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Ash levels in milk replacer

Ash content in milk replacer has recently become a subject of much discussion. This is not surprising as ash is a significant component in milk replacer. What is surprising is just how little most know about ash. The purpose of this article is to help the reader understand what ash means to both the milk replacer and the growing calf.

Before delving into a discussion of ash in too much detail, we first must ask ourselves an important question: What are the major components of milk replacer? Milk replacer has four major components: Protein, Fat, Lactose and Ash. Protein and Fat are traditionally set by the formula such as creating a 20:20 or 24:20 milk replacer, respectively. Ash is fixed for the formula depending on the ash content of the various ingredients. Lactose is variable and makes up the difference of the total weight from the weights of protein, fat and ash. For example with a 20:20 milk replacer, if ash is 10% and protein and fat are each 20% of the total weight, then the lactose level has to be 50%. If protein is raised to 24%, then lactose will have to drop to 46% if fat and ash remain the same. Understanding the above concept is critical to better understanding the impact and influence ash has on a milk replacer formula.

Now that the groundwork for the four main components of milk replacer has been laid, lets dig a little deeper into ash, itself. Raw whole milk has an ash content of about 5.5-6.5%. Milk replacers will have higher ash content because the ingredients making up the powder are primarily milk-based ingredients that concentrate natural minerals. Milk replacers also include additional additives that will increase the ash content. These additional additives include trace minerals, vitamins, medications and other additives. Milk replacers will range in ash from about 7% to as high as 12%. Most are usually around 9% ash. It is also important for us to understand, as alluded to above, that the ingredients that make up milk replacer can drive ash content for better or worse. Therefore, a basic breakdown of milk replacer ingredient ash content is provided below for your reference. This, of course, is only as helpful as the ingredient label of the milk replacer in question.

Table 1. Various milk-based ingredient can vary significantly in their natural ash content:

Ingredient	Ash content %
Non-fat dry milk (dry skim milk)	8.2-8.6
Dry Whole Milk	5.5-6.5
Dry Butter Milk	8.3-8.8
Dry Sweet Whey	8.2-8.8
Reduced Lactose Whey ('delac')	11.0-22.0
Whey Protein Concentrate (WPC)	4.0-8.0
Lactose	0.1-0.3
Source: American Dairy Products Institute Brochure 2002	

Even with the above information, the most common question received in the field in regards to ash is simply: What is ash? By definition, ash is what is left after complete combustion or burning of a substance. What primarily remains during combustion of milk replacer are ions of sodium, potassium, chloride, calcium and trace minerals. These are critical components of all nutritional substances in food, water and electrolytes. Although ash and the components that constitute ash do not provide the key components of protein and energy for growth and maintenance of the calf, the minerals found in ash are of absolute critical importance for cellular function, and a lack of these components can actually limit calf performance.

As with just about anything in animal agriculture, the impact of ash on calf growth and health is not black and white. The impact of ash on the calf is highly dependent upon various other factors, including feeding rate of the milk replacer. As described above, the formula of the milk replacer and the types of ingredients used determine the resultant ash and lactose levels. As will be shown in some examples below, the levels of protein and fat in the formula as well as the feeding rate of the milk replacer will impact what the gain will be in the growing calf. These estimates of average daily gain are derived from the calf growth model in the Nutrient Research Council publication demonstrating the impact of the type of feed consumed at various ambient temperatures and body weights of the calf.

A traditional method of feeding calves is to use a 20:20 milk replacer formulated with various all-milk ingredients and is fed at about 1-1.5 pounds of dry matter per day. The following chart demonstrates the predicted gain at varying levels of ash and dry matter fed. Note that the predicted gain is predicated on the availability of protein or energy (fat and lactose) limiting the gain. This concept of limiting nutrients for growth is worthy of further discussion. Protein is required by the calf for lean/structural growth. Protein builds frame. Fat and lactose fill the frame, and together make up the energy fragment of the milk replacer. Therefore, when ash is increased, thus decreasing lactose, we may enter into a situation where energy becomes the limiting nutrient. If protein availability for growth is lower than fat + lactose availability, protein is limiting. This will become more apparent in the below examples.

Predicted Gains (milk only)--Varied Nutrition, Ambient Temperature and Body Weight

Ambient Temperature:	70	° F			Quarts water:	4		
Body Weight:	100	pounds						
	Protein (dry matter)	Fat (dry matter)	Feeding rate (lbs. dry matter)	% solids	Energy Allowable Gain lbs./d	ADP Allowable Gain lb./d	**Actual predicted gain lbs./day**	Ash
Feeding Plan 1	20.0%	20.0%	1.00	10.7%	0.38	0.52	**0.38**	7%
Feeding Plan 2	20.0%	20.0%	1.00	10.7%	0.35	0.52	**0.35**	9%
Feeding Plan 3	20.0%	20.0%	1.25	13.0%	0.77	0.72	**0.72**	7%
Feeding Plan 4	20.0%	20.0%	1.25	13.0%	0.75	0.72	**0.72**	9%

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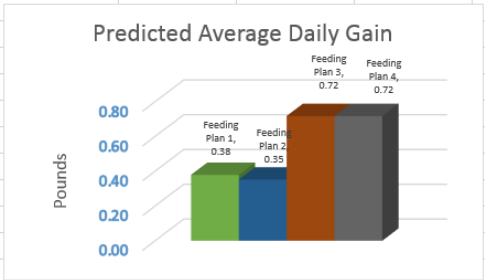
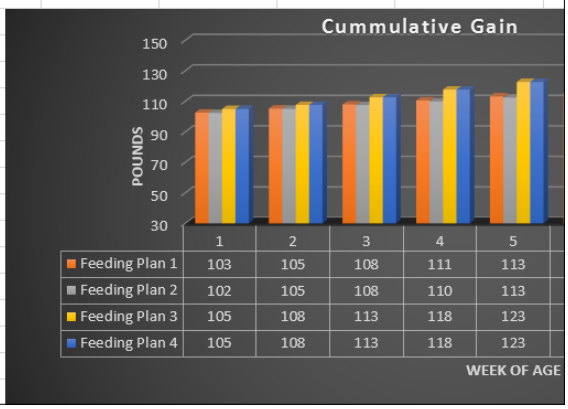
	Location:	Green Bay, WI
	Month	July
Average Ambient Temperature °F :		**71**





When the 20:20 is fed a 1.25 lbs. of dry matter, there isn't enough protein to meet the predicted gains from the energy, therefore the gain predicted is .72 lbs. /day and is not impacted by the ash level. In this example, protein is the limiting nutrient and thus changes in energy content (as a result of ash content) are essentially irrelevant. Furthermore, although there is a numerical different in predicted gain at the 1.0 lb. feeding rate, the cumulative gain is still the same at 5 weeks of age.

When the milk replacer ration is formulated for a more intensive nutrition program with high feeding rates, the formula should include a higher rate of protein to meet the needs of the rapidly growing calf. In the example below, when the 25:20 is fed at 1.5 lbs. of dry matter/day, the ash levels have an impact on the predicted gain of .03 pounds/day. Cumulative over 5 weeks however, the total gain is only decreased by one pound of body weight.

Predicted Gains (milk only)--Varied Nutrition, Ambient Temperature and Body Weight

Ambient Temperature:	70	° F		Quarts water:	6			
Body Weight:	100	pounds						
	Protein (dry matter)	Fat (dry matter)	Feeding rate (lbs. dry matter)	% solids	Energy Allowable Gain lbs./d	ADP Allowable Gain lb./d	Actual predicted gain lbs./day	Ash
Feeding Plan 1	25.0%	20.0%	1.50	10.7%	1.17	1.21	**1.17**	7%
Feeding Plan 2	25.0%	20.0%	1.50	10.7%	1.14	1.21	**1.14**	9%
Feeding Plan 3	25.0%	20.0%	2.00	13.8%	1.83	1.70	**1.70**	7%
Feeding Plan 4	25.0%	20.0%	2.00	13.8%	1.79	1.70	**1.70**	9%

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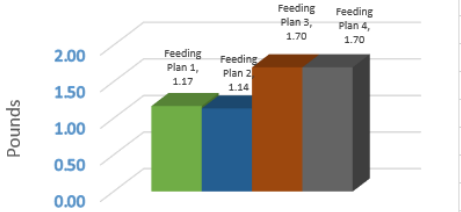

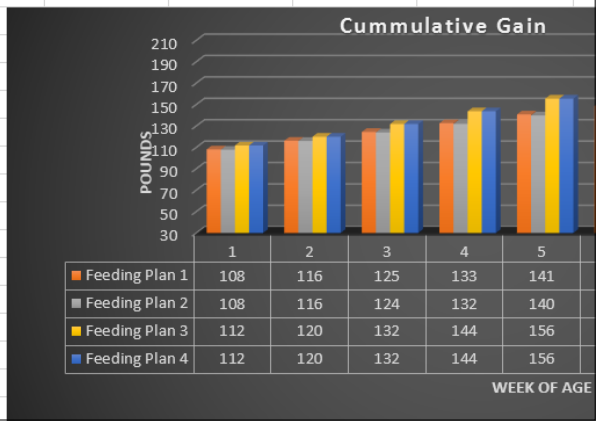

When the 25:20 milk replacer is fed at 2.0 lbs. of dry matter/day, the ash levels don't have an impact on predicted gain because protein is the limiting nutrient. Essentially, minor alterations in the available energy for gain (lactose + fat) do not matter because at this feeding rate, protein is not laying enough frame for energy to fill in.

Additionally, when milk ingredient proteins are relatively high priced, milk replacer formulators strive use an ingredient combination that provides the least cost ration. This typically involves utilizing milk ingredients that are a better value and this usually means that reduced lactose whey, commonly called "delac", is a favored ingredient. As shown in the table above, delac is higher in ash than the other common ingredients. During these economic conditions, it is advantageous to utilize delac while setting a limit on the total ash level desired in the final formula.

Below is an example of a typical milk replacer used in an intensive feeding program formulated at varying ash levels. When the ash levels reaches 12%, the cumulative predicted gain at 5 weeks of age is decreased by 2 pounds from formulas fed at 7% and 9% ash.

Predicted Gains (milk only)--Varied Nutrition, Ambient Temperature and Body Weight

Ambient Temperature:	70	° F		Quarts water:	6			
Body Weight:	100	pounds						
	Protein (dry matter)	Fat (dry matter)	Feeding rate (lbs. dry matter)	% solids	Energy Allowable Gain lbs./d	ADP Allowable Gain lb./d	Actual predicted gain lbs./day	Ash
Feeding Plan 1	28.0%	22.0%	2.25	15.2%	2.23	2.21	**2.21**	7%
Feeding Plan 2	28.0%	22.0%	2.25	15.2%	2.19	2.21	**2.19**	9%
Feeding Plan 3	28.0%	22.0%	2.25	15.2%	2.14	2.21	**2.14**	11%
Feeding Plan 4	28.0%	22.0%	2.25	15.2%	2.12	2.21	**2.12**	12%

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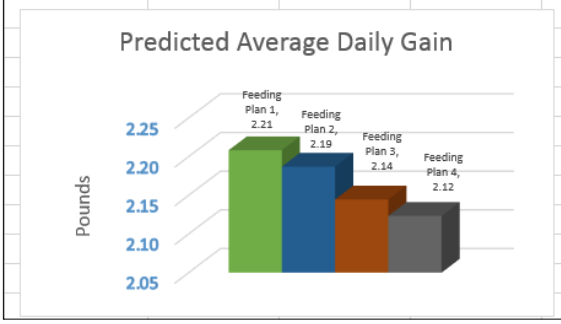

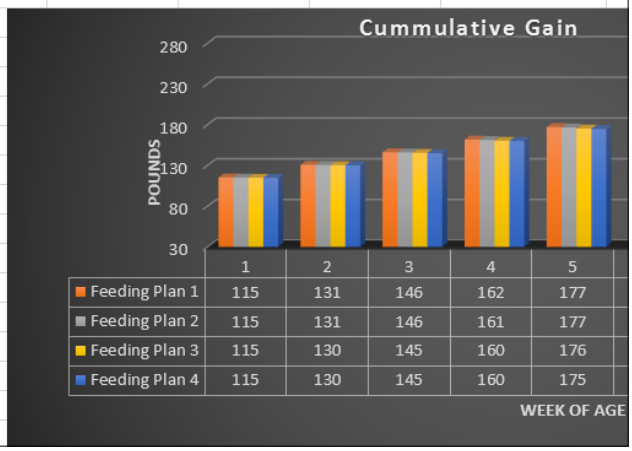

The decision a calf raiser will need to make is an economic one where the cost of a 12% ash milk replacer compared to a 7-9% milk replacer is worth the two pound loss in gain. The use of delac in milk replacers during high ingredient markets can decrease the cost of a 50 lb. bag of milk replacer by $1-2/bag. Avoiding the 12% ash milk replacer can, in this example, result in a cost of $1.50-$3.00 per calf during the 5 week feeding period to achieve the gain of 2 extra pounds of body weight. This results in an obviously inferior cost/lb of gain for those calves and should be considered.

It is important to also understand that ash is not the only "factor" in milk replacer that is poorly understood. Milk replacers can have a variable amount of moisture and can range from as low as 2.5% to as high as 7%. Moisture as low as 2.5%-3.5% is typical of milk replacers that are agglomerated or "instantized" but this type of processing is also unique to different manufactures. It is obvious that milk replacer with a moisture of 7% has 4% more water in it than the milk replacer with 3% moisture. This results in a 50 lb. bag of milk replacer with 2 pounds less powder and nutritional value.

Below is an example of the impact that different levels of moisture can have on calf growth. Note that the difference in moisture levels has a greater magnitude impact on cumulative gain than what was demonstrated with varying ash levels. This is extremely important to consider. Previous literature aiming to discredit high ash milk replacers used a milk replacer that had a moisture content of 5%. This talking point received little attention, but should have. Essentially, all talk of ash content is moot when moisture content of milk replacer becomes too great, as this is much more detrimental to calf growth potential.

Predicted Gains (milk only)--Varied Nutrition, Ambient Temperature and Body Weight

Ambient Temperature:	70	°F		Quarts water:	4				
Body Weight:	100	pounds							
	Protein (dry matter)	Fat (dry matter)	Feeding rate (lbs. dry matter)	% solids	Energy Allowable Gain lbs./d	ADP Allowable Gain lb./d	**Actual predicted gain lbs./day**	Ash	Moisture
Feeding Plan 1	20.0%	20.0%	1.00	10.7%	0.35	0.52	**0.35**	9%	0%
Feeding Plan 2	20.0%	20.0%	0.97	10.4%	0.30	0.50	**0.30**	9%	3.00%
Feeding Plan 3	20.0%	20.0%	0.95	10.2%	0.26	0.48	**0.26**	9%	5.00%
Feeding Plan 4	20.0%	20.0%	0.93	10.0%	0.23	0.47	**0.23**	9%	7.00%

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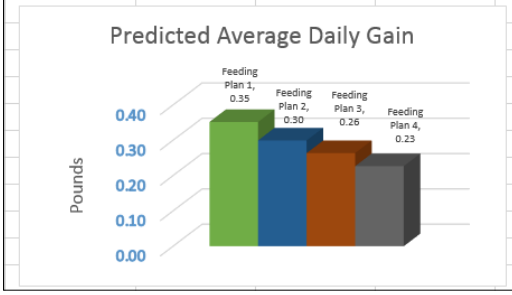

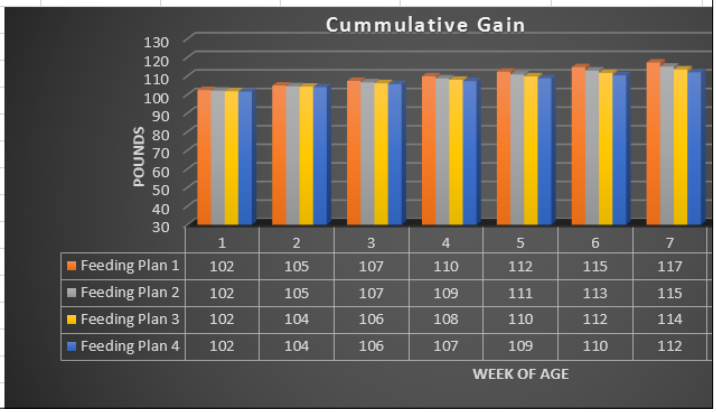

Bottom Line:

Minerals in the ash component of milk or milk replacer are essential for the growth and health of the animal. Suggesting they are harmful to the animal is either naïve or shows a marketing strategy that is self-serving. The only impact that higher ash levels have on the nutrition of the animal is the resulting impact described above on the amount of energy available from lactose. Ash content of the milk replacer should only be considered in detail when energy is known to be the limiting nutrient in the diet. However, next time a salesman approaches with a low-ash product, consider the cost associated with the minor opportunities for gain. Rarely, is the additional gain from such products worthwhile.