# ANIMAL FEED APPLICATIONS FOR WHEY PRODUCTS AND LACTOSE

*Photo courtesy: Sungwoo Kim*

*The animal feed industry is a large and important consumer of whey products. In addition to dried whey, a number of other whey-based products have been consumed in significant quantities by the animal feed industry. These products include whey permeate, lactose, delactosed whey, whey protein concentrate and others. Estimates suggest that nearly 50% of the whey produced annually in the U.S. is utilized in animal feeds.*

Whey products are consumed in varying amounts by a wide variety of animal species, including swine, dairy and veal calves, dogs and cats, poultry, aquaculture and numerous other species. The greatest utilization of whey products in animal feeds is in the swine industry. It is estimated that 51% of the dried whey used in animal feeds in the U.S. is consumed by swine. Dried whey use in calf feeds is second at 42%, followed by pet foods (5%), and other animal species (2%).

## WHEY PRODUCTS IN SWINE STARTER DIETS

Whey products are especially important in the diet of the young pig. The practice of weaning piglets from mother's milk to a dry feed at an early age requires the use of milk components in the dry feed to ease this transition. Within the last decade, the typical weaning age for piglets in the U.S. has been reduced from 5 down to 3 weeks of age, or less. Other countries have also adopted earlier weaning ages. To provide optimum nutritional management for the early weaned pig, it is necessary to include milk protein and milk sugar (lactose) in the weaned pig diet.

Whey products provide a rich source of essential nutrients, including lactose, high quality milk proteins, milk minerals such as calcium and phosphorus, and vitamins. The table below illustrates the contribution of milk products to a prestarter early-wean diet fed to baby pigs. One hundred percent (100%) of the pig's requirement for lactose is derived from milk products, particularly whey and whey-based products. Significant and economically important levels of high quality protein, lysine, calcium and phosphorus are also of whey origin.

*Photo courtesy: Sungwoo Kim*

**Contribution of milk products to a swine prestarter diet**

| Items | Requirement, % | % of Requirement Provided by Whey Product |
|---|---|---|
| Lactose | 22.5 | 100 |
| Protein | 24 | 13 (high quality) |
| Lysine | 1.70 | 13 |
| Calcium | 0.90 | 22 |
| Phosphorus | 0.80 | 22 |

CREDITS

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Lactose is a 2-unit sugar (disaccharide) made up of two simple sugars, glucose and galactose. The enzyme, lactase, is required to breakdown lactose into its constituent sugars. As shown in the adjacent figure, baby pigs are born with high levels of the lactase enzyme that allows them to efficiently utilize lactose as a primary source of energy. In contrast, amylase and maltase are the enzymes required for starch digestion (the principal carbohydrate in corn and other grains), and these enzymes are present at low levels at the birth of the pig. The pig's positive response to whey can largely be attributed to the lactose component.

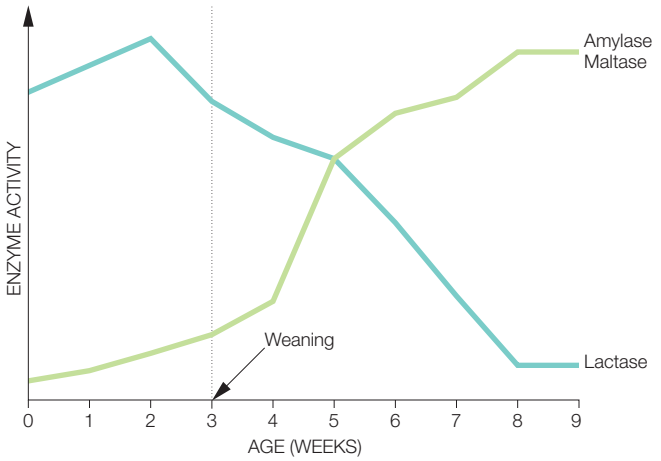
Lactose has also been shown to increase calcium, magnesium, phosphorus and zinc retention in the intestinal system of young pigs and therefore improve absorption of these essential minerals. In addition, lactose promotes the growth of beneficial bacteria at the expense of pathogenic bacteria in the digestive tract, and therefore improves the pig's health status.

Historically, skim milk and whey have been used by the feed industry to meet the lactose (and protein) requirement of the young animal. In the early 1990's, the animal industry began to utilize crystalline lactose (99%) and dried whey permeate (80% lactose). Progressive swine nutritionists have included whey, lactose, whey permeate, and other milk components in their computer formulation matrix, which allows them to "least cost" their pig's requirement for dietary lactose.

Whey is also an excellent source of high quality protein. Protein quality in animal feed is primarily determined by two key factors:

- The pattern and levels of amino acids that make up the protein
- The digestibility of the protein (amino acids).

**Digestive enzyme activity in the young pig**




Considerable research has been conducted with weaned pigs to determine a requirement for each amino acid. The relative proportion or pattern of these amino acid requirements, one to another, has been calculated, and an "ideal" amino acid pattern has been established for the baby pig. The amino acid that is first limiting (or most critical) in diets for young pigs is lysine. Therefore, using the "ideal protein" concept, the requirements for other essential amino acids are expressed as a percent of lysine. For example, threonine is generally considered to be one of the more limiting amino acids in diets for young pigs, and the estimated ideal threonine level relative to lysine is 65% for the weaned pig.

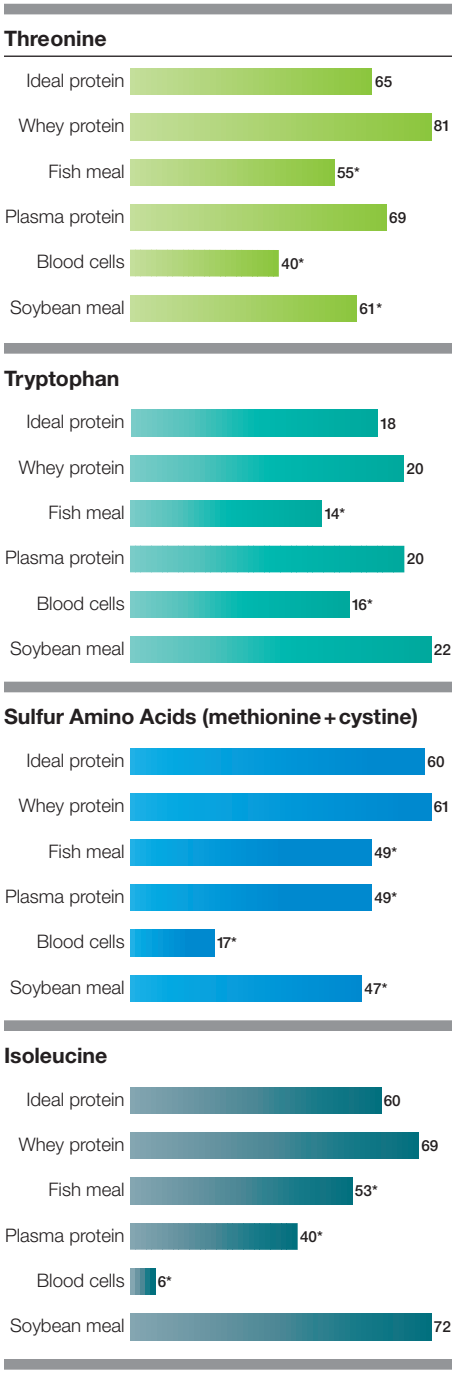
The amino acid levels in a given protein source largely determines its value to the animal. If a protein is a rich source of the most limiting amino acids and the amino acids are in good balance one to another, it would be considered as a high quality protein. The most limiting amino acids for young pigs are: lysine, threonine, tryptophan, total sulfur amino acids (methionine + cystine), and isoleucine.

The adjacent graph compares the pattern of these most limiting amino acids in several protein sources commonly fed to weaned pigs. The amino acids are expressed as a percent of lysine, as noted above for "ideal protein." If an individual amino acid level (expressed as a percent of lysine) is lower than that considered to be the ideal ratio for the young pig, the protein might be considered to be low or deficient in that particular amino acid. As noted in the graph, whey protein is a high quality protein, as the levels of the most critical amino acids meet or exceed the ideal ratio relative to lysine. In contrast, many of the other proteins commonly fed to young pigs fall short in one or more amino acids when compared to the ideal protein pattern.

This ideal protein concept provides similar findings to the protein efficiency ratio (PER) approach frequently used in human and pet nutrition. Protein sources with high PER values generally contain well-balanced levels of the essential amino acids. Using this approach, whey proteins generally compare favorably to many common proteins that have a PER value of less than 2.5. The protein efficiency ratios graph illustrates the high PER values of egg and milk proteins compared to other protein sources used in foods and animal feeds.

In addition to the amino acid composition of a given dietary protein source, the other factor that must be considered is the digestibility of the protein to the animal. Digestibility refers to the breakdown of the protein into its constituent amino acids in the digestive tract of the animal and the subsequent uptake of those amino acids into the body. Here again, whey protein compares favorably to many other protein sources commonly fed to young pigs. The amino acids in whey and whey products are 85-95% digestible, or higher. Lower amino acid digestibility values are common for many of the grains and other protein sources fed to pigs. Whey protein is readily digested and utilized by the young pig.

**Amino acid patterns of various dietary proteins compared to ideal amino acid requirements (data are expressed as a % of lysine).**




*Denotes amino acid levels (expressed as % of lysine) that fall below ideal requirements.

Source: Chung and Baker, 1992.

In summary, research has consistently shown that the addition of whey products to starter diets for young pigs improves feed intake, daily gain, feed conversion (the conversion of feed into body weight gain), and animal health. Whey or whey products are generally included in the diet for the first 3-5 weeks after a baby pig is weaned from sow's milk. The improvement in performance of early-weaned pigs fed diets containing whey products is primarily due to the ability of the young pig to utilize the carbohydrate and protein fractions from whey more effectively than those components from plant-origin and other animal-origin feed ingredients.

**Formulation of typical diets for nursery pigs at various weights**

| Ingredient | Pig Weight 2.5 to 5 kg | 5 to 7.5 kg | 7.5 to 12.5 kg |
|---|---|---|---|
| Corn, % | 31.0 | 41.0 | 57.0 |
| Dried Whey, % | 25.0 | 20.0 | 10.0 |
| Lactose, % | 5.0 | .0 | .0 |
| Soybean Meal, % | 14.0 | 24.0 | 23.0 |
| Fat, % | 6.0 | 5.0 | 3.0 |
| Porcine Plasma, % | 7.5 | 2.5 | .0 |
| Blood Meal, % | 2.0 | 2.5 | 2.5 |
| Fish Meal, % | 6.0 | .0 | .0 |
| Premix, % | 3.5 | 5.0 | 4.5 |
| **Calculated Analysis** | | | |
| Lactose, % | 22.5 | 14.0 | 7.0 |
| Lysine, % | 1.7 | 1.45 | 1.25 |
| Calcium, % | 0.9 | 0.9 | 0.9 |
| Phosphorus, % | 0.8 | 0.8 | 0.8 |

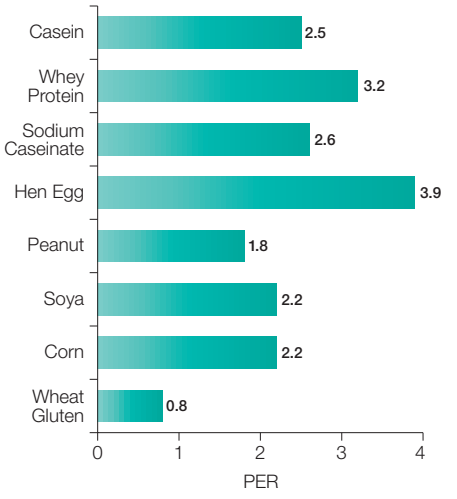
Source: Kansas State University, 1994.

**Formulation of a typical calf milk replacer**

| Ingredient | |
|---|---|
| Whey Protein Concentrate | 44.5% |
| Delactosed Whey | 10.0% |
| Dried Whey | 25.2% |
| Fat | 19.0% |
| Premix | 1.3% |
| **Calculated Analysis** | |
| Protein | 20.0% |
| Fat | 20.0% |

Source: Tomkins and Jaster, 1991.

**Protein Efficiency Ratios of various animal and vegetable proteins**

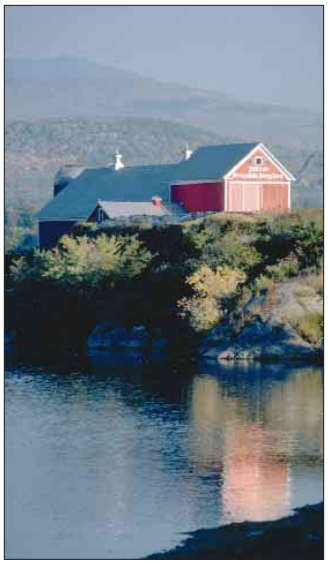



Source: Anon. 1972.

**Nutrient Comparison of Different Whey Products[1,2]**

| Product | Dried whey | Delactosed whey | Whey permeate | Whey protein concentrate | Lactose |
|---|---|---|---|---|---|
| Protein, % | 12.0 | 17.6 | 3.8 | 34.0 | – |
| Fat, % | 1.0 | 1.1 | 0.2 | 4.0 | – |
| Lactose, % | 70.0 | 55.0 | 82.0 | 50.0 | 99.5 |
| Ash,% | 8.7 | 16.0 | 8.5 | 5.0 | – |
| Calcium, % | 0.8 | 2.0 | 0.9 | 0.5 | – |
| Phosphorus, % | 0.7 | 1.4 | 0.7 | 0.6 | – |
| Sodium, % | 0.7 | 1.9 | 1.0 | 0.6 | – |
| Chloride, % | 1.4 | 3.4 | 2.2 | | – |
| Potassium, % | 2.1 | 4.7 | 2.1 | 1.7 | – |
| Moisture, % | 5.0 | 4.0 | 4.0 | 4.0 | 0.5 |
| Lysine, % | 0.9 | 1.5 | 0.2 | 2.8 | – |
| Threonine, % | 0.7 | 1.2 | 0.1 | 2.3 | – |
| Tryptophan, % | 0.2 | 0.3 | 0.1 | 0.6 | – |
| Sulfur amino acids, % | 0.4 | 0.8 | 0.1 | 1.7 | – |
| Isoleucine, % | 0.6 | 1.2 | 0.2 | 1.9 | – |
| Metabolizable energy, kcal/kg | 3,190 | 2,910 | 3,300 | 3,624 | 3,435 |

[1] Nutrient profile on an as-fed basis.
[2] Please consult your U.S. supplier for detailed product specifications.



## WHEY PRODUCTS IN CALF MILK REPLACERS

Under typical North American dairy and veal calf rearing programs, calves are fed colostrum for the first three days after birth and are then fed a liquid feed or feeds of choice. Milk replacers are very popular sources of feed for dairy calves. They are primarily intended to replace whole milk and provide a lower cost alternative for raising the young animal. The utilization of whey products is of great importance to the milk replacer industry. Approximately 42% of the whey products (dried whey, whey protein concentrate, and delactosed whey) used in the U.S. animal feed industry is consumed by calves.

The young (preruminant) calf is as dependent upon its diet for proper nutrition as is the simple stomach animal (such as the pig). The amount and activity of digestive enzymes secreted by the preruminant calf dictate the kinds and amounts of substances that can be digested. Dairy and veal calves are extremely limited in their ability to digest carbohydrates beyond lactose. However, the young calf can readily digest lactose due to high levels of the lactase enzyme (similar to the pig).

The young calf is also well equipped enzymatically to digest the proteins found in milk. Until midway through the 1980's, skim milk was the principal milk protein used in calf milk replacers. Due to economic reasons, the use of whey protein concentrate in milk replacers became favorable. Research shows that whey protein concentrate can completely replace skim milk protein in calf milk replacers without affecting protein digestibility or performance.

Commercial milk replacers typically range in crude protein content from 18 to 24%, and the lactose level generally ranges from 45-55%. The percentage of protein from milk origin varies from 100% to as little as 20% milk protein. However, it is generally recommended that the level of non-dairy protein not exceed 50% of the total protein level. Depending on the formulation, inclusion rates of whey protein concentrate may range from 7 to 55%, based on the amounts of skim milk or other proteins added. The inclusion rate of dried whey may vary from 25% to 50%.

Many of the benefits of utilizing whey products in calf milk replacers are similar to those noted for swine: improved diet palatability and feed intake; enhanced nutrient digestibility; improved animal performance; better animal health; and overall profitability.

## WHEY PRODUCTS IN PET FOODS, AQUAFEEDS AND POULTRY FEEDS:

Whey products often play important dietary and functional roles in pet foods, aquafeeds, and poultry feeds. Dried whey powder and whey protein concentrate are used in pet foods for their nutritional value, palatability-enhancement, and as a coating substance. In some feeds for aquaculture, 3 to 10% dried whey is included in the diet as a rich source of nutrients and as a pellet binding agent.

Promising research with various whey products in poultry feed has investigated the inhibiting effects of lactose on salmonella and other pathogenic bacteria in the digestive tract of broiler chickens. The results indicate that the inclusion of lactose in poultry diets at 2 to 10% can significantly decrease salmonella growth in the lower gut (caecum). This positive effect of lactose was attributed to marked increases in the concentration of volatile fatty acids and significantly reduced pH of the caecal contents.