slightly which explains why pH was slightly lower in the nonsupplemented steers.

Finally it must be noted that many of the supplementation trials reported by DelCurto et al., (1990c) Sunvold et al., (1991) and Vanzant and Cochran. (1994) used lower quality roughages as the basal diet than that used in this experiment. Perhaps the difference in the quality of the basal diet may explain for the differences in rumen fermentation and VFA production observed in this study and those observed in other studies.

Experiment 2 - Cow performance trial:

The results of this performance study showed significant advantages of supplemental alfalfa on cow BW and BC (Table 2.7). Supplemented cows gained more BW ($P < .01$) over the 84-d supplement feeding period than nonsupplemented cows. Likewise, supplemented cows also had an average 8% ($P < .01$) advantage in final BC

score over the nonsupplemented treatment. In contrast, no difference ($P > .10$) between the low and high-quality alfalfa supplements for overall BW change and BC were observed. Body weight gains for all treatments were greatest for d 0 to 42 (Table 2.7). However, alfalfa supplemented cows still gained more than twice as much BW ($P < .01$) as compared to nonsupplemented cows. Increases in BC for control treatments were negligible for the first 42-d period; however, alfalfa supplemented cows increased in BC by more than .25 ($P < .01$). Body weight gain during d 43-84 was reduced in all treatments. However, alfalfa supplemented cows still had an average of 50% better BW gain ($P < .01$). All treatments experienced losses in BC during this period; however, alfalfa supplemented cows lost on average 35% less ($P < .01$) than control cows. Although alfalfa supplemented cows experienced less loss in BC than control cows, low-quality alfalfa supplemented cows lost more BC ($P < .05$), than high-quality alfalfa supplemented cows. Day 43-84 also coincided with an 8-d period of below average temperatures and above average precipitation. Postpartum BW at breeding (d 152) was greater ($P < .05$) for alfalfa supplemented cows than control cows (Table 2.7). However, BC only tended ($P < .10$) to be different between treatments.

Calving began February 13, 1996 and continued until March 25 th. March 1 was the average date of birth (Table 2.7). There was no treatment effect ($P > .10$) on date of birth. However, there was a strong relationship ($P < .01$) between supplementation and calf birth weight. Calves from the alfalfa supplemented treatments were on average 2.9 kg heavier than calves from the nonsupplemented treatment.

Cochran et al., (1986b), DelCurto et al., (1991), and Horney et al., (1992) have all reported similar results in BW and BC with protein supplementation of low-quality roughages. Cochran et al., (1986b) noted losses in BC and decreases in BW gain with cows during periods of severe weather. Severe weather conditions increase the maintenance energy requirements of cows (NRC, 1984) and, as reported earlier could, be the reason for decreases in these two parameters during d 43-84. The last 42-d of the feeding period also coincided with cows being removed from the stockpiled pasture (6.8% CP) and fed baled meadow grass hay (5.2% CP). Protein supplementation may not have as big an effect on BW and BC in situations where cattle are not able to be selective (Clanton and Zimmerman 1965). As parturition approaches, ruminal capacity decreases (Vanzant et al., 1991; Stanley et al., 1993) which potentially reduces the supplementation effect of maximizing forage DM intake. This may be another reason for greater condition loss during the last 42-d period. Postpartum BW and BC seem to be a function of prepartum BW and BC (DelCurto et al., 1990b). This explains why alfalfa supplemented cows still had an advantage in BW and BC over nonsupplemented cows at the time of breeding. The results on calf birth weights are comparable to results observed by Clanton and Zimmerman, (1965) in which supplemented cows consistently had higher birth weights than nonsupplemented cows.

Experiment 3 - Cow performance trial:

Over the 84-d feeding period cow BW was influenced quadratically ($P < .05$) by the quality of supplemental alfalfa (Table 2.8). Cows supplemented with 18% CP alfalfa

had the highest BW gain. Likewise cow BC was also affected quadratically ($P < .10$) and again the 18% CP alfalfa had the greatest gain (Table 2.8). Increases in cow BW were greatest for d 0-42 ($P < .05$), but no differences ($P > .10$) in cow body condition were noted. However, d 43-84 showed quadratic changes in cow body condition ($P < .01$) and no difference in cow BW ($P > .10$). No differences ($P > .10$) between treatment groups for both date of calving (avg. = April 1) and birth weight (39.6 kg) were detected (Table 2.8). Cow BW gain prior to breeding tended to display a slight quadratic effect ($P = .12$); however, the BW differences were negligible. Cow BW at weaning (d 295) was less than cow BW at d 0, due to poor summer range production. No linear ($P > .10$) or quadratic ($P > .10$) interactions were detected for final BW and BC. Subsequent conception rates for treatments showed supplementation effects ($P < .05$). However, the magnitude in body weight and condition differences during the winter feeding period do not fully explain this observation.

Results in this study are in general agreement with previous studies, although subtle differences do exist. Vanzant and Cochran (1994) found that cow BW increased linearly with increased alfalfa supplementation. However, others have compared the effects of prepartum nutritional status on postpartum performance and have found compensatory changes in weight (Clanton and Zimmerman, 1965; DelCurto et al., 1990a) by cows that were nutritionally restricted during the prepartum period. However, cows in this study did not appear to be nutritionally restricted, and for that reason there were few treatment effects on body weight. Subsequent weight change from 187 d to trial termination was unaffected ($P > .10$) by previous nutritional treatment.

The success of any beef operation is reliant on maximizing cattle production and minimizing input costs. Previous research by Clanton and Zimmerman (1965) has proven that poor nutritional status of beef cows leads to lower conception rates, longer time periods to first estrus, and reduced calf crops at the time of weaning. Protein supplementation of low-quality roughages can have a tremendous impact on cow BW and body condition score. Evaluation of previous research (Cochran et al., 1986b; DelCurto et al., 1990b) using different protein supplements in comparison to alfalfa, indicate similar winter performance could be realized for less cost using long stem alfalfa hay. However, the cost of alfalfa varies according to quality. In this study 16% to 18% CP alfalfa performed as well as high-quality alfalfa (20% CP) when fed on an isonitrogenous basis. When the alfalfas used in this study were compared on an economic basis, mid- to low-quality alfalfa appeared the most cost effective (Table 2.9).

Implications:

All three supplementation experiments suggest that alfalfa hay is an effective protein supplement to low-quality roughages. Alfalfa supplementation increased forage DM intake, digestibility and ruminal ammonia levels. Improvements in intake and digestibility of low-quality roughages led to increased cow BW and body condition when compared to unsupplemented cows. However, quality of alfalfa did not dramatically effect BW and (or) body condition changes when fed on an isonitrogenous basis.

Table 2.1. Chemical composition of feeds in Experiment 1.

	Meadow grass hay	Low-quality alfalfa hay	High-quality alfalfa hay
CP, %	5.2	15.2	18.8
ADIN, % of total N	28.7	29.5	25.3
ADF, %	38.8	45.1	40.2
NDF, %	60.5	31.9	29.7
IADF[a], %	19.2	15.0	13.7

[a] Indigestible ADF; based on a 144 h in vitro followed by ADF extraction.

Table 2.2. Chemical composition of feeds in Experiment 2.

	Stockpiled meadow	Meadow grass hay	Low-quality alfalfa hay	High-quality alfalfa hay
CP, %	6.8	5.2	17.1	19.9
ADIN, % of total N	33.4	28.7	29.5	25.3
ADF, %	67.2	38.8	37.7	38.3
NDF, %	43.0	60.5	27.7	28.0
IADF[a], %	23.0	19.2	15.0	15.2

[a] Indigestible ADF; based on a 144 h in vitro followed by ADF extraction.

Table 2.3. Chemical composition of feeds in Experiment 3.

	Meadow grass hay	Low-quality alfalfa hay	Mid-quality alfalfa hay	High-quality alfalfa hay
DM, %	96.4	96.9	95.0	93.4
CP, %	5.6	16.1	17.8	20.0
ADF, %	36.4	36.2	32.3	29.8
NDF, %	59.2	48.7	42.8	41.4

Table 2.4. Effects of low-quality versus high-quality alfalfa hay supplementation on intake and digestibility of beef steers consuming low-quality roughages, Exp. 1.

	Treatments				Contrasts	
	Alfalfa quality					
	Control	Low	High	SE[a]	Supplement vs. non-supple.	Low-quality vs. high-quality
No. of animals	5	5	5			
DMI, kg/day						
Total DMI	4.61	5.45	6.00	.31	.0174	.2369
Meadow DMI	4.61	4.07	4.87	.31	.8925	.0615
Supp DMI	-	1.38	1.13	-	-	-
DMI, %BW						
Total DMI	1.85	2.18	2.41	.12	.0156	.1898
Meadow DMI	1.85	1.63	1.96	.12	.8602	.0479
Supp DMI	-	.55	.45	-	-	-
TDN[b] (kg/day)	2.36	3.07	3.28	.18	.0058	.4355
DMD[c], %	51.8	56.4	54.6	.87	.0081	.1685
NDF dig, %	47.5	47.6	52.0	1.03	.1005	.0159
Supplement in situ digestion kinetics:						
Lag, h	-	.59	.65	.03	-	.2458
Rate, %/h	-	12.4	10.5	1.10	-	.2943
18h Extent, %	-	66.4	68.7	.38	-	.0119

[a] SE = Standard error of the means
[b] Total digestible nutrients TDN
[c] Apparent DM digestibility

Table 2.5. Effects of low-quality alfalfa versus high-quality hay supplementation on digesta kinetics of beef steers consuming low-quality roughages, Exp. 1.

	Treatments				Contrasts	
		Alfalfa quality				
	Control	Low	High	SE[a]	Supple. vs. non-supple.	Low-quality vs. high-quality
No. of animals	5	5	5			
DM fill (kg)						
5 h	6.44	6.81	6.21	.53	.9131	.4470
Liquid volume(l)						
5 h	55.42	50.86	55.49	4.20	.6752	.4586
IADF[b] fill (kg)						
5 h	4.16	3.95	4.23	.30	..8538	.5340
IADF passage, %/h						
5 h	2.22	2.51	2.53	.14	.1167	.9211
IADF outflow, g/h	41.6	44.88	47.4	.20	.1041	.3769

[a]SE = Standard error of the means
[b]Indigestable ADF

Table 2.6 Effects of low-quality alfalfa versus high-quality alfalfa hay supplementation on ruminal fermentation characteristics of beef steers consuming low-quality roughages, Exp. 1.

	Treatments				Contrasts	
		Alfalfa quality				
	Control	Low	High	SE[a]	Supplement vs. non-supple.	Low-quality vs. high-quality
No. of animals	5	5	5			
pH	6.46	6.53	6.54	.03	.0869	.8243
Total VFA, mM	78.7	78.0	80.8	2.01	.7879	.3443
Acet:Prop	4.21	4.13	3.98	.14	.3600	.4438
		...mol/100mol..				
Acetate	72.0	71.0	70.9	.59	.1715	.9125
Propionate	17.2	17.4	17.9	.49	.5103	.4368
Butyrate	9.3	9.5	9.2	.29	.8923	.4958
Valerate	.50	.95	.70	.16	.1338	.3061
Isobuterate	.50	.59	.63	.02	.0047	.2252
Isovalerate	.38	.56	.59	.03	.0003	.4388

[a] SE = Standard error of the means

Table 2.7 Influence of low-quality hay versus high-quality alfalfa hay supplementation on cow weight, condition changes, and calf birth weights, Exp. 2.

	Treatments				Contrasts	
		Alfalfa quality				
	Control	Low	High	SE[a]	Supplement vs. non-supple.	Low-quality vs. high-quality
No. of cows	32	32	32			
Initial						
Body weight, kg	539.0	534.2	533.5	2.1	-	-
Condition score	4.88	4.85	4.87	.08	-	-
d 0-42						
Weight change, kg	+17.3	+36.3	+30.5	2.9	.0038	.2105
C-score change	0.00	+.21	+.28	.07	.0310	.4978
d 43-84						
Weight change, kg	+12.4	+23.2	+26.3	2.7	.0093	.4514
C-score change	-.28	-.24	-.12	.03	.0219	.0152
d 0-84						
Weight change, kg	+29.7	+58.5	+56.8	2.5	.0001	.6608
C-score change	-.28	+.04	+.09	.08	.0154	.6816
d 0-152						
Weight change, kg	-7.5	+5.3	+1.9	3.3	.0347	.5025
C-score change	-.09	+.07	+.10	.07	.0800	.8133
Calf Birth Wt, kg[b]	39.41	41.75	42.91	.65	.0100	.2465
Calf Birth Date[c]	62.2	63.5	59.2	2.2	.2235	.7013

[a]SE = Standard error of the means
[b]Based on weight within 24h of birth.
[c]Julian days

Table 2.8 Influence of 16.1%, 17.8%, and 20.0% CP alfalfa hay supplementation on cow weight, body condition score changes, and calf birth weights, Exp. 3.

	Treatments				Contrasts	
	Alfalfa quality					
	16.1% CP	17.8% CP	20.0% CP	SE[a]	Linear	Quadratic
No. of cows	30	30	30			
Initial						
Body weight, kg	474.3	474.4	475.4	7.3	-	-
Condition score	4.53	4.54	4.79	.11	-	-
d 0-42						
Weight change, kg	+47.3	+53.6	+51.0	1.8	.1526	.0469
C-score change	+.14	0.0	+.08	.07	.6150	.2491
d 43-84						
Weight change, kg	+25.3	+26.1	+24.0	1.6	.5572	.4654
C-score change	-.01	+.31	+.04	.08	.6659	.0048
d 0-84						
Weight change, kg	+72.7	+79.7	+75.0	2.3	.4744	.0412
C-score change	+.13	+.31	+.13	.09	.9720	.0937
d 0-157						
Weight change, kg	+18.0	+13.8	+11.5	4.4	.3058	.1238
d 0-295						
Weight change, kg	-8.5	-6.2	-11.5	4.5	.6360	.5044
d-295						
Conception rate[d],%	83.3	100.0	92.3	4.2	-	-
Calf Birth Wt, kg[b]	40.7	39.1	38.9	.93	.1748	.5568
Calf Birth Date[c]	91.8	88.9	88.9	2.6	.4219	.6512

[a]SE = Standard error of the means
[b]Based on weight within 24h of birth.
[c]Julian days
[d] CATMOD procedure, SAS (1991)

Table 2.9 Comparative values, production and daily supplemental costs of alfalfa.

Alfalfa Description	% CP	Price $ / Tonne[a]	Average pro. kg/ha[b]	$/ha	$ / kg CP	kg required / day[c]	$ / day[d]
Pre Bloom	22%	$145	-	-	$0.66	2.5	$0.36
Early Bloom	20%	$130	3575 kg	$465	$0.65	2.75	$0.36
Mid Bloom	18%	$85	3508 kg	$298	$0.47	3.06	$0.26
Late Bloom	16%	$75	4220 kg	$317	$0.47	3.4	$0.26

[a] Prices courtesy of Pendelton Grain Growers, March 8, 1995.
[b] Production data: Eastern Oregon Agriculture Research Center, Burns Oregon.
[c] Based on a 500 kg cow in late trimester, provided at .55 kg supplemental CP.
[d] Cost based on maintaining isonitrogenous supplemental inputs.

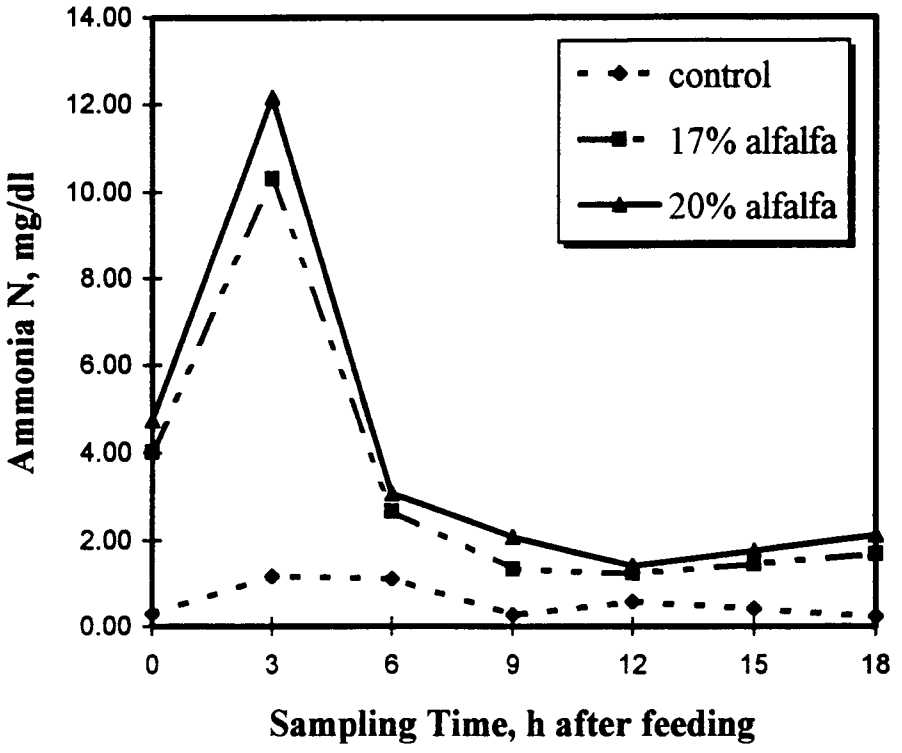

Figure. Influence of supplemental alfalfa hay on ruminal ammonia concentrations in beef steers consuming low-quality roughages. Control vs. alfalfa supplements differ ($P < .01$) for all sampling times. Low-quality versus high-quality alfalfa differ ($P < .10$) for 3 and 9 h after feeding. Standard errors within time periods ranged from .58 mg/dl to .23 mg/dl.

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APPENDIX

Table A.1. INITIAL & FINAL WEIGHTS OF STEERS IN (Exp. 1)[a].

Steer #	Treatment Description	Treatment #	Block	Start wt (kg)	Final wt (kg)
1	HQA	1	1	262	247
2	LQA	2	1	273	274
3	Control	3	1	271	264
4	HQA	1	2	261	258
5	LQA	2	2	261	256
6	Control	3	2	259	258
7	HQA	1	3	253	258
8	LQA	2	3	249	234
9	Control	3	3	253	246
10	HQA	1	4	237	235
11	LQA	2	4	240	237
12	Control	3	4	248	217
13	HQA	1	5	233	222
14	LQA	2	5	221	213
15	Control	3	5	234	222

[a] Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement. Average initial weight = 250 kg.

Table A.2. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON FORAGE AND TOTAL DM INTAKE (Exp. 1)[a].

Steer #	Blk	Trt	Fint 1 (lb/d)	Fint 2 (lb/d)	Tint 1 (lb/d)	Tint 2 (lb/d)	Intake % BW	DM Fecal output (lb/d)	Total DM digestibility (%)
1	1	1	10.2	9.9	12.6	12.4	2.19	5.84	52.21
2	1	2	12.0	12.8	15	15.8	2.50	6.81	56.87
3	1	3	11.9	12.3	11.9	12.4	2.00	6.32	48.37
4	2	1	11.8	10.9	14.3	13.4	2.49	5.95	55.35
5	2	2	9.1	13.1	12.1	15.1	2.11	6.36	57.34
6	2	3	8.4	10.3	8.4	10.3	1.47	4.63	55.09
7	3	1	11.2	10.8	13.7	13.3	2.46	5.94	55.19
8	3	2	9.5	9.5	12.5	12.5	2.28	5.78	53.70
9	3	3	10.8	10.8	10.8	10.8	1.94	5.67	47.52
10	4	1	10.7	10.3	13.2	12.8	2.53	5.59	56.21
11	4	2	7.5	8.5	10.5	11.5	1.99	4.94	56.95
12	4	3	8.3	10.4	8.3	10.4	1.52	4.65	55.19
13	5	1	11.4	9.6	12.2	12.1	2.38	5.59	53.60
14	5	2	6.8	9.7	9.8	12.7	2.61	5.39	57.38
15	5	3	11.2	11.9	11.2	11.9	2.31	5.71	52.61

[a] Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.3. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON DIGESTA KINETICS (Exp. 1)[a].

Steer #	Blk	Trt	Liquid Volume (l)	Liquid Dil. (%/h)	Liquid Flow (l/h)	DM Fill (kg)	Actual Liquid Fill (lb)	NDF Dige (%)	IADF Fill (kg)	IADF Outflow (g/h)	IADF Pass. (%/h)
1	1	1	50.68	10.32	5.23	5.08	94.0	44.8	3.68	42.7	2.6
2	1	2	33.14	19.04	6.31	7.63	113.0	51.3	4.79	55.5	2.5
3	1	3	60.71	11.03	6.70	7.70	103.3	45.2	5.07	46.4	2.0
4	2	1	63.13	9.69	6.12	7.48	114.2	47.5	4.23	51.4	2.7
5	2	2	63.69	9.40	5.99	7.46	125.8	54.8	4.69	52.7	2.5
6	2	3	46.10	11.22	5.17	5.78	99.0	49.9	3.97	38.7	2.1
7	3	1	54.45	10.26	5.59	7.55	122.7	48.7	4.95	46.4	2.1
8	3	2	50.15	12.33	6.18	5.56	90.4	46.5	3.71	44.5	2.6
9	3	3	60.58	9.34	5.66	6.55	108.1	42.4	4.12	40.9	2.2
10	4	1	63.98	9.25	5.92	5.55	96.7	48.9	3.75	43.2	2.5
11	4	2	65.75	7.76	5.10	7.52	114.1	53.3	4.73	40.5	1.9
12	4	3	55.95	8.82	4.94	5.33	93.6	51.7	3.41	38.2	2.5
13	5	1	45.22	12.23	5.53	5.40	84.5	48.0	3.16	40.9	2.8
14	5	2	41.59	14.08	5.86	5.90	94.5	54.3	3.23	44.1	3.0
15	5	3	53.74	11.64	6.25	6.83	114.0	48.1	4.24	44.5	2.3

[a] Rumen evacuations were conducted 5 h after feeding. Liquid flow was based on Cr EDTA estimates of liquid volume.

Table A.4. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON RUMEN FERMENTATION CHARACTERISTICS (Exp. 1).

Steer				Volatile Fatty Acids (mM basis)						
#	Trt	hr	Blk	acetate	propionate	butyrate	isobutyrate	isovalerate	valerate	TVFA
1	1	0	1	47.248	12.159	4.560	0.579	0.574	0.361	65.481
1	1	3	1	53.116	15.580	6.222	0.599	0.631	0.616	76.764
1	1	6	1	56.538	16.295	7.994	0.588	0.384	0.689	82.488
1	1	9	1	60.134	16.418	7.961	0.527	0.352	0.569	85.961
1	1	12	1	60.740	17.323	8.731	0.518	0.361	0.628	88.301
1	1	18	1	53.774	14.189	6.626	0.537	0.456	0.520	76.102
2	2	0	1	50.309	10.475	5.690	0.487	0.588	0.383	67.932
2	2	3	1	65.943	16.818	7.943	0.660	0.722	0.927	93.013
2	2	6	1	58.213	13.810	7.311	0.515	0.459	0.602	80.910
2	2	9	1	58.709	14.582	8.503	0.487	0.447	0.542	83.270
2	2	12	1	52.986	12.631	7.525	0.442	0.435	0.439	74.458
2	2	18	1	45.259	10.005	5.786	0.407	0.431	0.341	62.229
3	3	0	1	52.794	11.957	4.860	0.434	0.314	0.282	70.641
3	3	3	1	55.739	15.496	8.028	0.400	0.472	0.441	80.576
3	3	6	1	58.518	15.508	8.853	0.430	0.554	0.432	84.295
3	3	9	1	63.323	15.364	8.771	0.473	0.326	0.426	88.683
3	3	12	1	67.160	17.620	11.061	0.463	0.310	0.524	97.138
3	3	18	1	57.568	11.296	7.160	0.323	0.250	0.344	76.941
4	1	0	2	51.654	11.994	4.987	0.533	0.546	0.383	70.097
4	1	3	2	56.759	16.097	6.599	0.626	0.619	0.780	81.480
4	1	6	2	63.121	15.796	7.383	0.494	0.351	0.622	87.767
4	1	9	2	73.875	17.272	8.208	0.532	0.429	0.638	100.95
4	1	12	2	61.003	15.418	7.948	0.455	0.431	0.562	85.817
4	1	18	2	67.397	16.384	8.606	0.536	0.463	0.595	93.981
5	2	0	2	55.721	11.246	5.478	0.427	0.510	0.309	73.691
5	2	3	2	67.243	17.074	8.141	0.540	0.502	0.779	94.279
5	2	6	2	58.588	13.632	7.127	0.378	0.286	0.572	80.583
5	2	9	2	56.048	12.603	7.034	0.403	0.311	0.422	76.821
5	2	12	2	54.897	12.827	7.521	0.393	0.449	0.396	76.483
5	2	18	2	53.883	11.194	6.182	0.395	0.303	0.325	72.282

[a] Samples were obtained at 0, 3, 6, 9, 12 and 18 h post-feeding. Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.4 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON RUMEN FERMENTATION CHARACTERISTICS (Exp. 1)[a].

Steer				Volatile Fatty Acids (mM basis)						
#	Trt	hr	Blk	acetate	propionate	butyrate	isobutyrate	isovalerate	valerate	TVFA
6	3	0	2	54.297	12.041	5.135	0.388	0.394	0.344	72.599
6	3	3	2	57.406	15.902	7.859	0.406	0.282	0.531	82.386
6	3	6	2	57.797	15.969	8.933	0.349	0.210	0.519	83.777
6	3	9	2	58.033	13.031	7.027	0.427	0.327	0.421	79.266
6	3	12	2	63.250	14.778	8.898	0.432	0.349	0.457	88.164
6	3	18	2	52.510	10.581	5.638	0.376	0.308	0.306	69.719
7	1	0	3	55.133	12.793	5.846	0.630	0.694	0.491	75.587
7	1	3	3	71.864	19.168	8.523	0.754	0.795	0.883	101.98
7	1	6	3	55.452	14.195	7.845	0.444	0.355	0.615	78.906
7	1	9	3	60.183	14.147	7.611	0.458	0.399	0.518	83.316
7	1	12	3	71.292	16.482	8.635	0.529	0.517	0.600	98.055
7	1	18	3	57.517	12.772	6.287	0.567	0.628	0.483	78.254
8	2	0	3	40.126	8.326	5.425	0.390	0.377	0.323	54.967
8	2	3	3	53.874	15.741	7.689	0.416	0.471	7.596	85.787
8	2	6	3	57.913	15.206	9.607	0.373	0.234	0.758	84.091
8	2	9	3	69.905	16.057	10.261	0.422	0.342	0.693	97.680
8	2	12	3	55.914	13.395	8.933	0.361	0.285	0.532	79.420
8	2	18	3	53.981	12.032	8.060	0.422	0.429	0.534	75.458
9	3	0	3	56.431	13.201	5.765	0.470	0.422	0.367	76.656
9	3	3	3	58.295	16.622	7.820	0.412	0.303	0.437	83.889
9	3	6	3	61.733	17.728	9.263	0.424	0.266	0.504	89.918
9	3	9	3	61.214	17.375	10.030	0.458	0.311	0.516	89.904
9	3	12	3	62.307	16.255	9.710	0.455	0.323	0.529	89.579
9	3	18	3	51.804	12.039	7.076	0.414	0.340	0.385	72.058
10	1	0	4	45.329	9.480	5.255	0.422	0.488	0.374	61.348
10	1	3	4	52.809	14.537	6.445	0.509	0.572	0.602	75.474
10	1	6	4	62.113	16.333	8.664	0.479	0.380	0.720	88.689
10	1	9	4	54.001	14.569	8.456	0.370	0.306	0.591	78.293
10	1	12	4	62.547	15.798	8.812	0.469	0.427	0.643	88.696
10	1	18	4	52.463	12.764	6.910	0.447	0.494	0.524	73.602

[a] Samples were obtained at 0, 3, 6, 9, 12 and 18 h post-feeding. Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.4 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON RUMEN FERMENTATION CHARACTERISTICS (Exp. 1)[a].

Steer				Volatile Fatty Acids (mM basis)						
#	Trt	hr	Blk	acetate	propionate	butyrate	isobutyrate	isovalerate	valerate	TVFA
11	2	0	4	41.138	8.400	4.437	0.610	0.645	0.337	55.567
11	2	3	4	36.429	10.345	4.205	0.317	0.354	0.372	52.022
11	2	6	4	54.961	15.116	8.465	0.434	0.310	0.632	79.918
11	2	9	4	55.670	14.268	8.452	0.430	0.286	0.570	79.676
11	2	12	4	56.087	13.422	7.929	0.435	0.326	0.523	78.722
11	2	18	4	55.984	12.082	6.445	0.529	0.478	0.252	75.770
12	3	0	4	55.627	11.368	5.108	0.450	0.357	0.285	73.195
12	3	3	4	54.946	14.238	6.630	0.415	0.279	0.402	76.910
12	3	6	4	58.278	14.048	7.063	0.395	0.229	0.387	80.400
12	3	9	4	52.473	11.900	6.054	0.333	0.182	0.338	71.280
12	3	12	4	55.047	12.473	6.561	0.375	0.247	0.333	75.036
12	3	18	4	55.132	12.452	6.550	0.373	0.263	0.370	75.140
13	1	0	5	43.918	9.390	6.183	0.528	0.535	0.355	60.909
13	1	3	5	51.914	14.464	7.384	0.465	0.535	0.599	75.361
13	1	6	5	53.727	14.173	9.064	0.432	0.281	0.651	78.328
13	1	9	5	53.046	13.253	8.918	0.390	0.266	0.503	76.376
13	1	12	5	55.890	13.726	9.186	0.392	0.320	0.552	80.066
13	1	18	5	54.469	12.770	8.134	0.468	0.434	0.493	76.768
14	2	0	5	50.105	12.260	5.807	0.603	0.654	0.492	69.921
14	2	3	5	56.038	18.995	7.925	0.528	0.595	0.724	84.805
14	2	6	5	59.954	17.064	9.264	0.438	0.331	0.835	87.886
14	2	9	5	64.016	16.739	9.360	0.510	0.405	0.729	91.759
14	2	12	5	60.402	17.533	10.225	0.450	0.323	0.721	89.654
14	2	18	5	56.721	14.382	7.745	0.453	0.416	0.556	80.273
15	3	0	5	51.920	10.914	5.831	0.367	0.283	0.284	69.599
15	3	3	5	46.990	11.094	6.339	0.305	0.203	0.325	65.256
15	3	6	5	55.465	12.175	7.316	0.340	0.222	0.352	75.870
15	3	9	5	58.009	12.888	8.065	0.398	0.246	0.368	79.974
15	3	12	5	54.316	12.147	7.733	0.335	0.201	0.351	75.083
15	3	18	5	49.385	10.487	7.014	0.330	0.216	0.318	67.750

[a] Samples were obtained at 0, 3, 6, 9, 12 and 18 h post-feeding. Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.5. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON RUMINAL pH AND AMMONIA CONCENTRATION (Exp. 1)[a].

Steer #	Trt	hr	Blk	ammonia	pH
1	1	0	1	4.88	6.38
1	1	3	1	13.60	6.78
1	1	6	1	3.08	6.19
1	1	9	1	2.80	6.67
1	1	12	1	1.32	6.67
1	1	18	1	1.82	6.78
2	2	0	1	3.43	6.32
2	2	3	1	11.70	6.70
2	2	6	1	1.86	6.26
2	2	9	1	1.34	6.59
2	2	12	1	1.24	6.77
2	2	18	1	1.53	6.90
3	3	0	1	0.14	6.36
3	3	3	1	1.20	6.69
3	3	6	1	1.55	6.15
3	3	9	1	0.22	6.74
3	3	12	1	0.40	6.43
3	3	18	1	0.14	6.69
4	1	0	2	2.75	6.34
4	1	3	2	10.60	6.75
4	1	6	2	3.15	6.19
4	1	9	2	1.38	6.62
4	1	12	2	1.88	6.60
4	1	18	2	1.67	6.75
5	2	0	2	0.84	6.21
5	2	3	2	6.60	6.63
5	2	6	2	1.13	6.18
5	2	9	2	0.51	6.75
5	2	12	2	0.18	6.67
5	2	18	2	0.10	6.77

[a] Samples were obtained at 0, 3, 6, 9, 12 and 18 h post-feeding. Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.5 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON RUMINAL pH AND AMMONIA CONCENTRATION (Exp. 1)[a].

Steer #	Trt	hr	Blk	ammonia	pH
6	3	0	2	0.24	6.21
6	3	3	2	1.82	6.46
6	3	6	2	0.57	5.87
6	3	9	2	0.15	6.25
6	3	12	2	0.19	6.48
6	3	18	2	0.13	6.75
7	1	0	3	5.72	6.26
7	1	3	3	13.50	6.82
7	1	6	3	1.58	6.10
7	1	9	3	1.08	6.63
7	1	12	3	0.58	6.37
7	1	18	3	2.64	6.72
8	2	0	3	4.70	6.45
8	2	3	3	12.00	6.63
8	2	6	3	3.45	6.09
8	2	9	3	1.60	6.48
8	2	12	3	1.86	6.65
8	2	18	3	2.10	6.81
9	3	0	3	0.28	6.31
9	3	3	3	1.15	6.66
9	3	6	3	3.00	5.91
9	3	9	3	0.42	6.35
9	3	12	3	0.41	6.50
9	3	18	3	0.38	6.72
10	1	0	4	4.45	6.39
10	1	3	4	11.80	6.72
10	1	6	4	4.15	6.17
10	1	9	4	2.73	6.52
10	1	12	4	1.73	6.56
10	1	18	4	1.64	6.78

[a] Samples were obtained at 0, 3, 6, 9, 12 and 18 h post-feeding. Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.5 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON RUMINAL pH AND AMMONIA CONCENTRATION (Exp. 1)[a].

Steer #	Trt	hr	Blk	ammonia	pH
11	2	0	4	6.93	6.55
11	2	3	4	10.50	6.71
11	2	6	4	4.43	6.07
11	2	9	4	1.84	6.53
11	2	12	4	1.58	6.64
11	2	18	4	3.21	6.79
12	3	0	4	0.58	6.20
12	3	3	4	0.64	6.57
12	3	6	4	0.17	6.05
12	3	9	4	0.13	6.54
12	3	12	4	1.57	6.63
12	3	18	4	0.22	6.65
13	1	0	5	5.97	6.41
13	1	3	5	11.30	6.85
13	1	6	5	3.37	6.14
13	1	9	5	2.34	6.69
13	1	12	5	1.56	6.56
13	1	18	5	2.84	6.68
14	2	0	5	4.16	6.38
14	2	3	5	10.70	6.48
14	2	6	5	2.47	5.98
14	2	9	5	1.40	6.56
14	2	12	5	1.30	6.47
14	2	18	5	1.51	6.77
15	3	0	5	0.24	6.25
15	3	3	5	1.08	6.76
15	3	6	5	0.28	6.22
15	3	9	5	0.40	6.82
15	3	12	5	0.33	6.70
15	3	18	5	0.34	6.81

[a] Samples were obtained at 0, 3, 6, 9, 12 and 18 h post-feeding. Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement; 2) low-quality alfalfa (LQA; 15.2% CP) supplement; and 3) control, no supplement.

Table A.6. IN SITU DEGRADATION OF ALFALFA SUPPLEMENTS (Exp. 1)[a].

Steer #	Trt	Blk	hr	Extent of Digestion (%)
1	1	1	0	10.5%
1	1	1	3	29.0%
1	1	1	6	47.6%
1	1	1	9	51.7%
1	1	1	12	65.1%
1	1	1	18	71.1%
2	2	1	0	16.0%
2	2	1	3	31.4%
2	2	1	6	45.4%
2	2	1	9	58.1%
2	2	1	12	62.1%
2	2	1	18	69.1%
4	1	2	0	9.2%
4	1	2	3	25.4%
4	1	2	6	40.1%
4	1	2	9	53.4%
4	1	2	12	60.2%
4	1	2	18	69.9%
5	2	2	0	12.0%
5	2	2	3	29.7%
5	2	2	6	39.0%
5	2	2	9	50.7%
5	2	2	12	58.8%
5	2	2	18	67.2%
7	1	3	0	15.0%
7	1	3	3	21.5%
7	1	3	6	36.3%
7	1	3	9	42.4%
7	1	3	12	55.7%
7	1	3	18	65.7%
8	2	3	0	14.0%
8	2	3	3	29.0%
8	2	3	6	43.6%
8	2	3	9	54.7%
8	2	3	12	56.2%
8	2	3	18	63.9%

[a] Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement and 2) low-quality alfalfa (LQA; 15.2% CP) supplement.

Table A.6 (Continued). IN SITU DEGRADATION OF ALFALFA SUPPLEMENTS (Exp. 1)[a].

Steer #	Trt	Blk	hr	Extent of Digestion (%)
10	1	4	0	18.4%
10	1	4	3	34.8%
10	1	4	6	50.1%
10	1	4	9	59.2%
10	1	4	12	53.2%
10	1	4	18	69.4%
11	2	4	0	14.9%
11	2	4	3	28.7%
11	2	4	6	42.4%
11	2	4	9	43.0%
11	2	4	12	51.3%
11	2	4	18	65.1%
13	1	5	0	15.8%
13	1	5	3	27.9%
13	1	5	6	39.1%
13	1	5	9	51.5%
13	1	5	12	59.8%
13	1	5	18	67.6%
14	2	5	0	14.0%
14	2	5	3	29.2%
14	2	5	6	41.9%
14	2	5	9	53.3%
14	2	5	12	58.2%
14	2	5	18	66.5%

[a] Treatments supplements consisted of: 1) high-quality alfalfa (HQA; 18.8% CP) supplement and 2) low-quality alfalfa (LQA; 15.2% CP) supplement.

Table. A.7 THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW WEIGHTS (Exp. 2).

			Beef Cow Weights (lbs)			
Trt	Blk	Cow#	d 0	d 42	d 84	d 149
Control	1	1009	1095	1195	1200	1089
Control	1	1073	1135	1195	1260	1175
Control	1	2016	1130	1125	1130	1087
Control	1	6160	1335	1335	1380	1333
Control	1	7175	1190	1230	1200	1107
Control	1	9153	1095	1125	1190	1085
Control	1	0109	1250	1280	1285	1275
Control	1	0142	1180	1220	1230	1162
Control	2	1057	1000	1135	1170	1055
Control	2	2079	1160	1160	1195	1105
Control	2	2083	1145	1090	1115	1042
Control	2	6089	1105	1140	1205	1075
Control	2	7177	1290	1270	1330	1245
Control	2	8062	1195	1250	1300	1230
Control	2	9086	1418	1470	1440	1360
Control	3	1116	1200	1280	1300	1210
Control	3	1159	1235	1310	1335	1290
Control	3	2013	1105	1165	1200	1090
Control	3	2061	1115	1200	1160	1063
Control	3	8066	1205	1220	1260	1210
Control	3	9078	1190	1250	1305	.
Control	3	9189	1330	1415	1420	1305
Control	3	0196	1355	1400	1410	1304
Control	4	2082	1145	1085	1070	1020
Control	4	5135	1255	1240	1295	1255
Control	4	6153	1145	1220	1220	1110
Control	4	7082	1315	1330	1400	1310
Control	4	8063	1315	1380	1420	1320
Control	4	8074	1195	1185	1260	1190
Control	4	0143	1005	1090	1130	1074
Control	4	024	1135	1165	1180	1114

[a] Beef cow weights were determined after a 18 h overnight fast. Treatments supplements consisted of: 1)control, no supplement; 2)high-quality alfalfa (HQA; 19.9% CP) supplement; and 3)low-quality alfalfa (LQA; 17.1% CP) supplement.

Table A.7 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW WEIGHTS (Exp. 2)[a].

			Beef Cow Weights (lbs)			
Trt	Blk	Cow#	d 0	d 42	d 84	d 149
HQA	1	1190	1130	1195	1270	1136
HQA	1	2035	1015	1135	1185	1088
HQA	1	7084	1085	1185	1170	1079
HQA	1	7140	1205	1240	1300	1150
HQA	1	7187	1285	1380	1490	1285
HQA	1	8116	1250	1325	1400	1267
HQA	1	8123	1250	1265	1365	1220
HQA	2	1063	1090	1180	1240	1096
HQA	2	1067	1135	1225	1310	1210
HQA	2	2069	1115	1190	1245	1075
HQA	2	6158	1315	1360	1400	1220
HQA	2	8129	1155	1185	1125	1070
HQA	2	9044	1275	1365	1420	1336
HQA	2	9128	1125	1285	1300	1240
HQA	2	9177	1155	1205	1245	1225
HQA	3	1062	1120	1150	1225	1192
HQA	3	1098	1270	1365	1435	1330
HQA	3	2060	1000	1110	1165	998
HQA	3	6161	1160	1285	1345	1210
HQA	3	7091	1170	1250	1300	1162
HQA	3	8085	1335	1405	1475	1368
HQA	3	9127	1280	1325	1405	1266
HQA	3	061	1115	1200	1290	1165
HQA	4	1008	1095	1110	1185	1052
HQA	4	2020	1150	1215	1280	1165
HQA	4	2141	1130	1160	1150	1076
HQA	4	5078	1285	1330	1405	1310
HQA	4	5132	1255	1275	1385	1156
HQA	4	5133	1215	1300	1360	1180
HQA	4	7200	1115	1160	1230	1115

[a] Beef cow weights were determined after a 18 h overnight fast. Treatments supplements consisted of: 1)control, no supplement; 2)high-quality alfalfa (HQA; 19.9% CP) supplement; and 3)low-quality alfalfa (LQA; 17.1% CP) supplement.

Table A.7 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW WEIGHTS (Exp. 2)[a].

			Beef Cow Weights (lbs)			
Trt	Blk	Cow#	d 0	d 42	d 84	d 149
LQA	1	1011	1185	1200	1265	1104
LQA	1	2164	1115	1230	1270	1170
LQA	1	6137	1220	1325	1355	1200
LQA	1	7158	1305	1400	1490	1365
LQA	1	7193	1300	1350	1400	.
LQA	1	0132	1020	1075	1135	995
LQA	1	021	1090	1190	1215	1075
LQA	1	032	1155	1245	1320	1148
LQA	2	1066	1245	1370	1455	1285
LQA	2	1167	995	.	1045	967
LQA	2	1176	1145	1200	1265	1195
LQA	2	2014	1195	1320	1350	1235
LQA	2	2022	1130	1155	1220	1089
LQA	2	6057	1310	1415	1450	1310
LQA	2	7132	1115	1195	1240	1190
LQA	2	9132	1150	1210	.	1156
LQA	3	6033	1145	1240	1265	1133
LQA	3	7151	1115	1190	1225	1130
LQA	3	7213	1165	1250	1290	1190
LQA	3	9049	1145	1210	1305	1165
LQA	3	9065	1130	1220	1290	1210
LQA	3	9073	1075	1155	1220	1090
LQA	3	9116	1290	1360	1350	1317
LQA	3	9146	1385	1440	1505	1425
LQA	4	1075	1140	1200	1265	1160
LQA	4	1172	1010	1170	1105	985
LQA	4	2029	1160	1255	1355	1235
LQA	4	6026	1345	1430	1460	1375
LQA	4	7130	1240	1275	1330	1170
LQA	4	9136	1195	1330	1360	1245
LQA	4	016	1105	1145	1220	1036
LQA	4	018	1285	1335	1425	1330

[a] Beef cow weights were determined after a 18 h overnight fast. Treatments supplements consisted of: 1)control, no supplement; 2)high-quality alfalfa (HQA; 19.9% CP) supplement; and 3)low-quality alfalfa (LQA; 17.1% CP) supplement.

Table A.8. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY CONDITION AND CALF BIRTH WEIGHTS (Exp. 2)[a].

			Beef Cow Body Condition					
Trt	Blk	Cow#	d 0	d 42	d 84	d 149	Birth Date	Birth Wt. (lb)
Control	1	1009		4.67	3.67	4.70	53	93
Control	1	1073	4.67	4.33	4.33	4.80	72	92
Control	1	2016	5.00	4.83	5.00	5.00	46	79
Control	1	6160	5.00	5.00	4.67	5.00	74	73
Control	1	7175	5.33	4.17	3.83	4.80	47	66
Control	1	9153	4.33	4.50	4.00	4.50	69	78
Control	1	0109	4.83	4.50	4.67	4.70	50	82
Control	1	0142	4.83	4.50	4.17	4.50	51	95
Control	2	1057	4.67	4.50	4.50	4.70	67	96
Control	2	2079	5.00	5.33	4.83	4.80	51	90
Control	2	2083	4.83	4.67	4.17	4.80	52	79
Control	2	6089	4.83	5.00	5.00	5.00	48	77
Control	2	7177	5.33	5.17	5.00	5.00	57	79
Control	2	8062	5.17	5.67	5.17	5.00	84	89
Control	2	9086	6.00	5.17	5.00	5.00	48	93
Control	3	1116	4.17	4.17	3.50	4.70	46	87
Control	3	1159	4.67	5.00	4.33	5.00	74	91
Control	3	2013	4.83	4.67	4.83	5.00	54	80
Control	3	2061	4.67	4.83	6.67	4.20	52	84
Control	3	8066	5.00	5.33	4.17	4.70	57	72
Control	3	9078	5.33	5.33	5.00	.	73	102
Control	3	9189	4.33	5.17	4.50	4.80	53	97
Control	3	0196	5.33	6.00	5.17	5.00	74	101
Control	4	2082	4.67	4.50	4.83	4.70	75	90
Control	4	5135	4.67	4.50	4.33	4.70	50	89
Control	4	6153	5.00	5.00	4.83	5.00	71	90
Control	4	7082	4.83	5.00	4.83	5.00	56	94
Control	4	8063	4.83	4.83	4.50	5.00	59	117
Control	4	8074	5.00	5.17	4.83	4.80	51	69
Control	4	0143	5.00	4.67	4.50	4.00	74	84
Control	4	024	4.33	4.83	3.50	4.00	47	80

[a] Beef cow body condition was determined using a 9-point scale(1 = extreme emaciated, 9 = extremely obese) after a 18 h overnight fast. Treatments supplements consisted of: 1)control, no supplement; 2)high-quality alfalfa (HQA; 19.9% CP) supplement; and 3)low-quality alfalfa (LQA; 17.1% CP) supplement.

Table A.8 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY CONDITION AND CALF BIRTH WEIGHTS (Exp. 2)[a].

			Beef Cow Body Condition					
Trt	Blk	Cow#	d 0	d 42	d 84	d 149	Birth Date	Birth Wt. (lb)
HQA	1	1190	4.83	5.17	5.17	5.20	71	91
HQA	1	2035	4.17	4.17	4.00	4.50	48	82
HQA	1	7084	5.83	5.67	5.33	5.70	51	92
HQA	1	7140	5.17	5.17	5.00	4.80	57	110
HQA	1	7187	4.33	5.00	5.00	5.20	50	81
HQA	1	8116	5.17	5.67	5.83	5.80	74	94
HQA	1	8123	5.50	6.00	5.83	5.20	61	109
HQA	2	1063	4.67	4.33	4.50	4.80	48	95
HQA	2	1067	4.67	4.83	4.67	5.00	67	89
HQA	2	2069	4.83	4.17	4.83	4.70	47	87
HQA	2	6158	5.67	5.67	5.00	5.00	84	100
HQA	2	8129	5.00	5.00	5.00	5.20	51	93
HQA	2	9044	5.33	6.00	5.50	5.20	78	101
HQA	2	9128	5.17	5.33	5.00	5.00	52	105
HQA	2	9177	5.00	5.00	5.17	5.20	52	75
HQA	3	1062	5.17	6.00	5.67	5.30	81	98
HQA	3	1098	4.50	4.83	4.83	4.80	49	78
HQA	3	2060	4.67	4.83	5.00	4.70	78	93
HQA	3	6161	4.67	5.00	5.00	4.80	84	95
HQA	3	7091	4.83	5.17	5.00	4.70	61	78
HQA	3	8085	4.50	4.50	4.50	4.70	84	106
HQA	3	9127	4.33	4.67	4.33	4.50	51	91
HQA	3	061	5.17	6.00	5.17	5.20	66	88
HQA	4	1008	5.17	5.00	5.00	4.80	51	82
HQA	4	2020	4.67	5.00	5.00	5.00	65	91
HQA	4	2141	4.33	4.17	4.17	5.00	68	101
HQA	4	5078	4.50	5.00	4.83	4.50	51	72
HQA	4	5132	5.00	5.33	5.00	4.80	74	96
HQA	4	5133	5.00	5.00	5.00	5.00	57	99
HQA	4	7200	4.50	4.67	4.50	4.80	76	97

[a] Beef cow body condition was determined using a 9-point scale(1 = extreme emaciated, 9 = extremely obese) after a 18 h overnight fast. Treatments supplements consisted of: 1)control, no supplement; 2)high-quality alfalfa (HQA; 19.9% CP) supplement; and 3)low-quality alfalfa (LQA; 17.1% CP) supplement.

Table A.8 (Continued).THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY CONDITION AND CALF BIRTH WEIGHTS (Exp. 2)[a].

			Beef Cow Body Condition					
Trt	Blk	Cow#	d 0	d 42	d 84	d 149	Birth Date	Birth Wt. (lb)
LQA	1	1011	5.17	5.33	5.17	4.80	55	102
LQA	1	2164	4.33	5.17	4.67	4.70	53	109
LQA	1	6137	4.67	5.00	5.00	5.00	48	85
LQA	1	7158	5.17	5.67	5.50	5.00	56	93
LQA	1	7193	4.50	4.67	4.67	.	47	78
LQA	1	0132	4.67	4.50	4.67	4.30	50	85
LQA	1	021	5.83	6.00	5.83	5.00	57	103
LQA	1	032	5.00	5.50	5.33	5.00	77	117
LQA	2	1066	4.33	5.17	4.50	4.70	75	104
LQA	2	1167	4.83	.	4.83	4.80	53	84
LQA	2	1176	5.00	5.00	5.00	5.00	52	87
LQA	2	2014	4.17	4.33	4.83	4.80	53	96
LQA	2	2022	4.33	4.67	4.33	4.70	49	86
LQA	2	6057	5.33	5.83	4.83	5.00	54	101
LQA	2	7132	4.83	4.83	5.00	5.00	51	83
LQA	2	9132	4.83	5.00	.	5.00	44	105
LQA	3	6033	3.83	4.50	4.17	4.50	77	85
LQA	3	7151	5.83	6.00	5.00	5.00	75	87
LQA	3	7213	4.83	4.83	4.67	5.00	74	99
LQA	3	9049	4.67	5.00	5.00	4.80	73	99
LQA	3	9065	4.67	5.33	4.83	5.00	80	95
LQA	3	9073	5.00	5.17	5.00	5.00	74	91
LQA	3	9116	5.67	6.50	6.00	5.50	73	94
LQA	3	9146	5.67	6.17	5.83	6.20	73	82
LQA	4	1075	4.33	4.83	3.83	4.70	50	93
LQA	4	1172	5.00	4.83	4.33	5.00	50	85
LQA	4	2029	4.50	4.50	4.83	5.00	88	104
LQA	4	6026	4.83	4.83	4.33	4.50	88	93
LQA	4	7130	4.33	4.50	4.33	5.00	69	95
LQA	4	9136	5.33	5.67	5.17	5.70	51	97
LQA	4	016	5.00	5.17	5.33	4.70	48	78
LQA	4	018	4.67	4.50	4.67	4.70	74	126

[a]Beef cow body condition was determined using a 9-point scale(1 = extreme emaciated, 9 = extremely obese) after a 18 h overnight fast. Treatments supplements consisted of: 1)control, no supplement; 2)high-quality alfalfa (HQA; 19.9% CP) supplement; and 3)low-quality alfalfa (LQA; 17.1% CP) supplement.

Table A.9. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY WEIGHT (Exp. 3)[a].

		Cow Body Weight (lbs)				
TRT	Cow#	d 0	d 42	d 84	d 157	d 295
1	9	1036	1170	1210	1097	950
1	11	1044	1152	1198	.	.
1	42	1000	1084	1162	1003	970
1	46	1094	1230	1320	1197	1140
1	65	1006	1130	1180	.	.
1	73	980	1060	1104	1023	950
1	75	1092	1160	1236	1095	1010
1	81	1148	1226	1310	1189	1190
1	85	864	952	996	863	810
1	101	1064	1178	1198	1136	990
1	104	990	1108	1142	1079	1010
1	110	984	1080	1140	1070	980
1	125	970	1068	1088	929	840
1	287	1122	1250	1344	1185	1130
1	320	1180	1300	1362	1277	1210
1	342	1064	1172	1224	.	.
1	347	1000	1100	1142	1015	960
1	352	944	1030	1102	1063	980
1	355	912	1014	1074	930	920
1	364	952	1044	1094	1030	1010
1	365	1072	1188	1242	1080	1060
1	378	1006	1098	1136	990	930
1	385	964	1064	1120	.	.
1	390	1238	1384	1438	1286	1145
1	403	1076	1208	1244	1078	1050
1	431	1172	1260	1322	.	.
1	434	1046	1156	1234	1072	1050
1	435	1082	1182	1238	1097	1110
1	449	1160	1236	1300	1176	1170

[a] Beef cow weights were determined after a 18 h overnight fast. Treatments supplements consisted of: 1)low-quality alfalfa (16.1% CP) supplement; 2)mid-quality alfalfa (17.8% CP) supplement; and 3)high-quality alfalfa (20.0% CP) supplement.

Table A.9 (Continued).THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY WEIGHT (Exp. 3)[a].

		Cow Body Weight (lbs)				
TRT	Cow#	d 0	d 42	d 84	d 157	d 295
2	5	990	1108	1142	1065	940
2	39	946	1078	1142	.	.
2	44	1030	1146	1208	1037	970
2	56	1064	1212	1238	1100	1050
2	97	1060	1166	1242	1075	1030
2	99	1172	1238	1310	1258	1180
2	114	1112	1260	1322	1208	1040
2	118	890	962	1014	885	850
2	154	1036	1160	1198	1033	1010
2	159	1146	1226	1288	1269	1160
2	162	932	1044	1084	969	910
2	179	1026	1176	1200	1125	1100
2	291	1174	1298	1352	1213	1150
2	336	1040	1148	1222	1026	990
2	338	1056	1174	1280	.	.
2	341	1174	1290	1344	1208	1210
2	357	900	1030	1096	963	920
2	361	1108	1236	1300	1064	1070
2	379	1038	1148	1230	1080	1050
2	380	1070	1196	1256	.	.
2	383	1140	1278	1336	1153	1070
2	398	978	1078	1134	1009	1030
2	410	1152	1290	1342	1289	1140
2	428	1024	1140	1204	1116	1030
2	436	934	1058	1114	1160	1070
2	447	1162	1300	1356	1192	1100
2	455	926	1014	1078	928	820
2	458	946	1074	1104	1005	920

[a] Beef cow weights were determined after a 18 h overnight fast. Treatments supplements consisted of: 1)low-quality alfalfa (16.1% CP) supplement; 2)mid-quality alfalfa (17.8% CP) supplement; and 3)high-quality alfalfa (20.0% CP) supplement.

Table A.9 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY WEIGHT (Exp. 3)[a].

		Cow Body Weight (lbs)				
TRT	Cow#	d 0	d 42	d 84	d 157	d 295
3	14	960	1090	1140	967	960
3	17	1004	1110	1190	.	.
3	18	978	1126	1170	1075	980
3	23	938	1046	1130	973	895
3	32	990	1086	1120	972	910
3	82	1032	1142	1140	1108	1060
3	103	1078	1190	1254	1136	1120
3	117	1058	1192	1220	1064	1020
3	122	1090	1244	1312	.	.
3	132	982	1104	1150	1060	1020
3	157	908	1016	1070	950	920
3	185	1096	1184	1218	1108	1040
3	186	964	1028	1062	936	890
3	278	1148	1262	1314	1141	1080
3	333	1086	1224	1268	1098	1020
3	343	1116	1222	1302	1099	1040
3	372	1098	1196	1244	1116	1110
3	373	1270	1374	1440	1356	1270
3	377	1128	1184	1220	1060	980
3	387	914	1016	1058	960	880
3	388	1120	1250	1316	1189	1110
3	392	1008	1098	1152	970	930
3	395	964	1088	1162	1046	990
3	396	948	1052	1122	1014	980
3	401	1080	1216	1290	1180	1060
3	404	1080	1210	1270	1070	1080
3	419	1096	1210	1242	1064	1030
3	441	1040	1160	1216	1045	1060
3	454	1148	1248	1324	1155	1110

[a] Beef cow weights were determined after a 18 h overnight fast. Treatments supplements consisted of: 1)low-quality alfalfa (16.1% CP) supplement; 2)mid-quality alfalfa (17.8% CP) supplement; and 3)high-quality alfalfa (20.0% CP) supplement.

Table A.10. THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY CONDITION AND SUBSEQUENT CALF WEIGHTS AND PREGNANCY RATES (Exp. 3)[a].

		Cow Body Condition			Pregnancy	Julian	Calf Weights (lbs)		
Trt	Cow#	d 0	d 42	d 84	Rate	Birth Date	d 0	d 67	d 153
1	9	5	5.5	5.5	P	100	82	220	318
1	11	4.5	4	3.5	.	.	.	.	.
1	42	4.5	4.5	4	P	91	100	265	372
1	46	4.5	4	4.5	P	113	94	260	384
1	65	4.5	4.5	4.5	.	116	82	.	.
1	73	4.5	4	4	P	83	74	220	304
1	75	4	4.5	4.5	P	77	82	270	396
1	81	4	5	4.5	P	82	92	280	396
1	85	3	4	3.5	O	85	68	170	244
1	101	5	4.5	5	P	87	104	240	340
1	104	5	4.5	4.5	P	82	102	230	318
1	110	4.5	4.5	5	O	118	78	175	288
1	125	4	4.5	3.5	O	67	94	290	380
1	287	4	5	5.5	P	113	112	255	342
1	320	5	5.5	5.5	P	106	90	215	338
1	342	5	5	5.5	.	.	.	.	.
1	347	5.5	6	5	P	72	82	285	396
1	352	4	3.5	4	O	111	80	195	278
1	355	4.5	5	5	P	84	80	230	322
1	364	4.5	4.5	5	P	108	86	230	296
1	365	5	4.5	5	P	90	90	250	342
1	378	6	5.5	5.5	P	81	94	235	346
1	385	4	4	3.5	.	86	94	.	.
1	390	4	4.5	4.8	P	88	96	290	426
1	403	4.5	4.5	4.5	P	87	100	250	360
1	431	4.5	4.5	4.5	.	90	88	.	.
1	434	4.5	4.5	4	P	93	98	270	372
1	435	4	5.5	5.5	P	96	83	230	322
1	449	5.5	5.5	6	P	90	88	245	368

[a] Beef cow body condition was determined using a 9-point scale(1 = extreme emaciated, 9 = extremely obese) after a 18 h overnight fast. Treatments supplements consisted of: 1)low-quality alfalfa (16.1% CP) supplement; 2)mid-quality alfalfa (17.8% CP) supplement; and 3)high-quality alfalfa (20.0% CP) supplement.

Table A.10 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY CONDITION AND SUBSEQUENT CALF WEIGHTS AND PREGNANCY RATES (Exp. 3)[a].

		Cow Body Condition			Pregnancy	Julian	Calf Weights (lbs)		
Trt	Cow#	d 0	d 42	d 84	Rate	Birth Date	d 0	d 67	d 153
2	5	5	5	5	P	104	90	245	354
2	39	4.5	4	5	.	.	.	.	.
2	44	4	4.5	4.5	P	83	64	215	322
2	56	4.5	4.5	5	P	76	94	280	380
2	97	5	5	5	P	91	108	280	396
2	99	6	5.5	5.5	P	114	74	165	278
2	114	5	5	4.5	P	84	84	260	370
2	118	4	4	4.5	P	83	84	220	290
2	154	4	4.5	4.5	P	90	90	280	374
2	159	4	4.5	5.5	P	83	90	160	284
2	162	4.5	4.5	4.5	P	88	88	220	292
2	179	5	5	4.5	P	98	105	230	318
2	291	6	6	6	P	83	92	285	418
2	336	4	4	4.5	P	80	88	265	380
2	338	4.5	4	4.5	.	74	94	.	.
2	341	4.5	3.5	4.5	P	88	76	245	372
2	357	4	4.5	4.5	P	88	88	260	374
2	361	5	5	5.5	P	85	88	.	382
2	379	4	3.5	5	P	82	86	235	304
2	380	4	4.5	4.5	.	94	90	.	.
2	383	4	4	4.5	P	81	80	230	328
2	398	4	4	4.5	P	85	68	240	318
2	410	5.5	5.5	6	P	116	90	215	378
2	428	4.5	4.5	5	P	97	68	155	278
2	436	4	4.5	4.8	P	104	78	200	294
2	447	5	5	5	P	95	92	250	384
2	455	4.5	4.5	4.5	P	80	88	230	344
2	458	4	4	4.5	P	65	98	265	328

[a] Beef cow body condition was determined using a 9-point scale(1 = extreme emaciated, 9 = extremely obese) after a 18 h overnight fast. Treatments supplements consisted of: 1)low-quality alfalfa (16.1% CP) supplement; 2)mid-quality alfalfa (17.8% CP) supplement; and 3)high-quality alfalfa (20.0% CP) supplement.

Table A.10 (Continued). THE INFLUENCE OF SUPPLEMENTAL ALFALFA ON BEEF COW BODY CONDITION AND SUBSEQUENT CALF WEIGHTS AND PREGNANCY RATES (Exp. 3)[a].

		Cow Body Condition			Pregnancy	Julian	Calf Weights (lbs)		
Trt	Cow#	d 0	d 42	d 84	Rate	Birth Date	d 0	d 67	d 153
3	14	4.5	4.5	4.5	O	90	84	225	314
3	17	4.5	4.5	5	.	83	86	.	.
3	18	4.5	4	4.5	P	81	84	260	376
3	23	4	4	3.5	O	92	88	210	290
3	32	4.5	5	4.5	P	88	90	245	326
3	82	5	4.5	4.5	P	113	84	165	264
3	103	5	5	5	P	111	108	210	304
3	117	4	4.5	4.5	P	84	84	290	368
3	122	5	5	5.5	.	64	80	.	.
3	132	4.5	4.5	4	P	56	74	270	358
3	157	4.5	4.5	4.5	P	80	78	255	340
3	185	4.5	4.5	4.5	P	86	80	200	292
3	186	5	5	4.8	P	82	72	180	268
3	278	5	5.5	5	P	65	94	280	396
3	333	5	5	5	P	93	104	265	374
3	343	5	5	5	P	83	90	260	362
3	372	5	5	5	P	85	90	260	368
3	373	6.5	6.5	7	P	83	70	230	312
3	377	5.5	5.5	6	P	78	86	250	380
3	387	4	4.5	4	P	85	84	220	332
3	388	4	4	4	P	95	94	230	328
3	392	4.5	4.5	5	P	102	62	180	278
3	395	4	4.5	4.5	P	90	96	240	332
3	396	4.5	4.5	5	P	100	80	225	324
3	401	4.5	4.5	5	P	113	86	215	314
3	404	4.5	4	4.5	P	84	82	250	348
3	419	4.5	5	4.5	P	82	74	290	392
3	441	5	5.5	5	P	114	94	205	316
3	454	5.5	5.5	6.5	P	85	98	280	384

[a] Beef cow body condition was determined using a 9-point scale(1 = extreme emaciated, 9 = extremely obese) after a 18 h overnight fast. Treatments supplements consisted of: 1)low-quality alfalfa (16.1% CP) supplement; 2)mid-quality alfalfa (17.8% CP) supplement; and 3)high-quality alfalfa (20.0% CP) supplement.