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Products and Services for American Dairymen

Improving
Potassium Supplementation

Livestock Waterers
Product Review

The International
Dairy Market

Methane
Digesters

Improving Potassium Supplementation in Dairy Cow Diet With a Protected Potassium Carbonate

By Feed Products North, Inc.

Anhydrous potassium carbonate (PotCarb) with chemical formula K2CO3 is utilized in dairy cattle diets for increased milk production and dry matter intake, by providing the necessary nutritional requirements for potassium without negative chlorides (Cl-) or sulfates (S-). Potassium is especially important during lactation and heat stress. Dietary cation-anion difference (DCAD) has a major influence on electrolyte balance and is dependent on physiological status in dairy cattle and diet composition. Defined as mill equivalents of sodium and potassium (Na+K)-(Cl+S) per kg Dry Mater (DM) diet.

Commercially available feed grade PotCarb (granular) general properties can vary widely, depending on the grade and composition. It is found that the workability and performance differ by reactivity, stability, corrosiveness, hygroscopicity and shelf life.

A hydrogenated mixture of triglycerides in a low amount (<5%) is coated onto granular anhydrous PotCarb to encapsulate and provide a protective barrier and stabilize hygroscopic and corrosive properties; formulated to make a safe and stabile electrolyte with a high level of potassium, with >53% K+. For example, there exists a commercially available product as a feed grade coated granular PotCarb supplement, with a protective encapsulate of mixed triglycerides at a concentrated level of potassium with 53% K+ and is claimed to have improved storage and handling capabilities for a safe work environment with bulk delivery and storage.

The present objective was to ascertain the stability of a granular anhydrous PotCarb and a protected PotCarb by a better understanding of the hygroscopic nature and shelf life under conditions to which they will be exposed in the market place and to better understand how delivery and storage conditions affect the efficacy of mineral supplement potassium.

The following study analyzed granular anhydrous PotCarb and a protected encapsulated PotCarb in triplicate large open containers at ambient (normal) and stressed conditions, monitored by HOBO devices (15 min.) up to 14 days. The moisture content was measured prior and throughout storage. Samples were visually observed and pictures were captured. The overall results revealed the protected PotCarb as a superior product that is considerably stable under normal and stressed conditions with excellent flow ability, low change in moisture content, and no visually observed corrosiveness over time as shown in the following charts and pictures.

In addition the following study tested for heat of hydration wherein a test compromising 5 grams of PotCarb and protected PotCarb in equal parts water, checking the temperature over a five minute period such that a maximum heat rise to 120 degrees Fahrenheit by anhydrous PotCarb.

The coated nature of this product is a means to help the feed formulator deliver a high level of potassium as "k" in the ration.

Introduction

High-producing cows lose potassium through the normal, everyday function of producing milk, especially during heat stress. Potassium (K+) supplementation is critical in dairy cattle during early or peak lactation for proper dietary electrolyte balancing and several studies have shown it to be the most efficient way to reach a dietary positive balance necessary for buffering and ultimately maintaining high producing milk and milk protein production. Forages alone do not provide the necessary potassium supplementation during lactation and have counterproductive minerals in the form of negative anions.

A cation is a positively charged ion e.g., Na+, K+, Ca2+, Mg2+. The simple formula used to maintain a positive dietary cation-anion difference (DCAD) balance is defined as mill equivalents of sodium and potassium (Na+K)-(Cl+S) per kg DM diet. Many heat stress mineral components also include magnesium. However when balancing it is important to ration the amount of sodium and potassium; the choice between potassium and sodium carbonate is based on both economics and chemical properties, as potassium carbonate has a greater effect with the potassium ion more reactive than sodium ion, has greater solubility and is needed for heat stress as it regulates sweat gland secretions, along with various other functions. Cows lose up to 13% of daily potassium needs in heat stress through milk production. Potassium is main regulator of sweat glands and potassium dissipates in hot weather to keep cows temperature regulated.

Today PotCarb is produced with the electrolysis of potassium chloride brine to produce potassium hydroxide and is carbonated with carbon dioxide to form PotCarb. K2CO3 is the chemical formula representing anhydrous potassium carbonate or PotCarb, as it is commonly called today. Although it is known by several other common names; such as PC, potash, pearl ash and carbonic acid, dipotassium salt.

Providing controlled protection with a coated mixture of triglycerides, decreases hygroscopicity and allows protected material to be exposed to moist or humid environments for significant periods of time by encapsulation with small % of coating; and keeps potassium level high with > 53% K+ by weight. It is recognized that PotCarb can be inefficiently utilized in ruminant diets, as it degrades in humid conditions or with moisture in feed. As well it causes an exothermic reaction with moisture or acidic components and lime in feed. Thus there remains a need for methods and compositions for the controlled protection of hygroscopic PotCarb that will be exposed to moist or humid environments and for providing controlled protection from moisture and acidic components in animal feeds. In addition the coated PotCarb is stabilized and reduces the reactivity to incompatible substances and lowers the heat of hydration as compared to anhydrous PotCarb, with additional nutritional value from the coating. Protected PotCarb can also be handled easier in bulk handling and storage facilities and bulk quantities may be shipped with more options for shipment, location with longer distances and storage facilities.

Table 1: Visual observations of initial stability study, ambient and stressed conditions, 7 days.

Product	Ambient Conditions	Stressed Conditions
Protected Potassium Carbonate (Protected PotCarb)	No Visual changes in open container. No Visual changes in closed bag.	Reacted slightly with aluminum pan, small crystals on outside. Bagged material- moderate visual crusts and wet material.
Anhydrous Potassium Carbonate (PotCarb)	Moderate Visual Crust Only minimal dark spots, "wet" on bottom of bag	Solid block in aluminum pan and moderately disintegrated outside pan. Side bags wet, with crystals all over outside. Material- solid block.

Methods and Results

An initial study at a Midwestern University analyzed by visual observations of anhydrous PotCarb and protected PotCarb in triplicate in open aluminum containers and closed paper bags for 7 days at ambient and stressed conditions of 90 deg F with 90% humidity. The following table 1 revealed protected PotCarb as more stable than anhydrous PotCarb in an initial stability study.

A following study analyzed granular anhydrous PotCarb and a protected PotCarb in triplicate large open plastic containers at ambient (normal) on aluminum foil and stressed conditions, monitored by HOBO devices (15 min.) up to 14 days. The moisture content was measured prior and throughout storage. Samples were visually observed and pictures were captured. The overall results revealed protected PotCarb as a superior product that is considerably stable under normal and stressed conditions with excellent flow ability, low change in moisture content and no visually observed corrosiveness over time as shown in the following figures and pictures.

The present data shows that the methods and compositions of a protected PotCarb make a safer electrolyte that is more stable than anhydrous PotCarb and has a much better shelf-life, reducing hygroscopic nature and maintaining a high level of K+.

Continuous recording of temperature and humidity was conducted by HOBO measurements of temperature and humidity in 15 minute increments at ambient (normal) chart 1 and stressed conditions chart 2 up to 14 days or 336 hours.

Chart 1: HOBO measurements at ambient conditions, hours.

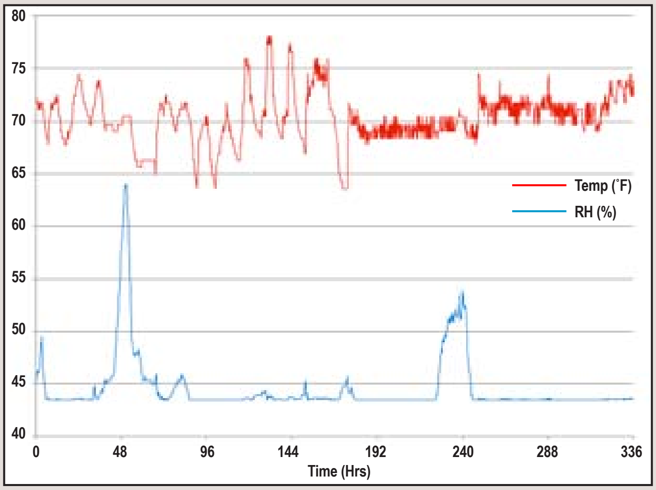
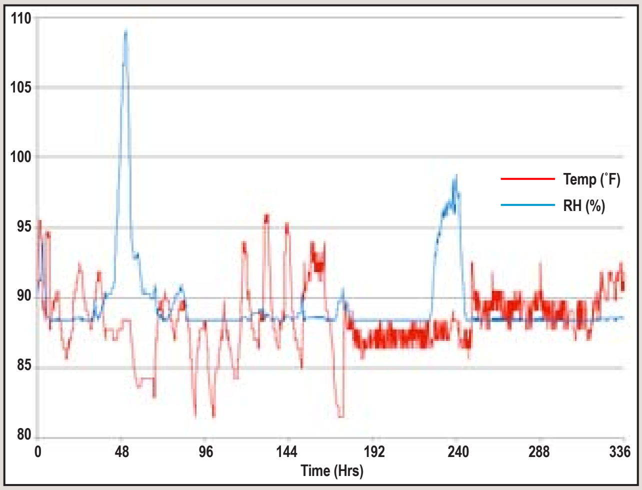


Chart 2: HOBO measurements at stressed conditions, hours.

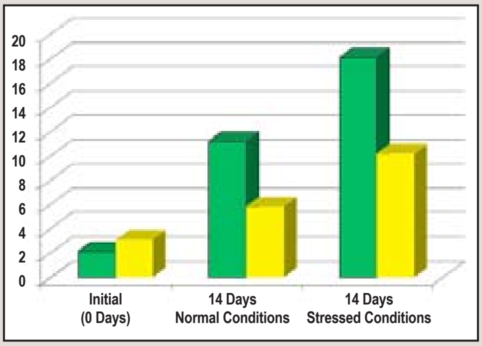


The moisture content is the quantity of water contained in a material by determining mass loss on heating. The classic laboratory method of measuring high level moisture in solid or semi-solid materials is loss on drying (LOD). In this technique a sample of material is weighed, heated in an oven for an appropriate period, cooled in the dry atmosphere of a desiccator, and then reweighed. Moisture is measured as a percentage of total weight. The moisture content % in table 2 and Chart 3 of PotCarb and protected PotCarb in ambient and stressed conditions initially and after 14 days.

Table 2: % Moisture content.

% Moisture Content	Initial (0 days)	14 Days Normal Conditions	14 Days Stressed Conditions
PotCarb	2.14	11.22	18.07
Protected PotCarb	3.12	5.89	10.25

Chart 3: % Moisture content; initially (0) ambient and stressed conditions, 14 days.



According to this figure and pictures proceeding the moisture content of protected PotCarb treatments stored at ambient conditions increased only moderately where anhydrous PotCarb increased more rapid. As well, the moisture content of protected PotCarb treatments at stressed conditions increased slightly overtime and anhydrous PotCarb at stressed conditions increased rapidly within 2 weeks.

Figure 1: Protected PotCarb, open container, 2 weeks, ambient conditions.

Figure 2: PotCarb, open container, 2 weeks, ambient conditions.

Figure 3: Protected PotCarb, open container, 2 weeks, stressed conditions.

Figure 4: PotCarb, open container, 2 weeks, stressed conditions.

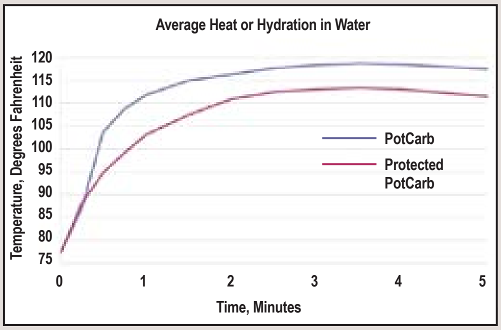
Figure 5: Protected PotCarb, storage-foil area, where container sat.

Figure 6: PotCarb, storage-foil area, where container sat.

The following study tested for heat of hydration chart 4 wherein a test compromising 5 grams of PotCarb and protected PotCarb in equal parts water 5 ml, checking the temperature over a five minute period such that a maximum heat rise to 120 degrees Fahrenheit by anhydrous PotCarb.

According to the chart the following methods and compositions for a protected PotCarb makes a safer electrolyte that is less reactive than granular anhydrous PotCarb. In particular protected PotCarb has a reduced heat of hydration that occurs from exothermic reaction in moisture-water and acidic conditions.

Chart 4: Average heat of hydration in water, temperature over time, minutes.



Discussion

Potassium is the third most abundant mineral element in the animal body. It is a major intracellular cation and is involved in the osmotic regulation of tissue fluids and in acid-base balance. An ionic balance exists amongst K, Na, Ca and Mg.

The requirements for K by ruminants are estimated to be between 0.5 and 0.8% of the diet. The potassium requirement appears to be increased by stress. Research has shown that the potassium requirements for heat-stressed dairy cows increases to approximately 1.1%. Levels higher than 1.5% have been associated with decreased dry matter intakes. Grass contains high levels of potassium and deficiencies therefore are uncommon in grazed stock. High potassium levels in well-fertilized pastures can be a problem, especially with regard to Mg absorption. The maximum tolerable level for K is suggested to be 3% of the total dietary dry matter, although surpluses are readily excreted in the urine.

An excess of potassium can aggravate a sodium deficiency, depressing sodium levels by 30 to 60 %. This may be particularly serious on certain, but rare pastures, which are inherently low in sodium. The pastures with potassium in excess of 5% have been implicated in cases of bloat and of infertility.

Sodium is a major extracellular cation and plays an active part in regulating the neutrality of blood serum. Considerable amounts of sodium appear in the muscles and it is associated with their contraction.

A shortage of sodium adversely affects utilization of both digested proteins and energy, and also prevents reproduction. A shortage of sodium has been associated with cases of bloat on pastures that were heavily fertilized with nitrogen. High levels of potassium have been shown to depress the concentration of sodium in plants. Pastures contain several times more potassium than sodium, thus cows on pastures require more salt than do cows on dry feeds or complete feeds. At a given potassium intake level; increasing the sodium intake increases the sodium and decreases the potassium concentrations in the rumen-reticulum digesta. Increased sodium levels have also been shown to be antagonistic to magnesium absorption.

It should be known that pastures vary greatly in various macro- mineral contents and forage analysis must be performed often. During early or peak lactation and during heat stress it is important to have a positive level of potassium and sodium to sulfur and chloride; with proper cation-anion balancing. This ratio can be formulated into complete feed with proper feed rationing and mineral supplementation.

Potassium along with sodium, are cations. Sulphur and chloride are anions. A diet too high in cations increases the DCAD (dietary cation-anion difference) and blood pH. This leads to a decrease in calcium (Ca) absorption from the gut and in bone mineralization. This can result in milk fever especially in dry cows.

Several forages can be very high in K and vary significantly. It is beneficial to use dry feeds or complete feed with proper feed mineral additive supplementation through ration formulations for different stages of lactation. Recommended mineral levels are not constant; they vary with changing production, body size, environment and other dietary factors. According to Schroeder, J.W. an extension dairy specialist in order to calculate correct formulation for mineral needs it is essential to know and formulate for the physiological status (pregnancy, milk production level, maintenance requirements and growth rate).

Further difficulty in meeting mineral needs is that most mineral vary by mineral and form of mineral in solubility, absorption and bioavailability. As well there are numerous mineral interactions to consider. With many minerals high levels of one mineral will decrease absorption of another. Physiologically, DCAD influences the animal's acid-base status, calcium level around calving and mineral utilization.

DCAD varies for late pregnant dry cows and for lactating cows. During late pregnancy it is important to formulate with a low or negative DCAD to reduce the risk of low blood calcium and milk fever around calving. In some cases simply using feedstuffs with lower K and Na will lower enough to prevent milk fever and improve transition cow performance. It is better and more accurate as indicator of DCAD urine pH with feed supplemental minerals as anion sources that will also reduce DCAD, e.g. ammonium, calcium and magnesium chlorides or ammonium, calcium and magnesium sulfates will suffice.

During lactation increasing DCAD with supplementation of cations Na and K are fundamental for neutralizing ruminal acidosis during rumen fermentation. The DCAD can be increased by lowering feed ingredients with high concentrations of anions and also critical to supplement with sodium bicarbonate and especially vital for potassium carbonate supplementation. Especially during heat stressed conditions, DCAD should be at upper end of the optimal DCAD range; since potassium supplementation is crucial as cows lose up to 13% of daily potassium needs in heat stress through milk production. Potassium is main regulator of sweat glands and potassium dissipates in hot weather to keep cows temperature regulated.

Conclusion

Potassium carbonate is a fundamental mineral feed ingredient. The use of a protected PotCarb is an advantageous supplement of K+ for the lactating cow's diet, during heat stress to meet the animal's nutritional requirements and adds additional nutritional value from the mixture of triglycerides used in encapsulation. The protected potassium carbonate provides a high source of potassium with > 53% K+. Its use if as feed for various types of animals beyond dairy and beef cattle, sheep, poultry, swine and horses. It is a positive cation for DCAD.

Protected PotCarb is specially formulated to be less reactive then granular anhydrous PotCarb with a decreased level of heat of hydration, reducing level of heat produced from exothermic reactions with moisture. In addition it is a safer electrolyte that increases overall stability for a free-flowing material that is easier to distribute, store and handle; as well for bulk distribution and storage. The shelf-life and stability is substantially better than granular anhydrous PotCarb even in open storage in hot and humid weather, the material remained intact, granular and free-flowing for minimum of 14 days storage. While the granular anhydrous PotCarb absorbed moisture from the atmosphere and became gooey and runny with 18% moisture content.

A commercially available feed grade protected PotCarb has been in the feed market for many years that buyers reported satisfaction with the ability to handle, especially in bulk and for the high level of potassium. Most importantly protected PotCarb during lactation increased feed intake, performance in heat stress conditions and greater milk production. As well it increases profit potential since the level of potassium is very high with greater than 53% K+ and remains protected according to stability studies, with little decrease in dry matter even in hot and humid conditions. ■

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