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California Animal Nutrition Conference

Challenging the Dogma of Subclinical Diseases in Dairy Cattle

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Introduction

Optimizing cow health and productivity during the transition period represents a significant hurdle to the dairy industry. During early lactation inadequate nutrient consumption is coupled with increasing milk energy output; a scenario that creates a negative energy balance (NEB; Drackley, 1999). Therefore, milk yield during NEB is prioritized by alterations in carbohydrate, lipid, protein, and mineral metabolism. Traditionally, excessive adipose tissue mobilization, the ensuing hyperketonemia and the magnitude of hypocalcemia were thought to be the pathological foundation of transition cow problems and immunosuppression. However, high producing healthy cows may also present high NEFA, hyperketonemia and transient subclinical hypocalcemia. These are key homeorhetic adjustments that cows employ to prioritize milk synthesis at the expense of tissue accretion. Further immune activation also markedly influences metabolism and mineral trafficking, and these adjustments are utilized to prioritize an activated immune system. Thus, an inflamed cow also has a very similar bioenergetic and mineral metabolism footprints as a high producing healthy cow. We believe that altered NEFA, ketones, and calcium are due to one of two reasons: 1) high producing healthy cows are naturally adjusting metabolism during NEB to emphasize milk synthesis, or 2) unhealthy cows in which metabolic alterations reflect immune activation and subsequent hypophagia. The difference in these two models is more than an academic debate, since this nuance has immense economic implications for the producer.

Correlation is Unequal to Causation

Dairy cow lactation maladaptation has extensively been researched for more than five decades and this is primarily because the incidence of health problems is highest in the first two months of lactation. The periparturient period certainly has the dynamic variations in bioenergetics (NEFA, glucose, ketones, insulin, glucagon, BUN, etc.) and minerals (Ca and P) during lactation. Importantly, these temporal patterns are often occurring while negative health events are detected. Correlation and causality are sometimes incorrectly assumed to be equal in regard to the events that occur during the transition period and are claimed to be inevitable rather than coincidental. Most of the assumptions have been largely based on associations and not cause-and-effect relationships garnered from controlled and intervening experimentation. Even from a relationship perspective, assessing the strength or robustness of the associations is difficult due to variability in analysis and statistical methods. In particular, different metabolite thresholds are biasedly set for different outcomes and time points among observational studies. Additionally, inconsistent association metrics (e.g., odds ratio, relative risk, hazard ratio) are used to assess these relationships. The inconsistency and inaccuracy of using correlation to interpret causation creates suspect on-farm decision-making and unnecessary farm expenses. More detailed description of this area is covered herein, see our recent review (Horst et al., 2021).

Traditional Dogmas

Long-standing tenets describe a causal role of hypocalcemia, increased NEFA, and hyperketonemia in the incidence of transition diseases and disorders (Figure 1). Hypocalcemia has traditionally been considered a gateway disorder leading to ketosis, mastitis, metritis, displaced abomasum, impaired reproduction, and decreased milk yield (Curtis et al., 1983; Goff, 2008; Martinez et al., 2012; Chapinal et al., 2012; Riberio et al., 2013; Neves et al., 2018a,b). The proposed mechanisms by which hypocalcemia leads to these ailments include impaired skeletal muscle strength and gastrointestinal motility (Goff, 2008; Oetzel, 2013; Miltenburg et al., 2016; Goff, 2020), decreased insulin secretion (Martinez et al., 2012, 2014), and the development of immunosuppression (Kimura et al., 2006). Like hypocalcemia, increased NEFA and hyperketonemia are presumed causative to illnesses such as DA, retained placenta, metritis, reduced lactation performance, poor reproduction, and an overall increased culling risk (Cameron et al., 1998; LeBlanc et al., 2005; Duffield et al., 2009; Ospina et al., 2010; Chapinal et al., 2011; Huzzey et al., 2011). Excessive NEFA mobilization and the affiliated increase in hepatic lipid uptake, triglyceride (TG) storage, and ketone body production has been traditionally believed to be the driving factor leading to ketosis and fatty liver (Grummer, 1993; Drackley, 1999). Additionally, elevated NEFA and ketones are thought to compromise immune function (Lacetera et al., 2004; Hammon et al., 2006; Scalia et al., 2006; Ster et al., 2012) and suppress feed intake (Allen et al., 2009). Thus, the magnitude of changes in NEFA, BHB and Ca have traditionally been purported as predictors of future performance.

Culling Trends

A cow's entire lactation and the opportunity to have an additional lactation are heavily dependent on how successfully she adapts throughout the transition period. There is a disproportionate amount of health care and culling that occurs within 60 days after parturition. Minimizing large increases in NEFA and hyperketonemia and preventing subclinical hypocalcemia have been a key strategy in an attempt to improve overall herd health (because the dogma is that they are causal to disease). However, despite our industry's endeavors (medically treating for hyperketonemia and subclinical hypocalcemia), herd health has arguably not improved with time (Table 1). The question then needs asking: "are we attempting to fix the wrong problem"?

Inflammation in the Transition Period

Regardless of health status (Humblet et al., 2006), increased inflammatory biomarkers are observed in nearly all cows during the periparturient period (Ametaj et al., 2005; Humblet et al., 2006; Bionaz et al., 2007; Bertoni et al., 2008; Mullins et al., 2012). The magnitude and persistency of the inflammatory response seems to be predictive of transition cow performance (Bertoni et al., 2008; Bradford et al., 2015; Trevisi and Minuti, 2018). During the weeks surrounding calving, cows are exposed to a myriad of stressors which may permit endotoxin entry into systemic circulation and thereby initiate an inflammatory response (Khafipour et al., 2009; Kvidera et al., 2017c; Barragan et al., 2018; Proudfoot et al., 2018; Koch et al., 2019). The frequency and severity of these inflammation-inducing insults presumably determine the level of inflammation that follows (Bertoni et al., 2008; Trevisi and Minuti, 2018). Common origins of endotoxin entry include the uterus (metritis) and mammary gland (mastitis). Additionally, we believe the gastrointestinal tract may contribute as many of the characteristic responses (rumen acidosis, decreased feed intake, and psychological stress) occurring during the transition period can compromise gut barrier function (Horst et al., 2021).

Although an overt inflammatory response is present around calving, numerous reports have described a reduction in immune competence during this time (Kehrli et al., 1989; Goff and Horst, 1997; Lacetera et al., 2005). Traditionally, hypocalcemia and hyperketonemia have been primary factors considered responsible for periparturient immunosuppression (Goff and Horst, 1997; Kimura et al., 2006; LeBlanc, 2020), however, recent evidence suggests this is more complex than originally understood and that the systemic inflammatory milieu may be mediating the immune system to become “altered” and not necessarily “suppressed” around calving (Burton et al., 2005; Trevisi and Minuti, 2018; LeBlanc, 2020). While some functions of immunity are reduced, others are robustly increased (Mann et al., 2019; Minuti et al., 2020). In agreement, we observed the inflammatory response in 20 DIM cows was more reactive towards a sterile antigen than mid-lactation cows (Opgenorth et al., 2022). Thus, the use of the term immunosuppression seems to be an oversimplified generalization in an attempt to explain the phenomenon of increased disease susceptibility around parturition. We find it difficult to justify how evolution could favor an immune suppressed or dysregulated state in the transition cow since these statements imply their unique immune status is inferior, when rather the adjustments around parturition are likely intentional changes required to transition immunity from fetal tolerance to postpartum status. Whether or not the “immune incompetence” frequently reported post-calving is causative to future illnesses or is a consequence of prior immune stimulation still needs further attention.

The Importance of Glucose

To adequately recognize the connection between inflammation and transition period success, an appreciation for the importance of glucose is a prerequisite. Glucose is the precursor to lactose, the milk constituent primarily driving milk volume through osmoregulation (Neville, 1990). Approximately 72 g of glucose is required to synthesize 1 kg of milk (Kronfeld, 1982). A variety of metabolic adaptations take place in lactating mammals including increased liver glucose output and peripheral insulin resistance which allows for skeletal muscle to have increased reliance upon lipid-derived fuel (i.e., NEFA and BHBA) to spare glucose for milk synthesis and secretion by the mammary gland (Baumgard et al., 2017). The immune system is also heavily reliant on glucose when activated. The metabolism of inflammation (discussed below) has its own unique metabolic footprint to direct glucose toward the immune system. Consequently, when the onset of inflammation and lactation coincide, glucose becomes an extremely valuable and scarce resource.

Ketogenesis occurs when glucose is in short supply. This can come from a combination of factors including lack of substrate (i.e., reduced feed intake and ruminal fermentation) or high glucose utilization by other tissues (i.e., the immune system or mammary gland). When glucose demand is high, the TCA cycle intermediate oxaloacetate leaves the cycle to supply carbon for gluconeogenesis (Krebs, 1966). Oxaloacetate is also the molecule that combines with acetyl CoA (the end-product of adipose-derived NEFA) to allow the TCA cycle to continue progressing. If the TCA cycle is limited in its progression due to lack of oxaloacetate, acetyl CoA enters into ketogenesis. The link between onset of lactation, immune system activation, and lack of glucose leading to ketogenesis may help explain the metabolic footprint of a poorly transitioning dairy cow.

Metabolism of Inflammation

Inflammation has an energetic cost which redirects nutrients away from anabolic processes (see review by Johnson, 2012) and thus compromises productivity. Upon activation, most immune cells become obligate glucose utilizers via a metabolic shift from oxidative phosphorylation to aerobic glycolysis (not anaerobic glycolysis typically learned about in biochemistry classes), a process known as the Warburg effect. This metabolic shift allows for rapid ATP production and synthesis of important intermediates which support proliferation and production of reactive oxygen species (Calder et al., 2007; Palsson-McDermott and O'Neill, 2013). In an effort to facilitate glucose uptake, immune cells become more insulin sensitive and increase expression of GLUT3 and GLUT4 transporters (Maratou et al., 2007; O'Boyle et al., 2012), whereas peripheral tissues become insulin resistant (Poggi et al., 2007; Liang et al., 2013). Furthermore, metabolic adjustments including hyperglycemia or hypoglycemia (depending upon the stage and severity of infection), increased circulating insulin and glucagon, skeletal muscle catabolism and subsequent nitrogen loss, and hypertriglyceridemia occur (Filkins, 1978; Wannemacher et al., 1980; Lanza-Jacoby et al., 1998; McGuinness, 2005). Interestingly, despite hypertriglyceridemia, circulating BHB often decreases following LPS administration (Waldron et al., 2003a,b; Graugnard et al., 2013; Kvidera et al., 2017a). The mechanism of LPS-induced decreases in [BHB] has not been fully elucidated but may be explained by increased ketone oxidation by peripheral tissues (Zarrin et al., 2014). Collectively, these metabolic alterations are presumably employed to ensure adequate glucose delivery to activated leukocytes.

Energetic Cost of Immune Activation

The energetic costs of immunoactivation are substantial, but the ubiquitous nature of the immune system makes quantifying the energetic demand difficult. Our group recently employed a series of LPS-euglycemic clamps to quantify the energetic cost of an activated immune system. Using this model, we estimated approximately 1 kg of glucose is used by an intensely activated immune system during a 12-hour period in lactating dairy cows. Interestingly, on a metabolic body weight basis the amount of glucose utilized by LPS-activated immune system in mid- and late-lactation cows, growing steers and growing pigs were 0.64, 1.0, 0.94, 1.0, and 1.1 g glucose/kg $BW^{0.75}$/h, respectively; Kvidera et al., 2016, 2017a,b, Horst et al., 2018, 2019). A limitation to our model is the inability to account for liver's contribution to the circulating glucose pool (i.e., glycogenolysis and gluconeogenesis). However, both glycogenolytic and gluconeogenic rates have been shown to be increased during infection (Waldron et al., 2003b; McGuinness, 2005) and Waldron et al. (2006) demonstrated that ~87 g of glucose appeared in circulation from these processes. Furthermore, we have observed both increased circulating glucagon and cortisol (stimulators of hepatic glucose output) following LPS administration (Horst et al., 2019) suggesting we are underestimating the energetic cost of immunoactivation. The reprioritization of glucose trafficking during immunoactivation has consequences as both are considerable glucose-demanding processes. Increased immune system glucose utilization occurs simultaneously with infection-induced decreased feed intake: this coupling of enhanced nutrient requirements with hypophagia decreases the amount of nutrients available for the synthesis of valuable products (milk, meat, fetus, wool, etc.).

Inflammation and Metabolic Disorders

The periparturient period is associated with substantial metabolic changes involving normal homeorhetic adaptions to support glucose sparing for milk production. Early lactation dairy cows enter a normal physiological state during which they are unable to consume enough nutrients to meet maintenance and milk production costs and typically enter negative energy balance (NEB; Drackley, 1999; Baumgard et al., 2017). During NEB, cows mobilize NEFA in order to partition glucose for milk production in a homeorhetic strategy known as the "glucose sparing." However, increasing evidence suggests that chronic inflammation may be an additional energy drain that initiates the sequence of these disorders (Bertoni et al., 2008; Eckel and Ametaj, 2016) and this is supported by human, rodent, and ruminant literature which demonstrate effects of lipopolysaccharide (LPS) and inflammatory mediators on metabolism and hepatic lipid accumulation (Li et al., 2003; Bradford et al., 2009; Ilan et al., 2012; Ceccarelli et al., 2015). We and others have demonstrated that cows which develop ketosis and fatty liver postpartum have a unique inflammatory footprint both pre- and post-partum (Ohtsuka et al., 2001; Ametaj et al., 2005; Abuajamieh et al., 2016; Mezzetti et al., 2019; Figure 3). Because the activated immune system has an enormous appetite for glucose, it can exacerbate a glucose shortage by both increasing leukocyte glucose utilization and reducing exogenous gluconeogenic substrates by inhibiting appetite. Reduced DMI is a highly conserved response to immune activation across species (Brown and Bradford, 2021) which can further increase NEFA mobilization and hepatic ketogenesis (Figure 3).

Inflammation and Subclinical Hypocalcemia

Subclinical hypocalcemia (SCH) remains a prevalent metabolic disorder afflicting ~25% of primiparous and ~50% of multiparous cows in the United States (Reinhardt et al., 2011). Although no overt symptoms accompany SCH, it has been loosely associated with poor gut motility, increased risk of DA, reduced production performance (i.e., milk yield and feed intake), increased susceptibility to infectious disease, impaired reproduction, and an overall higher culling risk (Seifi et al., 2011; Oetzel and Miller, 2012; Caixeta et al., 2017). Recent reports indicate that the severity of negative health outcomes observed in SCH cows appears dependent on the magnitude, persistency, and timing of SCH (Caixeta et al., 2017; McArt and Neves, 2020). For example, Caixeta et al. (2017) classified cases as either SCH or chronic SCH and observed more pronounced impairments on reproductive performance with chronic SCH. Similarly, McArt and Neves (2020) classified cows into 1 or 4 groups based on post-calving Ca concentrations: normocalcemia (>2.15 mmol/L at 1 and 2 DIM), transient SCH (≤ 2.15 mmol/L at 1 DIM), persistent SCH (≤ 2.15 mmol/L at 1 and 2 DIM), or delayed SCH (> 2.15 mmol/L at 1 DIM and ≤ 2.15 mmol/L at 2 DIM). Cows experiencing transient SCH produced more milk and were no more likely to experience a negative health event when compared to normocalcemic cows, whereas the opposite (i.e., higher health risk and hindered productivity) was observed in cows experiencing either persistent or delayed SCH. Clearly not all cases of SCH are equivalent; in fact, transient hypocalcemia appears to be correlated with improved “health” and productivity and this may explain why inconsistencies exist in the relationship between SCH and reduced productivity and health (Martinez et al., 2012; Jawor et al., 2012; Gidd et al., 2015). However, it remains unclear why, despite successful implementation of mitigation strategies, SCH remains prevalent, why SCH is associated with a myriad of seemingly unrelated disorders, and what underlying factors may be explaining the different “types” of SCH.

Impressively, immune activation was originally hypothesized by early investigators to be involved with milk-fever (Thomas, 1889; Hibbs, 1950), but until recently (Eckel and Ametaj, 2016) it has rarely been considered a contributing factor to hypocalcemia. Independent of the transition period, we and others have repeatedly observed a marked and unexplainable decrease in circulating calcium following LPS administration in lactating cows (Griel et al., 1975; Waldron et al., 2003; Kvidera et al., 2017b; Horst et al., 2018, 2019; Al-Qaisi et al., 2020). Infection-induced hypocalcemia is a species conserved response occurring in humans (Cardenas-Rivero et al., 1989), calves (Tennant et al., 1973; Elsasser et al., 1996;), dogs (Holowaychuk et al., 2012), horses (Toribio et al., 2005), pigs (Carlstedt et al., 2000) and sheep (Naylor and Kronfeld, 1986). Additionally, hypocalcemia occurs in response to ruminal acidosis in dairy cows (Minuti et al., 2014). It is unlikely that cows (even those that are presumably “healthy”) complete the transition period without experiencing at least one immune stimulating event and we are likely underestimating its contribution to postpartum hypocalcemia. In summary, it is probable that immune activation is at least partially explaining the incidence of SCH in the postpartum period. It is intriguing to suggest that cases of delayed, persistent, and chronic SCH recently described by Caixeta et al. (2017) and McArt and Neves (2020) may be related to the severity of the periparturient inflammatory response. This hypothesis may explain why these cases of SCH are associated with reduced health, as these may represent direct consequences of immune activation rather than simply decreased Ca.

In addition to SCH, there are on-farm milk-fever situations that are biologically difficult to explain. For example, even while strictly adhering to a pre-calving calcium strategy, there remains a small percentage (~<1%) of cows that develop clinical hypocalcemia. Additionally, reasons for why a mid-lactation cow develops milk-fever are not obvious. Further, there appears to be an undecipherable seasonality component to clinical hypocalcemia in the southwest and western USA that coincides with the rainy season. Inarguably, there remain some aspects of Ca homeostasis that continue to evade discovery.

Conclusions

New evidence and thinking around inflammation are challenging the traditional dogmas surrounding hypocalcemia, elevated NEFA, and hyperketonemia as the causative factors in transition cow disease. We suggest, based upon the literature and on our supporting evidence, that activation of the immune system may be the causative role in transition cow failure (rather than the metabolites themselves) as inflammation markedly alters nutrient partitioning and these metabolites as a means of supporting the immune response (Figure 3). More research is still needed to understand the causes, mechanisms, and consequences of immune activation and how to prevent immune activation or support its efficacy to provide foundational information for developing strategies aimed at maintaining productivity.

Table 1. National Animal Health Monitoring Systems

Culling Reason	NAHMS (1996)	NAHMS (2002)	NAHMS (2014)
Voluntary Reasons	21.3	19.3	21.1
Reproduction	25.3	26.5	24.2
Mastitis	25.1	25.9	24.4
Injury	4.1	6.0	5.2
Death	3.8	4.8	4.2
Disposition	0.9	0.9	-
Lameness	14.2	16.3	16.8
Other	3.9	4.1	-

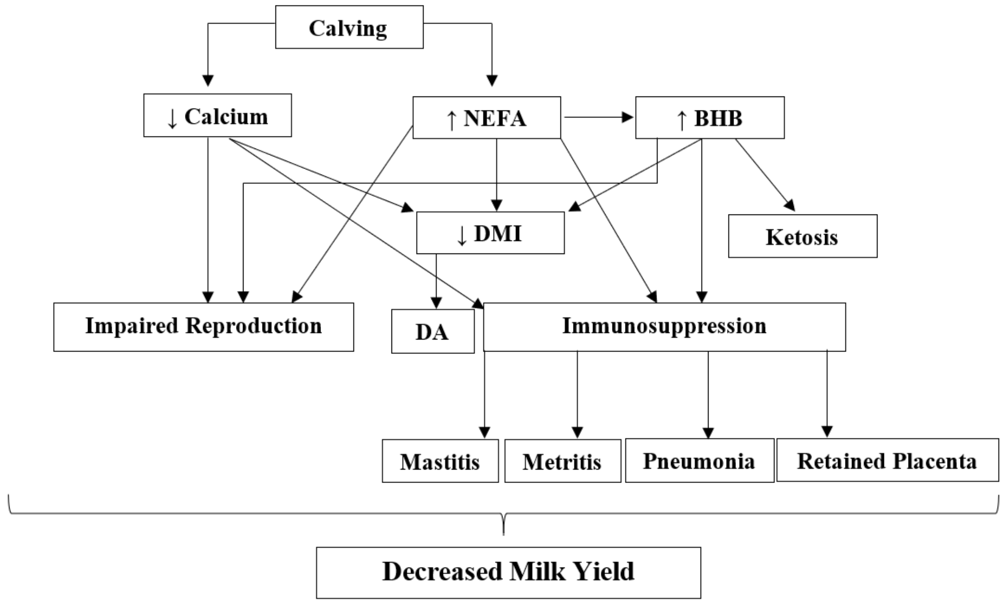

Figure 1. Traditional mechanisms by which hypocalcemia and increased NEFA and ketones are thought to cause poor transition cow health and performance.

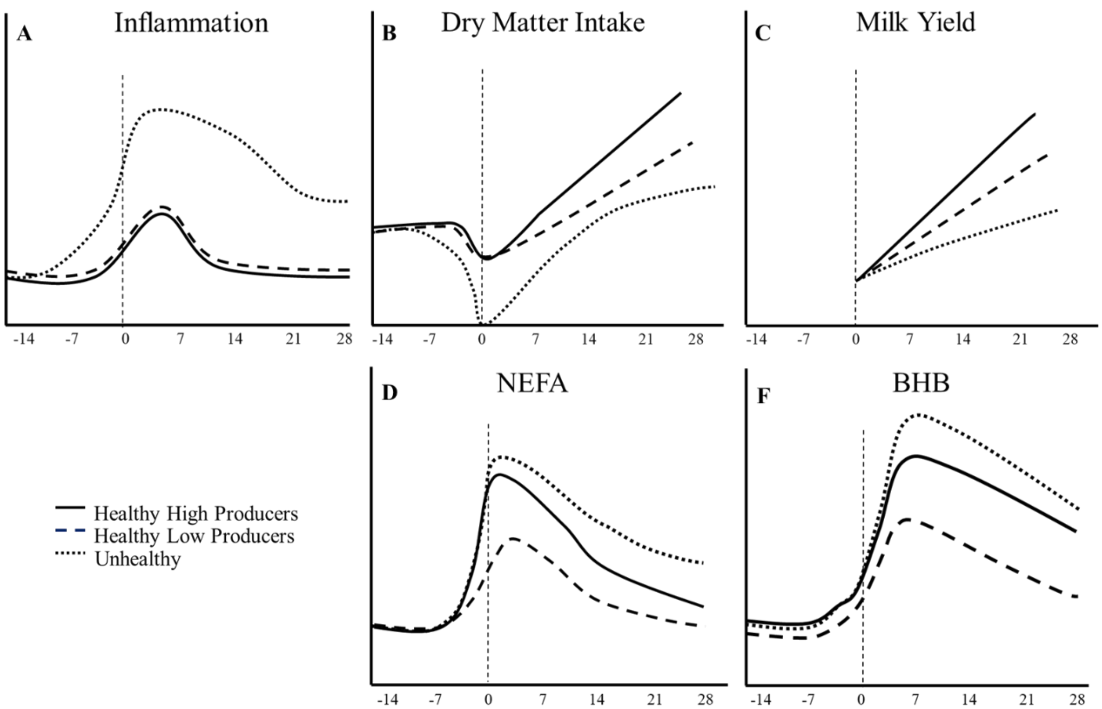

Figure 2. Transition period patterns inflammation (A), dry matter intake (B), milk yield (C), NEFA (D) and BHB (F) in healthy high producers (solid line), healthy low producers (dashed line) and unhealthy (dotted line).

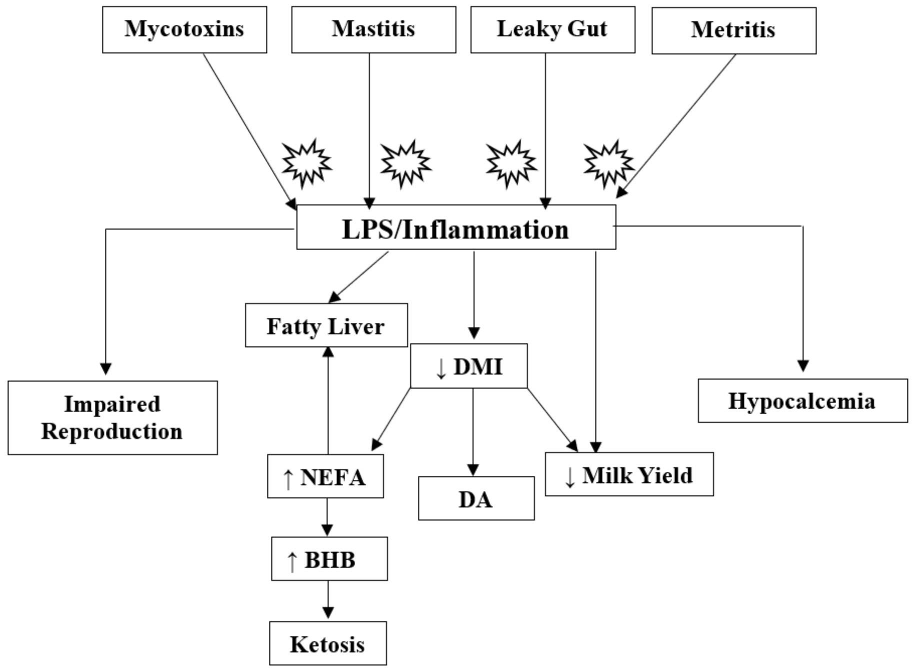

Figure 3. Potential downstream consequences of immune activation. In this model, decreased feed intake, hypocalcemia, excessive NEFA, hyperketonemia and hepatic lipidosis are not causative to poor transition cow performance and health, but rather a reflection of prior immune stimulation.

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Nutritional Management for Robotic Milking Dairies

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Introduction

The continued adoption of automated (robotic) milking systems (AMS) has necessitated a fundamental shift in nutritional management on farm, with the division of the ration into a partial mixed ration (PMR) and the supplement provided in the AMS. As result, the composition of the PMR, allocation of the PMR, type of AMS supplement, and feeding strategy of the supplement delivered in the AMS differ from conventional farms using a TMR. To date, the large diversity in feeding practices coupled limited controlled research regarding feeding management have led to many recommendations being largely based on survey studies or based on anecdotal data from single-farm case studies. Further, with increasing adoption of AMS in large dairy herds, there is need to understand how nutritional management may vary in those larger farms. This paper describes the current state of knowledge in this area of nutritional management for AMS herds, along with areas where research is needed.

Varied Concepts in Feeding Management in AMS Herds

There are two main goals when considering the nutritional program for cows milked with AMS. The first, as with all planned dairy cow nutritional programs, is to provide a diet that meets nutrient requirements for maintenance and production. However, with AMS, there potentially some opportunity that this goal can be shifted from the pen level to the cow level. Thus, producers could be providing a different diet for each cow within the same pen by adjusting the amount of supplement (often in form of a pellet) provided in the AMS. The second goal, which is unique to AMS, is to stimulate cows to voluntarily enter the AMS by dispensing supplement in the AMS. A disproportionately large focus has been placed on the AMS supplement, considering that the PMR provides the majority of the dry matter and nutrients consumed. For example, assuming a static dry matter intake (DMI) of 28 kg, the PMR could be estimated to contribute between 89 and 71% of the total dietary dry matter for cows offered 3 and 8 kg of supplement in the AMS (dry matter basis), respectively.

Published survey data suggest that producers with free-flow traffic barns program greater AMS supplement allocations than those with guided-flow traffic barns (Salfer and Endres, 2018). Feeding greater quantities of supplement in the AMS, by default, also indicates the PMR will be less nutrient dense. While this may not be considered to be a problem, recent research has demonstrated that feeding a PMR with a greater proportion of forage increases the ability of cattle to sort that PMR (Menajovsky et al., 2018; Paddick et al., 2019). Providing more supplement in the AMS with free-flow barns is typically done because cows can choose when, and if, they voluntarily enter the AMS, whereas with guided flow barns, cows are ultimately directed to the commitment pen and the AMS using automated sorting gates.

It was reported by Salfer and Endres (2018) that in their survey the upper limit for supplement allocation in AMS (computer programmed value) was 11.3 kg /cow/d. Assuming cows could consume 11.3 kg/d, each cow would need to consume over 2.8 kg/milking (assuming 4 milkings/day) equal to 350 to 400 g/min if milking duration was between 7-8 min. This high rate of supplement feeding may outpace the ability of cows to consume supplement while milking, and likely would result in a significant quantity of supplement that is either not delivered to the cow (Penner et al., 2017) or delivered in the AMS, but not consumed by the cow (Bach and Cabrera, 2017).

There is, however, a lack of data evaluating whether traffic flow truly affects the amount of supplement required to be offered in the AMS. A study conducted in a feed-first, guided-flow barn reported no effect on voluntary attendance or milk yield when the amount of pellet delivered varied from 0.5 to 5.0 kg of DM/d (Paddick et al., 2019), whereas similar treatments in a free-flow barn resulted in more frequent voluntary milkings (Schwanke et al., 2019). One might conclude that these data provide support for allocating greater quantities of AMS supplement under free-flow systems; however, the AMS pellet composition, PMR composition, total DMI, and days in milk also differed between the two studies thereby preventing a direct comparison. Moreover, Bach et al. (2007) reported that the amount of pellet provided in a free-flow system did not affect voluntary attendance or milk yield. As a result, studies should not be interpreted to indicate the absolute amount of pellet provided because the amount likely differs on a farm-to-farm basis.

Effect of AMS Pellet Allocation on DMI, Voluntary Milking, and Milk Yield

The approach taken to determining AMS supplement allocation should be considered because there are two very different nutritional strategies. First, producers need to decide how much supplement is required from a basal level and this basal amount must consider the formulation of the PMR. Studies have been conducted in the past to evaluate how the amount of supplement offered in AMS affects production responses when the total dietary nutrient supply is equivalent. In other words, with this strategy, increasing the amount of supplement provided in the AMS requires an equal reduction in the amount of supplement in the PMR, such that the total diet (PMR + AMS) does not differ. The first study published using this nutritional strategy compared treatments with computer programmed values of three or eight kg of pellet in the AMS in a free-flow barn design (Bach et al., 2007). In that study, despite having programmed values of 3 and 8 kg/d, pellet delivery was 2.6 and 6.8 kg/d (dry matter basis) and the amount of pellet delivered did not affect milk production or milk component production. In two recent studies conducted in a feed first guided-flow barn at the University of Saskatchewan, AMS pellet delivery ranged between 0.5 and 5.0 kg of dry matter/cow/d (Hare et al., 2018; Paddick et al., 2019). Altering the amount of AMS pellet while maintaining equal dietary nutrient composition did not affect voluntary visits, milk yield or milk component yield. In contrast, in a recent study conducted at the University of Guelph in a free-flow barn, it was reported that with total diets (PMR + AMS pellet) that were the same in nutrient composition, increasing the AMS pellet from 3 to 6 kg/d (and correspondingly reducing the same pellet in the PMR), stimulated greater DMI (+1.3 kg/d), increased voluntary visits by 0.5 milkings/d, and numerically increased milk yield by 1.5 kg/d (Schwanke et al., 2019). In a similar study at the same facility, Schwanke et al. (2022) demonstrated that by increasing AMS pellet (6 vs 3 kg/d) when cows were fed the same PMR, cows again demonstrated greater total DMI (+1.3 kg/d) and numeric increase in milk yield (+1.6 kg/d)

It might seem counter-intuitive that increasing the AMS supplement allocation does not necessarily stimulate voluntary visits or milk yield in all situations. However, simply providing more supplement in the AMS does not necessarily translate to greater DMI, as cows will generally eat to a set level of intake based on BW and requirements (including production and DIM). For example, Hare et al. (2018) reported that for every 1 kg increase in AMS pellet delivered, there was a corresponding decrease in PMR DMI of 1.58 kg. Bach et al. (2007) reported a 1.14 kg reduction in PMR DMI and Paddick et al. (2019) reported that PMR DMI decreased by 0.97 kg for every one kg increase in AMS pellet delivered. The large or at least equal reduction in PMR DMI with increasing AMS pellet intake demonstrates that nutrient intake may not be positively affected. These effects of greater concentrate consumption in the AMS and subsequent PMR substitution rate may also vary due to the energy density of the PMR; Menajovsky et al. (2018) reported a 0.78 and 0.89 kg/d reduction of PMR for every 1 kg of concentrate, depending on PMR energy density (low or high). In contrast, in Schwanke et al. (2019) and (2022) it was reported that for every 1 kg increase in AMS pellet intake there was only a 0.63 kg and 0.54 kg, respective, reduction in PMR DMI (Table 1).

In those two later cases, providing more pellet in the AMS resulted in greater total DMI and likely explains their numerical improvement in milk yield. Across studies, the variable and currently unpredictable substitution rate may challenge the ability to formulate diets for individual cows in the same pen given that only the amount or types of pellet in the AMS can differ.

Table 1. Effect of increasing pellet in the automated milking system (AMS) on the reduction in PMR intake (DM basis).

Study	DIM (mean ± SD)	Cows, parity, and study design	Traffic and diet, dietary scenario	Substitution ratio, kg PMR/kg AMS concentrate
Bach et al., 2007	191 ± 2.13	69 primiparous Holstein, 46 multiparous Holstein Completely randomized design	Free Isocaloric	1.14
Hare et al., 2018	227 ± 25 123 ± 71	5 multiparous Holstein 3 primiparous Holstein	Guided Isocaloric	1.58
Henriksen et al., 2018	32-320 14-330	22 primiparous Holstein, 19 multiparous Holstein 11-week study	Free Static PMR with 2 concentrate	0.58 – 0.92
Henriksen et al., 2018	29-218 17-267	14 primiparous Jersey 28 multiparous Jersey 11-week study	Free Static PMR with 2 concentrate allocations	0.69-0.50
Menajovsky et al., 2018	141 ± 13.6	8 multiparous Holstein Replicated 4x4 Latin square	Guided Low energy PMR High energy PMR	0.89 0.78
Henriksen et al., 2019	Early (5 to 14) Mid (15 to 240) Late (241 to 305)	128 cows (68 Holstein + 60 Jersey) Continuous lactation study	Free Static PMR with 2 differing concentrate allocations	5 1.1 2.9
Paddick et al., 2019	90.6 ± 9.8	8 primiparous Holstein Replicated 4x4 Latin square	Guided Isocaloric	0.97
Schwanke et al., 2019	47.1 ± 15.0	15 primiparous Holstein cows, crossover design	Free, Isocaloric	0.63
Schwanke et al., 2022	123.9 ± 53.2	14 muliparous, 1 primiparous Holstein cows, crossover design	Free, static PMR	0.54

As a second strategy, the energy density of the diet for an individual cow can be changed by increasing or decreasing the AMS supplement allocation without changing the composition of the PMR. This approach is one strategy to apply precision feeding management. There has been limited research with this strategy; however, in a study where cows received 2 or 6 kg of AMS pellet (dry matter basis), there were only subtle differences in milking frequency and only numerical improvements for milk and milk protein yield (Menajovsky et al., 2018). At a farm level, Tremblay et al. (2016) reported a negative relationship between the amount of pellet offered in the AMS and milk yield. Their rationale was that poor forage quality requires more pellet; however, there was no information provided on PMR characteristics. To our knowledge, there is still a lack of research focusing on the use of precision feeding strategies, particularly with high-yielding and early lactation cows.

A challenge with adopting precision feeding strategies is that predictions are needed for the amount of PMR and AMS supplement that the cow will consume on a daily basis. The data are clear that increasing the quantity of AMS pellet offered in the AMS increases the day-to-day variability in the consumption of the AMS pellet and hence can creates more dietary variability (Hare et al., 2018; Menajovsky et al., 2018; Paddick et al., 2019; Schwanke et al., 2019), however that is not always the case (Scwhanke et al., 2022).

In most studies, a fundamental assumption is that as AMS supplement delivered, and presumably consumed, increased, PMR intake would decrease with an equal magnitude. We know this assumption is not true as substitution rates (amount of decrease in PMR intake for every 1 kg increase in AMS pellet intake) range from 0.54 to 1.58 kg (Table 1). Obviously, the reduction in PMR intake with increasing AMS supplement allocation will change the nature of the total diet and depending on the direction and magnitude of the PMR substitution, the proportions of forage neutral detergent fibre (NDF) or physically effective NDF may become marginal coupled with increases in ruminally degradable starch.

In AMS systems, there are three values that are relevant when considering AMS supplement delivery. The first value is the computer programmed target value. This value is the maximum amount that can be offered to cows in the AMS, assuming that carry-over of supplement is not included in the equation. The second value is the amount that is delivered to the cows in the AMS. The third value is the amount consumed in the AMS. The amount of supplement programmed in the computer does not correspond with the amount delivered. For example, Bach et al. (2007) allocated either 3 or 8 kg/d in the AMS but only 2.6 and 6.8 kg/d were delivered, respectively. Halachmi et al. (2005) offered either 7 kg/d or 1.2 kg/visit to cows and reported that cows offered 7 kg/d were only delivered 5.2 kg/d while those offered 1.2 kg/visit received 3.85 kg/d. AMS supplement delivery and supplement consumption below that of the formulated diet are major concerns. Evaluating the deviation between the amount programmed and the amount offered is an important management tool because it demonstrates the ability to deliver the formulated diet to the cows. The deviation between the amount programmed and the amount delivered increases as the amount programmed increases. While it cannot be evaluated on farm easily, residual supplement left in the AMS feeder also increases with increasing supplement allocation in the AMS (Bach and Cabrera, 2017). Differences among the amount of supplement programmed, amount delivered in the AMS, and amount consumed by cows in the AMS can pose a challenge to dairy producers and their nutritionists, and diminish the ability to formulate diets that reasonably predict production outcomes.

Type of Supplement Provided in the AMS

Another factor which influences the amount of feed provided and consumed in the AMS is the supplement composition, palatability and physical form. The rate of consumption of various feeds may limit the amount which may be consumed in the AMS. It is well established that eating rates vary with physical form of concentrate. For example, Kertz et al. (1981) demonstrated that a 4mm pellet was consumed by cows quicker than a pellet with cracked corn, a crumbled pellet, and a meal (in that order), with a maximal rate of consumption of ~430 g/min of the pellet. Pellet consumption rate in other studies has averaged 265 g/min (Beauchemin et al., 2002) and 199 g/min (Maekawa et al., 2002). Sporndly and Asberg (2006) recording concentrate intake rates of up to 200 g/min, with preferences of pellets to ground grain. Additionally, Harper et al. (2016) recorded eating rates varying from 223 - 312 g/min of non-pelletized concentrates with various flavors. Across the literature, it appears that the 'average' cow consumes concentrate at ~250 g/min. In a typical 7 min milking, this would equate to 1.75 kg/milking that the average cow can consume in concentrate. Thus, with a target of ~3 milkings per day, the 'average' cow would be expected to be able to consume ~5 to 5.5 kg/d of supplement in the AMS.

The palatability of the pellet provided in the AMS may also be important. Madsen et al. (2010) evaluated pellets containing barley, wheat, a barley-oat mix, maize, artificially dried grass, or pellets with added fat, with all cows fed a common PMR. Those researchers observed that AMS pellet intake and voluntary visits were greatest when the pellets contained the wheat or the barley-oat mix. However, pelleted barley and wheat are expected to have a rapid rate of fermentation in the rumen and feeding substantial quantities would be expected to increase the risk for low ruminal pH. To reduce fermentability, pellets could be prepared with low-starch alternatives (Miron et al., 2004; Halamachi et al., 2006; 2009). Substituting starch sources with soyhulls did not negatively affect voluntary attendance at the AMS or milk yield (Halamachi et al., 2006, 2009), and may slightly improve milk fat and reduce milk protein concentrations (Miron et al., 2004).

Producers may also choose to use home-grown feeds in the AMS. In a more recent study at the University of Saskatchewan, it was tested whether feeding a pellet was required or if they could deliver steam-flaked barley as an alternative (Johnson et al., 2022) in a feed-first guided-traffic flow barn. In that study, the pellet comprised only barley grain and the same source of barley grain was used for the steam-flaked treatment. In all cases, cows were programmed to have 2.0 kg of the concentrate in the AMS delivered. While PMR (27.0 kg/d DM basis) and AMS concentrate intake (1.99 kg/d DM basis) did not differ among treatments, cows fed the steam-flaked barley had fewer visits (2.71 vs 2.90 visits/d) to the AMS, tended to have a longer interval between milking events (541.7 vs. 505.8 min), and spent more time in the commitment pen prior to entering the AMS (139.9 vs. 81.2 min/d) than those fed pelleted barley. While this did not translate into differences in milk yield (average of 44 L/d), it may be expected that with a longer-term study, production impacts would be observed. In contrast, Henriksen et al. (2018) reported greater voluntary visits when a texturized feed (combination of pellet and steam-rolled barley) was provided in comparison to a pellet alone. Regardless, utilization of a pellet as the sole ingredient or part of the mix may limit the ability of producers to use home-grown feeds in the AMS.

Management of the Partial Mixed Ration

Management of the PMR may be a key factor in success of AMS, largely due to the fact that milking activity in AMS is largely tied to PMR feeding activity (DeVries et al., 2011; Deming et al., 2013). Stimulation of PMR eating behavior, through frequent feed delivery and push up across the day may, thus, be important for optimizing AMS usage. Interestingly, in recent observational study of AMS herds, Siewert et al. (2018) reported that farms with automatic feed push-up produced 352 kg more milk/robotic unit and 4.9 kg more milk/cow per day than farms that manually pushed up feed. In an even more recent study by our group (Matson et al., 2021), we demonstrated in an observational study of 197 Canadian robot milking farms, that each additional 5 feed push-ups per day was associated with 0.35 kg/d/cow greater milk yield. Interestingly, given the mean push up frequency between those that pushed up feed manually (4.4 times per day; 19% of farms) and those that used a robotic feed pusher (16.8 times per day; 71% of farms) in our study, it is likely that our findings and that of Siewert et al. (2018) were driven by the frequency feed was pushed up within each system, rather than by the method itself. More specifically, these effects may not be directly attributable to the use of an automated feed pusher, but rather that those farms using such automated equipment had more consistent feed push-up, and thus continuous feed access, than those pushing up feed manually.

In addition to feed push-up, the frequency of PMR delivery may also have implications for milking activity, given positive effects of frequent feed delivery on stimulating feeding activity (DeVries, 2019). Those changes in feeding activity may also have impacts on cow health and efficiency. Specifically, when we deliver feed more often, cows may change their eating behavior, having more meals, eating slower, and sorting their feed less, resulting in a more consistent rumen environment. In support of that, Castro et al. (2022) demonstrated in a study of 124 AMS farms that greater frequency of partial mixed ration (PMR) delivery (>2×/d vs. 1 and 2×/d) was positively associated with a greater proportion (g/100 g of FA) of de novo FA in the bulk tank milk of those farms. Interestingly, the majority of those farms in that study feeding >2×/d were using some type of automated feeding technology to achieve that higher frequency.

Early Lactation Challenges?

Automated milking systems provide the ability to milk and feed cows individually based on production potential and stage of lactation. However, individualized milking may not only lead to more frequent milking and greater milk yield in early lactation, but may lead to issues with negative energy balance and metabolic disorders. Tatone et al. (2017) reported that AMS herds in Ontario, Canada had higher within-herd prevalence of subclinical ketosis (SCK; 26%; as measured through milk ketone levels) than did conventional herds (21%). Those researchers also reported that multiparous cows in AMS herds were more likely to have SCK than in conventional herds (Tatone et al., 2017). Higher SCK prevalence may be the result of increased frequency of milking during early lactation or inadequate supplemental feeding of concentrates in the AMS. In a field study King et al. (2018) reported that development of SCK in AMS cows was associated with greater production of milk relative to the amount of feed consumed in the AMS, suggesting that inadequate supplementation was potentially occurring at that time. This provides evidence that AMS feed supplementation must be based on stage of lactation and production level. Alternative and additional energy sources may also be beneficial in early lactation. Specifically, alternatives to starch (to improve rumen conditions) including sugars and other gluconeogenic precursors may have benefits. As one example, we demonstrated that we could improve energy balance and minimize body condition loss in early lactation by supplementing cows milked in AMS with a molasses-based liquid feed supplement in addition to their regular AMS concentrate (Moore et al., 2020).

Implications for AMS on Large Dairy Herds

In the past few years we have seen a dramatic increase in the adoption of AMS, including among large dairy herds. Several large herds have switched completely to AMS, while others have maintained parlor milking for a segment of the herd. Despite a lack of specific research on those larger herds, the challenges and opportunities for AMS on large dairy herds are most likely similar to small and medium sized herds. In fact, in large herds, size of group/pens (and number of AMS units per pen) are typically similar to that of smaller herds, and thus could be thought of a collection (or replication) of small herds in a single location. From a nutritional management standpoint, this can actually provide more opportunities. For example, with multiple groups, just like in conventional dairies, cows can be managed better according to nutritional need (e.g. 1st lactation vs mature, fresh cows, etc). The use of on farm (commodity) feeds and mixes for AMS supplements may be more attractive for large AMS dairies, however, that does come at a risk. As described earlier, eating rates are optimized with pelleted supplements, and so ensuring targeted consumption may be more difficult with other supplements. Further, the risk of feed waste and shrink at the AMS can be much greater with commodity feeds/mixes. As such, the cost of pelleting that feed at a large scale may be offset by the benefits of feeding pellets in the robot, as well as reductions in feed waste/shrink.

Conclusions

The adoption of AMS systems continues to rise and sound feeding management practices are needed to support efficient and cost-effective milk production. Feeding strategy in AMS herds must take into account the stage of lactation and production level, as well as the behavioral capabilities of dairy cows. It is well established that the feeding strategy at the AMS will impact PMR consumption levels, thus this needs to be accounted for when formulating dietary plans. Finally, encouraging PMR feeding will help drive total intake and milking activity. While there is a paucity of research and data available for large dairy herds milking with AMS, the same nutritional management concepts would be expected to apply in those herds.

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Reflecting on 2022 Silage Quality and Winning in 2023

John Goeser

PhD, PAS, Dipl. ACAN

Rock River Laboratory, Inc.

University of Wisconsin - Madison: Animal & Dairy Science Dept.

Cows Agree Consulting, LLC

Goeser's Agenda

- Economic opportunity in Dairy
- Basic silage nutrition training
- Zero in on 2022 Silage quality
- Arm you with insight & strategy for better nutrition decisions:
  - Feeding 2022 silage
  - Growing & harvesting better 2023 silage

It's a different year for dairy in

hoards.com/article-33219-its-a-different-year-for-dairy-in-the-west.html?utm_medium=email&utm_campaign=230206-494&utm_content=230206...

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HOARD'S DAIRYMAN INTEL Feb. 6 2023 08:05 AM

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It's a different year for dairy in the West

BY **COREY GEIGER, MANAGING EDITOR**

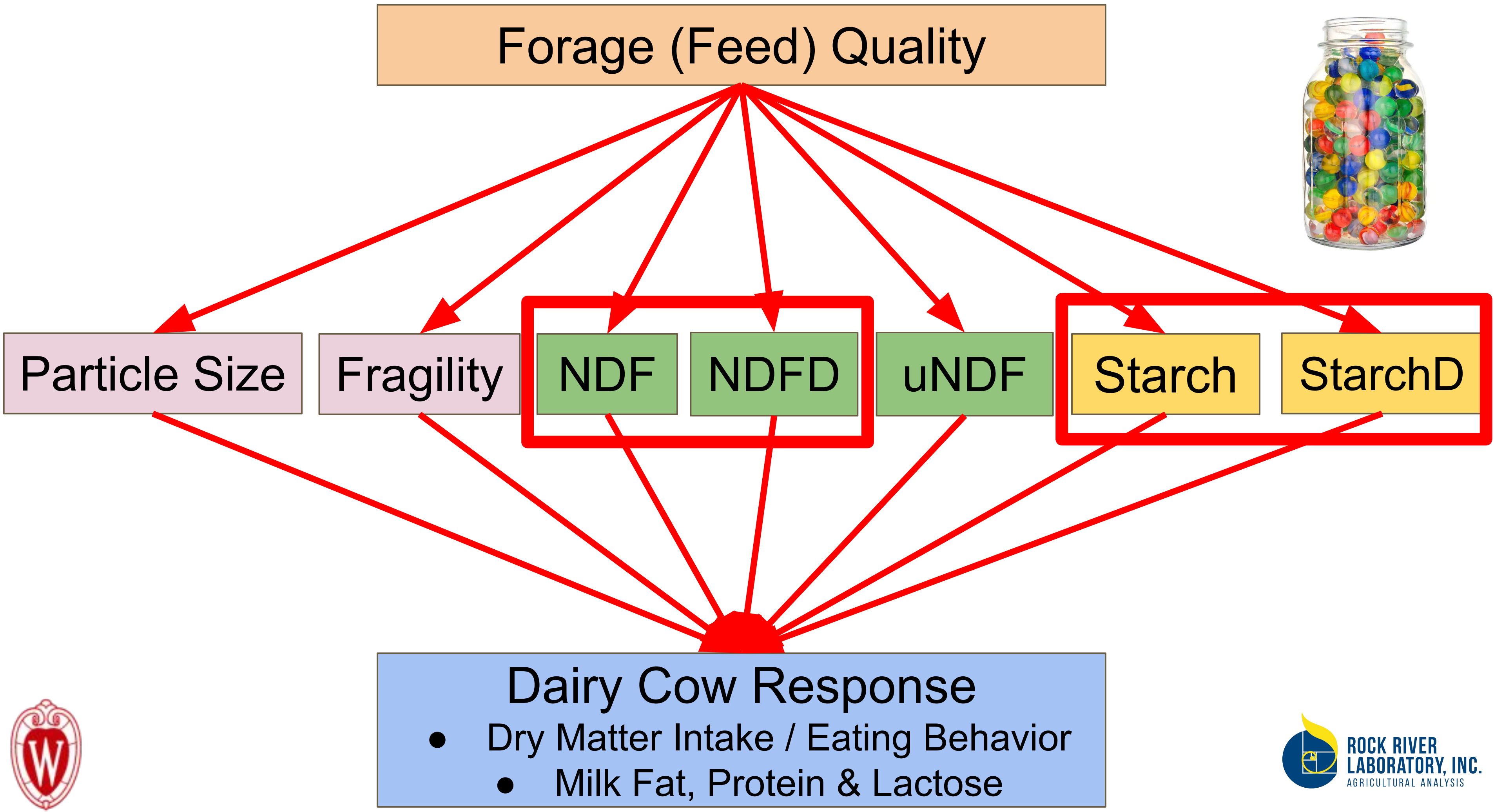
ROCK RIVER LABORATORY, INC.
AGRICULTURAL ANALYSIS

ECM, lb.	Purch. Feed $ / cwt ECM	Total Feed $ / cwt ECM	ECM / DMI - Feed Effic.	DMI
106.52	$5.51	$8.25	2.01	53.1
106.60	$6.24	$9.13	1.77	60.4
103.49	$5.22	$8.54	1.80	57.6
109.60	$5.74	$9.29	1.79	61.3
107.35	$8.97	$8.97	1.62	66.2
98.02	$5.37	$8.80	1.76	55.8
98.75	$4.08	$9.07	1.74	56.8
90.99	$3.06	$8.14	1.71	53.2
98.59	$6.17	$9.52	1.76	55.9
93.82	$2.31	$8.85	1.74	53.8
92.54	$5.39	$9.09	1.58	58.6
95.84	$3.56	$10.25	1.55	61.8
104.69	$6.91	$11.07	1.73	60.6
102.79	$6.69	$10.76	1.68	61.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

$2.43 / cwt. ECM

1.73 v 1.80 FCE

Data courtesy Stacy Nichols, personal communication



Forage (Feed) Quality
Particle Size
Fragility
NDF
NDFD
uNDF
Starch
StarchD
Dairy Cow Response
• Dry Matter Intake / Eating Behavior
• Milk Fat, Protein & Lactose

Silage Quality - More than NDFD

Nutrient %
(Fiber, Starch)

Nutrient
Digestibility

Total Digestible Nutrients

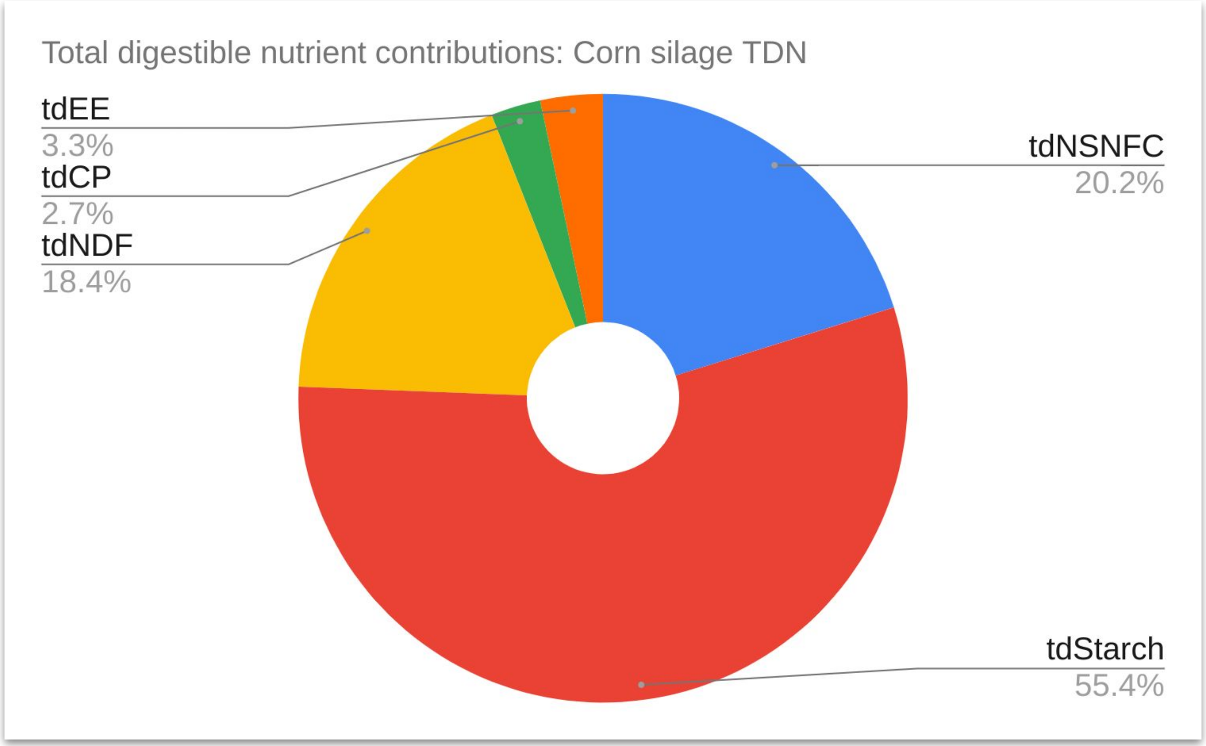
Energy & Protein Predictions, $$$

Weiss, 1998

Silage Total Digestible Nutrients

70+% Caloric value =

- Fiber
  - Fiber digestibility
- Starch
  - Starch digestibility



Hoard's Dairyman - Jan. 10, 2020 issue.

Received: 11/9/2022 **Sampled:** 11/9/2022

Rep: Jordan Matthews Paul Roden

Moisture: 63.81

ROSY-LANE HOLSTEINS LLC / corn silage 4 20[illegible] [illegible] (Feed Avg = 36.90)

ROCK RIVER LABORATORY, INC. AGRICULTURAL ANALYSIS

Protein & Amino Acid	%DM	N=3	4 yr
Crude Protein	6.99	7.13	7[illegible]1
Total Amino Acid	6.55	6.60	6[illegible]7
Sol. CP, % of CP	78.77	71.71	53[illegible]1
NH3-N CP Equivalent	1.24	0.98	0[illegible]9
NH3-N, % of CP	17.68	13.85	5[illegible]3
ADICP	0.30	0.31	0[illegible]4
NDICP	0.70	0.74	1[illegible]3
ADICP, % of CP	4.25	4.31	8[illegible]0
Available CP	6.69	6.82	6[illegible]7
Nitrate-N, ppm			
Non-Protein Nitrogen			

Calculated Amino Acids			
Lysine, % of CP	2.99	2.96	3.04
Methionine, % of CP	1.88	1.86	1.92
Histidine, % of CP	2.20	2.18	2.24

Minerals & Ash			
Ash	4.81	4.62	4.28
Calcium	0.20	0.18	0.16
Phosphorus	0.21	0.21	0.22
Magnesium	0.14	0.13	0.13
Potassium	1.20	1.03	0.94
Sodium			
Sulfur	0.09	0.08	0.08
Chloride			
Aluminum			
Boron			
Copper			
Iron			
Manganese			
Molybdenum			
Zinc			

Carbohydrates	%DM	N=3	4 yr
ADF	23.84	23.93	22.31
aNDF	41.31	40.58	38.59
aNDFom	39.98	39.00	37.15
Lignin	4.37	4.18	4.06
Starch	32.10	32.67	34.72
Sugar (ESC)	0.25	0.67	1.66
Sugar (WSC)	4.05	4.53	4.32
Glucose			
Fructose			
Sucrose			
Lactose			
Mannitol			
Total Sugar			
Crude Fiber			

Fermentation Products			
pH	3.85	3.73	3.96
Lactic Acid	6.20	6.29	3.61
Acetic Acid	4.14	2.79	1.53
Butyric Acid	0.03	0.01	0.00
Propionic Acid			
Succinic			
Formic			
Total Acids			
Ethanol			
1,2 Propanediol			
1 Propanol			
2,3 Butanediol			
2 Butanol			
2 Propanol			
Fermentation DM Loss	2.07	1.70	2.14
Ethyl Lactate			
Ethyl Acetate			

Fat	%DM	N=3	4 yr
Ether Extract	2.47	2.41	2.58
Total Fatty Acid	2.02	1.87	1.78
Acid Hydrolysis			
% of FA			
Myristic (C14:0)	0.34	0.36	0.41
Palmitic (C16:0)	15.76	17.62	15.11
Stearic (C18:0)	1.56	1.80	1.90
Oleic (C18:1 c9)	22.61	21.75	20.90
Linoleic (C18:2 c9,12)	50.90	48.45	47.60
Linolenic (C18:3 c9,12,15)	7.79	6.85	6.42
RUFAL	81.30	77.05	74.92

Nutrient Digestion, % of nutrient			
tNDFD12	23.83	23.00	20.68
tNDFD30	60.72	60.47	58.20
tNDFD48	65.16	64.71	67.22
tNDFD72			
tNDFD120	69.06	70.23	70.71
tNDFD240	71.77	72.66	74.03
tNDFD30om	63.87	63.33	61.25
tNDFD120om	71.80	72.68	73.20
tNDFD240om	74.38	75.01	76.38
sNDFD24	26.42	27.78	23.16
sNDFD30	34.08	35.18	28.96
sNDFD48	46.99	48.41	47.51
uNDF30, % DM	16.23	16.05	16.05
uNDF240, % DM	11.66	11.11	9.98
isSD0	46.32	53.29	25.15
isSD3	77.53	75.61	68.16
isSD7	94.36	96.76	80.06
isSD16	98.02	98.67	91.49
isSD24	98.19		
in situ RUP 16h			
RUP intest. dig., % RUP			

Powered by Rock River Laboratory **Bold results by wet chemistry**

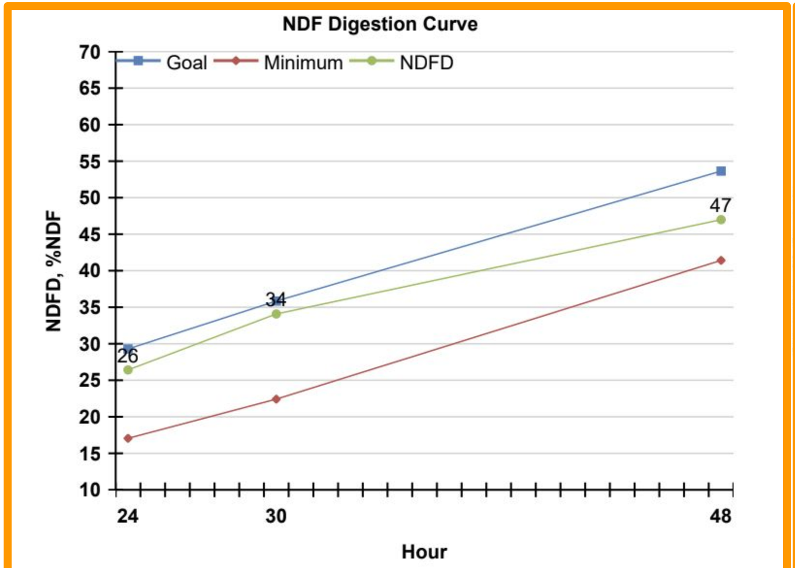
ROCK RIVER LABORATORY, INC. AGRICULTURAL ANALYSIS

Comprehensive Nutrition Analysis Report

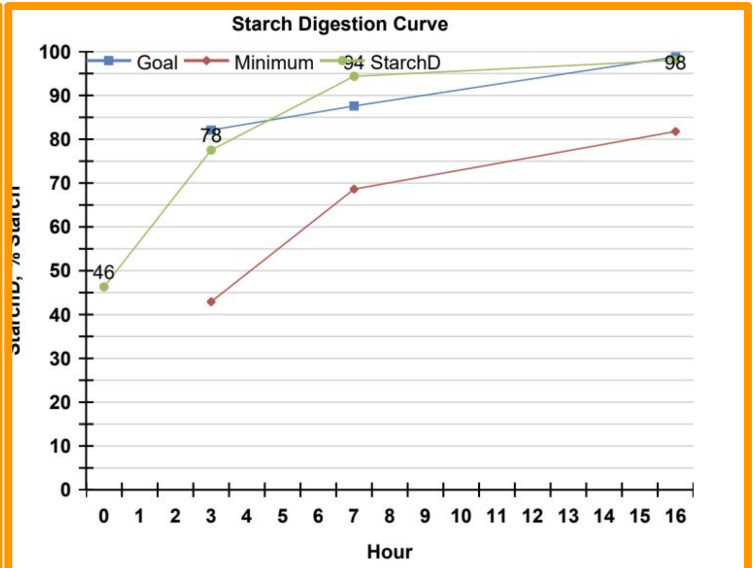
Calculations	%DM	N=3	4 yr
Dynamic NDF kd, %/h	4.28	4.37	4.20
Dynamic Starch Kd, %/h	39.58	39.77	22.42
RFV			
RFC			
TTNDFD, % of NDF	40.71	41.82	41.30
Total Tract Starch Dig			
NFC	45.13	46.00	48.00
DCAD			
Salt			
RDP %CP			

Energy Calculations	N=3	NEL	NEG	NEM
ADF (PA)				
OARDC Dairy				
NRC2001 Dairy				
Milk2006 Dairy	71.85	0.701	0.541	0.826
NRC2016 Beef				
Milk/Ton, lb	3313			
Beef lb/Ton				

Anti-Nutrients
Mold (Guidelines)
Yeast (Guidelines)
DON, ppm
Aflatoxin, ppb
Zearalenone, ppb
Fumonisin, ppm
T-2, ppb
Ochratoxin-A, ppb
Clostridium perfringens
Enterobacteria

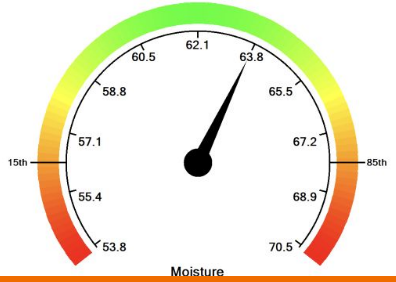


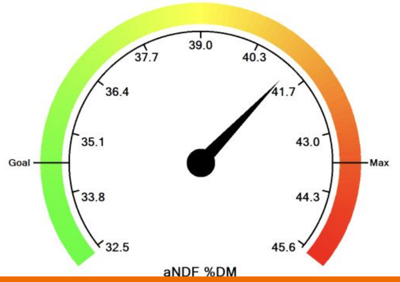
This Feed Avg lab numbers: 1419677,1419248

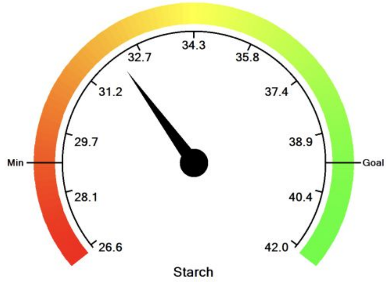


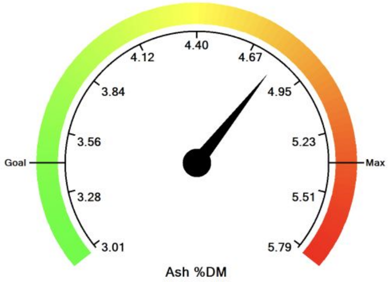
Visual Feed Analysis Report

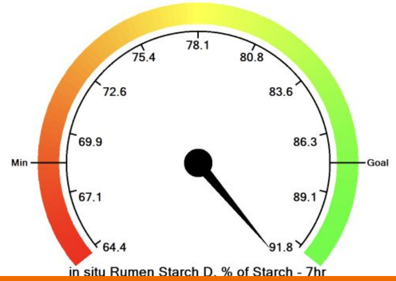
Lab Number 1421226 11/9/2022
Sample ID corn silage 4
Farm ROSY-LANE HOLSTEINS LLC
Consultant Jordan Matthews; Paul Roden

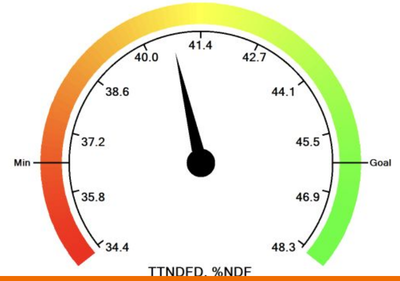




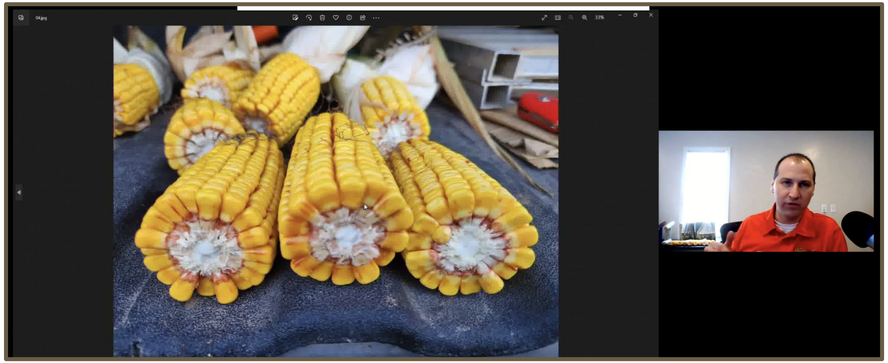








Todd Schaumburg, Tilth Agronomy



Dr. Rick Grant, Miner Institute


HOARD'S DAIRYMAN

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The doctor's script for sluggish corn silage

BY JOHN GOESER, ROCK RIVER LAB

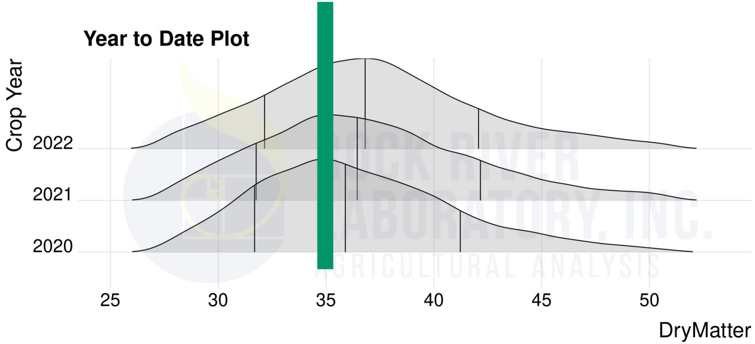
General Thoughts

- 2022 was a wild ride
  - Extreme drought out West
  - Extremely expensive inputs
    - Water
    - Fertilizer
- Highly variable growing conditions for US as a whole
- 2023 - Hang on for the ride
  - ***Zero in*, know what you've got, & feed around it**

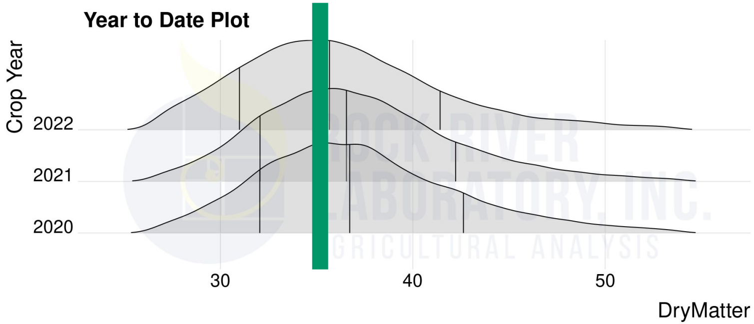
‘22 Silage Dry Matter / Moisture

- Very different crop by region
- E -> drier
- MW -> wetter
- W -> wetter

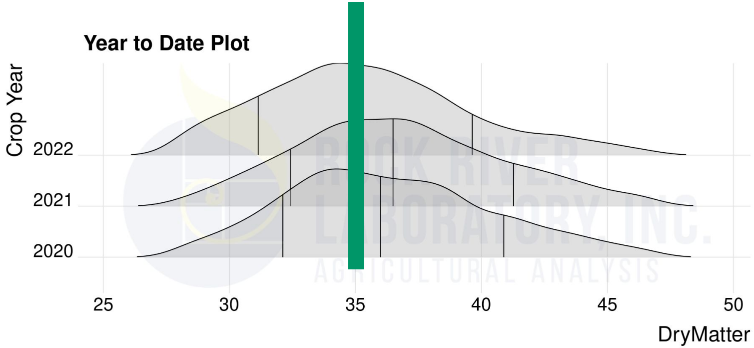
…Maturity impact?



Eastern US



Midwestern US



Western US

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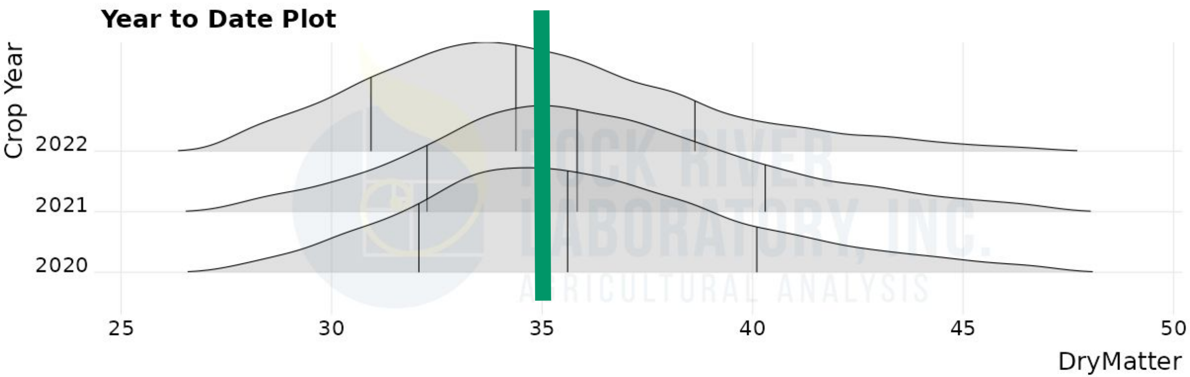
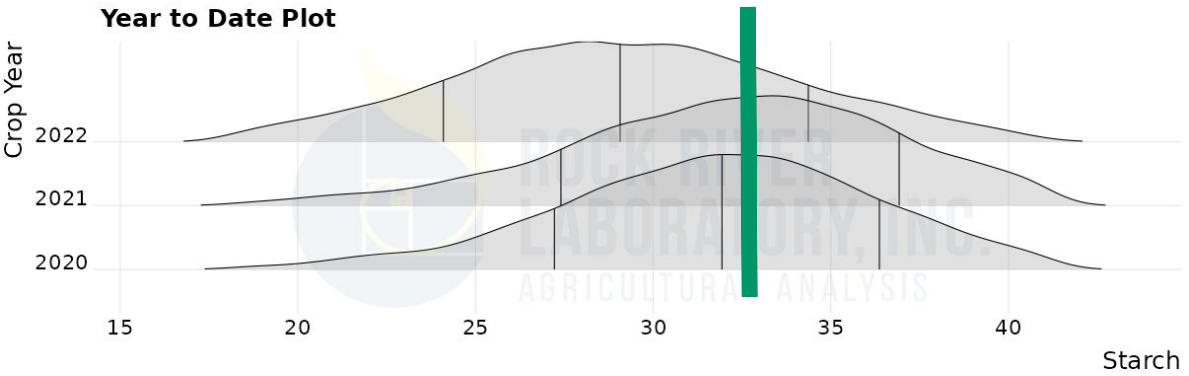
AGRICULTURAL ANALYSIS

Western Corn Silage

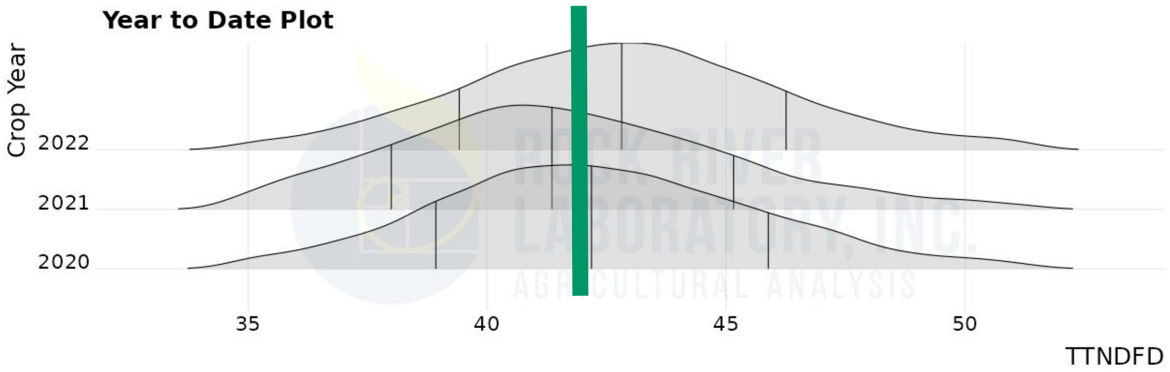
- Ideal moisture in 2022
- Starch levels are way down
  - Expensive input impact?
  - Water $ impact?

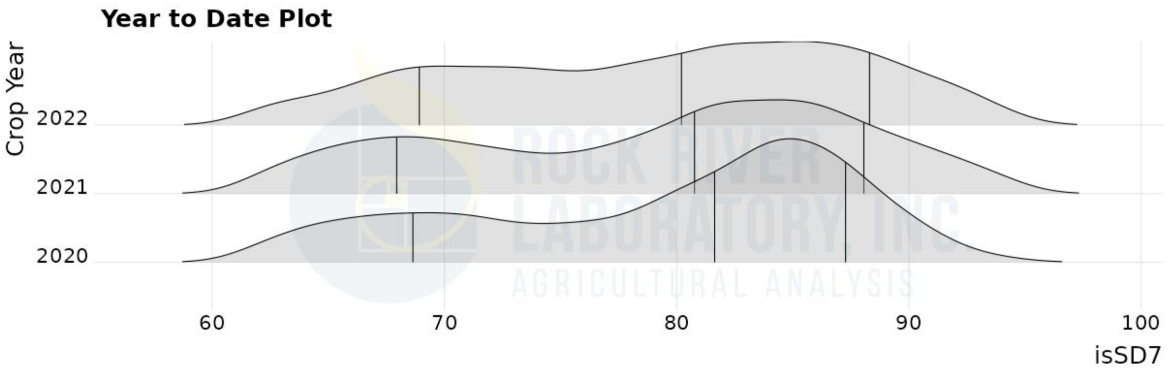




Western Corn Silage

- TTNDFD looking good on average
  - Faster digesting fiber
- Wide ranging StarchD
  - *Western silage winning here*



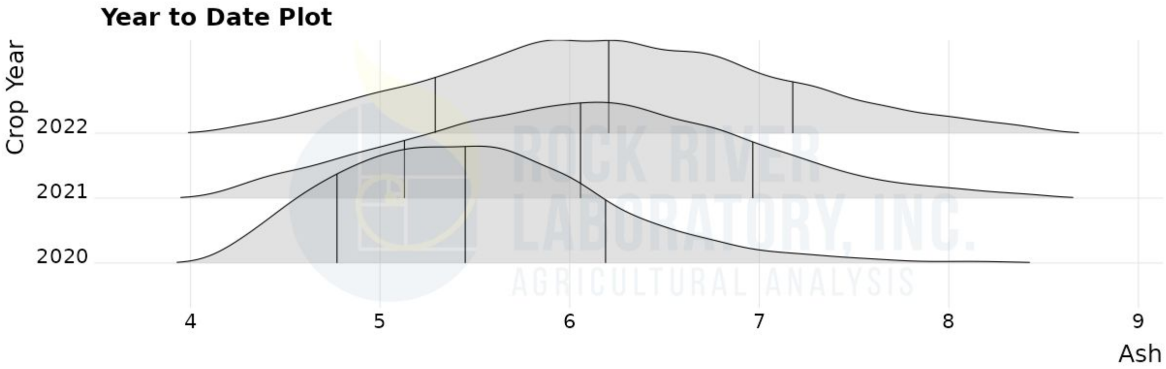


Western Corn Silage

- Ash is an issue
- Extreme drought & blowing dust / dirt

Watch-Out: fermentation quality

Bound to change in '23



Overly Simple 2022 Silage Recap

Region/Parameter	Moisture	Maturity	Starch	NDFD	StarchD	Feeding Potential?
East	Down	Up	Up	Down	Down	Down
Midwest	Up	Not sure	Up	Up	Down	Neutral to Up
West	Up	Down	Down	Up	NC	Neutral to Down

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AGRICULTURAL ANALYSIS

Unique Observations / Questions

- Extremely wide range to quality across the US this year
    - **Western US higher moisture, less starch, ash creeping up and average NDFD**
    - ***2023 bound to flip 180 degrees...***
    - Eastern US lower moisture and more mature corn silage
    - Midwestern US ideal moisture, more starch but less starchD, and decent TTNDFD … Black Sheep?!
    - Southern US silage looks to be good quality
- Watch outs for feeding 2023
    - ***Know what you've got… incredible variation in our pits & piles***
    - West? Fermentation quality
    - East & Midwest? Rumen starch digestibility!

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AGRICULTURAL ANALYSIS

Zeroing in on your Silage - Like sighting in a rifle

Dr. John Goeser

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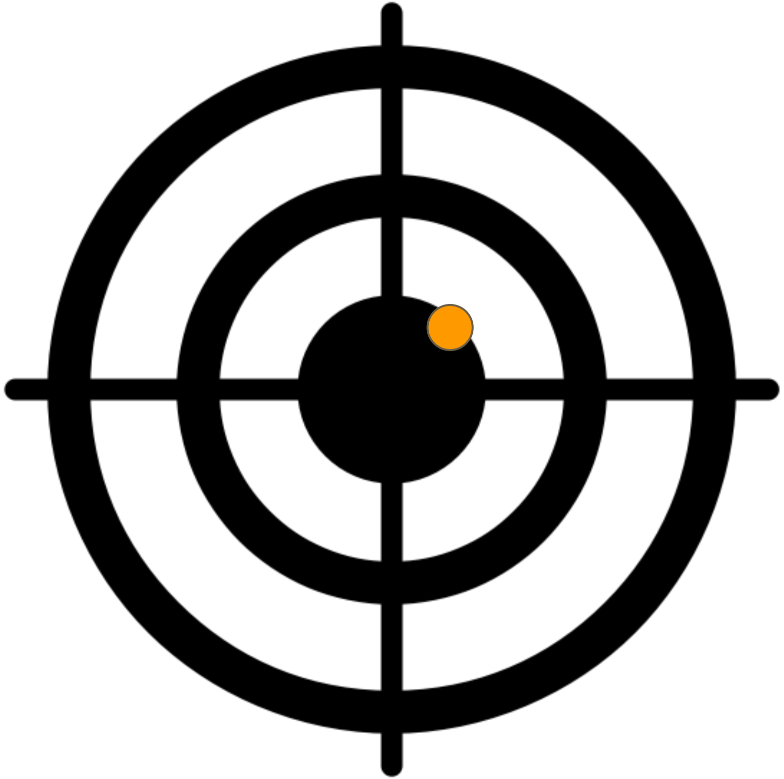
AGRICULTURAL ANALYSIS

Sample with a 3 to 5 shot group

VORTEX



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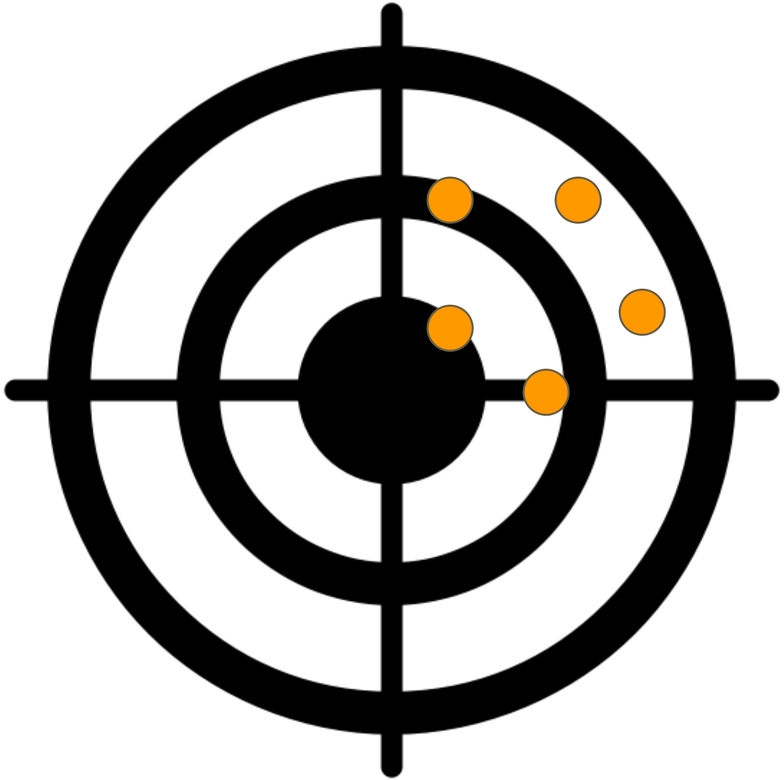
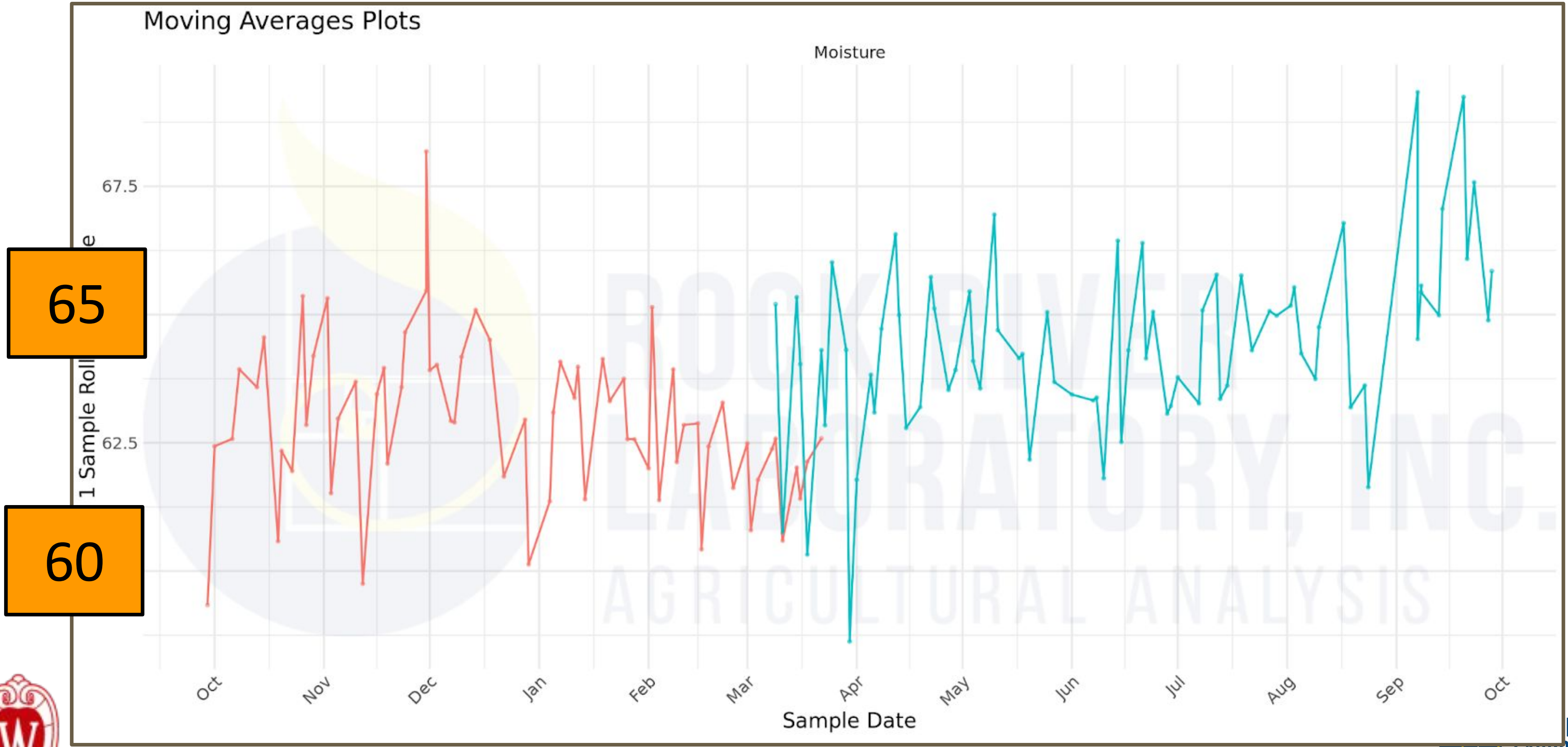
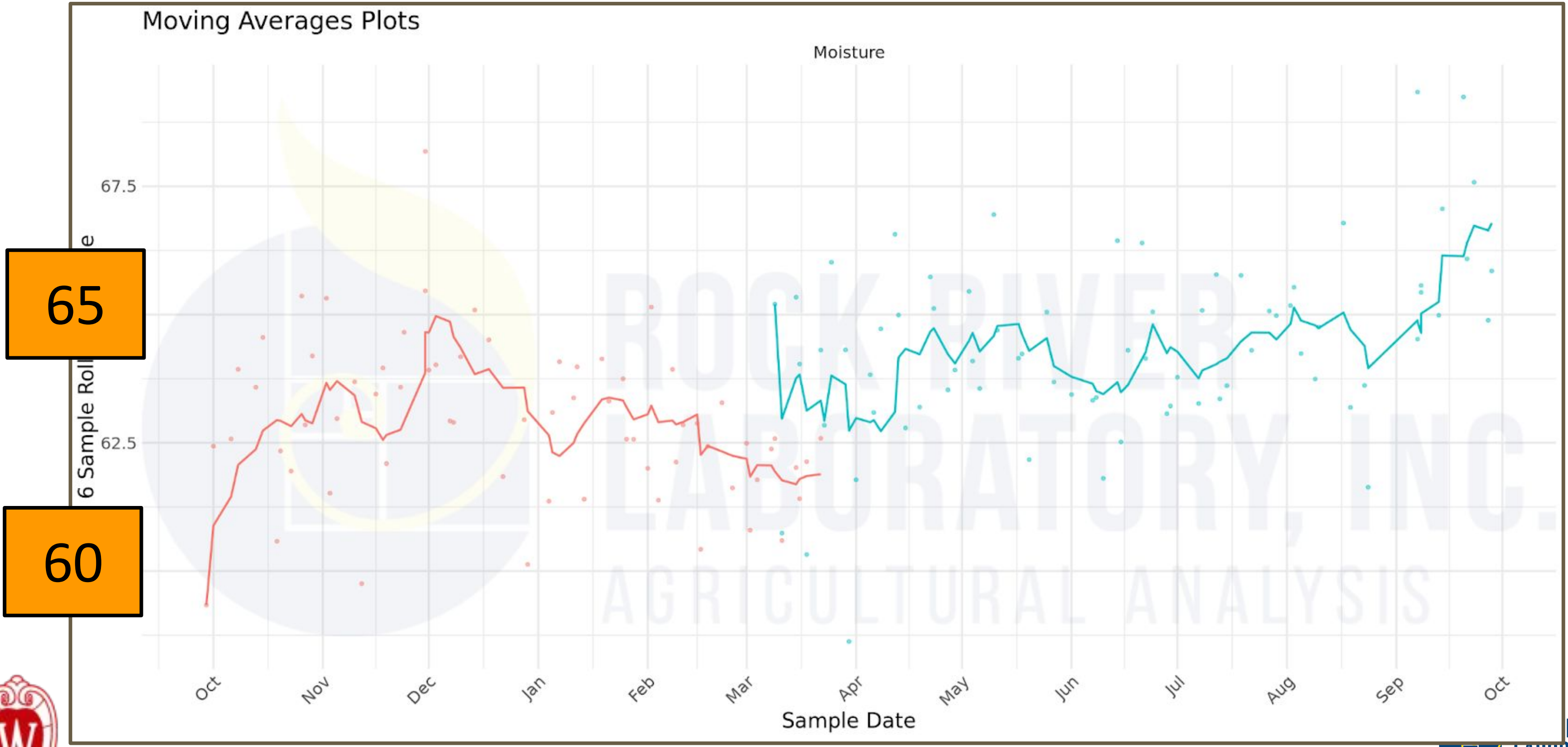
Sample with a 3 to 5 shot group



Single samples miss the buck

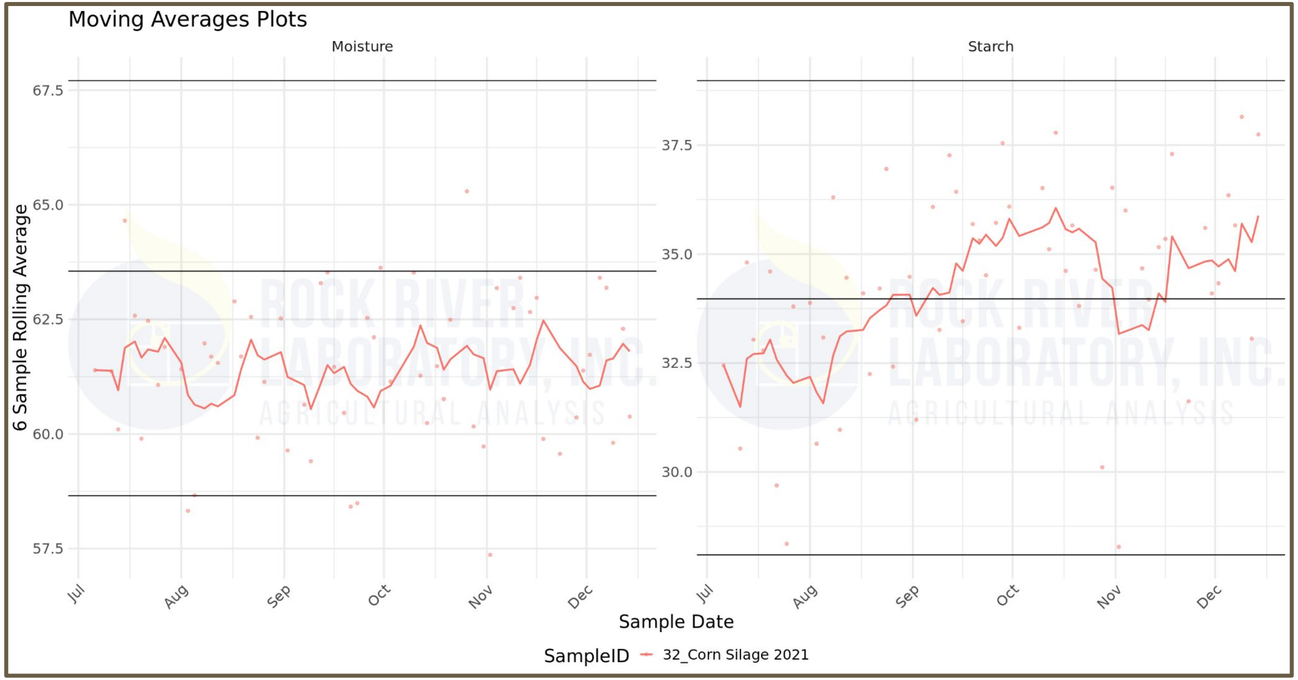


Six shot average for the win



Making Silage Adjustments

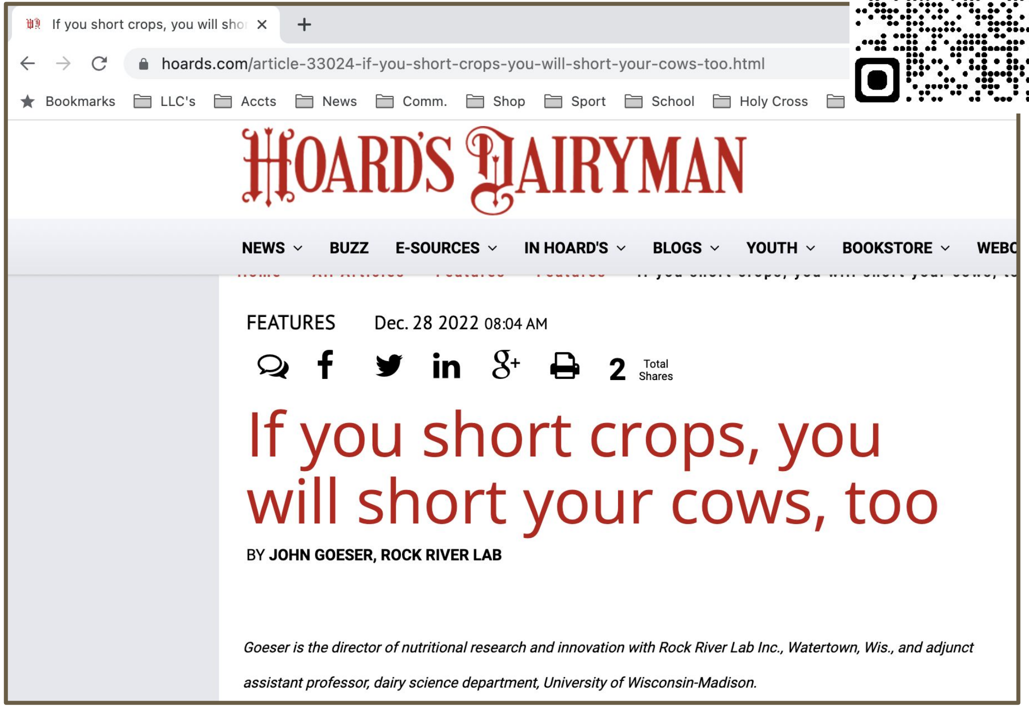
- Use 3 to 5 shot groups
- There's more changing in your silage than we've known
  - Follow the trendline. Don't assume moisture trends with starch…



Turning the page to 2023 - Economic Driven Decisions… with Water

Crop Input Decisions

- Fertility
  - N, P, K
  - Sulfur
- Crop protection & health
  - Fungicide
- ***Biologicals…***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HOARD'S DAIRYMAN

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FEATURES Dec. 28 2022 08:04 AM

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If you short crops, you will short your cows, too

BY JOHN GOESER, ROCK RIVER LAB

Goeser is the director of nutritional research and innovation with Rock River Lab Inc., Watertown, Wis., and adjunct assistant professor, dairy science department, University of Wisconsin-Madison.

2023 CA Growing Conditions

- Ample water for first time in a decade
  - Flooding
- Changing yield & quality expectations
  - *Management?*

Corn Agronomy

It's by an agronomist and is about corn.

Tuesday, July 19, 2022

Halfway there! Yield and quality changes of corn silage during challenging first-half environments.

Managing the Environment

- Irrigation / Moisture - **Shut off water = little or negative effect**
  - Masoero et al. (2013) - no effect
  - Gallo et al. (2014) - negative effect w/50 vs 200 mm water
- Fertility
  - **N - No NDFD effect, but harder grain**
    - Lynch et al. (2013) - no effect
    - Sabata & Mason (1992) - More N = harder kernels, less breakage
    - Sheaffer et al. (2006) - No N impact on NDFD for BMR, LFY or conv. hybrids
  - P - no P effect or manure vs inorganic source
    - Ali et al. (2019)
  - K - **Added K = less lodging & increased rind thickness, crushing strength in stover**
    - Less NDFD?
    - Arnold et al. (1974)

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AGRICULTURAL ANALYSIS

Planning Harvest 2023

- *Note tasseling date*
  - *45 to 60d window*
- *Monitor*
  - *Moisture*
  - *Kernel maturity*
  - *Plant health*
- *Processing & Cut height…*

Cut Height Impact

Table 2. Effects of cutting height on nutritive value of whole-plant corn silage. [1,2]

Parameter	n	Effect
Dry matter, % of as fed	62	+2.18
NDF, % of DM	64	-2.48
Lignin, % of DM	25	-0.29
NDFD, % of NDF	49	+2.02
Starch, % of DM	55	+2.08
DM yield, ton/acre	52	-0.52

[1] Adapted from Paula et al. (2019).
[2] Data expressed as expected response per each 10-inches of increased cutting height.
[3] NDFD – ruminal in vitro or in situ NDF digestibility at 30 or 48 h.

Table courtesy of Luiz Ferraretto (2020, personal communication)

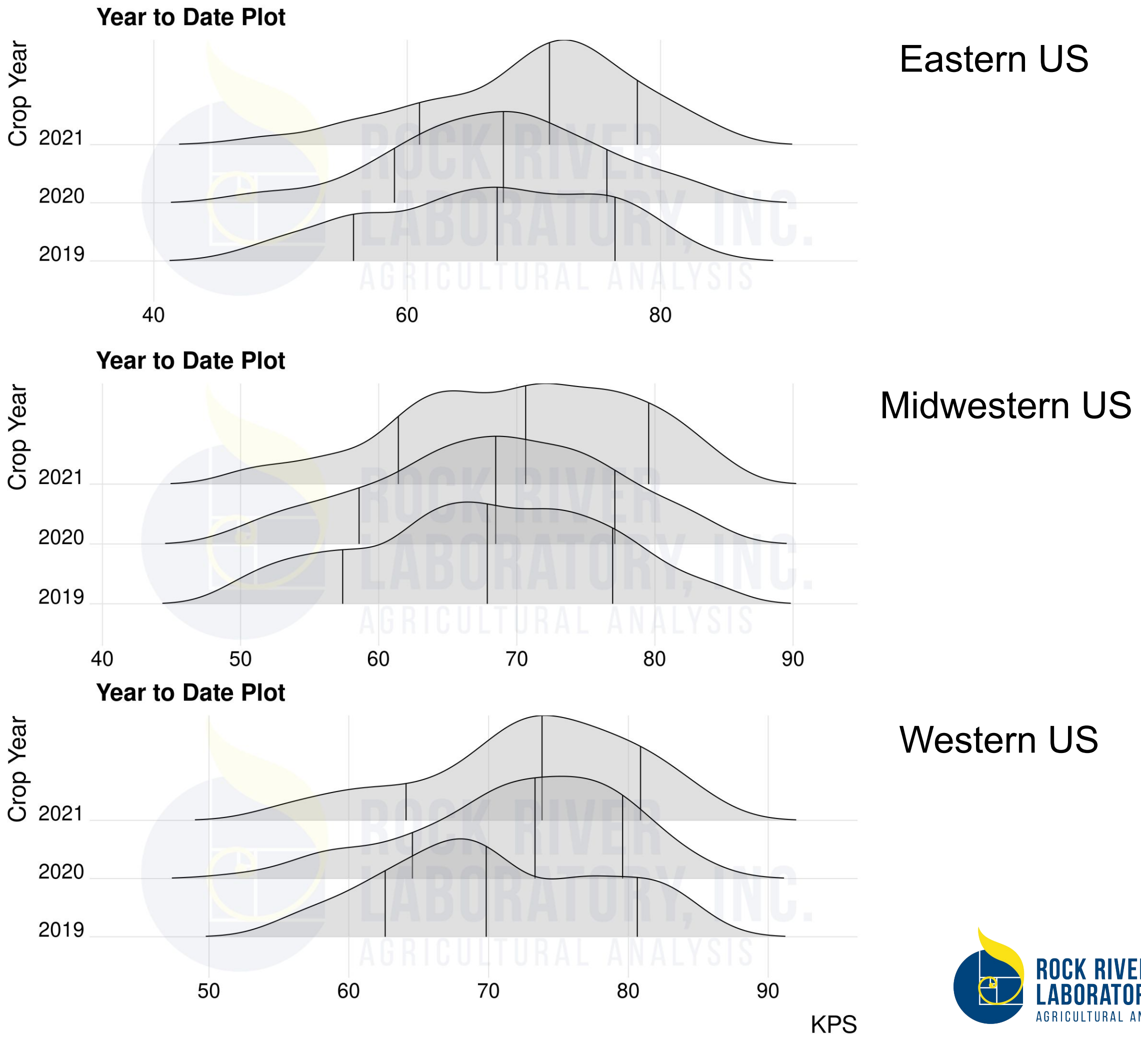
Cut Height Performance Impact

High cut vs Normal CS			Diet outcome		
	Normal	High (+10")		Normal	High (+10")
CP	7.5	7.5	CP	15.4	15.4
aNDF	40.0	37.5	aNDF	28.2	27.4
Starch	33.0	35.1	Starch	26.3	27.0
Fat	2.5	2.5	Lbs dig fiber	7.34	7.26
Ash	4.0	4.0	Lbs rumen dig starch	10.5	10.8
uNDF240	10.0	9.0	Lbs uNDF240	4.09	3.90
NDF kd	3.0	3.2			
0h Starch	25.0	25.0			
Starch kd	25.0	25.0	TTSD	95.60%	95.60%
Rum. StarchD	77.7	77.7	Rum. StarchD	72.3	72.3
TTNDFD	41.5	43.6	TTNDFD	47.3	48.2
NDFD240	75.0	76.0			
Lbs Fed	19.0	19.0	DMI	55	55
			Forage/Conc	52.7%	52.7%
			Milk/Cow	88.0	89.2
			FCE	1.60	1.62
Milk Price	$20.00	$20.00	Milk $/cow	$17.61	$17.85
Cost/lb TMR	$0.11	$0.11	Feed $/cow	$6.05	$6.05
			Feed cost / CWT	$6.87	$6.78

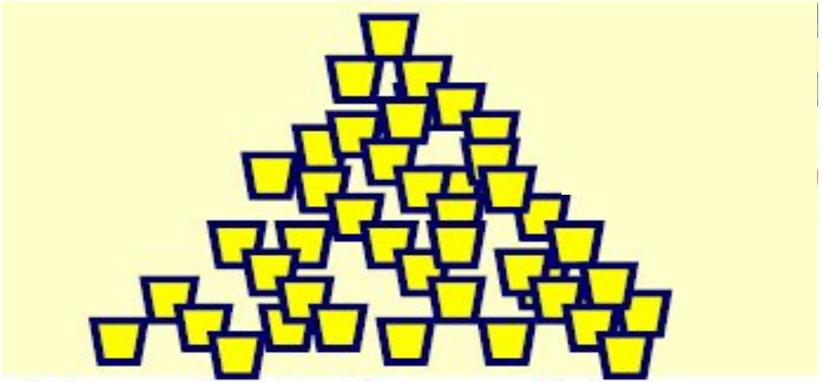
Projections using table provided by Luiz Ferraretto (2020, personal communication)

Corn Silage Kernel Processing Score

- Western US is winning
- *New goal in KPS is 75 to 80*



WPCS Starch Summary



80 to 98% StarchD

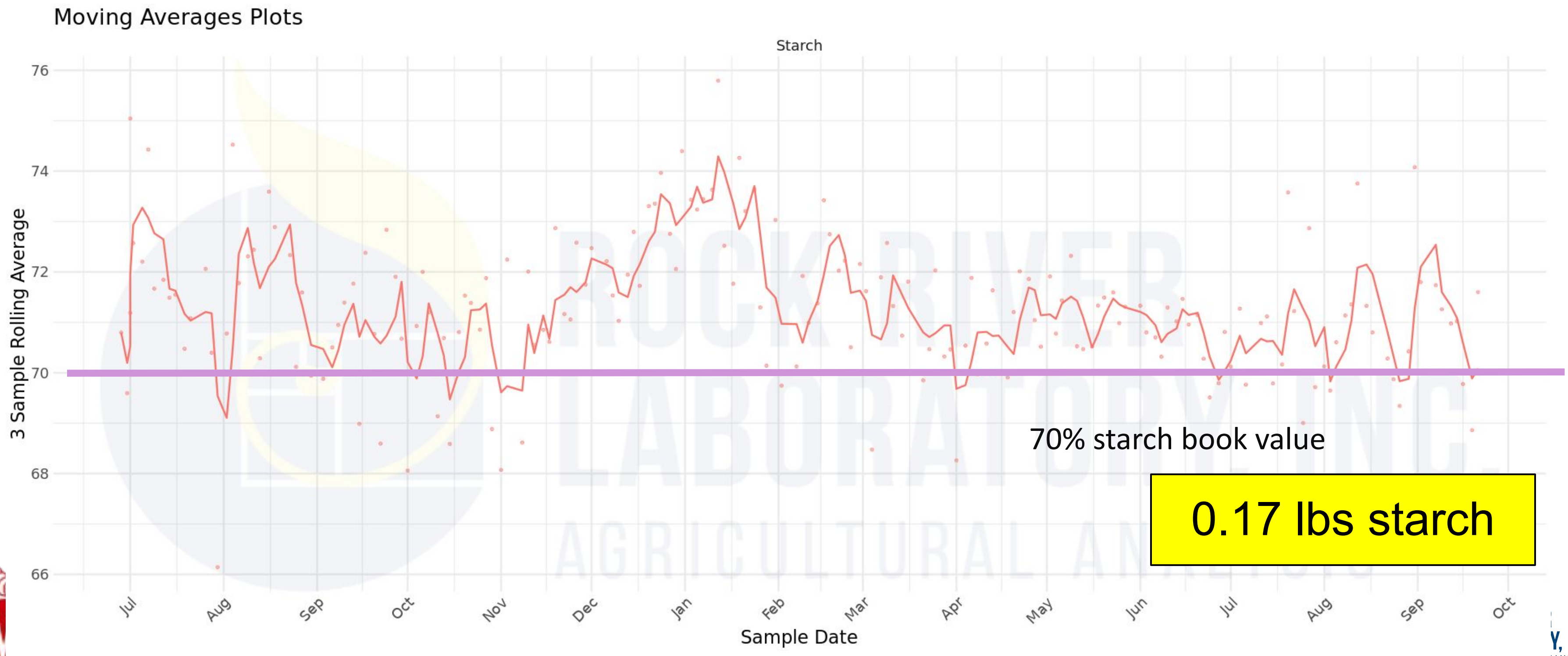
- Kernel particle size
- Duration of silage fermentation
- Kernel maturity
- Endosperm properties
- Additives

- Broken kernels are essential
- Allow silage to ferment for an extended period
- Harvest at the correct maturity
- Use hybrids with less vitreous endosperm, if available
- Additives???

Slide courtesy Prof. Luiz Ferraretto

Corn Grain Starch Over Time

Time Frame	Starch
2 Week	70.5
30 Day	70.9
90 Day	70.9



Slide courtesy Katie Raver

Hybrid Plots

- <u>Control for:</u>
  - Growing conditions
  - Plant population
  - Soil type & fertility
  - Crop protection
- **Basic**:
  - Run strips
  - Measure yield & 3+ samples per hybrid for quality
  - Compare hybrids
- **Advanced**:
  - Plant replicated plots
  - Measure Yield
  - Several samples per replicate plot
  - Data robust for stats analysis

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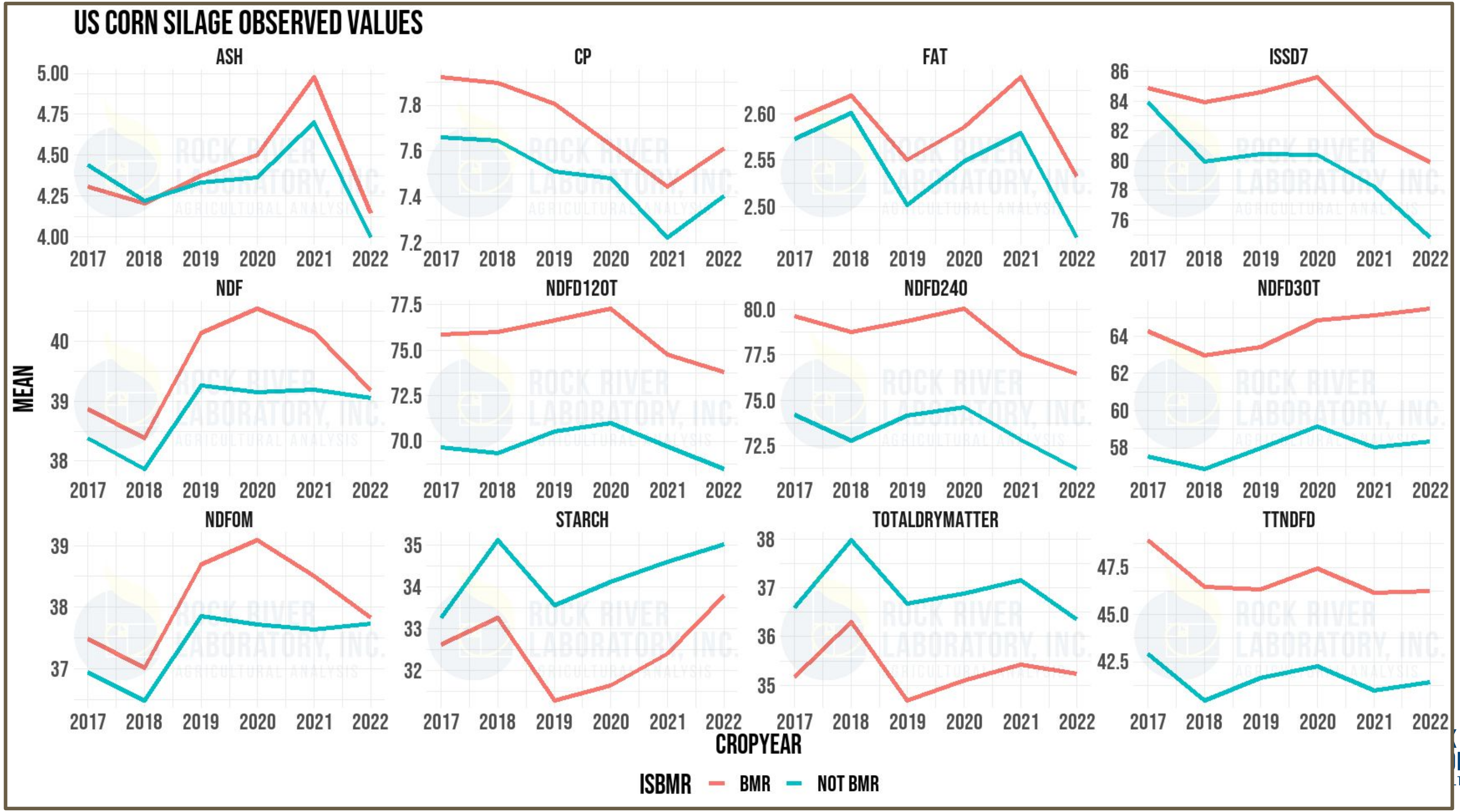
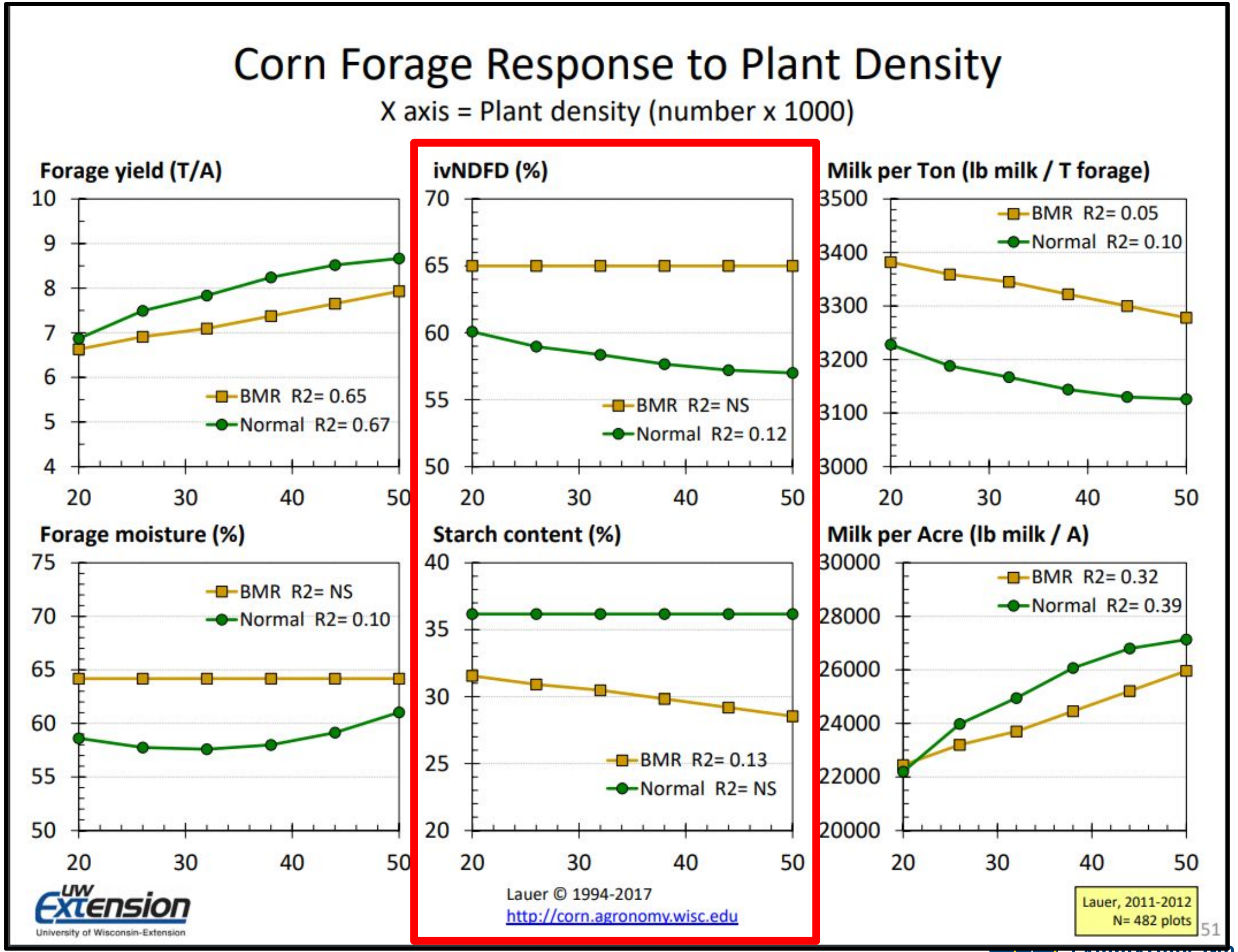
BMR v Conventional: RRL Database



Plant Population Impact

- Plant populations matter
- Conventional corn responds differently than BMR



Slide adapted from J. Lauer

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Opportunities for Implementation of Selective Dry Cow Therapy on US Dairy Farms

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Selective dry cow therapy (SDCT) refers to the treatment with long-acting antimicrobials of only cows or quarters identified with or at risk of having an intramammary infection at dry-off, or at risk of acquiring one during the dry period. Conversely, blanket dry cow therapy (BDCT) consists in the treatment of every quarter of every cow at dry off. BDCT has been widely adopted in the last decades and led to an important success in the reduction of contagious mastitis. However, recent studies report a low prevalence of intramammary infections at dry-off in many herds. This, in addition to the recent introduction of rapid on-farm diagnostic tests, and the availability of teat sealants, may allow us to develop successful SDCT strategies.

Bulk tank SCC, as well as intramammary infection prevalence and etiology at dry off have been used to select herds benefiting from SDCT. Thereafter, the accurate identification of cows or quarters benefiting from antimicrobial treatment is the cornerstone for the implementation of SDCT. Strategies followed vary from use of cow records (SCC records, clinical mastitis history, etc), culture results, cow-side diagnostic test results (California Mastitis Test, milk leukocyte differential count, etc), or a combination of them.

The current epidemiology of mastitis in addition to the availability of new technologies make SDCT a logical step to reduce antibiotic use in dairy cows. The most recent clinical trials show that either culture or data based SDCT programs can be implemented successfully. Antibiotic use was reduced by more than half without any negative effects on health and productivity. Therefore, it represents an additional opportunity to improve antibiotic stewardship on farms.

Data from a large multi-herd multi-state randomized controlled clinical supported by USDA NIFA funding granted to the University of Minnesota, Cornell University, Iowa State University and California based research firm DairyExperts will be presented at the meeting. For further reading see below a list from peer-reviewed publications reporting the study:

1. Rowe S.M., Nydam D.V., Godden S.M., Gorden P.J., Lago A., Vasquez A.K., Royster E., Timmerman J., Thomas M.J., Lynch R.A. (2021). Partial budget analysis of culture and algorithm-guided selective dry cow therapy. J. Dairy Sci.104(5):5652-5664.

2. Rowe S.M., Godden S.M., Nydam D.V., Gorden P.J., Lago A., Vasquez A.K., Royster E., Timmerman J., Thomas M.J. (2020). Randomized controlled trial investigating the effect of 2 selective dry-cow therapy protocols on udder health and performance in the subsequent lactation. J. Dairy Sci. 103(7):6493-6503.

3. Rowe S.M., Godden S.M., Nydam D.V., Gorden P.J., Lago A., Vasquez A.K., Royster E., Timmerman J., Thomas M.J. (2020). Randomized controlled non-inferiority trial investigating the effect of 2 selective dry cow therapy protocols on antibiotic use at dry-off and dry period intramammary infection dynamics. J. Dairy Sci. 103(7):6473-6492.

4. Rowe S.M., Godden S.M., Nydam D.V., Gorden P.J., Lago A., Vasquez A.K., Royster E., Timmerman J., Thomas M.J. (2020). Evaluation of rapid culture, a predictive algorithm, esterase somatic cell count and lactate dehydrogenase to detect intramammary infection in quarters of dairy cows at dry-off. Prev. Vet. Med. 179:104982.

Reducing Antibiotic Use in Dairy Herds: The Potential Impact of Selective Dry Cow Therapy during the Dry Period – Evidence from the Western US

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Summary

Mastitis is a common and expensive disease in dairy cows worldwide. One way to prevent mastitis is to give cows antibiotics when they stop producing milk. This is called dry cow therapy. Another approach is called selective dry cow therapy, where only cows at high risk for infection receive antibiotics. In this study, data from dairy herds in the western United States was used to estimate how much antibiotic use could be reduced if selective dry cow therapy was used instead of blanket dry cow therapy. The study also looked at factors that make a cow more likely to need antibiotics and found that older cows and cows with longer days of milk production before dry-off were at higher risk. However, cows with higher milk yield and protein percentage before dry-off were less likely to need antibiotics. The study also found that the prevalence of infection varied by season and by state. Overall, the results suggest that using selective dry cow therapy could reduce antibiotic use by 31% to 66% in the US dairy industry. This could help prevent the development of antibiotic-resistant bacteria and save dairy operators money.

Introduction

Mastitis is a disease that affects dairy herds worldwide, and it is classified as clinical, which is detectable by clinical signs, or subclinical, which is difficult to detect. Subclinical mastitis can be detected by monitoring somatic cell counts (SCC) in the milk, or somatic cell score (SCS). The administration of long-acting, intramammary antimicrobials to all cows at dry-off has been used as a management strategy to control mastitis in dairy herds. This practice is known as blanket dry cow therapy (BDCT). However, there is an increasing pressure to limit the use of antimicrobials in dairy systems. An alternative to BDCT is selective dry cow therapy (SDCT), in which only cows at high risk for an intramammary infection (IMI) at dry-off receive antimicrobial therapy and is considered a judicious approach to the use of antimicrobials. One concern regarding the use of SDCT is an increase in the incidence of both clinical and subclinical mastitis at the beginning of the subsequent lactation. Nevertheless, studies have shown that when SDCT is combined with the use of internal teat sealants in all cows, the incidence of clinical and subclinical mastitis in the subsequent lactation is comparable with BDCT. Moreover, SDCT can reduce the use of antimicrobials around the dry period in dairy systems by 29–80 %.

Methods

A cross-sectional study was conducted to determine the prevalence of intramammary infections (IMI) in cows during the dry period. The authors obtained lactation data records from the Dairy Herd Improvement Association and excluded herds with less than 100 lactation records, test-day records before 10 days in milk, and other variables, to create a final dataset that included 1210,540 lactations from 620 dairy herds in the western US and Texas. The authors used different thresholds to classify cows as high or low risk for IMI at dry-off based on lactation number and test-day somatic cell score (SCS) or somatic cell count (SCC) used by different publications in the literature. Cows with subclinical mastitis at dry-off were classified as having an IMI at dry-off. The last test-day SCS was used to classify cows as having an IMI or not and used different thresholds to classify cows as high or low risk for IMI at dry-off based on lactation number and test-day SCS or SCC used by different publications in the literature. In scenario 1, cows were classified as high risk for IMI at dry-off according to their last test-day SCS, using the thresholds proposed by Scherpenzeel et al. (2016). In scenario 2, when the last test-day SCS was ≥ 4 (SCC ≥ 200,000 cells/mL; Schukken et al., 2003), the cow was considered as having an IMI, regardless of parity. The final dataset contained variables such as state, herd, cow identification number, calving date, parity, test-day dates and milk, protein, and fat yields, and test-day SCS. All herds in the dataset were assumed to use dry cow therapy and an internal teat sealant at dry-off.

Results and Discussion

The current showed that adopting selective dry cow therapy (SDCT) could potentially reduce the use of antimicrobials around the dry period by 31-68%. However, herd, environmental, and cow-specific characteristics should be considered, as they can influence the dynamics of intramammary infections (IMI) around the dry period and the feasibility of an SDCT program. The study outcomes agree with previous research estimating that adopting SDCT would reduce the use of antimicrobials by 49-80% in various dairy farms (Kabera et al., 2021) and in the US by at least 29% (Hommels et al., 2021). The results also show that these opportunities exist regardless of the criteria used to classify cows as high-risk at dry-off.

Although the US has decreased the levels of SCC in milk over the years, previous research has shown an increased risk of mastitis in the subsequent lactation when SDCT was used, but these studies did not use an internal teat sealant at dry-off. However, more recent studies in the US have demonstrated that SDCT with the use of an internal teat sealant has no negative impact on the incidence of subclinical and clinical mastitis in the subsequent lactation. In Nordic countries, where SDCT is the default approach, no teat sealant is used at dry-off. The use of SDCT is an economically feasible alternative to blanket dry cow therapy (BDCT), even when internal teat sealants are not used, as demonstrated by previous studies.

To calculate the potential change in antimicrobial use if the SDCT approach is adopted by US herds, two RR (risk ratios) for the incidence of clinical mastitis in the subsequent lactation were assumed: 1.0 and 1.3, to account for variation in the reported RR in the literature. The results show that even when an increased risk of clinical mastitis in the subsequent lactation is assumed, antibiotic usage would still be reduced relative to BDCT. However, more studies are needed to evaluate the long-term impact of an SDCT approach in the US, as well as its impact on cow welfare and longevity.

Parity, season of dry-off, milk yield, days in milk, fat and protein percentage at last test-day before dry-off, herd size, and state where herds were located were associated with the risk of a cow being classified as high-risk for intramammary infection at dry-off. However, small differences may not be practically important. When SDCT was used, a greater reduction in the use of antimicrobials was seen in primiparous cows, as multiparous cows have overall greater somatic cell counts at dry-off and a higher risk of mastitis throughout lactation. The observed interaction could be due to the large dataset used in this study, and focus should be given to the differences observed in the reported odds ratio.

The study concludes that selective dry cow therapy is a promising technique to reduce antibiotic use in dairy herds. However, herd, environmental, and cow-specific characteristics should be considered, as they can influence the dynamics of intramammary infections around the dry period and the feasibility of an SDCT program. The findings can help dairy farmers and veterinarians better manage and prevent intramammary infections in cows during the dry period.

Original article by: Ferreira, F.C., Martínez-López, B., Okello, E., 2022. Potential impacts to antibiotics use around the dry period if selective dry cow therapy is adopted by dairy herds: An example of the western US. Prev. Vet. Med. 206, 105709. https://doi.org/10.1016/j.prevetmed.2022.105709

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Improving Diet Accuracy: Challenges and Impacts of Managing Forage Variability

K.F. Reed and J.A. Barrientos Blanco

Introduction

Variability in forage composition is one factor that leads to differences between the formulated diet and the delivered diets of livestock. In dairy cattle diets, inaccuracy of delivered diets increases the risk of underfeeding and overfeeding cows which can impact milk production, feed efficiency, and cow welfare (Weiss and St-Pierre, 2009). Dairy industry practices for monitoring feed composition and diet adjustments vary. In the absence of data-driven protocols, the decisions for how often to sample feeds and reformulate diets either rely on nutritionist experience and intuition or are a reaction to changes in milk production or cow health. Other industries, however, take advantage of standardized methods for quality control known generally as statistical process control that balance the costs of monitoring the process or system with the expected cost or impact of a deviation in the target quality. Previous works have suggested application of these methods to dairy cattle feeds and diets to improve the accuracy of delivered diets by routinely sampling and analyzing ingredients with moderate and high variability (Weiss and St-Pierre, 2009). Specifically, St-Pierre and Cobanov (2007a) proposed the use of a renewal reward model (RRM) and genetic algorithm (GA) to optimize sampling and forage composition monitoring practices under commercial farm conditions. The RRM model requires at least 16 parameters, 7 of which were identified as being particularly influential on the quality control cost. Of the 7 most influential parameters, 4 of them are easily and precisely identified for any commercial farm setting and include the herd size, the milk price, the cost of feed sampling, and the time required to analyze a feed sample. The remaining 3 parameters are less easy to define and include the expected change in milk production that will result from a change in feed composition and 2 parameters that define the expected variability of the feedstuff being monitored. In our current work, we focus on the 2 parameters that describe the variation of the feedstuff which can be defined as the expected stable time ($1/\lambda$) in days and the magnitude of change (Δ) which is in units of the number of standard deviation (SD) of the nutrient being monitored. Our objectives are first to understand the extent of forage variability and specific factors that contribute to this variation on individual farms. Then we developed a method to estimate the expected stable time ($1/\lambda$) and magnitude of the change(Δ) between stable periods in a commercial farm setting. Finally, using the optimization method and RRM formulation proposed by St-Pierre and Cobanov (2007a), we implemented our proposed protocol for forage quality monitoring and diet reformulation to assess the practicality and impacts of using this technique on a commercial farm in NYS.

Extent and Source of Variation in Forages

To assess variability of forage composition on individual farms, we sampled corn silage and alfalfa-grass haylage from multiple cuts from 8 New York state (NYS) dairy farms at harvest in the summer of 2020 and at feed-out in the winter-spring of 2021. Forage of each field-of-origin were sampled and the location within a silo at harvest was recorded. Here, we define the field-of-origin as the individual field from which the forage originated. Corn silage and alfalfa-grass haylage were sampled at feed-out 3x week for 16 weeks. Silage maps from harvest were used to identify the field-of-origin of each silage section fed to cows at feed-out. In addition to the forage composition samples, we collected information related to the silage management practices, field soil composition, and weather during the growing season, at harvest, and at feed out.

Although, as expected, between farm variation was a significant factor for both forages at feed out, more (> 65%) of total variation in haylage composition was attributed to farm-specific factors including variation between fields, silos, and days. Considering the expected variation within a given farm, the day-to-day variation was over 50% of the variability in forage DM for both forages and accounted for a large proportion of the variation in the nutrients (30% and 21% of variation in haylage NDF and CP respectively; 31% and 34% of corn silage NDF and starch, respectively). The relatively large day-to-day variation emphasizes the need for more frequent forage sampling practices. In addition, the contribution of differences between farms and silo types to the extent of variation supports the need for monitoring practices that are specific to each farm.

Forage Stable Time and Magnitude of Change

To develop a method for estimating $1/\lambda$ and Δ we used the time-series data of the corn silage and haylage composition collected during feedout as described above. Our proposed method uses k-means clustering to determine meaningful differences in sample composition which are then mapped to the original time-series of sample collection and is illustrated in Figure 1. Heuristically, the number of sequential days that the observed time-series of samples remains in a single cluster is an observation of one stable time period. The stable time observations were collected for each silo and summarized by forage and farm to get an estimate ($\widehat{1/\lambda}$) of the true stable time($1/\lambda$). Similarly, we estimated the value of Δ for corn silage and haylage at feed-out through the change in composition between the stable periods that were defined by the k-means clusters. To estimate the $\hat{\Delta}$ in our sample set, we took the median of number of SD in each change between two consecutive stable groups within a silo. The results of applying this method to each farm are provided in Table 1 and indicate (with the exception of Farm A which was a small herd using silage bags) that the expected stable times for both corn silage and haylage are much lower than the value of 30 days that was proposed as a default by St-Pierre and Cobanov (2007a,b). Similarly, the expected magnitude of change estimated through our k-means clustering method is larger than the value of 1.5 that was previously proposed. These outcomes suggest that the silages studied here are less consistent and have a higher degree of variation than previously thought.

Application of Forage Monitoring Protocol

We hypothesized that adjusting diets according to changes in forage components signaled by the control-chart application increases diet consistency and accuracy and will result in increased feed efficiency and IOFC. Thus, the objective of our study is to measure the impact of implementing a diet reformulation protocol using our control chart application on diet accuracy, feed efficiency, and IOFC of NY dairy farms.

To test our hypothesis that a data-driven protocol for adjusting diets can increase diet consistency and accuracy, we implemented a protocol for diet reformulation based on the recommendations of the RRM (treatment protocol) and compared the outcomes with the farm’s standard practices (control protocol). We worked with a 2,000 cow dairy in upstate NY and monitored changes in starch and NDF of corn silage and CP and NDF of alfalfa-grass haylage using a quality control-chart decision process that is illustrated in Figure 2. Corn silage, alfalfa-grass haylage, and TMR were sampled 3x a week for 16 weeks and when our protocol signaled a change in the composition of corn silage or haylage, we requested a diet adjustment from the nutritionist using the average composition of the forages within the new stable time period. In addition to the samples of the forages and the mixed diet, we collected records of diet mixing and delivery in order to independently assess the impact of changes in forage composition and mixing errors on the diet composition.

During the 16-week trial period, 13 adjustments to the formulated diets were made in the treatment pens in comparison to 5 diet adjustments for the control pens. To assess the expected impact of the changes in forage composition on the diet, for each day the forages were sampled, we calculated the composition of the expected or target diet using the diet recipe and the results of the forage sample analysis on that day. The absolute value of the difference between this target using the daily variation in forage composition and the original formulated diet composition was calculated and averaged over the sample period. Similarly, the expected impact of mixing errors on the diet composition was calculated by using the records of the mass of each feed actually mixed in the diet each day to determine the mixed recipe and calculate a mixed diet composition for comparison with the target diet. Finally, to assess the overall impact of the protocol on diet accuracy, we compared the results of the observed diet composition using the results from the TMR sample analysis compared with the original formulated diet and the expected mixed diet.

Results from our analysis of the diet accuracy are presented in Table 2. When comparing the Formulated diet composition with the Expected diet compositions, the treatment protocol decreased the deviation of CP and NDF in the Expected diet from those of the Formulated diet but did not decrease the deviation of Starch. The deviations in diet composition that resulted from errors in the mixing process (Expected – Mixed) were relatively small compared to the deviations due to changes in the forage composition (Formulated – Expected). The deviation from the sampled TMR or the Observed diet from the formulated diets were smaller for CP, NDF, and Starch under the treatment protocol for forage monitoring and diet reformulation frequency.

Preliminary results suggest that the treatment protocol resulted in an increase in average milk production (104 lbs/hd/day vs. 102 lbs/hd/day; P=0.053) although there was no difference in feed intake, feed efficiency, or income over feed costs.

Conclusions

We proposed a method to adapt a renewal reward model for monitoring forage composition to the conditions and expected behavior of the forages on individual farms and implement the recommendations for forage monitoring with a quality control chart. Initial evaluation of the proposed methods suggests it can improve diet accuracy which may lead to increases in milk production. Future work is needed to evaluate the impact of the proposed approach under a wider variety of conditions and to develop new methods to estimate the expected change in milk production that results from changes in diet composition due to variation in feed ingredients.

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Weiss, W. P. and N. St-Pierre. 2009. Impact and Management of Variability in Feed and Diet Composition. Pages 83-96 in Proc. Tri-State Dairy Nutrition, Fort Wayne, Indiana. Michigan State University, East Lansing, Purdue University, West Lafayette, IN; The Ohio State University, Columbus.

Table 1: Estimated stable time ($\widehat{1/\lambda}$, d) and $\hat{\Delta}$ for corn silage and haylage using k-means clustering methods for 8 NYS dairy farms.

Feed	Farm	†$\widehat{1/\lambda}$ (d)	$\hat{\Delta}$
Corn Silage	A	32 (24, 35)	6.46
	C	4 (2, 5)	2.53
	D	5 (3, 5)	3.69
	E	5 (3, 7)	2.51
	F	3 (2, 4)	2.79
	G	4 (2, 9)	2.51
	H	2 (2, 4)	4.19
Haylage	A	9 (7, 18)	5.10
	B	4 (2, 7)	3.73
	C	2 (2, 3)	
	D	3 (2, 4)	1.68
	E	2 (2, 3)	4.06
	F	2 (2, 4)	5.86
	G	5 (3, 10)	3.26
	H	2 (2, 5)	3.80

†Median (Quantile 1, Quantile 3)

Table 2. Differences in diet composition from formulation to delivery.

Diet Comparisons[1]	Nutrient (%DM)	Median of the absolute difference between the diets		Difference
		Control protocol	Treatment protocol	(Trt-Ctl)
Formulated - Expected	CP	0.34	0.17	-0.17
	NDF	0.66	0.56	-0.10
	Starch	0.53	0.64	0.10
Expected - Mixed	CP	0.14	0.09	-0.05
	NDF	0.14	0.07	-0.06
	Starch	0.19	0.12	-0.07
Formulated - Observed	CP	0.51	0.49	-0.03
	NDF	5.06	4.82	-0.24
	Starch	1.06	0.86	-0.19

[1]Formulated diet is the composition based on the recipe of the formulated diet for that day; the Expected diet is the expected composition of the diet using the formulated recipe and the updated composition of the feeds based using the forage sample analyses collected on that day; the Mixed diet is the composition of the diet using the observed inclusion rates from the mixing records that day and the daily forage compositions; the Observed diet is the composition reported from the TMR samples on that day

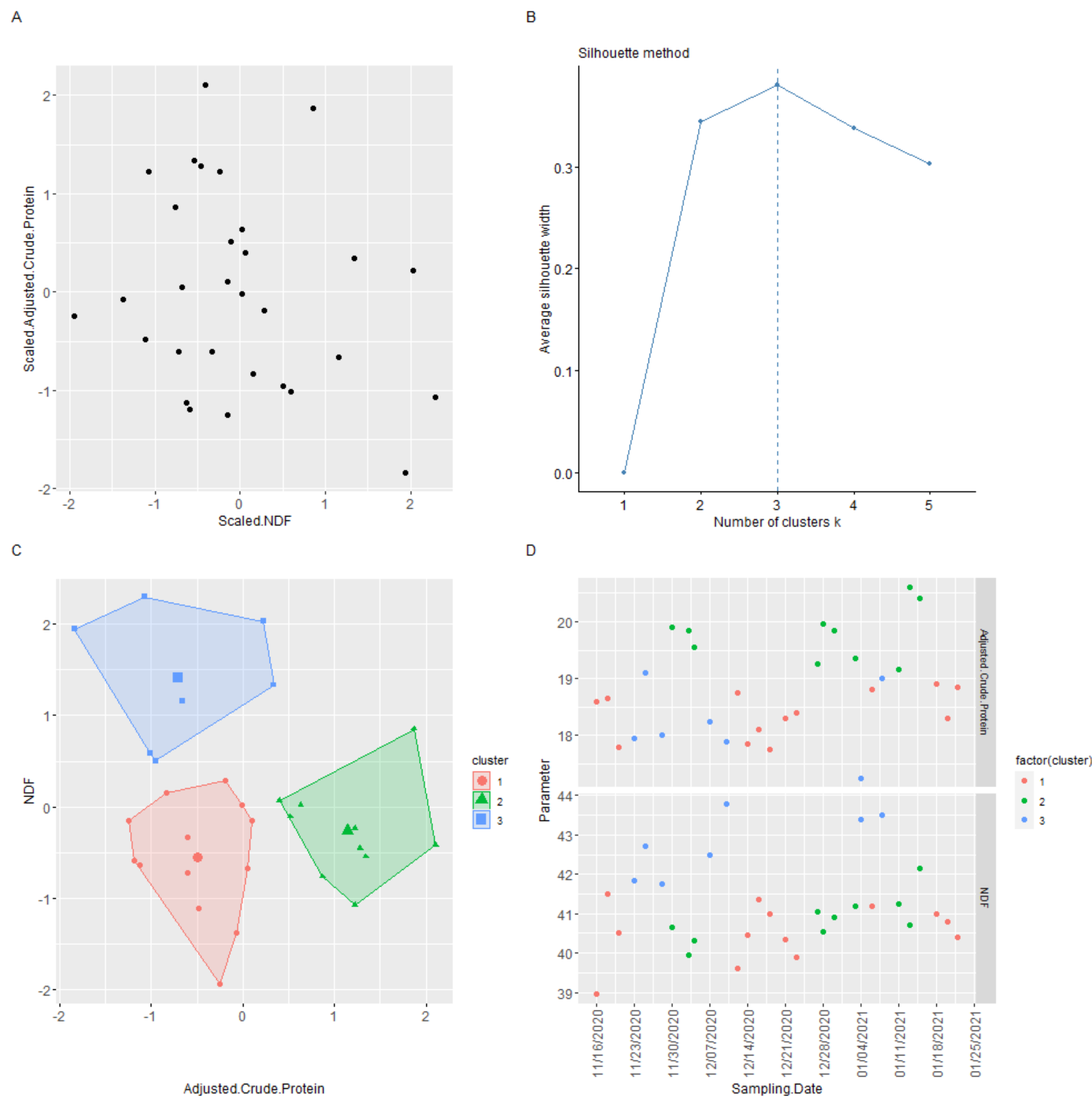

Figure 1: The first 4 steps of our method to estimate the average stable time: 1) A scatter plot of standardized CP and NDF of haylage (A), Optimal number of clusters from silhouette method (B), clusters after k-means analysis of haylage CP and NDF (C), and time series plot of the clustered haylage CP and NDF (D)

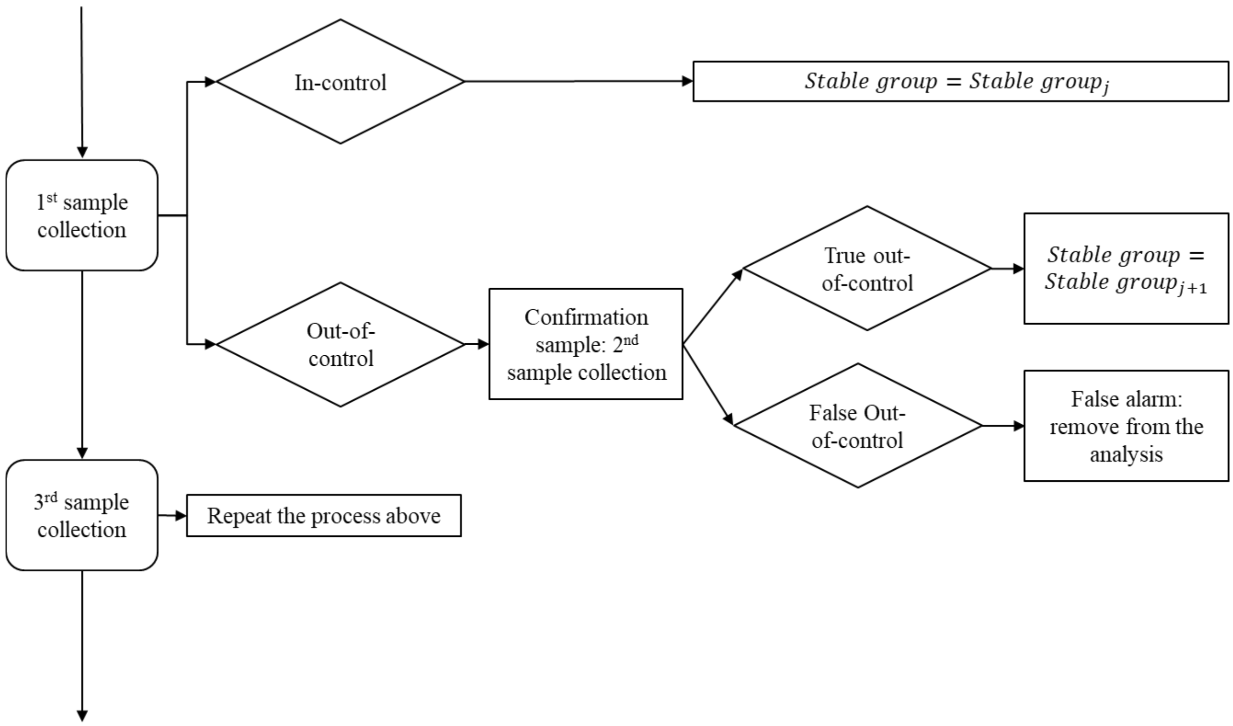

Figure 2. Decision tree for monitoring forage with $\bar{X}$-chart and $\bar{R}$-chart quality control analysis. Before the 1st sample collection, the first stable group j was previously established to start the quality control analysis. The decision process of 1st sample collection must be repeated for the 3rd and the following sample collections.

The Cornell Net Carbohydrate and Protein System version 7: Comprehensive Changes in Predictions and what that Might Mean for Formulation, Precision, and the Environment

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Dept. of Animal Science, Cornell University

Introduction

The development of the Cornell Net Carbohydrate and Protein System (CNCPS) has previously been discussed and the intent of this paper and presentation is to provide a description of the predictions of the model with respect to detail and what that might mean for precision in diet formulation. The architectural and computational structure of the CNCPS model has been conserved for from the model's inception in 1990 (Fox et al., 1992, Russell et al., 1992, Sniffen et al., 1992, O'Connor et al., 1993) to 2015 (Van Amburgh et al., 2015a, Van Amburgh et al., 2015b), a 25-year period where incremental changes (Van Amburgh et al., 1998, Fox et al., 2004, Lanzas et al., 2007, Tylutki et al., 2008) were made to predictive equations of both cattle requirements and nutrient supplies through the rumen and gastro-intestinal tract, as well as refinements and additions to the model's feed library. These updates to the model have been more frequent throughout these 25 years and the methodical updating of equations based on model performance feedback and new data have allowed for the refinement of equations that have not predicted well, resulting in a more robust prediction and reconciliation of nutrient supply and requirements for cattle. This refinement in the model can be a slow, painstaking at times, process; however, it is important to note that in an integrated model, one permutation in an equation or system usually illuminates an offset in the next system or set of equations. This process of working through updated and new equations can turn into a proverbial game of "whack-a-mole", where each update leads to another unveiling of an offset which requires more work and time. This becomes more of an issue with models that exhibit greater complexity, as demonstrated in version 7, where more time is warranted, relative to v.6.5.5, to ensure that accurate predictions relative to observed data. The focus of this paper will highlight changes in supply predictions that are significantly different than v6.5.5, discuss the boundary testing which provided additional revisions to version 7, and outline the steps our group has taken to deploy this version in an appropriate timeframe. For a more mechanistic review of CNCPS v7, please refer to Higgs and Van Amburgh (2016).

Updated Nutrient Supply Predictions

Nutrient supply predictions within the updated version of CNCPS build upon ruminal and intestinal transactions that are reported in previous model versions and further describe their dynamic flow starting at the mouth, ending at the rectum, and providing pool size and flux predictions for the rumen, omasum, and small and large intestines

(Table 1). This disaggregation of compartmental modeling will utilize a similar feed fractionation scheme, with a greater description of fiber carbohydrates and revisions on how intestinal digestibility of protein in feeds which contain little to no fiber are calculated. A more descriptive report becomes useful during formulation as it will allow the user to understand total tract digestibility of fiber and if feed inventory and costs allow, make modifications to enhance digestibility and energy availability. This will also provide useful information about ruminal digestibility of aNDFom as its digestion will be explicitly quantitative. The total tract digestibly estimations have been tested on four prospective studies, three of which were formulated to North American specifications and one using an Irish grazing system. On average, the resolution of predicted aNDFom total tract digestibility was within 7%, or 2.9 units, of observed total tract digestibility. We will continue to use future studies to evaluate the accuracy of these predictions and will modify equations when biases present themselves under varying fiber feeding conditions.

There are two aspects to this pool size data on aNDFom which will become relevant to the user as the steady state rumen pool size of the potentially digestible aNDFom and the uNDF will be a determinant of potential dry matter intake (DMI) for the animal (Table 2). This approach is meant to complement existing equations provided within previous versions of the CNCPS, in addition to an equation published in the NASEM (2021) model, providing users with an additional tool to troubleshoot and reconcile predicted and observed DMI on farm. In v7, the recommended DMI and rumen aNDFom fill values are based on work conducted at Miner Institute, University of Bologna and Cornell University (Cotanch et al., 2014) using the intake metrics developed by Mertens (2010). This information is one of the outcomes of the Informal Fiber Working Group that has been meeting at the Cornell Nutrition Conference for over ten years.

The model will provide predictions for bacterial protein flows, as in previous versions, based on the fiber (Feed fractions CHO B3 and CHO C; FC) vs non-fiber carbohydrate (Feed fractions CHO A1, A2, A3, A4, B1, and B2; NFC) characteristics, with many of the existing metabolic coefficients, including maintenance and growth potential, remaining intact. Ruminal protozoal relationships have been studied, quantified, and published, including the uptake of free peptides and amino acids (AA), predation and engulfment of bacteria, and lysis/excretion of nutrients back into their environment. The CNCPS v.7 can capture these relationships, where predictions for protozoal growth and flow will be quantified as a source of microbial nitrogen, carbohydrates, and fatty acids (Table 3 and Table 5). Evaluations of research diets previously fed and of diets of prospective studies have elucidated a supply of protozoal MP that ranges between 10 and 20% of the total metabolizable microbial supply in most Northeastern US diets. In the study by Dineen et al. (2020) cattle were fed high quality Irish pasture grass, resulting in protozoal contributions representing 23% of microbial supply. It is plausible that cattle fed these highly degradable grasses, with high sugar content, maximize microbial growth and thereby represent the upper limit of protozoal contributions between 22-25% of total microbial yield. The addition of protozoal metabolism also provides insights on the microbial yield response when varying the supply of other carbohydrate fractions to a diet, particularly regarding protozoal growth, and subsequent microbial MP supply, when sugar is increased in a diet. Previous versions of the CNCPS were not sensitive to capture the full microbial yield response when sugar was added, only modestly improving NFC degrading bacteria growth. Further efforts to quantify microbial metabolism in the rumen will refine the effect other carbohydrates have on the proliferation of varying microbial communities.

In this version of the model, rumen ammonia levels are estimated based on a sub-model which predicts ammonia production, hepatic ammonia uptake, subsequent hepatic urea production and full urea recycling back to the gastrointestinal tract. This updated approach has at least two benefits. First, it will provide a more stochastic approach to estimating rumen ammonia as the flux generally displays a large amplitude throughout the day with recycling of nitrogen into the rumen is generally constant (Reynolds and Kristensen, 2008). It is important to note that behavioral patterns, including meal frequency and cow time budgets, in conjunction with dietary composition, including carbohydrate digestibility and nitrogen solubility, can interact to cause large swings in rumen ammonia, which can be problematic throughout periods of the day where the concentration could drop below 5.5 mg/dL and causing microbial growth depression. The information in Figure 1 describes the rumen ammonia concentration for a North American based diet that is formulated for 68% forage DM and uses various concentrate feedstuffs to provide other required nutrients. Two of these ingredients, soybean meal and canola meal, are fed at varying levels to provide a different soluble and degradable protein supply in the rumen. As with previous versions of the CNCPS, version 7 can calculate an average ammonia concentration for this diet; however, a static evaluation of this concentration will not provide a meaningful explanation if microbial growth is depressed by low rumen ammonia based on eating patterns and solubility of ingredients. For example, the diet which splits 2.5 kg of DM into equal parts of soybean meal and canola meal has an average ammonia concentration of 6.5 mg/dL which can raise some concerns but does not flag microbial growth depression within the model. Conversely, if a user was to describe the feeding behavior of the target animal, in this case an 8 meal/day behavior was designated, the model would provide a more dynamic form of rumen ammonia concentration that would indicate periods throughout the day where this concentration would be fall below 6.0 md/dL and microbial growth would be marginally depressed. Users will also be provided with a summarized table (Table 4) indicating both the average and range of rumen ammonia concentration within the rumen including the prediction of microbial growth depression. Microbial growth, especially fiber digesting bacteria will become depressed when the ammonia concentration is less than 5.5 mg/dL as we expect the fiber (aNDFom) degradation to be disproportionately decreased under N limiting conditions. Also under these conditions, branched chain amino acids (BCAA) can become limiting as the soluble true protein in the rumen is deficient and this leads to a deficiency in branched chain volatile fatty acids (BCVFA) which are obligately required by the fiber digesting bacteria to meet their BCAA requirements as they cannot synthesize those amino acids (Andries et al., 1987). We are currently working on a rumen sub-model to quantify and predict the requirements and supply of the BCVFA in an effort to improve the precision in rumen nitrogen requirements and ensure that fiber digesting bacteria can meet their requirements for aNDFom digestion and for microbial growth. An argument could be made that the reduction in aNDFom digestibility observed in dairy cattle with higher levels of dietary starch (de Souza et al., 2019) is due to this resource competition. Bacteria that digest starch have the capacity to take up peptides and amino acids (Russell and Sniffen, 1984; Chen et al., 1987) which provides them a competitive advantage over fiber digesting bacteria which can only utilize ammonia and have a much slower growth rate (Bryant and Robinson, 1963).

As the industry looks to reduce protein feeding in lactating diets, the likelihood that a nutritionist would encounter a scenario where predicted rumen N is not sufficient to meet potential carbohydrate degradation is greater than previously seen. When such scenarios present themselves, it is imperative to understand the context of this limitation. Presently, the CNCPS amalgamates all nitrogenous substrates into one N pool, considering them all equal when reconciling the necessary substrates for proper microbial metabolism, proliferation, and feed degradation. Inclusion of dietary urea can often be used as a method to improve rumen N pool size, giving the appearance that sufficient N is present to realize potential carbohydrate degradation and microbial yield. This solution creates a fallacy, as rumen ammonia content may not be the prevailing cause for this limitation in carbohydrate degradation. Branch chain amino acids, which are not only considered in the rumen N pool, but, because they are precursors for BCVFA, also have a unique carbon backbone used for other metabolic processes, become limited in scenarios when dietary protein concomitantly limited. This presents an opportunity to disaggregate the rumen N pool, allowing for the consideration of BCAA/BCVFA sufficiency. To account for BCAA/BCVFA adequacy in the CNCPS, an approach similar to Tedeschi et al. (2000) will be considered for future iterations of the model. In brief, the supply of BCAA and any exogenous sources of BCVFA will be estimated using provided feed chemistry. Because oxidative deamination of BCAA by microbes is still the primary source of ruminal BCVFA (Allison et al., 1962), the rate of BCAA deamination, release of BCVFA by bacteria, and assimilation of BCVFA by other bacteria to be used for metabolism are currently under investigation with the aim to include them in supply calculations. The primary fates of BCVFA are defined in the CNCPS as BCAA or BCFA, with the understanding that a small proportion of BCVFA may be used for branch chain keto acid production (Firkins, 2021). Using literature data to define the BCAA and BCFA composition of bacteria will create recommended feeding rates of RDP, BCAA, and exogenous BCVFA. Similar to the concept of the total rumen N pool, in situations where rumen degraded BCAA and exogenous BCVFA are not sufficient enough to meet the potential microbial growth from degraded carbohydrates, the system will restrict carbohydrate degradation and subsequent microbial growth based on what is supplied. Independent of the rumen N pool, a user of the CNCPS would be able to troubleshoot whether a low protein diet was limited in either rumen N, BCAA/BCVFA, or a combination of both. As such, limitation born from BCVFA deficiencies cannot be overcome with the supplementation of other nitrogenous compounds, such as urea, and will only be reconciled when either true RDP with an appropriate level of BCAA or a concomitant substitution of exogenous BCVFA are provided.

The ability to essentially isolate the requirements of the rumen from the requirements for AA for the rest of the cow is one of the strengths of this new version of the model. This approach allows for much greater precision and refinement in the formulation of diets to meet the overall N requirements of the rumen to ensure optimum carbohydrate digestion and microbial yield and more precisely supplement escape protein and AA to meet the cow's requirements for productivity. Depending on the forages and feeds available, this can result in reduced N intake by 155 to 20%, while maintaining adequate rumen function and meeting the AA requirements of the cow. Any reduction in intake N will concomitantly reduce N excretion, thus improving the efficiency of N utilization, reducing manure ammonia production and the potential for nitrous oxide production.

Another quantitative addition to the updated version of CNCPS is the inclusion of endogenous transactions which occur ubiquitously throughout the gastro-intestinal tract (Ouellet et al., 2007, Ouellet et al., 2010). The inclusions of these flows do not add an appreciable increase in the supply of metabolizable protein, as most endogenous secretions that are quantified in the model are offset by the maintenance requirement calculated for the loss of these endogenous fractions. This, however, does not mean that these fractions should be left unquantified, given that the remains of salivary proteins, ruminal secretions, and sloughed cells can all be utilized by microbial populations within the rumen to proliferate and further alter the supply of amino acids flowing out of the rumen. Contributions of endogenous proteins within the CNCPS v.7 include salivary proteins (Yisehak et al., 2012), sloughed ruminal, omasal, and abomasal cells (Larsen et al., 2000), omasal and abomasal secretions (Ørskov et al., 1986), pancreatic secretions (Hamza, 1976, Larsen et al., 2000), bile secretions (Larsen et al., 2000), and small and large intestinal sloughed cells and secretions (Larsen et al., 2000, Jansman et al., 2002).

Excretion and Productive Use

There is undoubtedly more pressure on dairy producers to evaluate and decrease nitrogen excretion, while maintaining productivity. As with the current version of the model, there will be excretion predictions for N and because of the model architecture, the user will be provided more information about the sources of N excretion and what typical values are and what can be modified (Table 5). This group aims to have users reference the breakout of nitrogen recycling along the gastro-intestinal tract, as partitioning of urea will be quantified in the rumen, small intestine, and large intestine. In doing so, users are encouraged to feed lower protein diets that will capture the native ability of a ruminant to recycle nitrogen, while minimizing excessive nitrogen loss in manure and maintain productive responses. A comprehensive outline of nitrogen excretion, including the sourcing of excreted nitrogen back to its origin, as well as quantifying metabolic urinary and urea urinary N, will provide the means to explicitly quantify and report excretion numbers for stakeholders and affiliated industries looking to inventory emissions and excretions on dairy farms. Our intent is to provide upper and lower boundaries for these excretion values and incorporate them into the current calculations based on grams of urinary urea N per unit of productivity N.

Efficiency of use has also become a means to measure productive efficiency of cattle, maximizes the productive output of cattle using more targeted nutrient supplies relative to predicted requirements. Amino acid efficiency of use, particularly describing with EAA, has been made a priority within the CNCPS v.7. In addition to calculating the metabolizable gram amount of each EAA, this supply is related to the metabolizable energy supply of the diet (Higgs and Van Amburgh, 2016). Efficiencies of use for each amino acid that are considered energetically optimum have been calculated and used to provide recommendations for the grams of metabolizable AA relative to metabolizable energy needed to achieve this efficiency. Users of the new version will be provided with these targets to formulate towards; however, the regressions used to calculate the optimum supply of AA relative to ME will also provide the efficiency of use for varying supplies of AA which might not meet the recommended targets. This is to ensure that in the event nutritional or financial constraints or limitations in feed inventory are preventing the desired AA supply, the model will appropriately calculate an efficiency of use for these AA and allow the user with a better indication of productive expectations. Conversely, this system will produce marginal improvements in productive outputs if AA are supplied in excess, resulting in increased excretion of nitrogen relative to its intake.

The updated model will contain updated equations related to the environmental impact of dairy and milk production. Given the extreme pressure on the dairy industry to reduce methane emissions, updated equations will be included to help nutritionists and dairy producers develop farm level inventories of methane production. In addition, there will be "switches" built into the model over time to account for feed additives and other management opportunities to reduce methane emissions or intensity. It is likely that reduced intensity is the first best option now. A series of dairy cattle enteric CH_4 production prediction models were developed and one that works well and is easily adapted is: CH_4 (g/d) = -73.74 + 17.08 x DMI + 2.64*forage – 0.06*forage^2, (observed vs predicted = 346.4 vs 341.3; RMSPE = 10.7%, MB = 1.92%; SB = 1.75%, CCC = 0.95). This equation works reasonably well and is driven by DMI and forage content of the diet. We learned in the process that ADF digestion has the highest correlation with methane production, whereas aNDFom digestion has a negative relationship with methane production, which is why forage turns out to be a better predictor. And like the recent NASEM (2021) we evaluated the effect of monensin on methane emissions in dairy cattle and observed a 5.4% reduction in daily CH_4 production (g/d) and 4.0% in CH_4 yield (g/kg DMI). This information will be incorporated into the model so that nutritionists can start calculating changes in farm level methane inventories.

Short- and Long-Term Goals

Beyond the computational goals of this system, we continually aim to improve the nutrient supply and predicted requirements for cattle at all stages of life. Given the rate in which fatty acids research is expanding in dairy cattle, it is apparent that the expansion of the fatty acid sub-model is warranted. And further disaggregation of feed fractions to provide better resolution of their supply, particularly regarding five and six carbon sugars, soluble fiber, and proteins, and perhaps a fractionation of starch to better define its degradability. Lastly, and perhaps of greatest importance, is the quantification of behavior and its changes over time on nutrient supply. Figure 1 provides a dynamic concentration of rumen ammonia over the course of a day; however, the CNCPS v.7 predicts this concentration cycle as redundantly symmetrical, implying that cattle eat the same amount of dry matter at all meals. This obvious departure from cattle behavior is one that would provide a more robust insight into the way nutrient flows, and by extension the deficiencies of those flow relative to requirements, change throughout a day if they were corrected. Future updates of the model will look to include a behavioral sub-model which will utilize current and new animal inputs provided by the user to provide a more accurate prediction of nutrients flows and productive outputs. Overall, the intent of the updated model is to provide better information about functions that should help nutritionists improve their understanding of what might be limiting milk yield through improved mechanistic solutions.

Table 1. Intake, digestion, and excretion by digestive compartment of carbohydrate pools from both forage and concentrate sources according to CNCPS v7 calculations.

	Digestion by compartment[1] (g/d)					
				Neutral Detergent Fiber		
	Sugar	Starch	Soluble Fiber	Fast Degrading	Slow Degrading	Undegradable
Proportion of diet, % DM	4.2	30.5	3.7	18.5	5.0	7.1
Forages, g						
Intake	181	6212	424	3481	1122	1629
Rumen degraded	105	5037	340	2954	615	0
Rumen pool[2]	15	488	35	1241	1193	3802
Rumen escape	76	1175	84	528	507	1629
Small intestine digested	76	877	0	0	0	0
Small intestine passed	0	298	84	528	507	1629
Large intestine degraded	0	207	57	226	71	0
Fecal excretion	0	91	27	302	437	1629
Apparent total tract digestion, %	100	98.5	93.7	91.3	61.1	0
Concentrates, g						
Intake	998	3078	626	1706	283	358
Rumen degraded	730	2116	445	1290	172	0
Rumen pool	50	329	62	821	216	709
Rumen escape	269	961	180	416	110	358
Small intestine digested	269	754	0	0	0	0
Small intestine passed	0	208	180	416	110	358
Large intestine degraded	0	120	107	131	22	0
Fecal excretion	0	88	73	285	88	358
Apparent total tract digestion, %	100	97.2	88.3	83.3	68.8	0

[1] Cattle consumed an average of 28.0 kg of DMI from this diet .

[2] Defines the residual quantity of each carbohydrate fraction which resides in the rumen and has not been degraded or passed.

Table 2. Output from CNCPS v.7 describing the flux and pool size of fiber fractions within the rumen. Outcomes aid in the determination of dry matter intake according to pdNDF or uNDF fill limits.

Fiber Fraction	Flux, $g \cdot d^{-1}$	Flux, kg $BW^{-1} \cdot d^{-1}$	Rumen pool size, g	Rumen pool Size, kg BW^{-1}
CHO B3; Fast	5187	0.69%	2070	0.28%
CHO B3; Slow	1405	0.19%	1421	0.19%
CHO B3; Total	6593	0.88%	3318	0.47%
NDF Recommendations[1]	-	1.27-1.47%	-	-
CHO C (uNDF)	1987	0.26%	4596	0.61%
uNDF Recommendations[1]	-	0.39-0.48%	-	0.48-0.62%

[1] Recommendations according to Cotanch et al. (2014)

Table 3. Metabolizable protein predictions from feed, bacteria, and protozoa under CNCPS v.7 predictions.

Metabolizable protein flows	Quantity
Feed MP, g	1349
Bacterial MP, g	1343
Protozoal MP, g	325
Feed MP, %	45.0%
Microbial MP, %	55.0%
Protozoal MP, % microbial supply	19.5%

Table 4. Rumen ammonia concentrations and associated microbial growth depression, both with provided minimum and maximums predicted over a day.

Rumen N concentrations	Mean	Min	Max
Rumen ammonia, mg/dL	9.3	8.1	11.1
Microbial growth depression			**% Depression**
Mean depression			0.0%
Minimum depression			0.0%
Maximum depression			0.1%

Table 5. Nitrogen supply transactions throughout the gastro-intestinal according to CNCPS v.7 predictions.

Parameter	Quantity	Parameter	Quantity
Ruminal transactions, g		**Duodenal flows, g**	
Feed		Non-ammonia nitrogen	777
Intake	664	Non-ammonia, non-microbial nitrogen	358
Degradation	359	Microbial nitrogen	506
Escape	224	**Small intestinal transactions, g**	
Free peptide and amino acids (PAA)		**Digested and absorbed**	
Degradation to ammonia	278	Feed	216
Uptake by NFC degrading bacteria	160	FC degrading bacteria	132
Uptake by protozoa	27	NFC degrading bacteria	194
Escape	38	Protozoa	79
Urea and Ammonia		Endogenous	38
Intake	81	Ammonia	29
Recycled	208	**Passage**	
Absorption	207	Feed	36
Escape	29	FC degrading bacteria	38
Uptake by FC degrading bacteria	191	NFC degrading bacteria	56
Uptake by NFC degrading bacteria	145	Protozoa	9
Excretion by protozoa	5	Endogenous	48
Microbial		Urea	96
FC degrading bacteria escape	170	**Large intestinal transactions, g**	
NFC degrading bacteria escape	250	Free PAA degraded to ammonia	13
Protozoal escape	87	Free PAA uptake by NFC degrading bacteria	13
Protozoal lysis and excretion	11	Ammonia absorption	163
Endogenous		FC degrading bacteria growth	20
Secretions	146	NFC degrading bacteria growth	27
Degradation	134	Feed excreted	36
Escape	12	Ruminal FC degrading bacteria excreted	37
		Ruminal NFC degrading bacteria excreted	56
		Ruminal protozoa excreted	9
		Endogenous excreted	33

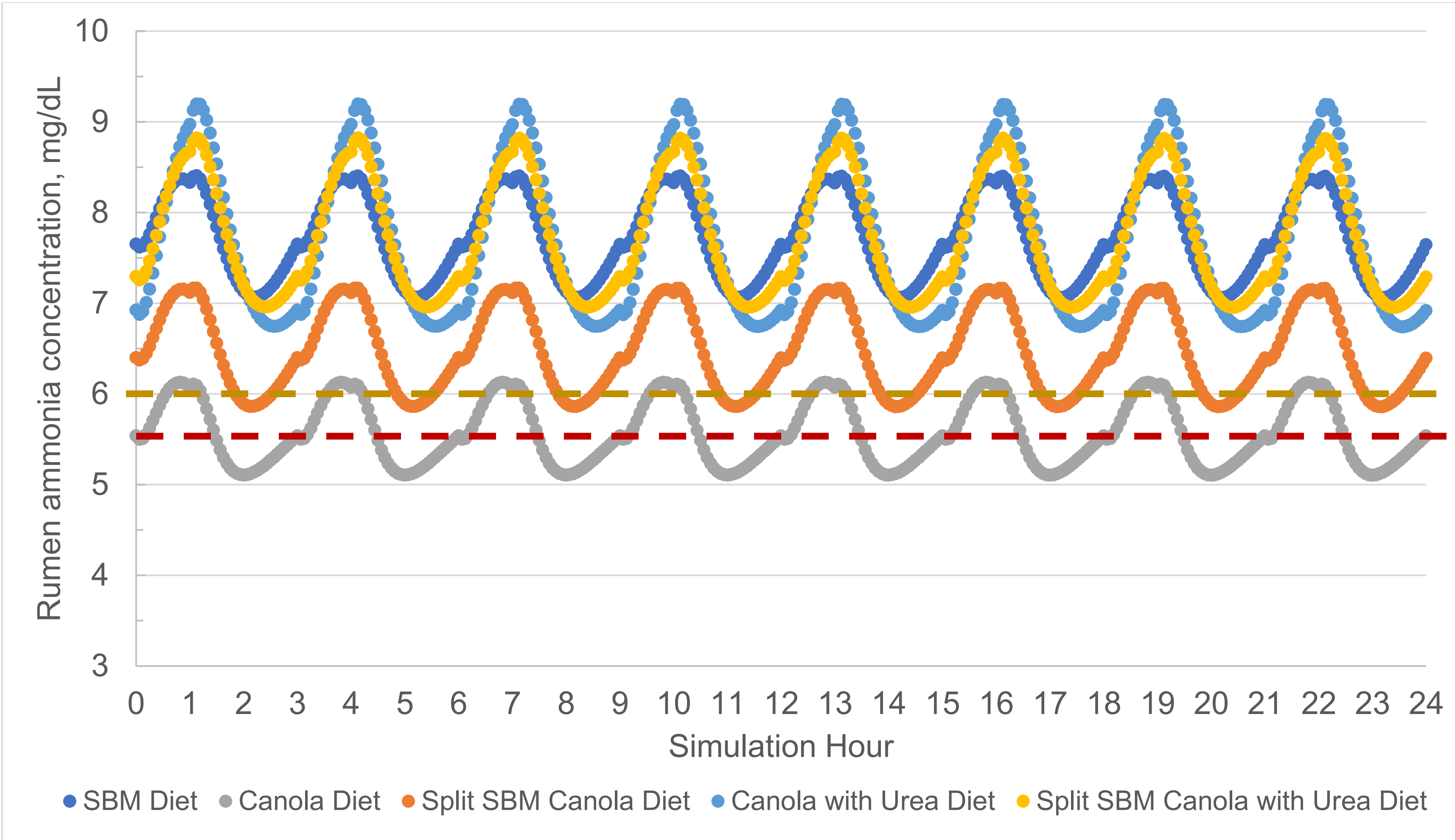

Figure 1. Rumen ammonia concentration after feeding a high forage diet (68% DM) with either A. 2.5 kg of soybean meal (SBM) included; B. 2.5 kg of canola meal included; C. 1.25 kg of SBM and 1.25 kg of canola meal included; D. 2.5 kg of canola meal with 125 grams of urea included; and E. 1.25 kg of SBM and 1.25 kg of canola meal with 125 grams of urea included. Within CNCPS v.7, microbial growth depression begins when ammonia concentration falls below 6.0 mg/dL and is significantly impactful when falling bellowing 5.5 mg/dL. Feed library values from the CNCPS were used to describe all feeds within this ration.

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Peripheral Blood Mononuclear Cell Mitochondrial Enzyme Activity in Calves is Associated With ADG, Future Lactation Performance and Survival

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Mitochondria are central to metabolism and are the primary energy producers for all biosynthesis. The objective of this study was to determine if the mitochondrial enzyme activity rates of peripheral blood mononuclear cells (PBMC) in calves are associated with ADG, lactation performance, and survival. Twenty-three Holstein and 23 Jersey heifer calves were enrolled at 1 California commercial dairy, blood and body weight data were collected at 1, 2, 8, 36, 52 wk and 2 y of age. Respiratory and fecal scores and treatment number were recorded for the first 30 d of life. Milk production data were collected from herd management software on surviving animals (9 Holsteins, 17 Jerseys). Mitochondrial isolation and enzyme activities for citrate synthase, complex I, complex IV, and complex V were determined using kits from Abcam (Cambridge, MA). Data were analyzed using GLM and the Logistic procedure of SAS (Version 9.4, Cary, NC). Multivariate regression analyses were conducted to determine if calf mitochondrial enzymatic activity was associated with ADG and lactation performance. Average daily gain parameters (pre-wean, 9 mo, 12 mo and 2 y ADG) were regressed on calf enzymatic activity rates with pre-wean health indices (respiratory and fecal score, treatment number, hematology) as covariates with the criteria for inclusion at $P \leq 0.05$. Milk production parameters (milk yield, fat yield, solids yield, ECM, 305ME and relative value) were regressed on enzymatic activity and pre-wean health indices (respiratory and fecal score, treatment number). For both breeds, mitochondrial enzyme activities and pre-wean health were correlated to all ADG and milk production parameters ($R^2 \geq 0.64$, and $R^2 \geq 0.47$, respectively). Logistic regression analyses were performed to determine if early life enzymatic activity impacted survival outcomes in the herd. Calves in the lowest quartile for complex V enzyme activity at 1 wk had 13.5 greater odds of being culled or dying prior to their first lactation. These findings suggest that predictions of cow performance and survival could be improved by considering the impact of early life mitochondrial enzymatic activity and pre-wean health indices.

Dietary Optimization of Macronutrients in On-growing White Sturgeon, *Acipenser transmontanus*

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White sturgeon, *Acipenser transmontanus*, is an economically valuable freshwater species farmed in Idaho and California. Sturgeon farmers rely on commercial diets that have been found successful even though no commercial feeds, other than a larval diet, have been specifically designed for sturgeon grow-out. Despite the growing interest in white sturgeon aquaculture around the world, there is scarcity of information on sturgeon specific nutrient needs. The diet-related issues of fatty ovaries and elevated visceral fat observed in white sturgeon at sexing indicate poor nutrient partitioning when existing commercial diets are fed to white sturgeon, which suggest that some of the feeds are not optimized for the sturgeon on-growing period. A preliminary study was carried out using a statistical mixture model design to optimize the combination of macronutrients in grow-out feeds for dietary protein, lipid and digestible carbohydrate levels on growth, feed utilization, nutrient retention, and deposition of mesenteric fat in on-growing white sturgeon. Fourteen diets containing fishmeal, fish oil, and wheat starch at various mixture levels were formulated and fed to 1.5 yr old white sturgeon until fish reached 200 percent growth in the California reared fish. The range of mixtures used in the test diets were as follows: fishmeal (450 – 650 g/kg), wheat flour (100 – 350 g/kg), and fish oil (100 – 300 g/kg). The sum of the macronutrients accounted for 900 g/kg of the test ingredients per diet while the remaining 100 g/kg accounted for binder, mineral, vitamin premix and yttrium oxide as an inert marker to estimate for digestibility. Skretting feed was used as a reference diet in the study. Four hundred and sixty-three fish (9.6 ± 0.47 kg) were allocated to twenty-six (2m) diameter tanks, hand-fed twice daily at 1.5 percent body weight, and weighed every 6 wks using a complete randomized design. At the end of the 120 day feeding trial, the fish fed the mixture diets showed the highest weight gain and the best efficiency in feed utilization, compared to the commercial diet in the 1.5 yr old white sturgeon. The findings of this research will be used to develop cost-effective diet formulations for white sturgeon farmers and feed producers. This study is funded by the USDA Western Regional Aquaculture Center.

In-vitro DM Disappearance Comparison of Whole Soybean, Whole Sudangrass, Alfalfa Hay and Dried Olive Pomace

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California is the number one producer of olives and olive oil in the United States with a yield of 167,500 tons of olives valued at more than $130 million. A challenge in this industry is the utilization or disposal of the byproduct of olive oil production, olive pomace (OP). Olive pomace consists of olive pulp and pit materials with most of the water removed. Currently, there are no guidelines or affordable means of disposal for OP in California. The objective of this experiment is to determine the extent of DM disappearance of OP compared to common whole forage plants. Other forages evaluated in determination of DM disappearance included alfalfa hay (ALF), whole plant sudangrass (SUD), and whole plant soybean (SOY). Samples were air dried in a forced air oven at 55°C and ground to pass a 2mm screen (Wiley Mill). In-vitro DM disappearance was determined using the Daisy^{II} Incubator (ANKOM Technology). ANKOM F-57 bags were pre-rinsed with acetone and air dried to remove the surfactant followed by adding 0.25g dried sample and sealed for analysis. Rumen fluid was collected from a cannulated cow at the Chico State Beef Unit. Combining both buffer solutions as well as the rumen fluid to each of the digestion jars in the Daisy Incubator the heat/allegation switch was turned on allowing each jar to maintain a consistent temperature of 39º. The standard buffers and protocol from ANKOM was followed with the only change being the duration of incubation. To estimate the rate of disappearance, bags were added to the incubation jars containing buffers and rumen fluid at 72, 60, 48, 36, 24, 18, 12, 6 and 0h before rinsing. Following the incubation, all samples were rinsed thoroughly and then processed through the ANKOM NDF protocol. In-vitro DM disappearance data was calculated in Excel and final data was analyzed as a repeated measures model using the MIXED procedure of SAS, comparing both feed type and time point in the model. Feed type was significant ($P<0.05$) at all time points. Time point was significant for ALF, SUD, and SOY($P<0.01$). Olive pomace had a mean DM disappearance of 42.80%, across all time points ($P=0.39$). By the completion of the 72-hr fermentation, SUD had the highest ($P<0.01$) DM disappearance of 81.93%, followed by ALF (78.20%), SOY (71.75%) and OP (44.31%). This study showed that DM from OP disappeared in-vitro early and does not increase with longer incubation periods, in contrast to the forage crops. Characterizing alternative forage and feed sources is essential to understanding their potential for incorporation into livestock rations.

In-vivo Digestibility of Total Mixed Rations in Finishing Lambs Containing Olive Pomace

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California agriculture produces over 400 commodities and is always seeking to improve nutrient cycling and efficiency while maintaining production. Olives are a major commodity in northern California and finding a method to repurpose the waste from pressing olives for oil is a key issue for producers. In the fall of 2022, the ANSC 330L Applied Animal Nutrition Research course conducted an in-vivo digestion trial to evaluate the digestibility of dried olive pomace (OP). Eight wethers were used in a cross-over design to evaluate the digestibility of total mixed rations for growing lambs. The base diet (CON) was 40% alfalfa sweeps and 60% of a bulk 18% CP grain mix. The test diet (OP) contained 30% alfalfa sweeps, 10% olive pomace, and 60% of the bulk grain mix. All TMR proportions are on an as fed basis. Lambs were fed in individual feeding stalls twice daily at 0700 and 1800h, and allowed 45-60 minutes to ingest the meal. Bunk scoring was used to make feeding allocations and fecal scores were assessed during each feeding period to monitor health. Each feeding period had a 14-d adaptation period followed by a 5-d collection period. Lambs were outfitted with fecal collection bags during the collection periods. Feed, orts, and fecal samples were collected twice daily, following feeding, during the collection period. Subsamples were air dried in a forced air oven at 55°C for a minimum of 48h. Following Period 1, the dietary treatments (CON and OP) were switched, and lambs were allowed an additional 14-d to adapt to the new rations. Following drying, samples were ground to pass a 2mm screen (Wiley Mill). Feed (TMR and ingredients), orts, and feces were analyzed for DM, ash, fat, NDF, ADF, protein, and gross energy. Data were analyzed using the GLM procedure of SAS with dietary treatment, feeding period and the subsequent interaction included in the model. Means were separated by least squares and significant factors ($P<0.05$) were separated using the PDIFF function in SAS. Neither treatment nor period impacted the DM intake of lambs as a percentage of their body weight, all lambs averaging approximately 4% of their body weight in DMI per day. Dietary treatment did not impact DM digestibility ($P=0.57$), however, a period impact was observed ($P<0.001$) with lambs during the second period having higher DM digestibility. Organic matter digestibility experienced a treatment by period interaction ($P<0.01$). Lambs fed OP had higher NDF digestibility ($P=0.001$) that CON lambs, and all lambs had higher NDF digestibility in Period 2, compared to Period 1 ($P<0.001$). Dietary treatment had no effect on fat digestibility ($P=0.60$). Digestible energy (kcal/lb DM) was calculated for both CON and OP lambs and dietary treatment did not influence DE ($P=0.26$), however, Period 2 expressed a higher DE (1655 kcal/lb DM) compared to Period 1 (1335 kcal/lb DM; $P<0.01$). Period proved to be a compounding factor in this project, and we recommend replication of this project to clarify the impact that diets with 10% olive pomace may have on fiber digestibility in growing lambs.

Smectite Supplementation to Preweaned Dairy Calves: Effects on Serum Igg Concentration, Trace Serum Minerals, Antibiotic Treatments, and Mortality

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The objective of this study was to evaluate the effects of supplementing preweaned dairy calves with smectite on serum IgG levels, mineral concentrations, number of antibiotic treatments, and mortality. A total of 200 newborn calves were enrolled (Holstein = 88; Jersey = 112). Calves were randomly assigned to control (**CON**; force-fed 50 mL of tap water; n = 100**)** or smectite supplementation [**SMECT**; force-fed 2.5 g of smectite (calcium montmorillonite bentonite clay, Redmond Inc, UT) diluted in 50 mL of tap water; n = 100]. Treatments were administered two h prior to the afternoon milk feeding from d 1 to 10 of age. Jugular blood samples were collected at d 1 from all calves for serum total protein determination. From a subset of 44 calves (SMECT = 21; CON = 23), serum IgG concentration was determined at d 1, 4, 8, 12, and 16 by Radial Immunodiffusion (RID). From the same subset of calves, serum mineral concentration was determined at d 1 and 8 by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Farms' records of antibiotic treatments and mortality of enrolled calves were collected up to d 20 of age. Statistical analyses were performed in SAS. Multiple linear regression models were used to evaluate serum IgG and mineral concentrations. Antibiotic treatment and mortality were analyzed using log-binomial regression models. Serum IgG concentration tended to have higher for SMECT than CON calves during the treatment period (18.2 vs. 22.3 g/L), but it was similar during the post-treatment period (14.9 vs. 15.2 g/L). Except for serum K concentration which tended to be higher for CON than SMECT calves (5.92 vs. 5.63 mmol/L), similar serum concentrations of Ca, P, Mg, Na, Cu, Fe, and Zn were observed for SMECT and CON calves at d 8 of age. Compared to CON, SMECT calves had a 45% lower risk for antibiotic treatment and tended to have a 63% lower risk of mortality. Results of this study suggest supplementation with smectite to newborn dairy calves has a positive effect on serum IgG concentration, antibiotic treatment, and mortality. Future research is needed to elucidate smectite's potential to improve calf health and reduce antibiotic use and mortality on US dairy farms and calf-raising facilities.

Keywords: preweaned calves, smectite, antibiotic, mortality, IgG

Global Warming Potential Star (GWP*) More Closely Represents Modeled Warming Contributions from California Dairy Methane Emissions

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The objective of this research was to model the California dairy industry's warming contributions utilizing the Finite Amplitude Impulse Response (FaIR) model from 1950 to 2030 under different scenarios using both GWP100 and GWP*. Methane (CH_4) is by far the main greenhouse gas (GHG) of California dairy production and accounts for 45% of California's methane emissions. The two sources of CH_4 on dairy farms are in the form of enteric fermentation and manure management. The second most common GHG is carbon dioxide (CO_2), which accumulates in the atmosphere even if the rate of CO_2 emissions decline due to its long half-life of 120 years. In contrast, CH_4 has a half-life of 12 years and has been termed a short- lived climate pollutant (SLCP). GHGs have been compared using the accounting metric global warming potential 100 (GWP100), which integrates the warming of a GHG over 100-years. However, GWP100 does not accurately represent the warming contributed by CH_4 emissions in cases of increasing or declining emission levels. To overcome this misrepresentation of SLCP warming, global warming potential star (GWP*) has been developed. Lactating dairy cow enteric and manure management CH_4 sources were acquired from the California Air Resources Board. Scenarios analyzed included business-as-usual and reduction scenarios of a 40% decrease in manure CH_4 emissions and a 40% decrease in manure CH_4 along with an 11.7% decrease in enteric CH_4 emissions. Compared with GWP100, GWP* CO_2 warming equivalents (CO_2we) emissions were greater under increasing annual CH_4 emission periods but were lower under decreasing CH_4 emission rates and more closely matched modeled warming under CH_4 emission reduction scenarios. With assumptions in anticipated warming based on cumulative CO_2we emissions from 1990 to 2030, the business-as-usual scenario was assumed to add 1.16 mK of warming along with 1.10 mK and 1.09 mK for the 40% manure reduction scenario and the manure and enteric fermentation scenario, respectively. To meet temperature and policy emission reduction goals for the California dairy industry, GWP* may provide a more accurate representation for evaluating SLCP emissions impact on atmospheric warming.

Impact of ComforT® Essential Oil Blend on Growth and Carcass Performance in Finishing Lambs During Summer Months

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California has a Mediterranean climate; specifically, winters and springs tend to be cool and have precipitation while summer and fall are characterized by high temperatures and minimal precipitation. The changing climate has caused these characteristics to be increasingly variable and extreme, which compromises animal comfort and production. The objective of this research was to determine the impact of ComforT® (Ralco Animal Nutrition) essential oil blend on market lamb body temperature, feeding performance, and carcass yield. Sixteen crossbred ewes (n=5) and wethers (n=11) lambs were randomly assigned to a control (n=8) and experimental (n=8) diet in a 58-d feeding study. Lambs were fed a base ration of 60% grain (18% CP; as fed basis) and 40% alfalfa hay. Those assigned to the ComforT® diet were supplemented at the rate of 0.5 g per 100 lbs of body weight of the ration. Lambs were fed in individual feeding stalls twice daily at 0700 and 1800 h, and allowed 45-60 minutes to ingest the meal. Bunk scoring was used to make feeding allocations and fecal scores were assessed during each feeding period to monitor health. Weekly thermal imaging of the right fore armpit of each lamb was collected at the morning and evening feed shifts to monitor body temperature. Climate data was collected to estimate the thermal heat index (THI) weekly. Weekly differences of actual body temp and the THI to estimate potential for heat stress (DIFF). At the end of the feeding trial, lambs were harvested and hot carcass weight, yield grade, quality grade, retail cut weights were collected. Data were analyzed as a completely randomized design with GLM procedure of SAS. At trial onset, wethers were heavier than ewe lambs ($P<0.001$), however, treatment groups did not differ in body weight. Treatment did not impact total feed intake ($P>0.50$), ADG ($P>0.90$), and feed efficiency ($P>0.50$). Sex affected intake ($P<0.02$), likely due to differences in body weight. Sex did not impact average daily gain or feed efficiency ($P<0.05$). During the first four weeks of the study, neither sex nor dietary treatment impacted DIFF ($P>0.10$), however, sex of lamb did impact DIFF during weeks 4 and 5 ($P<0.05$). In this study, the impact of ComforT® was limited when fed to finishing lambs, however, the interaction of ComforT® and sex of the lamb needs to be explored further.

Dietary Valerate Glycerides: Effects on Growth, Diarrhea, Fecal Culture, and Inflammatory Status of Weanling Piglets Infected with *Escherichia coli* F18

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Short chain fatty acid-based compounds are commonly used in piglet feed during the post-weaning period for their potential benefits on animal health and growth. Valerate is a 5-carbon short chain fatty acid that has previously exhibited antimicrobial effects against F18+ Enterotoxigenic *Escherichia coli* (ETEC) and may modulate gut health and immunity. However, its impact on the health and performance of newly weaned pigs experiencing ETEC-associated diarrhea has not been evaluated. The utilization of glyceride esters of valerate such as monovalerin and trivalerin are of interest for their dietary application to protect the compound from absorption and promote efficient delivery to the small intestine. The present experiment aimed to investigate the effects of dietary valerate glycerides on performance, frequency of diarrhea, and systemic inflammatory status of weanling piglets infected with ETEC. Sixty weaned piglets (6.97 ± 0.75 kg body weight; 21 day old) were randomly assigned to one of four dietary treatments: nursery basal diet (control), 0.075% or 0.1% monovalerin, or 0.1% trivalerin added to control. After 7- day adaptation, all piglets were orally inoculated with F18+ ETEC (10^{10} CFU/3 mL) on d 0, d 1, and d 2 post-inoculation (PI). Daily diarrhea scores (scale range of 1 to 5) were recorded and body weight data were collected throughout the experiment. Fecal samples were collected on d -7, d 0, d 3, d 7, d 14 and d 21 PI and cultured on blood agar to measure the percentage of β-hemolytic coliforms in total coliforms, indicating the fecal shedding of ETEC. Serum samples were collected on d 0 prior to ETEC inoculation, d 3, d 6, and d 21 PI to analyze concentration of tumor necrosis factor- α (TNF-α), C-reactive protein (CRP), and haptoglobin. All data were analyzed in Rstudio by ANOVA in a linear mixed model with treatment as fixed effect and pig as random effect. Frequency of diarrhea was calculated and analyzed by the chi-squared test. No significant differences in body weight or average daily gain were detected in any treatment groups compared with the control. Supplementation of 0.1% trivalerin reduced ($P < 0.05$) the frequency of diarrhea throughout the trial and reduced ($P < 0.05$) the percentage of β-hemolytic coliforms in fecal cultures on d 7 PI, compared with control. Pigs fed trivalerin had reduced ($P < 0.05$) serum TNF- α on d 0 and d 6 PI compared with pigs in control. Whereas pigs supplemented with 0.1% monovalerin tended ($P \leq 0.10$) to have lower serum TNF-α on d 0 and d 3 PI, and lower serum CRP on d 3 PI compared with pigs in control. No differences in serum levels of haptoglobin were detected among dietary treatments. In conclusion, trivalerin supplementation reduced frequency of diarrhea and fecal shedding of β-hemolytic coliforms, while both valerate glycerides could regulate systemic immune response of weanling piglets infected with F18+ ETEC.

Key words: Enterotoxigenic *Escherichia coli* infection, valerate glycerides, weanling pigs

The Effects of Probiotic Supplementation on the Prevention of Diarrhea in Pre-Wean Holstein Dairy Calves

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Feeding probiotics can improve health and mitigate adverse effects caused by pathogens entering a calf's gastrointestinal tract. The objective of this study was to evaluate the effectiveness of a probiotic fed daily, on fecal consistency and fecal pathogen shedding. Holstein heifers were enrolled within 48 h of birth into two treatment groups: 1) Control (CON: n = 173) 0.5 g of lactose, and 2) Probiotic (PRO: n = 151) 0.5 g of a multi-stra in probiotic. Treatments were administered 1 / d in milk from 48 h to weaning at 60 d. The probiotic was a combination of *B. subtilis*, *B. lichenformis*, *L. animalis*, and *P. freudenreichii* (1.1×10^{10} CFU/g). Fecal scoring for fecal consistency was performed daily using a scale from 1-3, with 1 being normal and 3 being loose. Feces were collected from 50 calves per treatment at 7, 14, 21, and 42 d via digital stimulation to assess fecal pathogen shedding. A Kaplan-Meier analysis was used to compare age at first diarrhea event using the lifetest procedure (SAS Institute v. 9.4, 2021). All other data were analyzed using the general linear models procedure in SAS. No differences were observed between treatment groups for age at first diarrhea event, length of first diarrhea event, total days with a 2 fecal score, and risk of having a diarrhea episode during the prewean period. However, total days with a 3 fecal score were higher in the PRO than in the CON (3.46 ± 0.35 d vs. 2.85 ± 0.31 d; $P < 0.05$) during the first 4 wk after birth. There were no differences in episode length, age at first episode, and risk of diarrhea. No differences were observed between treatment groups for fecal shedding of *E. coli* and *E. coli* O157:H7 at all time points and *C. perfringens* at 7 and 14 d. However, fecal shedding for *C. perfringens* was higher in the PRO group than in the CON group at 21 d (4.38×10^5 CFU/g vs. 2.34×10^5 CFU/g, $P < 0.05$) and at 42 d (1.29×10^6 CFU/g vs. 6.11×10^5 CFU/g, $P < 0.05$). Under these study conditions, the use of this probiotic had variable results regarding diarrhea prevention.

Describing the Distribution Shape of Cow Pen Dry Matter Intake to Predict the Total Quantity Required Using Machine Learning

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Precision feeding meets the requirements of each animal to increase efficiency but is not achieved when feeding a group. Cows are fed by pen, but diets formulated to a single cow. Our objective was to describe the distribution of DMI for pens of fresh, mid and late lactation and predict the pen DMI using machine learning. Our hypothesis is that the distribution shape model will have lower error when compared to the NASEM 2021 model. One hundred unique replicates of three pen types (fresh, mid-lactation, late lactation) were generated by randomly assorting observed cows. The DMI was fitted to the best distribution shape, and its parameters used to generate distribution plots that predicted the total pen DMI value. The second model estimated the DMI of each replicate using the NASEM equation with the input values set at the mean cow values. The beta distribution type was the most common fit to pen DMI, at 85 % of fresh, 60 – 80 % of mid lactation, and 30 – 60 % of late lactation pens. Percentage error for the distribution model was significantly lower than the NASEM, at 1 % compared to 10 %, and 95 % of the mean square predicted error was due to random variation, compared to 18 – 68 % for the NASEM. Machine learning models were trained to predict this distribution shape and its parameters. The training dataset was labeled with the distribution shape and parameters as outputs, and descriptive statistics of milk and the range of lactation of the pen as inputs. Random forest and neural net models were tested with k-fold validation for the lowest RMSE. Predicting the distribution shape provides accurate estimates of feed quantity. Reducing error by using the distribution of DMI instead of the nutrient requirements of an individual animal can provide a precision nutrition approach to group feeding.

Dietary Supplementation of Monoglycerides on Growth Performance, Diarrhea, and Intestinal Health of Weaned Pigs Experimentally Infected with a Pathogenic *Escherichia coli*

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This study aimed to investigate the effects of monoglycerides on growth performance and intestinal health of weanling pigs experimentally infected with a pathogenic *Escherichia coli* (*E. coli*) F18. Sixty weaned pigs (BW = 6.49 ± 0.74 kg) were housed individually and allotted to one of four diets (15 replicates/treatment): 1) control diet (CON); 2) CON+0.3% monoglycerides (MGs); 3) CON+3000 mg/kg ZnO and 4) CON+50 mg/kg antibiotics. The experiment lasted 28 days; 7 days of adaptation period and 21 days post-inoculation (PI). All piglets were orally challenged with *E. coli* F18 (10^{10} CFU/3 mL) for 3 days. Growth performance and fecal scores were recorded throughout the experiment. Intestinal segments and mucosa were collected on d 5 PI (6 pigs/treatment) and 21 PI (9 pigs/treatment) to measure intestinal morphology and immune- related gene expression. Data were analyzed by ANOVA using PROC MIXED of SAS with randomized complete block design. Supplementation of ZnO increased ($P < 0.05$) BW on d 5, 14, and 21 PI, and average daily gain and average daily feed intake from d 0 to 21 PI, compared with other treatments. Compared with CON, supplementation of ZnO or antibiotics reduced ($P < 0.05$) the incidence and severity of diarrhea, while supplementation of MGs tended to have lower ($P < 0.10$) severity of diarrhea throughout the experiment. Pigs supplemented with ZnO had more ($P < 0.05$) goblet cell numbers per villus, greater ($P < 0.05$) villi area and villi height, and higher ($P < 0.05$) villi height:crypt depth ratio in duodenum than pigs in other treatments on d 5 PI. Supplementation of MGs, ZnO, or antibiotics reduced ($P < 0.05$) ileal crypt depth compared with CON on d 5 PI. Pigs in ZnO group tended ($P = 0.064$) to have the biggest villi height:crypth depth ratio in the ileum, followed by pigs in MGs and antibiotics groups on 5 PI. Consistently, pigs fed with ZnO expressed less ($P < 0.05$) *TNFA*, *IL6*, *IL10*, *IL12*, *IL1A*, *IL1B*, and *PTGS2* in ileal mucosa, compared with other treatments on d 5 PI. However, no difference in the expression of listed genes was observed between pigs fed with MGs vs. ZnO. Pigs supplemented with MGs expressed lowest ($P < 0.05$) *PTGS2* in ileal mucosa compared with other treatments on d 21 PI. In conclusion, dietary supplementation of 0.3% monoglycerides did not enhance growth rate but may reduce diarrhea severity, intestinal and systemic inflammation of weaned pigs infected with *E. coli* F18, although the efficacy was not comparable to high dose ZnO.

Key words: diarrhea, intestinal health, growth performance, weaned pigs

Effects of Three Rumen Available Protein to Microbial Crude Protein Ratios on Growth Performance, Greenhouse Gas, and Ammonia Emissions from Feedlot Steers

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One hundred and twelve Black Angus steers (body weight; **BW** = 401 $\pm$ 3.6 kg) were used in a randomized incomplete block design, with the objective of evaluating the effects of 3 rumen available protein to microbial crude protein ratios (**RAP:MCP**) on growth performance, greenhouse gas, and ammonia emissions, from feedlot steers. Steers were blocked by initial BW and randomly assigned to 1 of 3 treatments. Treatments were deficient (**DEF**; RAP:MCP = 0.8), control (**CON**; RAP:MCP = 1.0), and excess (**EXS**; RAP:MCP = 1.2). Steers were allocated and housed in cattle pen enclosures (**CPE**) which consist of a 22.0 m × 11.3 m hoop house shaped building with a height of 6 m equipped with 185 m^2 of soil surface, 9.1 m of linear bunk space, and connected to gas chromatographs to quantify gas emissions. Treatments were delivered daily as a total mixed ration aiming for 5% refusal. Two 42-day periods were done with orts collected weekly and BW every 14 days. Gas measurements were obtained daily in 20- minute intervals and in sequential order from all CPE. Data were analyzed with R statistical software (4.2.2). The linear mixed effect model procedure within the "lme4" package was used with CPE as the experimental unit, treatment as fixed effect, and block and period as random variables. There was a treatment × period interaction ($P = 0.0129$) for final BW where EXS cattle were heavier than DEF ($P = 0.0404$) but only in period 2, and a tendency for a similar effect on dry matter intake ($P = 0.0585$). Average daily gain and feed efficiency were not affected ($P > 0.10$). There was a tendency for a treatment × period interaction ($P = 0.0765$) on CH4 emissions where DEF produced more CH4 ($P = 0.0474$) than CON and EXS in period 2. Ammonia emissions were affected by treatment ($P < 0.01$) where EXS increased NH3 by up to 66% and 19% compared to DEF and CON, respectively. Similarly, SO2 emissions increased with EXS ($P < 0.01$) by 44% and 28% from DEF and CON, respectively. Emissions of CO2, N2O, and H2S were not affected ($P > 0.10$). Based on the data observed in the current experiment, adequate growth performance can be achieved regardless of RAP:MCP; however, NH3 emissions are directly impacted by RAP:MCP.

Keywords: Rumen available protein, microbial crude protein, growth performance, ammonia emissions.

Effects Of L-Glutamate and L-Aspartate Supplementation on Growth Performance and Systemic Immunity of Weaned Piglets Challenged with F18 ETEC

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L-glutamate (Glu) and L-aspartate (Asp), functional amino acids with multifaceted roles in cellular processes, have shown promising benefits in piglet growth efficiency and immunological responses. This study aimed to investigate the effects of Glu and Asp on growth performance and systemic immunity of weaned piglets challenged with an enterotoxigenic *Escherichia coli* (ETEC) F18. A total of forty-nine weaned pigs (8.18 ± 1.54 kg BW) were randomly assigned to one of seven treatments, with seven piglets per treatment. The treatments included negative control (NC) and positive control (PC) that were fed with control diet without or with ETEC challenge, respectively. The other five dietary treatments were supplemented with either 1% or 2% Glu or Asp, or 50 mg/kg of Carbadox, and were challenged with F18 ETEC. All pigs except for NC were challenged with F18 ETEC orally for three consecutive days at the dose of 10^{10} CFU/dose/day. The study period lasted for three weeks, with a 7-day adaptation period and 14 days post-inoculation (PI). Pig body weights and feed consumption were recorded throughout the experiment. Blood samples were collected on d 0 before ETEC inoculation, and on d 2, 5, and 14 PI to analyze the white blood cell profile. All data were analyzed with ANOVA using the PROC MIXED of SAS with the pig as the experimental unit. Compared with PC, pigs supplemented with 1% Glu, 2% Asp, or Carbadox had greater ($P < 0.05$) average daily weight gain (ADG) and gain:feed ratio on d -7 to 5 PI and on d 0 to 5 PI. The counts of white blood cells, neutrophils, lymphocytes, and monocytes were increased ($P < 0.05$) on d 2 PI and peaked ($P < 0.05$) on d 5 PI, and reduced ($P < 0.05$) on d 14 PI. Supplementation of 2% Glu had lowest ($P < 0.05$) lymphocytes on d 2 PI, but had highest ($P < 0.05$) neutrophils on d 5 and 14 PI among all treatments. Supplementation of 2% Glu or 1% Asp also had lowest ($P < 0.05$) monocytes on d 5 PI. Compared with other treatments, pigs fed with 1% Glu had lowest ($P < 0.05$) neutrophils:lymphocytes ratio on d 2 PI, while pigs fed with 2% Glu had highest ($P < 0.05$) neutrophils:lymphocytes ratio on d 5 PI. Supplementation of 1% Asp had greatest ($P < 0.05$) total protein in blood on d 2 and 5 PI among all treatments. In conclusion, results of the present study indicate that dietary supplementation of 1% Glu or 2% Asp enhanced growth performance of ETEC-challenged weaned pigs at early stage. Both amino acids could modulate the systemic immunity of weaned pigs, which needs to be further investigated.

Keywords: glutamate, aspartate, weaned pigs

Technical Symposium
Speaker Biographies

Dave Taysom joined Dairyland Laboratories as a sales rep in 1986. Dairyland Laboratories is a family-owned, independent laboratory providing extensive analysis of feed and forage. Dairyland operates and manages NIR instruments and calibration for over 60 entities worldwide. During his 37 years at Dairyland Laboratories, Dave has served on numerous boards related to forage analysis and forage quality. This includes the Midwest Forage Council, National Forage Testing Ass, and NIRS Consortium as well as a stakeholder for the US Dairy Forage Research Center.

Fernanda Lopes, Ph.D., is Adisseo's North American (NA) Regional Category Manager for the SmartLine™ of protected amino acid products. Fernanda joined Adisseo eight years ago. The first seven years she spent developing and educating the South American dairy market on amino acid balancing and the importance of methionine as a nutritional and functional nutrient for dairy cows. In 2022 she joined the Adisseo NA team. Fernanda is from Brazil where she received her bachelor's degree in animal science from the University of Lavras. From 2009 to 2014, she worked with Dr. David Combs at the University of Wisconsin to obtain first her master's degree and then her Ph.D. Her Ph.D. work focused on dairy science fiber digestibility (TTNDFD method).

Mike Shearing grew up on a dairy farm in New York State and has a Bachelor of Science degree in Agricultural Economics from Cornell University. His background includes dairy nutrition consulting, dairy farm management, and dairy farm ownership. In 10 years at Perdue Agribusiness, Mike worked with dairy nutritionists in 20 different US states to implement amino acid balancing. Mike joined Adisseo almost 8 years ago and now supports their Global Ruminant staff and their customers. His specialty is diet formulation with CNCPS and using least-cost nonlinear optimization to best meet the nutritional and economic objectives of the customer. Mike currently resides in Arizona with his wife Colleen.

Frank Gaudin, no biography provided.

Phil Cardoso, Ph.D., is an associate professor at the University of Illinois at Urbana-Champaign. He received his D.V.M., and M.S. degrees from the Universidade Federal Do Rio Grande do Sul in Brazil, and his Ph.D. from the University of Illinois. Since 2012, Cardoso has established a unique program that seamlessly blends his teaching, extension, and research efforts. Phil's Dairy Science program impact by placing students in applied positions and academia. Phil and his students have published over 90 peer-reviewed manuscripts (original research and invited reviews) and 3 invited book chapters to date. The program builds from questions asked by dairy producers and focuses on having the dairy cow's diet as a medical prescription for performance, health, and reproduction. That is achieved by understanding the impact of nutrition on metabolism, reproduction, and health in dairy cows, as well as mechanisms of metabolic adaptation to stressors and forage quality.

CANC Speaker Biographies

Lance Baumgaurd, Ph.D., grew up on a mixed livestock and row-crop farm in southwestern Minnesota. He received his B.S. and M.S. degrees from the University of Minnesota and a Ph.D. from Cornell University. Lance joined the University of Arizona's Animal Science department in 2001 and then joined Iowa State University in 2009 as the Norman Jacobson Professor of Nutritional Physiology. He became the C.F. Curtiss Distinguished Professor in 2022.

Trevor DeVries, Ph.D., is a Professor and Canada Research Chair in the Department of Animal Biosciences at the University of Guelph. Trevor received his B.Sc. in Agriculture from The University of British Columbia (UBC) in 2001. Immediately following he began graduate studies at UBC, where he received his Ph.D. in 2006 Following that, he spent one year as a post-doctoral fellow with Agriculture and Agri-Food Canada.

In 2007 he was appointed as faculty with the University of Guelph in the Department of Animal Biosciences. In that position, Trevor leads a highly productive research program and has published over 200 peer-reviewed papers focused on dairy cattle nutrition, management, behavior, and welfare. He is also committed to extending that work to the field, as evidenced by over 300 invited research presentations.

Trevor also contributes to teaching at the university, including instructing undergraduate and graduate courses in the areas of dairy cattle management, behavior, and welfare, coaching the university Dairy Challenge team, as well as mentoring of graduate and undergraduate students. Trevor also works diligently in public service, serving on several university committees, as well as various local, national, and international professional committees.

John Goeser, Ph.D., grew up in the dairy industry following in her father's footsteps as a dairy nutritionist. Goeser holds several degrees from the University of Wisconsin – Madison, including B.S. degrees in Dairy Science and Agronomy, M.S. degrees in Plant Breeding & Genetics and Dairy Science, and a Ph.D. in Dairy Science. Goeser has offered dairy nutrition and management expertise for over 10 years and has been overseeing animal nutrition, technical support, and research with Rock River Laboratory since 2012. In 2014, Goeser joined the UW-Madison Animal & Dairy Science Department as an adjunct professor and began offering consulting services for agricultural businesses. Goeser's focus is improving our understanding of ruminant nutrition, seed genetics, forage management, and feed hygiene in relation to feed conversion efficiency, sustainability, and agribusiness profitability.

Emmanuel Okello, BVM, MSc, Ph.D., is an Assistant Cooperative Extension Specialist in Antimicrobial Stewardship at the University of California Davis. The goal of his extension program is to develop antimicrobial stewardship guidelines and best management practices that reduce the spread of antimicrobial resistance while maintaining the health and welfare of the herds and flocks. His research work is focused on understanding the dynamics and risks for antimicrobial resistance in livestock, and the development of health management strategies for reduced antimicrobial resistance and improved health and welfare of herds and flocks. Other areas of interest include the use of alternatives to antibiotics to control infectious diseases in livestock, and the development and evaluation of vaccines and rapid diagnostics tests.

Prior to joining UC Davis faculty in 2018, Okello was a postdoctoral scholar at the UC Davis Veterinary Medicine Teaching and Research Center in Tulare, California. His postdoctoral research included surveillance for antimicrobial resistance on California dairies and developing decision tools to guide antimicrobial drugs treatments for dairy cows. Okello earned his Bachelor of Veterinary Medicine from Makerere University in Uganda, Master of Molecular Biology from *Katholieke Universiteit Leuven* and a Ph.D. in Bio-Engineering Sciences from *Vrije Universiteit Brussel* in Belgium.

Alfonso Lago, DVM, Ph.D., no biography provided.

Roberta Brancher Franco, Ph.D., works as a Senior Environmental Scientist (Supervisory) at the California Department of Food and Agriculture (CDFA). In her current, Roberta oversees several programs that have the goal of reducing methane emissions from California agricultural operations, with a focus on dairy and livestock facilities. These programs are the Dairy Digester Research and Development Program (DDRDP), the Alternative Manure Management Program (AMMP), the California Livestock Methane Measurement, Mitigation and Thriving Environments Research Program (CLIM3ATE-RP), and the CDFA Organic Waste Composting. She has a Ph.D. in Horticulture and Agronomy and an M.S. in Animal Biology from the University of California Davis, and a B.S. in Agronomic Engineering from the University of São Paulo, Brazil.

Alyssa Louie, DVM, MPVM, is a Senior Environmental Scientist at the California Department of Food and Agriculture (CDFA) and leads the Alternative Manure Management Program (AMMP), a Climate Smart Agriculture grant program incentivizing the implementation of non-digester manure management practices that will reduce greenhouse gas emissions on California dairy and livestock operations. Previously, she worked as the Bovine Programs Veterinarian Specialist with the CDFA Animal Health Branch. She received her Doctor of Veterinary Medicine and Master of Preventive Veterinary Medicine degrees from the University of California, Davis.

Harsimran (Rosie) Gill, Ph.D., is a Senior Environmental Scientist at the California Department of Food and Agriculture (CDFA). In her current job, she leads the Dairy Digester Research and Development Program (DDRDP). It is a Climate Smart Agriculture grant program which awards the competitive grants to California dairy operations and digester developers for the implementation of anaerobic digesters on dairies resulting in methane emission reductions and minimizing or mitigating adverse environmental impacts.

She received her Ph.D. in Entomology from University of Florida, USA, and M.S. in Entomology (Minor: Plant Pathology), and a B.S. in Agriculture (Hons.) from the Punjab Agricultural University, India.

Kristan F. Reed, Ph.D., grew up on St. Croix in the US Virgin Islands before earning her B.S. in Animal Science from Cornell University. She spent three years as a Peace Corps Volunteer in the mountain nation of Lesotho before returning to school to complete a Ph.D. in Animal Biology at the University of California at Davis. She has a research and extension position in the Department of Animal Science at Cornell focused on using modeling tools to support dairy farm management. The Ruminant Farm System model is a major component of her research program, through which she aims to improve dairy production efficiency and sustainability.

Mike Van Amburgh, Ph.D., is a Professor in the Department of Animal Science and a Stephen H. Weiss Presidential Fellow at Cornell University where he has a dual appointment in teaching and research. His undergraduate degree is from Ohio State University and his Ph.D. is from Cornell University. He teaches multiple courses and leads the Cornell Dairy Fellows Program, advises approximately 50 undergraduate students and is the advisor for the Cornell University Dairy Science Club. Mike currently leads the development of the Cornell Net Carbohydrate and Protein System (CNCPS/CPM Dairy), a nutrition evaluation and formulation model used worldwide. Through the modeling effort, he focuses on enhancing the efficiency of nutrient use by ruminants to improve the environmental impact of animal food production. A significant component of his current work is to understand whole animal and ruminal nitrogen metabolism and amino acid supply and requirements to enhance the development of the Cornell Net Carbohydrate and Protein System. Further, his group is active in developing methods to better describe the interaction between forage and feed chemistry, rumen function, and nutrient supply to compliment the model. He has authored and co-authored over 100 journal articles and many conference proceedings and is the recipient of several awards including the American Dairy Science Foundation Scholar Award, the Land O'Lakes Teaching and Mentoring Award from ADSA, the American Feed Ingredient Association Award for Research, Journal of Dairy Science Most Cited Award, the CALS Professor of Merit Award and the CALS Distinguished Advisor Award. In 2016, he was named a Stephen H. Weiss Presidential Fellow, the highest teaching award given by Cornell University.

Tony Rubino was born in Mission Hills, California. He graduated from William S. Hart High School, Newhall, California in 1981. He earned a Bachelor of Science degree in Electrical Engineering from California State University, Fresno (CSUF) in 1988 and earned an Executive Masters of Business Administration from CSUF in January 2010. In April 2013 he completed Air War College with Excellence through distance learning. In October 2018 he completed coursework to be a Myers-Briggs Type Indicator (MBTI) Certified Practitioner.

He has been a student of leadership for 30 years and is passionate about teaching and studying it to empower people to develop their leadership skills to impact their lives, both personally and professionally, and to positively influence those around them, to include their families and their communities. He has taught beginning and advanced leadership courses to over 1000 personnel for the Department of Defense for the Air Force since 2003. In addition, he has taught beginning leadership courses at California State University, Fresno and Ventura Community College to over 260 students since 2009. He has also taught leadership material in California for the International Leadership Institute since 2011. He has been providing Leadership and Strategic

Development Consulting to companies in the Dairy Industry since 2014, Renewables Industry since 2015 and Private School Boards since 2016.

He has served in many different leadership positions for the Department of Defense for the Air Force for over 34 years. He has also served in leadership positions on a number of Councils for CSUF and California State University, Northridge (CSUN). He served as the Chairman of the CSUF Valley Industry Partnership Engineering Council for two years where he and the council members developed the “Quadruple Win” philosophy. He also served on the CSUF Electrical and Computer Engineering Advisory Council where he proposed professional development in undergraduate engineers which resulted in him and other industry members offering leadership, lean, and project management courses. For his work, in 2008 he received the CSUF College of Engineering Outstanding Community Partner Award for Electrical and Computer Engineering for 2008. For his work on the Mechanical Engineering Industrial Advisory Board at CSUN as the Industry Chairman from 2004 through 2006, he received the 2005 Volunteer Service Award for the College of Engineering and Computer Science. He also served on the Tehachapi Unified School District School Board from 2002 to 2006, holding the Vice-President and President positions. In 2016, he received the 2016 Top Dog Award from the Division of Graduate Studies from California State University Fresno for his volunteer work and Leadership Development of Fresno State Engineering Students.

He has been married to his wife, Tami, for 26 years and they have twin sons and twin daughters and nine grandchildren. He and his wife enjoy gardening, traveling, and serving others in their community. In addition, Tony enjoys fishing, camping, and backpacking in the Sierra Nevada Mountains.

California Animal Nutrition Conference
2023 Steering Committee

Chairperson: Ruben Almada, B.A.Sc., Turlock Dairy & Refrigeration
Ruben Almada was born and raised in the Hilmar, California area. Growing up on a dairy steered him toward a life in the dairy world. He graduated from California Polytechnic State University-San Luis Obispo in 2006 with a Dairy Science Degree. Upon completing his degree Ruben joined Cargill Animal Nutrition in the fall of 2006 where he was a Dairy Management Consultant for 3 years. He then joined Kemin Animal Health and Nutrition in July of 2010 as the Key Account Manager covering California and Arizona for the Dairy Segment. In April of 2021, Ruben joined Turlock Dairy & Refrigeration as a Farm Management Support Specialist helping dairymen merge cows with automation. He is married to his wonderful wife, Jennifer, and they have two children, Kinley (9) and Jaxson (7).

Vice Chairperson: Kyle Thompson, Ph.D.
Kyle Thompson received his B.S. degree in animal science from Fresno State (2006) and his master's and Ph.D. degrees in animal science from Oklahoma State (2011/2015). He joined the Fresno State staff in the fall of 2016 after taking classes and teaching at Oklahoma State from January 2007-June 2016 and serving as the graduate student assistant manager of the campus dairy cattle center. His research included dairy nutrition research trials and lactating cow probiotics. He also assisted in research for bovine respiratory disease, rumen temperature bolus, milk production by weigh-suckle-weigh, and swine antimicrobial replacements. He also assisted in 4-H and FFA Field Day dairy judging competitions. While in Stillwater, OK, he owned and operated Wild Acre Farms and Exotics, which raised ewes, game birds, free-range hens, and other fowl/animals, and produced grasses and winter wheat for grazing and hay production. As a Fresno State student, he worked in the sheep unit for three years, served as a campus farm tour guide, and dairy unit herdsman and feed/hospital technician. He also worked as an exotic animal nutrition intern (2009) and a global nutrition fellow at the San Diego Zoo (2013).

Ex-Officio: Zachery Meyer
Zachery Meyer was raised in Ixonia, Wisconsin. He grew up immersed in his family's business, Rock River Laboratory. Meyer spent many hours helping in various jobs around the laboratory, seeing first-hand the dedication and commitment his father and the late Twilah Kulow had to the business and their customers. Meyer gathered business experience at Clear Channel and GE Medical while working toward his degree from the University of Wisconsin-Milwaukee. In 2007, Meyer resumed his involvement in Rock River Laboratory, starting as a soil sampler, moving to outside sales, and eventually taking on his current role of director of operations. Meyer still gathers inspiration from the Rock River Laboratory employees and mentors who cultivated his drive for customer satisfaction and service, while continuing to learn and deepen his understanding of animal nutrition and agronomy. When he isn't building relationships with customers or overseeing laboratory operations, Meyer spends his time playing or watching sports and sharing family time with his wife and two young daughters.

Committee Members:

Brian Rainey, M.S., MBA, P.A.S., Pine Creek Nutrition Service, Inc.
Upon graduating from Kansas State University, Brian made a gradual progression west seeking career fulfillment in working hands-on with livestock producers. Brian joined Pine Creek Nutrition Service, Inc. in May 2010 and brings a science, business, and industry portfolio to the consulting staff. Brian received a Bachelor of Science degree in Animal Science in 2001 from Kanas State University, Manhattan, KS, a Master of Science in Ruminant Nutrition in 2004 from Montana State University, Bozeman, and a Master of Business Administration, with Distinction, Phi Kappa Phi, May 2010 California State University, Fresno.

Carlyn Peterson, Ph.D., P.A.S., Selko USA
Carlyn Peterson is a Dairy Technical Manager covering the Western region of the US for Selko (formerly Micronutrients). Carlyn specializes in sustainable dairy systems and their interaction with dairy nutrition. Prior to joining Selko in October, Carlyn provided technical support for the Smartline category with Adisseo for two years. Between 2013 to 2020 she worked with Dr. Frank Mitloehner at the University of California, Davis, to complete a Master's degree and PhD in Animal Biology with a focus on Ruminant Nutrition and Sustainability. Carlyn also holds a Bachelor's degree in Animal Science, emphasis in Livestock and Dairy, from UC Davis. She is originally from San Diego County where she got her start in agriculture through participating in the FFA.

Josh Davy, M.S., University of California Cooperative Extension
Josh Davy is the livestock, range, and pasture advisor for Tehama, Glenn, and Colusa Counties and the county director in Tehama County. He started with extension in Tehama County in 2004. His program is diverse including research topics such as animal disease, supplementation, pasture and range improvement, forage production, and weed control. Josh is board certified by the American College of Animal Sciences, is a Certified Professional Animal Scientist specializing in beef cattle, and a Certified Range Manager through the California Department of Forestry and Fire Protection. His education includes an MS in Animal Biology and a bachelor's in agriculture business, with minors in animal science and business administration.

Joanne Verstuyft, B. A. Sc., Zinpro Corporation
Joanne Verstuyft was born and raised on her grandparent's ranch in the East Bay near El Sobrante, CA. Joanne started early in horses and cattle with her grandfather and uncle's influence. She competed in 4-H and jackpots with her horses and purebred Angus cattle at a young age. Joanne graduated from California Polytechnic University-San Luis Obispo in 2003 with an Agriculture Business degree concentration in marketing and beef cattle. After two successful college internships with Elanco, she joined Elanco as a Beef Cattle Sales Associate covering Western Nebraska, Northeastern Colorado, and Wyoming calling on feedlots and cow-calf operations. She returned to California as a Pharmaceutical Sales Representative for Lilly, and in late 2009, she joined Elanco's Dairy Team promoting rBST in the Central Valley. After fifteen years with Elanco, Joanne left to work for Pinnacle Premix in sales covering California and Arizona. In January 2019, Joanne joined Zinpro Corporation as an account manager

covering dairy and equine in California. She promotes Zinpro performance minerals in sharing data while also providing farm support, lameness evaluations, and hoof trimming. Joanne enjoys working in the animal agriculture industry and matching her passion and career. Joanne lives in the Bay Area, where she enjoys riding her horse and spending time with family and friends.

Noelia Silva-del Rio, Ph.D., University of California, Davis Veterinary Medicine School
Noelia Silva del Rio is the UC Davis Cooperative Extension Dairy Specialist at the veterinary medicine school. She is located at the Veterinary Medicine Teaching and Research Center in Tulare. She earned her veterinary degree from the University of Santiago de Compostela in Spain in 1998. She practiced for two years in the northwest region of Spain by supporting dairy producers with the implementation of reproduction, nutrition, and herd health programs. In 2007, she obtained her Ph.D. in Dairy Science from the University of Wisconsin with focus on nutrition and reproduction. Soon after graduation, she joined UCCE as a Tulare Dairy Advisor, a position she held for over three years before joining the UC Davis SVM as a Specialist in 2012. Her extension program aims to improve herd health through management from feeding to treatment decisions, with special focus on finding management solutions to mitigate transition cow disorders and calf health issues.

Sam Pearle, M.S., P.A.S., Adisseo

No biography provided.

CANC Chairperson History

YEAR	CHAIRPERSON	COMPANY AFFILIATION
2023	Mr. Ruben Almada	Turlock Dairy & Refrigeration
2022	Mr. Zachery Meyer	Rock River Laboratory, Inc.
2021	Jennifer Heguy, M.S., P.A.S.	University of California, Coop. Ext.
2020	NO CANC CONFERENCE	
2019	David Ledgerwood, M.S., P.A.S.	Chr-Hansen
2018	Jason Brixey, M.S., P.A.S.	Pine Creek Nutrition Service
2017	Dr. Phillip Jardon, DVM, MPVM	Elanco Animal Health
2016	Dr. Phillip Jardon, DVM, MPVM	Elanco Animal Health
2015	Mr. Ben Tarr	Adisseo USA Inc.
2014	Dr. Jeffrey M. DeFrain	Zinpro Performance Minerals
2013	Mr. Doug DeGroff	Diversified Dairy Solutions, LLC
2012	Mr. Eduardo Galo	Novus International, Inc.
2011	Dr. Michael A. DeGroot	DeGroot Dairy Consulting
2010	Dr. Jim Tully	Pine Creek Nutrition Service, Inc.
2009	Mr. Michael Braun	Phibro Animal Health
2008	Dr. Luis Rodriguez	Zinpro Corporation
2007	Dr. Marit Arana	A.L. Gilbert Company
2006	Mr. Dennis Ervin P.A.S.	Prince Agri Products, Inc.
2005	Dr. Lawson Spicer	Nutri Management Inc.
2004	Dr. Luis Solorzano	Purina Mills, Inc.
2003	Dr. Alfonso Mireles, Jr.	Foster Farms
2002	Mr. Edmund Vieira	Pine Creek Nutrition Service, Inc.
2001	Dr. Melinda Burrill	California State Polytechnic University - Pomona
2000	Mr. Dave Fischer	Foster Farms
1999	Dr. M. Steven Daugherty	California State Polytechnic University - SLO
1998	Dr. Doug Dildey	Alltech, Inc.
1997	Ms. Carla Price	Nutritionist
1996	Dr. H.John Kuhl, Jr.	Nest Egg Nutrition
1995	Mr. Dennis Ralston	M. Rinus Boer Co., Inc.
1994	Dr. Doug Dildey	Alltech, Inc.
1993	Dr. Mark Aseltine	ConsultingAnimal Nutritionist
1992	Dr. Carl Old	MacGowan-Smith Ltd.
1991	Mr. Nick Ohanesian	Ohanesian & Associates
1990	Mr. Rod Johnson	M. Rinus Boer Co., Inc.
1989	Mr. Timothy Riordan	Nutri-Systems, Inc.
1988	Dr. Russ W. Van Hellen	Great West Analytical
1987	Dr. John E. Trei	California State Polytechnic University, Pomona
1986	Dr. A.A. Jimenez	Ancon, Inc.
1985	Dr. Wm. A. Dudley-Cash	Foster Farms
1984	Dr. Joel Kemper	Penny-Newman Co.

CANC Chairperson History Continued

YEAR	CHAIRPERSON	COMPANY AFFILIATION
1983	Dr. Alex J. Kutches	O.H. Kruse Grain & Milling Co.
1982	Dr. Howard Waterhouse	Bell Grain & Milling
1981	Mr. Don Ulrich	Diamond Shamrock Chemical Co.
1980	Mr. Tom Geary	PMS-West, Inc.
1979	Dr. Frank Parks	Kemlin Industries
1978	Mr. Fred Pfaff	Zacky Farms
1977	Mr. Rene Lastreto	Diamond Shamrock Chemical Co.
1976	Mr. Rene Lastreto	Diamond Shamrock Chemical Co.
1975	Dr. R.D. Hendershott	Nulaid Foods
1974	Dr. R.D. Hendershott	Nulaid Foods
1973	Dr. Leland Larsen	Nutri-Systems, Inc.
1972	Dr. Leland Larsen	Nutri-Systems, Inc.
1971	Mr. Rene Lastreto	Diamond Shamrock Chemical Co.
1970	Mr. Fred Pfaff	Balfour Guthrie
1969	Mr. Fred Pfaff	Balfour Guthrie
1968	Mr. Fred Pfaff	Balfour Guthrie
1967*	Mr. Gary L. Frame	J.G. Boswell Co.
1966*	Mr. Gary L. Frame	J.G. Boswell Co.
1965*	Mr. Arne Jalonen	Topper Feed Mills
1964*	Mr. Arne Jalonen	Topper Feed Mills
1963*	Dr. W.P. Lehrer	Albers Milling Co.
1962*	Dr. H.J. Almquist	The Grange Co.
1961*	Dr. H.S. Wilgus	The Ray Ewing Co.
1960*	Mr. Bert Maxwell	Nulaid Foods
1959*	Mr. Bert Maxwell	Nulaid Foods
1958*	Mr. Robert Caldwell	Anderson Smith Milling Co.
1957*	Mr. Emery Johnson	P.C.A., Los Angeles
1956*	Mr. Emery Johnson	P.C.A., Los Angeles
1955*	Dr. H.J. Almquist	The Grange Co.
1954*	Dr. H.J. Almquist	The Grange Co.
1953*	Mr. Clifford Capps	California Milling Co.
1951*	Mr. Dolph Hill	Golden Eagle Milling Co.
1950*	Dr. H.J. Almquist	The Grange Co.
1949*	Dr. H.J. Almquist	The Grange Co.
1948*	Dr. H.J. Almquist	The Grange Co.

* California Animal Industry Conference

History of the
California Animal Nutrition Conference

The California Animal Nutrition Conference (CANC) originated in the 1940s as the California Animal Industry Conference, sponsored by the California Grain & Feed Association (CGFA). CGFA wanted to expand the continuing education program into a forum encompassing animal health, nutrition, and management. The expectations were that communications between (nutritionists) industry, educational institutions, and regulatory agencies would be improved. In 1972, CGFA discontinued sponsoring the Animal Industry Conference.

After the conference was discontinued, a small group of nutritionists began meeting annually in Fresno. Two or three invited speakers from industry or the universities presented information on nutrition, especially poultry.

In 1975 a set of organizational bylaws were developed by the steering committee. CANC was established and was provided support by CGFA. The CGFA Board of Directors appointed a chairperson annually and approved the steering committee. In 1978, Dr. Frank Parks, the Chairperson, requested that CANC be granted independent status and be established as a self-governing committee of CGFA. This request was granted.

For a few years, meetings were held in Fresno and Corona, California. For a couple of years starting in 1978, CANC published "Nutri-Facts," a "newsletter" consisting of articles on animal production.

In 1979, donations were requested from industry companies to help keep registration fees low. During the 1980s and through the 1990s the attendance at CANC continued to grow as the quality of the conference improved and the conference became known nationwide. In the 1990s a pre-symposium was added. The pre-symposium is sponsored by a company selected by the CANC Steering Committee and this process allows the selected company to showcase its research and products. In the year 2000, posters on research by students were included.

Attendance at the conference has grown from 50 in the 1970s to over 300 attendees. To encourage attendance, different activities have been tried such as keynote speakers, skiing expeditions, and a very successful barbeque dinner put on by the Animal Science Department at California State University, Fresno.

The California Grain & Feed Association has supported and allowed CANC to work and grow. The premise of the CGFA and CANC relationship is to work together to educate the feed industry with information for problem-solving and to disseminate valuable research information. CANC is not an industry, university, or government entity, but a committee collectively working together for the good of agriculture in California.