Feeding Organic Selenium to the Dairy Cow

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Selenium, like the other trace minerals, is necessary to sustain life and is essential for basic physiological functions in cattle. While the daily requirement for these minerals is obviously small, their importance to and impact on production livestock are well documented in research. Fortunately, the difference between deficiency and toxicity with most of these trace minerals is fairly broad. This allows for a wide range of supplemental feeding recommendations and practices to be implemented without causing too many problems. Selenium, on the other hand, was recognized as a potentially toxic mineral long before it was identified as an essential nutrient. This is one of the main reasons why federal regulations are in place to ensure that the industry is cognizant of the government's concerns.

It wasn't until 1957 that selenium was even recognized as being a required dietary trace mineral. That was when a German biochemist demonstrated that liver necrosis in rats fed torula yeast could in fact be prevented by simply supplementing the yeast that they were eating with selenium (Schwarz and Foltz, 1957). Because of the narrow range between deficiency and toxicity, coupled with the concern that selenium was an environmental toxicant, this was just the beginning of a long battle to get selenium approved as a feed additive. These concerns lead to an additional 30 years of research and political debate. Finally, in 1987, selenium was approved by the FDA for supplementation at 0.3 ppm in complete feeds for the major food-producing animals.

Selenium Concentrations in Soil and Feed Ingredients

The concentration of Se in the soil and its availability to crops vary greatly from one geographic region to another. Therefore, it is not surprising that Se in crops grown on those soils is also quite variable (Cantor, 1997). Early mapping (Kubota et al. 1967) showed a wide range of Se concentrations in forages and crops and classified the various regions as high, moderate, or low in selenium. A map was put together by the National Research Council in 1983 to show the Se concentrations of the various areas in North America based on a 0.1-ppm scale (Figure 1). The map shows that many of the midwestern states, which are major corn and soybean producing areas, have low to variable Se content in their forages and grains, even at the 0.1 ppm. The soils in a major portion of the dairy regions in the United States, east of the Mississippi river and west of the Rocky mountains, are low in selenium resulting in lower Se levels in the grains and forages produced there (Figure 2). Combine the above mentioned situations with the fact that even in high soil Se areas, soil pH, moisture level, and aeration also contribute to plant Se levels, and it is easy to see why Se deficiencies have been documented in 44 states.

Figure 1. Regional distribution of forages and grain containing low, variable, or adequate levels of selenium in the United States (National Research Council, 1983).

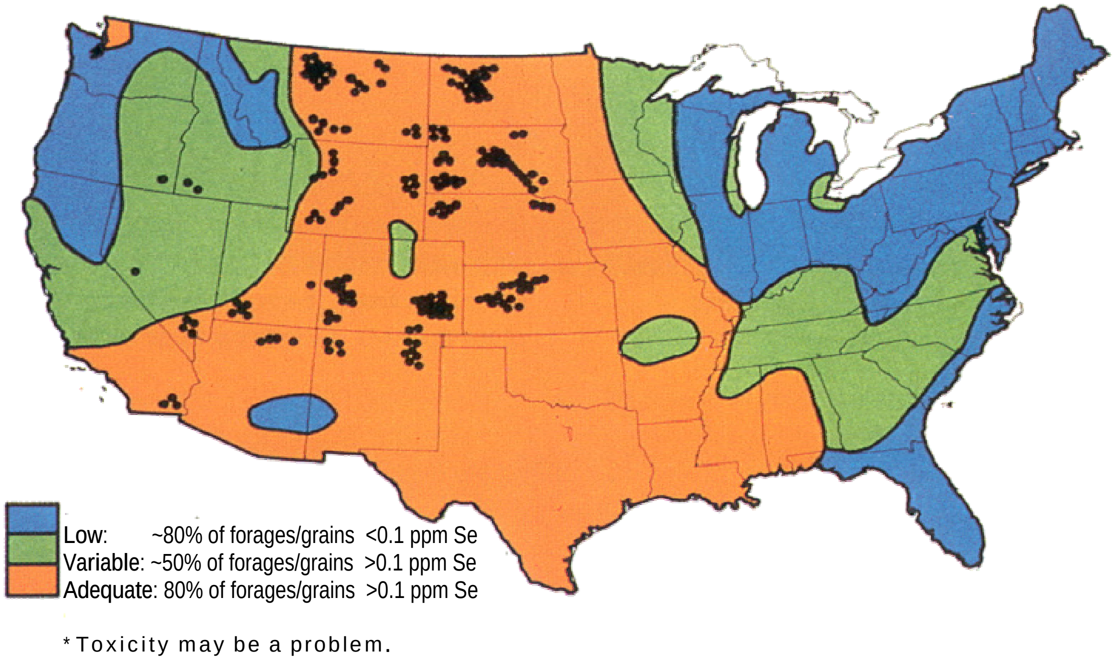
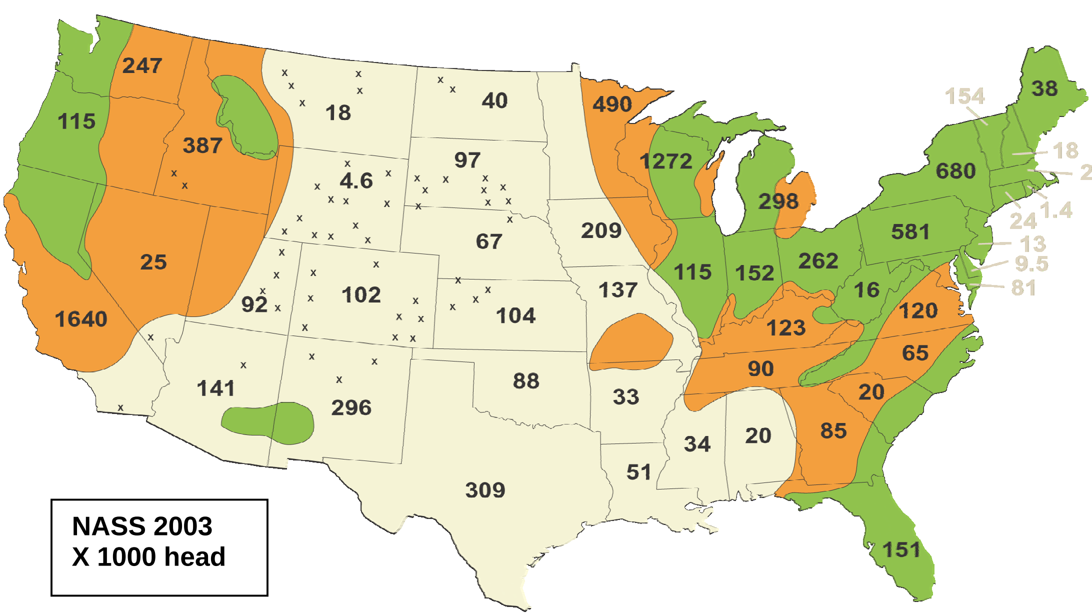


Figure 2. The state-by-state distribution of dairy cattle throughout the United States.



Selenium and its impact on production

Even though improvements in growth or milk production are rare, supplementing selenium to Se-deficient diets generally elicits a positive response in animal health (Wiess, 2003). Additionally, research with dairy and beef cattle has found that selenium supplementation to Se-deficient diets and/or Se-deficient areas can result in:

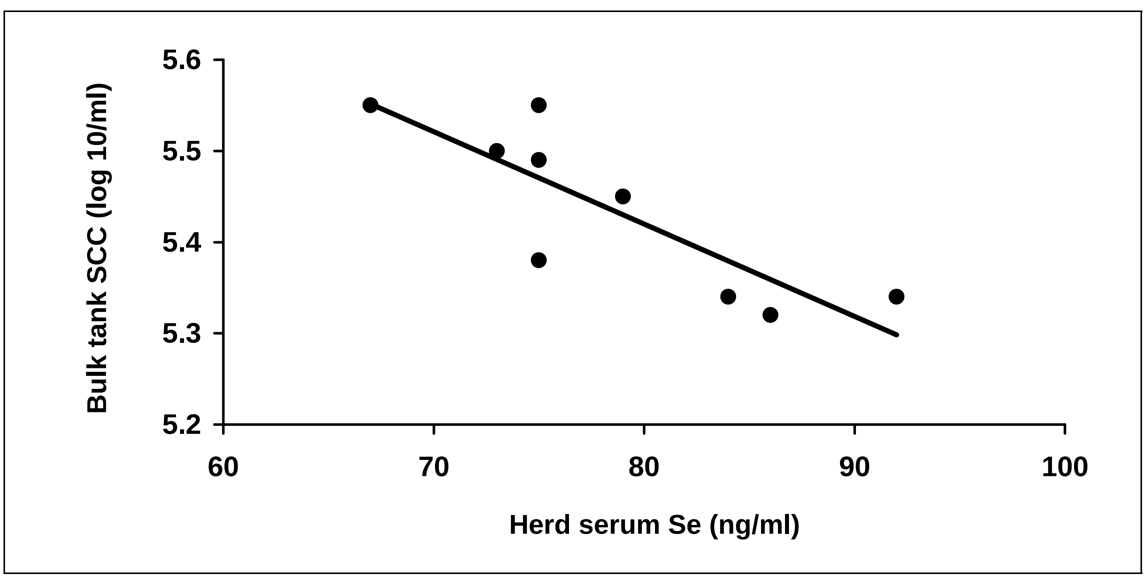
1. a reduction in milk somatic cell counts (Weiss et al., 1990);
2. a lower incidence and severity of clinical mastitis (Smith et al., 1997);
3. fewer retained placental membranes (Harrison et al., 1984); and
4. improved reproductive parameters (Arechiga et al., 1994).

Each of these areas can have an important impact on the profitability of a dairy farm, and by simply improving the selenium status of the animals, the economic value can be appreciated.

Selenium and Mastitis

Selenium status of lactating dairy cows is related to the incidence of mastitis and high somatic cell counts (SCC). A survey of Ohio dairy farms found a strong relationship between herd selenium and SCC (Figure 3). The herds with higher blood selenium concentrations had lower bulk tank SCC than herds with lower blood selenium levels (Weiss et al. 1990). The range of somatic cell counts in these farms was between 400,000 and 100,000, making them well within normal farm averages within the Ohio dairy region.

Figure 3. Relationship Between Herd Serum Selenium and Bulk Tank Somatic Cell Count in Ohio Dairy Herds (Weiss, 1990).



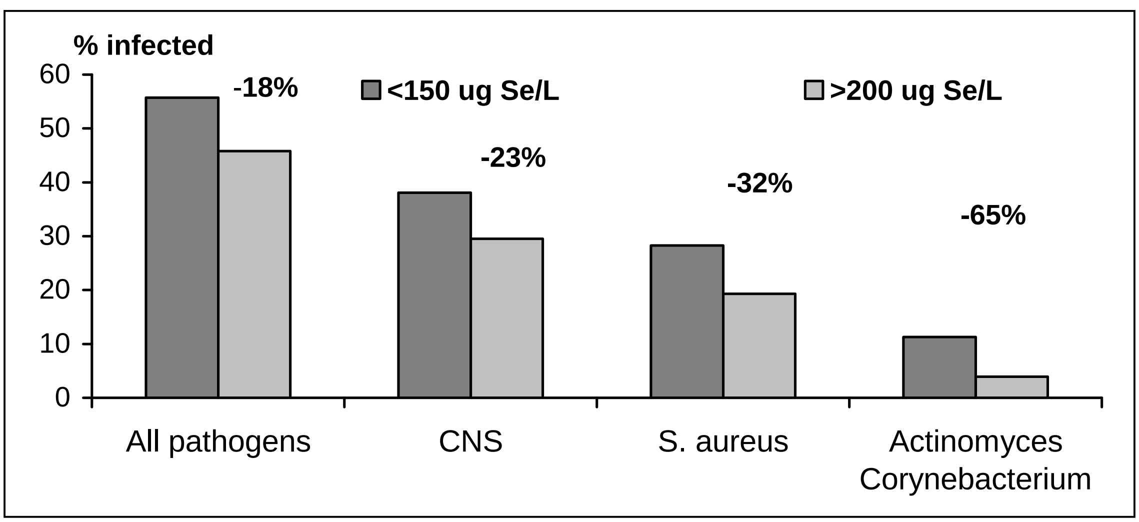
This reduction in somatic cell count not only improves milk quality, but can also lead to additional milk production over the total lactation of a cow (Figure 4). The chart shows how researchers have calculated that a 50% reduction in bulk tank somatic cell count could result in up to 400 lbs. of additional milk/cow/year in second lactation animals.

Figure 4. Relationship between somatic cell counts and lost milk production during the first and second lactation.

Average	Lactation Average	Difference in Milk Yield	
SCC Score	**SCC**	**Lactation 1**	**Lactation 2**
	cells/ml	*(lbs/305 Days)*	
2	50,000	---	---
3	100,000	-200	-400
4	200,000	-400	-800
5	400,000	-600	-1200
6	800,000	-800	-1600

Whole blood selenium is considered the best indicator of selenium status due to the incorporation of Se into developing red blood cells. A selenium level ranging between 130-150 ng/ml has historically been considered to be the adequate range. Some research suggests that higher blood selenium levels are beneficial for addressing specific mastitis pathogens (Jukola et al. 1996). It was determined that cows with blood selenium of 200 ng/ml or greater had 18% fewer mastitis infections than cows whose blood selenium levels were 150 ng/ml or less (Figure 5).

Figure 5. Prevalence of infections of cows with high and low blood selenium levels.



Selenium and reproduction

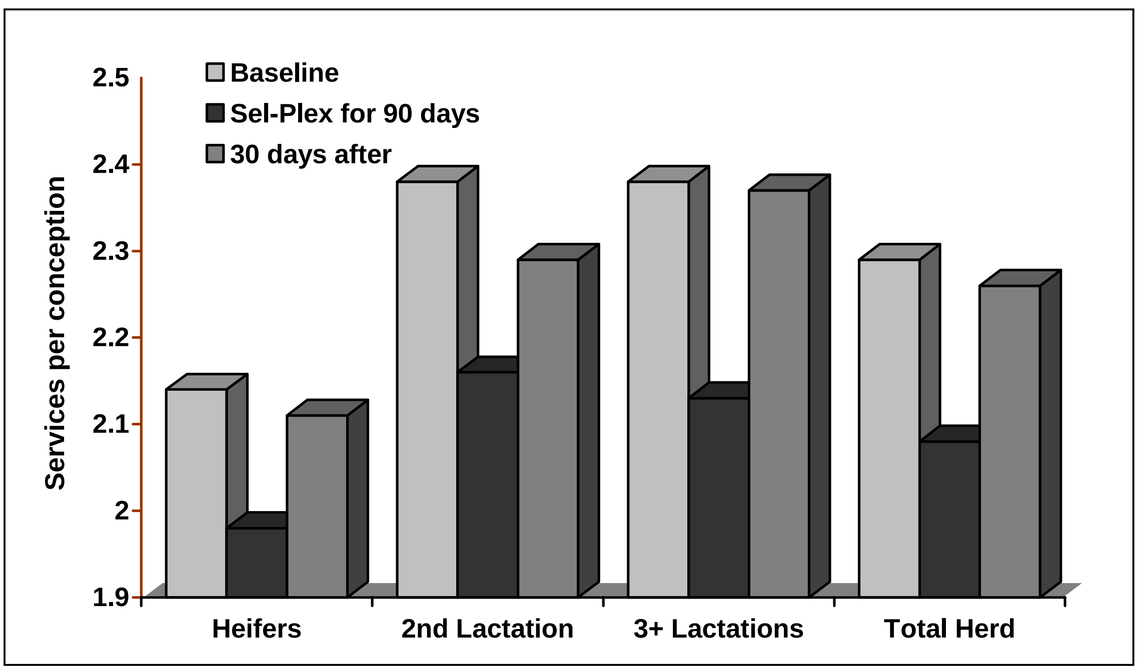
Successful reproductive performance is important to the profitability of every dairy operation, and selenium status has been shown to be important in many reproductive functions. Selenium supplementation to Se-deficient dairy cows can improve reproductive performance (Arechiga et al., 1994). Improvements from this trial included less services per conception, improved pregnancy rates at first service, and less days to conception (Table 1).

Table 1. Effect of selenium on post-partum reproduction in dairy cows

	Control	Se	P
Retained placentas	10/99	3/99	.06
Pregnancy at 1st service	25%	41%	.02
Services/conception	2.8	2.3	.03
Days to conception	141	121	.06

In a large field study conducted in the western US, replacing the inorganic selenium with an organic selenium source, Sel-Plex™, reduced services per conception over the 90 day period (Dildey, 1993). The benefits retreated when the organic selenium source was taken out of the diet (Figure 6).

Figure 6. Sel-Plex™ improved the reproductive performance in a commercial dairy herd.



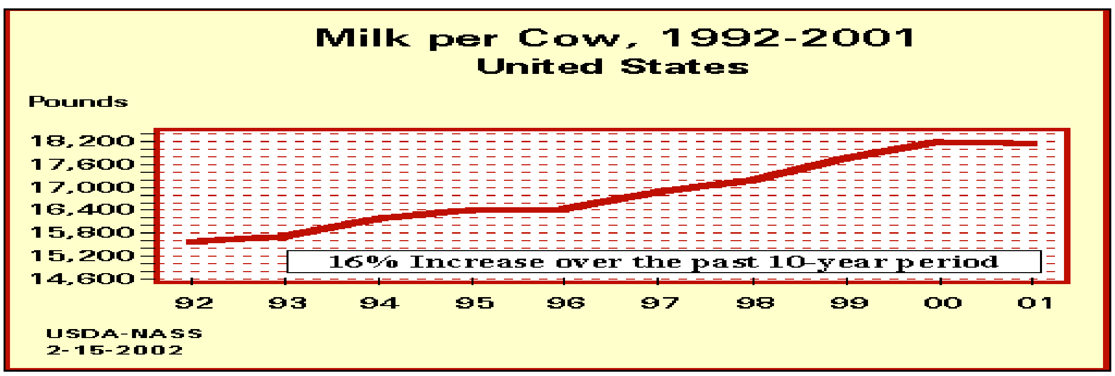
Meeting the selenium requirement of dairy cattle

The most recent edition of the National Research Council Nutritional Requirements of Dairy Cattle defines the selenium requirement for all classes of dairy cattle as 0.3 ppm (NRC, 2001). Moreover, the Food and Drug Administration has set the legal limit for supplemental selenium to dairy cattle at no greater than 0.3 ppm.

However, continuing problems with dairy cows, like the mastitis and reproductive disorders mentioned above, suggests that current practices of selenium supplementation using sodium selenite may not be adequate. NRC recommendations are generally based on providing adequate trace mineral levels to prevent measurable deficiencies, not on adequate levels to optimize animal health.

Another reason why the above mentioned selenium limits and/or sources may need to be reconsidered is that milk production per cow has increased by 16% in the last ten years (Figure 7. It stands to reason that higher-producing modern dairy cows require more selenium than their lower producing ancestors. Finally, it is well documented that the currently available inorganic selenium sources, sodium selenite and sodium selenite, are poorly absorbed and utilized by ruminants.

Figure 7. Milk production per cow, 1992-2001



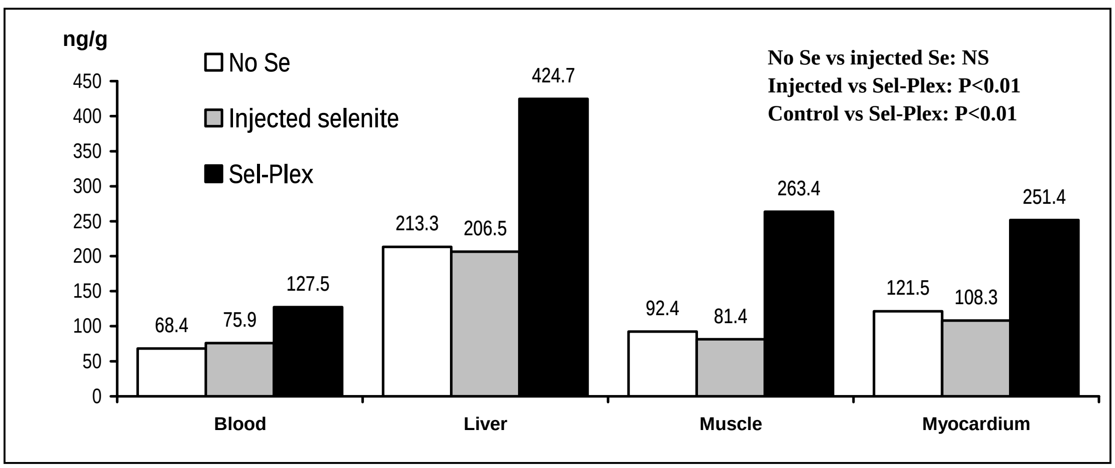
Inorganic selenium (selenite) is absorbed much less efficiently by ruminants than monogastrics (Gerloff, 1992). Absorption of selenite by ruminants has been reported at 29% (Van Saun, 1990) and between 17 and 50% (Harrison and Conrad, 1984). Poor absorption of inorganic selenium is likely due to the ruminal environment where oxidized selenite or selenate is in large part reduced by ruminal microbes to insoluble and unavailable elemental selenium, which is excreted via the feces (Van Saun, 1990). Other dietary factors also influence the availability of inorganic selenium. Dietary concentrates alter the ruminal reduction capacity with high concentrate/low pH presumably increasing the amount of inorganic selenium that the microbes would make unavailable to the animal (Gerloff, 1992). This variation in rumen acidity may be one reason why the response to a given amount of selenite can vary from farm to farm in the same region. In addition, other minerals including sulfur and iron interfere with selenium absorption (Gerloff, 1992).

Improving the selenium status of dairy cattle

Given the legal limits on supplemental selenium, what can we do to improve the selenium status of dairy cattle? One potential approach would be to use forages and grains with a higher selenium content. Plants, marine algae, and bacteria can convert inorganic selenium from the soil into organic selenoamino acids, like selenomethionine. These organic selenium sources are more available to the animal for absorption and utilization. However, this approach would require a consistent source of high selenium feedstuffs and monitoring of selenium content would be time-consuming and costly.

One way that dairymen have been circumventing the selenium regulations is by strategically using selenium injections. These injectable forms of selenium avoid the problem of poor absorption due to the ruminal environment and are routinely administered to dairy cows during the dry period. This practice has been used for many years as a short-term therapy, but does very little to improve the long-term selenium status of the animal (Pavlata et al., 2001). A study that looked at various storage tissues, found that injectable selenium was no better at improving selenium stores than the no Se group. In fact, only the group that received the organic selenium source**,** Sel-Plex^{TM}, showed significant improvements (Figure 8).

Figure 8. Blood and tissue Se of calves: Injected Se vs. Sel-Plex^{TM}



Maas and coworkers (1993) found that after an animal was injected with inorganic selenium, Se peaked at 5 hours post-injection. By 28 days, blood selenium in cows was around 50 ng/ml compared to the 100 ng/ml that was experienced during the first 24 hour period. So it appears that while injections may work as a short-term therapy, their effectiveness on body stores of selenium is very limited. Finally, injectable forms of selenium have been known to contribute to spontaneous abortions in the dry cow pen and are responsible for many injection site abscesses in the animals that receive them.

The major advantage of an organic selenium source over inorganic selenium source is its improved absorption and retention in the body. Selenoamino acids incorporated into body proteins provide a reserve of stored selenium when demand for selenium is high, particularly during disease challenge and gestation (Gunter et al., 2003). Maternal transfer of selenium (through the placenta, colostrum and milk) improves the ability of the calf to survive and thrive (Table 2).

Table 2. Sel-Plex Improves Se Status of Cows and Suckling Calves

				No Se	NaSe
	No Se	**NaSe**	**Sel-Plex**	**vs Se**	**vs SP**
Whole blood Se, ng/ml (cows)				Probability of no effect	
At calving	108	142	**174**	0.003	0.01
At 2 mo postpartum	93	150	**187**	0.003	0.03
Whole blood Se, ng/ml (calves)					
At birth	105	134	**203**	0.01	0.02
At 4 months	51	66	**122**	0.06	0.05

Summary

The modernization of dairy farms over the last few decades, has lead to many new stresses being placed on today's dairy animals. Increased demands for milk production and efficiency are forcing the scientific community to reconsider the nutrient requirements of dairy cattle on a frequent basis. The new NRC made several changes in vitamin and mineral recommendations, and yet federal regulations forced the committee to once again leave selenium at the original 0.3-ppm level. Recent discoveries and FDA approvals have now opened the door for another way to address our selenium dilemma.

Research done over the last several years suggests a more practical approach to improving selenium status is through the supplementation of high selenium yeast. More than a decade ago, Alltech researchers began the process of developing an organic form of selenium as an alternative to inorganic sources. The result of this research program is Sel-Plex, an organic selenium source produced by yeast. Yeasts, as part of the plant kingdom, have the ability to convert inorganic selenium into selenoamino acids. These seleno-compounds are what animals need in order to build body reserves of selenium for times of need. Currently, Sel-Plex is the only selenium yeast that has undergone over 7 years of scrutiny by the FDA. It was this evaluation that was responsible for the approval of selenized yeast in ruminant diets on September 4th, 2003.

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