Fumaric and Malic Acids used as Feed Acidulants

Acidulants are replacing antibiotics in animal feed. This is done to minimize the presence of antibiotic-resistant pathogens in meat and milk products. Acidulants improve animal health and weight gain by controlling microbial populations in animal digestive systems and in feed. Bartek Fumaric and Malic Acids are used in a wide range of animal feeds and have important advantages compared to other feed acidulants.

Benefits of Malic and Fumaric Acids

Convenient Handling and Storage

The physical form and hazard classification of feed acidulants is shown in the diagram at right. Fumaric and Malic Acids are both granular solids and are classified as irritants. Acidulants classified as corrosive (Acetic, Formic, Phosphoric, and Propionic Acids) are handled and stored with a higher degree of protection in order to ensure worker safety. This increases the effective cost of using these acidulants. Fumaric Acid has an additional advantage in that it does not cake during storage because it is non-hygroscopic.

Higher Acid Strength

pH reduction in the feed itself and in the digestive system is an important function of feed acidulants in most applications. The ability of acidulants to lower the pH of feed and of digestive contents is a function of acidulant strength. As shown in the graph at right, Fumaric Acid is stronger than all other feed acidulants at pH 4.50. Malic Acid is the fourth strongest acid. The stronger the acid, the lower the level required to achieve the same reduction in pH.

Retard Microbial Spoilage in High Moisture Feed

There are two ways in which a feed acidulant can act as an antimicrobial agent in animal feed:

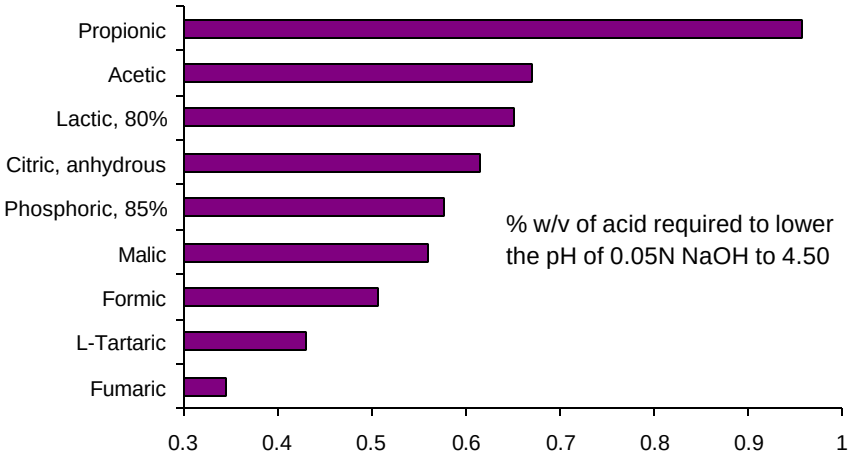
1. Indirectly by lowering the pH – this has two effects:
   - The rate of microbial growth is usually reduced.
   - The potency of preservatives derived from weak acids is improved because the level of the completely undissociated acid form of these preservatives is increased at lower pHs.
2. Directly by interacting with the microbial cells. Propionic, Acetic, and Formic Acids; or their salts, are effective direct antimicrobial agents in feed. If the salts (propionate, acetate, formate) are used, other acids must be included to lower the pH. The lower the pH, the higher the level of the undissociated acid form.

Fumaric and Malic Acids are more effective in lowering the pH of feed than most other feed acidulants, as discussed above under Higher Acid Strength.

Physical Form and Hazard Classification of Feed Acidulants

	Solid	Liquid	Volatile Liquid
Corrosive		Phosphoric	Acetic Formic Propionic
Irritant	Citric **Fumaric** **Malic** Tartaric	Lactic	

Acid Strength of Feed Acidulants at pH 4.50



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Swine Production: Fumaric and Malic Acids Improve Digestion Efficiency by Lowering the pH of the Gastric Contents

Lowering the pH of the gastric contents improves digestion efficiency in swine in several ways:

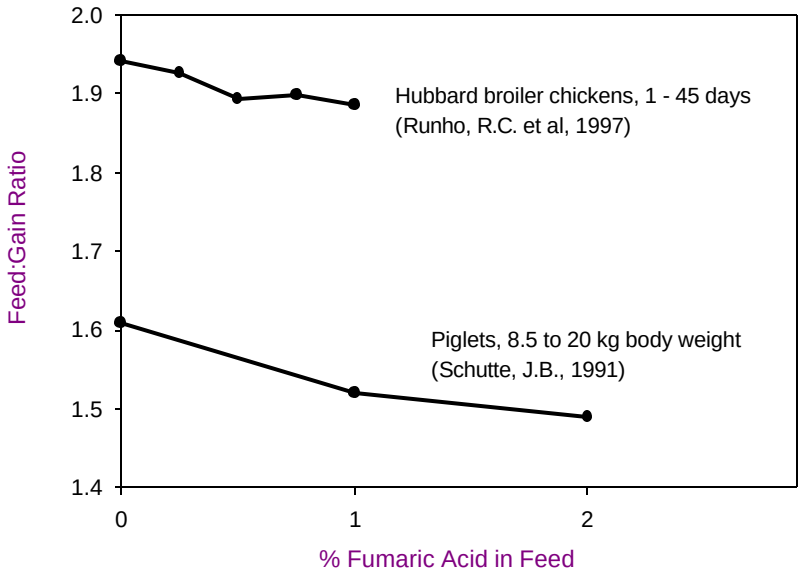
1. Numbers of coliform bacteria and other acid-intolerant pathogens are reduced.
2. The activity of digestive enzymes is increased, since these are more active at lower pHs.
3. The secretion of bile and pancreatic fluids increases.
4. The ileal digestibility of crude protein and amino acids increases.

This improvement is more important in piglets than in fattening pigs. Piglets in the post-weaning period have a limited ability to digest solid feed. Acidulants are widely used in piglet feed to help mediate the effects of post weaning stress. As discussed above, Fumaric and Malic Acids have an advantage over most other feed acidulants in that they are stronger acids at pH 4.50. The effect of added Fumaric Acid on feed:gain ratio in piglets is shown in the graph at right.

Poultry Production: Fumaric Acid Improves Feed:Gain Ratio

Fumaric Acid improved the feed:gain ratio in broiler chickens, as shown in the graph at right. The feed:gain ratio for chickens that consumed feed with 0.5%, 0.75%, and 1.0% Fumaric Acid was comparable to that of chickens that consumed feed containing an antibiotic (1.90). The improvement with Fumaric Acid is related to its ability to lower the pH of the crop and gizzard contents. This reduces the microbial load in the digestive system, especially the load of pathogenic bacteria, which favor higher pHs.

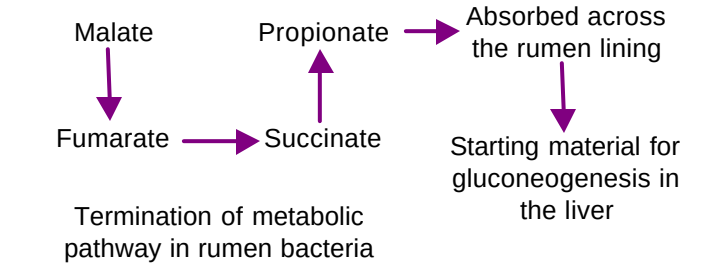
Feed:Gain Ratio vs. Fumaric Acid Level in Feed



Ruminant Production: Fumaric and Malic Acids Improve Ruminal Fermentation

In cattle, sheep, and goats, microbial fermentation in the rumen serves to break down most of the feed into nutrients that are absorbed by the animal. Fumaric and Malic Acids are now being used as alternatives to ionophore antibiotics in managing ruminal fermentation. They function by stimulating the growth of certain rumen bacteria that use the succinate-propionate metabolic pathway. As shown in the diagram below, Malate and Fumarate are intermediates in this pathway and for this reason are effective in stimulating the growth of these bacteria. Increasing the production of propionate in the rumen improves feed efficiency in ruminants. The results of Malic Acid feeding trials for cattle and sheep are discussed on page three.

Malate and Fumarate in Ruminant Nutrition



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Dairy Cows: Malic Acid Improves Milk Production

As shown in the table at right, Malic Acid improved milk production by as much as four lbs. per day when fed to Holstein cows. All of the cows in this trial had the same base diet, consisting of protein concentrate, a grain mixture, standard vitamin and mineral supplements, and forage.

Beef Cattle: Malic Acid Improves Feed/Gain Ratio

The optimum feed/gain ratio during the beef cattle trial was achieved by using 0.053 to 0.075 lbs. of Malic Acid per 1,000 lbs. of body weight per day, as shown at right. This was a thirty percent improvement over the control diet. All cattle were fed the same base diet.

Sheep: Malic Acid Improves Feed/Gain Ratio

The optimum feed/gain ratio during the sheep feeding trial was achieved by using 0.133 lbs. of Malic Acid per 1,000 lbs. of body weight per day, as shown at right. This was a twenty-seven percent improvement over the control diet. All sheep were fed the same base diet.

Malic Acid Feeding Trial for Dairy Cows

Malic Acid Feeding Rate (lbs. per 1,000 lbs. of body weight per day)	Milk Produced per Cow* (lbs. per day)	Solids Corrected Milk Produced per Cow* (lbs. per day)
0 (control)	33.3	30.4
0.061	35.4	32.4
0.127	37.8	34.0

*average values for Holstein milk cows over a 28 day trial; seven cows per feeding rate (Stallcup, O.T., 1979)

Malic Acid Feeding Trial for Beef Cattle

Malic Acid Feeding Rate (lbs. per 1,000 lbs. of body weight per day)	Feed/Gain Ratio*
0 (control)	16.2
0.035-0.050	11.6
0.053-0.075	11.3
0.075-0.100	11.7
0.175-0.200	16.7

*average values for steers over a 112 day trial; six steers per feeding rate (Stallcup, O.T., 1979)

Malic Acid Feeding Trial for Sheep

Malic Acid Feeding Rate (lbs. per 1,000 lbs. of body weight per day)	Feed/Gain Ratio*
0 (control)	12.2
0.067	9.3
0.133	8.9
0.200	9.9
0.500	9.3

*average values for sheep over a 28 day trial; six sheep per feeding rate (Stallcup, O.T., 1979)

For further information on this and other Bartek products, please visit our website at: *www.bartek.ca*

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