

Are There Unique Features of Alfalfa Hay in a Dairy Ration?

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ABSTRACT

Alfalfa hay is, or should, be highly valued as a dairy cattle feed due to its relatively high (for a forage) crude protein (CP) level which has a low rumen soluble fraction and a relatively high rumen escape fraction which contains a high level of the key amino acid lysine. It should also be valued for its high level of rapidly rumen digested pectin which has a high cation exchange capacity (CEC), as well as for its high levels of nutritionally important minerals. However, perhaps most importantly, alfalfa hay is, or should, be valued for its relatively low (for a forage) structural fiber (NDF) level which is relatively rapidly rumen fermented, has a high CEC and stimulates ruminative chewing and salivation. These characteristics, taken together, mean that alfalfa hay added to a dairy diet at 10 to 20% of dry matter (DM) tends to increase the nutritional value of the entire diet. Yet because all contemporary ration formulation software programs fail to describe many of these key characteristics, alfalfa hay is undervalued to varying degrees by these programs. However dairy nutritional professionals know this to be the case and frequently 'force' alfalfa hay into a diet when their computer programs tell them that it is economically unwise to do so, thereby increasing the real fiscal value of alfalfa hay.

INTRODUCTION

Alfalfa hay has been an important feedstuff in rations of California dairy cattle for a very long time. Indeed, it can be argued that local availability of high quality alfalfa hay allowed the dairy industry to become established in California. However as prices of alfalfa hay soared last winter, many dairy ranchers searched for ways to reduce, or eliminate, alfalfa hay from dairy rations while maintaining high milk production. This proved to be a difficult, often economically impossible, task since alfalfa hay combines a number of beneficial nutritional characteristics which are seldom found in the same feed.

Indeed, when we surveyed dairy ranchers in 2014, 19% of the dry matter (DM) in their high group diets (i.e., the diets for the highest milk producing cows) was from alfalfa hay, silage or fresh chop, very similar to the 20% which was found in an earlier 2009 survey. In contrast, diet incorporation levels of corn silage during this period declined from 17 to 15%, while whole crop winter cereal and sorghum silage, which are minor feeds in high group diets, increased from 4 to 6% and 0 to 1% respectively. Thus in spite of fiscal turmoil in the dairy industry, and large increases in the costs of many feeds (including alfalfa hay) during this period, alfalfa hay remained the single most important feed in most high group dairy diets in California. So what's the deal? Why are dairy nutritionists

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and dairy ranchers continuing to feed alfalfa hay in spite of its apparently high cost relative to competing feeds? The objective of this paper is to focus on some of the key nutritional attributes of alfalfa hay which may drive that high nutritional value.

POSITIVES OF ALFALFA HAY

Alfalfa hay has a number of beneficial nutritional characteristics which make it a high quality feedstuff for dairy cows. These are related to the key chemical components of alfalfa hay which, on a weight basis from highest to lowest level, are structural fiber (i.e., neutral detergent fiber- NDF), protein, pectin, starch/sugar, minerals and fat.

Structural Fiber

Level

Measured as NDF, structural fiber is by far the slowest fermenting (in the rumen) fraction of most feeds fed to dairy cattle. This can be negative since diets with excessive levels of NDF restrict overall feed intake (and milk production) by the cows due to rumen fill. Ideal NDF levels in high group diets range from 29 to 34% of DM. This is relatively close to the average of 38% NDF found in dairy quality alfalfa hays, and much lower than the 52% found in corn silage and 48% in winter cereal silages. If the objective of the dairy nutritionist is to formulate a high cow diet with 29 to 34% NDF, then diet incorporation levels of corn silage and winter cereals will have to be restricted.

Fermentability

A key characteristic of NDF, which hugely impacts its nutritional value, is the speed at which it degrades in the rumen. Feeds with rapidly fermented NDF release their NDF faster in the rumen, which provides the nutrients needed to support high milk production, while creating less undigested NDF which must pass through the entire gastrointestinal tract to be excreted in feces in largely the same form that it was eaten – essentially making that fraction ‘dead weight’ in a feed. In this regard, the fermentability of alfalfa hay NDF (42% at 30 h of fermentation) does not seem to compare well with those of corn silage (48%) and winter cereal (51%) but, when integrated with the absolute levels of NDF in the feeds, alfalfa hay only contains about 20% of its total dry weight as ‘dead weight’ NDF, whereas corn silage and winter cereals contain about 25%.

CEC

Alfalfa hay NDF has a high buffering capacity (measured as cation exchange capacity (CEC) and expressed in meq Cu/kg NDF). For example, alfalfa NDF has 80% more CEC than corn silage NDF (i.e., 36 vs. 20; McBurney et al. 1981). So why is buffering capacity in a feed important? Dairy diets can contain a great deal of rapidly fermented material, such as starch from grains, which are rapidly used by rumen micro-organisms (microbes) in the rumen to create a range of acids, of which lactic, acetic, propionic and butyric dominate. These acids are absorbed through the rumen wall and constitute an important source of energy for the cow to use to support milk production. However as the levels of acid in the rumen increase the rumen pH declines and, once the pH goes below about 6, the growth of the microbes slows. Referred to as ‘rumen acidosis’, this slower growth is important since it is the rumen microbes which do the bulk of the

fermentative digestion in the rumen. Thus unhappy microbes lead to less digestion which leads to lower feed intake and less milk production. However feeds with high buffering capacity, such as alfalfa (NDF), slow the decline in rumen pH which slows the decline in feed intake.

Stimulation of chewing

An important nutritional characteristic of a feed is its ability to support ruminative chewing (i.e., chewing the cud) in dairy cows. Beauchemin and Buchanan-Smith (1990) showed that addition of alfalfa hay to a silage/grain based diet at 15% of diet DM increased ruminative chewing from 4.6 to 5.5 h/d. This is not an insignificant nutritional impact because cud chewing stimulates flow of saliva to the rumen. As saliva has a very high buffering capacity, increased saliva flow to the rumen helps prevent the rumen pH from declining thereby inducing the metabolic problems associated with rumen acidosis (as discussed above). In addition, cud chewing is critical to reduction of feed particle sizes in the rumen – which both creates new surface areas on ingested feeds for microbes to ferment, while speeding passage of indigestible materials from the rumen. Increased cud chewing is critical to high feed intakes and has little impact on eating time, as Beauchemin and Buchanan-Smith (1990) also demonstrated with an increase of only 11 min/d of intake time in spite of the almost 1 h more cud-chewing per day.

Crude protein

Level

Protein is a critical, and expensive, nutrient in rations of dairy cows. Ideal crude protein (CP) levels in high group diets range from 16 to 17% of DM. This is relatively close to the average of 22% CP found in dairy quality alfalfa hays, and much higher than the 8% found in corn silage and 11% in winter cereal silages. If the objective of the dairy nutritionist is to formulate a high cow diet with 16 to 17% CP, then incorporation levels of high cost protein supplements, such as canola meal, will have to be increased as the levels of corn silage and winter cereals in the diet increase. In contrast, because the CP level of alfalfa hay is higher than what is needed in the total diet, its use in the diet will reduce the need for high cost supplemental protein meals to be added to the diet.

Rumen degradability

The CP which is consumed by dairy cows has two main functions. It can be used by rumen microbes to support their growth, or it can escape the rumen intact to be absorbed from the small intestine to support milk production. Protein used to support microbial growth should ideally be released relatively slowly in the rumen so that it provides a continuous supply to the microbes. Protein that is very rapidly released in the rumen is referred to as soluble protein (SP), and alfalfa hay with about 37% SP is close to the ideal level in dairy rations of 31 to 34%. In contrast, the SP levels of corn and cereal silages, at 55 and 50% respectively, are very high. This means that as their incorporation levels in the diet increase, the levels of other feeds in the diet with high levels of SP (which are often the less expensive protein sources) must be restricted. The ideal proportion of dietary protein which escapes the rumen and is available for direct absorption from the small intestine typically ranges between about 37 and 43% of total diet CP. In this

regard, alfalfa hay and corn silage (at 32 and 34% respectively) are much closer to the ideal range than is cereal silage at about 22%.

Amino acid profile of rumen escape protein

The amino acid profile of protein which escapes the rumen is important since dairy cows have requirements for the individual amino acids (AA) which make up the protein which is absorbed from the small intestine. In this regard, alfalfa hay protein which escapes the rumen is much more desirable than in corn silage protein since the level of lysine, a key AA in milk protein, is 4.2% of rumen escape protein in alfalfa *versus* only 2.9% in corn silage protein. Thus high corn product diets based upon corn grains, corn distillers and corn gluten pellets, which are common on California dairy farms, can become lysine deficient when more corn protein is added to the diet in corn silage. Indeed the main protein in all corn proteins, called zein, has a poor AA profile compared to milk protein. This problem is at least partly corrected by including alfalfa hay in the diet.

Pectin

Relatively little is known about pectin levels in feeds since there is no available method to reliably, rapidly and inexpensively analyze for it. However, overall, pectin (familiar to many folks as the additive which causes jams and jellies to not be a fluid) are the 'glue' which helps hold the plant cell wall together in many plants. Pectin is also referred to as 'soluble' or 'nonstructural' fiber. Because of its chemical structure pectin is very rapidly fermented in the rumen but, in contrast to starch, this fermentation does not lead to lactic acid which is the key acid which depresses rumen pH contributing to rumen acidosis. Alfalfa hay, which contains up to 10% pectin in its DM (Robinson and McQueen, 1989), has much more pectin than corn and cereal silages at 0.5 to 1% respectively. Part of this may be because some of the pectin which was in these crops at harvest was fermented by silage microbes during silo fermentation. This may be a part of the reason why short term (at 6 hours) digestion, as measured by a gas production method, of alfalfa hay (110 ml of gas/g DM) is much higher than that of corn and cereal silages (95 and 90 ml of gas/g DM respectively). In addition, the CEC of pectin is about 230 meq Cu/kg (McBurney et al. 1981), which is over 6 times that of alfalfa NDF! Overall, this all means that more pectin in a feed is a good thing, and that the nutritional value of alfalfa hay benefits from the attributes of pectin, whereas corn and cereal silages do not.

Ash

Ash represents the inorganic (i.e., mineral) content of a feed. Ash can be nutritionally useful (such as calcium) or not useful (such as silica). In this context, nutritionally useful ash could be referred to as 'good ash' whereas ash with no nutritional value could be referred to as 'bad ash', and accurate spelling is crucial. In this context, alfalfa hay with 6% of its DM as good ash (e.g., calcium, phosphorous, potassium) is much higher than corn and cereal silages which contain only about 3% good ash. Since dairy cows have nutritional requirements for the minerals in good ash, their presence at relatively higher levels in alfalfa hay means that less of them need to be supplied to dairy diets from supplemental sources, which can be costly. In contrast, bad ash is similar to indigested NDF in that it is essentially 'dead weight' in the feed. While alfalfa hay and corn silage have similar levels of bad ash, at 5% of total DM, the bad ash level of cereal silage is

much higher at 10%. If these levels of ‘dead weight’ ash are added to the dead weight NDF, then alfalfa hay has about 25% dead weight in its DM, corn silage has about 30% and cereal silage about 35%. Dead weight in a feed is not a good thing.

Starch and sugar

Alfalfa hay contains virtually no starch, about 1% of DM, but up to 5% sugars if it is dried rapidly after harvest so that the plant does not use the sugars and expire them to the atmosphere as carbon dioxide. This contrasts to normal starch levels in corn silage of up to 25% and in cereal silages of up to 15%. While starches and sugars are highly digestible and nutritious, they can be associated with too rapid digestion in the rumen leading to rumen acidosis. As discussed above, it is characteristics of alfalfa hay which can counter these effects to, in effect, lift the effective nutritional value of the starch in the silages to create, overall, a diet with a higher nutritive value.

Fats

Alfalfa hay contains very little fat, about 2 to 3% of DM, and as much as half of that may actually be cuticular waxes (which cover the plant) which have virtually no nutritional value. Corn and cereal silages contain slightly higher fat levels, at 3 to 4% of DM, but none of these feeds bring much fat to the nutritional party.

IS ALFALFA HAY VALUED CORRECTLY?

The nutritional parameters upon which diets for lactating dairy cows are based have become considerably more complex over the past 5 to 10 years. Most diets for lactating dairy cattle are now formulated by nutrition professionals using computer software programs. Nevertheless, the beneficial characteristics of alfalfa hay are often not completely described in these programs either because the programs do not include the characteristic (e.g., CEC of the feeds) or because little effort has been devoted to accurately describing the characteristic (e.g., pectin), or both. In order for alfalfa hay to be accurately priced in computer software programs, more of its nutritional characteristics should be included in the software but, because these characteristics are not available, it does not happen. Thus common dairy diet formulation computer programs consistently undervalue alfalfa hay relative to its true nutritional value.

However the good news is that nutritional professionals know this is the case and frequently ‘force’ alfalfa hay into a diet, even when their computer programs tell them that it is economically unwise to do so. It may be a very long time before this is not a part of the ‘art’ of formulating cost effective and nutritious diets for dairy cows.

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REFERENCES

Beauchemin, K.A. and Buchanan-Smith, J.G. 1990. Effects of fiber source and method of feeding on chewing activities, digestive function, and productivity of dairy cows. *J. Dairy Sci.* 73, 749-762.

McBurney, M.I., Van Soest, P.J. and Chase, L.E. 1981. Cation exchange capacity of various feedstuffs in ruminant rations. In: *Proc. Cornell Nutrition Conference for Feed Manufacturers*. Syracuse, NY, USA.

Robinson, P.H. and McQueen, R.E. 1989. Non-structural carbohydrates in rations for dairy cattle. In: *Proc. 10th Western Nutrition Conference*. Saskatoon, SK, Canada.