Playing Hide and Seek with Milk Performance Measures

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INTRODUCTION

Managing a dairy herd professionally requires making decisions based on objective data as opposed to managing "by feeling." Good managers (or dairy producers) identify bottlenecks, remove them, and capture marginal profits. There are many indicators of herd performance. Focusing on feed-related costs, and especially feed efficiency, is usually a very effective method to manage a dairy herd, because 1) feed costs account for between 40 and 60% of total production costs, 2) feed efficiency is a reflection of nutrition quality, reproductive performance, health, and management, 3) and it responds relatively fast (low lag, low momentum, and little bias; if calculated properly).

There are, however, other aspects of dairy production that will contribute to profits and need also to be closely looked at, such as rearing management and performance. In fact, in many occasions, it is easier to improve overall profits for a dairy herd by focusing on dairy replacements than actually attempting to improve milk yield. For example, improving age at first calving (AFC) may render copious profits. The number of required heifers to maintain lactating cow numbers of a dairy operation can be calculated with the following equation:

Number of cows × replacement rate / [(1-mortality) × (1-cull rate)] × 2 × (age at first calving/24)

From this equation, and assuming a 100-cow dairy herd with 30% replacement rate, 3% mortality, and a 1% culling rate, it can be determined that if AFC is 22, 24, or 28 months, the number of heifers needed is 57, 63, and 73, respectively. This means that, assuming an average daily feeding cost for heifers of $US 2, producers with an AFC at 22 save about $US 10,000/year compared with those having an AFC of 28 months.

This relatively large savings is due to the combination of both a lower number of heifers (good for the environment) and to the fact that they are fed for a shorter period of time (22 vs 28 months). Of course, this profit is a bit overemphasized, because it is likely that to improve AFC feed cost of calves will increase, but this associated increase is small compared with the profits to be obtained.

Last, herd performance is affected by a number of variables including nutrition, reproduction, genetics, environment, and management. Among these factors, the impact of management and environment where cows are housed is the least known. Thus, there are also many opportunities to improve profits through management. This article reviews some of these opportunities.

IMPROVING PROFITS THROUGH NUTRITION

Nutrition costs and performance need to be evaluated continuously independently of the evolution of market prices. In recent years, feed prices have experienced a high degree of volatility. When attempting to improve profits through a reduction of costs, it is important to differentiate between two types of expenses: those that could be considered an investment and those that could be actually spared and removed. For example, reducing the amount of bedding may actually save some money in a short run, but it really should be considered a credit (as the health and comfort of cows are placed at risk). If as a result of these apparent savings, cows become lame or mastitis increases, chances are that the costs associated with this management decision will overcome any savings originally captured. Similarly, a reduction in feed costs, if not properly allocated, may impair milk production and thus diminish returns. Therefore, when reducing expenses a careful evaluation of the consequences is mandatory.

A good opportunity for reducing feed costs without hampering production or future health of cows involves 1) minimizing feed losses due to forage preservation (especially with silages) and 2) revising mixing order of the ingredients in the total mixed ration (TMR) wagon. For example, ensiling directly on the ground should be avoided, and an incorrect slope of the silo may increase feed loses. Last, silage conservation is crucial, and it is advantageous to use silage preservatives when needed (excessively wet silages, etc.). In terms of mixing order, it is important to avoid feed losses due to dust (i.e., most of the protein in alfalfa is in the leaves, and if broken down when placed in the wagon most of the leaves separate from the stems and are blown away). To minimize dust, it is recommended to first introduce a wet ingredient in the wagon, such a silage, and then the dry components (concentrates, hays, etc.).

Last, in many occasions the decision of what type of crop to plant or what forage or ingredient to buy on the market is made by the producer without the involvement of the nutritionist. Ideally, the decision of what crop to plant and what ingredient to acquire should be made in conjunction with the nutritionist assessing the consequences on the total cost of the ration (combining all available ingredients). As a rule of thumb, value the ingredients based on the most important nutrient they provide. For example, alfalfa hay is commonly purchased on the basis of its crude protein (CP) content, but in reality, the unit cost of alfalfa CP is way more expensive than the unit cost of CP in soybean meal. Furthermore, alfalfa is included in the rations as a source of fiber, not as a source of protein (there are many more cost-effective alternatives), and thus alfalfa should be priced based on its fiber content and not CP. Another example is that commonly corn silage is assigned a bulk price. But really, the value of corn silage should depend on the level of starch and its digestibility, as not all corn silages are equal.

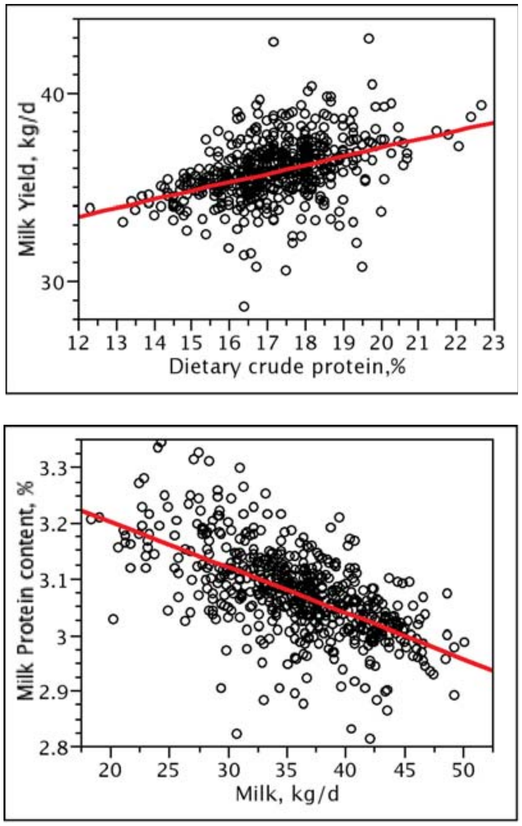

Figure 1. Relationship between dietary crude protein concentration and milk yield along with the relationship between milk yield and milk protein content.

In general, a ruminant nutritionist's goal is to formulate rations that meet the animal requirements by providing sufficient amounts of all nutrients. However, this approach can often lead to an excessive supply of some nutrients. Among the nutrients that are more likely to be in excess are those amino acids (AA) that are required in relatively small amounts by the animal but are relatively abundant in the feeds used to balance rations, such as aspartate. Due to the complexity of factors that contribute to determining the supply of AA to the dairy cow, coupled with the great ability of the mammary gland to modulate blood flow to compensate for AA imbalances (Bequette et al., 2000; Weekes et al., 2006), there is uncertainty as to the actual supply of AA by any given diet. Thus, it is rather difficult to know whether a change in the protein supply of the diet has corrected or actually induced an AA imbalance. An excess of certain AA may have negative repercussions on performance because some energy is diverted away from milk production and towards excretion of N excess.

The NRC (2001) acknowledged that there is a modest positive relationship for greater milk yield as the CP content of the diet increases, with about 12% of the variation observed in milk yield being attributed to CP content. Bach et al. (2006) conducted a meta-analysis using a data set with 131 studies from the Journal of Dairy Science (primarily from 2000 to 2006) and found a similar weak positive relationship ($R^2 = 0.17$; $P < 0.001$) between these two parameters (Figure 1). Also, a similar relationship was found between CP content of the diet and milk protein yield ($R^2 = 0.16$; $P < 0.001$). The relationship between dietary CP content and milk yield has probably stimulated the use of high-CP rations to improve milk production. However, as milk yield increases (Figure 1), milk protein content decreases ($r = -0.61$; $P < 0.001$), suggesting that as milk yield increases, milk protein synthesis may lag behind. As a result, the efficiency of protein utilization (EPU) is negatively associated ($R^2 = 0.81$; $P < 0.001$) with the level of CP in the diet (Figure 2). This negative relationship was expected, attributed in part to the mathematical equation used to calculate EPU, where CP intake is the denominator. Nevertheless, when evaluating a mixed-effects model that included CP intake and milk protein yield, to account for the mathematical dependence between CP

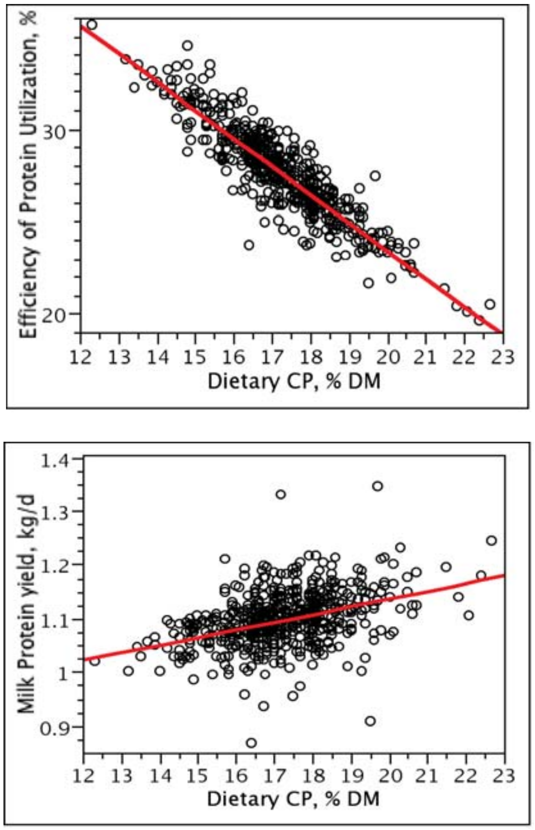

Figure 2. Relationship between dietary crude protein content and efficiency of protein utilization for milk production and protein yield.

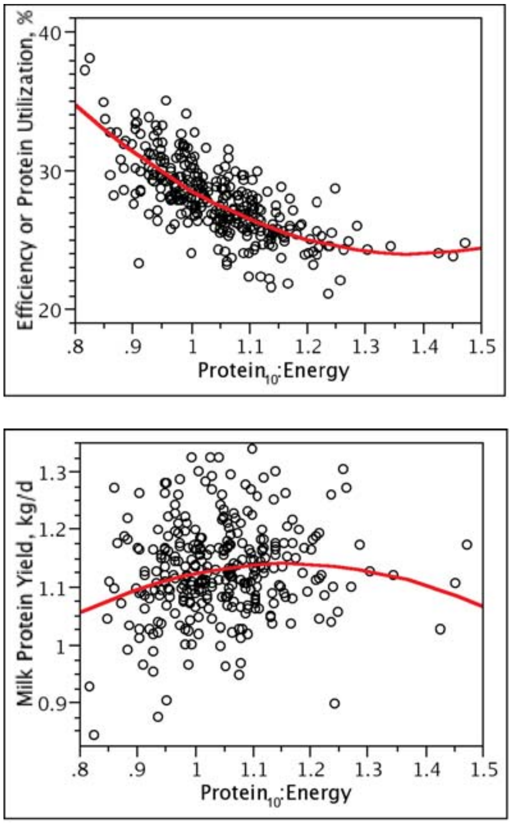

Figure 3. Relationship between the ratio of protein to energy intake and efficiency of milk protein synthesis and milk protein yield.

intake and EPU, plus the dietary CP content as dependent variables, dietary CP content was still negatively correlated with EPU and accounted for 13% of variation explained by the model. This observation indicates that as CP content of the diet increases, protein is used less efficiently. Because EPU is positively correlated with milk production ($r = 0.65$), it would seem possible to produce high amounts of milk with high milk protein efficiencies. Similar to what occurred with level of CP in the diet, this positive relationship was expected due to the fact that milk yield enters into the numerator in the equation to calculate CP efficiency.

A common approach used to meet the protein needs of dairy cows is to supply large amounts of CP in the diet, and nowadays it is not difficult to find dairy rations for high-producing animals containing more than 16% CP (which is commonly in excess of the needs). But the AA requirements in dairy cattle are not only dependent on energy intake, but also on the type of energy that the cow is receiving. Oke and Loerch (1992) and Tamminga (1992) stressed the importance of the ratio between absorbed protein and net energy in order to maximize the efficiency of nutrient utilization for milk protein production or protein accretion. Tamminga (1992) concluded that increasing the ratio between absorbed protein and net energy rapidly decreased the efficiency of transfer of absorbed protein to milk protein in early lactation. Van Straalen et al. (1994) indicated that energy status of the animal plays an important role in determining the response to absorbed protein. These authors found a strong negative correlation between the ratio of absorbed protein to energy intake and EPU. Similarly, in our meta-analysis we also found a strong relationship between the dietary protein to energy ratio (where protein is a percentage of CP divided by 10 to transform its units close to those of NE_L, and energy is expressed as Mcal/kg of NE_L) and EPU ($R^2 = 0.85$; $P < 0.001$). Again, this relationship was inflated by the fact that dietary CP content is mathematically linked to EPU. To remove this mathematical dependence, a model including dietary CP consumption (kg/d) and the linear and quadratic effects of protein to energy ratio was run (Figure 3). The relationship that was found ($R^2 = 0.44$; $P < 0.001$) indicates that to maximize EPU, the ratio between CP/10 and net energy concentration should be as close to 0.8 as possible. In other words, for a diet with an energy density of 1.7 Mcal/kg, the optimum CP content to maximize EPU should be about 13.6%.

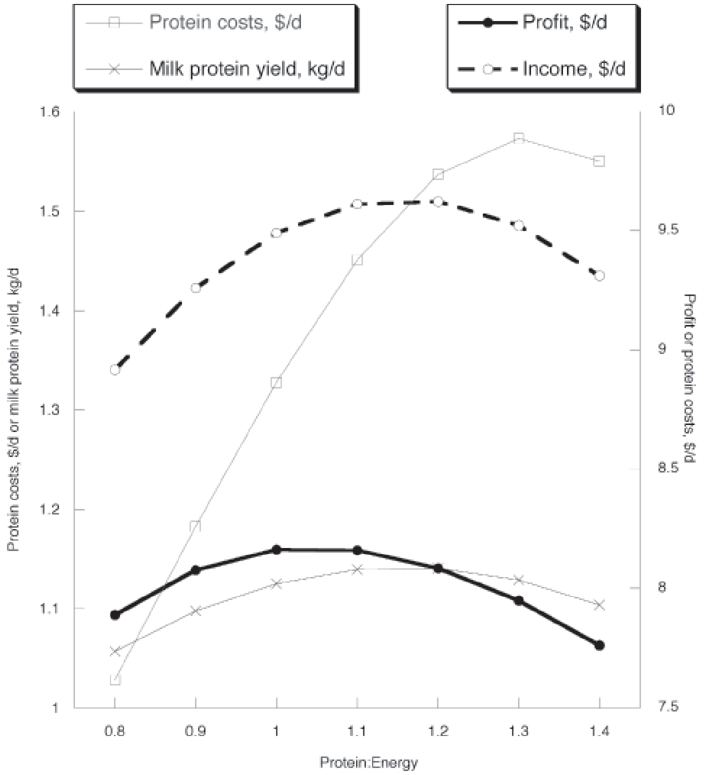

Figure 4. Expected evolution of milk protein yield, gross income from milk, protein costs associated with level of milk protein yield, and net profit (considering only protein costs) as affected by the protein to energy ratio.

A meta-analysis conducted by Bach et al. (2006) showed that to maximize milk protein yield, the optimum protein to energy ratio should be about 1.1 (Figure 3) or a 1.7 Mcal/kg energy dense diet should contain 18.7% CP. However, this optimum may not coincide with the maximum profit. Figure 4 shows the evolution of milk protein yield, gross income from milk, protein costs associated with the level of milk protein yield, and net profit (considering only protein costs) as affected by the protein to energy ratio. From this analysis, it can be concluded that the optimum dietary protein to energy ratio to maximize profit, not yield, would be about 1.0.

Just to illustrate the impact of EPU on profits, take the example of soybean meal. Current soybean prices are about $US 380/MT. Which means that a MT of protein from soybean meal is about $US 860. If this protein is fed in a ration that has an EPU of 28%, the cost of producing 1 MT of milk protein would be about $US 3,084; whereas, if the same soybean meal was fed in ration with an EPU of 35%, the cost of producing a MT of milk protein would be $US 2,467; yielding a profit of more than $US 500/MT of milk protein produced.

IMPROVING PROFITS THROUGH MANAGEMENT

A common practice in most dairy herds aiming at improving profits consists of feeding different rations in function of milk production. This is thought to reduce feed costs, but it is not always the case. When high-producing animals are moved from a high to a low-nutrient dense diet there is a loss of production. The decision of making two different rations will only be economical if the loss in milk production (in dollars) plus the labor costs associated with the two different rations do not offset the potential savings due to feeding a low-nutrient dense diet. Furthermore, it is likely that feed efficiency also diminishes when formulating a ration that is less expensive (typically including less digestible ingredients), thus it is also important to account for the loss in feed efficiency, not only milk production, when making groups of animals.

Feeding a TMR offers the great advantage of simplicity as it allows feeding large numbers of cows in groups. In addition, theoretically, with TMRs each mouthful of feed the cow consumes contains a balanced combination of nutrients. However, because cows do sort (Maulfair et al., 2010), the composition of the TMR actually changes throughout the day and the balanced nutrient profile may become imbalanced. Furthermore, cows need to consume a balanced-nutrient meal of the optimal size. In other words, because intake is variable between cows and also within cows depending on stage of lactation, BW, etc., a "balanced" mouthful of a TMR for one cow may be an "imbalanced" mouthful for another cow. For example, according to the NRC (2001) a cow producing 27 kg of milk per day needs 38 Mcal of NE_L and about 3.2 kg of CP. A cow with such a level of milk production would consume 20.6 kg/d, thus the TMR should have a nutrient density of 1.44 Mcal of NE_L/kg and 15.4% CP. If that TMR were consumed by a cow producing 30 kg of milk per day, according to NRC (2001) dry matter intake would increase by 1 kg and she would need additional 2 Mcal of NE_L and 103 g of additional metabolizable protein. If she consumes 21.6 kg of the TMR balanced for 27 kg of milk per day she would consume 1.42 additional Mcal (while she needed 2 additional Mcal) and 35 additional grams of metabolizable protein (while she needed additional 103 g). Thus, energy and protein consumption is progressively lagging behind needs at different proportions as milk production increases and the cow continues to eat the same TMR (Figure 5). Thus, within a given group of cows consuming the same TMR, as milk yield deviates from the level used to balance the TMR each mouthful of TMR consumed by the cow becomes progressively more imbalanced. Thus, when making groups of cows it is important to minimize the spread in milk production among the cows within a group.

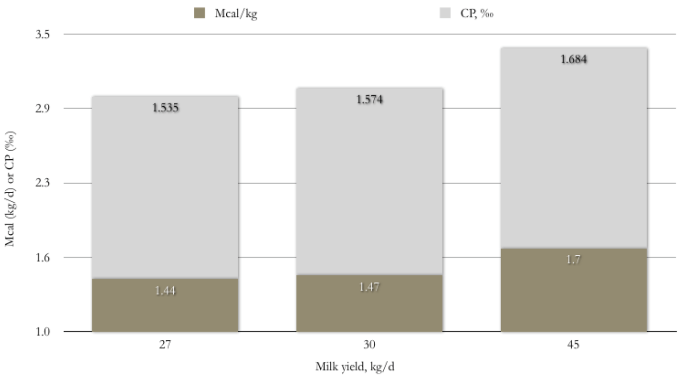

Figure 5. Evolution of energy and protein concentration (Mcal and %, respectively) needed in the dry feed consumed by cows as affected by level of milk production and consequent increase in dry matter intake according to NRC (2001).

There are other aspects of management beyond those related to nutrition that will have impact on profitability of dairy herds. We conducted a study (Bach et al., 2008) involving 47 herds that offered exactly the same ration and shared a similar genetic base and observed a range in average milk production per cow between 20.6 to 33.8 kg/d. This relatively large difference in milk production illustrates the importance that non-dietary factors exert on determining milk performance of a herd. Despite the fact that all herds fed the same diet, the amount of feed delivered per cow ranged from 16.2 to 24.8 kg of DM/d. As expected, the amount of feed delivered per cow was positively correlated with milk production. Reasons for the observed variation in intake could be, in part, attributed to the management and housing conditions of the animals. However, the ratio of free stalls to lactating animals was the only measured parameter that tended to be correlated with the amount of feed delivered per cow daily.

In the same study, herds that fed to ensure feed refusals tended to produce more milk (29.1 ± 0.61 kg/d) than those that did not allow feed refusals (27.5 ± 0.73 kg/d). Surprisingly, no relationship was found between the number of feeders or centimeters of feedbunk space per cow and animal performance, incidence of lameness, or culling rate. The average feed bunk space was 69 cm/animal (with less than 20% of herds with less than 50 cm of feed bunk per animal), which could be considered sufficient to avoid any limitations of feed intake and animal performance. In fact, Grant and Albright (2001) concluded that the minimum critical bunk space for dairy cattle was 20 cm/head.

Producers that did push up the feed performed this task 2 ± 0.67 (mean ± SD) times daily. Pushing up the feed had a positive impact on milk production. Herds that pushed-up feed produced on average 28.9 kg/d, whereas those that did not produced only 25.0 kg/d. However, there was no relationship between the number of daily feed push-ups and milk yield. Some producers pushed the feed up to 4 times per day, whereas others just pushed feed once daily. Although some researchers have noted a slight increase in feeding activity of cows experiencing more frequent feed push-ups (Menzi and Chase, 1994), a more recent study concluded that additional daily feed push-ups did not significantly increase feeding activity when compared with a baseline schedule of 2 feedings and 2 feed push-ups/d (DeVries et al., 2003). However, there are no studies that evaluate the relationship between changes in feeding behavior associated with pushing the feed and milk production. Perhaps, the most important aspect might be to ensure that cows have feed within their reach at all times (Albright, 1993; Grant and Albright, 1995).

Bach et al. (2008) found a positive relationship between the number of stalls per cow and milk production (Figure 6). When considering the maintenance status of the cubicle, both the number of stalls and the level of maintenance accounted for about 38% of the variation observed in milk production, with the stalls worst maintained resulting in the poorest performance, the intermediate stalls in the intermediate production, and the best maintained in the highest milk production per cow. In addition, a negative relationship between the number of stalls per cow and the proportion of cows culled was found. Grant and Albright (2001) reported that significant overcrowding appears to reduce feeding

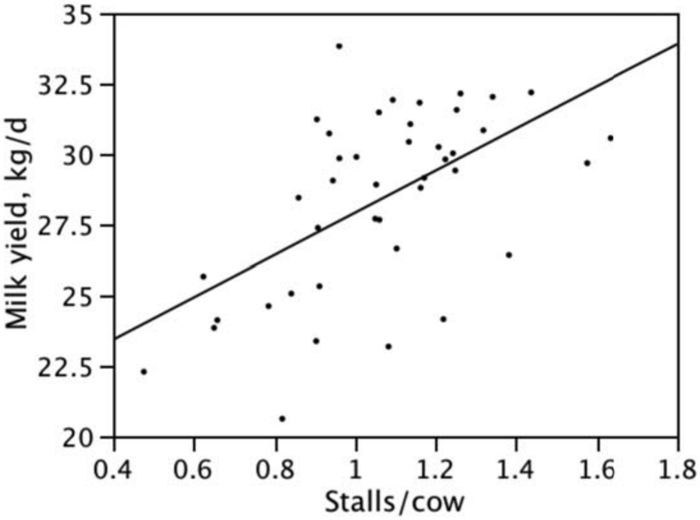

Figure 6. Relationship between the ratio of stalls per cow and milk production of dairy cattle in different herds (n = 47) feeding the same lactating ration. Milk yield = 20.4 + 7.5 × stall/cow.

activity, alter resting behavior, and decrease rumination activity. It could be speculated that the better the maintenance and the greater the availability of stalls, the longer resting times of cows and thus greater milk production. Increases in stocking density have been associated with increased risk of lameness (Wierenga and Hopster, 1990) and reduced feeding times (Huzzey et al., 2006). This association could have an impact on the proportion of cows that are involuntarily culled. In any case, it is important to note that in the study of Bach et al. (2008), only 29% of the herds had less than 1 stall per cow. When data from herds with at least 1 stall per cow was regressed against milk production no statistically significant relationship was found ($r = 0.22$; $P = 0.27$). These data indicate that over-stocking may have negative consequences on milk performance and under-stocking should have no positive impact on milk yield.

Table 1. Regression coefficients for several non-dietary factors in relation to daily average milk production (kg/d).

Term	Estimate	Std Error	*P* value
Intercept	28.37	4.434	< 0.01
Age at first calving, months	-0.26	0.126	0.05
Presence of feed refusals (yes=1, no=0)	0.64	0.372	0.09
Number of stalls / number of cows	5.91	1.468	< 0.01
Feed is pushed (yes=1, no=0)	1.29	0.640	0.05

Bach et al. (2008) developed a predictive regression equation that accounted for the effect of average age at first calving for heifers, presence or absence of feed refusals, ratio of number of free stalls per lactating cow, and whether feed was pushed up in the feed bunk and was able to explain 56% of the observed variation in milk production (Table 1). Thus, these four factors could be considered the most important non-dietary factors that impact milk production in the dairy herds under study.

CONCLUSIONS

When evaluating herd performance, one should focus on objective data and values that are sensitive, which implies that small deviations from target can be detected relatively rapidly and easily. Monitoring and managing feed costs starting by acquiring feed adequately, following by a proper mixing order in the TMR wagon, and finishing by splitting cows in the right groups and determining the optimum milk production of each of the them to generate maximum return (based on feed efficiency and feed costs) are effective ways of improving profits.

Last, milk production is affected by a number of aspects, but non-nutritional factors can account for as much as 13 kg/d of milk difference. The most important reasons for this variance in milk production are the rearing system of heifers (illustrated as age at first calving), feed bunk management (presence of refusals and pushing the feed), and the number of free stalls available per lactating cow. These factors explain about half of the observed variation in milk production not attributable to nutrition.

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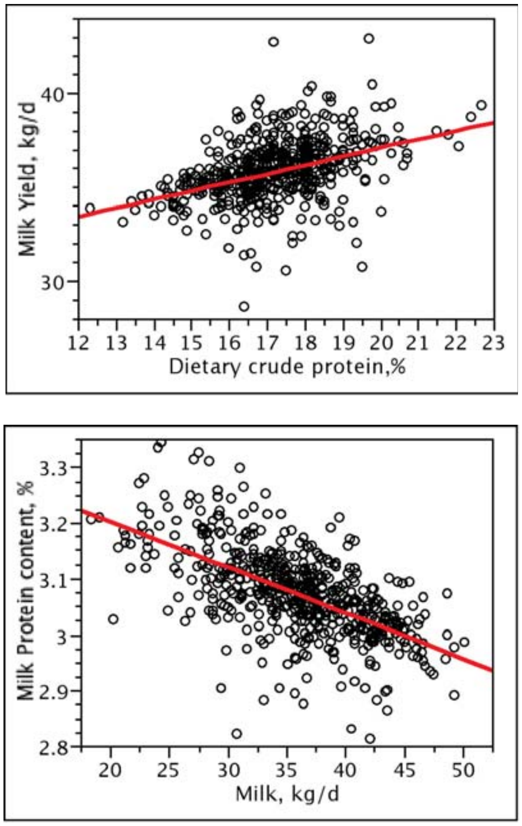

Figure 1. Relationship between dietary crude protein concentration and milk yield along with the relationship between milk yield and milk protein content.

In general, a ruminant nutritionist's goal is to formulate rations that meet the animal requirements by providing sufficient amounts of all nutrients. However, this approach can often lead to an excessive supply of some nutrients. Among the nutrients that are more likely to be in excess are those amino acids (AA) that are required in relatively small amounts by the animal but are relatively abundant in the feeds used to balance rations, such as aspartate. Due to the complexity of factors that contribute to determining the supply of AA to the dairy cow, coupled with the great ability of the mammary gland to modulate blood flow to compensate for AA imbalances (Bequette et al., 2000; Weekes et al., 2006), there is uncertainty as to the actual supply of AA by any given diet. Thus, it is rather difficult to know whether a change in the protein supply of the diet has corrected or actually induced an AA imbalance. An excess of certain AA may have negative repercussions on performance because some energy is diverted away from milk production and towards excretion of N excess.

The NRC (2001) acknowledged that there is a modest positive relationship for greater milk yield as the CP content of the diet increases, with about 12% of the variation observed in milk yield being attributed to CP content. Bach et al. (2006) conducted a meta-analysis using a data set with 131 studies from the Journal of Dairy Science (primarily from 2000 to 2006) and found a similar weak positive relationship ($R^2 = 0.17$; $P < 0.001$) between these two parameters (Figure 1). Also, a similar relationship was found between CP content of the diet and milk protein yield ($R^2 = 0.16$; $P < 0.001$). The relationship between dietary CP content and milk yield has probably stimulated the use of high-CP rations to improve milk production. However, as milk yield increases (Figure 1), milk protein content decreases ($r = -0.61$; $P < 0.001$), suggesting that as milk yield increases, milk protein synthesis may lag behind. As a result, the efficiency of protein utilization (EPU) is negatively associated ($R^2 = 0.81$; $P < 0.001$) with the level of CP in the diet (Figure 2). This negative relationship was expected, attributed in part to the mathematical equation used to calculate EPU, where CP intake is the denominator. Nevertheless, when evaluating a mixed-effects model that included CP intake and milk protein yield, to account for the mathematical dependence between CP

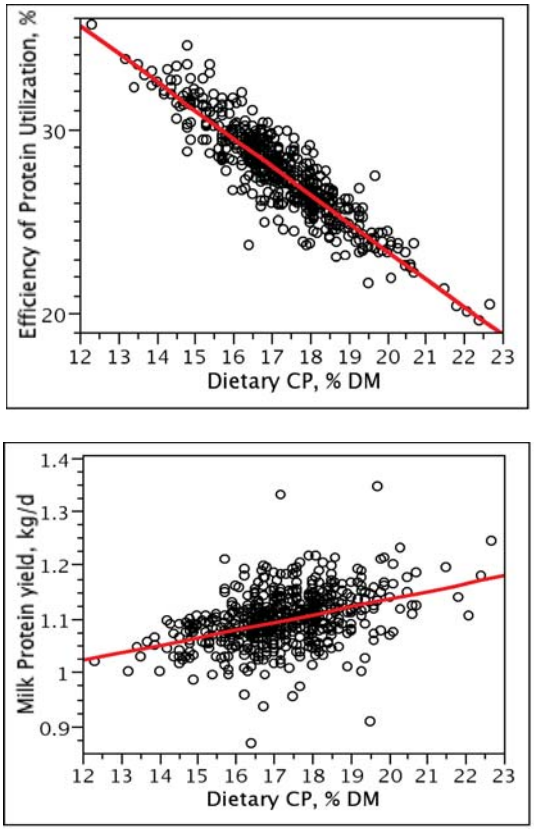

Figure 2. Relationship between dietary crude protein content and efficiency of protein utilization for milk production and protein yield.

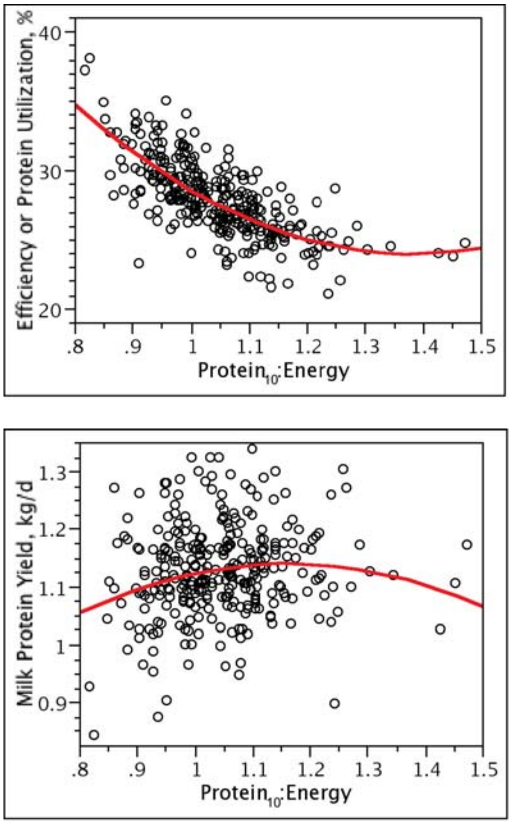

Figure 3. Relationship between the ratio of protein to energy intake and efficiency of milk protein synthesis and milk protein yield.

intake and EPU, plus the dietary CP content as dependent variables, dietary CP content was still negatively correlated with EPU and accounted for 13% of variation explained by the model. This observation indicates that as CP content of the diet increases, protein is used less efficiently. Because EPU is positively correlated with milk production (r = 0.65), it would seem possible to produce high amounts of milk with high milk protein efficiencies. Similar to what occurred with level of CP in the diet, this positive relationship was expected due to the fact that milk yield enters into the numerator in the equation to calculate CP efficiency.

A common approach used to meet the protein needs of dairy cows is to supply large amounts of CP in the diet, and nowadays it is not difficult to find dairy rations for high-producing animals containing more than 16% CP (which is commonly in excess of the needs). But the AA requirements in dairy cattle are not only dependent on energy intake, but also on the type of energy that the cow is receiving. Oke and Loerch (1992) and Tamminga (1992) stressed the importance of the ratio between absorbed protein and net energy in order to maximize the efficiency of nutrient utilization for milk protein production or protein accretion. Tamminga (1992) concluded that increasing the ratio between absorbed protein and net energy rapidly decreased the efficiency of transfer of absorbed protein to milk protein in early lactation. Van Straalen et al. (1994) indicated that energy status of the animal plays an important role in determining the response to absorbed protein. These authors found a strong negative correlation between the ratio of absorbed protein to energy intake and EPU. Similarly, in our meta-analysis we also found a strong relationship between the dietary protein to energy ratio (where protein is a percentage of CP divided by 10 to transform its units close to those of NE_L, and energy is expressed as Mcal/kg of NE_L) and EPU ($R^2 = 0.85$; $P < 0.001$). Again, this relationship was inflated by the fact that dietary CP content is mathematically linked to EPU. To remove this mathematical dependence, a model including dietary CP consumption (kg/d) and the linear and quadratic effects of protein to energy ratio was run (Figure 3). The relationship that was found ($R^2 = 0.44$; $P < 0.001$) indicates that to maximize EPU, the ratio between CP/10 and net energy concentration should be as close to 0.8 as possible. In other words, for a diet with an energy density of 1.7 Mcal/kg, the optimum CP content to maximize EPU should be about 13.6%.

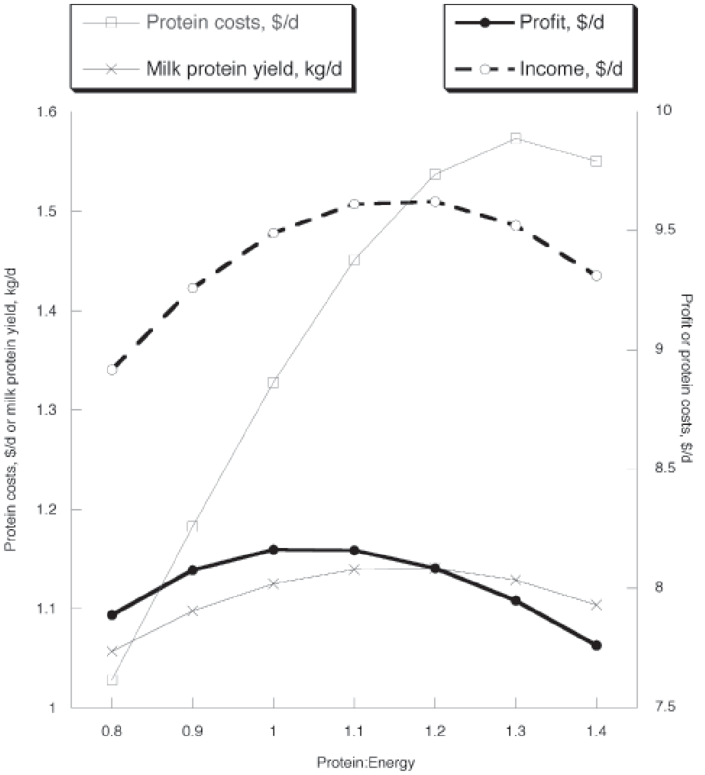

Figure 4. Expected evolution of milk protein yield, gross income from milk, protein costs associated with level of milk protein yield, and net profit (considering only protein costs) as affected by the protein to energy ratio.

A meta-analysis conducted by Bach et al. (2006) showed that to maximize milk protein yield, the optimum protein to energy ratio should be about 1.1 (Figure 3) or a 1.7 Mcal/kg energy dense diet should contain 18.7% CP. However, this optimum may not coincide with the maximum profit. Figure 4 shows the evolution of milk protein yield, gross income from milk, protein costs associated with the level of milk protein yield, and net profit (considering only protein costs) as affected by the protein to energy ratio. From this analysis, it can be concluded that the optimum dietary protein to energy ratio to maximize profit, not yield, would be about 1.0.

Just to illustrate the impact of EPU on profits, take the example of soybean meal. Current soybean prices are about $US 380/MT. Which means that a MT of protein from soybean meal is about $US 860. If this protein is fed in a ration that has an EPU of 28%, the cost of producing 1 MT of milk protein would be about $US 3,084; whereas, if the same soybean meal was fed in ration with an EPU of 35%, the cost of producing a MT of milk protein would be $US 2,467; yielding a profit of more than $US 500/MT of milk protein produced.

IMPROVING PROFITS THROUGH MANAGEMENT

A common practice in most dairy herds aiming at improving profits consists of feeding different rations in function of milk production. This is thought to reduce feed costs, but it is not always the case. When high-producing animals are moved from a high to a low-nutrient dense diet there is a loss of production. The decision of making two different rations will only be economical if the loss in milk production (in dollars) plus the labor costs associated with the two different rations do not offset the potential savings due to feeding a low-nutrient dense diet. Furthermore, it is likely that feed efficiency also diminishes when formulating a ration that is less expensive (typically including less digestible ingredients), thus it is also important to account for the loss in feed efficiency, not only milk production, when making groups of animals.

Feeding a TMR offers the great advantage of simplicity as it allows feeding large numbers of cows in groups. In addition, theoretically, with TMRs each mouthful of feed the cow consumes contains a balanced combination of nutrients. However, because cows do sort (Maulfair et al., 2010), the composition of the TMR actually changes throughout the day and the balanced nutrient profile may become imbalanced. Furthermore, cows need to consume a balanced-nutrient meal of the optimal size. In other words, because intake is variable between cows and also within cows depending on stage of lactation, BW, etc., a “balanced” mouthful of a TMR for one cow may be an “imbalanced” mouthful for another cow. For example, according to the NRC (2001) a cow producing 27 kg of milk per day needs 38 Mcal of NE_L and about 3.2 kg of CP. A cow with such a level of milk production would consume 20.6 kg/d, thus the TMR should have a nutrient density of 1.44 Mcal of NE_L/kg and 15.4% CP. If that TMR were consumed by a cow producing 30 kg of milk per day, according to NRC (2001) dry matter intake would increase by 1 kg and she would need additional 2 Mcal of NE_L and 103 g of additional metabolizable protein. If she consumes 21.6 kg of the TMR balanced for 27 kg of milk per day she would consume 1.42 additional Mcal (while she needed 2 additional Mcal) and 35 additional grams of metabolizable protein (while she needed additional 103 g). Thus, energy and protein consumption is progressively lagging behind needs at different proportions as milk production increases and the cow continues to eat the same TMR (Figure 5). Thus, within a given group of cows consuming the same TMR, as milk yield deviates from the level used to balance the TMR each mouthful of TMR consumed by the cow becomes progressively more imbalanced. Thus, when making groups of cows it is important to minimize the spread in milk production among the cows within a group.

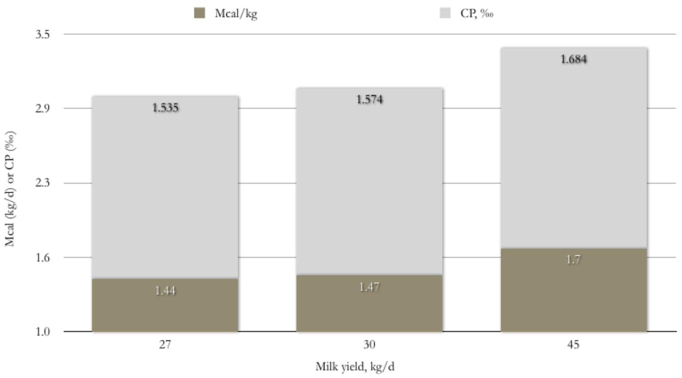

Figure 5. Evolution of energy and protein concentration (Mcal and %, respectively) needed in the dry feed consumed by cows as affected by level of milk production and consequent increase in dry matter intake according to NRC (2001).

There are other aspects of management beyond those related to nutrition that will have impact on profitability of dairy herds. We conducted a study (Bach et al., 2008) involving 47 herds that offered exactly the same ration and shared a similar genetic base and observed a range in average milk production per cow between 20.6 to 33.8 kg/d. This relatively large difference in milk production illustrates the importance that non-dietary factors exert on determining milk performance of a herd. Despite the fact that all herds fed the same diet, the amount of feed delivered per cow ranged from 16.2 to 24.8 kg of DM/d. As expected, the amount of feed delivered per cow was positively correlated with milk production. Reasons for the observed variation in intake could be, in part, attributed to the management and housing conditions of the animals. However, the ratio of free stalls to lactating animals was the only measured parameter that tended to be correlated with the amount of feed delivered per cow daily.

In the same study, herds that fed to ensure feed refusals tended to produce more milk (29.1 ± 0.61 kg/d) than those that did not allow feed refusals (27.5 ± 0.73 kg/d). Surprisingly, no relationship was found between the number of feeders or centimeters of feedbunk space per cow and animal performance, incidence of lameness, or culling rate. The average feed bunk space was 69 cm/animal (with less than 20% of herds with less than 50 cm of feed bunk per animal), which could be considered sufficient to avoid any limitations of feed intake and animal performance. In fact, Grant and Albright (2001) concluded that the minimum critical bunk space for dairy cattle was 20 cm/head.

Producers that did push up the feed performed this task 2 ± 0.67 (mean ± SD) times daily. Pushing up the feed had a positive impact on milk production. Herds that pushed-up feed produced on average 28.9 kg/d, whereas those that did not produced only 25.0 kg/d. However, there was no relationship between the number of daily feed push-ups and milk yield. Some producers pushed the feed up to 4 times per day, whereas others just pushed feed once daily. Although some researchers have noted a slight increase in feeding activity of cows experiencing more frequent feed push-ups (Menzi and Chase, 1994), a more recent study concluded that additional daily feed push-ups did not significantly increase feeding activity when compared with a baseline schedule of 2 feedings and 2 feed push-ups/d (DeVries et al., 2003). However, there are no studies that evaluate the relationship between changes in feeding behavior associated with pushing the feed and milk production. Perhaps, the most important aspect might be to ensure that cows have feed within their reach at all times (Albright, 1993; Grant and Albright, 1995).

Bach et al. (2008) found a positive relationship between the number of stalls per cow and milk production (Figure 6). When considering the maintenance status of the cubicle, both the number of stalls and the level of maintenance accounted for about 38% of the variation observed in milk production, with the stalls worst maintained resulting in the poorest performance, the intermediate stalls in the intermediate production, and the best maintained in the highest milk production per cow. In addition, a negative relationship between the number of stalls per cow and the proportion of cows culled was found. Grant and Albright (2001) reported that significant overcrowding appears to reduce feeding

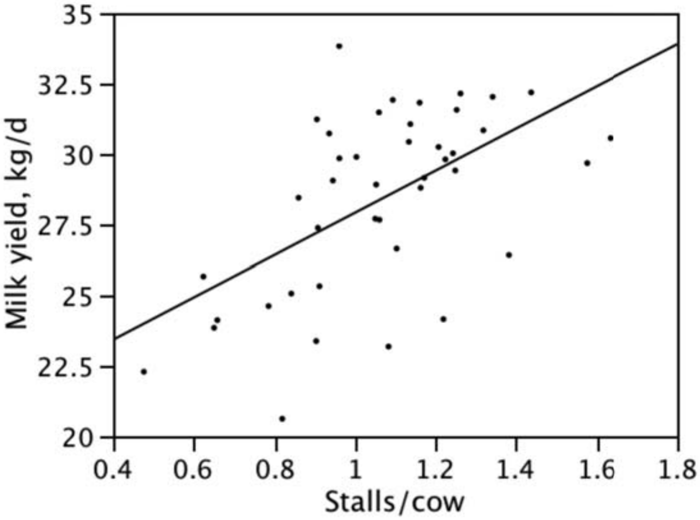

Figure 6. Relationship between the ratio of stalls per cow and milk production of dairy cattle in different herds (n = 47) feeding the same lactating ration. Milk yield = 20.4 + 7.5 × stall/cow.

activity, alter resting behavior, and decrease rumination activity. It could be speculated that the better the maintenance and the greater the availability of stalls, the longer resting times of cows and thus greater milk production. Increases in stocking density have been associated with increased risk of lameness (Wierenga and Hopster, 1990) and reduced feeding times (Huzzey et al., 2006). This association could have an impact on the proportion of cows that are involuntarily culled. In any case, it is important to note that in the study of Bach et al. (2008), only 29% of the herds had less than 1 stall per cow. When data from herds with at least 1 stall per cow was regressed against milk production no statistically significant relationship was found (r = 0.22; *P* = 0.27). These data indicate that over-stocking may have negative consequences on milk performance and under-stocking should have no positive impact on milk yield.

Table 1. Regression coefficients for several non-dietary factors in relation to daily average milk production (kg/d).

Term	Estimate	Std Error	*P* value
Intercept	28.37	4.434	< 0.01
Age at first calving, months	-0.26	0.126	0.05
Presence of feed refusals (yes=1, no=0)	0.64	0.372	0.09
Number of stalls / number of cows	5.91	1.468	< 0.01
Feed is pushed (yes=1, no=0)	1.29	0.640	0.05

Bach et al. (2008) developed a predictive regression equation that accounted for the effect of average age at first calving for heifers, presence or absence of feed refusals, ratio of number of free stalls per lactating cow, and whether feed was pushed up in the feed bunk and was able to explain 56% of the observed variation in milk production (Table 1). Thus, these four factors could be considered the most important non-dietary factors that impact milk production in the dairy herds under study.

CONCLUSIONS

When evaluating herd performance, one should focus on objective data and values that are sensitive, which implies that small deviations from target can be detected relatively rapidly and easily. Monitoring and managing feed costs starting by acquiring feed adequately, following by a proper mixing order in the TMR wagon, and finishing by splitting cows in the right groups and determining the optimum milk production of each of the them to generate maximum return (based on feed efficiency and feed costs) are effective ways of improving profits.

Last, milk production is affected by a number of aspects, but non-nutritional factors can account for as much as 13 kg/d of milk difference. The most important reasons for this variance in milk production are the rearing system of heifers (illustrated as age at first calving), feed bunk management (presence of refusals and pushing the feed), and the number of free stalls available per lactating cow. These factors explain about half of the observed variation in milk production not attributable to nutrition.

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Playing hide and seek with milk performance measures

ALEX BACH
DEPARTAMENT OF RUMINANT PRODUCTION
IRTA

Introduction

- Managing a dairy herd professionaly requires taking decissions objectively based on data
- Producers nowdays have a wealth of data that could (should) be used to take decissions
- Making decissions based on experience, expertise, feeling should be avoided

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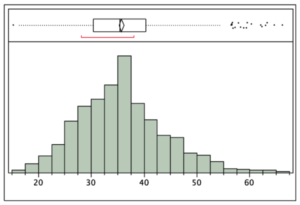
Data

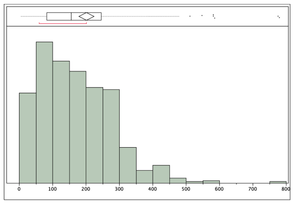
- When looking at data we need to bear in mind:
  - **Distribution**

Yield



Median: 35.5
Average: 35.7

DIM



Median: 155
Average: 210

Data

- **Lag**

Time elapsed between a change occurs and that change is reflected in the average. i.e. Calving interval and reproductive performance "today"

2013 CI: 380
2014 CI: 420

Do we have a problem?

We had a problem in 2012 (our cows did not conceive well)
Today? We do not know. Can we make a decision?

Data

- **Momentum**

Refers to the responsiveness of the average. i.e. ADG over the entire rearing period,…

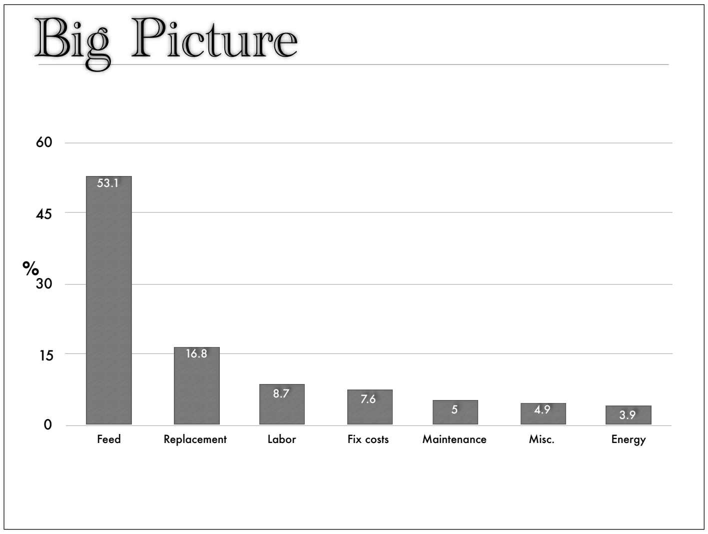
We add an additive to fresh cows
Look at milk bulk tank to see a change

Data

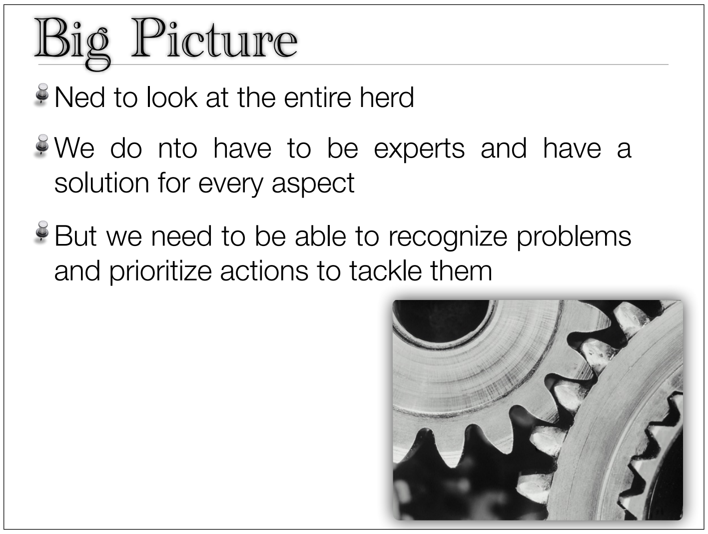
- **Bias**

Measures the difference of an average from that of a "larger" population

i.e. Conception rate (culled cows?)

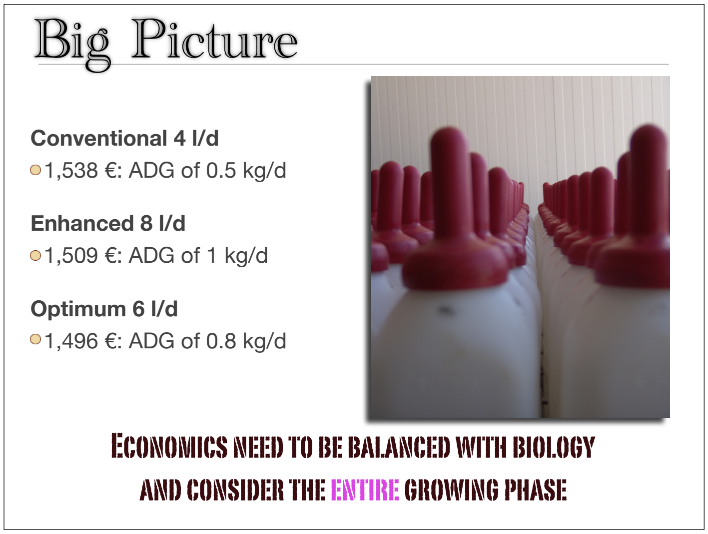


Big Picture



Big Picture

- Ned to look at the entire herd
- We do nto have to be experts and have a solution for every aspect
- But we need to be able to recognize problems and prioritize actions to tackle them



Big Picture

Conventional 4 l/d

- 1,538 €: ADG of 0.5 kg/d

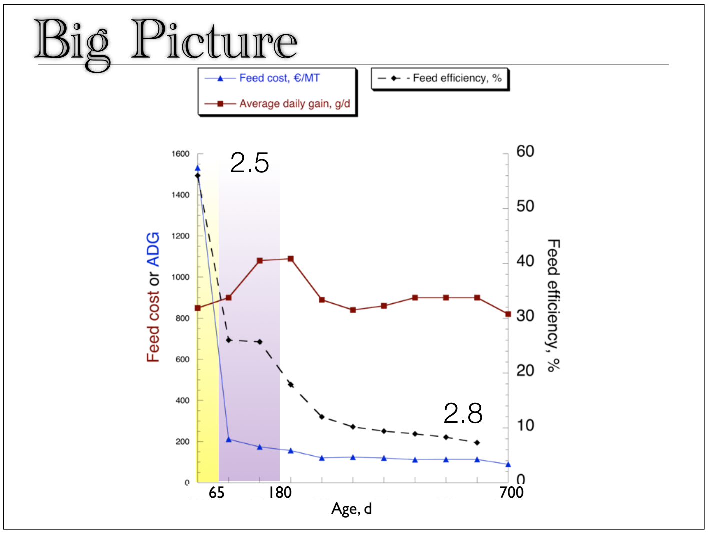
Enhanced 8 l/d

- 1,509 €: ADG of 1 kg/d

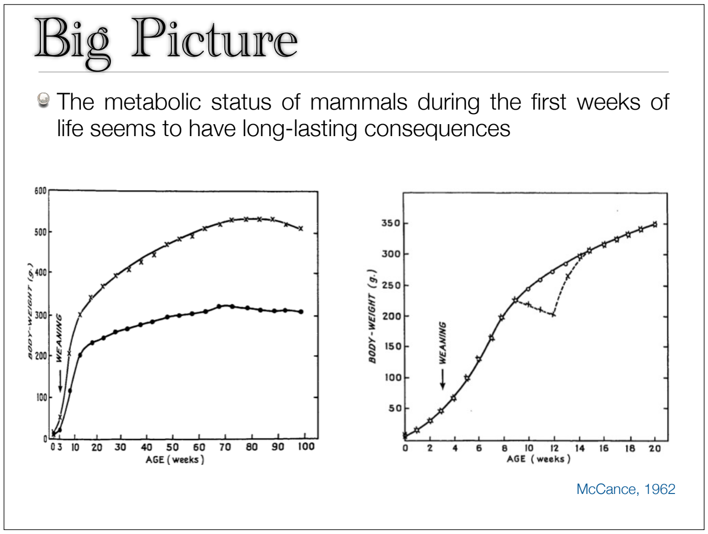
Optimum 6 l/d

- 1,496 €: ADG of 0.8 kg/d

ECONOMICS NEED TO BE BALANCED WITH BIOLOGY AND CONSIDER THE ENTIRE GROWING PHASE



Big Picture



Big Picture

- The metabolic status of mammals during the first weeks of life seems to have long-lasting consequences

McCance, 1962

Big Picture

Authors	X	ADG	Milk	Significance
Holloway and Totusek, 1973	Mom	N/A	+10%	$P < 0.10$
Bar-Peled et al., 1997	Mom 3X vs MR 2X	+100 g	+4%	$P < 0.10$
Shamay et al., 2005	WM 2X vs MR 1X	+300 g	+4%	$P < 0.05$
Moallem et al., 2010	WM 2X vs MR 2X	+100 g	+10%	$P < 0.05$
Davis Rincker et al., 2009	MR 2X	+200 g	+4%*	$P < 0.10$
Terré et al., 2009	MR 2X	+100 g	+6%	NS
Raeth-Knight et al., 2009	MR 2X	+150 g	+5%	NS
Morrison et al., 2009	MR 2X	+150 g	-1%	NS

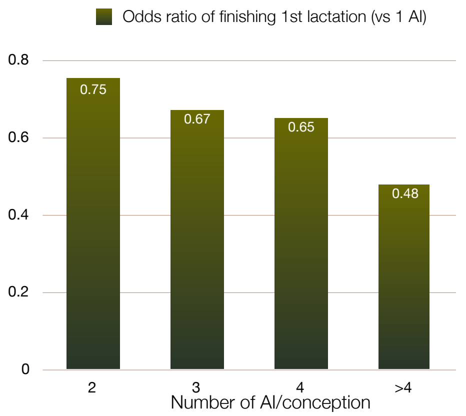
Bach, 2012 (JAS)

226 kg Milk/100 g
$P < 0.05$

Pro-Active Management

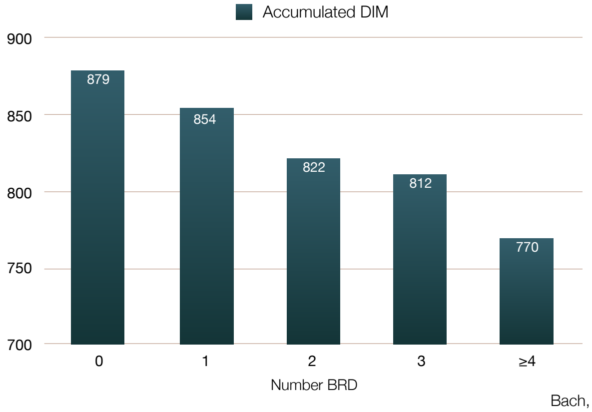
- The return on the investment allocated from birth to first lactation is commonly not fully recovered until at least the end of first lactation
- Voluntary culling decisions based on profit consist of substituting a cow with a replacement on the basis that the latter is expected to be more profitable and not because the cow being replaced was not profitable
- If the expected longevity/performance of a replacement is not attained, then it is likely that the culling decision will be unprofitable or less profitable than initially expected

Pro-Active Management



Bach, 2011

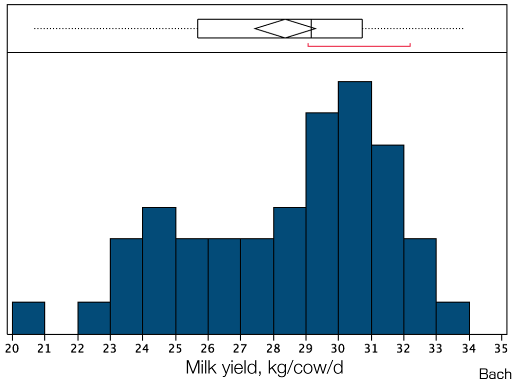
Pro-Active Management



Bach, 2011

Non-Nutritional Factors

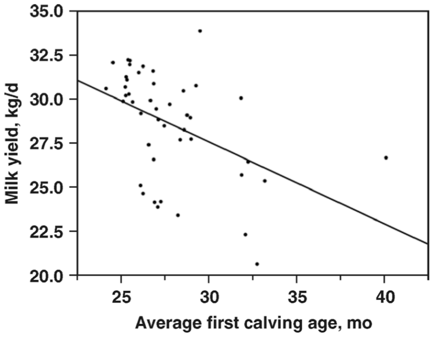
- Common TMR - Substantial differences in yield



Bach et al., 2008

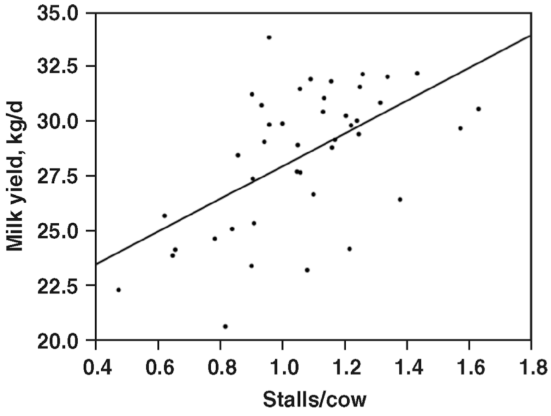
Non-Nutritional Factors

- Average breeding age: 16.9 months
- Average AFC 27.7 months



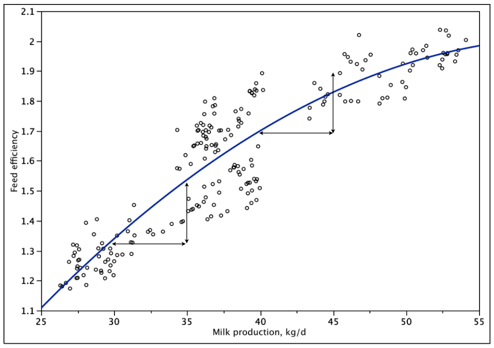
Bach et al., 2008

Non-Nutritional Factors

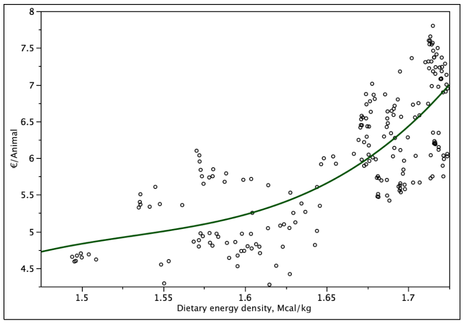


Bach et al., 2008

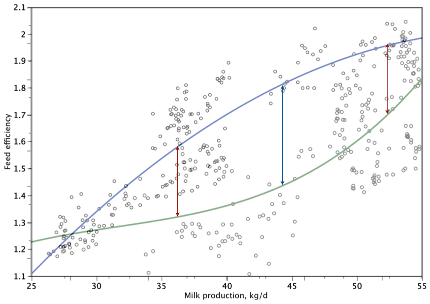
Nutrition



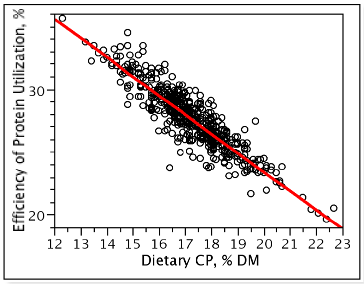
Nutrition



Nutrition



Nutrition



Bach et al., 2006

SBM at 370 $US/Ton → 44% → 840 $US/Ton of CP

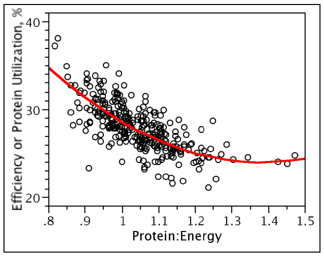
35%

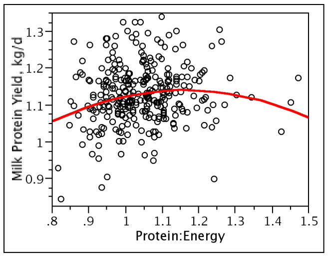
2,400 $US/Ton of milk protein

22%

3,820 $US/Ton of milk protein

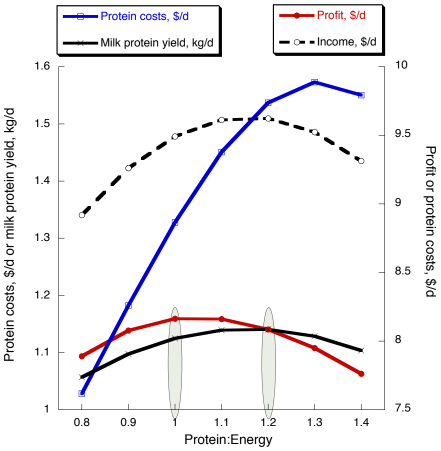
Nutrition





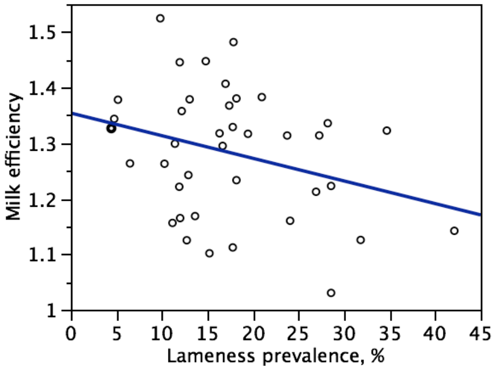
Bach et al., 2006

Nutrition



Bach et al., 2006

Nutrition



Guasch and Bach, 2010

Hypothesis

- A partial replacement of inorganic trace minerals (**ITM**) by homologous chelated trace minerals (**CTM**) would improve animal performance (both milk and reproduction) and leg health

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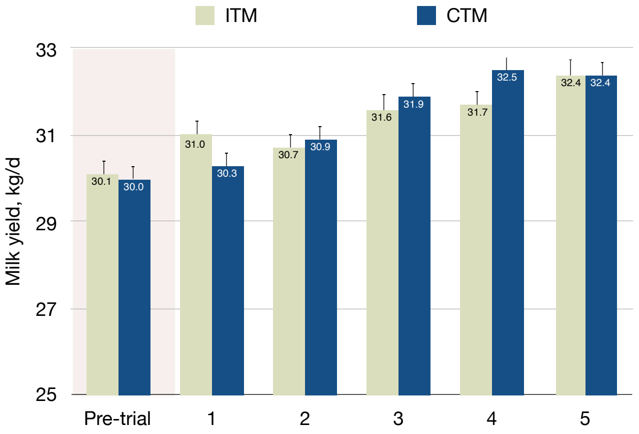

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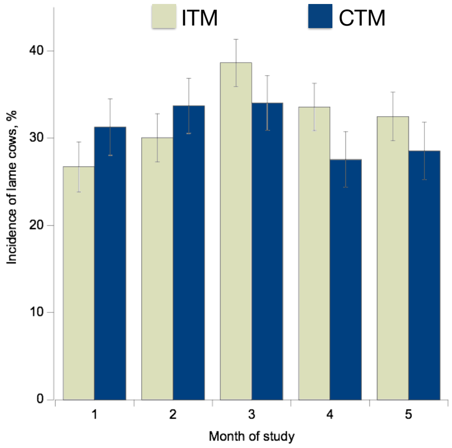

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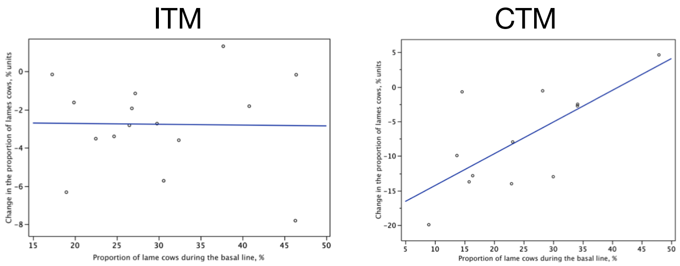


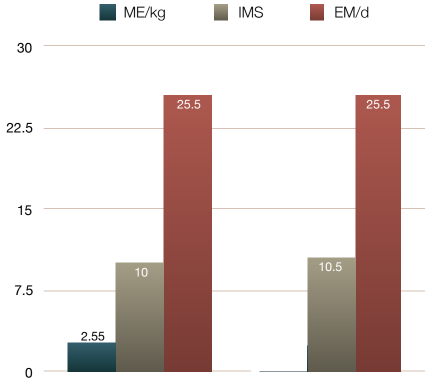
Nutrition

Item	Treatment		SE	P-value		
	ITM	CTM		Treatment	Month	TxM
Conception rate at 1st AI, %						
All cows	29.4	36.6	-	-	-	-
Odds ratio (95% CI)	1.29			0.15	<0.001	**<0.001**
Cows with ≥30 d on treatment	26.8	35.9	-	-	-	-
Odds ratio (95% CI)	2.90			**0.003**	0.45	<0.001

Nutrition

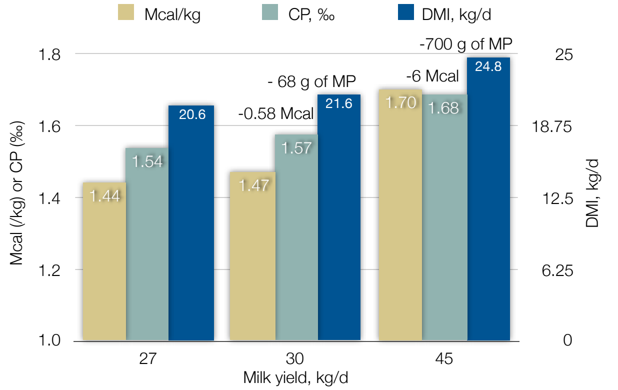
203 €/MT ~ 2.03 €/d

190 €/MT ~ 2.0 €/d

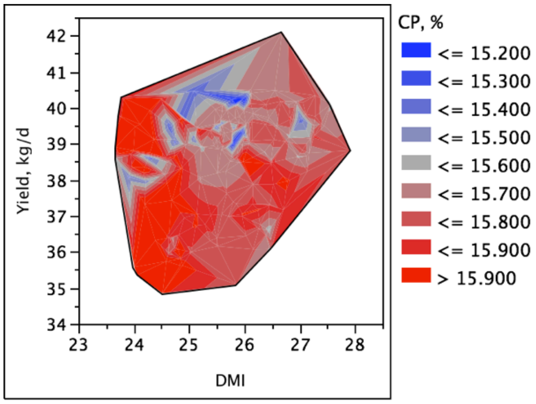


Nutrition

- A "balanced" mouth-full for cow A will be an "imbalanced" mouth-full for cow B



Interpretation



Interpretation

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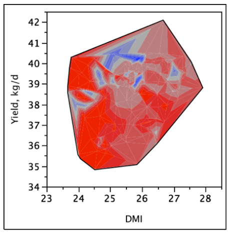

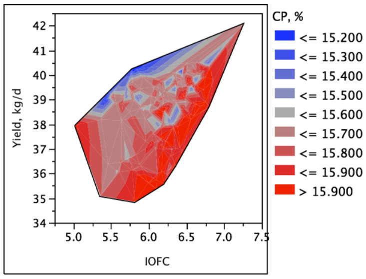

Interpretation

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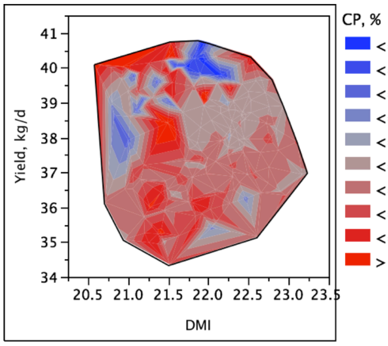

Yield – 38 kg/d
DIM ~ 130
PMC

Interpretation

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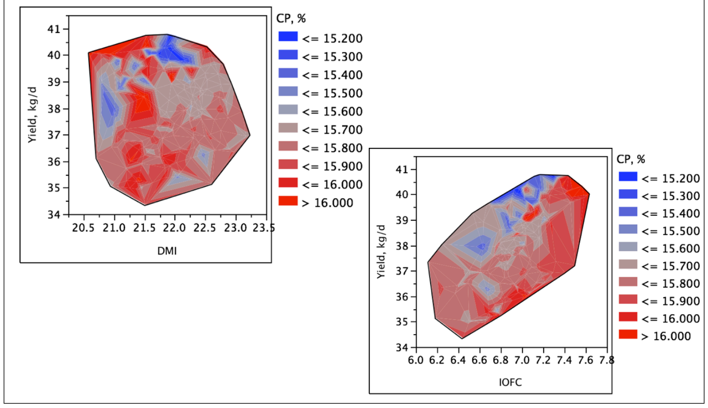

Summary

- Make managemet decision based on data
- Generating profit starts from properly rearing calves
- Milk production is affected by a number of aspects, but non-nutritional factors can account for as much as 13 kg/d of milk difference
- A partial replacement of inorganic organic forms of Cu, Mn, and Zn for Mintrex® improved hoof health in herds with a relatively low prevalence of lame cows
- Cows that were exposed to Mintrex® for at least 30 d had increased chances of becoming pregnant at first AI
- Feed (nutrient) efficiency is the driving force behind profit
- Set the right objectives

Thank you

alex.bach@icrea.cat

Playing hide and seek with milk performance measures

ALEX BACH
DEPARTAMENT OF RUMINANT PRODUCTION
IRTA

Introduction

- Managing a dairy herd professionaly requires taking decissions objectively based on data
- Producers nowdays have a wealth of data that could (should) be used to take decissions
- Making decissions based on experience, expertise, feeling should be avoided

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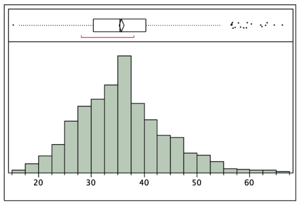
Data

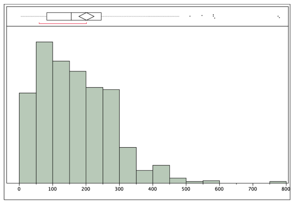
- When looking at data we need to bear in mind:
  - **Distribution**

Yield



Median: 35.5
Average: 35.7

DIM



Median: 155
Average: 210

Data

- **Lag**

Time elapsed between a change occurs and that change is reflected in the average. i.e. Calving interval and reproductive performance “today”

2013 CI: 380
2014 CI: 420

Do we have a problem?

We had a problem in 2012 (our cows did not conceive well)
Today? We do not know. Can we make a decision?

Data

- **Momentum**

Refers to the responsiveness of the average. i.e. ADG over the entire rearing period,…

We add an additive to fresh cows
Look at milk bulk tank to see a change

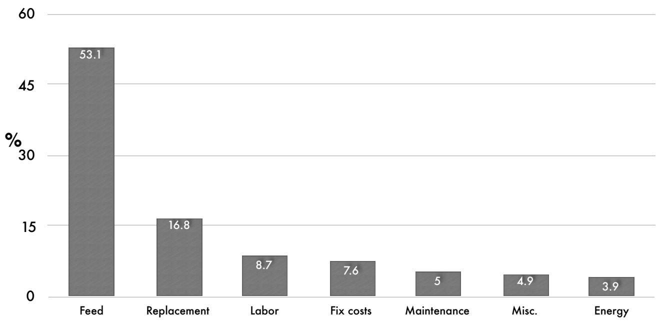
Data

- **Bias**

Measures the difference of an average from that of a “larger” population

i.e. Conception rate (culled cows?)

Big Picture



Big Picture

- Ned to look at the entire herd
- We do nto have to be experts and have a solution for every aspect
- But we need to be able to recognize problems and prioritize actions to tackle them

Big Picture

Conventional 4 l/d

- 1,538 €: ADG of 0.5 kg/d

Enhanced 8 l/d

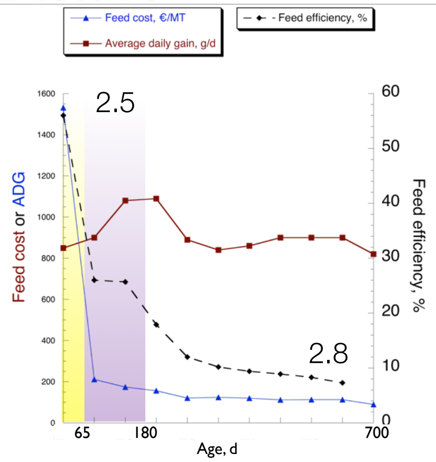
- 1,509 €: ADG of 1 kg/d

Optimum 6 l/d

- 1,496 €: ADG of 0.8 kg/d

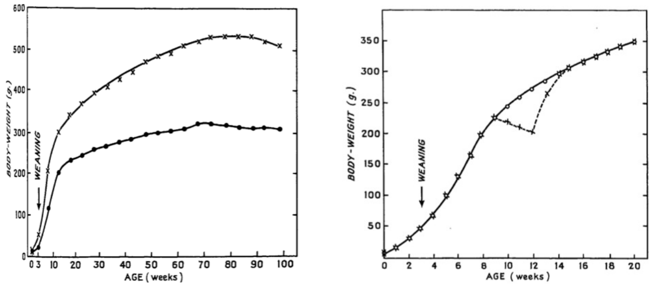
ECONOMICS NEED TO BE BALANCED WITH BIOLOGY AND CONSIDER THE ENTIRE GROWING PHASE

Big Picture



Big Picture

- The metabolic status of mammals during the first weeks of life seems to have long-lasting consequences



McCance, 1962

Big Picture

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Raeth-Knight et al., 2009	MR 2X	+150 g	+5%	NS
Morrison et al., 2009	MR 2X	+150 g	-1%	NS

Bach, 2012 (JAS)

226 kg Milk/100 g
$P < 0.05$

Pro-Active Management

- The return on the investment allocated from birth to first lactation is commonly not fully recovered until at least the end of first lactation
- Voluntary culling decisions based on profit consist of substituting a cow with a replacement on the basis that the latter is expected to be more profitable and not because the cow being replaced was not profitable
- If the expected longevity/performance of a replacement is not attained, then it is likely that the culling decision will be unprofitable or less profitable than initially expected

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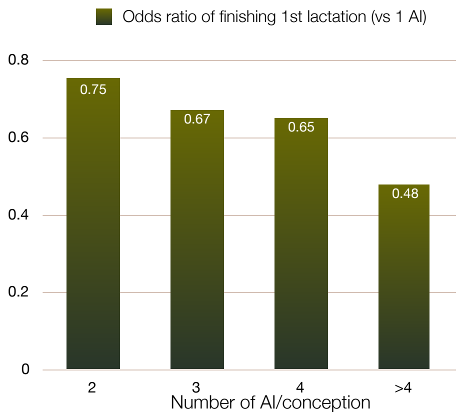
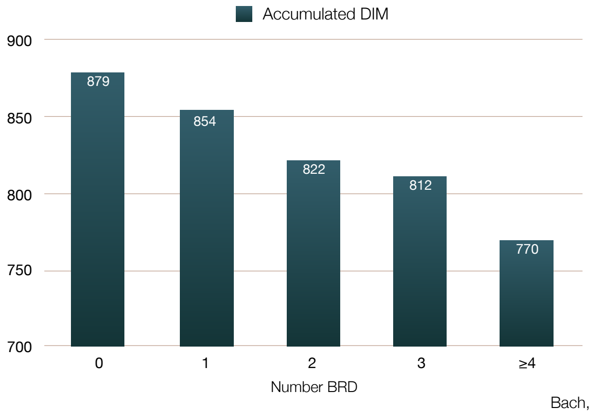
Pro-Active Management



Bach, 2011

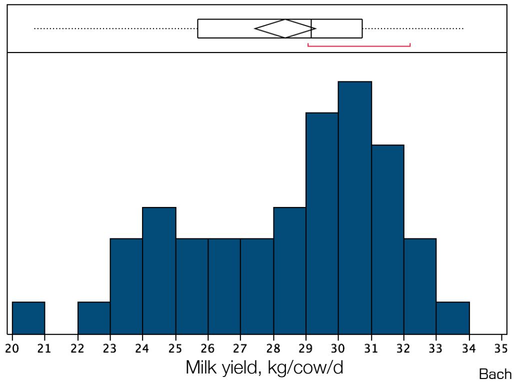
Pro-Active Management



Bach, 2011

Non-Nutritional Factors

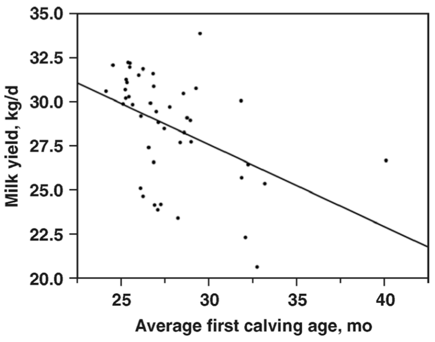
- Common TMR - Substantial differences in yield



Bach et al., 2008

Non-Nutritional Factors

- Average breeding age: 16.9 months
- Average AFC 27.7 months



Bach et al., 2008

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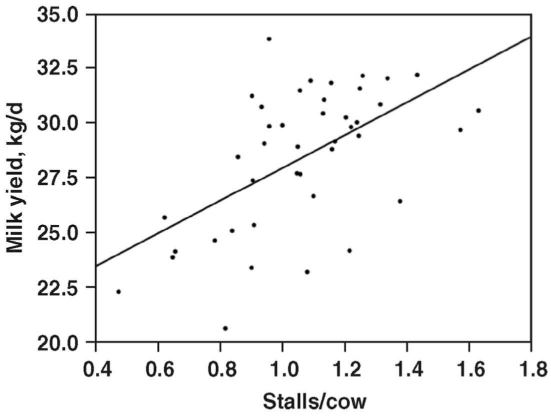

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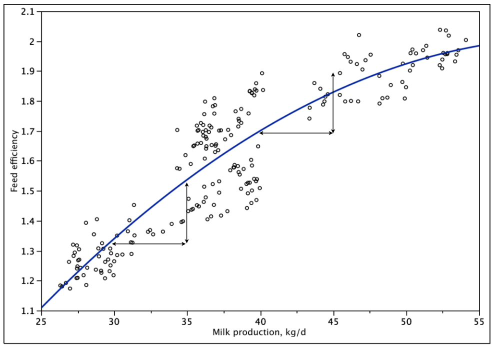
Nutrition



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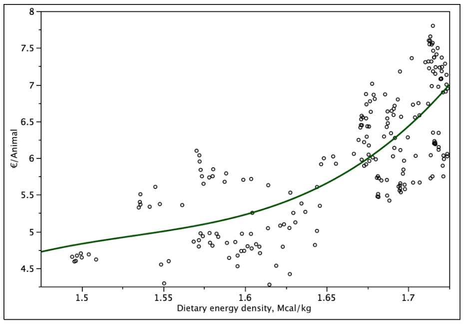

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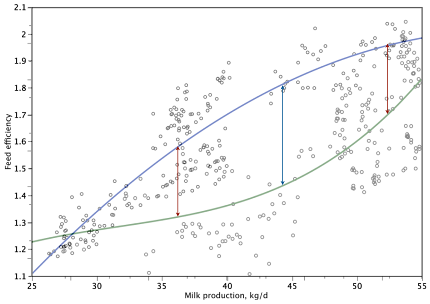

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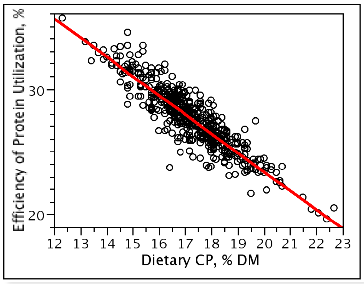


Bach et al., 2006

SBM at 370 $US/Ton → 44% → 840 $US/Ton of CP

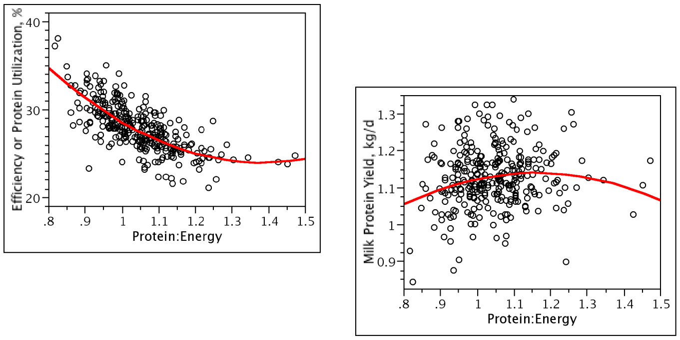
35%

2,400 $US/Ton of milk protein

22%

3,820 $US/Ton of milk protein

Nutrition



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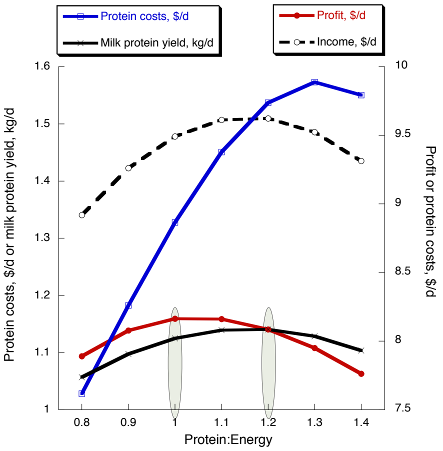

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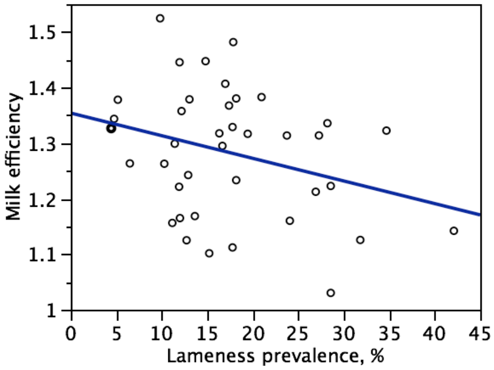

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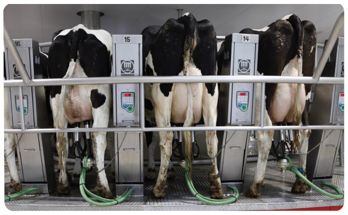

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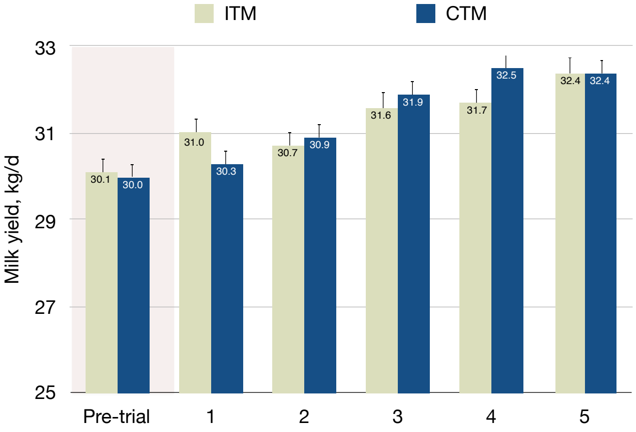

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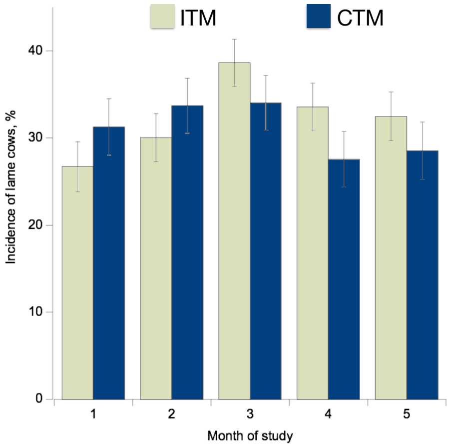

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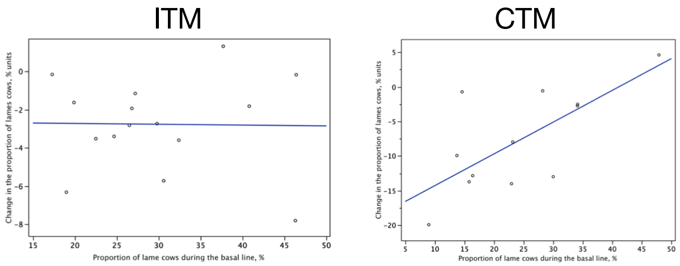

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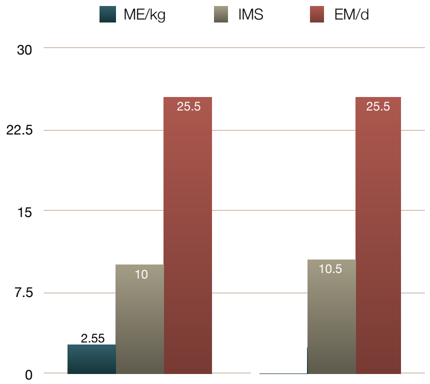
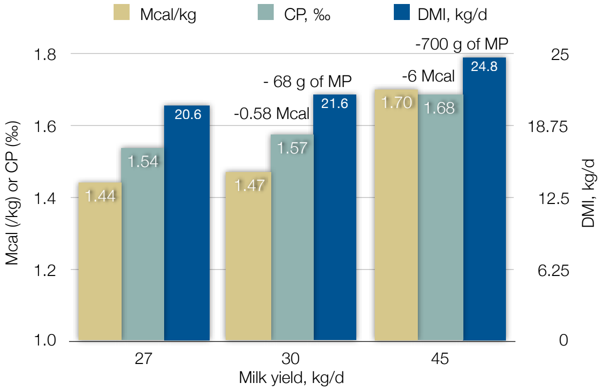


Nutrition

- A "balanced" mouth-full for cow A will be an "imbalanced" mouth-full for cow B



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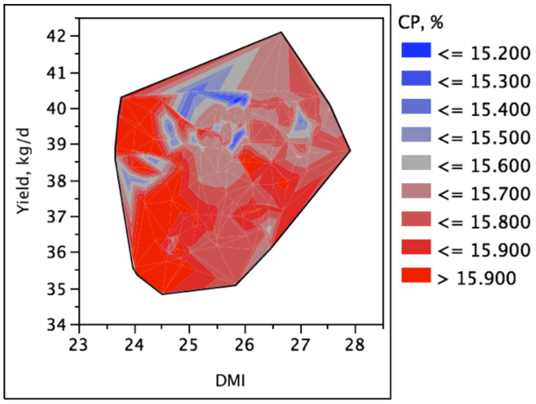

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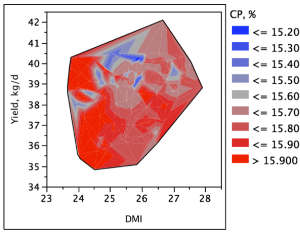

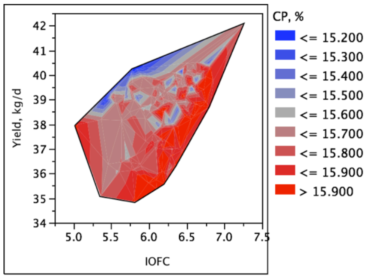

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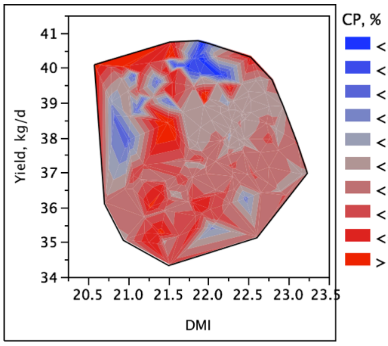

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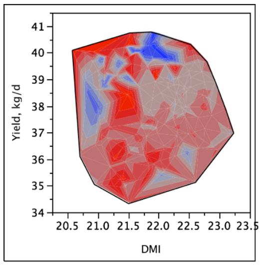

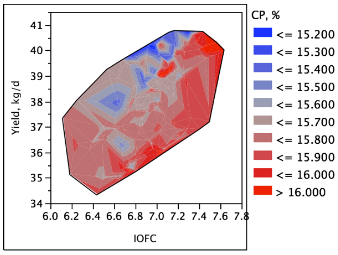

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Thank you

alex.bach@icrea.cat

Is forage needed for calves?

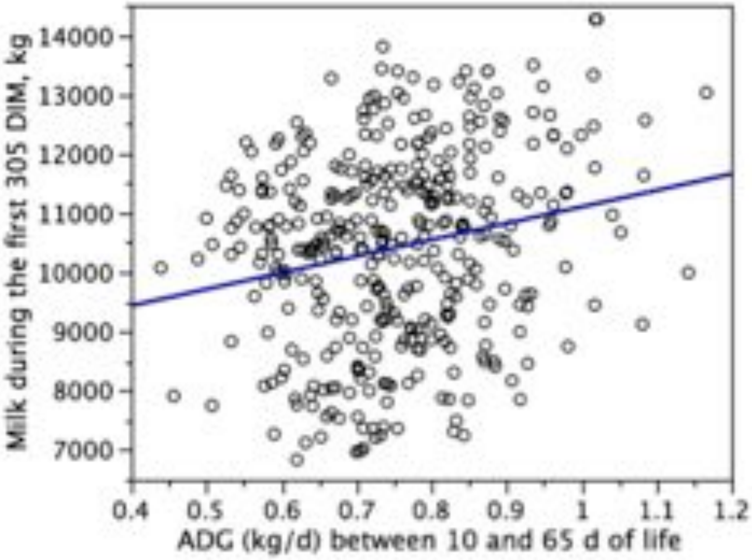
Xavier Suárez and Alex Bach

PROVIMI NORTH AMERICA

ICREA (CATALAN INSTITUTION FOR RESEARCH AND ADVANCED STUDIES)
DEPARTMENT OF RUMINANT PRODUCTION, IRTA (INSTITUTE FOR
RESEARCH AND TECHNOLOGY IN AGRIFOOD)

Objectives

- Maximize growth



Bach and Ahedo, 2008

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Several abstracts omitted

226 kg Milk/100 g
$P < 0.05$

Bach, 2012 (JAS)

- Let us hear from you…

Should calves be provided with forage?

A. Yes

B. No

C. Only after weaning

- Let us hear from you…

How much protein is in your starter?

A. 18

B. 20

C. 22

D. Don’t know

- Let us hear from you…

How much starch is in your starter?

A. 15

B. 30

C. 45

D. Don’t know

The effect of feeding forage on starter intake

- Most nutritionists agree that calves need grain, but do they need forage?
- In the last few years the debate over feeding forage to calves has been heated, research has yielded inconsistent results on the effects of feeding forage on starter intake.

Why?

  - We call them calves from birth to about 6 months of age
  - Starter is starter, no matter the ingredient or nutrient composition
    - 10 or 50% starch, its just starter…
  - Particle size of starter has a great impact on starch fermentability and rumen pH
    - 20 or 60% texturized, its just starter…
  - What about the forage? Straw or corn silage, it is all forage

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PENNSTATE

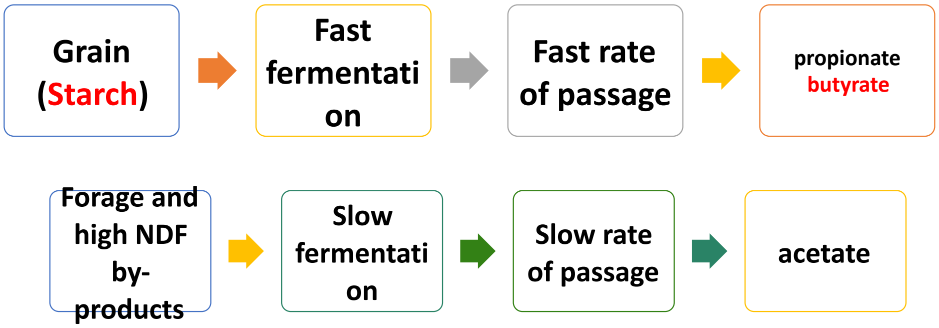
Rumen development

Milk

Milk + hay

Milk + grain

Papillae growth stimulation: butyrate > propionate > acetate



Grain (Starch)

Fast fermentation

Fast rate of passage

propionate butyrate

Forage and high NDF by-products

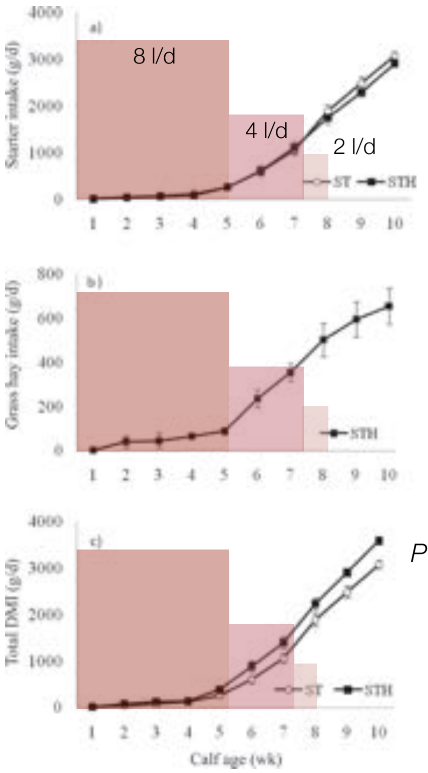
Slow fermentation

Slow rate of passage

acetate

Feeding forage

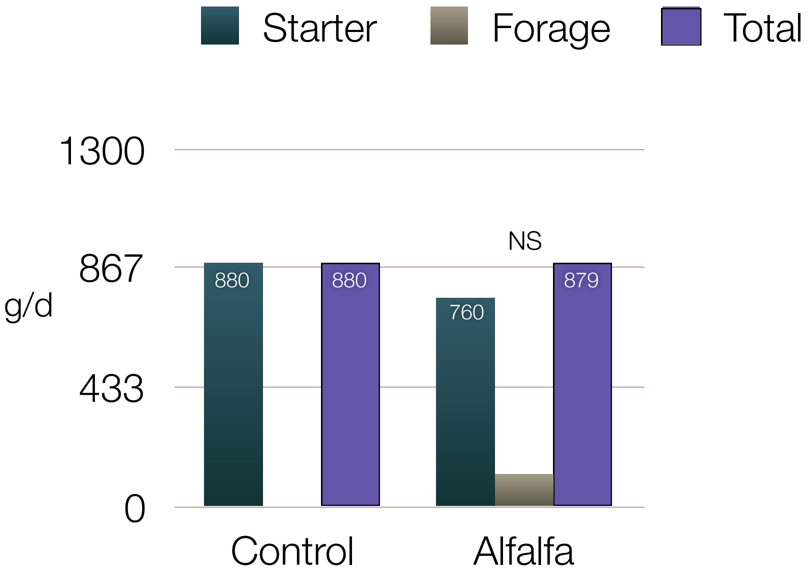
- Khan et al. (JDS, 2011)
  - Access to starter (ST)
  - Access to grass hay + starter (ST+STH)



$P<0.05$

Feeding forage

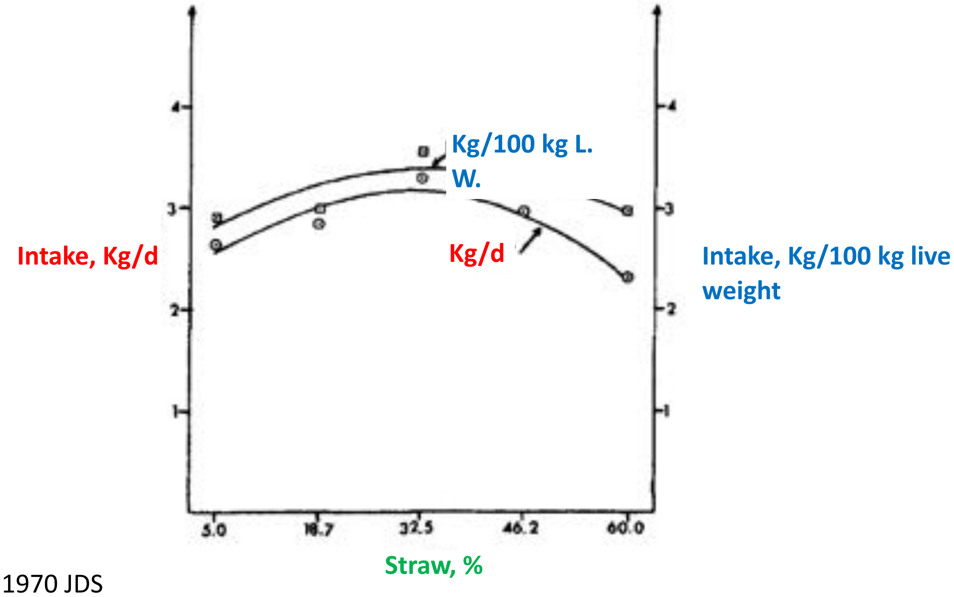
- Castells et al. (JDS, 2012) reported that offering chopped (2 cm) forages (except alfalfa) increases starter and total solid feed intake



Forage effects on starter intake

% DM	Treatments	Age, wk	Effect
Hibbs et al., 1956	4:1, 3:2 and 2:3 F:C ratio	< 12	-
Stobo et al., 1966	hay ad lib + 0.45, 0.91, 1.36, 2.27 kg/d concentrate	3 – 12	-
Jahn et al., 1970	5, 19, 32, 46, 60 %straw + 39% basal diet + sugar & starch	8 – 20	greater at 32%
Kincaid. 1980	Concentrate (C), C + alfalfa hay or alfalfa pellets	< 12	+ DMI
Thomas and Hinks, 1982	C, C + chopped or long straw, C + 18% straw pellets	< 3	=
		3 – 5	18% straw pellet +
		5 – 9	18% straw pellet +
Cummins, 1982	C, 40% grass hay, ground or chopped	8 – 12	ground > C > chopped
Coverdale et al., 2004	C, C + 7.5 or 15 % chopped grass hay	< 4	=
		4 -	+
Hill et al., 2008	5% chopped hay	< 8	=
	5% chopped hay	8 – 12	-
	5 vs. 15%	8 – 12	> for 5%
Khan et al., 2011	ad lib. chopped hay	< 5	=
		6 – 10	SI vs. DMI
Castells et al., 2012	triticale silage	4 (2) <	+
	oats hay	5 (3) <	+
	barley straw	6 (4) <	+
Terre et al., 2013	chopped oat hay	5 <	=
		5 – 9	+ DMI
Castells et al., 2013	alfalfa hay + C, oats hay + C	1 – 8	=

Effect of straw on feed intake



Jahn et al. 1970 JDS

Effects of fiber and ratio of starch to sugar on performance of ruminating calves

Ration	Ingredient, %				
	Basal	Straw	Starch	Sugar	Starch + Sugar
1	39	5.00	26.90	26.90	53.80
2	39	5.00	40.35	13.45	53.80
3	39	18.75	20.40	20.40	40.80
4	39	18.75	30.60	10.20	40.80
5	**39**	**32.5**	**13.70**	**13.70**	**27.40**
6	**39**	**32.5**	**20.55**	**6.85**	**27.40**
7	39	46.25	7.10	7.10	14.20
8	39	46.25	10.65	3.55	14.20
9	39	60.00	0.50	0.50	1.00
10	39	60.00	0.75	0.25	1.00

Jahn et al. 1970 JDS

Forage effects on starter intake

% DM	Treatments	Age, wk	Effect
Hibbs et al., 1956	4:1, 3:2 and 2:3 F:C ratio	< 12	-
Stobo et al., 1966	hay ad lib + 0.45, 0.91, 1.36, 2.27 kg/d concentrate	3 – 12	-
Jahn et al., 1970	5, 19, 32, 46, 60 %straw + 39% basal diet + sugar & starch	8 – 20	greater at 32%
Kincaid. 1980	Concentrate (C), C + alfalfa hay or alfalfa pellets	< 12	+ DMI
Thomas and Hinks, 1982	C, C + chopped or long straw, C + 18% straw pellets	< 3	=
		3 – 5	18% straw pellet +
		5 – 9	18% straw pellet +
Cummins, 1982	C, 40% grass hay, ground or chopped	8 – 12	ground > C > chopped
Coverdale et al., 2004	C, C + 7.5 or 15 % chopped grass hay	< 4	=
		4 -	+
Hill et al., 2008	5% chopped hay	< 8	=
	5% chopped hay	8 – 12	-
	5 vs. 15%	8 – 12	> for 5%
Khan et al., 2011	ad lib. chopped hay	< 5	=
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		5 – 9	+ DMI
Castells et al., 2013	alfalfa hay + C, oats hay + C	1 – 8	=

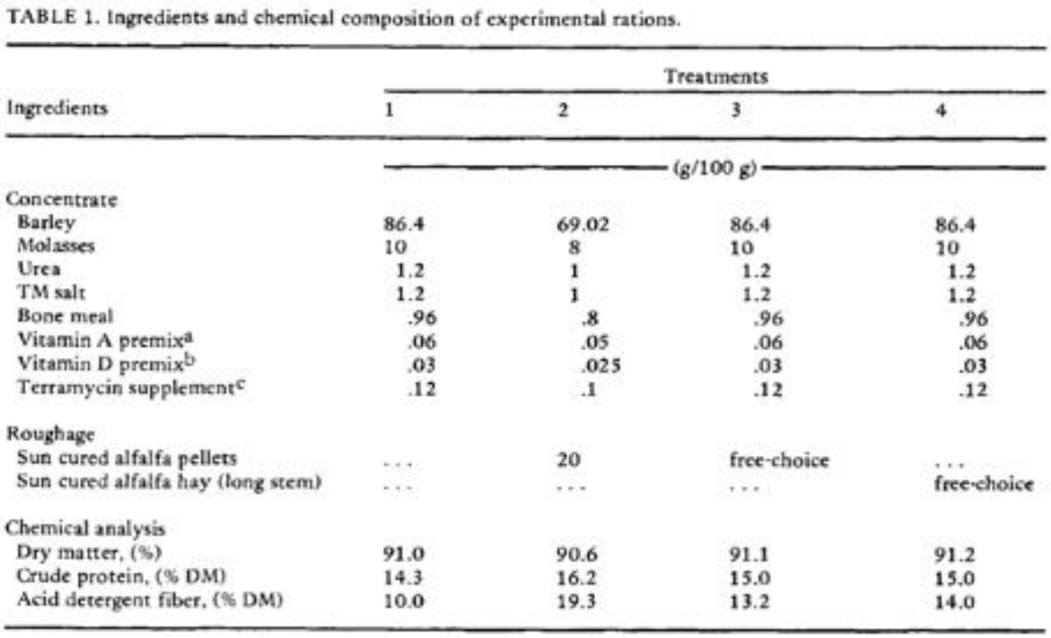

TABLE 1. Ingredients and chemical composition of experimental rations.

Ingredients	Treatments 1	2	3	4
	(g/100 g)			
Concentrate				
Barley	86.4	69.02	86.4	86.4
Molasses	10	8	10	10
Urea	1.2	1	1.2	1.2
TM salt	1.2	1	1.2	1.2
Bone meal	.96	.8	.96	.96
Vitamin A premix[a]	.06	.05	.06	.06
Vitamin D premix[b]	.03	.025	.03	.03
Terramycin supplement[c]	.12	.1	.12	.12
Roughage				
Sun cured alfalfa pellets	. . .	20	free-choice	. . .
Sun cured alfalfa hay (long stem)	. . .	. . .	. . .	free-choice
Chemical analysis				
Dry matter, (%)	91.0	90.6	91.1	91.2
Crude protein, (% DM)	14.3	16.2	15.0	15.0
Acid detergent fiber, (% DM)	10.0	19.3	13.2	14.0

Forage effects on starter intake

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Thomas and Hinks, 1982	C, C + chopped or long straw, C + 18% straw pellets	< 3	=
		3 – 5	18% straw pellet +
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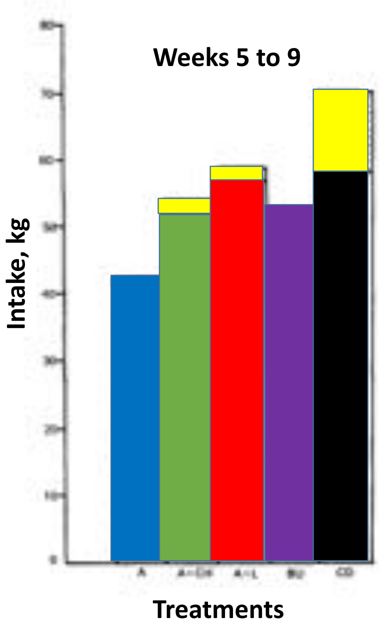
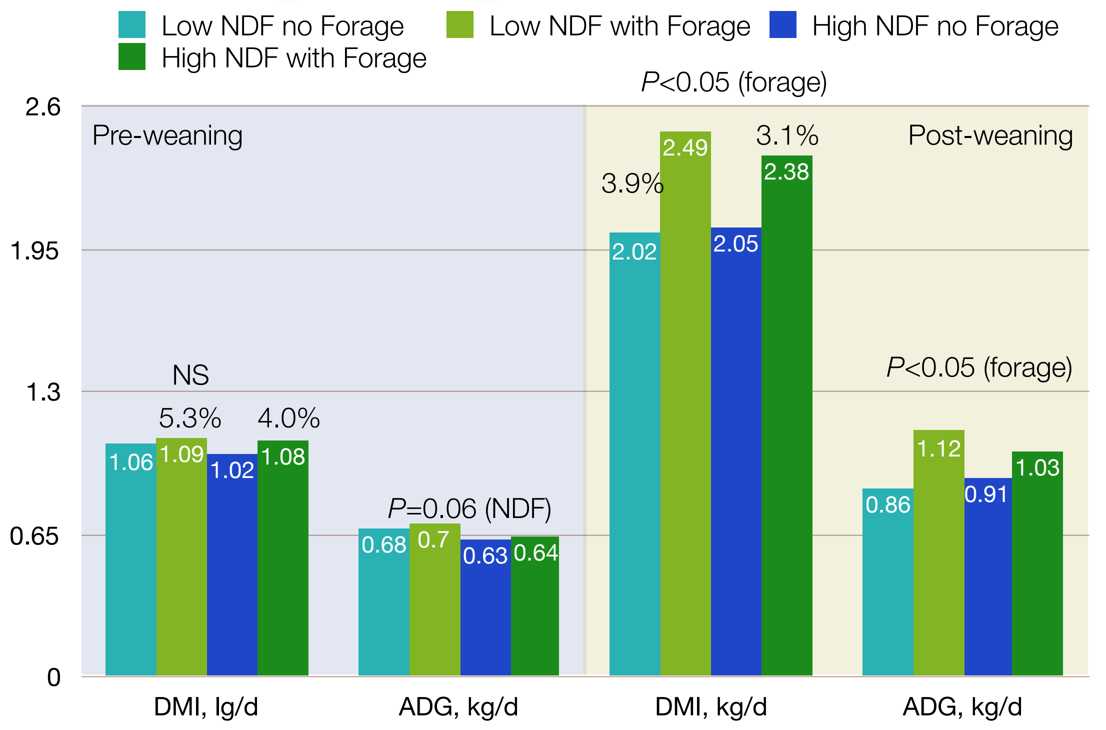


Treatments
🟦 Pellet
🟩 Pellet + chopped straw
🟥 Pellet + long straw
🟪 Pellet + sodium bicarbonate
⬛ Pellet containing 18% straw

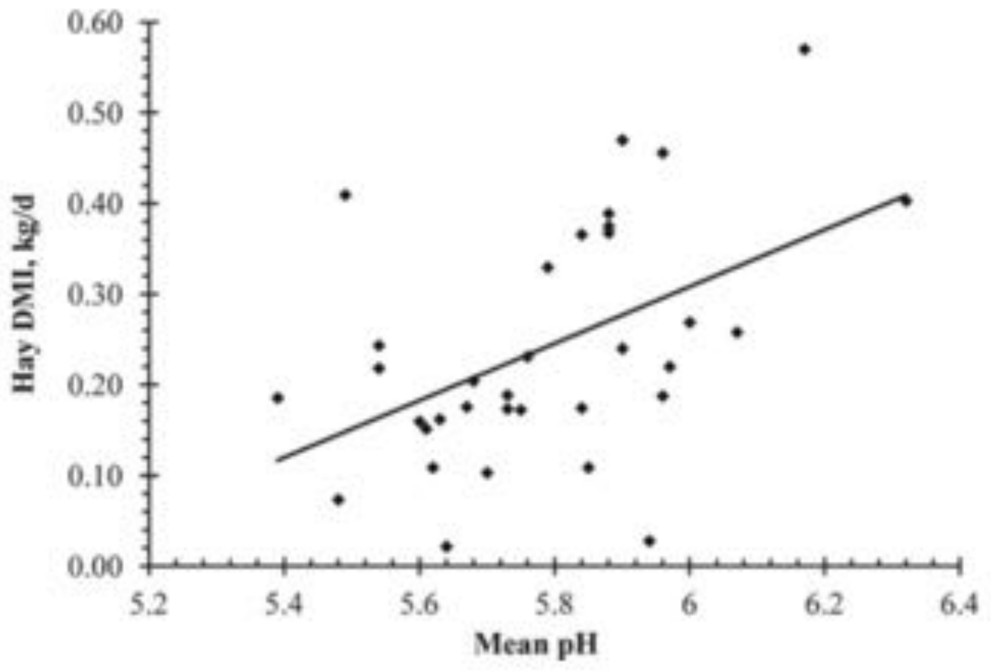
Pellet composition	
Flaked corn	40.0
Rolled oats	33.9
Fish meal	10.0
Soy bean meal	0.5
Molasses	10.0

Feeding forage



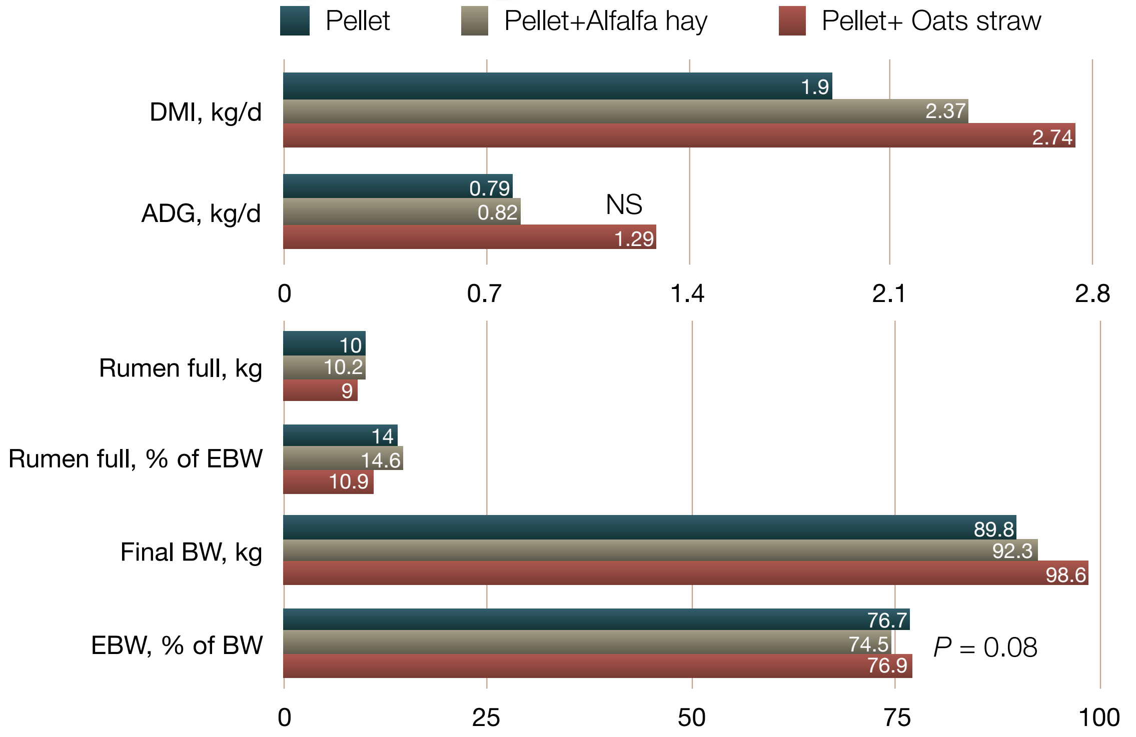
Terré et al. (JDS, 2013)

Rumen Function



Laarman et al. (JDS, 2012)

Feeding forage



Castells et al. (JDS, 2013)

- Let us hear from you…

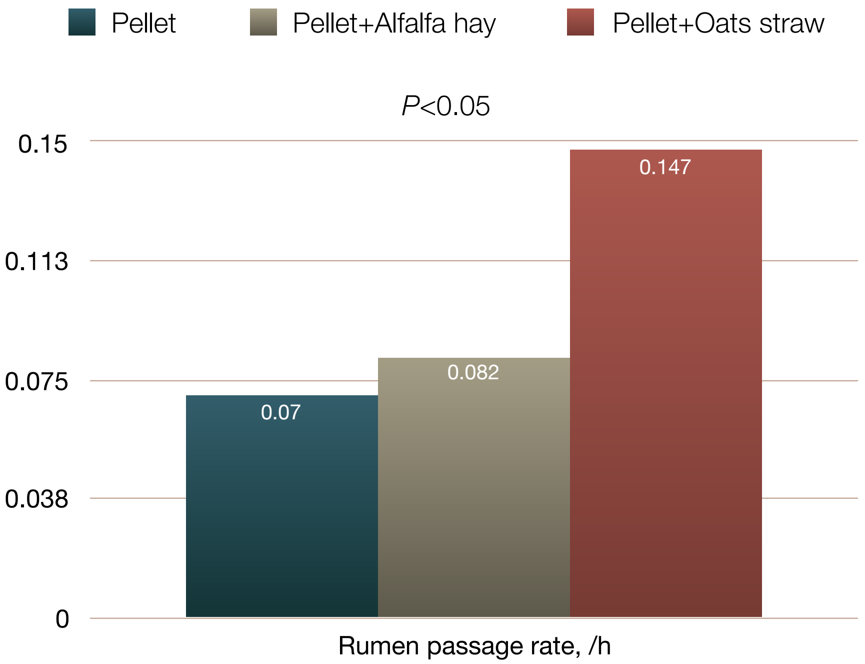
I am feeding forage. Is passage rate going to:

A. Increase

B. Decrease

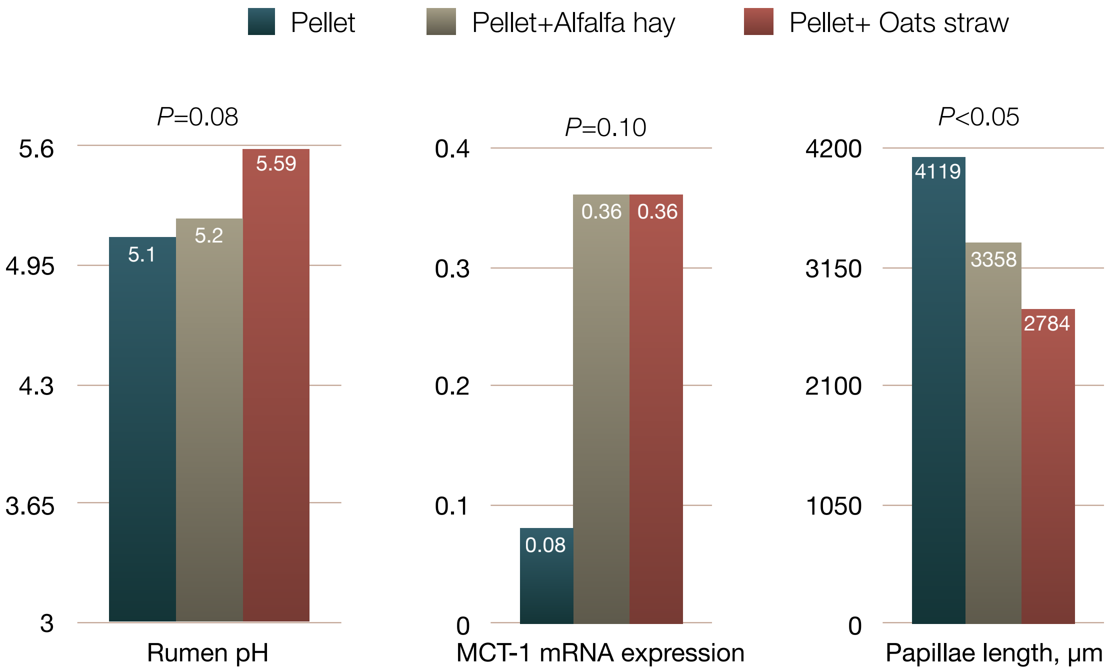
C. It depends

Feeding forage



Castells et al. (JDS, 2013)

Feeding forage

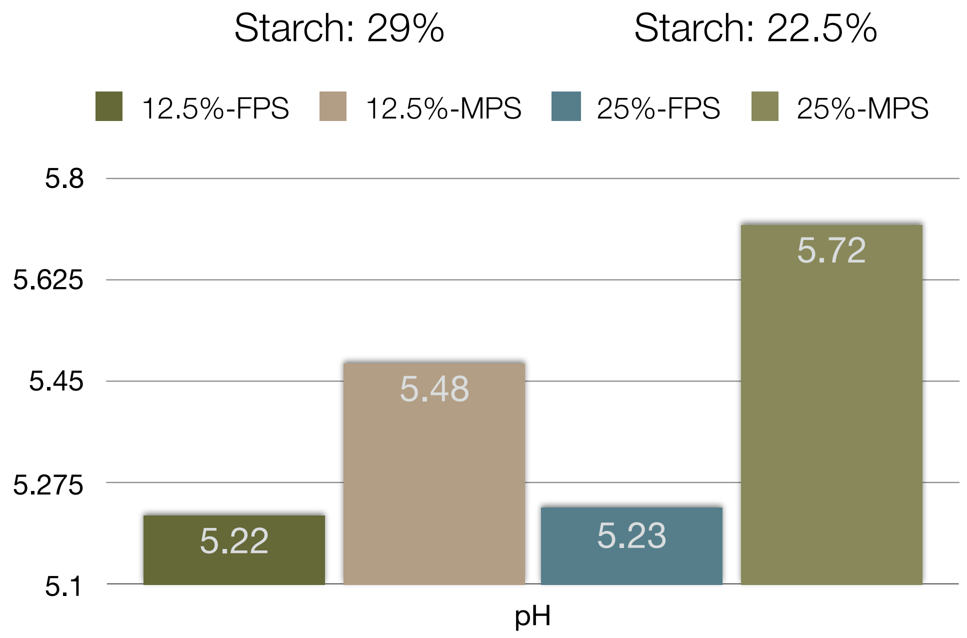


Castells et al. (JDS, 2013)

Rumen Function

- Rumen pH with **texturized** starters (no forage)
  - Lesmeister et al., 2004 (at 42 d): 5.44-5.66
  - Laarman et al., 2011: 5.72-5.83
- Rumen pH with **ground or pelleted** starters (no forage):
  - Porter et al., 2007 (at 56 d): 4.95-5.43
  - Khan et al., 2008 (at 50 d): 5.46-5.62
- Rumen pH with **forage** provision
  - Hibbs et al., 1956 (4 to 12 wk): > 6.4
  - Vázquez-Añón et al., 1993 (28 and 56 d): 6.0 and 6.01
  - Suárez et al. (2007): 5.09-5.29
  - Kristensen et al., 2007 (14 to 35 d): 5.56-6.19
  - Laarman and Oba, 2011: 6.27
  - Kahn et al., 2011 (at 70 d): No hay: 5.06, hay: 5.49
  - Castells et al., 2013 (at 78 d; pellet): 6.0-6.36

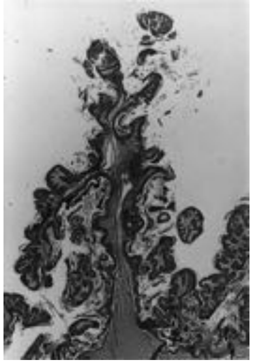
Feeding forage



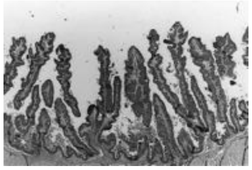
Nemati et al. (2015)

Particle size and diet abrasion

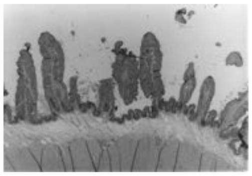
- Cross section from ventral cranial sac



Fine

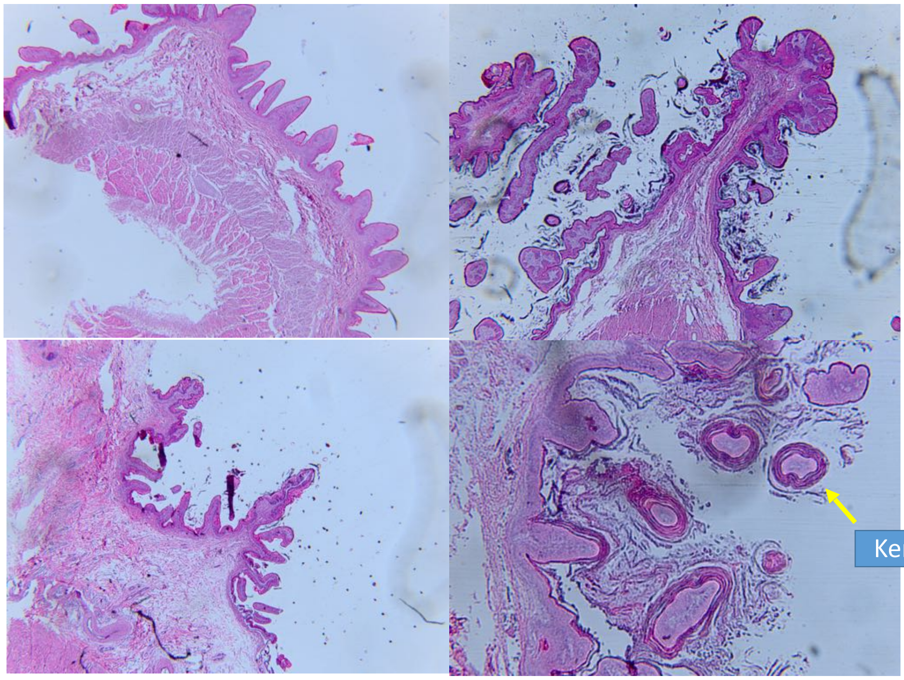


Intermediate



Coarse

Greenwood et al., 1997.



Keratin layer

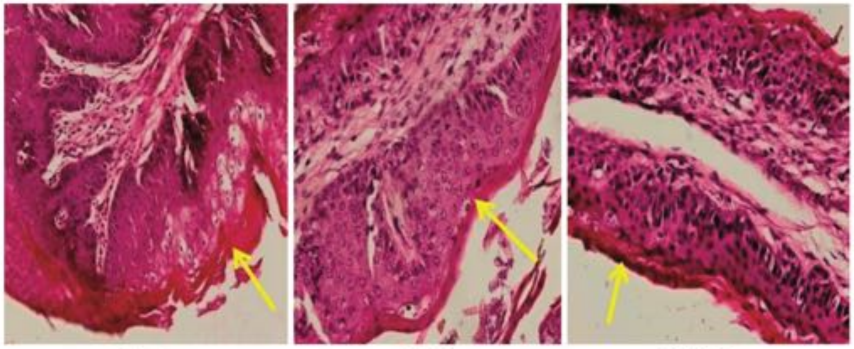
Rumen Function

Reduced plaque formation

Control 10%AH 10%AH + Pro

Thinner keratine layer

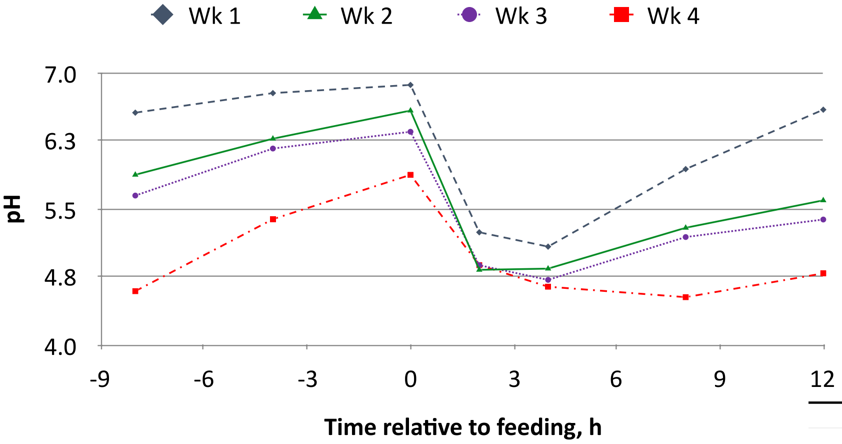
46 vs 40% starch



Control 10%AH 10%AH + Pro

Beiranvand et al., 2014

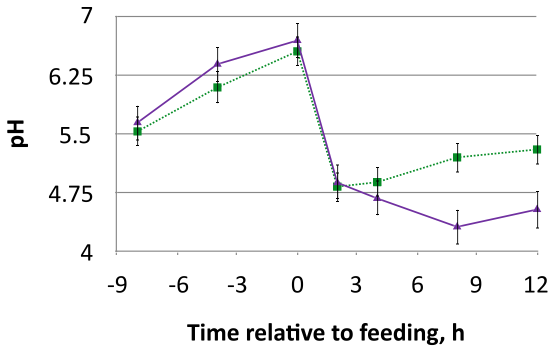
Effect of whole oats on rumen pH



P-value				
		Time		
Time	Time*Week	Linear	Quadratic	Cubic
<0.01	0.04	<0.01	<0.01	<0.01

Suarez-Mena et al.
2015 JDS

Effect of straw particle size on rumen pH



Rumen pH of calves that showed or not acidosis symptoms on wk 5

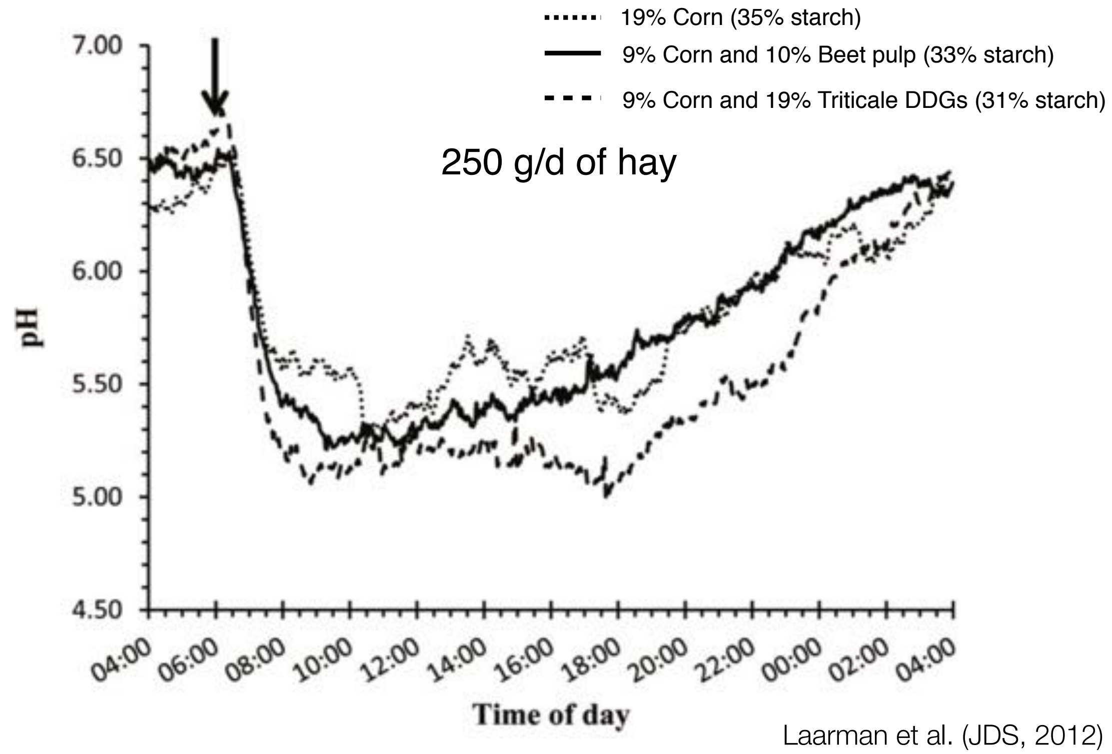
- calves that showed acidosis symptoms (5 calves; ▲)

- calves that did not show acidosis symptoms (7 calves; ■)

5% straw of various particle size + pellet

Suarez-Mena et al.
2015 JDS

Rumen Function



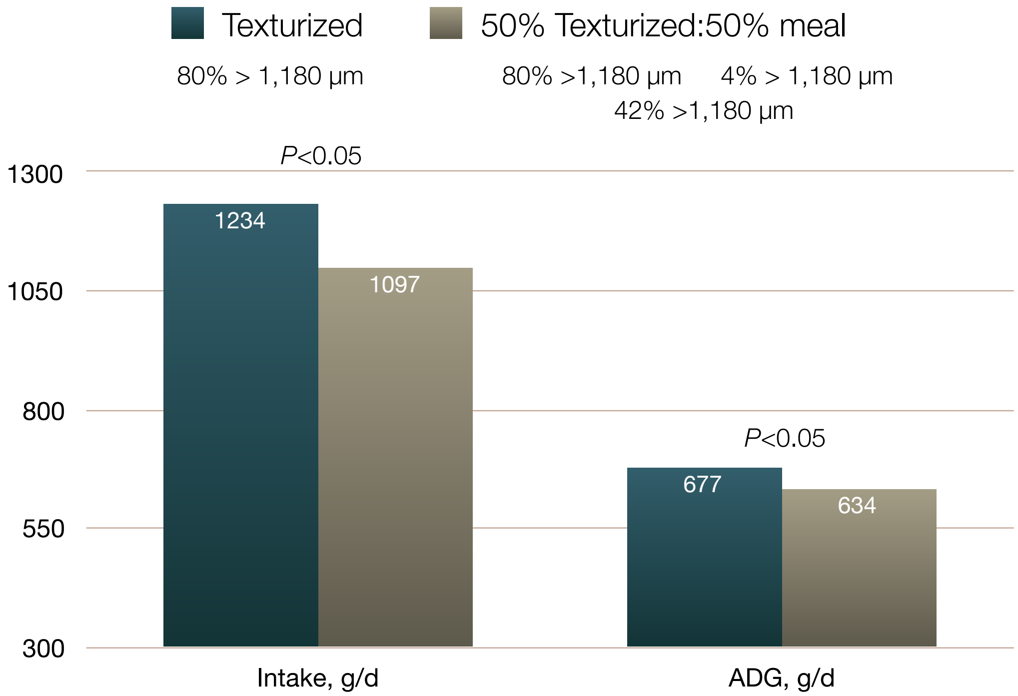
250 g/d of hay

Laarman et al. (JDS, 2012)

I am feeding a Texturized Starter...

Is it Good?

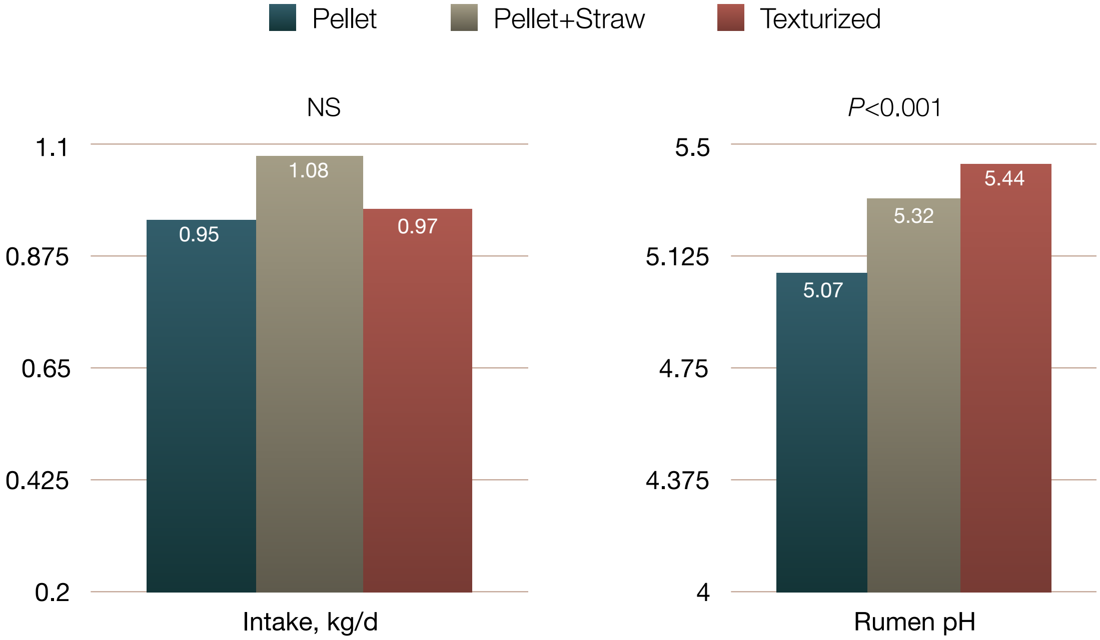
Physical form



Bateman et al. (JDS, 2009)

Texturized vs Pellet and Straw

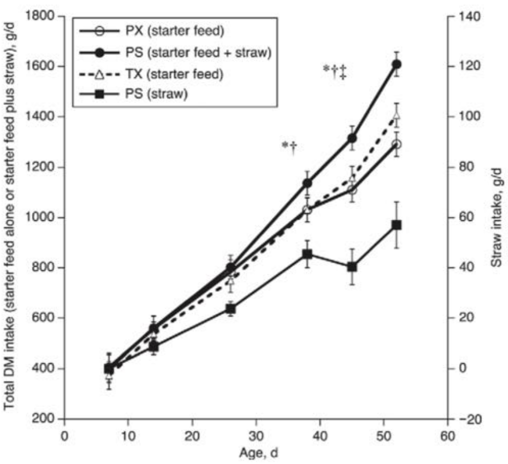
Texturized vs Pellet and Straw

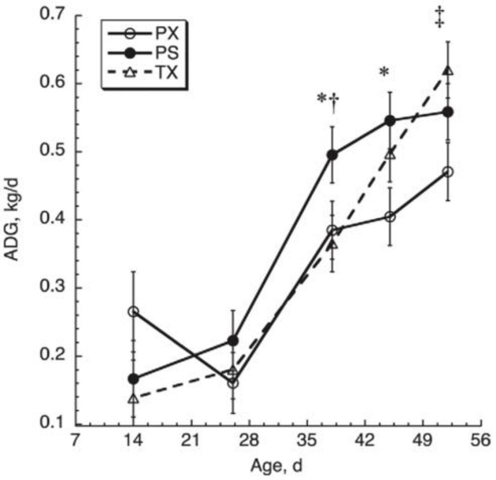


35% starch

Terré et al. (2015)

Texturized vs Pellet and Straw





Terré et al. (2015)

- Let us hear from you…

Weaning time. Are we changing the starter?

A. Yes

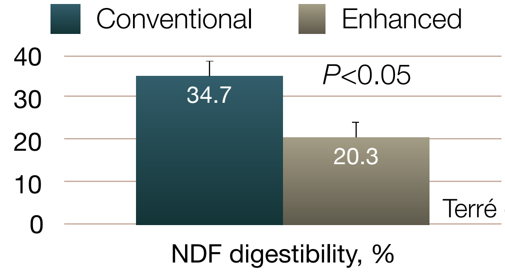
B. No

C. No, but we add forage on the side

Post-weaning

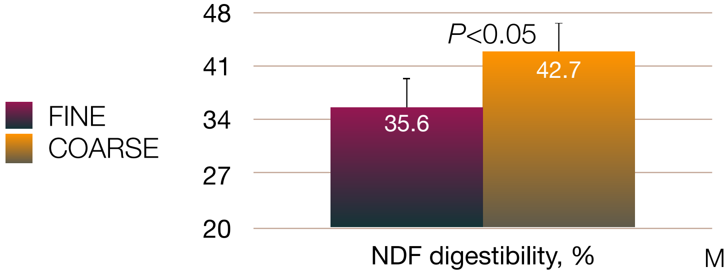
Post-weaning

- Digestibility of fiber is diminished post-weaning when feeding enhanced growth programs



Terré et al. (Livestock Sci., 2007)

- Digestibility (and performance) can be improved by offering chopped hay or straw during the suckling period



Montoro et al. (JDS, 2013)

Summary

- Intake response to forage addition will depend on:
  - starter ingredient composition
  - starter particle size/grain processing
  - intake level (age, milk allowance…)
  - forage type and particle size

- Forage increases starter intake when rumen buffering capacity is overwhelmed by starch fermentation
  - starter nutrient composition (starch)
  - physical nature of starter/particle size

Calves fed a complete pellet > 30% starch will benefit from forage as it will help buffer the rumen which would allow calves to eat more.

Thank you

HOW DOES FORAGE QUALITY AFFECT CASH FLOW PLANS?

T. BECK, R. GOODLING, V. ISHLER, AND H. WEEKS

Project supported in part by:
NORTHEAST SARE Sustainable Agriculture Research & Education
USDA
Risk Management Agency (RMA)

Penn State Extension

Take Home Points:

- Corn silage quality changes over time
- Neutral detergent fiber and starch digestibility are critical to determine the best ration formulation approach
- Forage quality & quantity affect cash surplus
- Producers need to know their cost of production to make well-informed decisions

Penn State Extension

Project Objective 1

1. Analyze feed best management practices and their effects on operational cash surplus
   a) Production (actual and DHIA test day)
   b) Annual cost of production
   c) Annual cash flow break-even

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Project Objective 2

2. Evaluate fecal starch & milk urea nitrogen as barometers for corn silage nutrient utilization by the cow.
   - *a) 7-hour starch digestibility*
   - *b) 30-hour NDF digestibility*

Note: All wet chemistry through Cumberland Valley Analytical Lab.

Over View of the Project

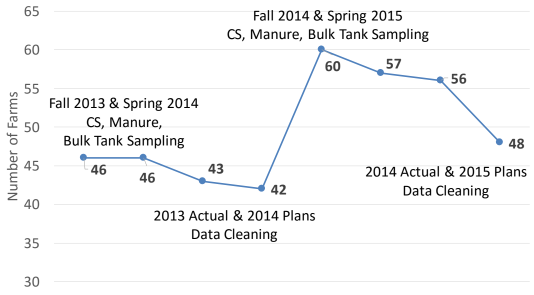
Participating Farm Data

- Annual Financials
  - 2013, 2014, & 2015 Actual Profit and Loss Statement
  - 2014 & 2015 Cash Flow Plan
- Production
  - 2013, 2014, & 2015 Annual Production
  - Monthly Test Day production (if available)

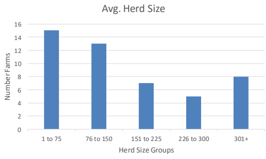
Farm Data, Continued

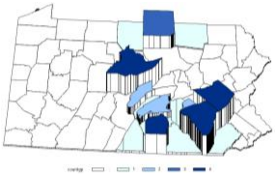
- Corn Silage analysis
  - Standard with 7-hr Starch & 30-hr NDF dig.
  - Sampled fall (several wk post-harvest)
  - Again in spring (5-6 mo. later)
  - Hybrids, harvest mgmt., structures (Year 2)
- Bulk tank MUN and composite herd fecal sample
  - At time of corn silage sampling

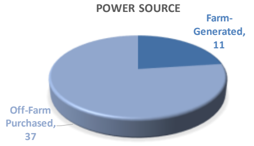
Participating herds over time

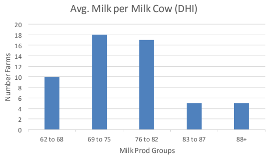


Herd Demographics (n=48)

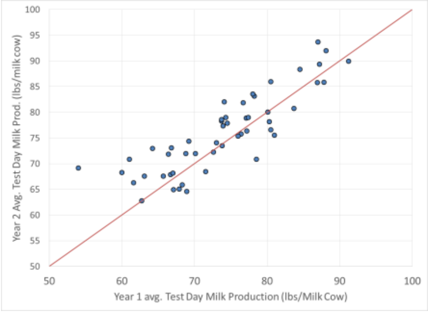








Test Day Milk: Year 1 vs. Year 2



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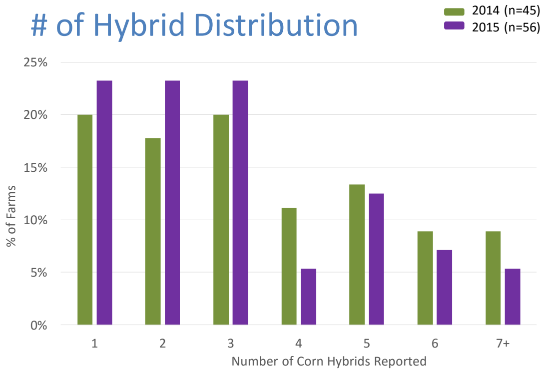
BMPS – Corn Hybrids

Penn State **Extension**

of Hybrid Distribution



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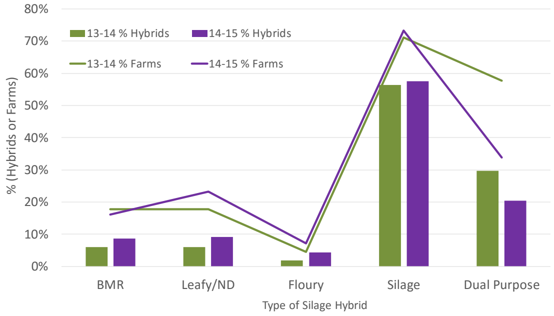
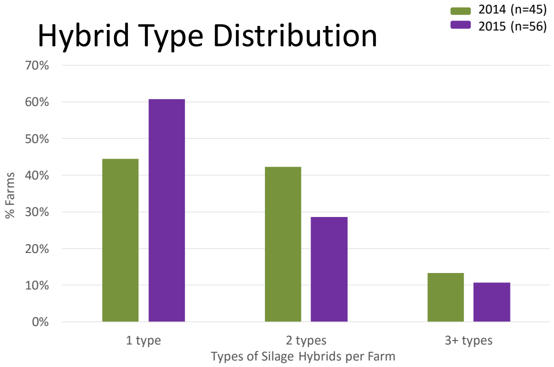
Types of Hybrids



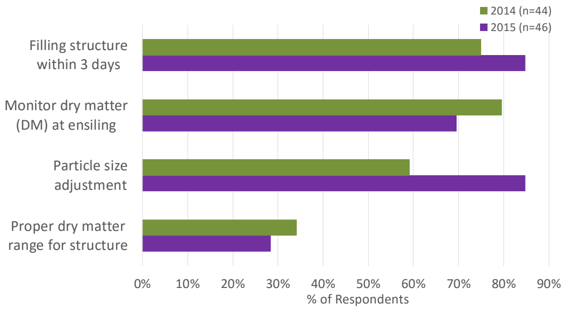
Hybrid Type Distribution



Corn Harvest Checklist

- Estimate maturity
- Identify hybrid/structure
- Additional harvest criteria
  - Kernel processing
  - Inoculants
  - Dry Matter
  - Particle size
  - Chop height
  - Time to harvest

BMPs for max. digestibility of forage



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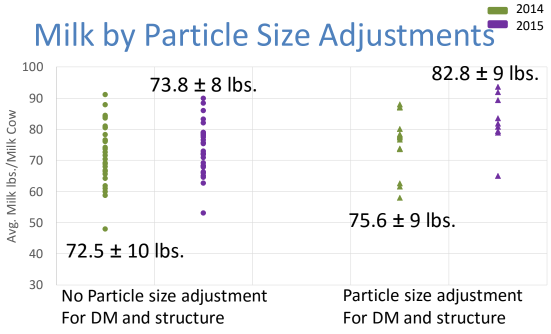
Milk by Particle Size Adjustments



*t=-1.94, p<0.05 initial analysis

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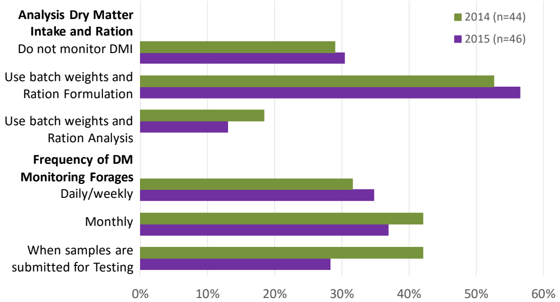
BMPS – Feed Management

Penn State **Extension**

Feed Management BMPs



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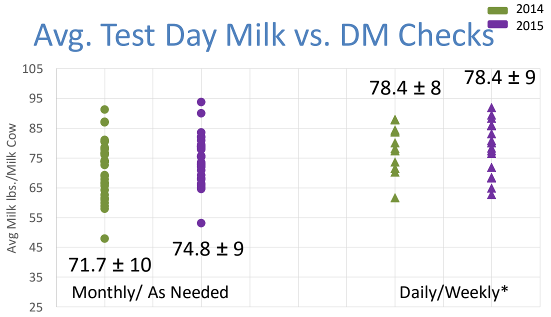
Avg. Test Day Milk vs. DM Checks



*t=2.59, p<0.01 initial analysis

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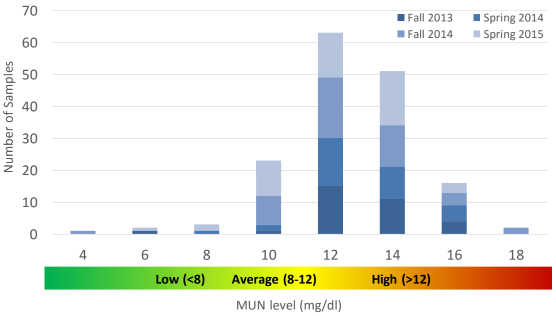
Histogram of MUN (mg/dl) by Season



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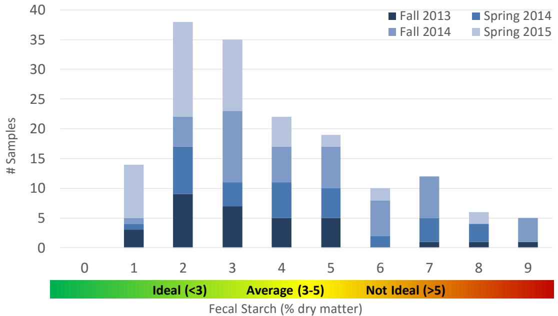
Histogram of Fecal Starch (% DM) by Season



Corn Silage Quality

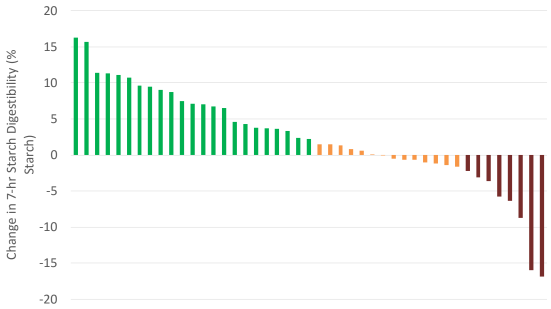
2 Season Corn Silage Correlations

- 163 samples (fall and spring)

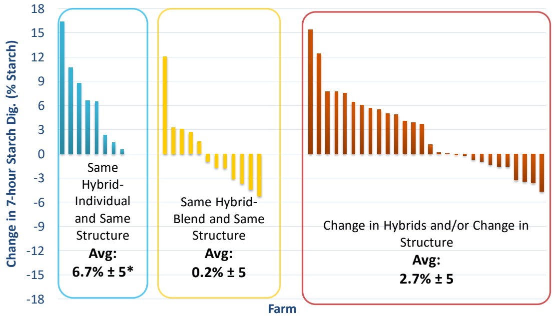
	Dry Matter	NDF-DM	Starch-DM	7-hr Starch Dig.	30-hr NDF Dig.
Dry Matter					
NDF-DM	$-^{1}$				
Starch-DM	$+^{1}$	$-^{1}$			
7-hr Starch Dig.	$-^{2}$	?	?		
30-hr NDF Dig.	$-^{2}$	$+^{2}$	$-^{2}$	?	

1: $p < 0.0001$
2: $p < 0.001$

Spring 14 – Fall 13 Starch Dig. Change



Spring 15 – Fall 14 Starch Dig. Change



Same Hybrid-Individual and Same Structure
Avg:
6.7% ± 5*

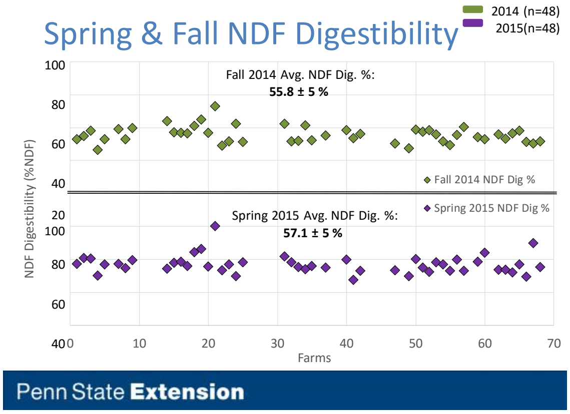
Same Hybrid-Blend and Same Structure
Avg:
0.2% ± 5

Change in Hybrids and/or Change in Structure
Avg:
2.7% ± 5

Comparison of Group Averages

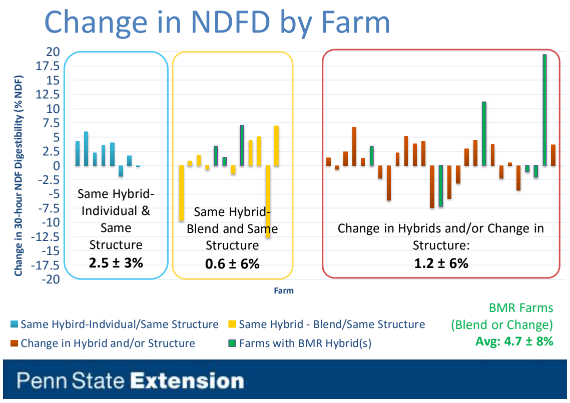
7-hour Starch Dig. (% starch)	Same Hybrid/Same Structure	Same Hybrid-Blend/ Same Structure	Change in Hybrid &/or Structure
Fall 2014	74.5%	76.0%	73.0%
Spring 2015	81.1%	76.2%	75.7%
Net change*	**6.7%**	**0.2%**	**2.7%**

*F=4.09, p<0.05, initial analysis



Spring & Fall NDF Digestibility

Penn State **Extension**



Change in NDFD by Farm

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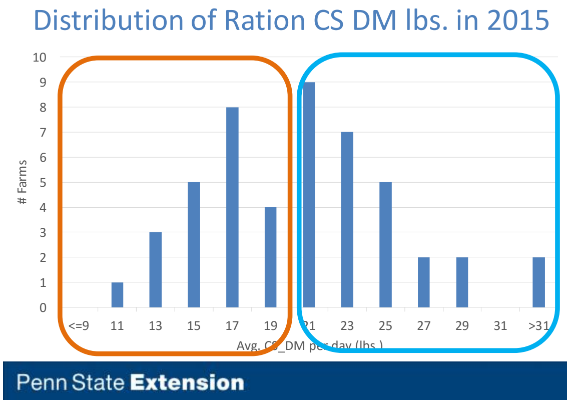
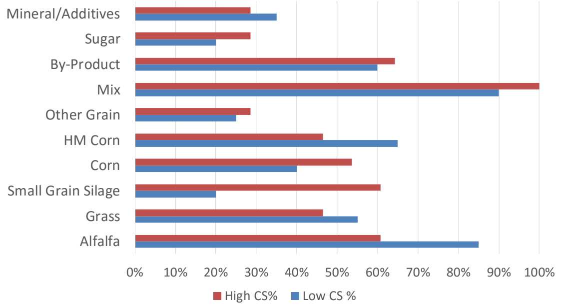


Distribution of Ration CS DM lbs. in 2015

Penn State **Extension**

2015 Rations by Corn Silage Rate



Penn State **Extension**

Virginia Ishler – Extension Dairy Team

NESARE PROJECT ENE15-136:

THE IMPACT OF CORN SILAGE HARVESTING AND FEEDING DECISIONS ON INCOME OVER FEED COSTS (IOFC)

Penn State **Extension**

Team Members

- **Crops Team**
  - Nicole Carutis, Chris Houser, Jessica Williamson Dr. Greg Roth, and Ron Hoover
- **Dairy Team**
  - Heather Weeks, Tim Beck, and Rob Goodling

Penn State **Extension**

Objectives

- **Train the trainers**
  - Work with producers, nutritionists and crop consultants to tie together management of:
  - Cropping
  - Feeding
  - Financials

What's Involved

- **24 dairy producers**
  - Nutritionists and crop consultants need to be willing to participate and communicate with each other.
  - Groupings
    - High CS (>18.5 lbs DM) with small grain silage (6)
    - ***High CS (>18.5 lbs DM) no small grain silage (6)***
    - ***Low CS (<18.5 lbs DM) with small grain silage (6)***
    - ***Low CS (<18.5 lbs DM) no small grain silage (6)***

What's Involved

- **Crops**
  - How to select silage seed balancing yield, cost, and quality parameters
  - Adjusting cropping strategies to utilize cover crops or alternative forages
  - Calculate costs to grow home raised feeds
  - BMPs related to harvesting and storage

What's Involved

- **Crops**
  - Sampling corn silage at 2 different time points
    - Fall – after a few weeks fermentation
    - Spring – after several months fermentation

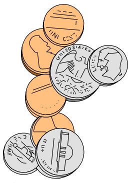
What's Involved

- **Feed Management**
  - Evaluate forages for fiber and starch digestibility
  - Calculate forage inventory
  - Monitor silage dry matter and adjust rations

What's Involved

- **Feed Management**
  - Sample total mixed ration at time of corn silage sampling
    - Actual ration vs. formulated
    - Batch weights with cow numbers to determine dry matter intake

What's Involved



- **Economics**
  - Calculate and monitor income over feed costs
  - Making decisions based on economic parameters
  - Beginning and ending balance sheets – cash flow plan

Outcomes

- **Improve understanding by producer and consultants regarding:**
  - Connection between decisions made on cropping practices with feeding management with nutrition and the impact on cash flow and IOFC.
  - Crop consultants have an improved understanding about how they influence cow performance and economics.
  - Nutritionists have improved understanding how cropping decisions influence nutrition and economics.

Outcomes

- **Consultants utilize what they learned with other clientele:**
  - What did they learn and implement from this project?
  - What were the **Successes** and **Challenges**?

Outcomes

- **What did the project team and participating partners learn from this?**
  - How will the results be used in future educational programs?
  - How will the results be used in future research proposals – what are the next steps?

Penn State **Extension**

Finding Lost Milk with the Novus C.O.W.S.® Program

Lindsay Collings

Novus C.O.W.S. Project Manager

DESCRIPTION

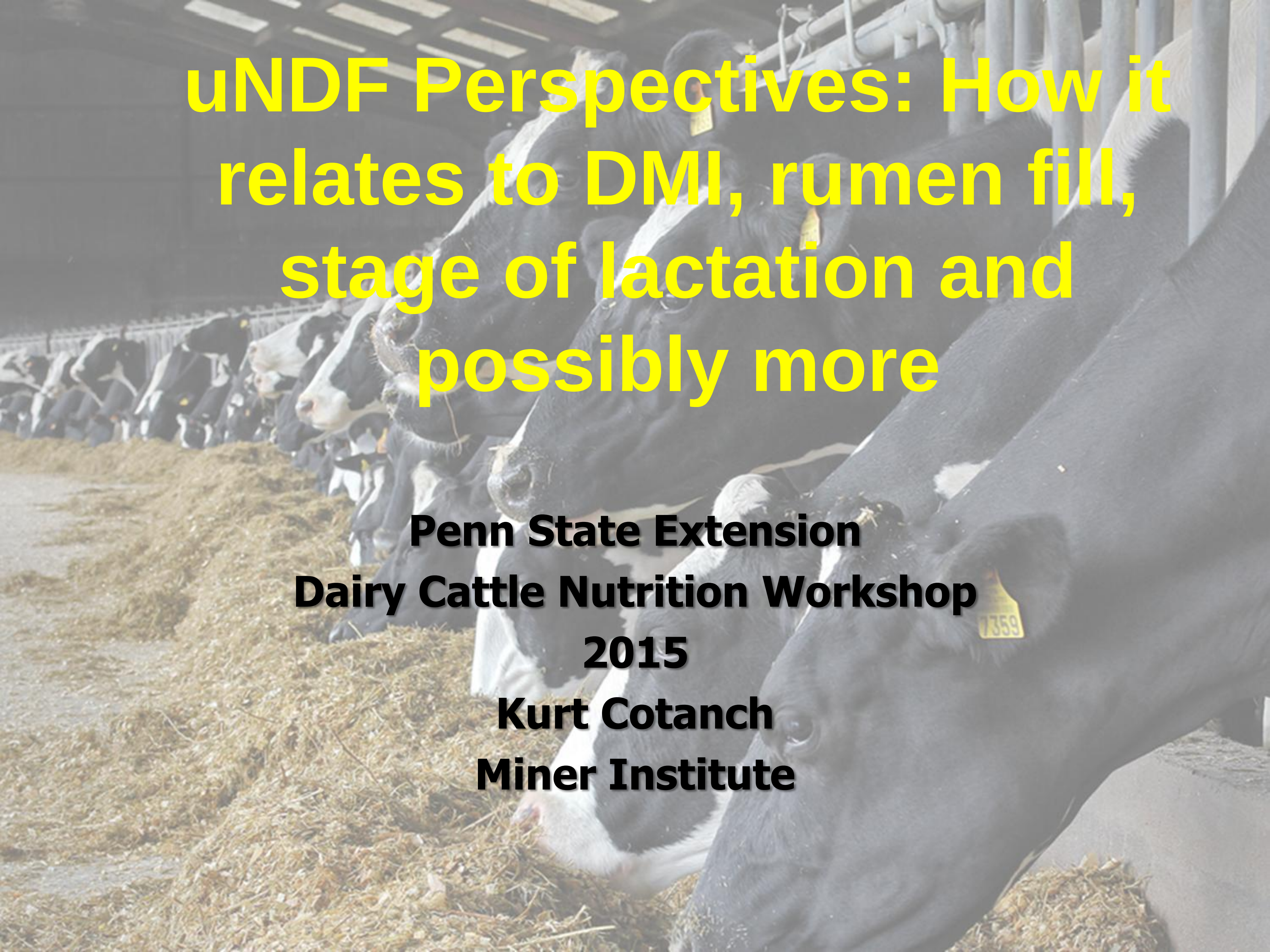
Data and case studies from the Novus C.O.W.S. Program show how producers have been able to identify bottlenecks on their dairies and different ways they have made changes to improve cow comfort and production.

Identifying cow comfort and production bottlenecks and potential areas of opportunity is a challenge for dairies across the globe. To help address this, Novus International offers value-added services to their customers through the Novus C.O.W.S.® Program. The program includes a comprehensive on-farm cow comfort assessment. To date, over 750 assessments have been completed on dairies in North America, by only a handful of assessors, ensuring accurate and consistent scoring.

Cow-based measures including lying behavior, leg injuries, and lameness are documented for each dairy. Across North America average daily lying times ranged from 7.0 to 13.5 h/d, and average prevalence of hock injuries, knee injuries, and lameness ranged from 0 to 100%, 0 to 53%, and 2 to 88% respectively. The data are compiled to create regional benchmarks (Freestalls: Canada, California, Midwest US, Northeast US; Open lots: Texas/New Mexico), and producers see how their data compares to data from other dairies in their regional benchmark.

Additionally, facility and management factors are recorded for the assessment pen. These measures are used in combination with the cow-based data to help identify potential bottlenecks on each dairy. Some issues that are common across the country, and especially in the Northeast, are overcrowding at the stalls and feedbunk, high time away from the pen for milking, and hard stall surfaces or too little bedding.

After participating in a Novus C.O.W.S. assessment, many dairies create action plans to make changes moving forward. Through re-assessments, producers can track how they have improved on their farm, as well as within the regional benchmark. Across the country, the Novus C.O.W.S. Program has documented several dairies that have made changes resulting in reduced lameness and injury prevalence and increased productivity. One dairy in particular reduced the time the cows were spending in the parlor by hiring another milker to speed up milking. After seeing a spike in milk production after this change, the producer then decided to switch to 3X milking and saw a similar production response. This is a great example of a producer that used the Novus C.O.W.S. Program to help identify bottlenecks specific to his farm and made changes that resulted in improved cow comfort and finding lost milk.



uNDF Perspectives: How it relates to DMI, rumen fill, stage of lactation and possibly more

Penn State Extension
Dairy Cattle Nutrition Workshop
2015
Kurt Cotanch
Miner Institute

uNDF: What is it?

- Not new concept:
- Opposite of digestible NDF (dNDF)
  - 100 – uNDF = dNDF as % of NDF (not DM)
  - 100% -uNDF% = NDFD%
- Undigested NDF residue after a specified time of digestion
  - 0, 24, 30, 48, 120, 240 h
  - At time 0h = 100% uNDF or NDF

uNDF: What is it?

- New terminology
  - Indigestible vs Undigested

Indigestible vs Undigested NDF (Mertens, 2013)

- iNDF: theoretical and defined by model; indigestibility measured at infinite time.
- uNDF: Undigested NDF is what we measure at a defined time point
  - uNDF 30, 120 and 240h for pools: CNCPS
  - uNDF240 analytical estimate of iNDF

uNDF: What is it?

- New perspective
- Focus on digestibility: milk yield
  - Forage Quality:
    - High NDFD = Inc. DMI & more milk
    - Low NDFD = Dec. DMI & less milk
- Focus on undigestibility: milk components, rumen & animal health,
  - Rumen mat: chew factor
  - peNDF: chew factor

uNDF: How is it measured?

- Lab: in vitro
  - Tilley-Terry: individual flask fermentation
    - Gold Standard method: 1.5um filter
  - Ankom Daisy: batch fermentation
    - Caution: Much different values than Tilley-Terry method: 25.0um filter
- Lab: NIR
- Cow: in situ
  - Dacron bags in rumen

uNDF: How is it measured?

- aNDFom
  - Amylase & Na Sulfite: aNDF
  - Organic matter basis: om (ash corrected)
  - Length of time of fermentation
- "uNDF" = generic term
- uNDFom30: undigested ash corrected NDF residue after 30h fermentation

uNDF: How do we use it?

- FQ: Quality assessment NDFD
  - ADF/lignin/lignin/NDF are insufficient
- DMI estimate
- Modeling:
  - uNDF240 as iNDF
  - Fast & Slow fiber pools
  - Calculate rate of digestion
    - energy value

Measured NDFD or Estimation from Lignin?

NDF %	Lignin %	30-hr NDFD %	Rate %/h
42.3	3.01	?	?
42.6	3.32	?	?
42.6	3.24	?	?
42.6	3.24	?	?
42.3	3.18	?	?

- Corn silage data set from Van Amburgh (2005).
- Similar relationships from 36.5 to 51.8% NDF.

Measured NDFD or Estimation from Lignin?

NDF %	Lignin %	30-hr NDFD %	Rate %/h
42.3	3.01	42.2	2.63
42.6	3.32	44.1	2.90
42.6	3.24	44.6	2.92
42.6	3.24	53.8	3.60
42.3	3.18	56.7	4.36

- Corn silage data set from Van Amburgh (2005).
- Similar relationships from 36.5 to 51.8% NDF.

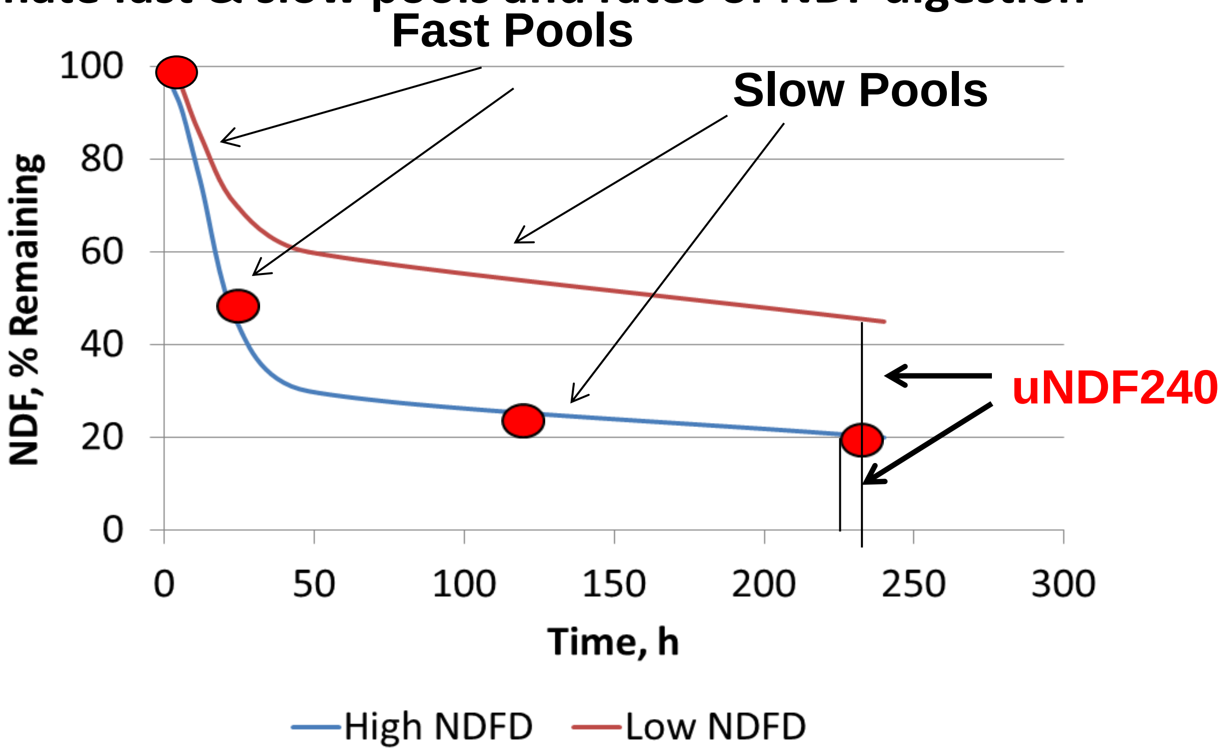
uNDF: How do we use it?

- FQ: Quality assessment NDFD
  - ADF/lignin/lignin/NDF are insufficient
- DMI estimate
- Modeling:
  - uNDF240 as iNDF
  - Fast & Slow fiber pools
  - Calculate rate of digestion
    - energy value

Biological importance of uNDF

- Estimate potentially digestible:
  - pdNDFom = NDFom – uNDF240om

Estimate fast & slow pools and rates of NDF digestion



Estimating iNDF … Measuring uNDF

- ADL x 2.4/NDF (Chandler et al., 1980)
- ADL/NDF$^{0.67}$ (Weiss et al., 1992)
- 288-h in situ (Huhtanen et al., 2007)
- 240-h in vitro fermentation (Raffrenato and Van Amburgh, 2010)

What should we measure & monitor?

- Indigestible NDF
  - Inverse of digestible NDF
  - Highly lignified, indigestible
  - iNDF to lignin ratio is highly variable and responsive to genetics, maturity, and growing conditions
  - Useful to measure in forage testing labs
- Measured as undigested NDF (uNDF)
  - 240 hr of in vitro fermentation
  - Tilley-Terry system (artificial rumen)
  - Labs are reporting uNDF values

Measured ranges in uNDF240

(source: Dairy One, May, 2015 newsletter)

- ☐ Corn silage
  - 8.7% of DM
  - Range: 2.0 to 25.5%
  - iNDF k = 2.83
- ☐ Legume silage
  - 17.6% of DM
  - Range: 5.5 to 31.7%
  - iNDF k = 2.46
- ☐ Grass silage
  - 15.5% of DM
  - Range: 2.3 to 44.8%
  - iNDF k = 2.52

Tremendous variation in uNDF that

we need to capture

when formulating diets

and predicting cow response!

iNDF = Lignin x 2.4 (Valid?)

Need to remember the basics of fiber quality…

- ☐ Total amount of digestible NDF
  - Potentially digestible NDF = NDF – uNDF
  - Digestible energy available in the forage
  - How far can you potentially go (gas in the tank)?
- ☐ Rate of NDF digestion
  - One vs two rates (fast- and slow-NDF)
  - "fuel efficiency"
- ☐ Need to know both to make the most milk

Corn silage uNDF residue after 47h in situ, laundered and NDF assay

Grass silage uNDF residue after 47h in situ, laundered and NDF assay

Straw (HB) uNDF residue after 47h in situ, laundered and NDF assay

uNDF240om

- End point: estimation of iNDF
- Digestion curve and estimation of pools: Fast, Slow & Indigestible
- Methodology
  - Wet Chem
    - Particle size and om basis
      - Tilley-Terry 1.5 µm
      - Ankom 25 µm
  - NIR

uNDF240om intake and rumen

Miner Institute Projects (2008, 2011)

Project	% of BW	Diets			
% Forage		53% 40%CS: 13% HCS	67% 54%CS: 13% HCS	49% 36%BMR: 13%HCS	64% 51%BMR: 13%HCS
2011	Intake	0.36^{ab}	0.39^{a}	0.30^{c}	0.33^{bc}
	Rumen	0.57^{a}	0.62^{a}	0.48^{b}	0.52^{ab}
	Rumen: Intake	1.60	1.58	1.58	1.57
	uNDF240om	8.2	9.6	6.9	7.6
		52% 0% Straw 37% NDF	47% 2% Straw 37% NDF	43% 6% Straw 37% NDF	39% 10% Straw 36% NDF
2008	Intake	0.33	0.33	0.35	0.36
	Rumen	0.53	0.52	0.52	0.56
	Rumen: Intake	1.61	1.59	1.49	1.58
	uNDF240om	9.2	9.2	9.2	9.3

Thoughts and more questions…

- Is uNDF30 or uNDF240 a better indicator of DMI or ration transition?
- How does uNDF intake vary across stage of lactation? Does it?
- Indicator of forage quality?
- Applications on farm?

TMR Analyses and Ration Dry Matter Intake (Nov 2014)

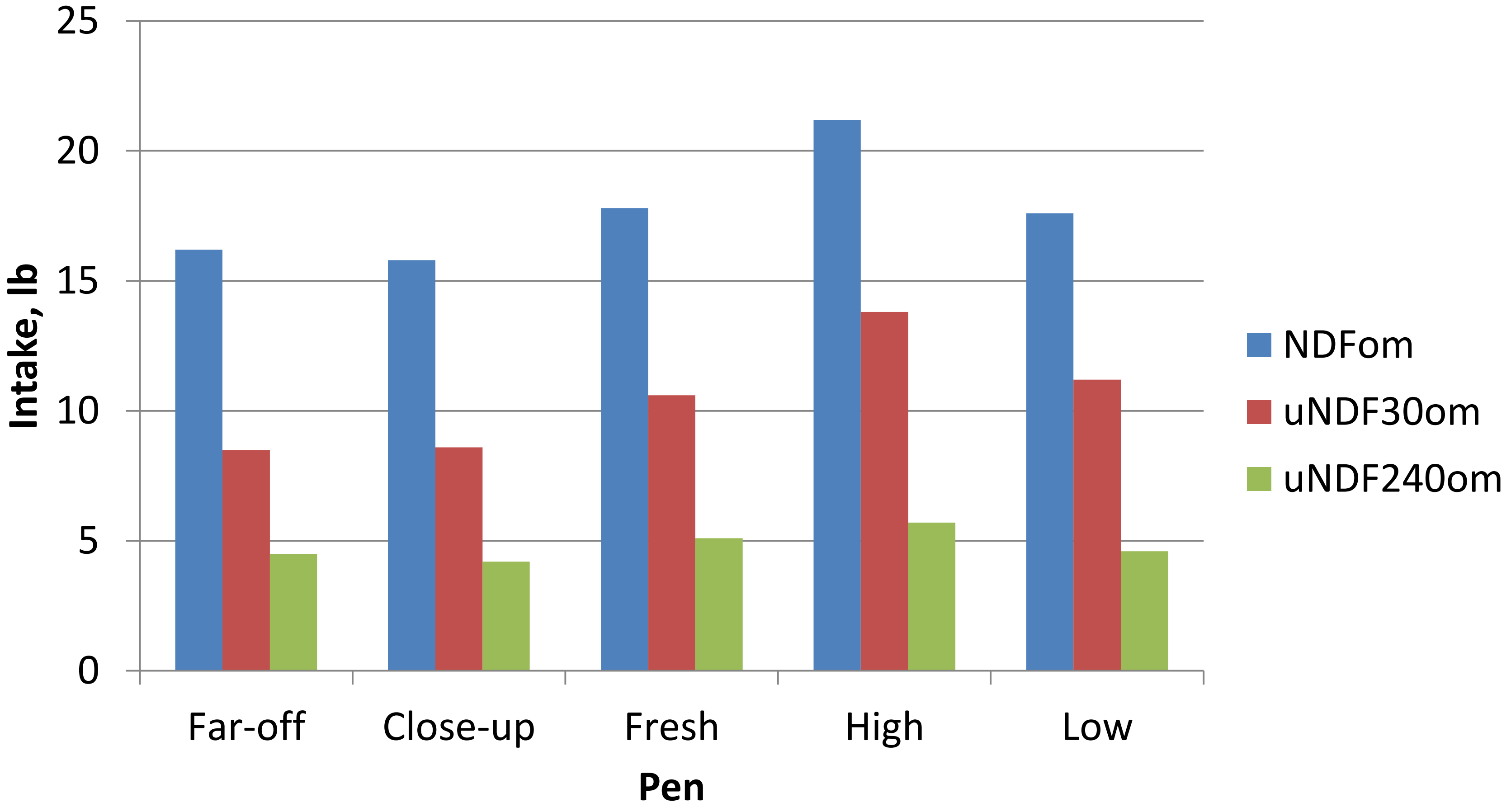
Pen	Ration DMI lbs	Tilley Terry NDFom % of DM	Tilley Terry uNDF30om % of DM	Tilley Terry uNDF240om % of DM
High	67	31.6	20.6	8.5
Fresh	48	37.1	22.1	10.6
Low	53	33.1	21.0	8.7
Far-off	31	52.2	27.5	14.5
Close-up	30	52.7	28.8	13.9

Miner Herd NDF and uNDFom Intake (lb and % of Close-up Diet Intake)

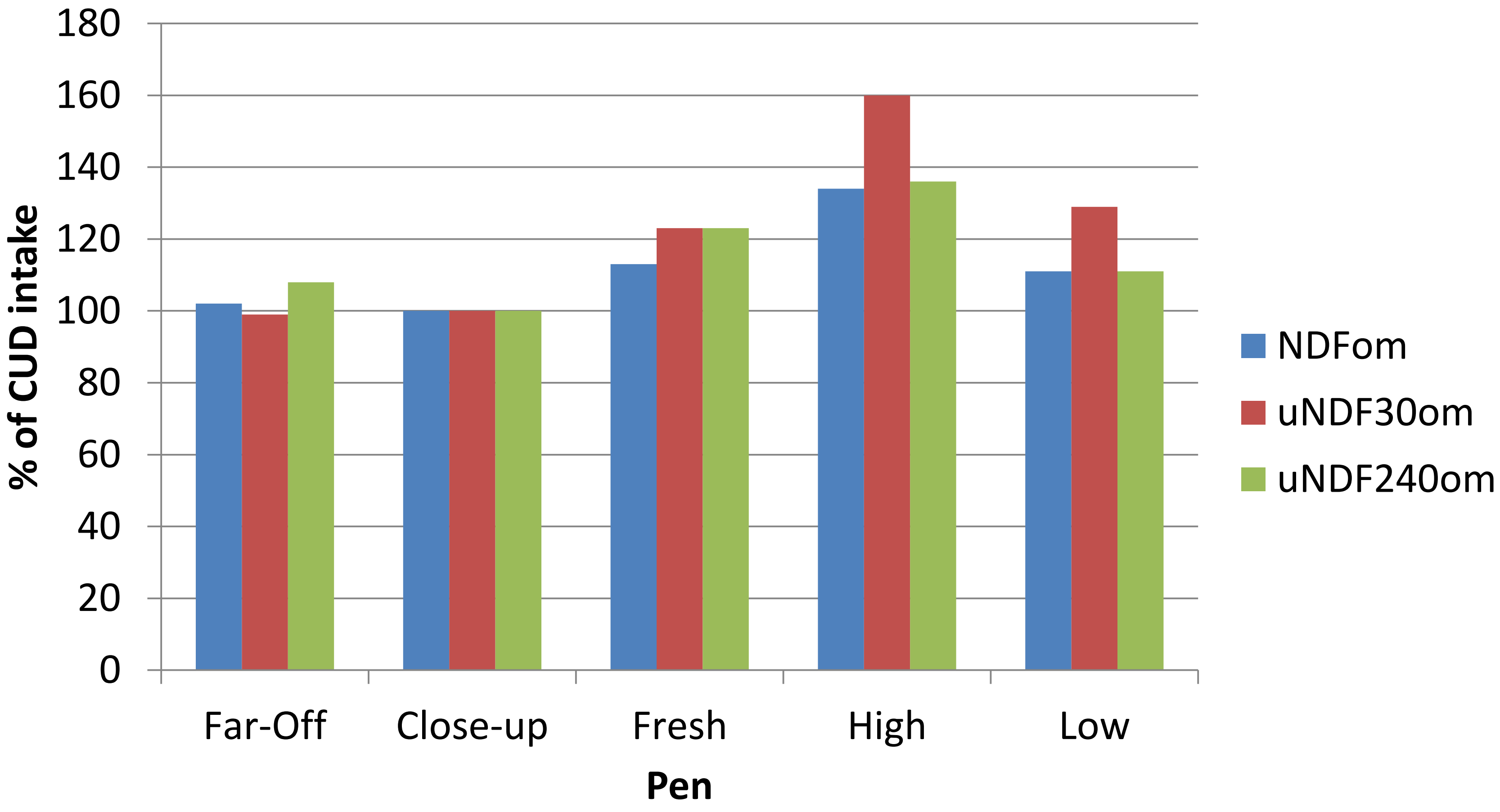
	Intake					
Pen	NDFom		uNDF30om		uNDF240om	
	lb	% of CUD	lb	% of CUD	lb	% of CUD
High	21.2	134	13.8	160	5.7	136
Fresh	17.8	113	10.6	123	5.1	123
Low	17.6	111	11.2	129	4.6	111
Far-off	16.2	102	8.5	99	4.5	108
Close-up	15.8	100	8.6	100	4.2	100

Tilley-Terry method values: use these as reference values for lb intake of uNDF30om and uNDF240om

Miner Herd NDF and uNDFom Intake (Tilley-Terry method values)



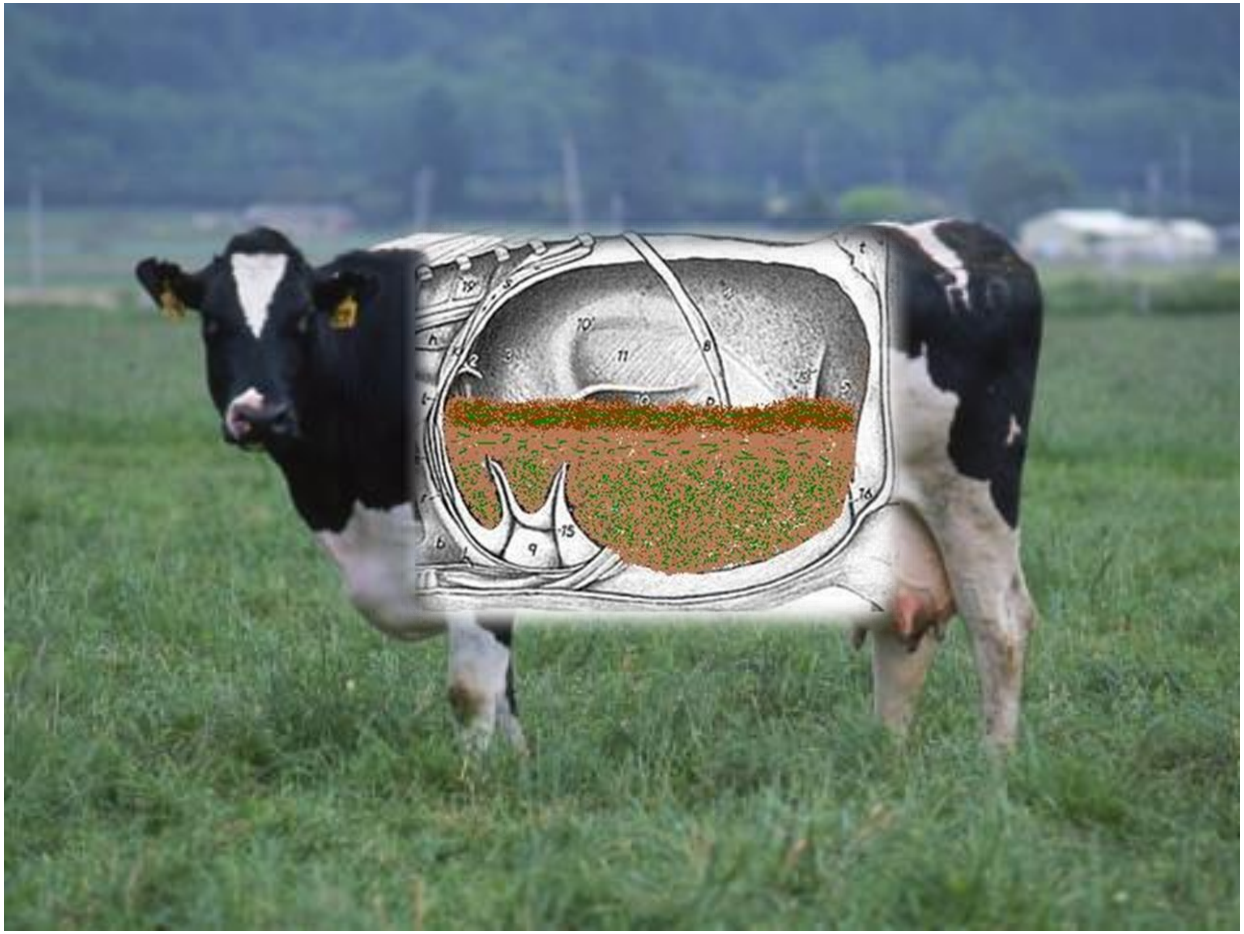
Miner Herd NDF and uNDFom Intake (Tilley-Terry method values)



uNDFom 30 vs 240?

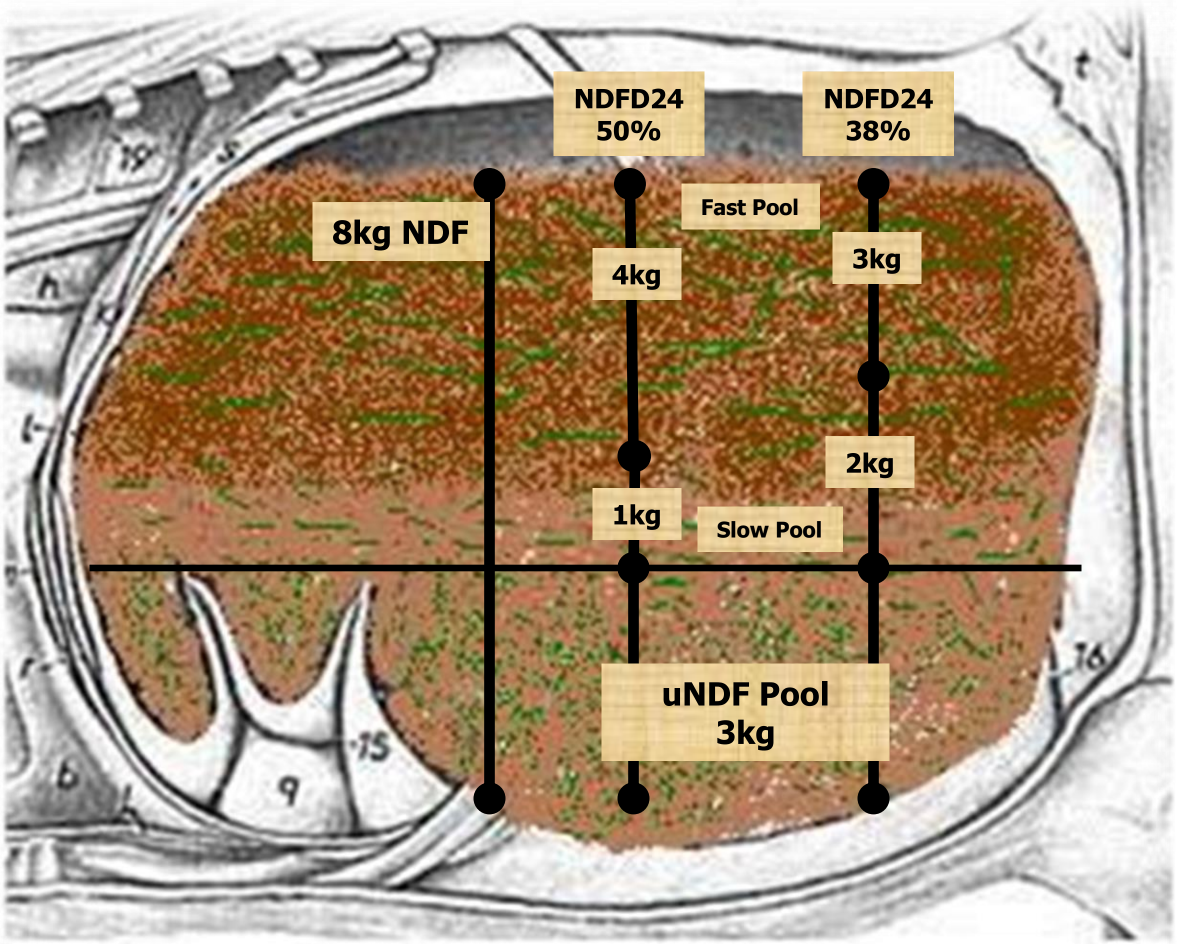
- uNDF30om better for predicting DMI?
  - How much rumen space can be “cleared” in 24 h for next day’s intake?
    - Including the amount of slow-pool NDF that can also be cleared on a daily basis.
- uNDF240om
  - Forage quality and DMI

Rumen Fill and Flux



Rumen Fill and Flux

Rumen Fill and Flux



8kg NDF

NDFD24
50%

4kg

1kg

Fast Pool

Slow Pool

NDFD24
38%

3kg

2kg

uNDF Pool
3kg

Sensitivity to uNDF240om: Case Scenario

- Miner Institute
    - Forage change from 2013 to 2014 crop year
    - Pen DMI and milk production
        - October 2014
        - February 2015
    - Across stages of lactation
        - Far dry/High/Late lactation

uNDF240om of diets and estimated intake lb and as percentage of BW based on pen intakes

	Date	DMI, lb est.	Milk, lbs	uNDF240om, % of TMR DM	uNDF240om, lb DMI, est.	uNDF240om, % of BW est.
Pen 2 High	**Oct 2014**	**67**	**120**	**8.5**	**5.7**	**0.32**
Pen 5 Low	**Oct 2014**	**53**	**60**	**8.7**	**4.6**	**0.26**
Far Dry	**Oct 2014**	**33**	**x**	**14.5**	**4.8**	**0.27**

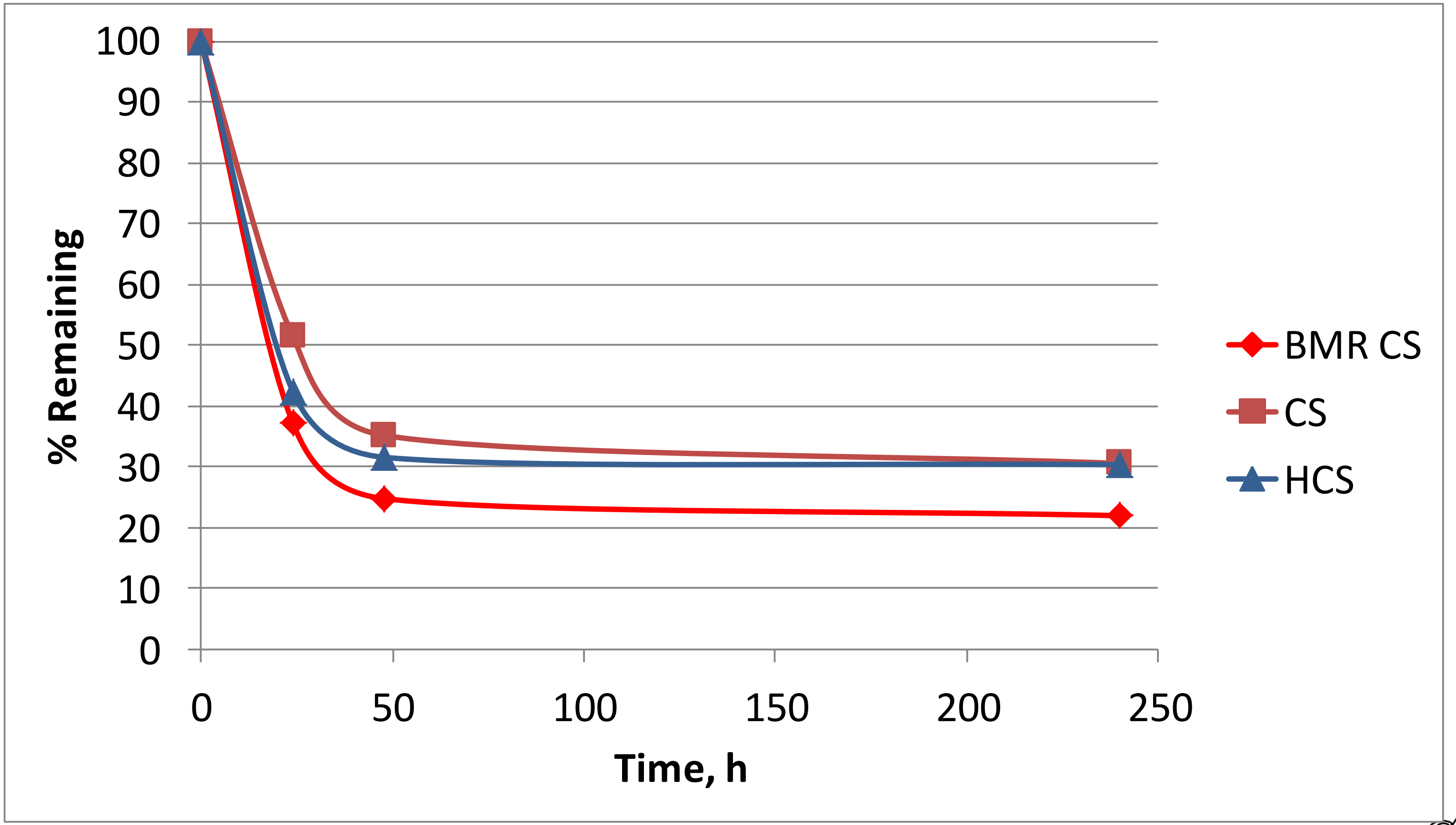
uNDF240om of diets and estimated intake lb and as percentage of BW based on pen intakes

	Date	DMI, lb est.	Milk, lbs	uNDF240om, % of TMR DM	uNDF240om, lb DMI, est.	uNDF240om, % of BW est.
Pen 2 High	Oct 2014	67	120	8.5	5.7	0.32
	Feb 2015	62	105	12.0	7.5	0.41
Pen 5 Low	Oct 2014	53	60	8.7	4.6	0.26
	Feb 2015	48	55	12.1	5.7	0.32
Far Dry	Oct 2014	33	x	14.5	4.8	0.27
	Feb 2015	29	x	19.2	5.5	0.31

uNDF240om of diets and estimated intake lb and as percentage of BW based on pen intakes

	Date	DMI, lb est.	uNDF30om, % of TMR DM	uNDF240om, % of TMR DM	Size of Slow pool, u30 –u240. % of DM
Pen 2 High	**Oct 2014**	**67**	**20.6**	**8.5**	**12.2**
	Feb 2015	**62**	**16.4**	**12.0**	**4.4**
Pen 5 Low	**Oct 2014**	**53**	**21.0**	**8.7**	**12.3**
	Feb 2015	**48**	**17.4**	**12.1**	**5.3**
Far Dry	**Oct 2014**	**33**	**27.5**	**14.5**	**13.0**
	Feb 2015	**29**	**26.4**	**19.2**	**7.2**

uNDFom Residue Remaining



Value of uNDF240om

- Size of potentially digestible slow NDF pool (30 h – 240 h)
- Kd of the potentially digestible slow NDF pool
- Effect on DMI, milk, and milk components

Total carbohydrate fast and slow pools

Fast Pool CHO

- Sugar
- Starch
- Soluble Fiber
- Fast pool NDF

Slow Pool CHO

- uNDF

Total carbohydrate fast and slow pools

Fast Pool CHO

- NSC
- NFC
- ME: Energy
  - Propionate: lactose, volume
  - Microbial protein

Slow Pool CHO (uNDF)

- Rumen Mat
- Forage-NDF
- peNDF
  - Chew/Rumination
    - Gut motility
    - Rumen buffer: saliva
    - Particle size reduction/exposure
    - Microbial attachment

Total carbohydrate fast and slow pools

Fast Pool CHO

- ME: Energy
  - Propionate: lactose, volume
  - Microbial protein

Slow Pool CHO (uNDF)

- Rumen Mat, Forage-NDF, peNDF
- Microbial protein
  - Metabolizable protein
  - Milk protein
- Milk Fat
  - Governor of rumen retention time. Biohydrogenation of CLA

Total carbohydrate fast and slow pools

Fast Pool CHO

- ME: Energy
  - Propionate: lactose, volume
  - Microbial protein
- Gas: Milk Volume

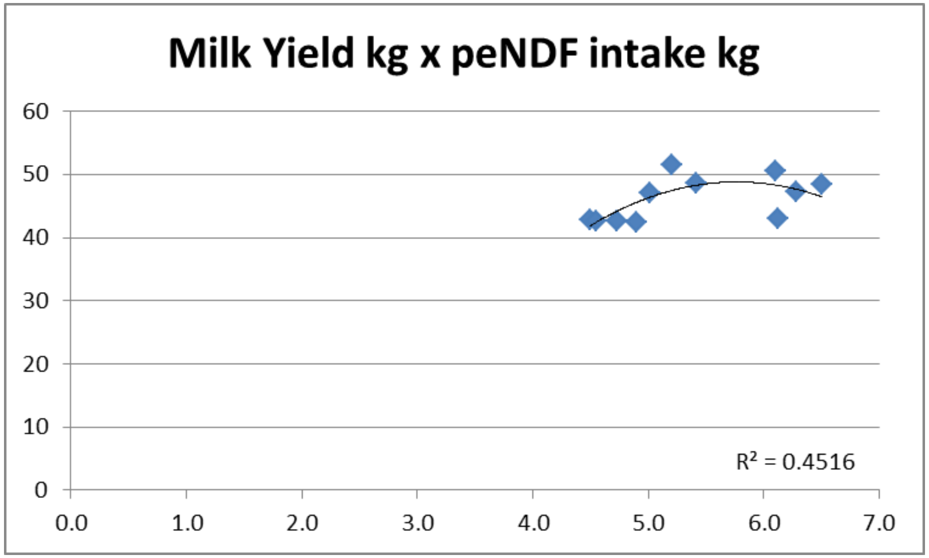
Slow Pool CHO (uNDF)

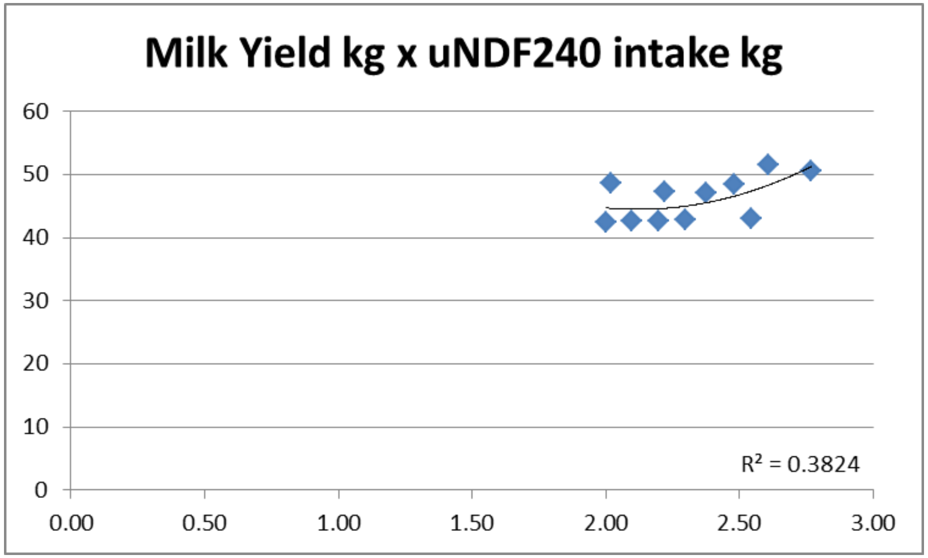
- Rumen Mat, Forage-NDF, peNDF
- Microbial protein
  - Metabolizable protein
  - Milk protein
- Milk Fat
  - Governor of rumen retention time. Biohydrogenation of CLA
- Brakes: Milk Components

Curiosity killed the lab guy: peNDF or uNDF?

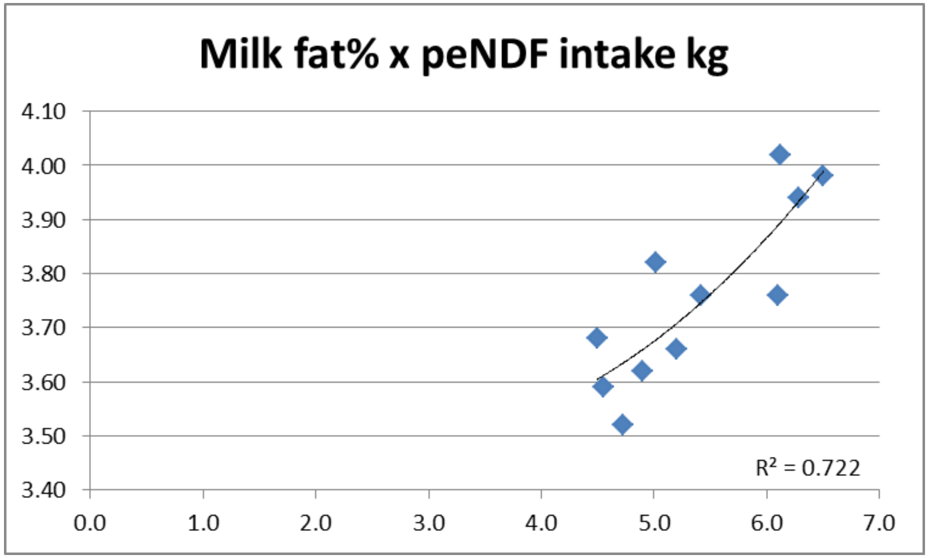
Project	Diet	Forage %	Starch %	NFC %	NDF %	peNDF %	uNDF240 % TilleyTerry
Z CHO	Control	50	26.0	41.3	34.7	18.6	9.3
	High Forage	63	21.4	37.8	38.3	25.5	9.2
	NFFS	50	21.3	38.7	38.0	22.3	10.0
TIJ	LCCS	53	28.0	43.1	32.1	17.3	8.2
	HCCS	68	21.2	37.1	35.6	23.1	9.6
	LBMR	49	27.8	41.3	31.5	18.5	6.9
	HBMR	64	23.8	39.3	35.1	21.5	7.6
LSLF	0 Straw	52	20.2	36.2	37.4	21.5	8.8
	2% Straw	47	20.8	35.8	37.5	20.2	9.0
	6% straw	43	21.2	36.0	37.0	19.2	9.8
	10% Straw	39	21.6	37.0	36.0	18.9	9.1

Curiosity killed the lab guy: peNDF or uNDF?

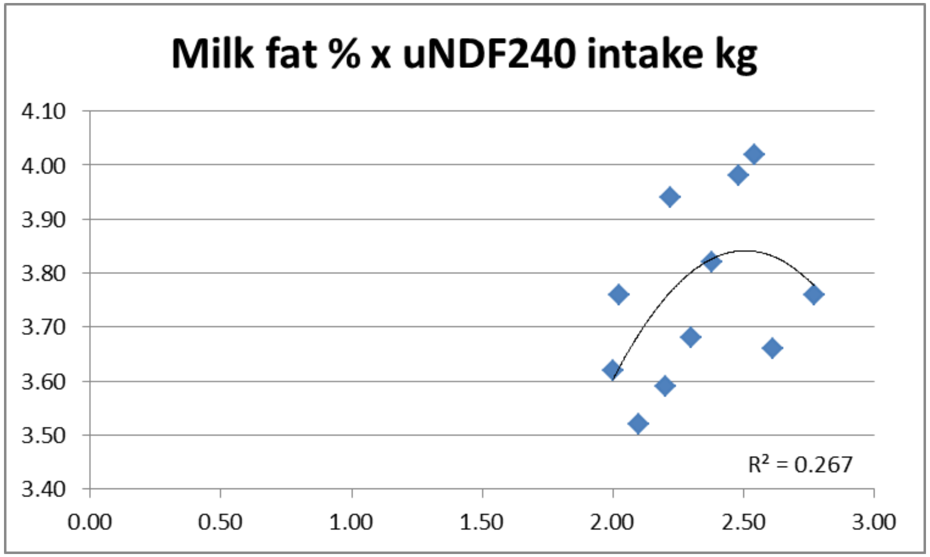

Milk Yield kg x peNDF intake kg


Milk Yield kg x uNDF240 intake kg

Curiosity killed the lab guy: peNDF or uNDF?

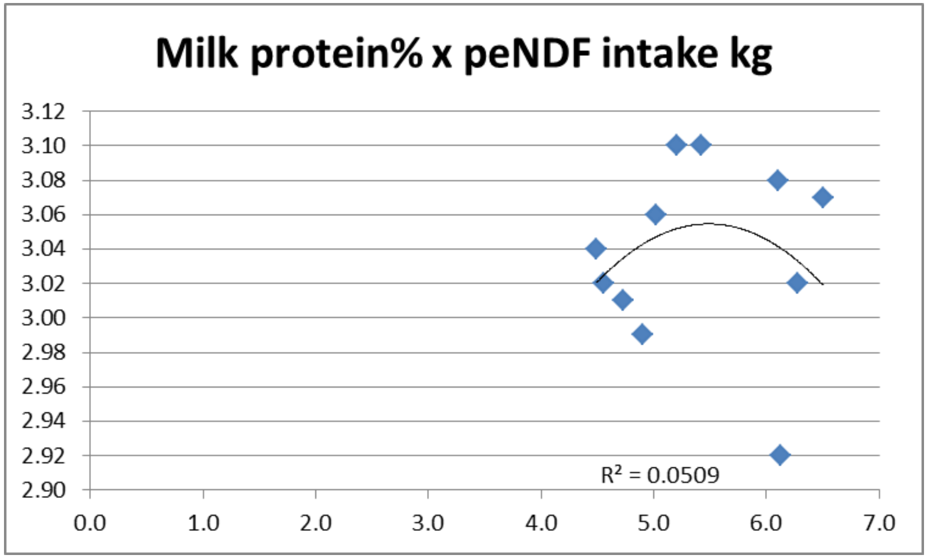


Milk fat% x peNDF intake kg

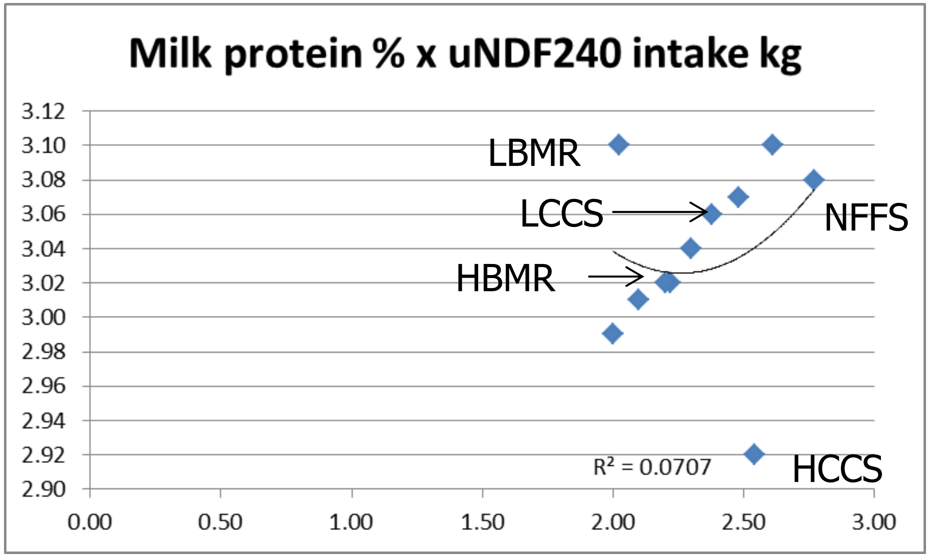


Milk fat % x uNDF240 intake kg

Curiosity killed the lab guy: peNDF or uNDF?

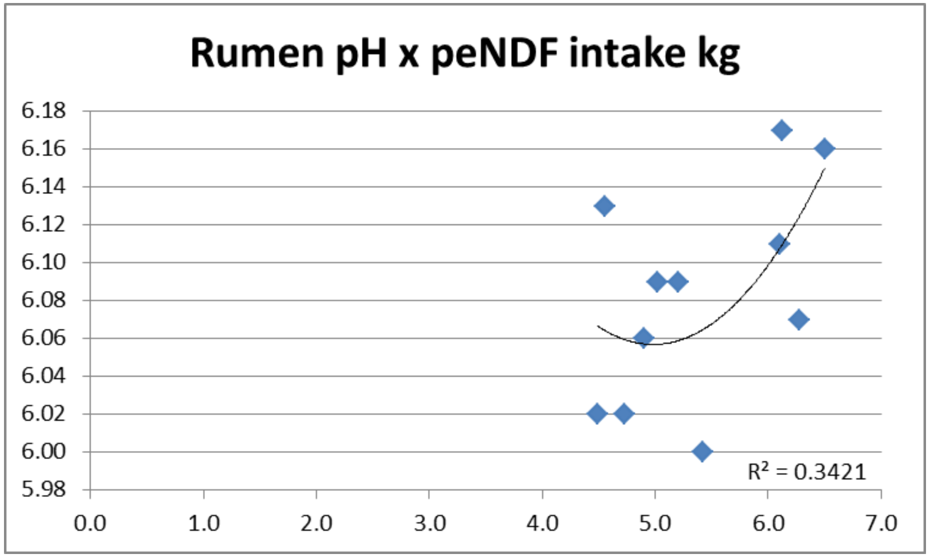


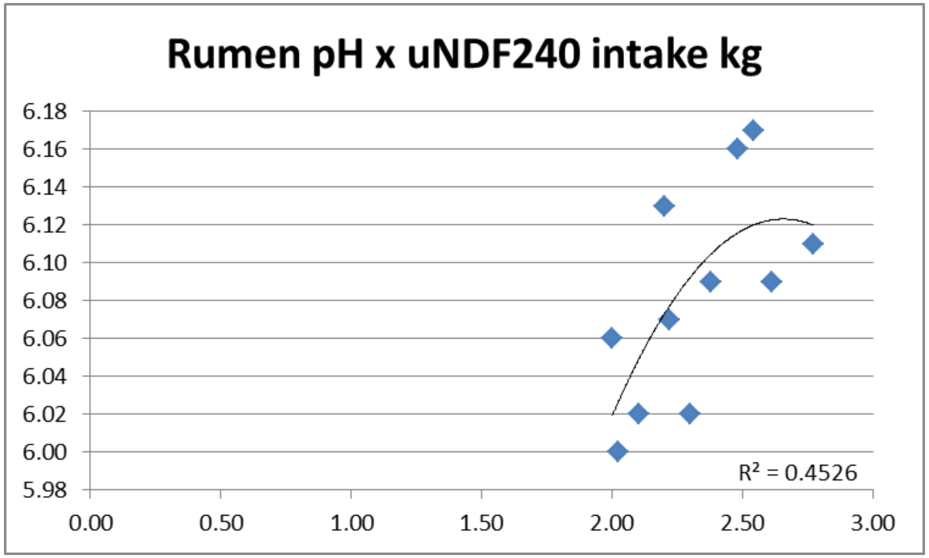
Milk protein% x peNDF intake kg



Milk protein % x uNDF240 intake kg

Curiosity killed the lab guy: peNDF or uNDF?





Summary: uNDF240om in the field

- Benchmark:
  - Farm specific: management, stage of lactation, grouping, forage type.
  - Forage Quality: crop year
  - Diet transitions: stage lactation
  - Better characterization of the Slow pool
    - Size & kd
    - How much “braking” to you need?

Thank You

MINER INSTITUTE
RESEARCH
EDUCATION
CHAZY, N.Y.
HEART'S DELIGHT FARM

Case scenario: Stocking density x peNDF 2014 Miner "BigMac"

Feed, % of ration DM	No Straw	Straw
Corn silage	39.7	39.7
Hay crop silage	6.9	2.3
Straw	0	3.5
Grain	53.4	54.5
Nutrient profile		
CP, %	16.3	16.2
aNDFom, %	27.8	28.6
peNDF, %	20.5	21.5
Starch, %	27.5	27.5
Rumen pH, predicted	5.93	5.93
ME milk, kg	42.2	41.4
MP milk, kg	44.2	44.3

Case scenario: Stocking density x peNDF 2014 Miner

(Miner lab Analysis)

Diet	NDF%	NDFd	pef RT	pef PSPS	ADF%	Lignin%	uNDF30 TT P1 only	uNDF240 TT P1 only
No Straw	**28.1**	**58.3**	**0.669**	**0.682**	**20.03**	**3.76**	**13.2**	**8.4**
Straw	**30.0**	**55.5**	**0.671**	**0.694**	**20.05**	**3.77**	**14.2**	**8.8**

Case scenario: Stocking density x peNDF 2014: Rumen pH

	100%		**SEM**	***P*-value**
	No Straw	Straw		Diet
Mean pH	6.17	6.13	0.03	0.62
Min pH	5.70	5.67	0.05	0.53
Max pH	6.63	6.58	0.04	0.22
pH < 5.8, h/d	2.29	1.90	0.41	0.01

Dry Period Heat Stress: Effects on Dam and Daughter

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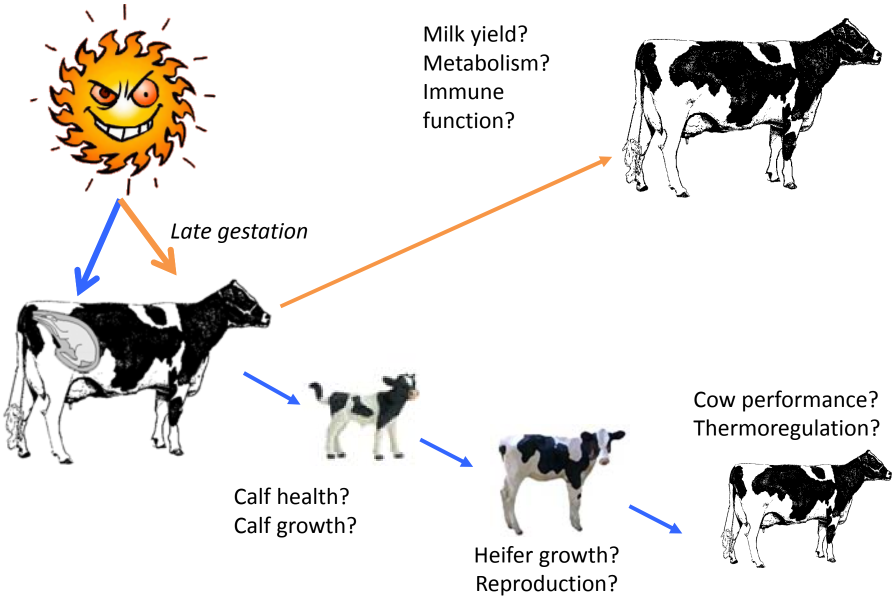
Institute of Food and Agricultural Sciences
gdahl@ufl.edu

Penn State Dairy Cattle Nutrition Workshop
12 November 2015

UF UNIVERSITY of FLORIDA



Late gestation

Milk yield?
Metabolism?
Immune function?

Calf health?
Calf growth?

Heifer growth?
Reproduction?

Cow performance?
Thermoregulation?

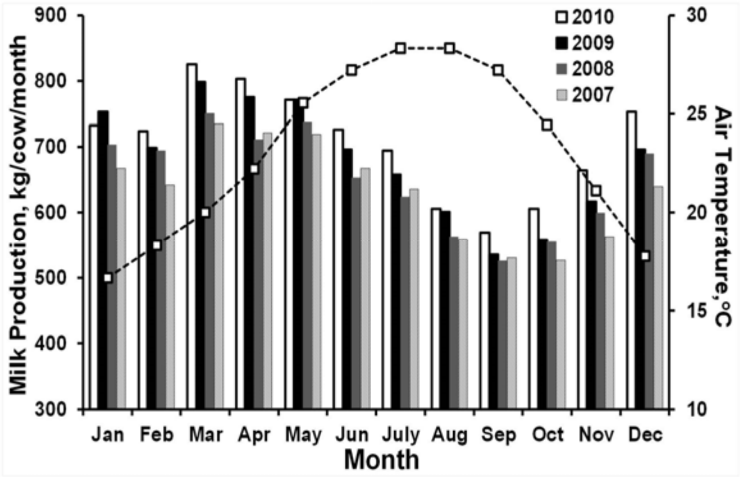
Heat Stress During Lactation

Heat Stress During Lactation

- Depresses DMI
- Reduces milk yield
- Recent studies suggest additional metabolic effects beyond DMI
- Recovery dependent on duration

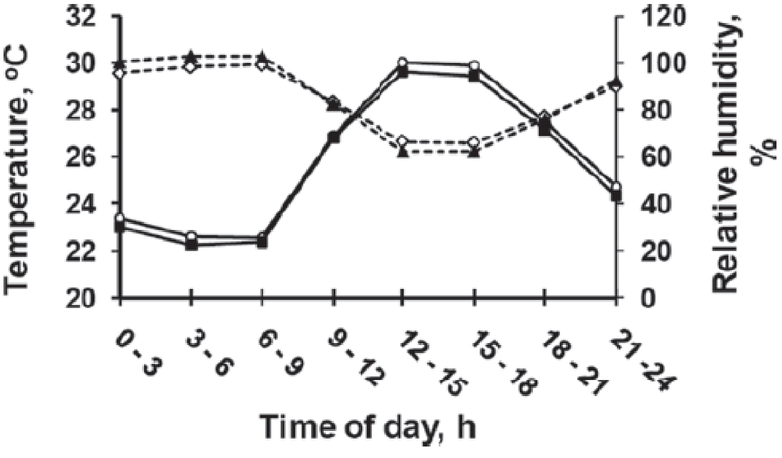
What about dry cows?

Heat Stress Effects on Yield Linger

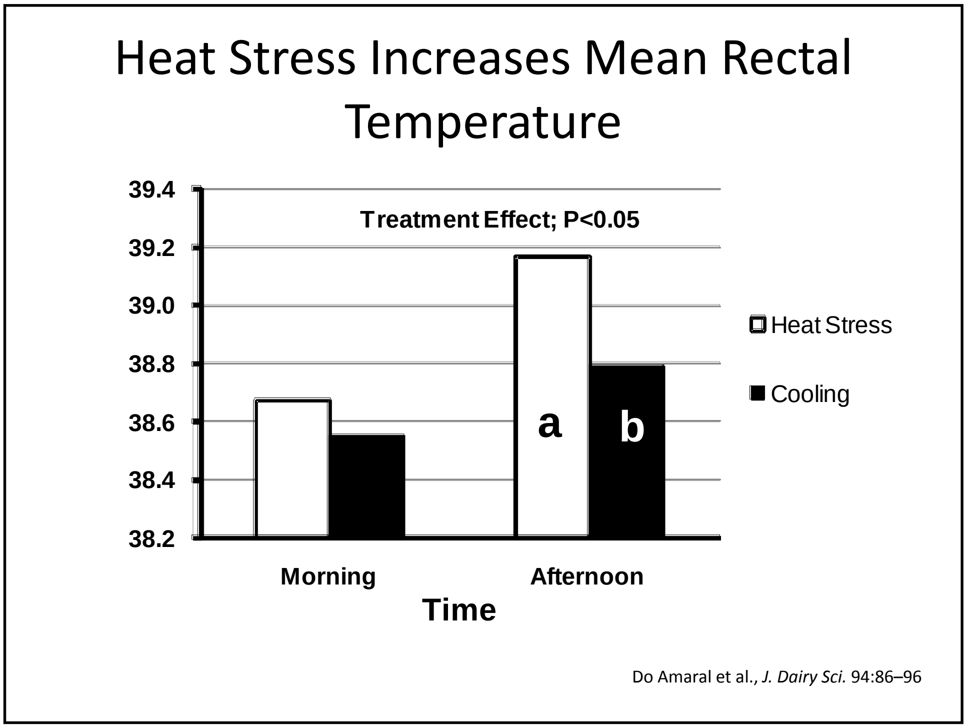


Tao & Dahl, *J. Dairy Sci.* 96:4079-4093

Study Design: Heat Load of Dry Cows

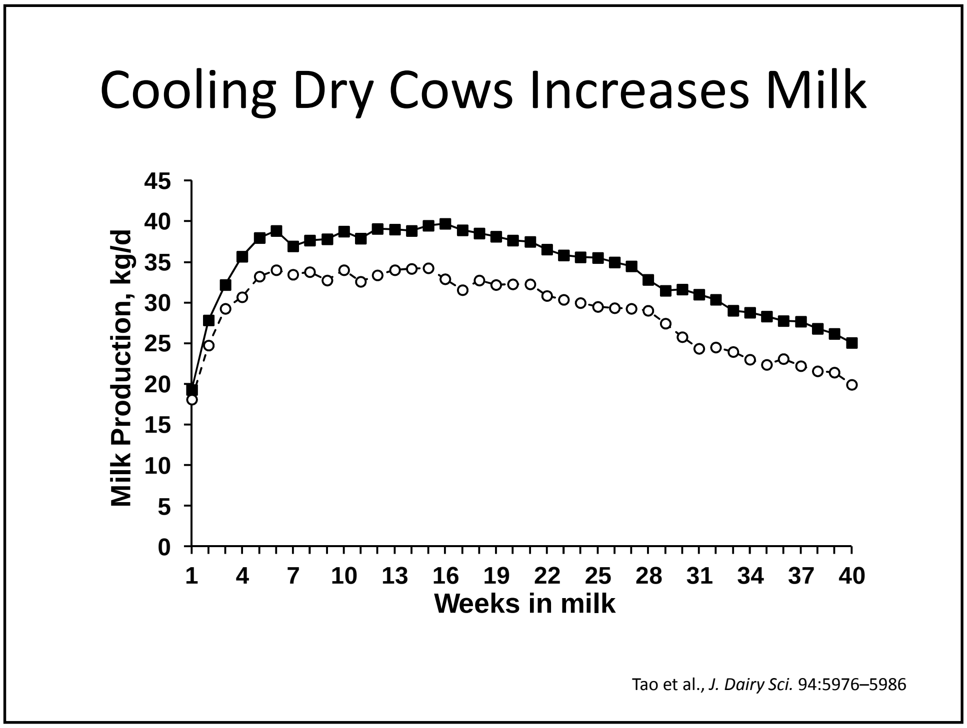


Do Amaral et al., *J. Dairy Sci.* 94:86–96



Heat Stress Increases Mean Rectal Temperature

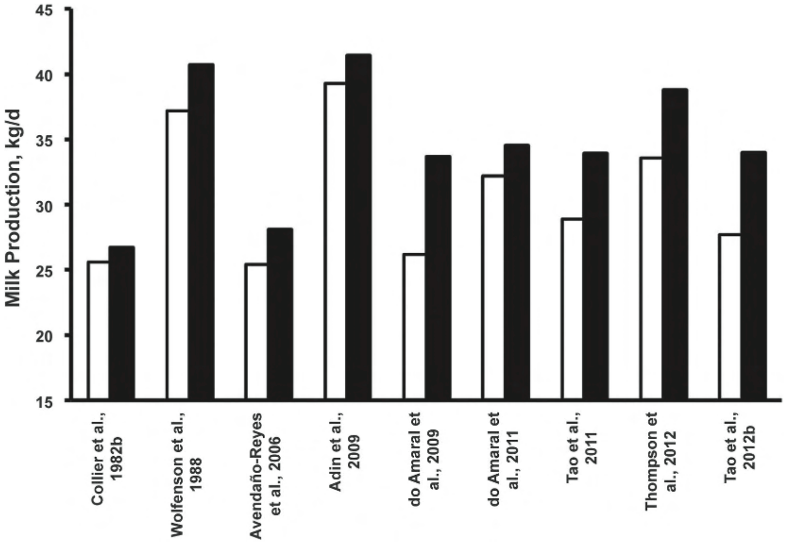
Do Amaral et al., *J. Dairy Sci.* 94:86–96



Cooling Dry Cows Increases Milk

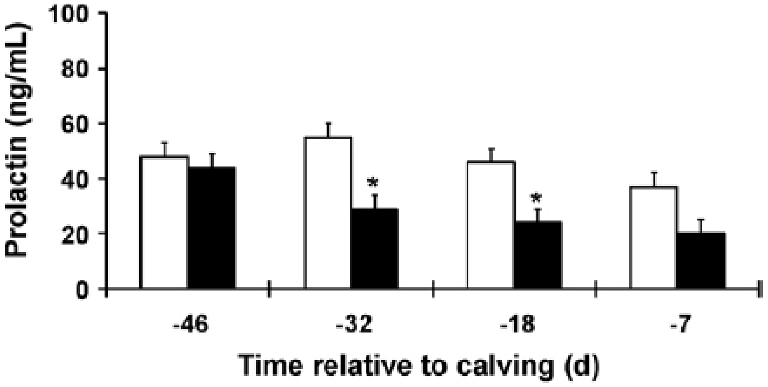
Tao et al., *J. Dairy Sci.* 94:5976–5986

Cooling Dry Cows Increases Milk



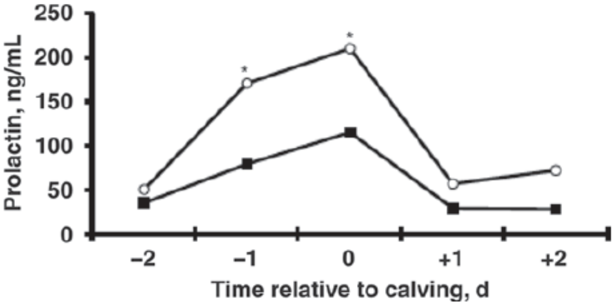
Tao & Dahl, *J. Dairy Sci.* 96:4079-4093

Cooling Dry Cows Decreases PRL – During Dry Period



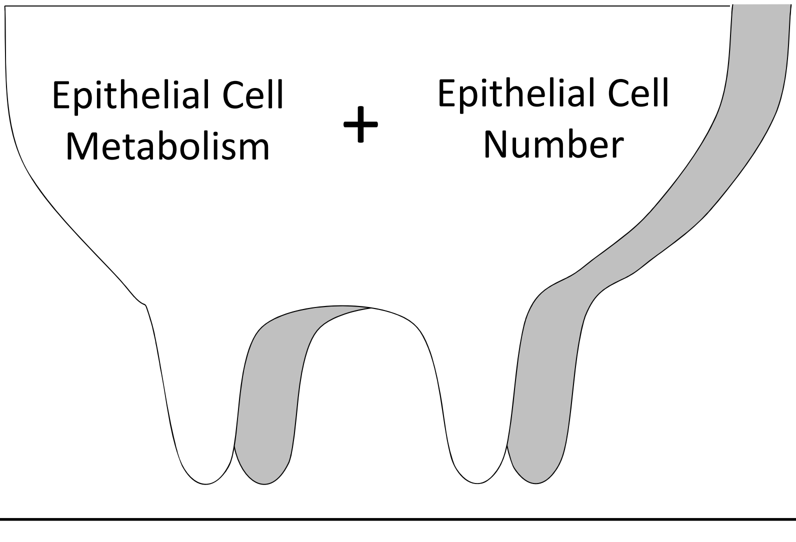
Do Amaral et al., *Domest. Anim. Endo.* 38:38-45

Cooling Dry Cows Decreases PRL – At Calving



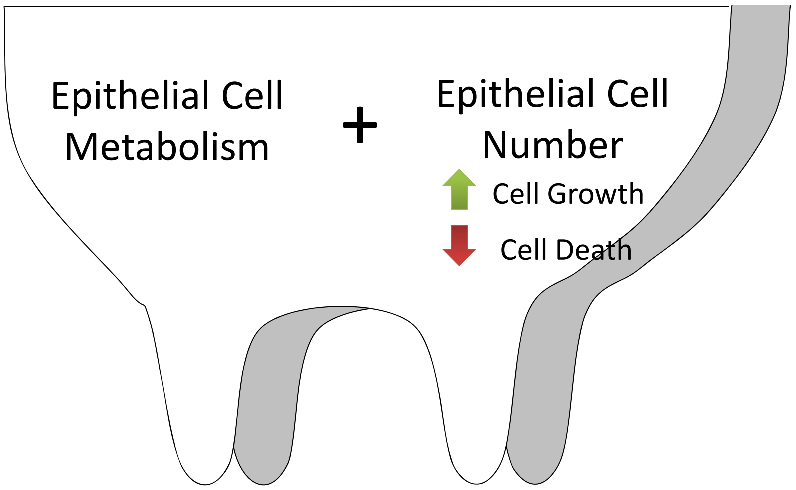
Do Amaral et al., *J. Dairy Sci.* 92:5988-5999

Milk Production



Epithelial Cell Metabolism + Epithelial Cell Number

Milk Production

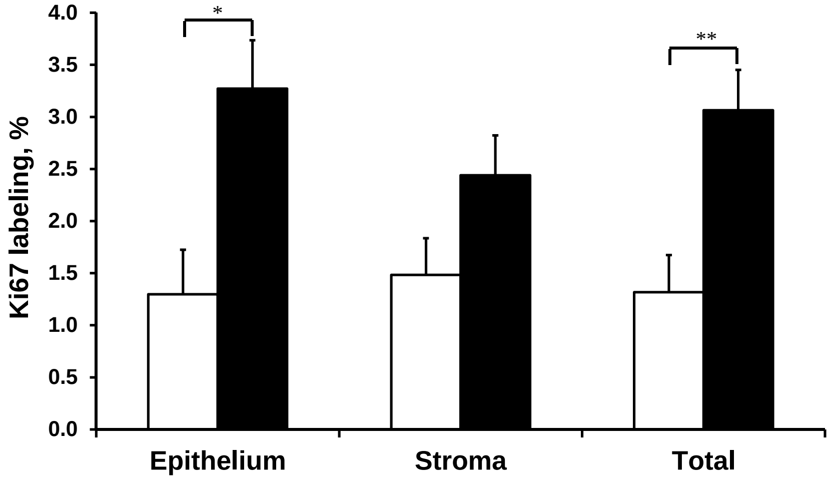


Epithelial Cell Metabolism + Epithelial Cell Number

↑ Cell Growth

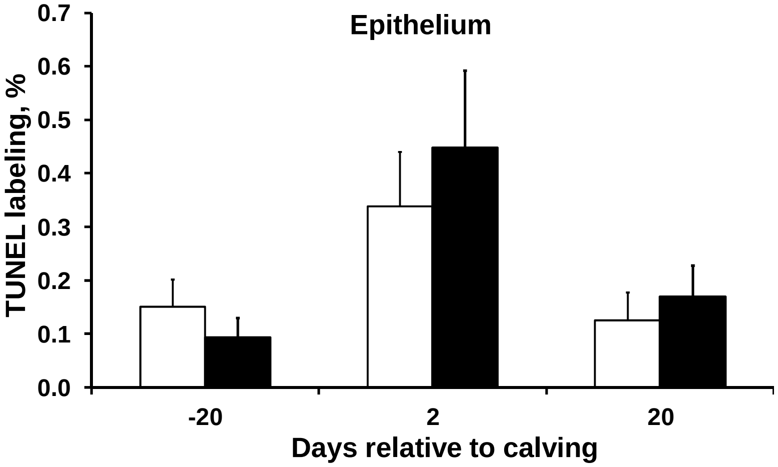
↓ Cell Death

Cooling Increased Proliferation of Mammary Cells Prepartum (d-20)



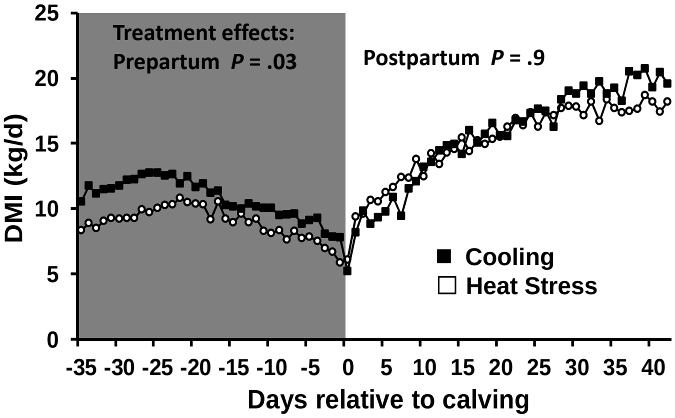
Tao et al., *J. Dairy Sci.* 94:5976–5986

Heat Stress During Dry Period – No Effect on MEC Apoptosis



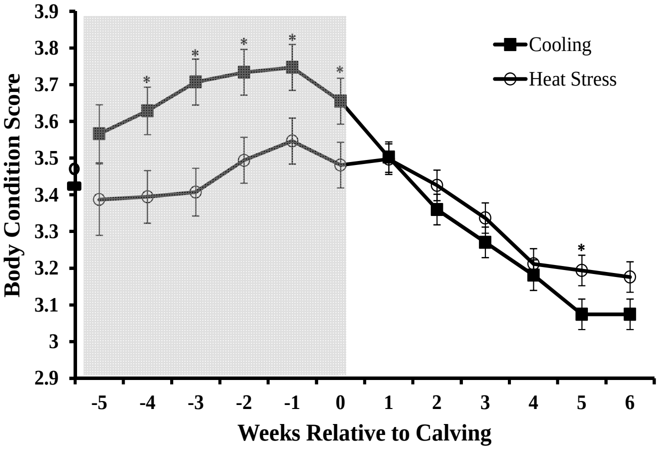
Tao et al., *J. Dairy Sci.* 94:5976–5986

Heat Stress Reduces DMI Prepartum But Not Postpartum



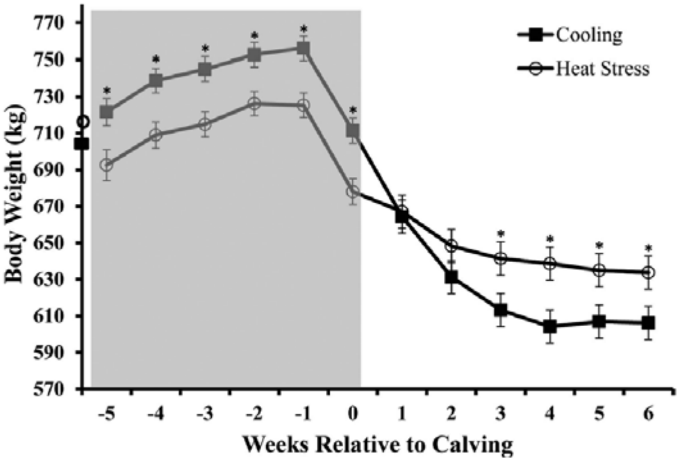
Tao et al., *J. Dairy Sci.* 94:5976–5986

Cooling Dry Cows Improves BCS



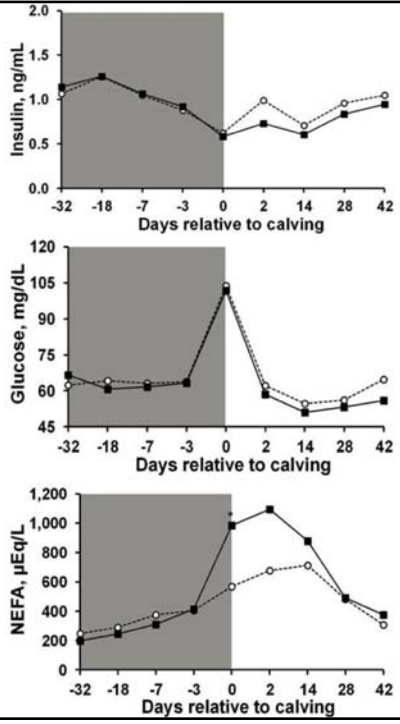
Thompson et al., *J. Dairy Sci.* 97:7426-7436

Cooling Dry Cows Increases BW Prepartum, Decreases Postpartum



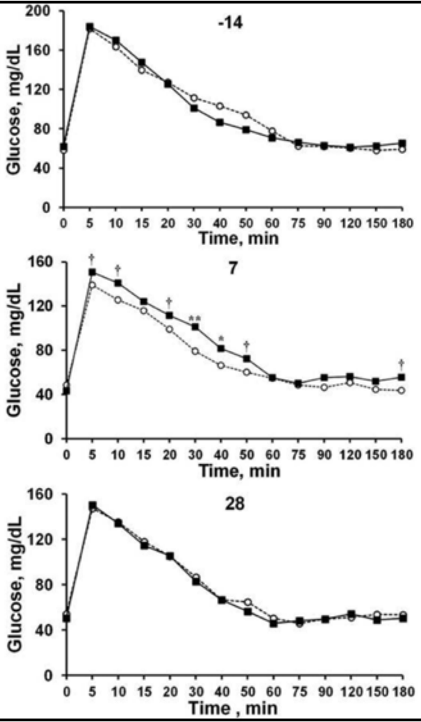
Thompson et al., *J. Dairy Sci.* 97:7426-7436

Effect of Cooling Dry Cows on Metabolic Profile



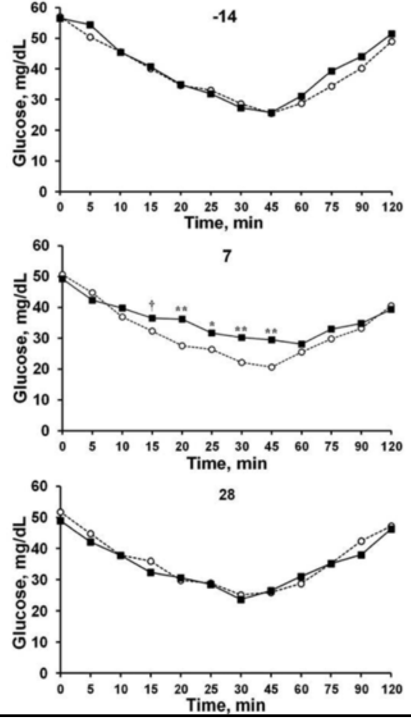
Tao et al., *J. Dairy Sci.* 95:5035-5046

Effect of Cooling Dry Cows on Glucose Profile with GTT



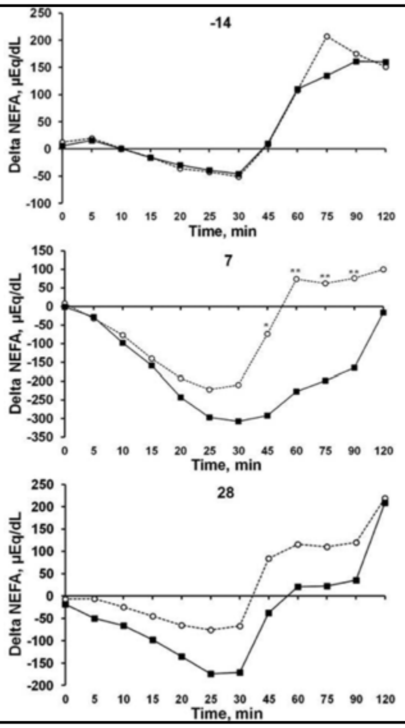
Tao et al., *J. Dairy Sci.* 95:5035-5046

Effect of Cooling Dry Cows on Glucose Profile with Insulin Challenge



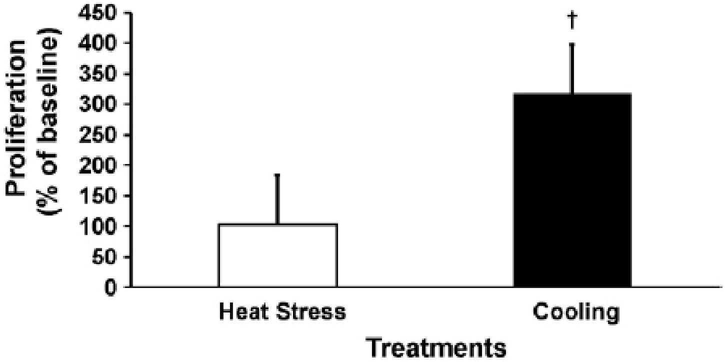
Tao et al., *J. Dairy Sci.* 95:5035-5046

Effect of Cooling Dry Cows on NEFA Profile with Insulin Challenge



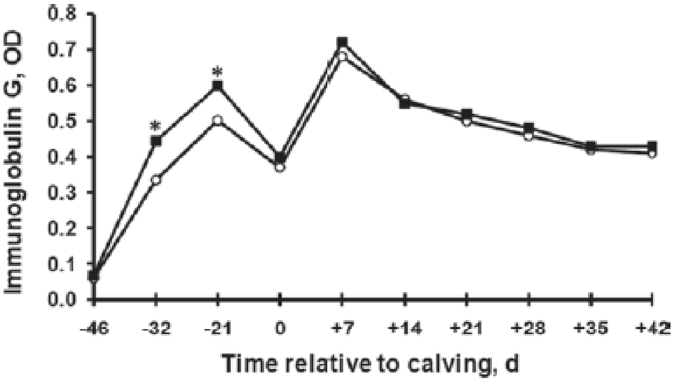
Tao et al., *J. Dairy Sci.* 95:5035-5046

Cooling Dry Cows Increases Lymphocyte Proliferation



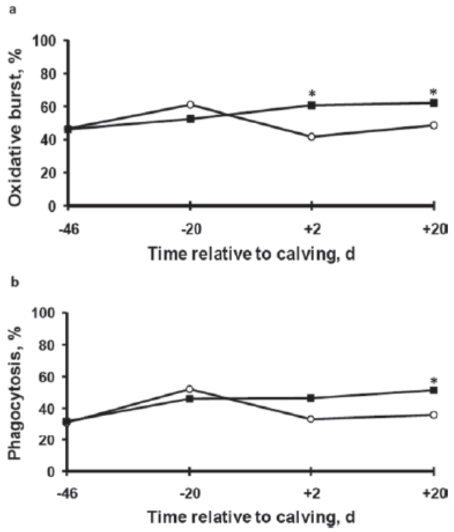
Do Amaral et al., *Domest. Anim. Endo.* 38:38-45

Cooling Dry Cows Effects on Acquired Immunity



Do Amaral et al., *J. Dairy Sci.* 94:86–96

Cooling Dry Cows Increases Neutrophil Action Postpartum



Do Amaral et al., *J. Dairy Sci.* 94:86–96

Dry in COOL Months Improves Performance

Table 1. Milk production and occurrence of mastitis, digestive and respiratory problems, retained fetal membranes, and metritis in cows dried during HOT months (Jun, Jul, Aug) or COOL months (Dec, Jan, Feb) in the first 80 DIM of the subsequent lactation

	Dry during HOT months (Jun, Jul, Aug), n = 1,569				Dry during COOL months (Dec, Jan, Feb), n = 1,044				
Item	Value	Disease[1]	n	%	Value	Disease[1]	n	%	*P*-value
Milk production (kg)	10,351 ± 59.8				10,902 ± 73.3				0.01
Mastitis		0	1,286	82.0		0	950	91.0	0.01
		1	283	18.0		1	94	9.0	
Digestive		0	1,516	96.6		0	973	93.2	0.01
		1	53	3.4		1	71	6.8	
Respiratory		0	1,346	85.8		0	942	90.2	0.01
		1	223	14.2		1	102	9.8	
Retained fetal membranes		0	1,500	95.6		0	1,013	97.0	0.06
		1	69	4.4		1	31	3.0	
Metritis		0	1,500	95.6		0	1,007	96.4	0.35
		1	67	4.2		1	38	3.5	

[1] Disease: 0 = cows without the disease; 1 = cows with the disease.

Thompson & Dahl, *Prof. Anim. Sci.* 28:628-631

Dry in COOL Months Improves Reproductive Performance

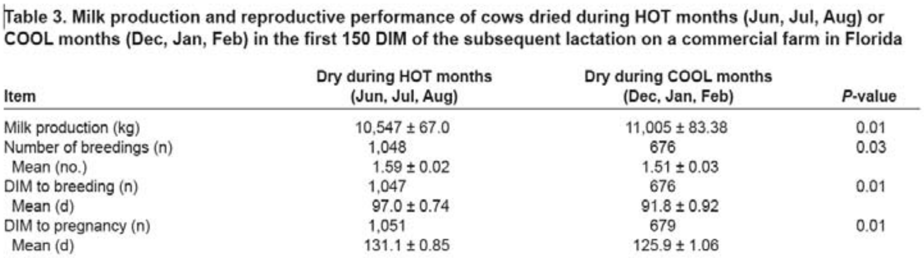


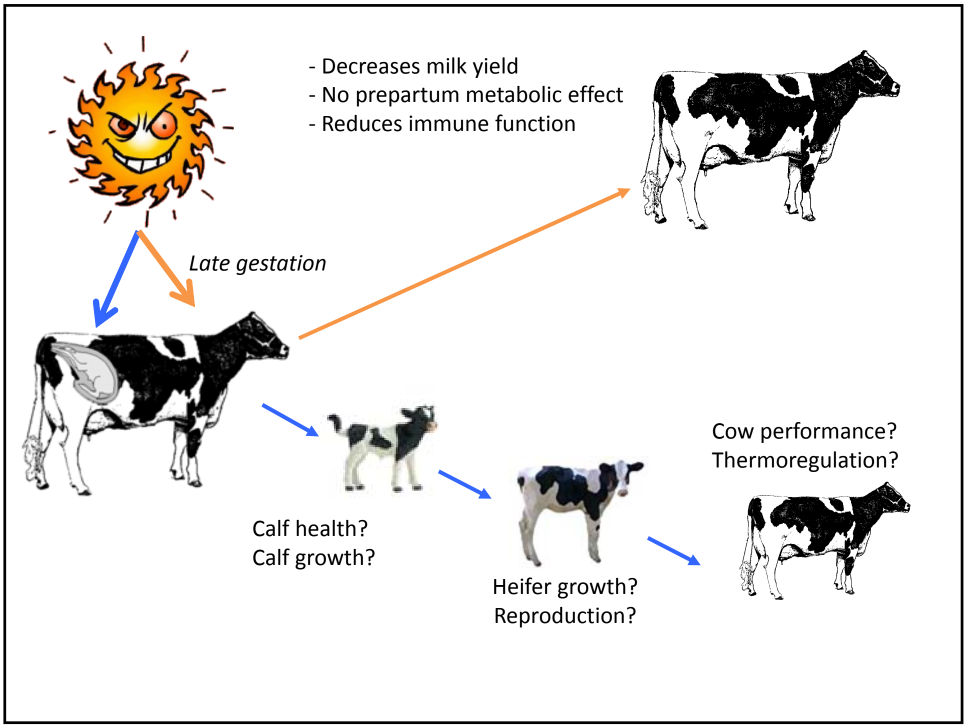
Table 3. Milk production and reproductive performance of cows dried during HOT months (Jun, Jul, Aug) or COOL months (Dec, Jan, Feb) in the first 150 DIM of the subsequent lactation on a commercial farm in Florida

Item	Dry during HOT months (Jun, Jul, Aug)	Dry during COOL months (Dec, Jan, Feb)	*P*-value
Milk production (kg)	10,547 ± 67.0	11,005 ± 83.38	0.01
Number of breedings (n)	1,048	676	0.03
Mean (no.)	1.59 ± 0.02	1.51 ± 0.03	
DIM to breeding (n)	1,047	676	0.01
Mean (d)	97.0 ± 0.74	91.8 ± 0.92	
DIM to pregnancy (n)	1,051	679	0.01
Mean (d)	131.1 ± 0.85	125.9 ± 1.06	

Thompson & Dahl, *Prof. Anim. Sci.* 28:628-631

Heat Stress Summary – Dry Cows

- Cooling increases milk in subsequent lactation; related to increase in mammary growth
- Cooling dry cows improves DMI, BW and BCS during dry period, but other metabolic effects limited
- Cooling improves immune status during transition



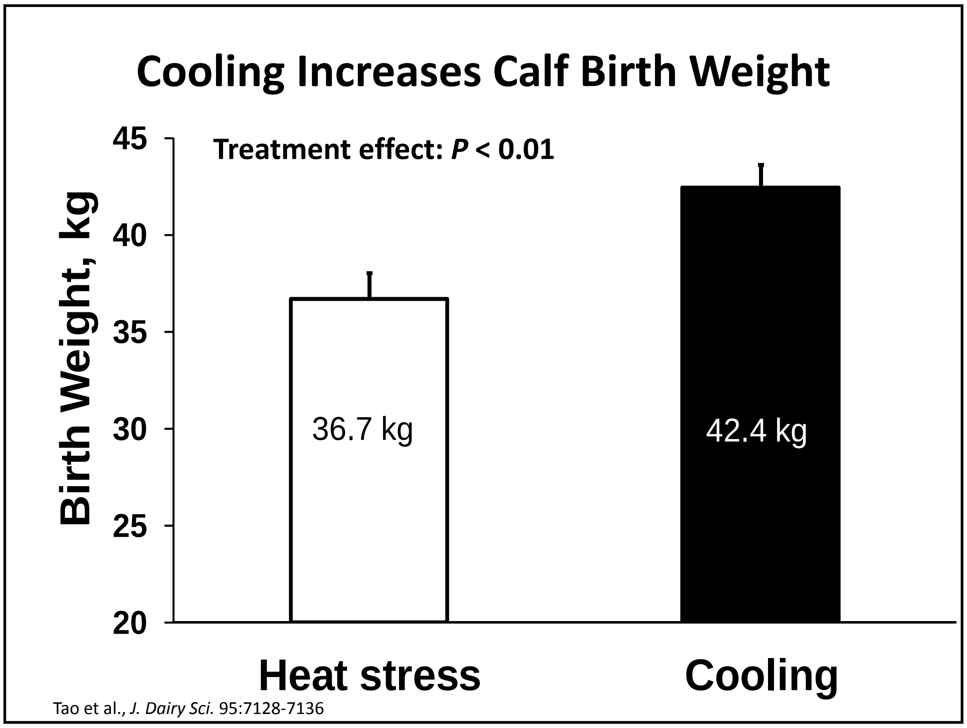
- Decreases milk yield
- No prepartum metabolic effect
- Reduces immune function

Late gestation

Calf health?
Calf growth?

Heifer growth?
Reproduction?

Cow performance?
Thermoregulation?

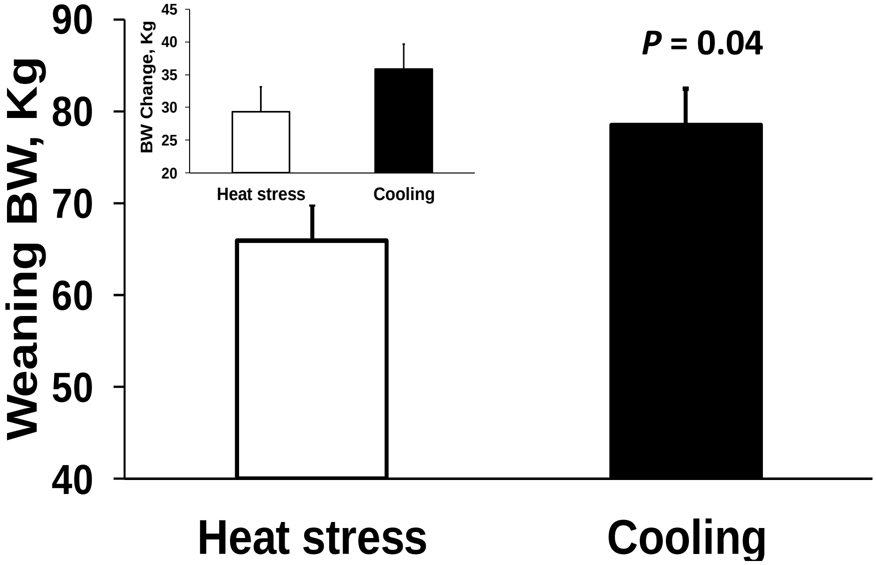


Cooling Increases Calf Birth Weight

Treatment effect: $P < 0.01$

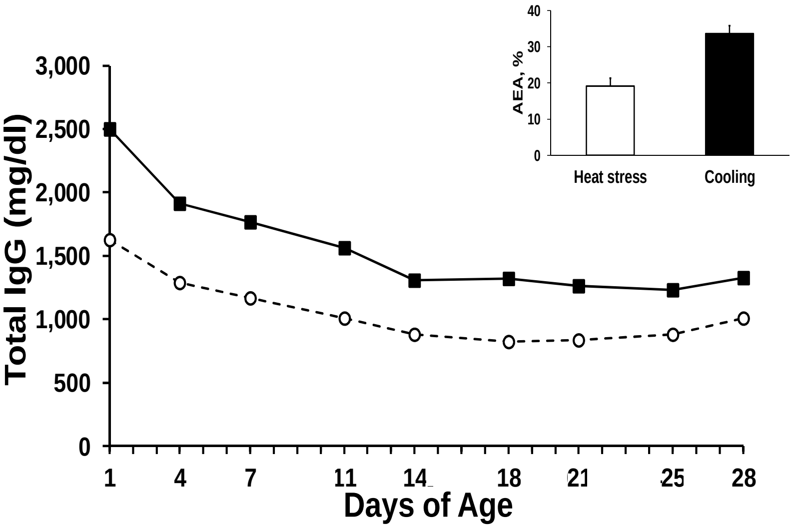
Tao et al., *J. Dairy Sci.* 95:7128-7136

Weaning Weight



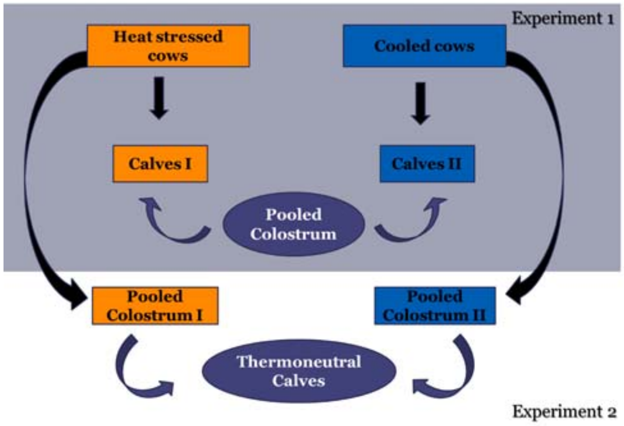
Tao et al., *J. Dairy Sci.* 95:7128-7136

Cooling Improves Total IgG and AEA



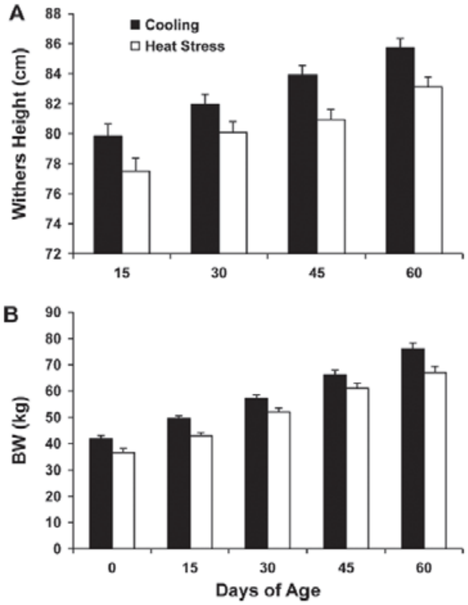
Tao et al., *J. Dairy Sci.* 95:7128-7136

Why Does Cooling Affect AEA? Calf or Colostrum Effect?



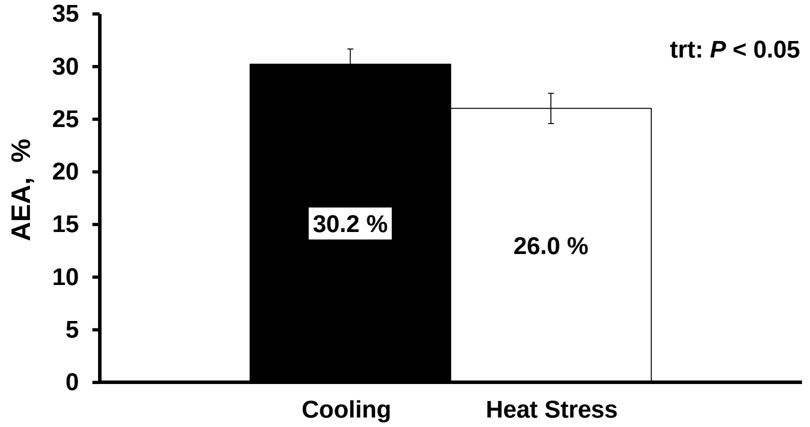
Monteiro et al., *J. Dairy Sci.* 97:6426-6439

Experiment 1 - In utero heat stress for ~6 weeks reduces body weight and height to weaning



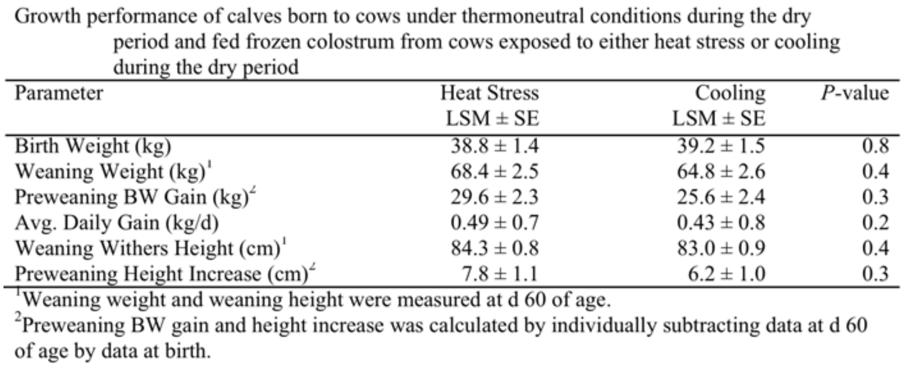
Monteiro et al., *J. Dairy Sci.* 97:6426-6439

Cooling Increased Apparent efficiency of IgG absorption (AEA*)



* AEA = [Serum [IgG] (g/L) * birth weight (kg) * 0.091 / IgG fed (g)] x 100

Experiment 2 – **No Effect** of Colostrum from Cooled or Heat Stressed Cows on Calf Performance



Growth performance of calves born to cows under thermoneutral conditions during the dry period and fed frozen colostrum from cows exposed to either heat stress or cooling during the dry period

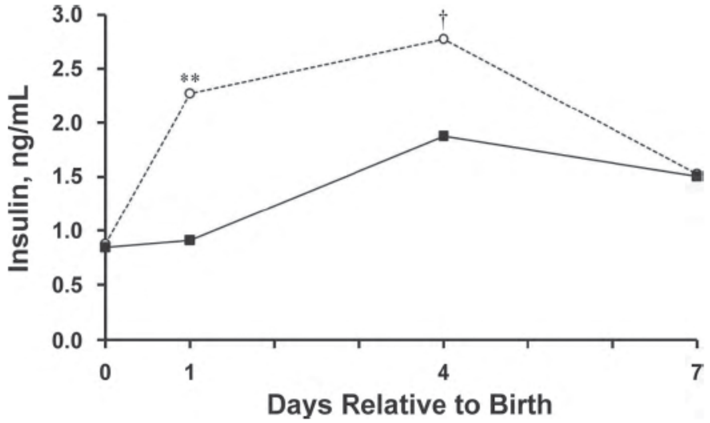
Parameter	Heat Stress LSM ± SE	Cooling LSM ± SE	*P*-value
Birth Weight (kg)	38.8 ± 1.4	39.2 ± 1.5	0.8
Weaning Weight (kg)[1]	68.4 ± 2.5	64.8 ± 2.6	0.4
Preweaning BW Gain (kg)[2]	29.6 ± 2.3	25.6 ± 2.4	0.3
Avg. Daily Gain (kg/d)	0.49 ± 0.7	0.43 ± 0.8	0.2
Weaning Withers Height (cm)[1]	84.3 ± 0.8	83.0 ± 0.9	0.4
Preweaning Height Increase (cm)[2]	7.8 ± 1.1	6.2 ± 1.0	0.3

[1] Weaning weight and weaning height were measured at d 60 of age.

[2] Preweaning BW gain and height increase was calculated by individually subtracting data at d 60 of age by data at birth.

Monteiro et al., *J. Dairy Sci.* 97:6426-6439

In Utero Heat Stress Increases Insulin in Calves



Tao & Dahl, *J. Dairy Sci.* 96:4079-4093

In Utero HS Increases Insulin Responsiveness in Calves

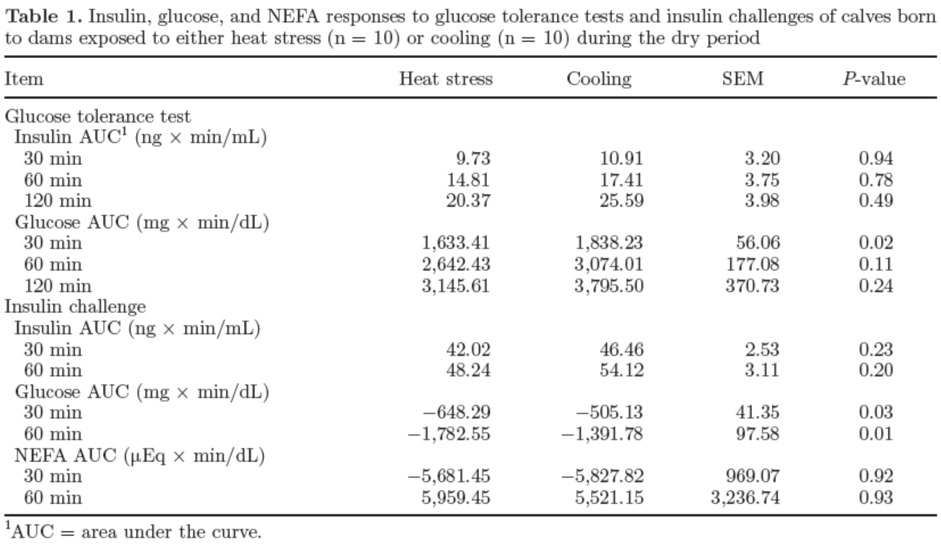


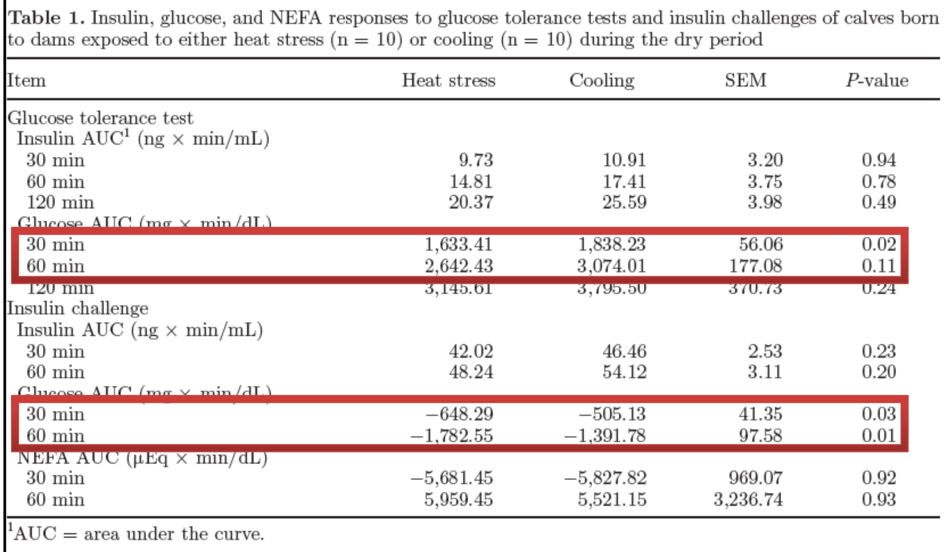
Table 1. Insulin, glucose, and NEFA responses to glucose tolerance tests and insulin challenges of calves born to dams exposed to either heat stress (n = 10) or cooling (n = 10) during the dry period

Item	Heat stress	Cooling	SEM	*P*-value
Glucose tolerance test				
Insulin AUC[1] (ng × min/mL)				
30 min	9.73	10.91	3.20	0.94
60 min	14.81	17.41	3.75	0.78
120 min	20.37	25.59	3.98	0.49
Glucose AUC (mg × min/dL)				
30 min	1,633.41	1,838.23	56.06	0.02
60 min	2,642.43	3,074.01	177.08	0.11
120 min	3,145.61	3,795.50	370.73	0.24
Insulin challenge				
Insulin AUC (ng × min/mL)				
30 min	42.02	46.46	2.53	0.23
60 min	48.24	54.12	3.11	0.20
Glucose AUC (mg × min/dL)				
30 min	−648.29	−505.13	41.35	0.03
60 min	−1,782.55	−1,391.78	97.58	0.01
NEFA AUC (μEq × min/dL)				
30 min	−5,681.45	−5,827.82	969.07	0.92
60 min	5,959.45	5,521.15	3,236.74	0.93

[1] AUC = area under the curve.

Tao et al., *J. Dairy Sci.* 97:897-901

In Utero HS Increases Insulin Responsiveness in Calves



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[1] AUC = area under the curve.

Tao et al., *J. Dairy Sci.* 97:897-901

Heat Stress Summary – Short Term Effects on Calves

- Cooling increases weight at birth and weaning
- In utero heat stress reduces apparent efficiency of IgG absorption, but not an effect on colostrum quality
- In utero heat stress alters carbohydrate metabolism, consistent with greater fat deposition

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Heat-stress abatement during the dry period: Does cooling improve transition into lactation?

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Heat stress abatement during the dry period influences metabolic gene expression and improves immune status in the transition period of dairy cows

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Effect of heat stress during the dry period on mammary gland development

S. Tao, J. W. Bubolz, B. C. do Amaral,[1] I. M. Thompson, M. J. Hayen, S. E. Johnson, and G. E. Dahl[2]
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J. Dairy Sci. 95:5035–5046
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Effect of cooling heat-stressed dairy cows during the dry period on insulin response

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J. Dairy Sci. 97:7426–7436
http://dx.doi.org/10.3168/jds.2013-7621
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Effect of cooling during the dry period on immune response after *Streptococcus uberis* intramammary infection challenge of dairy cows

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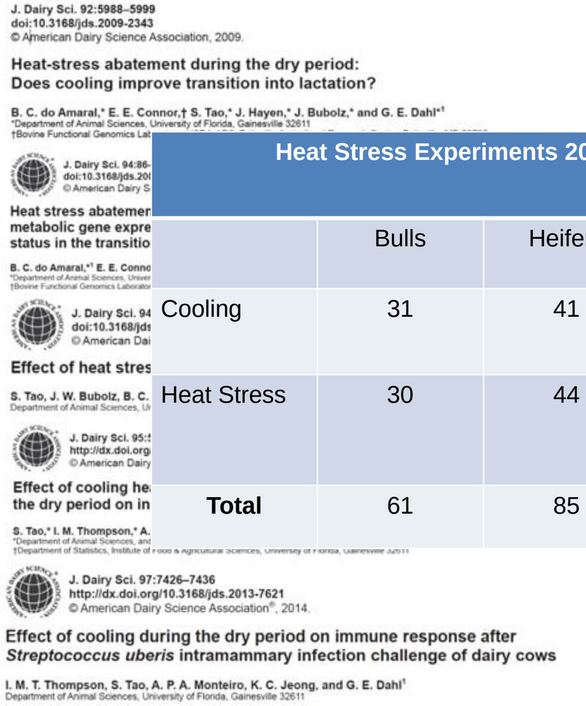
Retrospective analysis of records of calves from 5 studies between 2007 and 2011

Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163.



J. Dairy Sci. 92:5988–5999
doi:10.3168/jds.2009-2343
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Heat-stress abatement during the dry period: Does cooling improve transition into lactation?

B. C. do Amaral,* E. E. Connor,† S. Tao,* J. Hayen,* J. Bubolz,* and G. E. Dahl*[1]
*Department of Animal Sciences, University of Florida, Gainesville 32611

Heat Stress Experiments 2007 - 2011			
	Bulls	Heifers	**Total**
Cooling	31	41	72
Heat Stress	30	44	74
Total	61	85	147

J. Dairy Sci. 97:7426–7436
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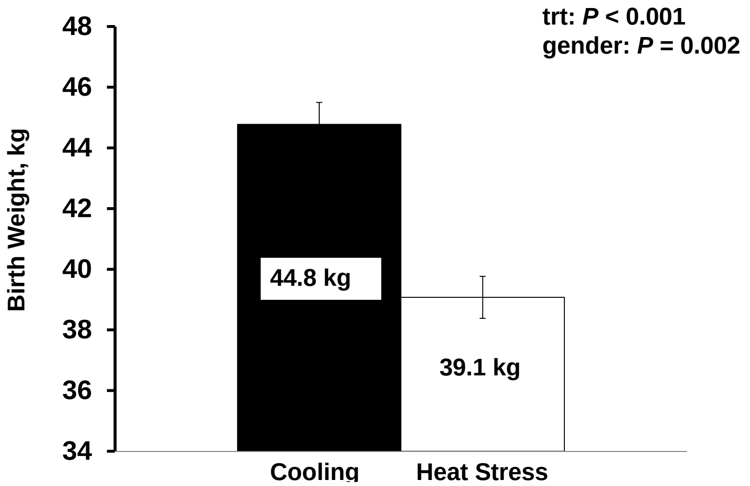
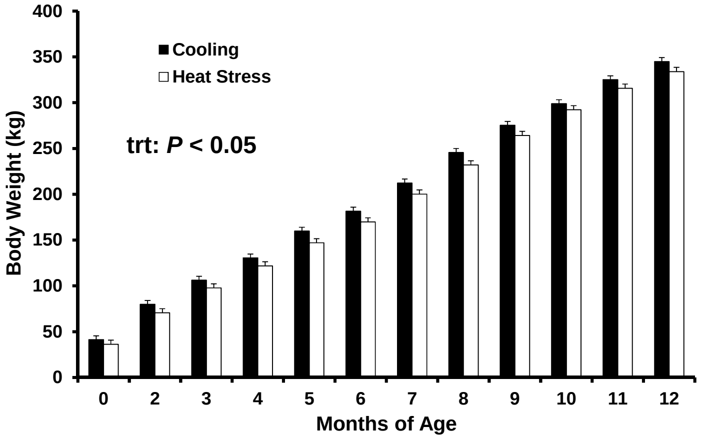
Birth Weight



Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163

In Utero Heat Stress Decreases Calf Bodyweight to Puberty



Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163

In Utero HS Decreases Calf Survival

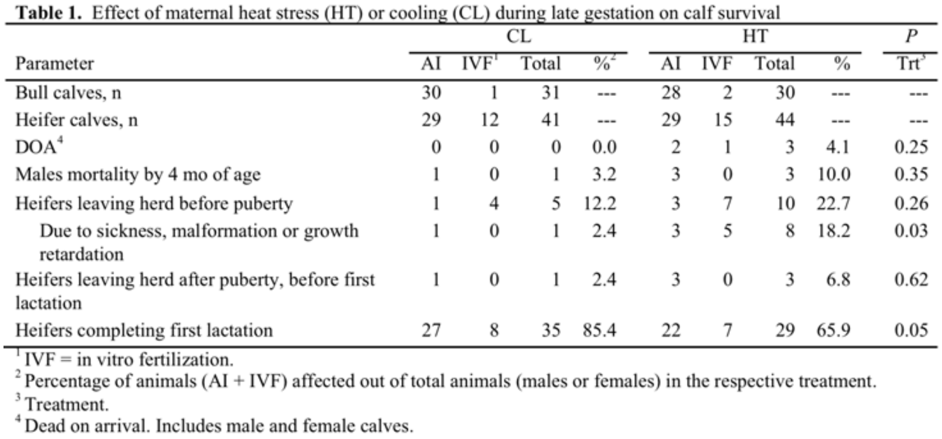


Table 1. Effect of maternal heat stress (HT) or cooling (CL) during late gestation on calf survival

	CL				HT				*P*
Parameter	AI	IVF[1]	Total	%[2]	AI	IVF	Total	%	Trt[3]
Bull calves, n	30	1	31	---	28	2	30	---	---
Heifer calves, n	29	12	41	---	29	15	44	---	---
DOA[4]	0	0	0	0.0	2	1	3	4.1	0.25
Males mortality by 4 mo of age	1	0	1	3.2	3	0	3	10.0	0.35
Heifers leaving herd before puberty	1	4	5	12.2	3	7	10	22.7	0.26
Due to sickness, malformation or growth retardation	1	0	1	2.4	3	5	8	18.2	0.03
Heifers leaving herd after puberty, before first lactation	1	0	1	2.4	3	0	3	6.8	0.62
Heifers completing first lactation	27	8	35	85.4	22	7	29	65.9	0.05

[1] IVF = in vitro fertilization.
[2] Percentage of animals (AI + IVF) affected out of total animals (males or females) in the respective treatment.
[3] Treatment.
[4] Dead on arrival. Includes male and female calves.

Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163.

In Utero Heat Stress Decreases Reproductive Performance

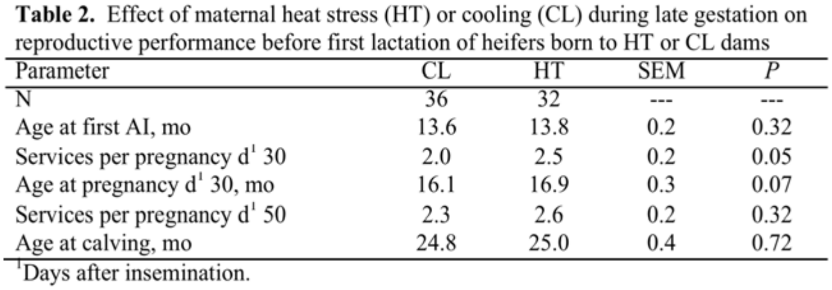


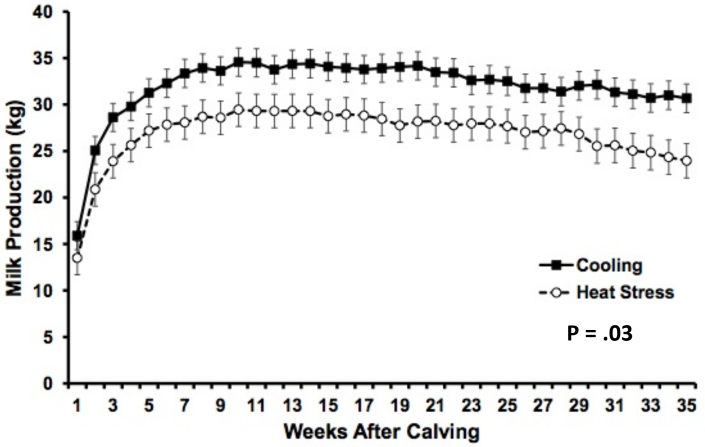
Table 2. Effect of maternal heat stress (HT) or cooling (CL) during late gestation on reproductive performance before first lactation of heifers born to HT or CL dams

Parameter	CL	HT	SEM	*P*
N	36	32	---	---
Age at first AI, mo	13.6	13.8	0.2	0.32
Services per pregnancy d[1] 30	2.0	2.5	0.2	0.05
Age at pregnancy d[1] 30, mo	16.1	16.9	0.3	0.07
Services per pregnancy d[1] 50	2.3	2.6	0.2	0.32
Age at calving, mo	24.8	25.0	0.4	0.72

[1] Days after insemination.

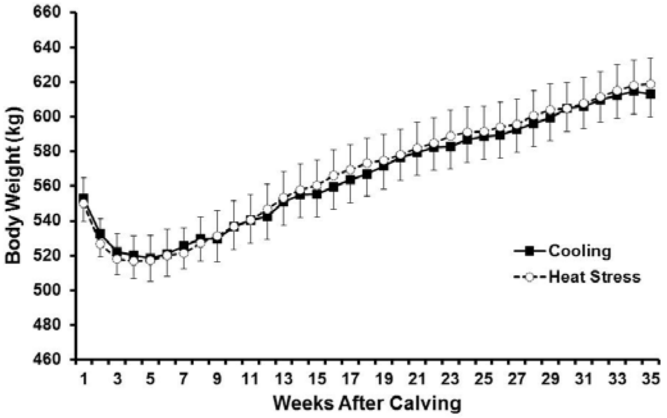
Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163.

In Utero Heat Stress Reduces Milk Production

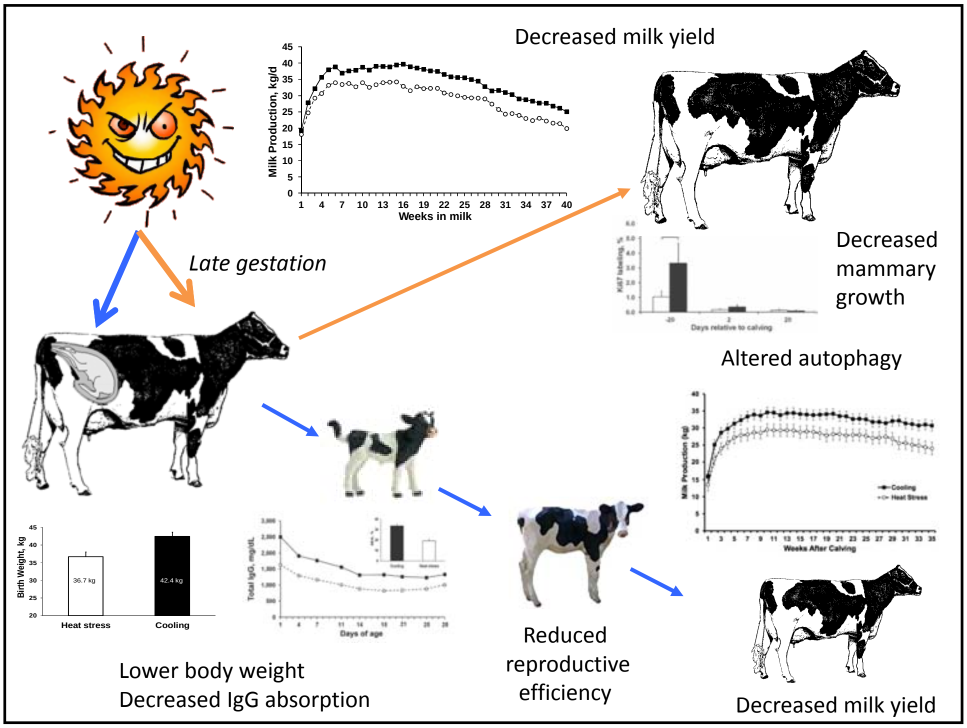


Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163.

In Utero Heat Stress Does Not Affect Mature Bodyweight



Monteiro et al. , *J. Anim. Sci*. 91(Suppl. 1):184. Abstract #163.



Decreased milk yield

Late gestation

Decreased mammary growth

Altered autophagy

Lower body weight
Decreased IgG absorption

Reduced reproductive efficiency

Decreased milk yield

Does it Pay to Cool Dry Cows?

- Assumptions:
  100 cow herd; 20 cow freestall barn; $1,700/stall = $34,000
- Other costs:
  16 cases ketosis = $1,600
  8 cases metritis = $2,400
  Feed 5 lb/cow/d ($20/cwt DM) = $30,000
- Revenue:
  10 lb/cow/d for 305 d = 3,050 cwt ($20) = $61,000
- $27,000 IOC IF hot 12 months; lower with less heat stress, but payback 15 to 30 months

Thanks!

- Dr. Sha Tao
- Dr. Izabella Thompson
- Ana Monteiro

- Dr. Bruno do Amaral
- Joyce Hayen
- Dr. Erin Connor – USDA-ARS
- Dr. Sally Johnson – Virginia Tech

NSF
USDA
United States Department of Agriculture
National Institute of Food and Agriculture
Phibro ANIMAL HEALTH CORPORATION ™

PHOTOPERIOD MANAGEMENT OF DAIRY CATTLE: CONSIDERATIONS AND APPLICATIONS

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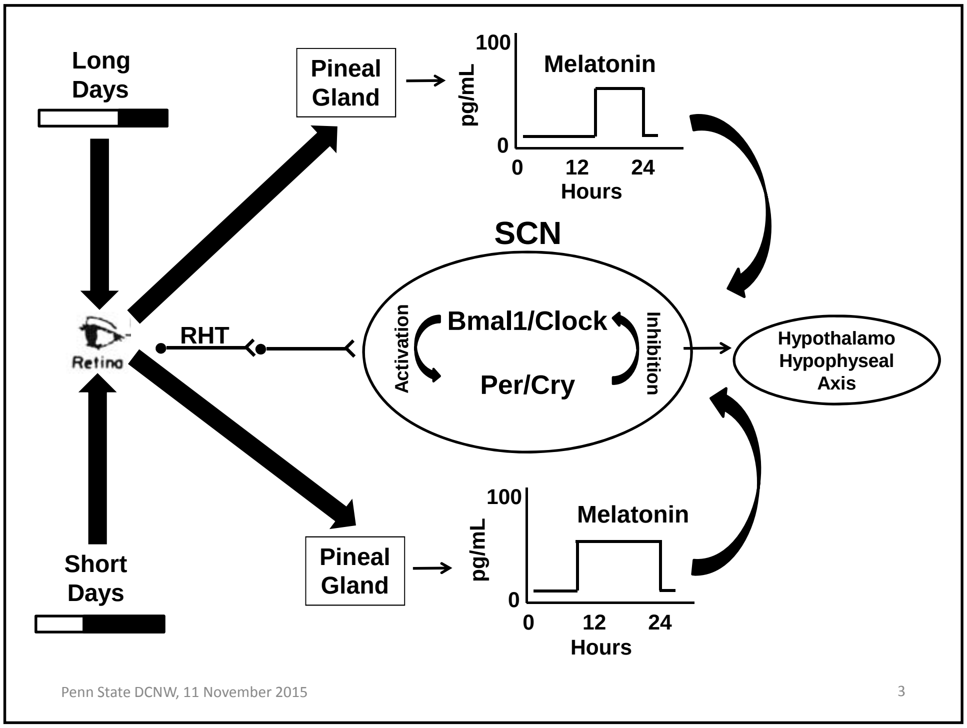
Penn State Dairy Cattle Nutrition Workshop
11 November 2015

UF UNIVERSITY of FLORIDA

Outline

- Growing animals
  - Endocrine responses
  - Carcass, mammary growth
- Lactation response
- Dry period
  - Production, endocrine effects
- Implementation
  - Lighting types, design



Long Days

Short Days

Retina

RHT

Pineal Gland

Pineal Gland

SCN

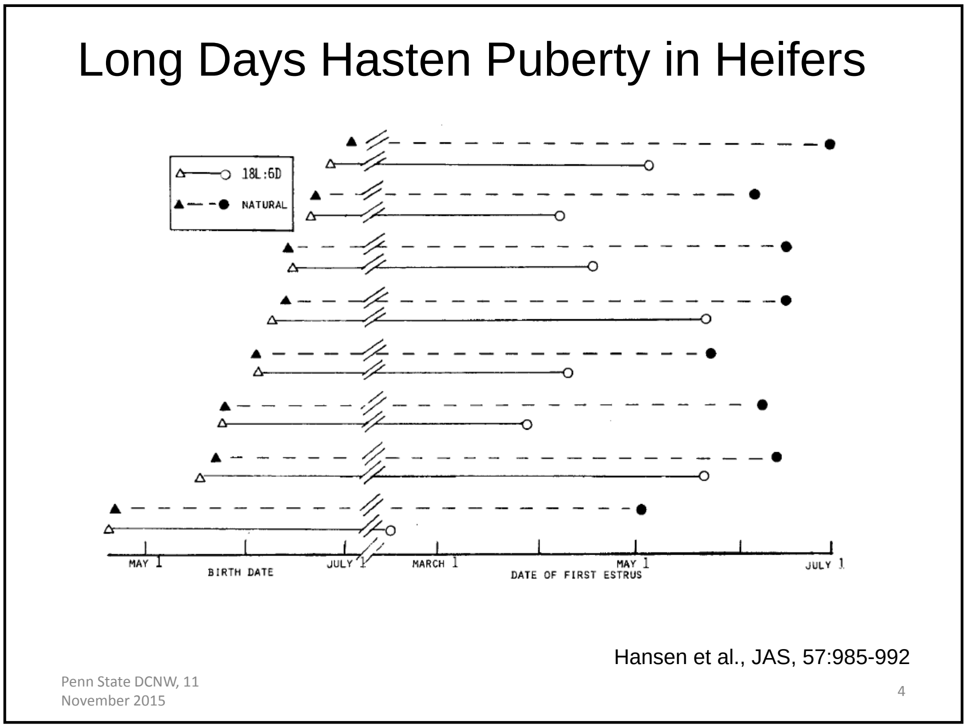
Bmal1/Clock

Per/Cry

Activation

Inhibition

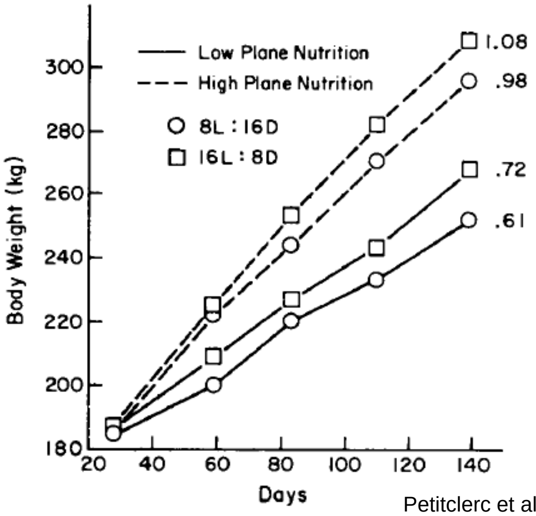
Hypothalamo Hypophyseal Axis



Long Days Hasten Puberty in Heifers

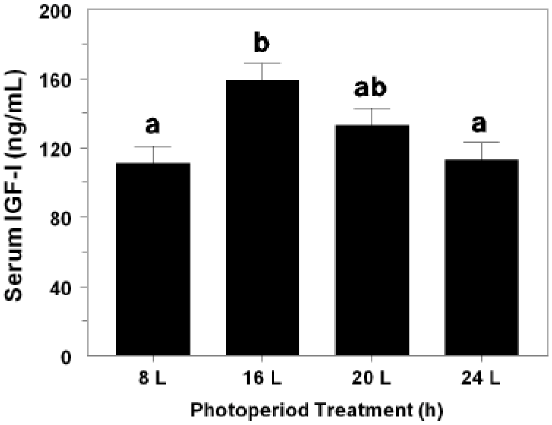
Hansen et al., JAS, 57:985-992

Long Days Increase Growth – Regardless of Intake



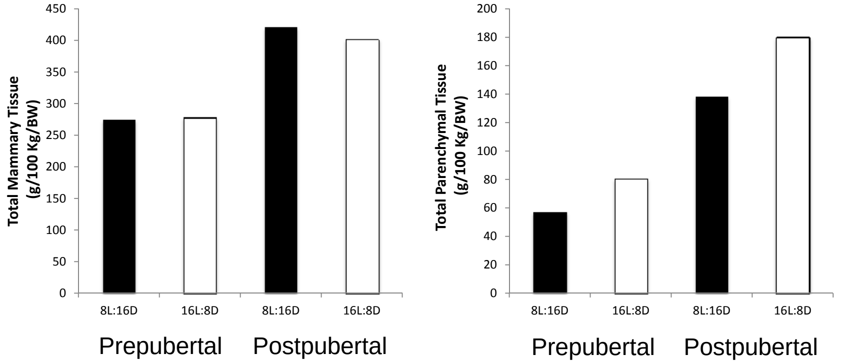
Petitclerc et al., JAS, 57:892-898

Long Days Increase IGF-I in Heifers



Spicer et al., AJAVS, 2:42-45

Long Days Increase Mammary Parenchymal Growth



Petitclerc et al., JDS, 68:86-90

Growth Effects of Prepubertal Long Days Persist to First Lactation

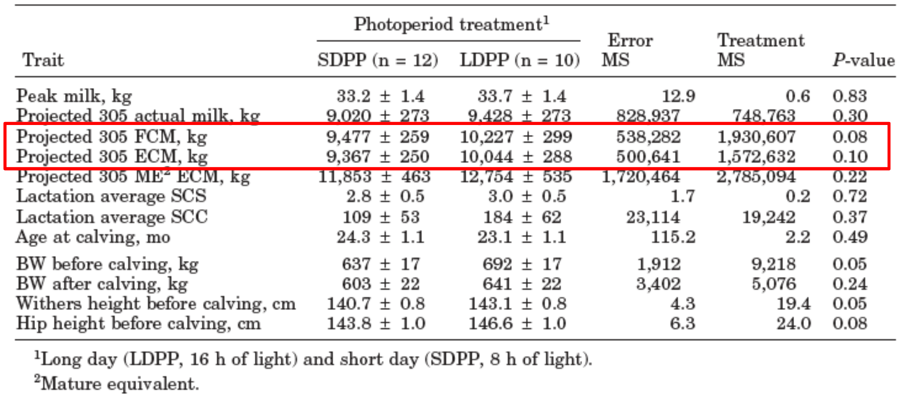
Trait	Photoperiod treatment[1] SDPP (n = 12)	Photoperiod treatment[1] LDPP (n = 10)	Error MS	Treatment MS	*P*-value
Peak milk, kg	33.2 ± 1.4	33.7 ± 1.4	12.9	0.6	0.83
Projected 305 actual milk, kg	9,020 ± 273	9,428 ± 273	828,937	748,763	0.30
Projected 305 FCM, kg	9,477 ± 259	10,227 ± 299	538,282	1,930,607	0.08
Projected 305 ECM, kg	9,367 ± 250	10,044 ± 288	500,641	1,572,632	0.10
Projected 305 ME[2] ECM, kg	11,853 ± 463	12,754 ± 535	1,720,464	2,785,094	0.22
Lactation average SCS	2.8 ± 0.5	3.0 ± 0.5	1.7	0.2	0.72
Lactation average SCC	109 ± 53	184 ± 62	23,114	19,242	0.37
Age at calving, mo	24.3 ± 1.1	23.1 ± 1.1	115.2	2.2	0.49
BW before calving, kg	637 ± 17	692 ± 17	1,912	9,218	0.05
BW after calving, kg	603 ± 22	641 ± 22	3,402	5,076	0.24
Withers height before calving, cm	140.7 ± 0.8	143.1 ± 0.8	4.3	19.4	0.05
Hip height before calving, cm	143.8 ± 1.0	146.6 ± 1.0	6.3	24.0	0.08

[1] Long day (LDPP, 16 h of light) and short day (SDPP, 8 h of light).

[2] Mature equivalent.

Rius & Dahl, JDS, 89:2080-2083

Milk Effects of Prepubertal Long Days Persist to First Lactation



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[1] Long day (LDPP, 16 h of light) and short day (SDPP, 8 h of light).

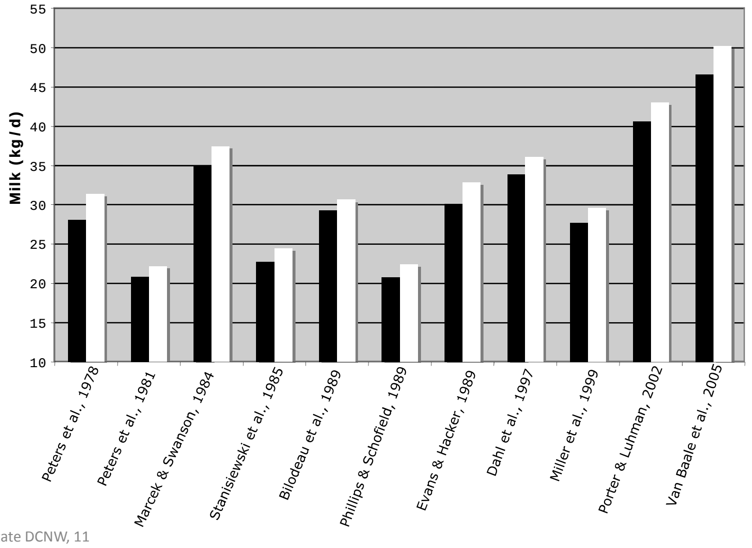
[2] Mature equivalent.

Rius & Dahl, JDS, 89:2080-2083

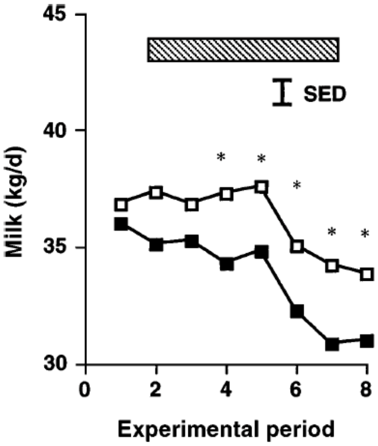
Growth Summary

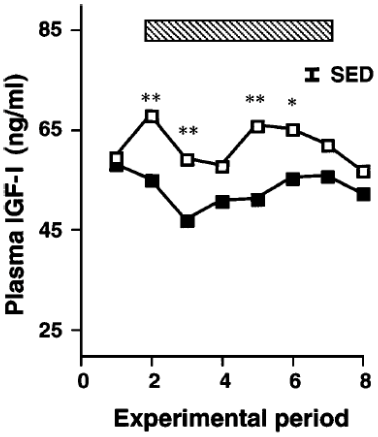
- Long days increase lean body and mammary mass.
- Responses to LD persist into lactation.
- Long days increase IGF-I and PRL.
- PRL effects independent of other photoperiod effects.

Long Days Increase Milk Yield During Lactation



Long Days During Lactation Increase Milk …

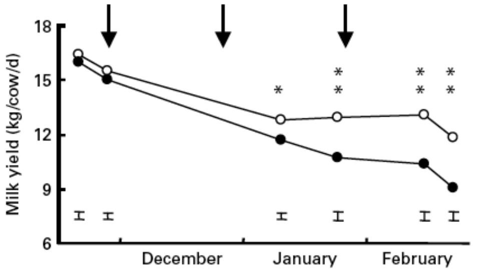


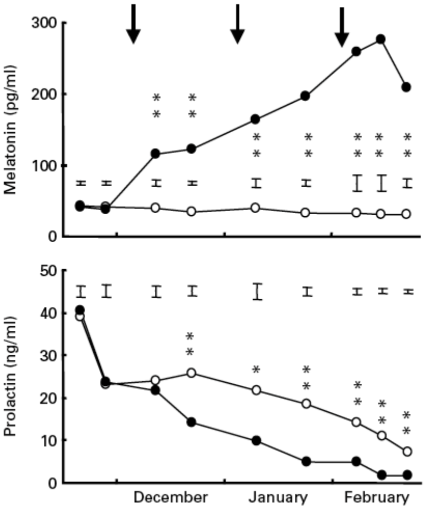


… and Increase IGF-I

Dahl et al., JDS, 80:2784-2789

Melatonin Implants Decrease Milk in Late Lactation

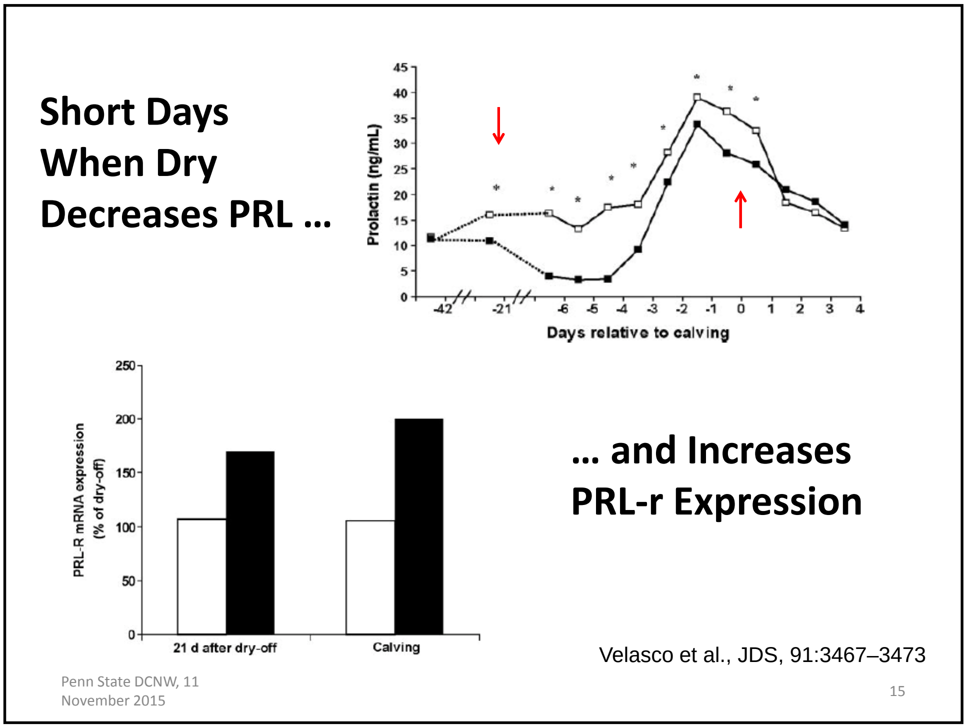




Auldist et al., J Dairy Res, 74:52-57

Lactation Summary

- Long days increase milk yield.
- IGF-I increases under long days, as does PRL.
- Short day decline absent; but melatonin decreased milk.



Short Days When Dry Decreases PRL …

… and Increases PRL-r Expression

Velasco et al., JDS, 91:3467–3473

Penn State DCNW, 11 November 2015

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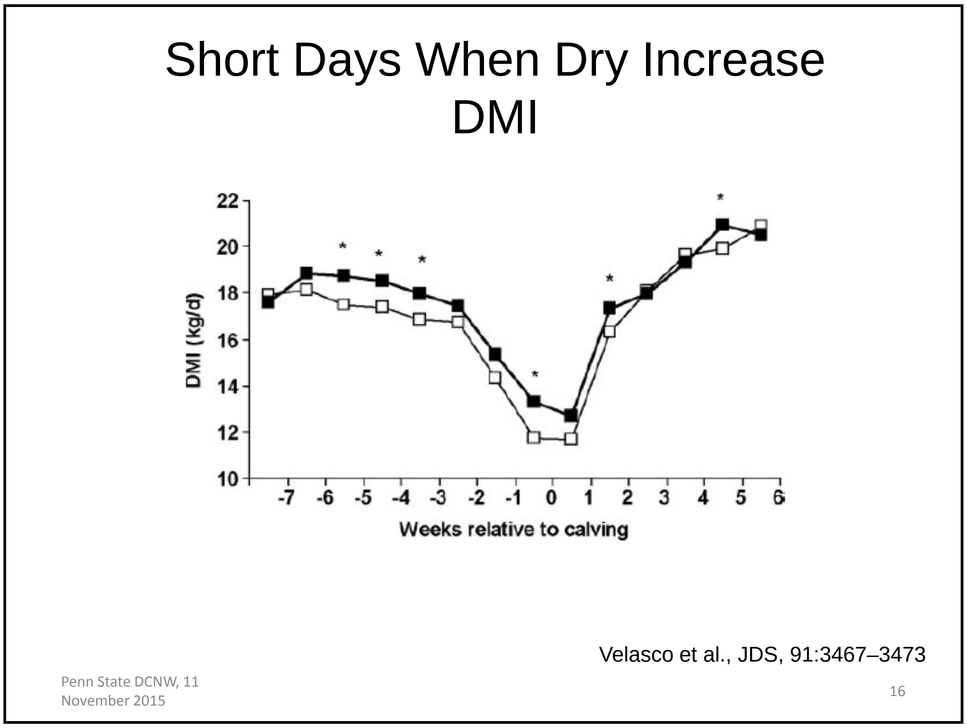

Short Days When Dry Increase DMI

Velasco et al., JDS, 91:3467–3473

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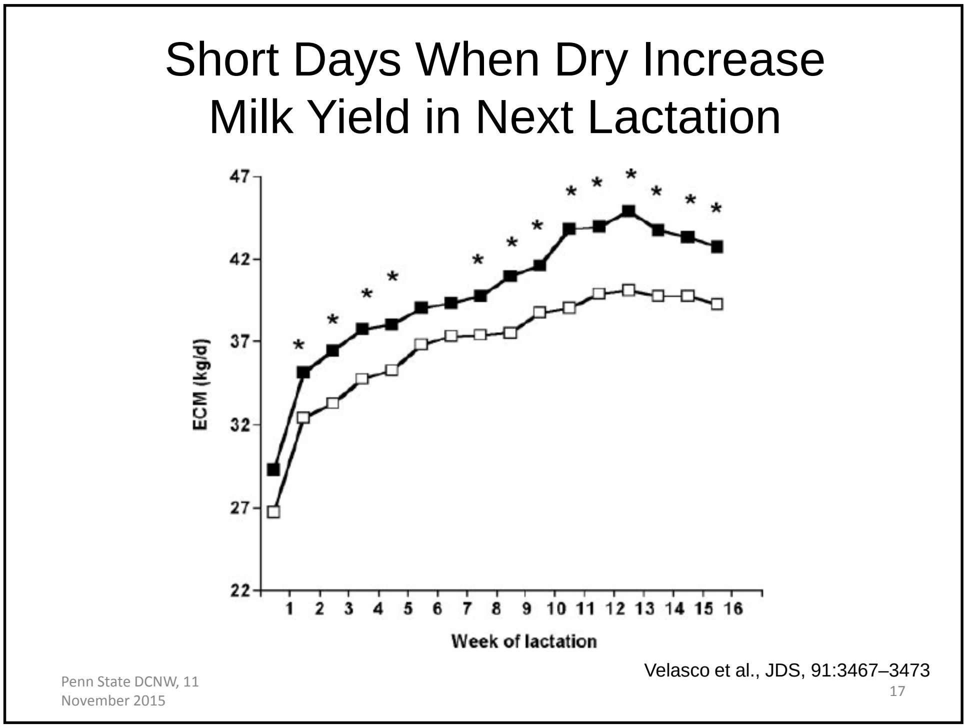
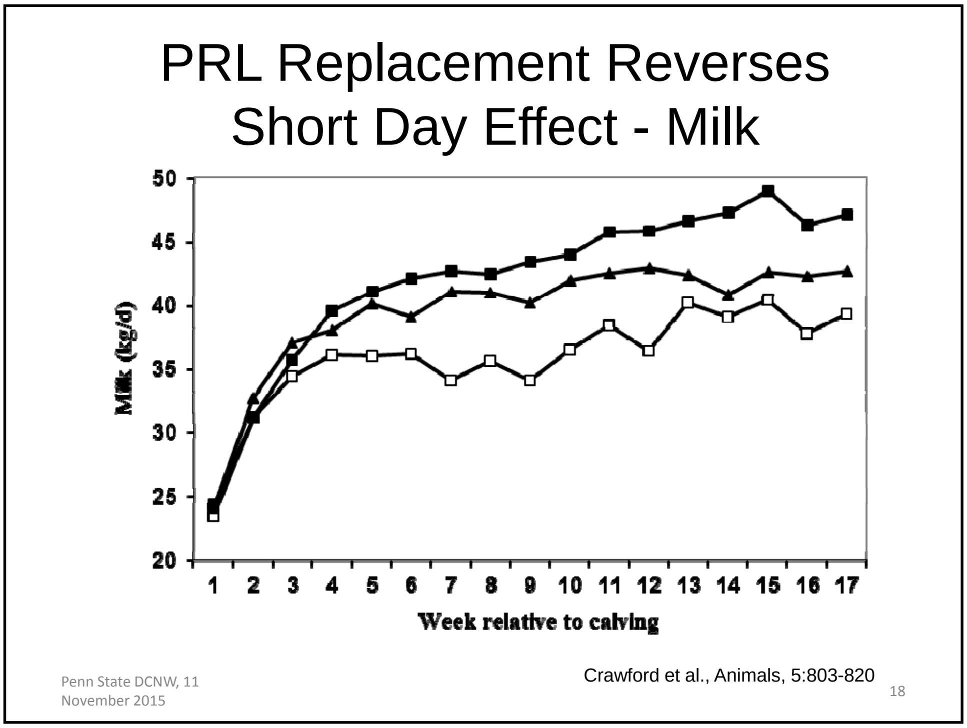


Short Days When Dry Increase Milk Yield in Next Lactation

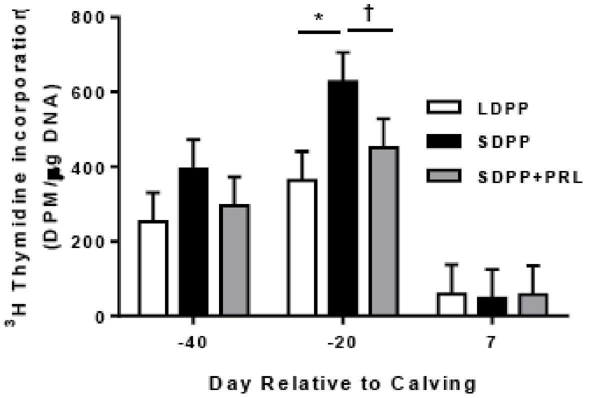
Velasco et al., JDS, 91:3467–3473



PRL Replacement Reverses Short Day Effect - Milk

Crawford et al., Animals, 5:803-820

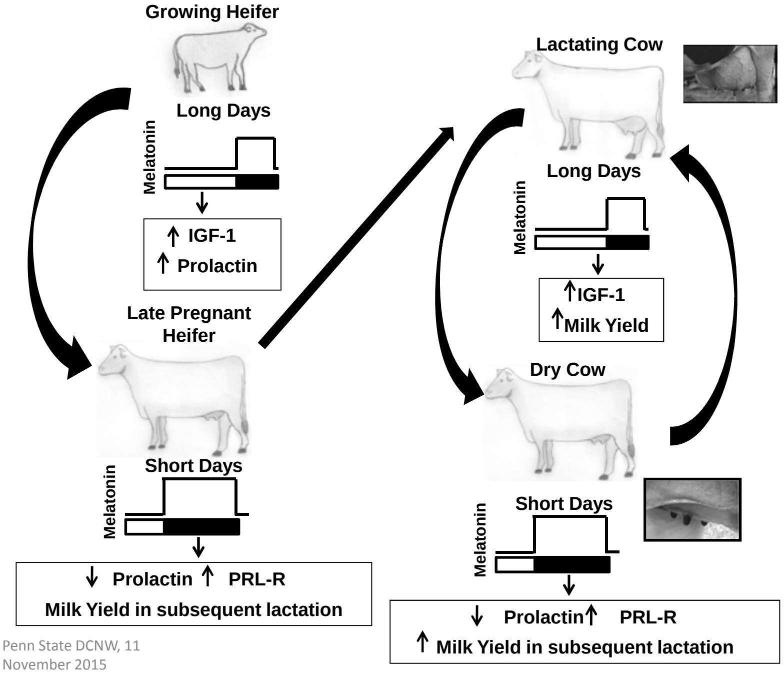
PRL Replacement Reverses Short Day Effect - MG



Crawford et al., Animals, 5:803-820

Dry Period Summary

- Short days when dry increases subsequent yield; PRL replacement reverses.
- MG growth increases under short days.
- MG growth effects consistent with 40 to 60 day response window.



Growing Heifer

Long Days

Melatonin

↑ IGF-1
↑ Prolactin

Late Pregnant Heifer

Short Days

Melatonin

↓ Prolactin ↑ PRL-R
Milk Yield in subsequent lactation

Lactating Cow

Long Days

Melatonin

↑IGF-1
↑Milk Yield

Dry Cow

Short Days

Melatonin

↓ Prolactin↑ PRL-R
↑ Milk Yield in subsequent lactation

Penn State DCNW, 11 November 2015

How to….

- Type of Light
  - – Fluorescent
  - – Metal halide
  - – High pressure sodium (HPS)
  - – LED ??
- Lighting choice should be made according to efficiency and the mounting height most appropriate to the barn.

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- Light intensity
  - 15 FC (i.e. ~150 lux) at 1 m from the floor of the stall
  - Dispersion of light over an area should be as uniform as possible
- Testing light intensity
  - Light meter

Estimating Fixture Requirements

Total Lumens = (AREA) (FC) (k)

$$\textbf{Fixture Number} = \frac{\textbf{TOTAL LUMENS}}{\textbf{LAMP LUMENS}}$$

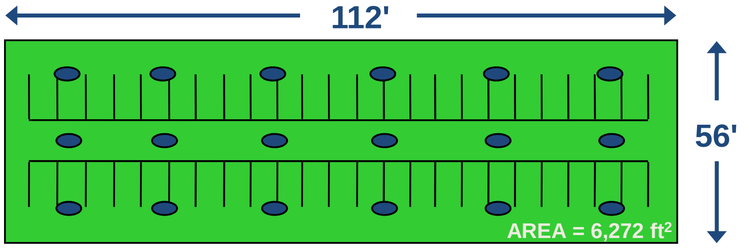
Outdoor: k = 3

Indoor: k = 2

Lamp Lumens

Watts	HPS	MH
400	50000	36000
250	27500	20500
150	16000	14000

Estimating Fixture Requirements

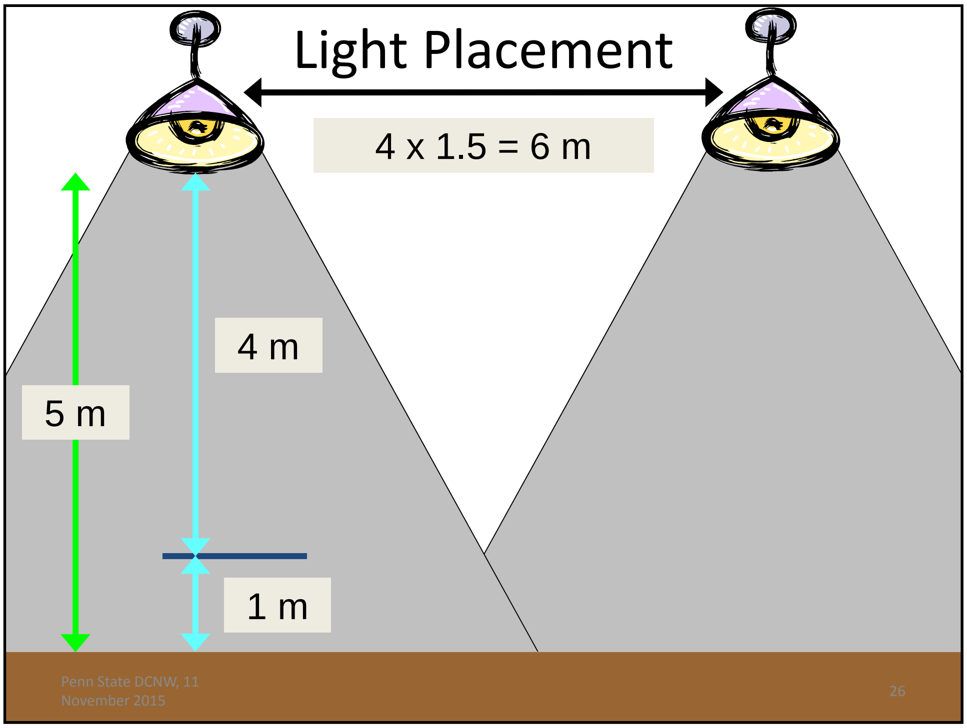


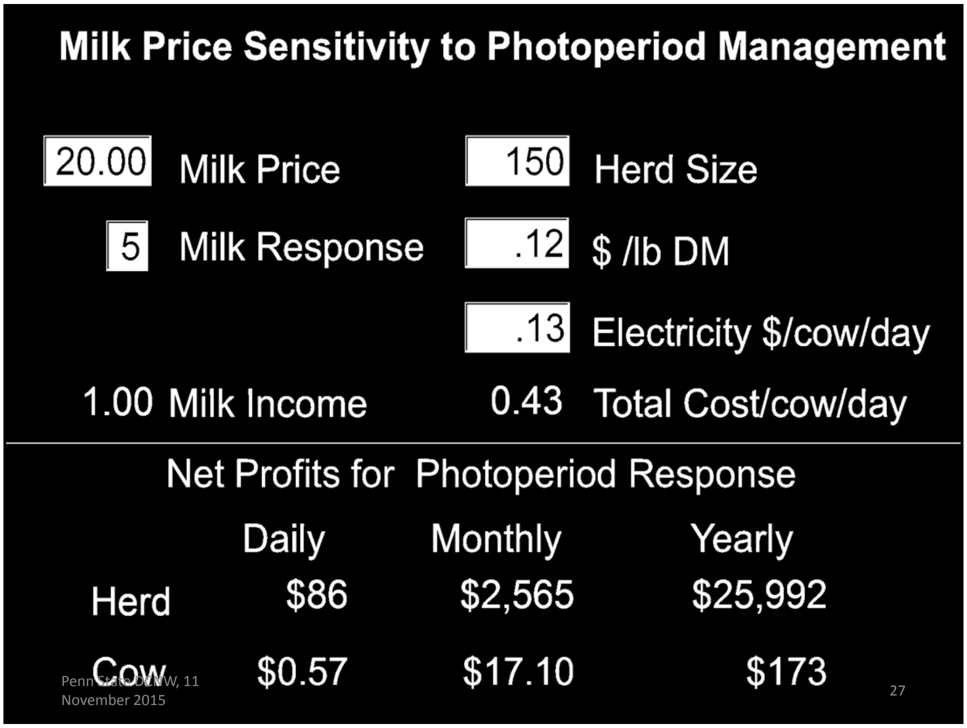
LAMP = 250 W Metal Halide **k = 3** **FC Desired = 20**

Total Lumens = (AREA) (FC) (k)
= (112' x 56') (20) (3)
= 376,320 Lumens

Fixture Number = 376,320 Lumens/20,500
= 18 Fixtures

Light Placement





Milk Price Sensitivity to Photoperiod Management

20.00 Milk Price

150 Herd Size

5 Milk Response

.12 $ /lb DM

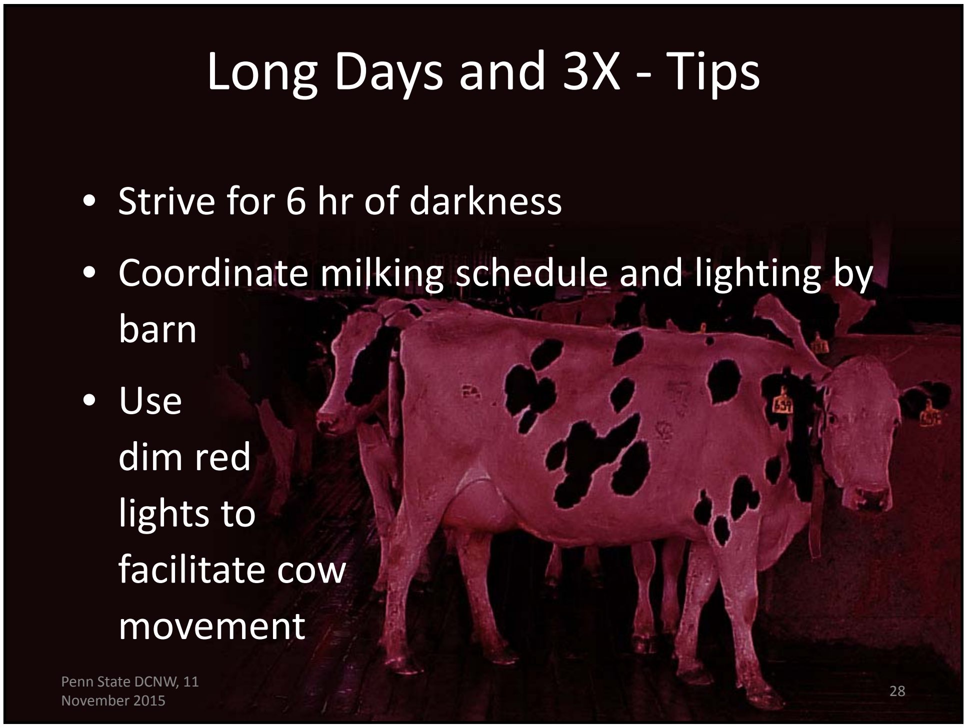
.13 Electricity $/cow/day

1.00 Milk Income

0.43 Total Cost/cow/day

Net Profits for Photoperiod Response

	Daily	Monthly	Yearly
Herd	$86	$2,565	$25,992
Cow	$0.57	$17.10	$173



Long Days and 3X - Tips

- Strive for 6 hr of darkness
- Coordinate milking schedule and lighting by barn
- Use dim red lights to facilitate cow movement

Long Days and bST

- Additive response to the combination
- Intake increased sooner in bST treated cows on LDPP vs. those on NDPP
- Energy balance did not decrease in cows on LDPP despite increased yield

Short Days When Dry?

- Need to provide cooling
- Solid sides on barn; mechanical ventilation
- Barn can be open 8 hr/day

Conclusions

- Photoperiodic manipulation profitable across the life cycle of the cow.
- Select light type based on efficiency and long term total cost.
- Combine with other management interventions, i.e. bST, 3X, dry period
- http://photoperiod.idtg.illinois.edu/

Questions?

PENNSTATE

Dairy Outlook
2016

Jim Dunn

Ag Economist

Pennsylvania State University

Current Situation

- Milk prices are up from earlier this year and feed prices are moderate
- Forecast of PA All Milk Price - $18.40/cwt. for 2016
- Feed prices will remain low

England

- Dairy situation in England is grim.
- Remember how 2009 was for dairying in the U.S.? A similar situation is unfolding in the U.K. this year.
- Farm milk prices have dropped by 40%. Feed prices have increased about 50%. Many farms are going out of business.
- European Union quotas ended on April 1.
- Supermarkets using milk as a loss leader

European Union

- Dairy quotas ended April 1.
- Farms can expand, or relocate
- The Dutch in particular are likely to do this
- Move to Poland, for example
- Milk production is up 2.9% since quotas ended
- Intervention remains

- China’s Inner Mongolia Yili Industrial Group Co. is setting up a powdered milk factory in Kansas with Dairy Farmers of America Inc
- The plant will be able to produce 80,000 metric tons of milk powder a year
- The company didn’t specify how much of the plant’s milk powder will be sold in China.

China

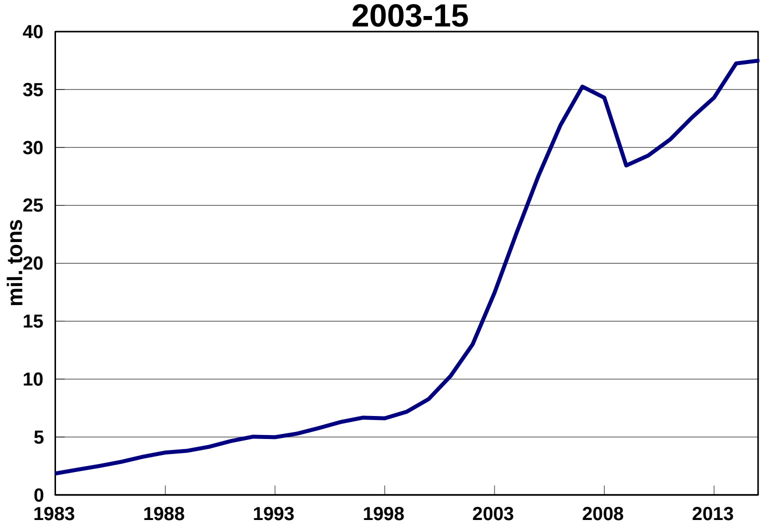
- Now world’s third largest milk producer
- One farm has 140,000 head
- Before long may not be a major importer
- All the small dairies are under severe pressure, on quality & price
- Very dependent on purchased feed

Issues in China

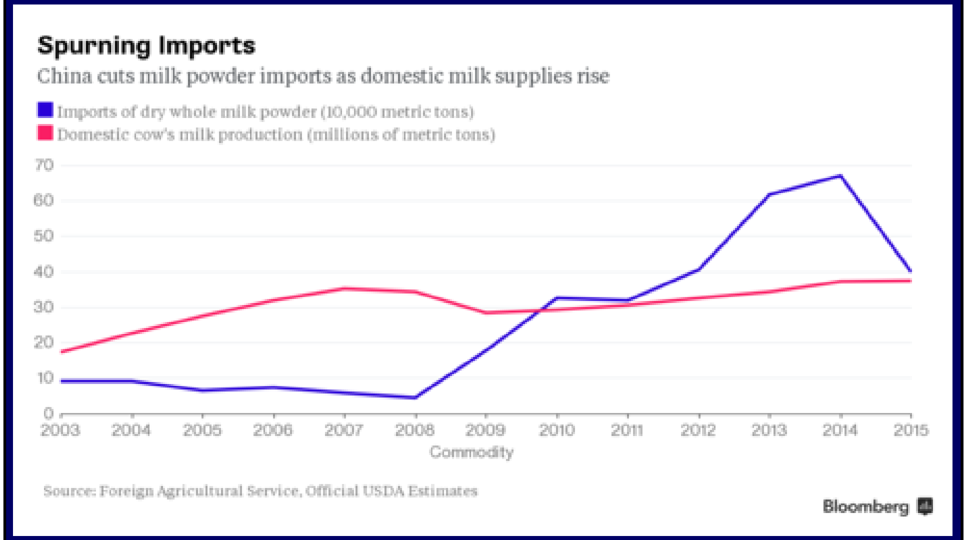
- Weather
- Foot-and-mouth disease
- Imports slowing – lots of inventory
- Slowing economy
- Devalued currency

Chinese Milk Production

2003-15



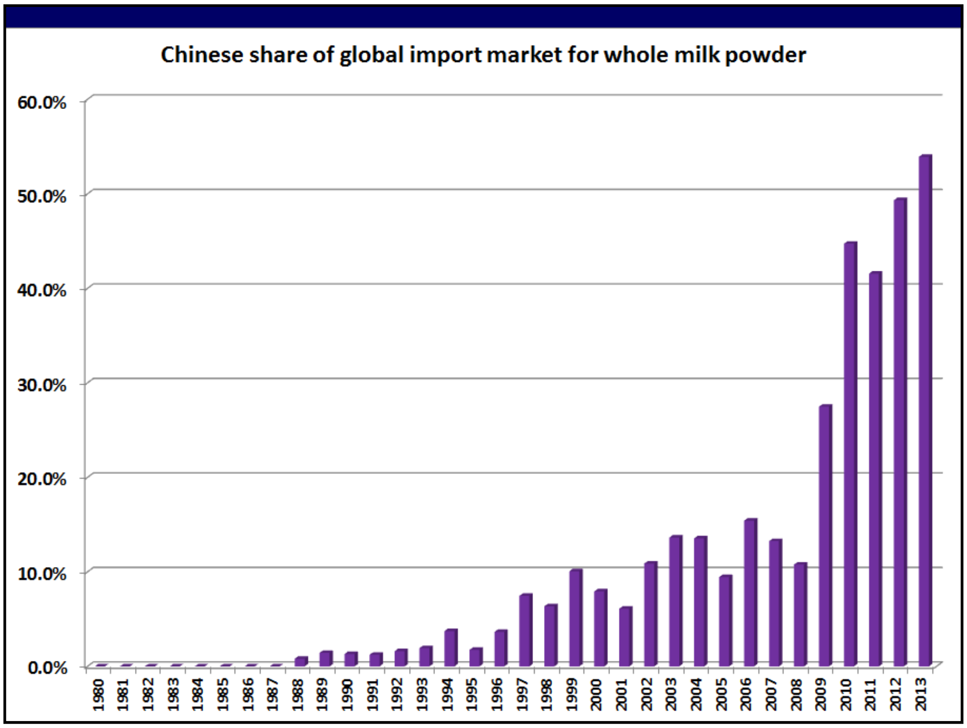
Source: USDA



Spurning Imports

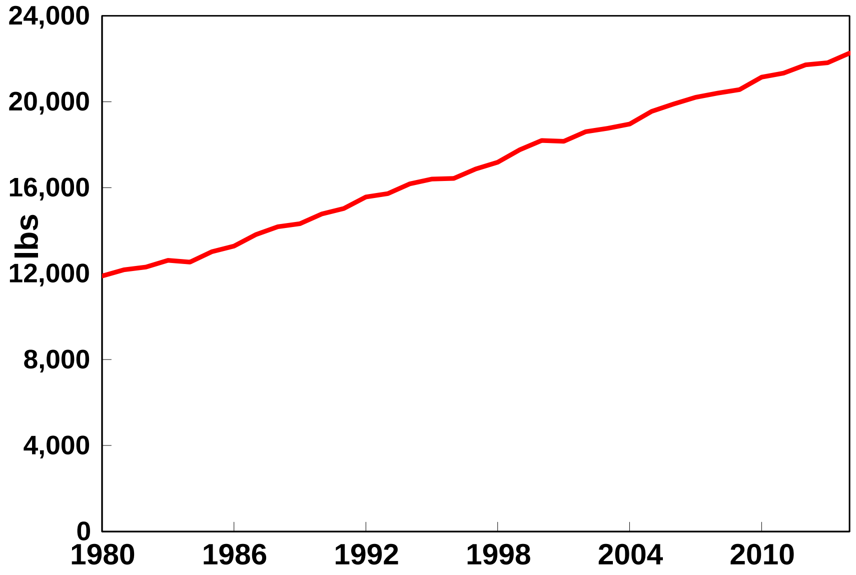
China cuts milk powder imports as domestic milk supplies rise

Source: Foreign Agricultural Service, Official USDA Estimates

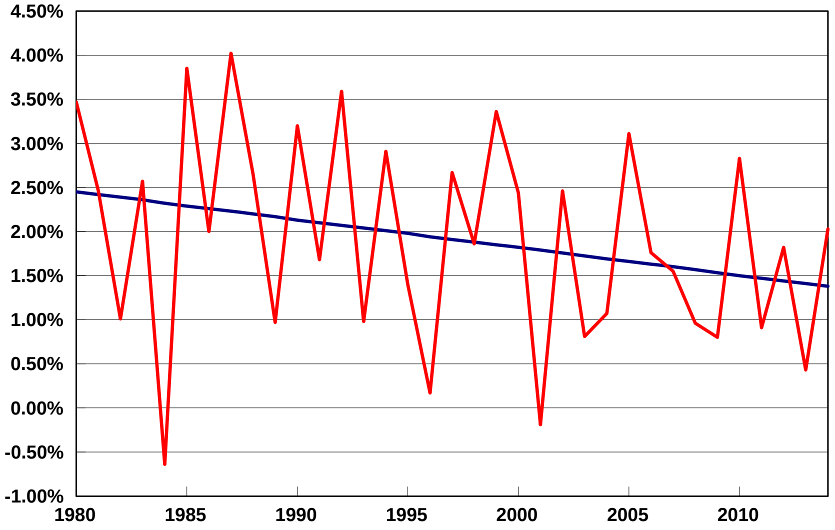


Chinese share of global import market for whole milk powder

Milk Per Cow

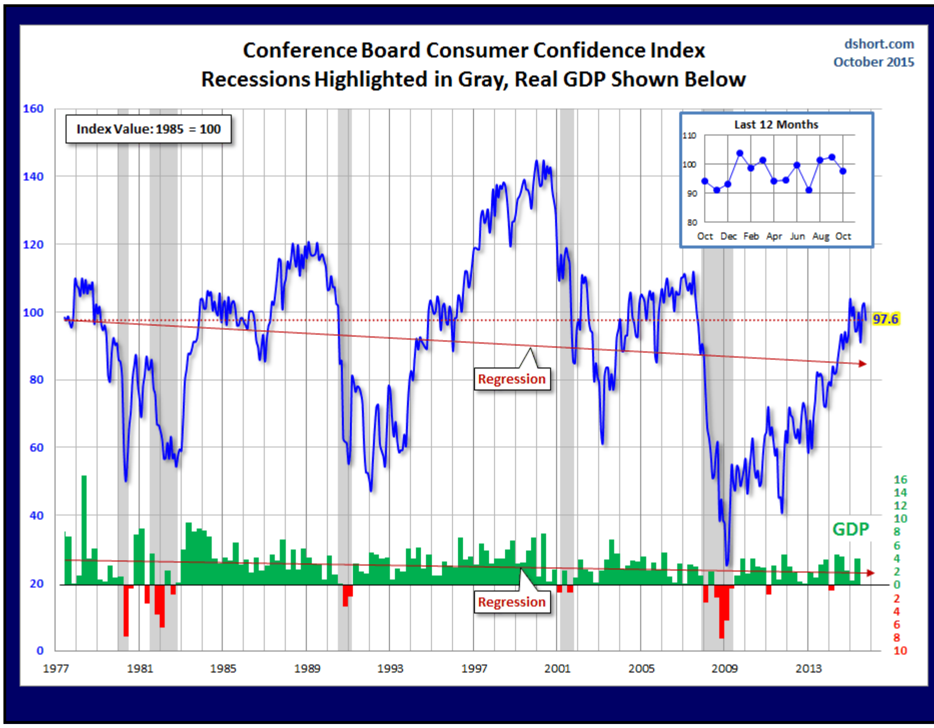


Changes in Milk per Cow and Trend



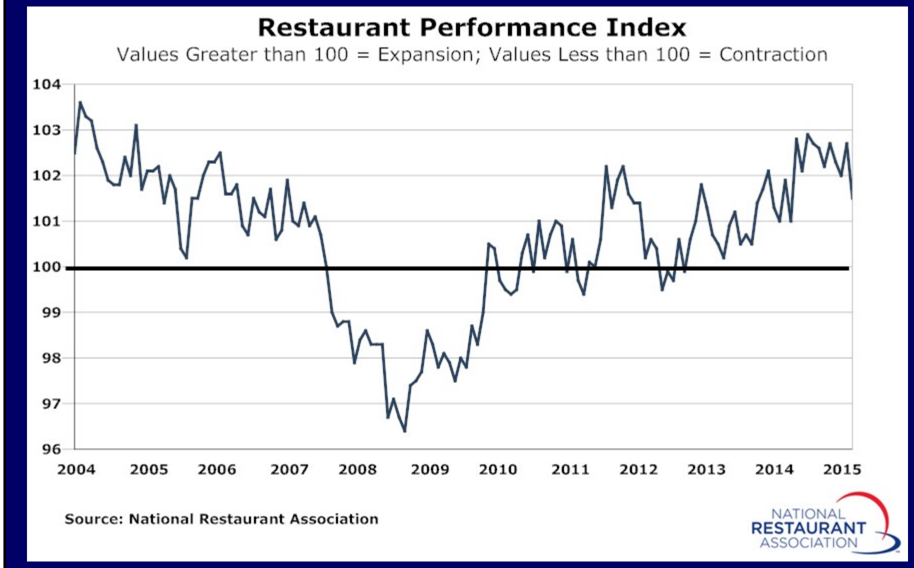
Economy

- Still improving
- Dairy isn't especially economy driven, although some products are more affected than others – fancy cheese
- Other products do well in recession – Macaroni & Cheese



Conference Board Consumer Confidence Index
Recessions Highlighted in Gray, Real GDP Shown Below

dshort.com
October 2015

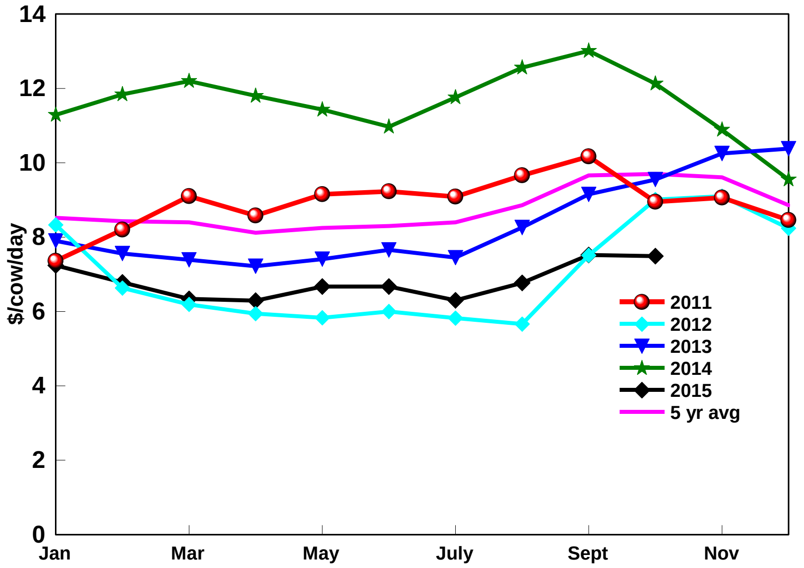


Restaurant Performance Index

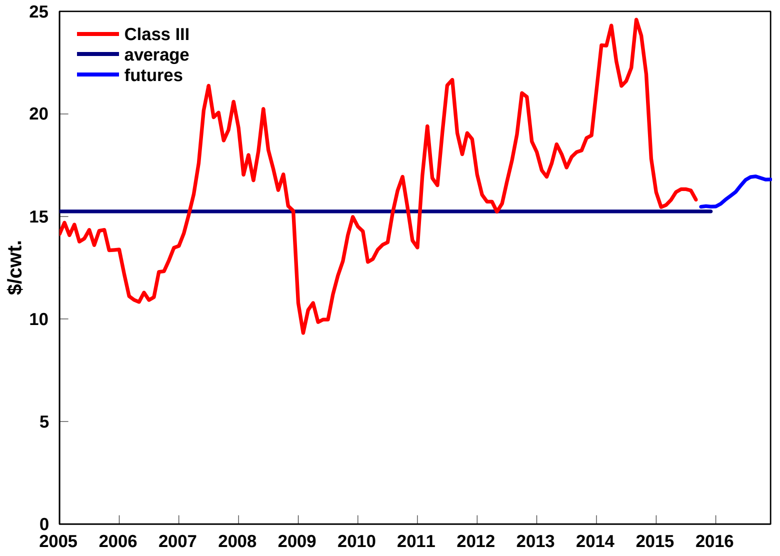
Values Greater than 100 = Expansion; Values Less than 100 = Contraction

Source: National Restaurant Association

PA Dairy Income over Feed Cost



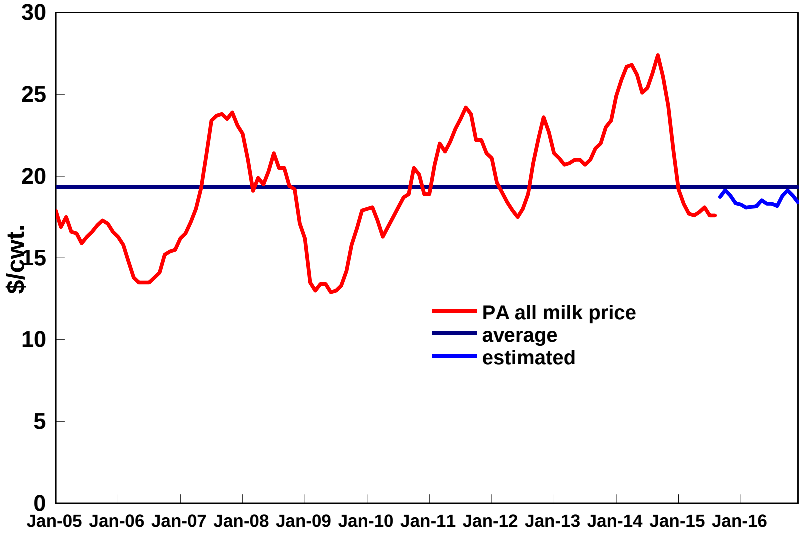
Class III Milk Price



Source: USDA

PA All Milk Price

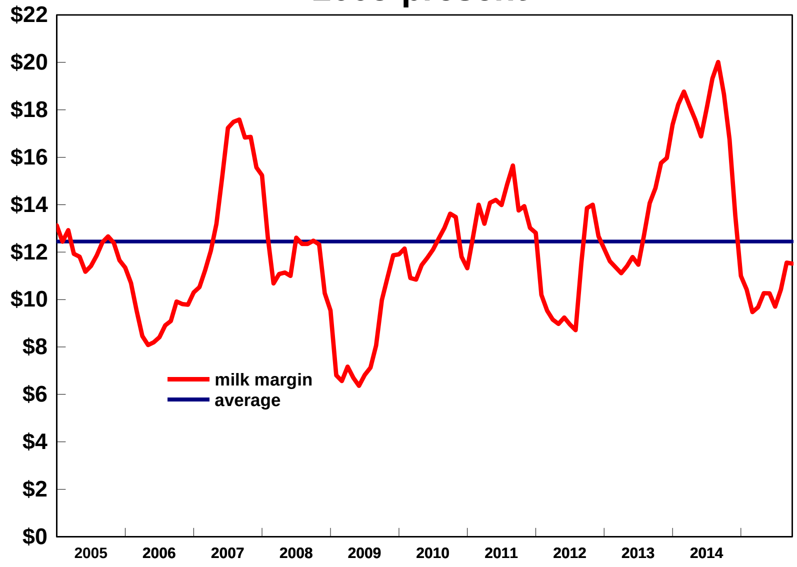
Jan 2005-present



Source: NASS

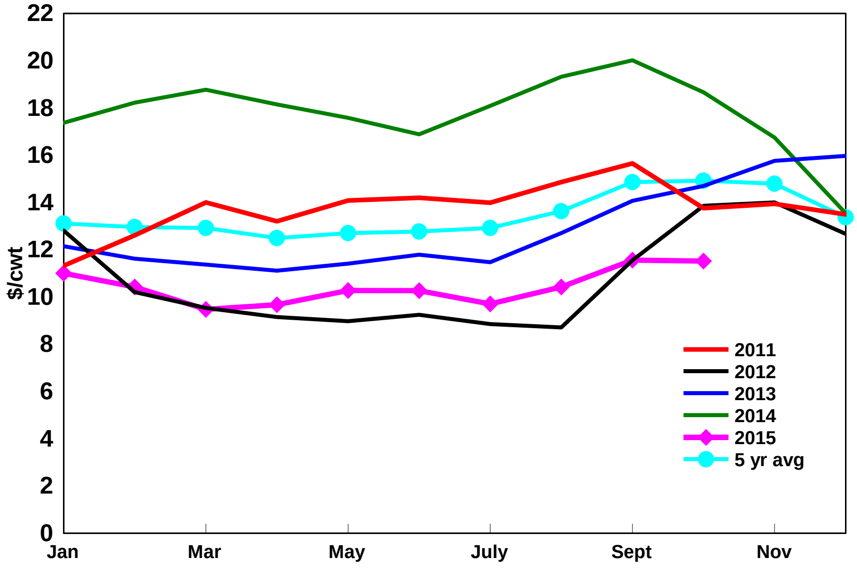
PA Dairy Milk Margin

2005-present



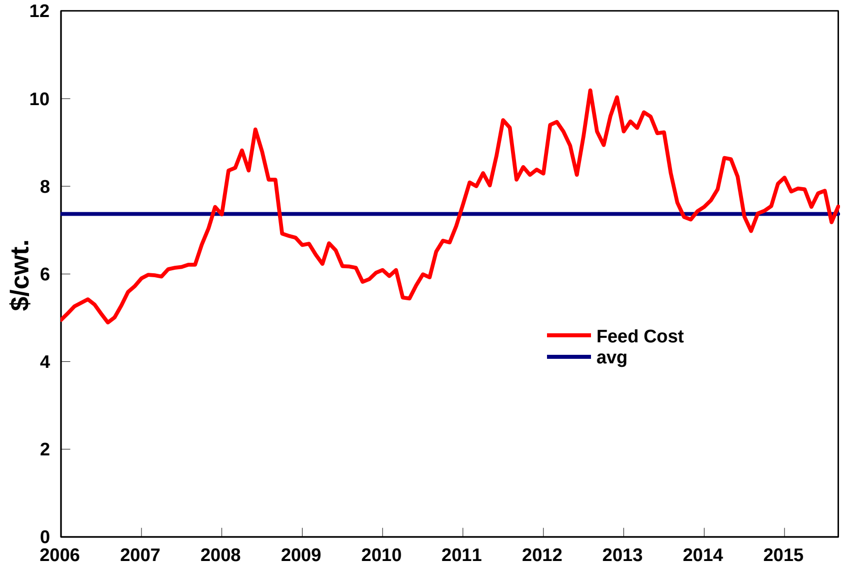
PA Milk Margin

2011-15



PA Feed Cost/cwt. Milk

Jan 2006 - present

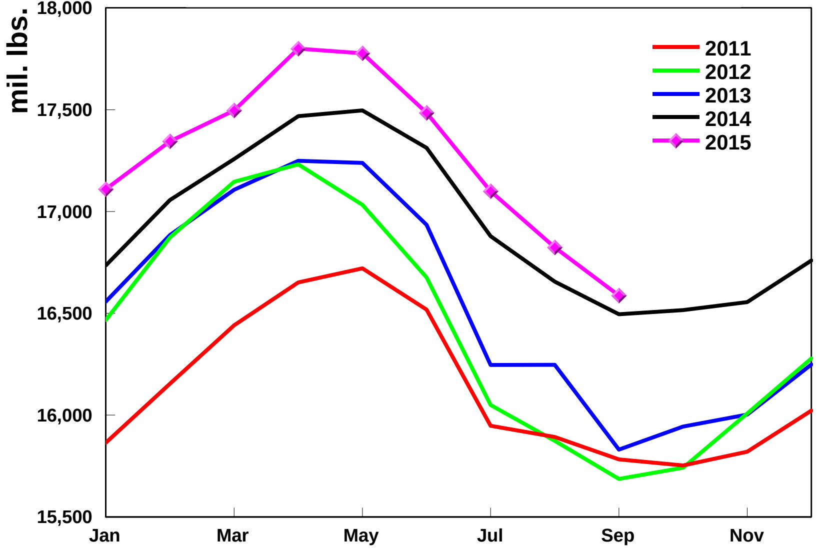


Measures of Dairy Farm Profitability 2006-15

	Avg.	High	Low	Oct 2015
PA All-Milk Price	$19.74	$27.40	$12.90	$18.90
Feed Cost/cwt.	$7.37	$10.19	$4.89	$7.60
Milk Margin	$12.36	$20.02	$6.36	$11.52

Monthly Milk Production

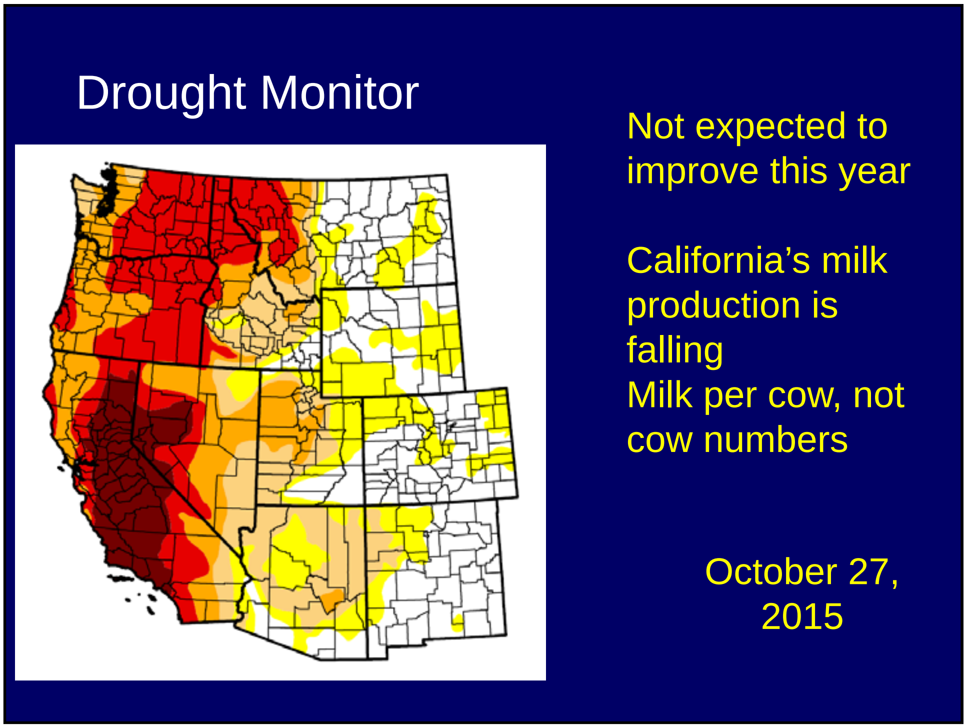
30 Day months



Source:USDA

Drought in West

- California officials will cut off water to local agencies serving 25 million residents and about 750,000 acres of farmland
- Severe drought in the California and Idaho dairy regions

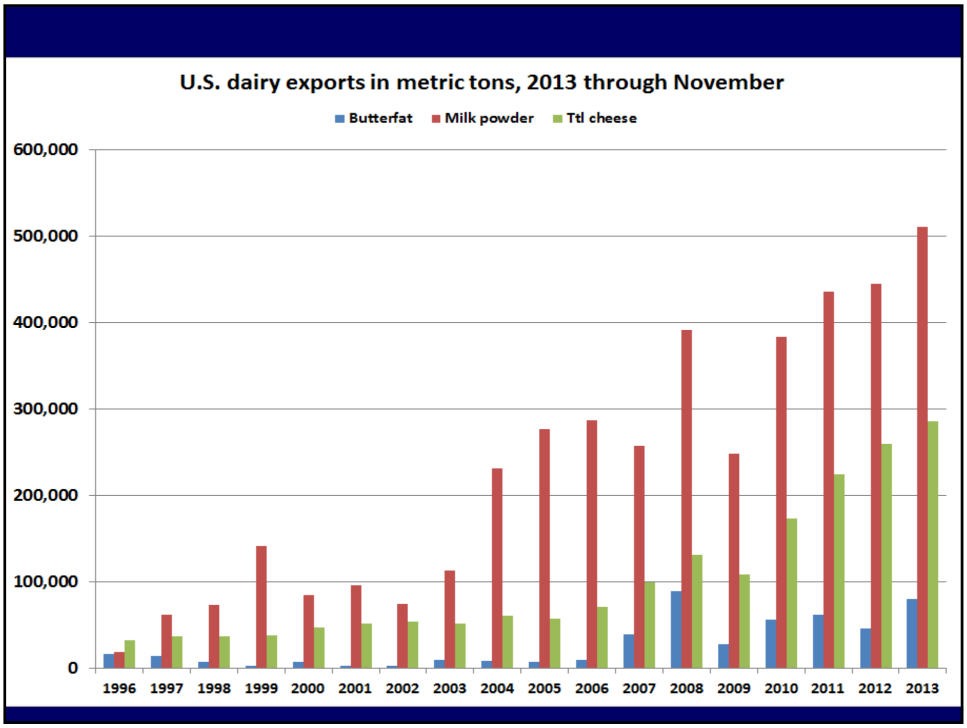


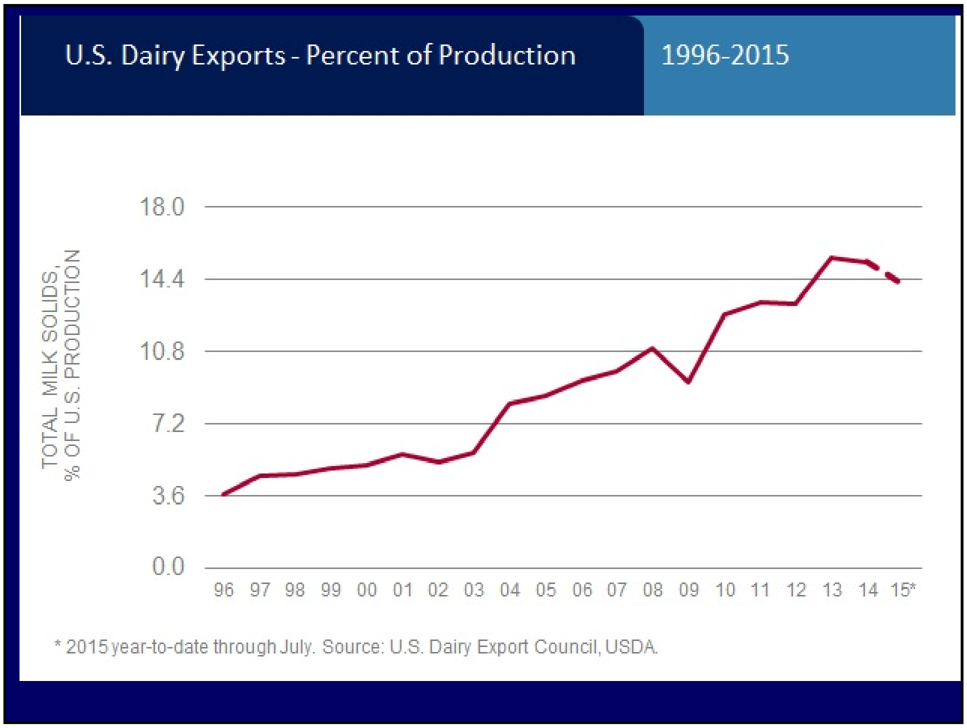
Drought Monitor

Not expected to improve this year

California's milk production is falling
Milk per cow, not cow numbers

October 27, 2015

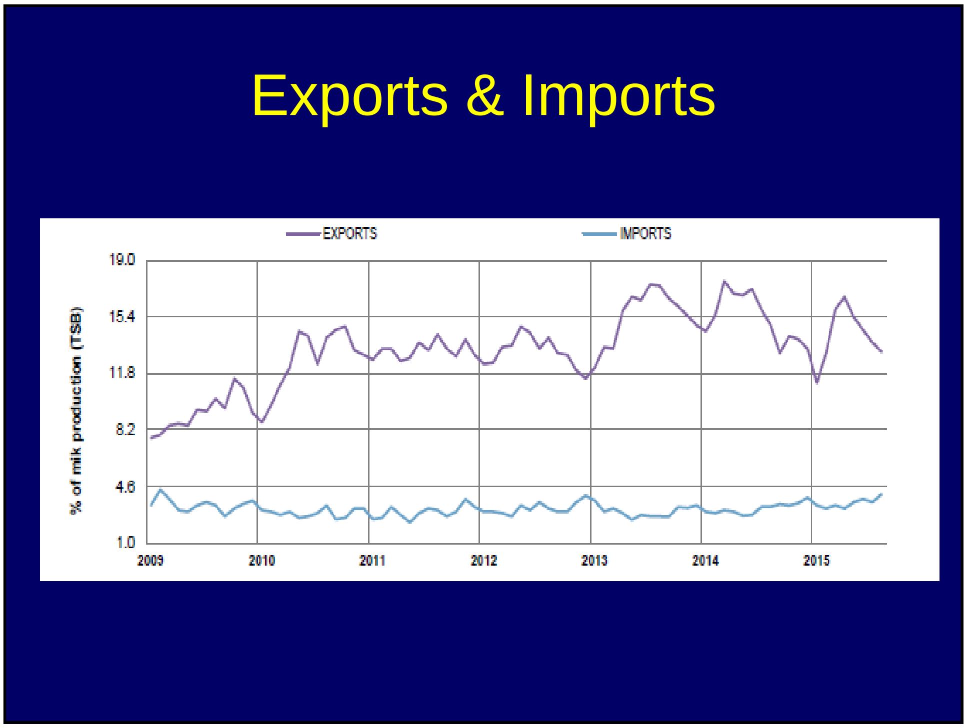




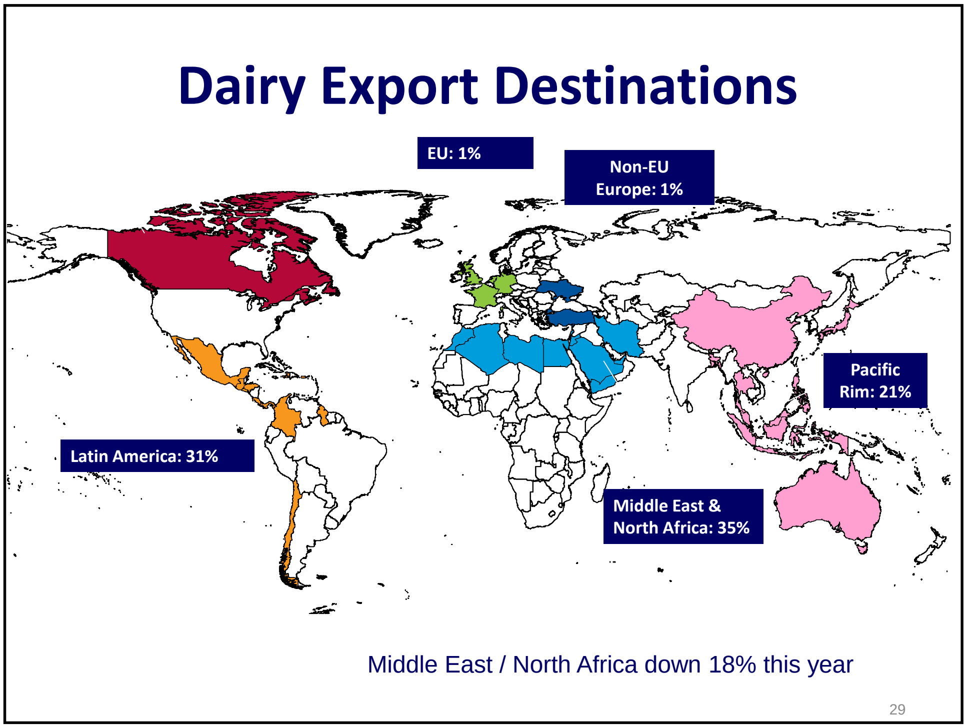
U.S. Dairy Exports - Percent of Production

1996-2015

* 2015 year-to-date through July. Source: U.S. Dairy Export Council, USDA.



Exports & Imports



Dairy Export Destinations

EU: 1%

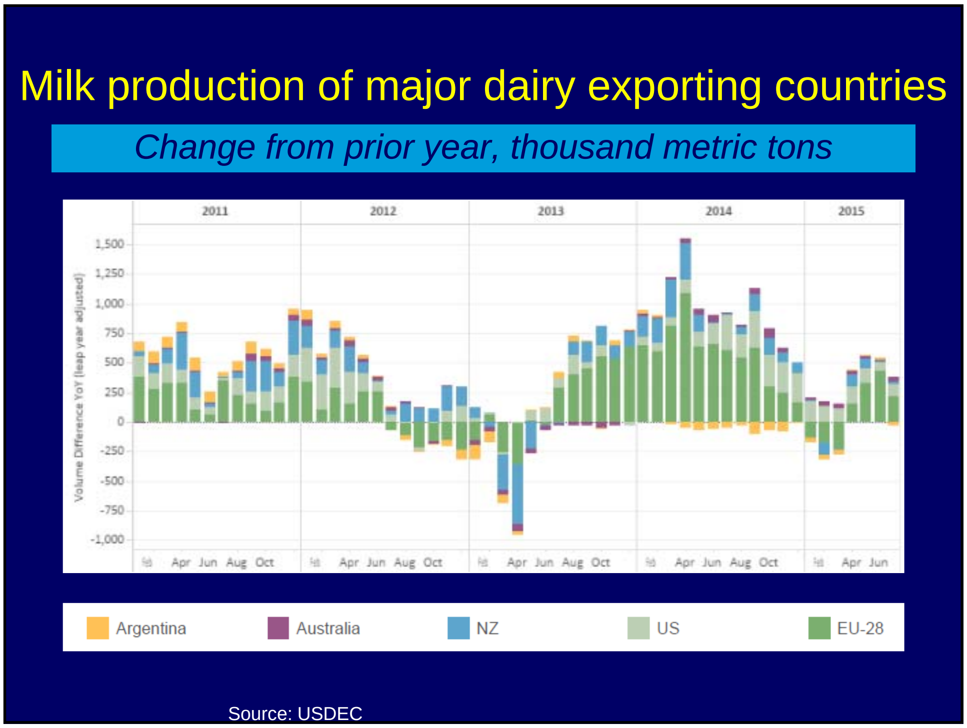
Non-EU Europe: 1%

Pacific Rim: 21%

Latin America: 31%

Middle East & North Africa: 35%

Middle East / North Africa down 18% this year



Milk production of major dairy exporting countries

Change from prior year, thousand metric tons

Source: USDEC

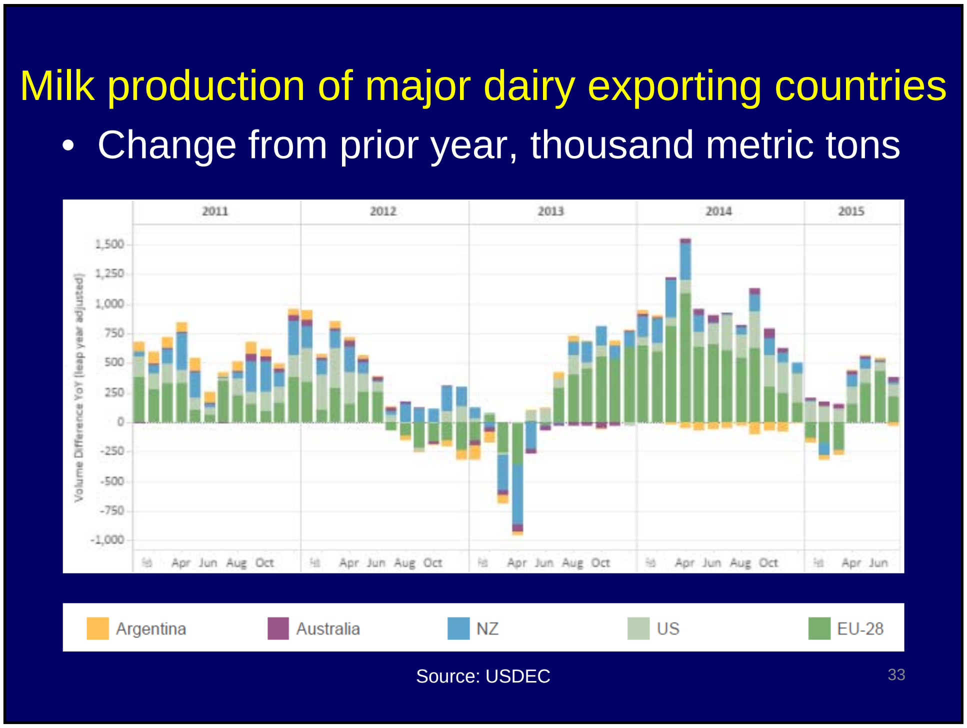
Share of World's Dairy Exports

Source: Dairy Australia

US Dairy Exports 2013

Top 10 Markets

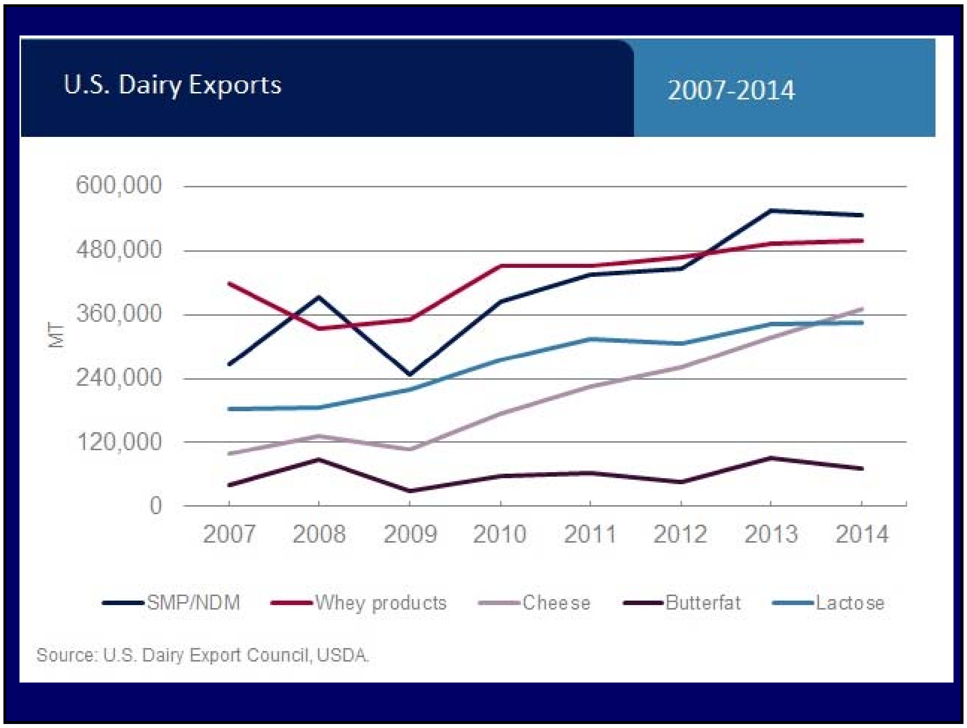
Source: U.S. Dairy Export Council



Milk production of major dairy exporting countries

- Change from prior year, thousand metric tons

Source: USDEC



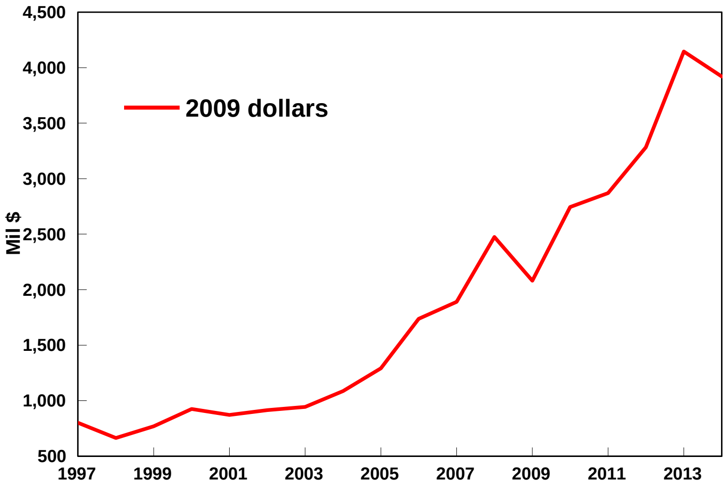
U.S. Dairy Exports

2007-2014

Source: U.S. Dairy Export Council, USDA.

US Dairy Exports

1997-2014

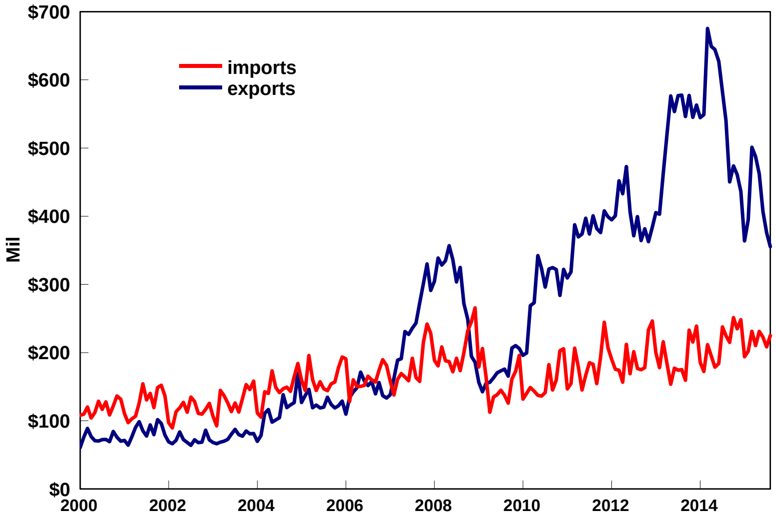


Source: USDA, BLS

Deflated by PPI Dairy

US Dairy Trade

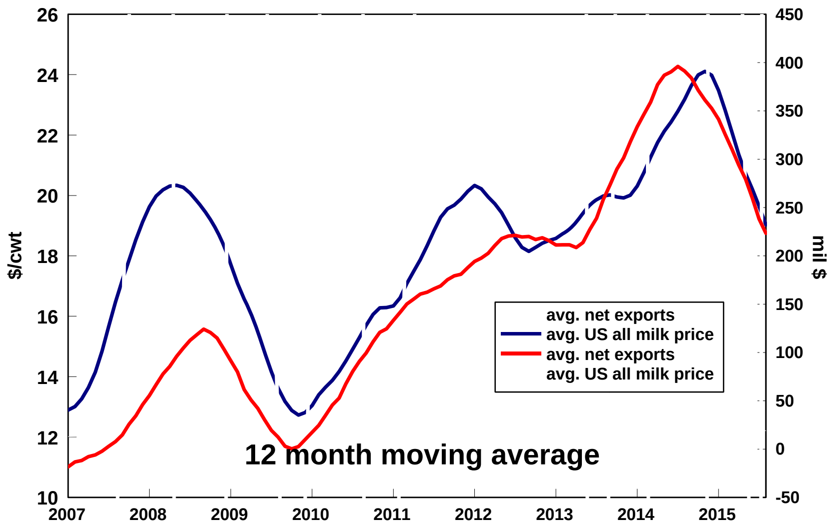
2000-15



Source: USDA

Net Dairy Exports and All Milk Price

2007-15

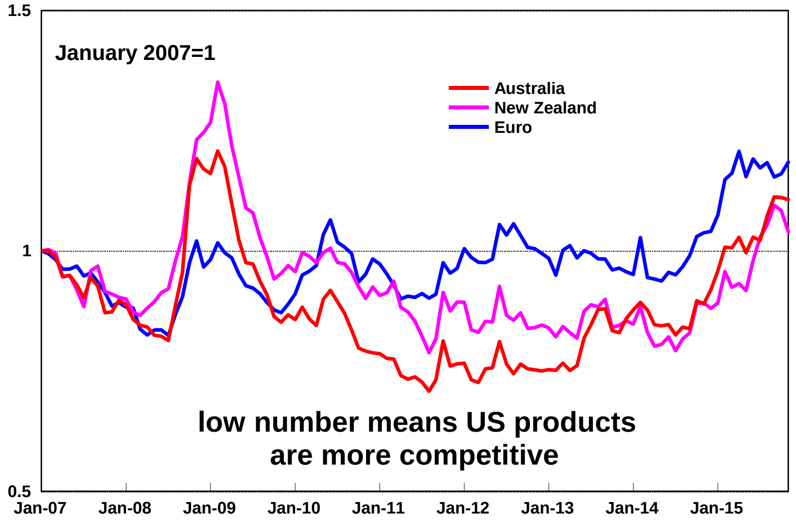


Source: USDA

The dollar

- Dollar stronger
- Aussie dollar down 17.5% against Greenback since July 2014
- Euro down 20%+
- Euro very shaky because of Russia
- Many Euro countries have serious economic problems

Selected Exchange Rates
Relative to US Dollar
2007-Present



Dairy Futures

- About the same over next year
- Class III around $15.10-$16.70 for 2016
- Class IV around $14.30-$16.90 for 2016
- Both climbing gradually on futures markets
- Feed prices about the same
- Margins depend on hay, not corn and beans

Forecast Summary

- Milk price in 2016 estimated to be similar to 2015, and about average for last decade
- Feed prices will be good
- Better feed prices should help California & West -drought & hay prices still major issues
- Income over feed cost will be like 2015
- Trade is decreasing – China slowing down – European exports diverted from Russia
- EU Dairy quotas ended April 1, 2015 and milk production is increasing, but markets scarce