There are several obvious differences between bottles and pails. A pail has a single component whereas a bottle also requires a nipple. Empty pails can be stacked for transport and storage, and pails can hold a greater volume of liquid than most bottles. On the other hand, bottles let the calf consume milk in a more natural position and at a more natural rate. Anatomical, physiological, nutritional and management aspects of bottle and pail feeding are explored in the sections that follow. Research evidence is provided wherever possible.

**Esophageal Groove**

When a calf swallows, solid food such as starter grain moves down the esophagus and passes through an opening called the esophageal groove just before it enters the rumen. Prior to weaning, milk and milk replacer take a different route. Factors such as suckling, anticipation, and a variety of sensual and neural stimuli cause muscles around the esophageal groove to contract. These muscular contractions close the groove, allowing milk and milk replacer to bypass the rumen and flow directly into the abomasum for digestion. See Figure 1.

The presence of milk in the rumen and reticulum is considered to be abnormal and is undesirable from a physiological and nutritional standpoint. Wise and Anderson (1939) observed that when calves suckled milk through a nipple, the frequency of milk entering the rumen was about 2.2%. The amount that entered the rumen never exceeded 3 milliliters. When milk was drunk from an open pail, the frequency of milk entering the rumen was over 40%. The amount that entered the rumen varied from a few milliliters to over 50% of the milk consumed.

Later research by Abe et al (1978) concluded that the efficiency of esophageal groove closure was similar for both nipple and open pail feeding, with very little milk replacer entering the rumen. Hegland et al (1957) found that stimuli such as the presence and activity of farm workers who fed the calves sometimes caused complete closure of the esophageal groove in certain calves.

How do we reconcile what may appear to be different research findings? Each study demonstrates that efficient closure of the esophageal groove is possible with either feeding method. Wise and Anderson (1942) found that the greatest portion of milk entering the rumen was during the first few seconds of drinking.
whether calves drank from an open pail or suckled a nipple. The reasons for milk escaping the esophageal groove can be due to a number of factors including variation in the stimuli for groove closure and the larger swallow sizes associated with drinking from an open pail compared to suckling a nipple. In the final analysis, feeding through a nipple provided consistent, efficient groove closure. Feeding with an open pail, however, appears to have a greater potential for variability in animal response.

**Ruminal drinking.** Feeding in open pails can occasionally lead to “ruminal drinking”, a situation where most of the milk or milk replacer consumed enters the rumen. Calves that are ruminal drinkers can develop feed intake and weight gain problems – a condition most commonly observed in veal calves. Under normal conditions, only about 3% of the milk or milk replacer consumed by veal calves enters the rumen (Davis and Drackley, 1998). However, when large volumes of milk repeatedly enter the rumen, calves can develop an overall appearance commonly referred to as “hay belly”. Although the term is incorrect in this case, calves can develop the classic short, squatty stature with a low-slung distended belly. The situation can lead to serious metabolic problems resulting in low rumen pH, growth of yeast rather than normal rumen microbes, small distorted rumen papillae, poor VFA production and low cellulose digestion. Ruminal drinkers are typically very aggressive drinkers and corrective action involves slowing down the drinking process. Providing multiple smaller feedings, using a floating nipple in the bucket or feeding with a bottle and nipple or a nipple pail are techniques that slow the rate of ingestion, allowing for efficient closure of the esophageal groove.

**Water drinking and esophageal groove closure.** A primary role of water consumption in pre-weaned calves is to provide the medium for starter feed digestion in the rumen and to encourage starter intake. If water bypasses the rumen and directly enters the abomasum, starter intake and rumen development may be slowed. The general recommendation is to remove each calf’s water bucket during feeding time and withhold water until 10 minutes after the calf has finished drinking its milk or milk replacer. The idea is that this delay makes water feeding a separate event and allows sufficient time for the esophageal groove to relax and open again. This way, water consumed at feeding time is more likely to enter the rumen where it facilitates the intake and digestion of starter feed and the development of rumen function.

The temperature of the water may also affect closure of the esophageal groove. Abe et al. (1978) found that when calves were accustomed to drinking milk replacer from an open pail, drinking warm water from an open pail also caused efficient closure of the groove, even after calves were weaned, up to at least 16 weeks of age.

**Body position and esophageal groove closure.** The position of the calf’s head and neck as it stands and nurses from a nipple is often cited as a benefit for the calf. Standing with its neck slanted downward from the shoulders and its head tilted upward is certainly a more natural suckling position for the calf than standing with its head pointed downward into a bucket. This natural head and neck position has been suggested as promoting efficient esophageal groove closure.

However, Wise and Anderson (1942) demonstrated that the position of the calf’s head and neck had no effect on the reaction of the groove. The esophageal groove is a functional part of the reticulo-rumen and is not part of the esophagus. Consequently, changes in the position of the calf’s head and neck in response to variation in the height of an open pail or nipple, do not affect the position or reaction of the groove (unless the position is extreme). Although nursing from a nipple is a more natural position for the calf, and may be of some other benefit, it does not physically affect esophageal groove function.
Effects of Feeding Method on Digestion

Calves obviously consume liquid feed more quickly when drinking from an open pail compared to sucking a nipple. Abe et al (1978) found that one to two week old calves required between 4 to 6 minutes to suck their milk replacer allotment from a nipple-pail compared to 40 seconds for calves drinking from an open pail. The rate of ingestion when suckling the cow is estimated to be about 1.2 lb per minute (0.55 kg/min) for a two week old calf and about 1.8 lb/min (0.82 kg/min) for an 8 week old calf (Roy 1980). This means that calves allowed to suckle the cow consume 2 quarts of milk in about 3.5 minutes when they are two weeks of age. By the time they are 8 weeks old, the time is reduced to about 2.4 minutes.

Research at Merrick’s Calf Research Facility found that 3 week old calves consumed 2 quarts of milk replacer from a nipple and bottle in about 2.1 minutes (+ 0.5 min). This rate was determined for Merrick’s Super Calf nipples and bottles and may not reflect the rates observed with nipples and bottles of other manufacturers.

After adjusting for age differences, the rate at which calves consume milk or milk replacer is about 35% faster with a nipple and bottle and about 40% slower with a nipple pail compared to a calf that nurses the cow. Both of these nipple feeding methods are much closer approximations of a calf’s natural consumption rate when compared to an open pail. Consumption rate is about 85% faster with an open pail compared to nursing the cow.

The rate at which a calf consumes liquid feed affects the rate at which liquid feed moves through its digestive tract. Abe et al (1978) measured a more rapid rate of passage of milk replacer into the lower gut when feeding with open pails than with nipples.

The slower consumption rate associated with nipple feeding appears to enhance several physiological processes associated with digestion. Roy (1980) cites research demonstrating that saliva production increases when calves suck milk through a nipple. Martin (1963) found a three-fold increase in saliva production with nipple feeding compared to bucket feeding. The additional saliva causes more salivary lipase (pre-gastric esterase) to be mixed with milk or milk replacer before it is swallowed. Salivary lipase begins the process of fat digestion in the calf’s abomasum. When low levels of salivary lipase are present, more intact fats pass through the abomasum, delaying digestion until the small intestine.

Radostits and Bell (1970) report that feeding from an open pail does not stimulate secretion of abomasal enzymes as readily as does feeding through a nipple. Wise and LeMaster (1967) also found that enzymatic activity in gastric solution is greater with nipple-feeding, resulting in more effective stimulation of protein digestion activity in abomasal fluids. In addition to greater protease secretion, Ternouth and Roy (1978) report secretion of more abomasal acid with nipple feeding. They also found a lower level of protein nitrogen relative to total nitrogen (PN:N) in the duodenum when calves were fed with nipples, indicating a higher level of protein digestion in the abomasum than with bucket feeding.

These studies demonstrate that nipple feeding, with its slower more natural rate of consumption, provides a slower rate of passage, thereby enhancing digestive processes when compared to open pail feeding. With the secretion of more enzymes and more digestive acid, nipple feeding promotes fat and protein digestion in the abomasum. More digested nutrients flow from the abomasum into the small intestine ready to be absorbed.
With open pail feeding, more digestion is pushed to the small intestine in addition to nutrient absorption. The increase in undigested nutrients leaving the abomasum with pail feeding means that more enzymes must be secreted from the pancreas and enter the upper portion of the small intestine to digest the additional nutrients. This process is confirmed by Ternouth and Roy (1978) who reported more pancreatic secretions when calves are fed with an open pail. Although calves fed with open pails do appear to respond to the situation, some physiological factors may be of concern, such as the limitation of most fat absorption to the first 30% of the small intestine (Roy 1990).

Effects of Feeding Method on Animal Health

As with esophageal groove closure, research designed to evaluate the possible effects of feeding method on calf diarrhea provide mixed results. Some studies show fewer episodes of diarrhea, less persistent and/or less severe diarrhea with nipple feeding while others do not. Roy (1969) reported a higher rate of diarrhea with open pail feeding. Wise and Lemaster (1967) found a higher incidence rate of diarrhea and greater persistence of diarrhea episodes with open pails when feeding higher rates of milk replacer. Rajala and Castren (1995) found no difference in the incidence of diarrhea, but found a three-fold increase in the duration of diarrhea with open pail feeding. Even so, many researchers did not observe a difference in overall health and weight gain due to the system of milk feeding.

Other Physiological and Behavioral Effects

Behavioral differences in calves have been reported between the two feeding systems. Veissier, et al (2002) found that in calves housed individually, nipple-feeding reduces non-nutritive oral activities such as sucking objects, sucking and nibbling on parts of the pen, self-licking or licking calves in adjacent pens. Nipple-fed calves also had a lower heart rate during and just after feeding and returned to a resting state more quickly after a meal than calves that drank from an open pail. The authors concluded that although these behavioral differences might be beneficial for the consumption of nutrients, they were not able to demonstrate an improvement in calf growth. In group feeding situations, Boe and Havrevoll (1993) report that sucking from a nipple may reduce cross-sucking that occurs in group housing situations. However, Vessier, et al (2002) did not find a reduction in cross-sucking among calves when group housed.

Feed Delivery and Clean-up

Whether feeding 10 calves or 10,000 calves, effective feeding and clean-up protocols can be developed and implemented regardless of whether bottles and nipples or buckets are used. Neither program is inherently simpler, easier or more sanitary than the other.

Even so, certain circumstances tend to favor the adoption of one feeding system over the other. Consider the example of large calf raising operations. At first glance one might assume that bucket feeding would be the obvious choice when feeding a large number of calves. The logistics of filling, delivering and cleaning large numbers of bottles and nipples pose a real challenge. Nevertheless, bottle feeding has become the program of choice for large calf raising operations throughout much of the United States.
Spread of Disease. Minimizing the potential for spreading disease is of primary importance. With pails, a number of different feeding techniques can be utilized. One technique is to use a fixed number of milk pails at each feeding. In this situation a milk pail is reused many times during feeding. The pails may be rinsed with water between calves, but few operations wash pails, and fewer sanitize pails between calves. As a result, both the outside and the inside of the buckets can provide a vector for spreading disease from one calf to another.

Another technique is to use each calf’s water pail for feeding milk or milk replacer. Any water that is in the pail is dumped prior to feeding. Milk or milk replacer is deposited into the pail by means of a hose attached to a portable milk tank. After feeding, pails can be collected and taken to the milk barn for cleaning. Both the inside and outside of each pail must be washed thoroughly since they will be stacked one inside the other and taken back to the hutch. Another approach to feeding with this method is, however, to leave the pails in place and simply fill them with water after feeding. With this technique, water pails are typically removed and cleaned infrequently, and may only be cleaned once -- after the calf has been moved from the hutch. Although feeding equipment is not shared between animals, lack of proper cleaning and sanitizing can lead to a build-up of bacteria in each calf’s water pail. This bacteria build-up can contribute to an increase incidence of disease and can also limit water and feed intake.

Bottles and nipples provide a practical alternative that can reduce the likelihood of spreading disease. With this system, each bottle and nipple is reused several times during each feeding. The only item of feeding equipment that comes into direct contact with calves is the nipple. To minimize the spread of disease, the system that developed pays special attention to cleaning/sanitizing each nipple between calves.

A specific health reason cited by many large calf raisers for using bottles and nipples instead of pails is the tendency of some calves to aspirate milk or milk replacer into their air passageway and even into their lungs when drinking from a pail. The telltale sign of the problem is coughing and a raspy or “rattling” sound during breathing after calves have finished drinking. These operations relate the use of bottles and nipples to fewer cases of pneumonia and fewer treatments.

How does a bottle feeding system work on large calf operations? The basic piece of equipment that allows bottles and nipples to be so widely used on these operations is the bottle cart (Figure 5). Bottle carts can be made to hold any number of bottles and are typically sized to correspond to the batch size of the mixing tank or to a specific number of hutchs or stalls within a given section of the calf facility. A large calf facility usually has multiple bottle carts, each cart holding several hundred bottles.

Each row of bottles on the cart is filled simultaneously, one row after the other with customized equipment that greatly speeds up the filling process. Workers attach a nipple to each bottle and the full cart is ready to be taken to the calf area.
The cart is pulled with a small tractor between the rows of hutches while calf feeders place a full bottle in the holder in front of each calf. Empty bottles are picked up and placed back on the cart which is then returned to the milk barn.

Once in the milk barn, the nipples are typically placed into a cleaning/sanitizing solution once they are removed from the bottles. If bottles stay on the cart for rinsing and refilling, they are filled with a rinse solution. Ideally, brushes are used to clean the inside of the bottles. A screen, mesh or other restraining device is then placed over the bottles to hold them in place. The bottle cage portion of the trailer is then rotated 180°, inverting the bottles, draining the solution. The empty bottles are then returned to their upright position to be refilled with milk or milk replacer. While the recently removed nipples remain in the cleaning/sanitizing solution, a second set of sanitized nipples are applied to the bottles and the cart is ready to go back to the calf area.

These versatile carts not only allow calf feeders to rapidly feed a large number of calves, they also allow farm personnel to rapidly clean and fill empty bottles when they are brought back to the milk barn.

Automatic washers. Many calf-raising operations now use automatic washing units as a way to control their cleaning and sanitizing process of calf feeding equipment. These washing units use the same technology developed for commercial dishwashing units in restaurants and cafeterias and are available for farm use. (Reference No. 4).

Nutrient Consistency. Delivering a precise, consistent amount of milk or milk replacer to each calf at each feeding is an important control measure for minimizing nutrient variability. Although either feeding method can be managed to minimize nutrient variability, pails can pose a particular challenge. The biggest challenge is the calf itself. If the calf has access to the pail while it is being filled, it can be difficult to gauge how much the calf actually receives. Often a calf will drink at the same time the pail is being filled. This is a problem if the pails are filled to a specific level at each feeding. In addition, the calf may put its head directly into the flow from the hose. Combine this with a forceful flow rate and milk or milk replacer can end up splashing into the starter feed as well as all over the calf. This not only encourages a healthy fly population, but can also decrease the palatability of the starter. Installing a mechanism within the feeding equipment to meter a specific amount of milk or milk replacer into each pail can help minimize some of the variability that occurs with pail feeding systems.

Feeding with bottles and nipples delivers a consistent amount milk or milk replacer to each calf at each feeding. Bottles typically hold two quarts, but three-quart bottles are also available. Bottles reduce nutrient variability and minimize the impact that individual employees can have on the feeding program.
Summary

Research evidence demonstrates a greater potential for variability in animal response with pail feeding compared to nipple feeding methods. Consider the effects on closure of the esophageal groove. Although some studies showed more milk entering the rumen with open pail feeding of milk or milk replacer, and other studies show little or no difference, no study shows an advantage of open-pail feeding over nipple feeding on groove closure.

A similar argument can be made for the effects of consumption rate on digestion. The slower consumption rate associated with nipple feeding stimulates more salivary lipase, enzyme and digestive acid production for fat and protein digestion than pail feeding. Although the pancreas can compensate for the higher level of undigested nutrients reaching the small intestine by increasing lipase and enzyme production, pail feeding narrows the time window for effective digestion and absorption of nutrients. Hence, there is a greater potential for digestive problems with pail feeding.

In terms of animal health, some researchers found that there were advantages of nipple feeding on the rate, persistence and severity of diarrhea. On the other hand, many researchers reported no observed differences in overall health and weight gain due to the feeding system used.

It should be noted that a relatively high level of animal management exists in research settings with protocols being implemented to minimize variability between treatments. These studies demonstrate that with sound management practices there should be few differences in animal health and performance directly attributable to the method of milk or milk replacer feeding. But when differences do occur, the underperformance tends to occur with pail-feeding.

The potential for variability in the amount of nutrients provided to calves is also greater with pails. Delivering a consistent level of nutrients is best achieved with the bottle and nipple combination. The confined, fixed volume of the bottle assures that each calf receives the same amount of milk or milk replacer at each feeding, and minimizes the effects of calf and employee behavior on the feeding routine.

When it’s all said and done, nipple feeding methods appear to be the gold standard against which pail feeding must be evaluated.
References


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