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## THIS MONTH'S ARTICLE:

# Effects of Inflammation on Nutrition: Is Sickness Causing Weakness in your Diets?

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# Effects of Inflammation on Nutrition: Is Sickness Causing Weakness in your Diets?

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**Summary:**

- Immune activity impacts metabolism
    - Proinflammatory cytokines act directly on metabolic tissues to alter metabolism
    - Proinflammatory cytokines act on endocrine tissues to alter hormone secretions
    - Altered hormone profiles have secondary effects on metabolic tissues
- Metabolic intermediates impact immune function
    - Nonesterified fatty acids and ketone bodies decrease immune function
    - Triglyceride accumulation in the liver decreases immune function
- Immune activation negatively affects variable important to livestock production
    - Growth is decreased during immune activation
    - Reproductive efficiency is decreased during immune activation
    - Milk synthesis is decreased during immune activation
    - Some aspects of metabolic health are decreased during immune activation
- Practical recommendations
    - Nutrient requirements that maximize immunity are unknown
    - Concept-based nutrition – if a nutrient has known importance for immunity, feed high-quality source to at least NRC requirements
    - Manage animals to decrease incidence and severity of infectious disease and inflammation in order to minimize negative effects on growth, reproduction, milk production, and metabolic health

## Background

Within the last several years, the relationship between immunity and metabolism has been realized to be very complex and intertwined. Thinking from our own experiences as humans, it becomes easy to appreciate some of the connections between health and nutrition that we may usually just take for granted. For example, we have all experienced changes in appetite when we get the flu or even during times when we had a severe headache. Often we accept these changes in appetite during periods of infection or inflammation without really thinking about them, but research has revealed that these changes in appetite actually physiological adaptations that our body makes such that infection or inflammation can be resolved as quickly and efficiently as possible (Kelley et al., 2003). Furthermore, many other underlying metabolic adaptations occur to support immune function during periods of sickness such that variables important to livestock production systems (i.e., growth, reproduction, lactation, or metabolic health) are compromised despite the presence of seemingly sound dietary formulation.

**Immunology 101**

Infection occurs when a population of invading pathogens (i.e., bacteria, viruses, protozoa, etc.) becomes established within another living organism. Infections of the respiratory or digestive tracts are common in growing animals, and additionally, infections of the mammary gland (mastitis) or uterus (metritis) are common sources of inflammation in lactating dairy cows. Other health disorders common during the periparturient period in dairy cows (e.g., milk fever and ketosis) do not directly arise from infectious organisms, but instead have metabolic origins.

During infection, a pathogen gains entry through the physical or mucosal barriers of the animal and becomes established within the tissue. Certain white blood cells, or leukocytes, of the immune system [including macrophages, monocytes, and polymorphonuclear neutriphils (PMN)] serve as sentinels for the animal and become activated when they come in contact with these "non-self" pathogens. Upon activation, leukocytes secrete signaling molecules that support the immune response called proinflammatory cytokines. The proinflammatory cytokines include tumor necrosis factor-$\alpha$ (TNF-$\alpha$), interleukin-1$\beta$ (IL-1), and interleukin-6 (IL-6); however, numerous other cytokines exist to support the immune response as well. These cytokines are initially secreted by leukocytes at the site of infection where they act locally to activate other immune cells. Furthermore, these cytokines and another group of leukocytic molecules called chemokines diffuse into the blood where they can activate and direct other leukocytes to the site of infection. Thus, the site of infection becomes a hotbed of activity where multiple leukocyte classes migrate into the tissue to help kill and clear pathogens from the infected tissue. The leukocytes of this immune response are made up of cells from the innate immune system that are very generic in their ability recognize and kill pathogens [earliest response (minutes to hours)], and also of cells from the adaptive immune system that are very specific for which pathogens they engage [later response (days to weeks)].

**Integration of Immune Function and Metabolism**

To this point, we have only discussed how the immune system responds to an infectious challenge. However, the events just described also have effects outside of the "traditional" immune system because metabolic tissues have functional receptors for the signaling molecules of the immune system. For example, the proinflammatory cytokines have direct effects on such metabolic tissues as the brain, skeletal muscle, adispose tissue (fat), liver, and endocrine glands (Johnson, 1997). Klasing (1988) reviewed the impacts of cytokines on metabolism and reported that feed intake, protein metabolism, fat metabolism, carbohydrate metabolism, mineral metabolism, and endocrine secretions were all affected by inflammation. Furthermore, secondary effects of immune activation also occur via classical metabolic endocrine regulation due to changes in endocrine gland secretions (Waldron et al., 2003; Waldron et al., 2006).

Further complicating the relationship between immune function and metabolism, it is now clear that not only do metabolic tissues respond to signals from the immune system, in many cases "metabolic" tissues actually produce and secrete immune-related molecules as well. Far from an exclusive list, it is has now been shown that mammary epithelial cells produce several acute-phase proteins and cytokines including TNF-$\alpha$ and interleukin-8 (Wellnitz and Kerr, 2004); the liver produces antimicrobial peptides (Sang et al., 2006) and acute-phase proteins and cytokines (Loor et al., 2005), the anterior pituitary gland produces among others, IL-6 and prostaglandins (Abraham et

al., 1998); and fat cells (adipocytes) produce such a wide range of immune-related molecules (including membrane-bound TNF-α, IL-6, resistin, etc.) that these molecules have been termed adipocytokines or adipokines (Hutley and Prins, 2005).

Completing the relationship between immune function and metabolism, it has also been reported that multiple metabolites influence immunity. The role of dietary nutrients in supporting immune function has received significant research attention. Vitamins (e.g., vitamins C, D, and E) and trace minerals (e.g., zinc or selenium) are all familiar to us from advertisements touting the role of these nutrients in human health and disease. Furthermore, at least basal levels, and in some cases supranutritional levels, of these nutrients have been shown be supportive for animal health in livestock production systems (Spears, 2000; Weiss, 1998). However, another set of nutrition-related molecules present in the blood that are intermediates in certain metabolic pathways also influence immune function. In this sense, molecules related to fat metabolism have received much attention for their effects on immunity. Concentrations of ketone bodies [e.g., β-hydroxybutyrate (BHBA) and acetoacetate] and nonesterified fatty acids (NEFA) are elevated in blood during periods of negative energy balance. As such, these molecules have been studied for their contribution to the period of immunosuppression that occurs around the time of calving in dairy cattle. Elevated concentrations of ketone bodies and/or NEFA decrease the ability of various leukocyte classes to multiply and grow in response to an immune challenge (Gregory et al., 1993; Sato et al., 1995), decreased the production of bacteriocidal compounds and bacteriocidal activity by PMN (Hoeben et al., 1997; Sartorelli et al., 2000), and decreased the capacity of leukocytes to migrate to the site of infection (Suriyasathaporn et al., 1999). Furthermore, physiological concentrations NEFA alone reduced the functional capacity of lymphocytes in vitro (Lacetera et al., 2004). These mechanistic reports of decreased immune function support the results of Kremer et al. (1993) who reported that cases of mastitis became more severe in ketotic cows than in non-ketotic cows. Similarly, accumulation of triglyceride in the liver of dairy cows was also associated with decreased ability to clear bacterial endotoxin from blood (Andersen et al., 1996), and decreased functional capacity of PMN harvested from either the blood or uterus (Zerbe et al., 2000).

**Effects of Immune Activation on Growth**

Sick animals grow more slowly than do healthy animals (Johnson, 1997; Spurlock, 1997). Reduced growth is a result of both changes in traditional endocrine hormones and also an effect of proinflammatory cytokines directly on metabolic tissues. Infection or inflammation results in decreased feed intake, but the reduction in growth caused by immune activation is often greater than can be explained by changes in feed intake alone (Tracey et al., 1988). In addition to decreased feed intake, immune activation in many species has resulted in GH resistance, or an apparent uncoupling of the somatotropic axis; that is, increased serum GH concentrations were not accompanied by changes in serum IGF-1 concentrations, or no change in growth hormone was associated with a decrease in plasma IGF-1 concentration. Spurlock (1997) also reported uncoupling of the somatotropic axis in immune challenged pigs such that administration of exogenous somatotropin did not prevent reductions in circulating IGF-1 concentrations. Investigations of immune-triggered uncoupling of the somatotropic axis in laboratory animals suggest that cytokines alter GH receptor signaling and subsequent expression of the acid-labile subunit of IGF-1 (Mao et al., 1999; Boisclair et al., 2000). Another aspect of the somatotropic axis that may influence trophic activities is the concentration of IGF binding proteins after immune activation. Changes in binding

proteins such as those reported in calves (Elsasser et al., 1995) and sheep (Briard et al., 2000) could tissue-specifically affect the metabolic influence of IGF-1, even without changes in plasma IGF-1 concentrations. Davis (1998) postulated that uncoupling of the somatotropic axis may indirectly play a role in the immune response by partitioning nutrients away from productive tissues (e.g., skeletal muscle or mammary gland) for subsequent use by the immune system and directly, by positive actions of GH on the immune system. Indeed GH has been shown to enhance immune function in healthy and diseased cows (reviewed by Burvenich, et al., 1999).

Alterations in the somatotropic axis discussed above, in addition to other endocrine changes and the direct effects of cytokines on metabolic tissues are responsible for changes in net protein deposition. Klasing and Austic (1984a,b) reported that immune activation resulted in changes in both, protein synthesis and degradation rates such that the net effect was decreased muscle mass gain. The reason for the increased protein catabolism relative to synthesis is uncertain; however, it has been hypothesized that the increased efflux of amino acids from skeletal muscle are shunted to the liver to support the immune response and are necessary to make up for the decreased intake of amino acids in feed, the increased need of the liver for gluconeogenic amino acids, and the significant amount and changed profile of amino acids needed for acute phase protein synthesis compared to the normal (non-inflammatory) hepatic proteins (Spurlock, 1997; Reeds et al., 1994).

**Effects of Immune Activation on Reproduction**

Integration of immune function with reproductive efficiency in cattle has often been studied using a mastitis model of immune activation. Not only has clinical mastitis been shown to reduce reproductive performance in lactating dairy cows (Barker et al., 1998), but subclinical mastitis also has negative effects (Schrick et al., 2001). Schrick et al. (2001) reported that subclinical mastitis decreased reproductive efficiency by increasing days to first service, days open, and number of services per conception. Immune activation via experimental means or natural infection of the mammary gland has been shown to affect multiple reproductive tissues at various times in the estrous cycle. Huszenicza et al. (1998) reported that mastitis infection occurring in the first 14 d after calving did not affect ovarian cyclicity, but that mastitis between d 15 through 28 delayed the time to first ovulation and first estrus. The authors also reported that Gram-negative mastitis in already cycling cows during the luteal phase resulted in luteolysis, whereas mastitis during the follicular phase prolonged the period of low progesterone, perhaps resulting from degeneration of the dominant follicle. During clinical Gram-positive mastitis of cows in the luteal phase of their cycle, Hockett et al. (2000) reported elevated circulating concentrations of cortisol and following oxytocin administration, greater circulating prostaglandin F($2\alpha$) concentrations. Such endocrine changes could result in luteal regression and decreased embryo viability.

**Effects of Immune Activation on Lactation**

Immune activation results in dramatic changes in circulating concentrations of cytokines and hormones in the blood. These alterations in endocrine profile, and cytokines themselves, cause a marked decreased milk production in lactating cows (Rajala-Schultz et al., 1999; Shuster and Harmon, 1992; Shuster et al., 1991a). Decreased milk synthesis is not due simply to decreased feed intake associated with sickness because healthy cows that were pair-fed to acutely mastitic cows displayed normal milk production while their mastitic counterparts decreased milk production by

up to 70% (Waldron et al., 2006). Lohuis et al. (1990) reported the loss of total daily milk production of cows was related positively with areas under the curves of heart rate, rumen amplitude, and counts of E. coli in secreta from inoculated quarters. The decreased milk production due to mastitis is mediated by multiple pathophysiological events and is not solely due to inflammatory damage in the mammary epithelium. Part of the reduced lactational performance may result from escape of milk components from the udder into the circulation (Shuster et al., 1991b). Reduced lactational performance is not mediated by the acute cortisol increase associated with inflammation (Shuster and Harmon, 1992) or by reduced concentrations of growth hormone or IGF-1 (Shuster et al., 1995). These authors also noted that inflammatory cytokines are produced at a time consistent with a possible role in the inhibition of milk synthesis (Shuster et al., 1995). The positive effects of growth hormone on milk production and recovery from coliform mastitis may be due to the enhanced function of neutrophils resulting in a better defense of the mammary gland (Burvenich et al., 1999).

**Effects of Immune Activation on Periparturient Metabolic Health**

A significant body of research has examined the effects of nutrition and metabolism on immune function. For example, dietary supplementation with certain trace minerals and vitamins improve immunity (Spears, 2000; Weiss, 1998) and the hyperketonemia that is common during early lactation is reported to have multiple negative effects on several aspects of immunocompetence (Suriyasathaporn et al., 2000). Furthermore, aspects of immune activation that affect milk synthetic physiology have also received significant attention (Shuster et al., 1995; Shuster et al., 1991a,b; Shuster and Harmon, 1992). The potential causal mechanistic relationship between mastitis and metabolic disease has received little attention. We hypothesized that immune activation of early-lactation dairy cows using an experimental mastitis model initiated by the intramammary infusion of bacterial LPS would result in quantitative changes in energy and mineral metabolism that be causal toward the development of periparturient metabolic disorders.

On d 7 of lactation, multiparous cows were administered intramammary LPS to cause experimental mastitis or sterile saline (control cows) and physiological measurements were made to study the metabolism of these in animals. Saline-treated cows were pair-fed with an individual LPS-infused cow such that the effects of LPS infusion would not be confounded with feed intake. Among the physiologic methods employed, a primed continuous infusion of stable isotopically labeled glucose (D2-glucose) was administered to serve as a "tracer" for the measure of glucose kinetics.

Variables that might be associated with the fatty-liver/ketosis complex were not negatively affected during the early stages of acute mastitis. Plasma glucose concentration was slightly increased, glucose rate of appearance into plasma was increased (Figure 1), and plasma NEFA (Figure 2) and BHBA (Figure 3) concentrations were decreased in mastitic cows relative to the pair-fed control cows. Among variables that might be associated with the development of milk fever, plasma concentrations of both, calcium (Figure 4) and phosphorus were significantly decreased during the early hours of mastitis.

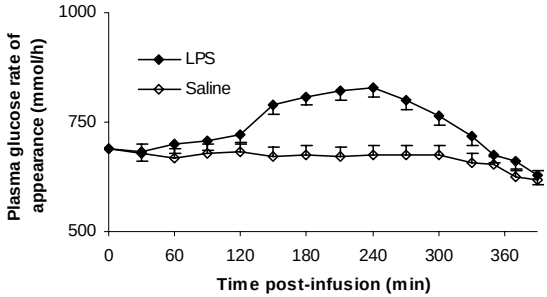


**Figure 1.** Plasma glucose rate of appearance of early-lactation dairy cows administered intramammary lipopolysaccharide (to cause mastitis) or saline at 0 minutes[a]. Data were covariately adjusted using the mean rate of appearance during the steady state period from -90 through 0 minutes.

[a] treatment by time effect, $P < 0.01$

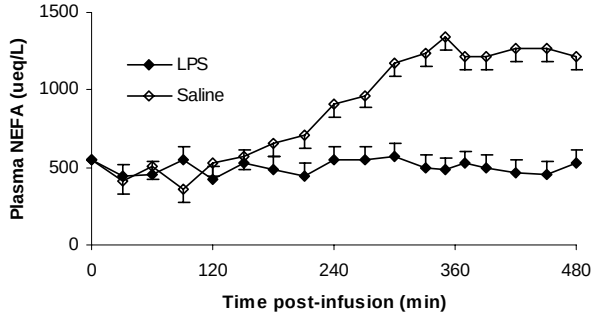


**Figure 2.** Plasma nonesterified fatty acid (NEFA) concentration following intramammary lipopolysaccharide (to cause mastitis) or saline infusion into early-lactation dairy cows[a]. Means were adjusted by analysis of covariance using the mean NEFA concentration for each treatment group from –240 through 0 minutes relative to intramammary infusion.

[a] treatment by time effect, $P < 0.01$

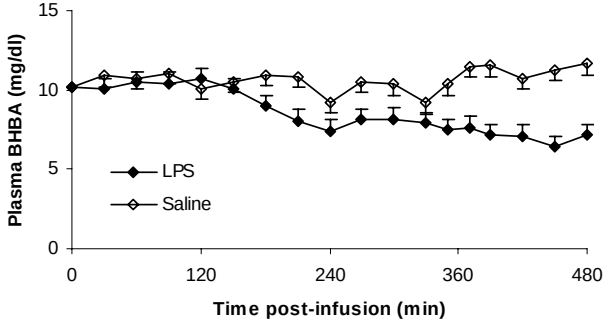


**Figure 3.** Plasma β-hydroxybutyrate (BHBA) concentration following intramammary lipopolysaccharide (to cause mastitis) or saline infusion into early-lactation dairy cows[a]. Means were adjusted by analysis of covariance using the mean BHBA concentration for each treatment group from –240 through 0 minutes relative to intramammary infusion.

[b] treatment by time effect, $P < 0.01$

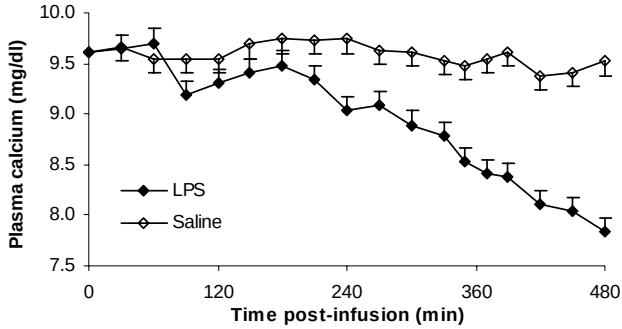


**Figure 4.** Plasma calcium concentration following intramammary lipopolysaccharide (to cause mastitis) or saline infusion into early-lactation dairy cows[a]. Means were adjusted by analysis of covariance using the mean calcium concentration for each treatment group from –240 through 0 minutes relative to intramammary infusion.

[b]treatment by time effect, $P < 0.01$

The implications of these results are that indeed, metabolism of periparturient cows is altered by activation of the immune system. The integration of the immune response with metabolic systems appears to protect the cow from energy-related metabolic disturbances, but this integration of response may not be adequate for eumineralemia in the periparturient cow. It is possible that hypocalcemia and hypophosphatemia may contribute to the clinical signs of acute mastitis (e.g., weakness and recumbency), and it is plausible that they could contribute to the secondary incidence of metabolic disease including milk fever, displaced abomasum, and retained placenta. The effects of sustained inflammation (i.e., 24-72 hours) on energy and mineral metabolism is warranted before further conclusions should be made.

**Practical Recommendations**

It is evident that the effects of nutrition and immunity are interrelated. Nutritional physiology impacts immune function and immune activity alters metabolism. At this time, specific recommendations to optimize nutritional immunology are difficult because research is lacking. Our current nutritional recommendations are based on the amount of a given nutrient that will result in no deficiency symptoms for the nutrient and maximizes productive processes (e.g., growth, milk production) - the amount of that same nutrient that maximizes immunity may be very different. Obviously, the best way to minimize the negative effects of immune activity on nutrition and metabolism is to minimize the occurrence and severity of infection and inflammation in livestock production systems. Unfortunately, we have little peer-reviewed research to support specific nutritional recommendations to maximize immunity, and most of our efforts to minimize immune activation will be management oriented. At this time, our best recommendations in feeding for optimal nutritional immunity are concept-based. That is, we don't know the specific requirements yet, but we are beginning to understand some of the nutrients that impact immune function, and we can therefore nutritionally manage the animal to optimize those nutrients and/or metabolites. For example, we know that many trace minerals and vitamins are important in immune function. We don't know what level of these nutrients maximizes immunity, but we do know that deficiencies impair immunity. Therefore, we strive to meet or exceed National Research Council requirements with these nutrients coming from high quality sources. Another example of concept-based feeding regards managing the periparturient dairy cow to minimize

negative energy balance. We know that excessive plasma NEFA and ketone-body metabolism can impair immunity, therefore we must attempt to manage the animal such that plasma NEFA and BHBA concentrations remain at moderate levels. To accomplish this we can incorporate the same strategies as those to maximize metabolic health in fresh cows – namely, balanced pre- and post-calving diets, watching for changes in the forage base that will result in nutritional imbalances, excellent feeding management, monitoring fresh cows to identify potential problems quickly, and minimizing stress on these animals.

**Implications**

Recent research highlights the interplay between the metabolic and immune systems such that we should not be surprised at the association between clinical events of the immune and metabolic systems. Researchers and farm advisors need to begin to think about nutrition and immunity not as exclusive concepts, but rather as integrated systems whereby the activity or events in one system have direct effects on the other. As such, the barriers between immunological and metabolic knowledge must be removed. Nutritionists need to make a concerted effort to understand at least the basics of immunology, and immunologists need to become comfortable with nutritionists delving into the subjects related to immunology. Growth, reproduction, milk synthesis, and metabolic health are all negatively impacted by immune activity; therefore, management of livestock production systems must strive to minimize both chronic and acute infectious or inflammatory insults in order to maximize the potential of dietary formulations.

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# HIGH COW REPORT
# AUGUST 2006

## MILK

| Arizona Owner | Barn# | Age | Milk | New Mexico Owner | Barn # | Age | Milk |
|---|---|---|---|---|---|---|---|
| * Stotz Dairy | 17414 | 04-10 | 40,880 | * Pareo Dairy | 8551 | 05-01 | 38,226 |
| * Stotz Dairy | 17427 | 04-11 | 39,740 | * Providence Dairy | 1100 | 04-03 | 38,210 |
| * Stotz Dairy | 20479 | 03-03 | 37,880 | * Providence Dairy | 137 | 05-05 | 37,250 |
| * Mike Pylman | 2410 | 04-05 | 37,850 | * New Direction Dairy | 1258 | ----- | 36,880 |
| * Mike Pylman | 22069 | ----- | 37,660 | * Butterfield Dairy | 1789 | 05-06 | 36,790 |
| * D & I Holstein | 486 | 09-04 | 37,370 | * Providence Dairy | 4365 | 06-10 | 36,600 |
| * Stotz Dairy | 16327 | 05-09 | 36,900 | * S.A.S. Dairy | 5568 | 06-03 | 36,390 |
| * Stotz Dairy | 15824 | 06-00 | 36,580 | * Butterfield Dairy | 5139 | 04-03 | 36,020 |
| * Stotz Dairy | 17283 | 04-11 | 36,320 | * Providence Dairy | 5402 | 04-11 | 35,840 |
| * Stotz Dairy | 18876 | 03-09 | 36,150 | * Pareo Dairy | 4562 | 04-09 | 35,503 |

## FAT

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| * Stotz Dairy | 17427 | 04-11 | 1,872 | * Caballo Dairy | 8036 | 04-00 | 1,782 |
| * Stotz Dairy | 17414 | 04-10 | 1,598 | * Caballo Dairy | 5585 | 05-00 | 1,575 |
| * Mike Pylman | 22069 | ----- | 1,587 | * Pareo Dairy | 4562 | 04-09 | 1,438 |
| * Stotz Dairy | 20479 | 03-03 | 1,422 | * Cross Country Dairy | 7176 | 08-06 | 1,399 |
| * Rio Blanco Dairy | 7041 | ----- | 1,413 | * New Direction Dairy | 1258 | ----- | 1,371 |
| * Stotz Dairy | 15824 | 06-00 | 1,409 | * Pareo Dairy | 1952 | 07-10 | 1,360 |
| * Stotz Dairy | 18226 | 04-02 | 1,345 | * Caballo Dairy | 9383 | 04-01 | 1,352 |
| * Rio Blanco Dairy | 6909 | 03-04 | 1,345 | * Caballo Dairy | 3642 | 07-02 | 1,334 |
| * DC Dairy, LLC | 4012 | 04-11 | 1,344 | * Providence Dairy | 5901 | 03-11 | 1,323 |
| * Stotz Dairy | 16327 | 05-09 | 1,341 | * Pareo Dairy | 9843 | 06-05 | 1,320 |

## PROTEIN

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| * Stotz Dairy | 17427 | 04-11 | 1,218 | * New Direction Dairy | 1258 | ----- | 1,188 |
| * Stotz Dairy | 17414 | 04-10 | 1,175 | * Caballo Dairy | 5585 | 05-00 | 1,138 |
| * Mike Pylman | 2410 | 04-05 | 1,128 | * S.A.S. Dairy | 5482 | 06-04 | 1,133 |
| * Shamrock Farms | Z3 | 04-04 | 1,100 | * Butterfield Dairy | 5139 | 04-03 | 1,129 |
| * Stotz Dairy | 20479 | 03-03 | 1,077 | * Providence Dairy | 8442 | 06-05 | 1,125 |
| * Goldman Dairy | 7416 | 04-11 | 1,074 | * Providence Dairy | 8873 | 05-11 | 1,124 |
| * Stotz Dairy | 18899 | 03-09 | 1,064 | * New Direction Dairy | 784 | ----- | 1,113 |
| * Ambian Dairy | 7220 | ----- | 1,062 | * Providence Dairy | 1100 | 04-03 | 1,095 |
| * Mike Pylman | 68 | 04-01 | 1,051 | * New Direction Dairy | 421 | ----- | 1,093 |
| * Mike Pylman | 1514 | 03-03 | 1,042 | * Cross Country Dairy | 2167 | 05-06 | 1,091 |

*all or part of lactation is 3X or 4X milking

# ARIZONA - TOP 50% FOR F.C.M.[b]
# AUGUST 2006

| OWNERS NAME | Number of Cows | MILK | FAT | 3.5 FCM | DIM |
|---|---|---|---|---|---|
| * Stotz Dairy West | 2,321 | 27,062 | 975 | 27,506 | 244 |
| * Stotz Dairy East | 1,076 | 25,357 | 920 | 25,878 | 244 |
| * Red River Dairy | 5,181 | 24,746 | 864 | 24,706 | 180 |
| * Mike Pylman | 7,879 | 24,550 | 851 | 24,410 | 226 |
| * Del Rio Dairy, Inc. | 1,386 | 24,294 | 833 | 24,008 | 182 |
| * Zimmerman Dairy | 1,219 | 23,695 | 847 | 23,976 | 225 |
| * Danzeisen Dairy, Inc. | 1,490 | 23,510 | 849 | 23,928 | 223 |
| * Withrow Dairy | 5,489 | 24,195 | 814 | 23,657 | 210 |
| Parker Dairy | 4,087 | 23,052 | 844 | 23,649 | 220 |
| * Arizona Dairy Company | 5,480 | 23,771 | 808 | 23,376 | 227 |
| * Dairyland Milk Co. | 2,978 | 23,377 | 818 | 23,368 | 206 |
| * Shamrock Farm | 8,425 | 23,927 | 773 | 22,876 | 214 |
| * Goldman Dairy | 2,157 | 22,793 | 798 | 22,791 | 226 |
| * Bulter Dairy | 590 | 22,663 | 784 | 22,508 | 221 |
| * Yettem | 2,905 | 19,291 | 872 | 22,477 | 169 |
| Paul Rovey Dairy | 335 | 21,754 | 792 | 22,245 | 219 |
| * RG Dairy, LLC | 1,236 | 22,017 | 778 | 22,132 | 219 |

# NEW MEXICO - TOP 50% FOR F.C.M.[b]
# AUGUST 2006

| OWNERS NAME | Number of Cows | MILK | FAT | 3.5 FCM | DIM |
|---|---|---|---|---|---|
| * Do-Rene | 2,469 | 26,687 | 939 | 26,766 | 196 |
| * Providence | 2,988 | 26,313 | 929 | 26,442 | 188 |
| * New Direction 2 | 2,199 | 25,399 | 942 | 26,258 | 244 |
| * Pareo | 1,570 | 25,543 | 909 | 25,785 | 195 |
| * Hide Away | 2,676 | 26,338 | 876 | 25,594 | 171 |
| * Butterfield | 2,027 | 25,765 | 879 | 25,395 | 220 |
| * Goff | 4,399 | 24,462 | 891 | 25,026 | 203 |
| * Milagro | 3,376 | 24,049 | 895 | 24,912 | 209 |
| * Vaz | 2,004 | 24,423 | 877 | 24,782 | 222 |
| * Wormont | 1,037 | 23,857 | 891 | 24,764 | 238 |
| * McCatharn | 1,020 | 24,900 | 861 | 24,729 | 185 |
| * Cross County | 3,748 | 24,018 | 863 | 24,380 | 179 |
| * Flecha | 2,359 | 23,454 | 870 | 24,249 | 212 |

* all or part of lactation is 3X or 4X milking

[b] average milk and fat figure may be different from monthly herd summary; figures used are last day/month

# ARIZONA AND NEW MEXICO HERD IMPROVEMENT SUMMARY FOR OFFICIAL HERDS TESTED AUGUST 2006

| | | ARIZONA | NEW MEXICO |
|---|---|---|---|
| 1. | Number of Herds | 35 | 27 |
| 2. | Total Cows in Herd | 67,188 | 44,954 |
| 3. | Average Herd Size | 1,920 | 1,665 |
| 4. | Percent in Milk | 88 | 87 |
| 5. | Average Days in Milk | 214 | 196 |
| 6. | Average Milk – All Cows Per Day | 51.2 | 63.8 |
| 7. | Average Percent Fat – All Cows | 3.5 | 3.6 |
| 8. | Total Cows in Milk | 57,258 | 36,677 |
| 9. | Average Daily Milk for Milking Cows | 60.0 | 72.6 |
| 10. | Average Days in Milk 1st Breeding | 84 | 71 |
| 11. | Average Days Open | 169 | 141 |
| 12. | Average Calving Interval | 14.2 | 13.9 |
| 13. | Percent Somatic Cell – Low | 86 | 73 |
| 14. | Percent Somatic Cell – Medium | 9 | 12 |
| 15. | Percent Somatic Cell – High | 5 | 15 |
| 16. | Average Previous Days Dry | 60 | 65 |
| 17. | Percent Cows Leaving Herd | 30 | 29 |
| | | | |
| | | **STATE AVERAGES** | |
| | Milk | 22,780 | 23,263 |
| | Percent butterfat | 3.48 | 3.58 |
| | Percent protein | 2.90 | 3.08 |
| | Pounds butterfat | 793 | 887 |
| | Pounds protein | 659 | 708 |

# HIGH COW REPORT
# SEPTEMBER 2006

## MILK

| Arizona Owner | Barn# | Age | Milk | New Mexico Owner | Barn # | Age | Milk |
|---|---|---|---|---|---|---|---|
| * Stotz Dairy | 20365 | 03-05 | 42,260 | * Providence Dairy | 8833 | 06-00 | 40,380 |
| * Stotz Dairy | 18288 | 04-03 | 38,480 | * Butterfield Dairy | 1665 | 05-06 | 39,830 |
| * Stotz Dairy | 18468 | 04-01 | 37,430 | * Butterfield Dairy | 425 | 06-06 | 39,640 |
| * Stotz Dairy | 17899 | 04-08 | 37,410 | * Cross Country Dairy | 1373 | 07-06 | 39,440 |
| * Mike Pylman | 2404 | 04-06 | 36,320 | * Butterfield Dairy | 1365 | 06-06 | 38,580 |
| * Shamrock Farms | 1497 | 06-07 | 36,040 | * Providence Dairy | 9535 | 05-09 | 38,500 |
| * Stotz Dairy | 17505 | 04-11 | 35,940 | * Providence Dairy | 6599 | 03-04 | 37,510 |
| * Stotz Dairy | 20025 | 03-09 | 35,750 | * Pareo Dairy | 4476 | 05-00 | 37,326 |
| * Stotz Dairy | 17838 | 04-08 | 35,600 | * McCatharn Dairy | 971 | 05-06 | 36,966 |
| * Stotz Dairy | 17267 | 05-01 | 35,400 | * Butterfield Dairy | 1099 | 06-06 | 36,440 |

## FAT

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| * Shamrock Farms | 6523 | 05-00 | 1,556 | * Cross Country Dairy | 1373 | 07-06 | 1,449 |
| * Stotz Dairy | 20365 | 03-05 | 1,546 | * McCatharn Dairy | 674 | 06-03 | 1,404 |
| * Stotz Dairy | 18288 | 04-03 | 1,469 | * Butterfield Dairy | 1099 | 06-06 | 1,358 |
| * Stotz Dairy | 16008 | 06-00 | 1,418 | * Vaz Dairy | 3215 | 03-11 | 1,348 |
| * Stotz Dairy | 11685 | 09-02 | 1,371 | * Vaz Dairy | 1988 | 05-09 | 1,347 |
| * Shamrock Farms | 2457 | 06-03 | 1,360 | * Butterfield Dairy | 425 | 06-06 | 1,334 |
| * Mike Pylman | 367 | 08-08 | 1,346 | * Vaz Dairy | 3202 | 03-10 | 1,327 |
| * Stotz Dairy | 17505 | 04-11 | 1,340 | * Providence Dairy | 6599 | 03-04 | 1,318 |
| * Stotz Dairy | 17474 | 04-11 | 1,335 | * Pareo Dairy | 317 | 07-04 | 1,317 |
| * Paloma Dairy | 3460 | 05-08 | 1,310 | * Vaz Dairy | 3064 | 04-00 | 1,291 |

## PROTEIN

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| * Stotz Dairy | 20365 | 03-05 | 1,403 | * Providence Dairy | 8833 | 06-00 | 1,242 |
| * Stotz Dairy | 18288 | 04-03 | 1,141 | * Providence Dairy | 6599 | 03-04 | 1,206 |
| * Shamrock Farms | Z3 | 04-04 | 1,100 | * Butterfield Dairy | 425 | 06-06 | 1,166 |
| * Stotz Dairy | 18468 | 04-01 | 1,057 | * Cross Country Dairy | 1373 | 07-06 | 1,134 |
| * Stotz Dairy | 18033 | 04-06 | 1,049 | * McCatharn Dairy | 2377 | 05-02 | 1,134 |
| * Stotz Dairy | 17231 | 05-01 | 1,039 | * McCatharn Dairy | 674 | 06-03 | 1,085 |
| * Shamrock Farms | V767 | 07-05 | 1,034 | * High Plains Dairy | 2429 | 03-04 | 1,084 |
| Parker Dairy | 9287 | 05-09 | 1,024 | * Cross Country Dairy | 384 | 04-03 | 1,084 |
| * Mike Pylman | 21714 | 03-04 | 1,022 | * High Plains Dairy | 6236 | 05-07 | 1,081 |
| * Cliffs Dairy | 157 | 05-09 | 1,018 | * High Plains Dairy | 2071 | 03-11 | 1,011 |

*all or part of lactation is 3X or 4X milking

# ARIZONA - TOP 50% FOR F.C.M.[b]
# SEPTEMBER 2006

| OWNERS NAME | Number of Cows | MILK | FAT | 3.5 FCM | RR |
|---|---|---|---|---|---|
| * Stotz Dairy West | 2,273 | 26,828 | 967 | 27,275 | 37 |
| * Stotz Dairy East | 980 | 25,280 | 927 | 25,958 | 35 |
| * Red River Dairy | 5,181 | 24,746 | 864 | 24,706 | 34 |
| * Mike Pylman | 7,796 | 24,203 | 837 | 24,033 | 38 |
| * Del Rio Dairy, Inc. | 1,386 | 24,294 | 833 | 24,008 | 22 |
| * Danzeisen Dairy, Inc. | 1,476 | 23,574 | 851 | 23,988 | 32 |
| * Zimmerman Dairy | 1,219 | 23,569 | 839 | 23,791 | 33 |
| * Withrow Dairy | 5,439 | 24,117 | 817 | 23,672 | 35 |
| Parker Dairy | 4,118 | 22,822 | 840 | 23,485 | 25 |
| * Arizona Dairy Company | 5,480 | 23,771 | 808 | 23,376 | 36 |
| * Dairyland Milk Co. | 2,978 | 23,377 | 818 | 23,368 | 37 |
| * Shamrock Farm | 8,520 | 23,931 | 775 | 22,911 | 38 |
| * Goldman Dairy | 2,150 | 22,767 | 796 | 22,748 | 26 |
| * Bulter Dairy | 595 | 22,889 | 789 | 22,687 | 25 |
| * Yettem | 2,905 | 19,291 | 872 | 22,477 | 23 |
| Paul Rovey Dairy | 335 | 21,754 | 792 | 22,245 | 32 |

# NEW MEXICO - TOP 50% FOR F.C.M.[b]
# SEPTEMBER 2006

| OWNERS NAME | Number of Cows | MILK | FAT | 3.5 FCM | CI |
|---|---|---|---|---|---|
| * Do-Rene | 2397 | 26910 | 952 | 27074 | 14 |
| * Providence | 2864 | 26559 | 941 | 26743 | 13 |
| * New Direction 2 | 2140 | 25399 | 942 | 26258 | 14 |
| * Hide Away | 2444 | 26538 | 890 | 25907 | 13 |
| * Pareo | 1574 | 25568 | 910 | 25812 | 14 |
| * Butterfield | 2013 | 25833 | 886 | 25538 | 14 |
| * McCatharn | 1011 | 25200 | 873 | 25053 | 14 |
| * Goff | 4275 | 24462 | 891 | 25026 | 14 |
| * Milagro | 3472 | 24045 | 896 | 24927 | 14 |
| * Wormont | 1026 | 23857 | 891 | 24764 | 15 |
| * Flecha | 2162 | 23454 | 870 | 24249 | 13 |
| * Cross County | 3386 | 23879 | 858 | 24239 | 14 |
| * Stark Everett | 2987 | 22870 | 841 | 23527 | 14 |

* all or part of lactation is 3X or 4X milking

[b] average milk and fat figure may be different from monthly herd summary; figures used are last day/month

# ARIZONA AND NEW MEXICO HERD IMPROVEMENT SUMMARY FOR OFFICIAL HERDS TESTED SEPTEMBER 2006

| | | ARIZONA | NEW MEXICO |
|---|---|---|---|
| 1. | Number of Herds | 31 | 24 |
| 2. | Total Cows in Herd | 66,944 | 42,455 |
| 3. | Average Herd Size | 2,159 | 1,769 |
| 4. | Percent in Milk | 88 | 75 |
| 5. | Average Days in Milk | 215 | 201 |
| 6. | Average Milk – All Cows Per Day | 50.8 | 64.7 |
| 7. | Average Percent Fat – All Cows | 3.6 | 3.5 |
| 8. | Total Cows in Milk | 57,177 | 40,627 |
| 9. | Average Daily Milk for Milking Cows | 59.4 | 75.4 |
| 10. | Average Days in Milk 1st Breeding | 83 | 71 |
| 11. | Average Days Open | 171 | 139 |
| 12. | Average Calving Interval | 14.3 | 13.7 |
| 13. | Percent Somatic Cell – Low | 86 | 70 |
| 14. | Percent Somatic Cell – Medium | 9 | 13 |
| 15. | Percent Somatic Cell – High | 5 | 17 |
| 16. | Average Previous Days Dry | 60 | 64 |
| 17. | Percent Cows Leaving Herd | 29 | 28 |
| | | | |
| | | **STATE AVERAGES** | |
| | Milk | 22,205 | 23,985 |
| | Percent butterfat | 3.60 | 3.59 |
| | Percent protein | 2.97 | 3.09 |
| | Pounds butterfat | 793 | 915 |
| | Pounds protein | 670 | 734 |

# UPCOMING EVENT:

SOUTHWEST NUTRITION &
MANAGEMENT CONFERENCE
FEBRUARY 22 & 23, 2007
TEMPE MISSION PALMS HOTEL
& CONFERENCE CENTER


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