# RECENT CHANGES IN CALIFORNIA DAIRY DIET FORMULATION STRATEGIES

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## ABSTRACT

The nutritional characteristics of 'high cow' diets fed in California have changed only slightly in the past 20 years, even though their ingredient profiles have changed substantially, with alfalfa hay levels in high cow diets declining ~50%. This decline appears poised to continue due to the anticipated large increase in the amount of almond hulls entering the feed market. It is critical that the alfalfa industry initiate research to quantify the enhanced nutritional value of new low lignin alfalfa hays, as well as demonstrate the nutritional benefits of alfalfa hay beyond energy and proximate nutrients. The current TDN based grading system has been a huge benefit to the alfalfa and dairy industries, but it must be updated to reflect contemporary practices in the dairy industry, and to capture the value of new alfalfa cultivars and cultivation approaches.

## INTRODUCTION

The California dairy and alfalfa industries have been a largely successful symbiotic duo for a very long time. However the days of spreading bales of alfalfa hay along a bunkline and feeding cows a grain mixture while they are being milked are long gone. Indeed the number of nutritional parameters upon which diets for lactating dairy cows are formulated has increased substantially, and become considerably more complex, over the past 10 to 15 years. As a result, most dairy diets in California are created by nutrition professionals using complex computer software programs which create least cost (LC) diets with defined nutrient profiles based upon the nutrient profiles (and prices) of all available feeds. In less than a generation, alfalfa hay has gone from being the default forage to just one of many feeds, and forages, which are available in the marketplace. During this period the dairy industry has also witnessed the emergence of what are essentially new feeds (e.g. distillers dried grains - DDGS), the functional disappearance of feeds (e.g. soy hulls and beet pulp), while the availability (e.g. almond hulls) and environmental desirability (e.g. winter cereal silages) of some feeds has increased.

During this same period the California alfalfa industry has been relatively inactive in sponsoring research to identify and quantity the beneficial characteristics of alfalfa hay that are often not completely described in the diet formulation computer programs used by nutrition professionals, thereby leading to it being undervalued (Robinson, 2014).

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This contrasts to other feed industries, such as those that produce DDGS, almond hulls and canola meal, which have been very active in funding research, and so directing it, to demonstrate the beneficial attributes of 'their' feeds. Far too much of the information used to commercially evaluate alfalfa hay in a nutritional sense, such as the California TDN system, is 20 to 60 years old and of dubious relevance to the contemporary California dairy industry, modern alfalfa cultivars and their cultivation/cutting practices.

This paper highlights the changes that have occurred in the ingredient profiles of California dairy diets in the past 20 years, suggests what may change in the next few years, while highlighting the desperate need for new research to bring alfalfa hay back into the California limelight, from which it disappeared some years ago.

## PAST, CURRENT AND PROJECTED CALIFORNIA FEEDSTUFF SITUATION

Since arriving in California over 20 years ago, I have endeavored to complete a survey of California dairy 'high cow' diets every 4 years (about). While the initial objective was primarily to inform myself of what and how much of which feeds were being used in California dairy cattle diets, and so determine which feeds to focus my research efforts on, after the first 2 or 3 surveys the objective changed to documenting the changes in diet nutrient and ingredient profiles over the years. The surveys all took a similar form in which a number of dairy farms employing different nutritional professionals, and being upper tier farms in terms of productivity, were identified and visited. Data collected included the productivity of the cows as well as the ingredient and chemical composition of the 'high cow' diets fed, since these diets represent by far the largest proportions of feeds utilized on dairy farms.

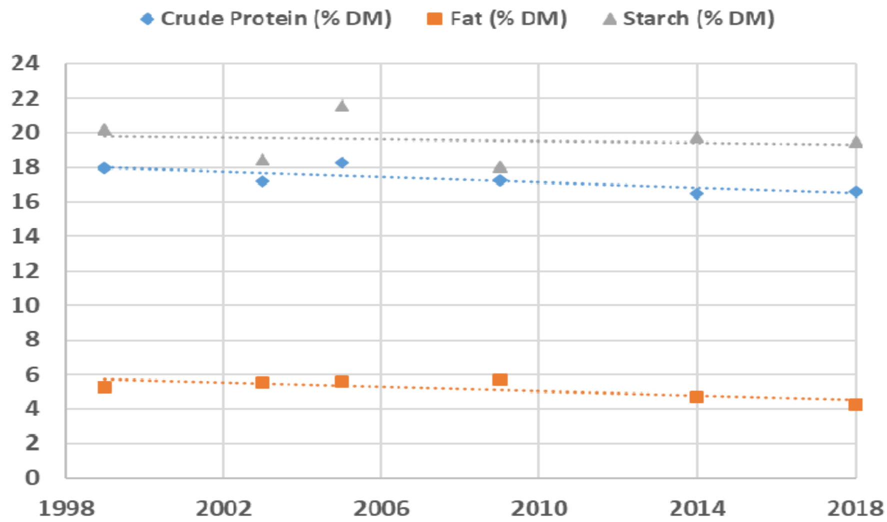
The last full survey took place in 2014 and that for 2018 seems destined to be delayed. However in preparation for this paper I contacted a few 'sentinel' dairy farms to obtain a sense of the current situation. Thus, presented 2018 data should be used with caution.

### Changes in the nutrient levels of high cow diets since 1999

As a general statement, the nutrient levels of high cow diets have not changed a great deal over the past 20 years (Figures 1 and 2). Levels of starch, a very rapidly fermented carbohydrate, have moved up and down a bit, but in general have been relatively steady in the 20% of dry matter (DM) range. In contrast, crude protein (CP) levels have steadily declined from ~18 to ~16% of DM, possibly due to consistently increasing costs of protein meals and/or to environmental concerns focused on limiting releases of nitrogen to the environment. Fat levels also seem to have trended down a bit over the years.

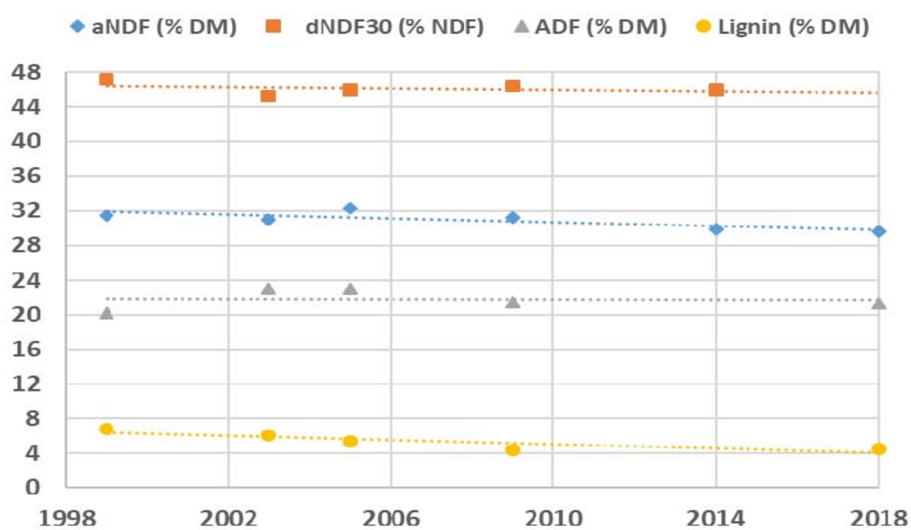
Levels of total structural carbohydrates (i.e., neutral detergent fiber – NDF) has trended down slightly (Figure 2), although oddly its major sub-fraction acid detergent fiber – (ADF) has remained constant. In contrast to ADF itself, its major sub-fraction lignin has trended down since 1999, mimicking NDF, perhaps reflecting a general focus on the perceived positive effects of lower dietary lignin levels on rumen fermentability of NDF.

*Figure 1. Changes in crude protein, fat and starch levels of high cow diets since 1999.*




Even though lignin has slid down a bit over the years, the *in vitro* fermentability of NDF has remained constant at about 46% of DM intake. This is remarkable in light of the steadily increased focus on the perceived importance of increasing *in vitro* rumen NDF fermentability in diets, as well as the decline in levels of lignin that actually occurred.

*Figure 2. Changes in fiber fraction levels of high cow diets since 1999.*



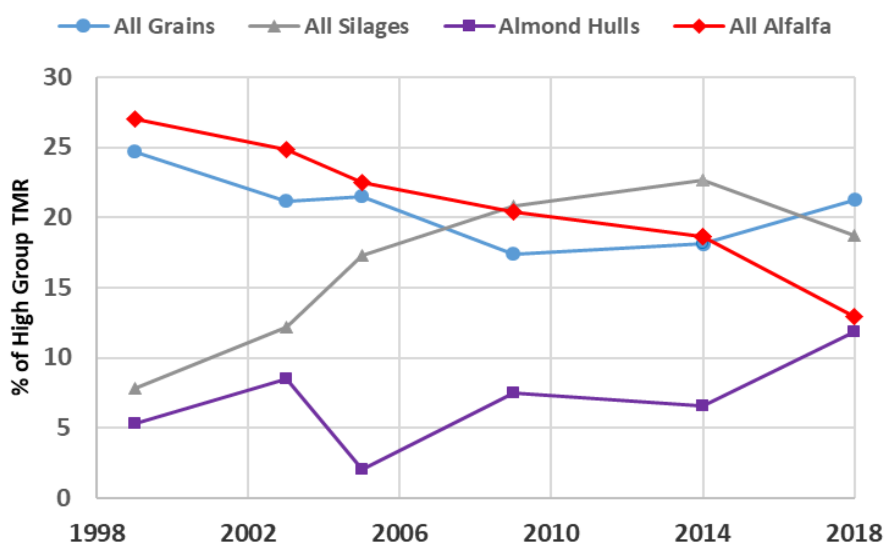

But overall, levels of the key nutrients in high cow diets have remained essentially constant since 1999. It seems that change takes time, especially in light of the lack of truly 'new' information in the area of optimal diet formulation during the past 20 years, the caution by nutritional professionals in fixing things that are not broken, and the lack of change in the underlying philosophy of diet formulation – which is the double headed coin of 'do no harm' and 'maintain correct nutritional profiles over all'.

**Changes in the ingredient levels of high cow diets since 1999**

In contrast to diet nutrient levels, ingredient levels of the high cow diets have changed a great deal over the past 20 years (Figure 3). In the period between 1999 and 2004, predominant diet changes were in the interlinked increases in use of (non-alfalfa) silages, the decline in levels of grains and the consistent linear decline in levels of alfalfa. While levels of almond hulls bumped around a bit, there was no net change in its feeding level in high cow diets during this period.

However the type of change in diet ingredient levels has changed somewhat since 2014. It seems that the impacts of all of those almond trees that were planted over the past 10 years have come home to roost with a substantial increase in feeding levels of almond hulls, a continuation in the uptick in grain feeding levels – likely due to continuing low prices for corn grain – and lower levels of (mostly) home grown silages. The only aspect that continues unabated is the linear decline in use of alfalfa, but since 2014 for a different reason. In contrast to 1999 to 2014, when alfalfa was losing market share to silages, it is now almond hulls that are gaining market share at alfalfa's expense. In light of the massive increases in almond hull availability projected in the next few years, it is a near certainty that this trend between 2014 and 2018 will continue and so alfalfa's market share will continue to decline.

*Figure 3. Changes in levels of grains, silages, almond hulls and alfalfa in high cow diets since 1999.*




**HOW DO ALMOND HULLS COMPARE NUTRITIONALLY TO ALFALFA HAY?**

What the heck are these almond hulls that are moving into the historical niche occupied by alfalfa hay? Almond trees are serious about protecting their seeds. They surround them with a thin skin (often not removed during processing) and then surround that with a woody shell that is about $^1/_{16}{}^{th}$ of an inch thick (which is mostly removed during processing), and finally surround everything with a relatively pliable hull that is about $^1/_8{}^{th}$ of an inch thick (entirely removed during processing). What dairy producers purchase as 'almond hulls' will generally be about 85 to 90% hulls, 5 to 10% shells, 1 to 2% sticks and 1 to 2% almond seeds.

The consistency of almond hulls (as purchased) is a continuing issue, due to variable levels of 'contamination' of the hulls with shell and sticks, which the almond industry is busy trying to address in a cost effective way. Nevertheless it is not difficult to compare average 'almond hulls' to alfalfa hays (Table 1) in a nutritional (and fiscal) sense. The results are telling in terms of why hulls have been displacing alfalfa hay.

*Table 1. Comparative nutritional value of alfalfa hays and almond hulls.*

| | Alfalfa Hay | | | Almond |
|---|---|---|---|---|
| | Supreme | Premium | Good | Hulls |
| Dry matter, % | 89.8 | 89.5 | 90.1 | 87.7 |
| Crude protein, % DM | 24.8 | 22.9 | 21.0 | 5.6 |
| Soluble CP, % CP | 35.4 | 34.3 | 35.3 | 37.3 |
| Indigestible CP % CP | 5.1 | 4.8 | 6.6 | 33.3 |
| NDF, % DM | 32.2 | 34.3 | 38.7 | 35.2 |
| $dNDF_{30}$ (% NDF) | 44.5 | 41.4 | 37.0 | 34.4 |
| ADF, % DM | 24.6 | 27.7 | 30.7 | 28.7 |
| Lignin, % DM | 4.4 | 5.2 | 5.6 | 11.3 |
| Fat, % DM | 2.3 | 1.8 | 1.9 | 2.3 |
| Ash, % DM | 10.9 | 11.6 | 10.4 | 6.5 |
| Sugars, % DM | 4.5 | 3.4 | 5.6 | 28.7 |
| $NE_l$, Mcal/lb DM | 0.67 | 0.61 | 0.59 | 0.64 |
| Cost, $/ton DM | 262 | 251 | 222 | 91 |
| Cost, $/lb CP | 0.53 | 0.55 | 0.53 | 0.81 |
| Cost, $/lb digested CP | 0.56 | 0.58 | 0.57 | 1.22 |
| Cost, $/Mcal $NE_l$ | 0.20 | 0.21 | 0.19 | 0.07 |

One of the most noticeable differences between alfalfa hays and almond hulls is that almond hulls have a much much lower CP content, and the proportion of that CP which is indigestible by ruminants is much higher. This makes almond hulls a non-player in the CP arena. However the levels of NDF and ADF in almond hulls compare closely to 'Premium' alfalfa hay, although the *in vitro* digestibility of the NDF in almond hulls is somewhat lower than 'Good' alfalfa hay. Another apparent disadvantage of almond hulls is its much higher level of lignin. However this may be somewhat misleading as much of that lignin is in the contaminant shells and sticks and so is concentrated where it will have no impact on the fermentability of the hulls, which have a relatively low lignin level.

Levels of fat do not differ meaningfully between alfalfa hays and almond hulls, but almond hulls contain much less nutritionally valueless ash than does alfalfa hay.

But almond hulls have a final ace to play in that their levels of free sugars are 5 to 6 fold higher than in alfalfa hay. And sugars are, nutritionally speaking for cows, a big plus because they are essentially 100% fermented in the rumen and (importantly) do not lead to accumulation of lactic acid, which is the main causative acid in rumen acidosis which can drive cows off feed, or even kill them. Finally almond hulls look pretty good compared to alfalfa hay on the energy ($NE_l$) front as they sit between the $NE_l$ values of 'Supreme' and 'Premium' alfalfa hays. And this is very important because after all nutrients are balanced in dairy diets it will be the $NE_l$ level of the diet that drives milk yield. In short, when you move from alfalfa hay to almond hulls in a dairy diet, you trade off CP to gain sugars, which is an energetic wash.

Finally, almond hulls currently trade at ~40% of 'Premium' alfalfa hay on a DM basis. This is huge because even though the cost/lb of digestible CP in almond hulls is more than double that of digestible CP in 'Premium' alfalfa hay, the cost per pound of $NE_l$ is 3 fold higher in 'Premium' alfalfa hay *versus* almond hulls. All factors considered, it is not hard to understand why almond hulls (at least when priced at roughly 40% of 'Premium' alfalfa hay) have been pushing alfalfa hay out of the dairy feed market.

## THE SERIOUS NEED TO ACCURATELY DEFINE AND INCREASE THE NUTRITIONAL VALUE OF ALFALFA HAY

Alfalfa hay has been in a virtual 20 year freefall relative to its importance to the California dairy industry. In less than a generation, alfalfa hay has gone from being the goto forage to just one of many feeds that are available in the marketplace. And, if action is not taken really soon, it is likely that its importance will erode further both in terms of levels of use and price. What to do?

### Increase the Energy Value of Alfalfa Hay

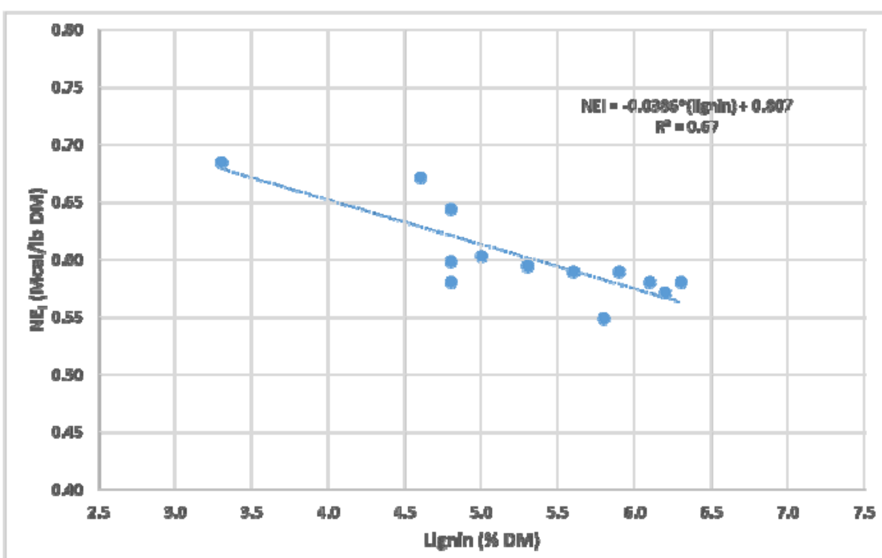
One of the huge advantages that Western pure stand alfalfa hays have relative to all other dairy feeds is a standardized grading system which reduces the product variation which plagues many competing feeds, including almond hulls. The main advantage of the current grading system is that is based upon the energy value of alfalfa hay which, as noted earlier, is the key nutritional attribute of the main feeds used to create dairy diets. But there are many serious problems with the current alfalfa grading system. It is based upon an obsolete nutritional system (essentially digestible energy (DE) – the dairy industry now uses $NE_l$), uses an even more obsolete nutritional term (TDN) that is no longer used to formulate dairy diets, is based entirely upon one analyte (ADF) which results in excessive variation among laboratories in TDN predictions, overvalues hays with high ash contents, may undervalue new low lignin alfalfa hay cultivars, is based upon research completed as much as 60 years ago (e.g. Meyer and Lofgreen, 1956; Meyer and Lofgreen, 1959) and, worst of all, it uses an equation (i.e. the 'Western States

Equation') with an obscure origin which cannot be re-created (Robinson and Old, 2014) and only appears in a long out of print leaflet (Bath and Marble, 1989).

Over the past 20 years, Dr. Dan Putnam and I have offered several low-cost replacement energy prediction systems for alfalfa hay that would retain the energy focus of the current alfalfa hay grading system while upgrading the energy prediction equation to contemporary standards using contemporary terms. Alas, to date, nothing has changed. Aversity to change leads to irrelevance and that may be the fate of the California alfalfa industry unless it embraces, and leads, change.

Predicting the energy value of alfalfa hay is important, as noted above, but increasing that energy value overall is also critical. One of the most promising innovations in this area has been extensive developmental efforts to create low-lignin alfalfa cultivars. *In vitro* data developed by my group at UC Davis (Figure 4), as well as by others, supports the belief that lower lignin alfalfa hays will have a higher $NE_l$ value. However it is critical that the superiority of these low lignin varieties be confirmed in dairy feeding studies so that their value can be captured by alfalfa growers. And so we return to the need to replace the current TDN equation which, as it is based solely upon ADF, will certainly undervalue these new low lignin varieties – the only question being by how much. The time for change has arrived.

*Figure 4. The relationship of alfalfa hay lignin level and it in vitro estimated $NE_l$ value.*




## Document the Beyond Energy Value of Alfalfa Hay

Previously at this conference (Robinson, 2014) I discussed at some length the reasons why alfalfa hay is consistently undervalued by contemporary dairy LC computer diet formulation programs and why it was important to initiate research to rectify the problem. In 2014 I wrote:

*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. cation exchange capacity (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.*

Once again, no research has been initiated in this area and so what I wrote in 2014 remains the case today. It is absolutely critical that the California alfalfa industry initiate a research program to fund a wide range of innovative research projects to demonstrate the beyond-energy value of alfalfa hay, and lobby the publishers of the key dairy LC diet formulation programs to include these characteristics because, in our times, if something is not in the diet formulation program then it does not exist.

## TWO CONCLUSIONS

The California alfalfa industry needs to regain leadership by initiating funded research to increase (and quantify) the energy value of alfalfa hay while simultaneously demonstrating its beyond-energy nutritional attributes. To be successful in these efforts, a revised equation to support the current grading terminology which accurately predicts the energy value of commercial hays (as $NE_l$) is urgently required.

## REFERENCES


Bath, D.L. and Marble, V.L. 1989. Testing alfalfa hay for its feeding value. Leaflet 21437. WREP 109. Division of Agriculture and Natural Resources, University of California, Oakland, CA. USA.

Meyer, J.H. and Lofgreen, G.P. 1959. Evaluation of alfalfa hay by chemical analysis. J. Anim. Sci. 18, 1233-1242.

Meyer, J.H. and Lofgreen, G.P. 1956. The estimation of total digestible nutrients in alfalfa hay from its lignin and crude fiber contents. J. Anim. Sci. 15, 543-549.

Robinson, P.H. and Old, C.A. 2014. A brief history of California alfalfa hay TDN equation. Feedstuffs, Feb. 7. pp 16-17.

Robinson, P.H. 2014. Are there unique features of alfalfa hay in a dairy ration? In: Proc. 2014 California Alfalfa, Forage & Grains Symposium, Long Beach, CA. 7 pp.