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Magnesium oxide has two jobs in dairy diets

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This issue explains why magnesium supply and alkalizing action require separate formulation, even when magnesium oxide contributes to both.

Magnesium oxide (MgO) has long occupied an unusual position in ruminant, and especially in dairy nutrition. It supplies magnesium, an essential mineral, but it is also used for its alkalizing action, particularly in diets for high-producing cows consuming substantial amounts of fermentable carbohydrate, including starch and sugars. In many commercial formulations, these two functions are often treated almost interchangeably, even though they arise from different parts of the same compound.

Recent research has brought this distinction back into focus. In continuous-culture fermenters, a program using high-solubility MgO and less sodium bicarbonate maintained a higher ruminal pH and improved fiber digestibility compared with a conventional MgO-plus-bicarbonate program. Because the MgO source and bicarbonate dose changed together, the experiment cannot assign the response to either change alone, and confirmation in cows is still required. It nevertheless raises a useful formulation question: should MgO be specified by kilograms added, magnesium supplied, or the alkalizing action actually delivered?

Magnesium and alkalizing action differ

MgO supplies magnesium, but magnesium itself is not responsible for the compound's acid-neutralizing action. The oxide component reacts with hydrogen ions, ultimately forming water while Mg is released as Mg^{2+} . Equal amounts of magnesium supplied from MgO, magnesium sulfate, magnesium chloride, or other Mg sources therefore cannot be expected to exert equal alkalizing effects. A formulation expressed only in grams of Mg describes the mineral contribution, but it does not describe the functional contribution of MgO to the rumen.

Excess magnesium still carries a cost

Using MgO as an alkalizing agent does not make the magnesium it contains disappear. Total Mg intake must include Mg supplied naturally by feeds and forages, mineral supplements, and other Mg-containing ingredients. Dolomitic limestone and calcium sources containing appreciable Mg can be easy to overlook, although their Mg may be less available. Cattle can excrete substantial absorbed Mg in urine, so clinical Mg toxicity is uncommon, but excessive intake is not harmless. High Mg intake can reduce diet digestibility and feed intake and cause osmotic diarrhea. MgO used for alkalizing purposes must therefore remain within the total dietary Mg constraint.

Magnesium oxide quality varies

Equal quantities of MgO do not necessarily provide equal nutritional or alkalizing value. Origin, calcination conditions, particle size, surface area, and purity influence reactivity and solubility. Published comparisons have found large differences in solubility among commercial MgO sources, and solubility is related to the Mg that becomes available for absorption. A feed specification stating only Mg concentration and MgO inclusion therefore leaves an important part of ingredient quality undefined: alkalizing potential.

Solubility affects both functions

Solubility connects the two functions, but it does not reduce them to one number. A poorly soluble MgO can appear to supply ample Mg on the formulation screen while releasing less usable Mg in the animal. Its effective acid-neutralizing action can also differ from that of a more reactive source within the time available in the rumen. A meta-analysis of 21 studies and 94 treatments estimated that dairy cows absorbed about 20% of Mg intake on average, with values ranging from 10% to 40%. That average is not a fixed coefficient for every source or ration: dietary potassium and other factors further modify absorption.

MgO changes bicarbonate needs

Sodium bicarbonate and MgO are often assigned standard inclusion rates, but the rumen responds to the combined chemical and biological effects of the complete diet. Recent continuous-culture work compared 0.66% sodium bicarbonate plus 0.40% low-solubility MgO with 0.30% bicarbonate plus 0.40% high-solubility MgO, all on a dry-matter basis. The latter program increased ruminal pH and improved fiber digestibility across diets containing 21% or 32% starch. The result does not isolate the effect of MgO quality from the lower bicarbonate dose or establish a universal replacement value. It shows that MgO quality can alter the performance of the complete alkalizing strategy.

Formulate both functions separately

A more useful approach is to recognize two formulation constraints. The first is nutritional: how much total and absorbable Mg the cow requires and how much the complete diet already supplies. The second is functional: how much alkalizing support is desirable given starch fermentability, physically effective fiber, intake, feeding management, and the other buffering agents being used. MgO contributes to both constraints. Sodium bicarbonate contributes buffering and acid-neutralizing action without Mg, whereas other Mg sources can provide available Mg without equivalent alkalizing action. Solubility tests can help rank MgO sources, but they cannot by themselves convert a laboratory result into absorbed Mg or bicarbonate equivalence.

In Brief, magnesium oxide supplies magnesium and contributes alkalizing action at the same time, but dose, solubility, and reactivity do not affect those functions identically. Total dietary Mg, Mg availability, MgO quality, and the contribution of other buffering and alkalizing agents all matter. Formulate the mineral and functional constraints separately, then recognize where MgO contributes to both. The objective is to supply adequate magnesium and appropriate alkalizing support without unnecessarily increasing either.

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