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TECHNOLOGY & NUTRITIONAL NEEDS OF MILK-FED CALVES

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Introduction

In the U.S., as well as other parts of the world, calves are fed using various nutrition plans and feeding systems, to meet the growth, performance and economic goals of the calf producer. Nutrition plans and feeding systems range from the traditional 1 lb per day of a 20% protein/20% fat milk replacer to 4-6 lb per day of 22-28% protein and 18-14% fat milk replacer, to other feeding levels of milk replacer, waste milk, returned milk, and/or other products. Growth, efficiency, and production cost of calves fed with these different programs vary widely. Regardless of the feeding program, several underlying nutritional principles need to be met to optimize calf performance and producer profit. This paper will attempt to identify and examine the key principles and available technologies to meet the nutritional needs of calves on milk. For the purpose of this paper, the term “milk replacer” will be used but can include other products such as pasteurized waste milk.

Basic Principles – Be Consistent

1. Feed calves at the same time every day
2. Milk replacer mixing should be consistent – temperature, time, concentration
3. Milk replacer feeding should be consistent – temperature, quantity
4. Mixing and Feeding Equipment Should be Cleaned on a Consistent Basis

Why Feed at the Same Time?

Like many other animals, calves develop circadian rhythms which should be met by the calf feeder. If calves become used to being fed at 7:00 am and 4:00 pm, for example, hormones, enzymes and even rumen protozoa become accustomed to feeding at these times. By feeding consistently at the same times, calf feeders (people and/or equipment) can minimize stress and maximize performance of calves, regardless of what is being fed.

Milk Replacer Mixing

The three important components of milk replacer mixing are: specific mixing temperature, specific amount of time, and a specific final concentration – weigh components.

Different milk replacer manufacturers use different methods to make milk replacers. As a result, milk replacers from different companies have different mixing characteristics which need to be met. Some milk replacers are made by

blending ingredients which were previously dried. Others are made by using heat to dry proteins on the outside of fats. Still others are made by using extreme cold to crystallize fat on the outside of protein. Ideal mixing temperature for a milk replacer depends on the method used for manufacturing: dry blended milk replacers can generally be mixed from 110-150^{o}F; milk replacers with protein dried on the outside of the fat can generally be mixed from 120-140^{o}F; while milk replacers made by crystallizing fat on the outside of protein generally require mixing temperatures from 150-170^{o}F.

The cow uses protein-encapsulated micelles to emulsify butterfat in milk but milk replacer manufacturers must use emulsifiers to facilitate powdered fat mixing into water. Different milk replacer manufacturers use different emulsification systems to accomplish this. Also, the composition of the fat will affect the final mixing temperature for the milk replacer because the fats' melting points will depend on their composition. For example, lard, tallow, and coconut oil have melting points of 97-113^{o}F, 86-104^{o}F, and 76^{o}F, respectively. Calf feeders should pay close attention to manufacturer's recommendation with regard to mixing temperature and mixing time to assure milk replacer has solubility, homogeneity and high digestibility.

Ideally, calf feeders should add approximately 50-70% of the total water needed for a batch of milk replacer at the hot mixing temperature. Then, the milk replacer powder should be slowly added while the mixer is running to avoid lumps. Milk powder should be weighed to assure desired nutritional levels. Next, the milk replacer should be mixed for 5 minutes, then cooler water should be added to meet the final volume and temperature of the mix.

Milk Replacer Feeding

Calves should be fed at the same time everyday. Milk replacer should be mixed and fed according to manufacturer's directions and always fed at the same temperature. This means that in winter, the final mix temperature should be warmer than in summer to accommodate the heat loss due to cold feeding equipment and colder ambient temperatures. What temperature should milk replacer be when fed? That seems to depend on where you live – most U.S. manufacturers and text books recommend feeding temperatures from 101 – 107^{o}F. European manufacturers recommend higher milk replacer feeding temperatures of 113 – 118^{o}F because of improved sanitation and feed conversion. Regardless of the feeding temperature chosen, the temperature should be consistent – use a thermometer. The amount of milk replacer fed should be accurate – use a flow meter, a scale or other weighing device to assure that calves are accurately fed milk replacer at every feeding.

Cleanliness is Next To…

The old adage says that "cleanliness is next to Godliness," but the reality in most calf operations is that cleanliness is next to impossible! To minimize disease transfer in calves from milk replacer mixing and feeding equipment, calf

producers should follow a clearly defined set of cleaning procedures with regard to temperature, time, and sanitizing agents. Generally, milk residue should be rinsed from equipment with warm water (110-120^{o} F) to remove manure, dirt, and all milk residues. Rinsing with lukewarm water allows milk residues to rinse off of the mixing and feeding equipment without becoming sticky and hard to remove. Use a thermometer to adjust rinse temperature to 110-120^{o}F every time you rinse. Next, clean equipment using a mixture of chlorinated alkaline soap and hot water (165^{o}F). Chlorine dissolves proteins and alkaline soap dissolves fat. Wear gloves and scrub all surfaces to remove protein, fat, and foreign materials that adhere to surfaces. Special brushes may be needed to clean nipples, bottles, esophageal feeders, floating nipples, feed buckets, etc. At the end of the washing cycle, final temperature should be above 130^{o}F to prevent scum from attaching to clean surfaces. Use a thermometer to adjust wash temperature to 165^{o}F every time you wash. Rinse with cool water after cleaning. Once per week, clean with acid cleaner per manufacturer's directions. Finally, rinse with an acid-sanitizing solution in warm water (70^{o}F) per manufacturer's directions. Acid final rinses reduce surface pH to less than 4 for up to 12 hours which reduces the growth of bacteria. After sanitizing, allow equipment to dry completely, if possible, between uses. Dry surfaces also inhibit the rate of bacterial growth.

Automated Milk Replacer Mixing Systems

Available technologies include automated milk replacer mixing equipment and automated mixing/feeding equipment with a wide range of capabilities. Automated milk replacer mixing systems have load cells under the mixer, and can offer temperature adjustment in the software program and have temperature probes, have pre-programmed mixing time, and result in a higher degree of consistency than is achievable with human labor. Automated milk replacer mixing equipment can consistently mix milk replacer at the same time each day, adjust milk mixing temperature, accurately weigh water and milk replacer powder into the mixer, mix for the set amount of time, then add cooler water and adjust final mix quantity and temperature. With the automated system labor is reduced and milk replacer consistency is increased which usually results in better calf performance.

Figures 1 and 2 show two different automated milk replacer mixing systems which are currently being used. Figure 1 shows the *Automat* system from Delimax, a company in St. Hyachinthe, Quebec, Canada. In this system, milk replacer is delivered in tote sacs and feeds into a stainless steel hopper. Dry milk replacer powder is augured from the hopper into a 500 liter liquid mixer which is on load cells and has two impellers to mix milk replacer. After mixing, milk replacer is pumped automatically into a 1000 liter holding tank (left) which is equipped with sensors to stop or start filling the holding tank from the mixer. With this system, the calf grower inputs the number of calves and the amount of milk powder and total solution per calf along with the time of day for the feedings. The *Automat* begins the milk preparation to have ready-to-feed milk replacer at the specified feeding time. As the grower feeds milk replacer, the *Automat* pumps

milk replacer from the mixer into the holding tank and mixes additional batches of milk replacer until a sufficient quantity of milk replacer has been mixed to feed all of the calves.

Fig. 1. *Delimax Automat* system (R to L): tote sac of milk replacer, hopper, mixer, storage tank

Figure 2 shows the *Turbo-Lait* system which was built by Corneli, in France. This particular system is at the *Institut de l'Elevage*, near Rennes, which conducts research with veal calves, hence the dual augers to supply two different experimental milk replacers into the mixer. The three small stainless steel tanks are needed to supply additives to the milk replacer such as antibiotics, iron supplements, and electrolytes for calves during various stages of veal production. In this particular system, the *Turbo-Lait* is part of an automated feeding system and milk replacer is pumped from the mixer into smaller milk holding tanks which are located next to the pens of calves, but could just as easily supply a feeding hose as is the case with the *Automat* system of Figure 1. This system has been in use for about ten years at the *Institut de l'Elevage*. The automated feeding system in use with the *Turbo-Lait* will be discussed in the following section.

There may be other automated milk replacer mixing systems which are not shown here, but the basic principles are the same: water and powder added according to weight with temperature adjustment and final quantity determined by

inputs from the producer. These systems often produce more consistent performance results in calves because of the consistent mixing sequence with the milk replacer and because the set time of mixing encourages producers to feed at the same times every day. Producers and hired labor have more time to review the appearance of calves and notice problems early rather than spending time weighing and mixing milk replacer and cleaning equipment.

Fig. 2. *Cornelli Turbo-Lait* system (R to L): double hopper, additive tanks, mixer

Automatic Milk Replacer Feeding Systems

Historically, automated milk replacer feeding systems started with *ad libitum* (free choice) milk replacer feeding systems and progressed with the advent of radio-frequency identification (RFID) to controlled feeding systems. *Ad libitum* systems are still available in the marketplace and have the advantage of low cost, but the disadvantage of inconsistent intake and inconsistent performance of calves.

Figure 3 is of the *Milkomat*, an older Feeding System which has been used for approximately twenty-five years for veal calves. This system is limited in the type of milk replacers which can be used because the only adjustment to water temperature is made by changing the set-point on the water heater. As a result, mixing temperature is limited to 20-30^{o} F higher than the feeding temperature depending on the ambient temperature, temperature of milk replacer powder,

milk replacer concentration, etc. And, although the cleaning is entirely manual, this system can feed calves successfully, as several veal producers can attest. Those who claim to be innovative pioneers because they are feeding calves with new automated feeding technology have been ignoring those veal growers that have been using this older technology for more than twenty five years.

Figure 3. *Milkomat* free-choice system used for veal calves for nearly 25 years in U.S.

Controlling feed intake of calves is important to prevent digestive disturbance, produce uniform groups of calves, and minimize cost of production. Figure 4 shows a feeding system that uses RFID technology to feed calves according to a prescribed feeding plan. This system is manufactured by Förster-Technik, in Germany. Similar systems, manufactured by Förster-Technik are marketed in the U.S. by DeLaval and others. These systems have the advantage of lower cost and are reliable to mix milk replacer and feed calves on an individual basis. The primary disadvantage is the milk replacer is not mixed by weight, but by volume which requires more frequent calibration to maintain accurate mixing. Also, nipples are not cleaned automatically so labor is needed for cleaning, to avoid the transfer of disease from calf-to-calf. But, this type of system offers clear technological advances over the older technology of the *Milkomat* generation and, with good management, can successfully raise calves.

Figure 4 *Förster-Technik* machine for veal calves

The next technological advancements are included in the systems manufactured by Asserva, in France. Asserva has a distinctive green color which is shown in figure 5. These systems have a retractable nipple to restrict access to the nipple when each calf finishes its daily allocation of milk replacer. Although the nipple does not have any exterior washing capability, the limited access reduces calf-to-calf disease transfer and increases the number of calves being fed because calves do not spend as much time suckling on a dry nipple. This system mixes by

weight and has programmable adjustments for mixing and feeding temperatures. Cleaning is not automatic, but can be accomplished by the grower at the end of feeding by switching to the cleaning cycle. This system is not currently marketed in the U.S. There are some of these machines in the U.S., which had been imported and used for veal calves, but they are not currently in use.

Figure 5. *Asserva* system for veal calves in France

Finally, the *Corneli* system has mixing and feeding by weight, programmable mixing and feeding temperature adjustment, automatic clean-in-place system, and the ability to wash the nipple between every calf, if desired. This equipment is now manufactured under the name “Jubilee Freedom Feeder” because a new company, Animal Technology, bought and improved on the original technology. This equipment also has the ability to feed both veal calves and herd replacement or dairy beef calves simultaneously.

Figure 6. *Corneli* System “Jubilee Freedom Feeder” for veal and/or replacement calves

Can a Machine Feed a Calf?

Producers often want to know how machine feeding compares with people feeding calves. There have been many small studies comparing machines and people and there have been studies using machines to test some other variables in research. But, perhaps the best study is by Dr. Gérald BERTRAND and Christophe MARTINEAU of the Institute de l’Élevage in France. They collected data from 56,589 veal calves in three systems: calves in group pens with hand feeding; machine-fed calves in group pens with slatted floors; machine-fed calves in group pens with straw bedding. The data set includes both Holstein calves and other breeds including cross-bred calves and was collected from participating veal growers in France using hand feeding or various feeding equipment systems. For ease of comparison, only the Holstein data is shown below in Table 1. Zootechnical results are presented for calves excluding dead and culled calves. One can easily see that for the majority of calves, zootechnical results are similar for machine-fed calves and calves fed by hand. The clear differences are in the number of calves that died or were culled during the growing/finishing period. With machine-fed calves, death loss was higher than with hand-fed calves. This is presumably due to the increased disease transfer with calves sucking a common nipple and cross-sucking by calves within larger pens. Comparing slatted floors and straw bedding, one can conclude that calves consuming straw bedding have a higher death loss, but lower culling rate than

calves with slatted floors. Indeed, mortality + culling rate for calves that were hand-fed (3.9%) was lower than machine-fed calves with slatted floors (6.0%) or machine-fed calves with straw bedding (5.5%). One could conclude that with slatted floors, poor calves become cull calves, but with straw bedding, poor calves simply died. Death loss in the French system is low for two reasons: calves were at least 8 days old before entering the veal facility and superior attention is paid to re-hydrating scouring calves in France than is typical in the U.S. In time/labor analysis, BERTRAND and MARTINEAU found that the total working time (per head) for the 135 day growing/finishing period was 2 hours 25 minutes for hand-fed calves, 2 hours 15 minutes for machine-fed calves with slatted floors, and 2 hours 38 minutes for machine-fed calves with straw bedding. Obviously the type of labor was different for calves fed with machines than hand-fed calves, and for the first 14 days, producers spent approximately 13 hours per day teaching calves to use machines, but the total amount of labor per calf was similar for hand feeding and machine feeding.

Table 1. Comparison of Veal Calf Performance in Different Housing Systems

	1	2	3
Breed	Holstein	Holstein	Holstein
Feeding	Individual/basin	Auto Machine	Auto Machine
Flooring	Slatted Floors	Slatted Floors	Straw Bedding
Number of Lots	60	15	24
Number of Calves	8,704	2,403	3,400
Percentage Female	5	2	2
Days on Feed	147	133	138
Mortality, %	2.5 ± 1.7	3.3 ± 2.0	4.8 ± 3.0
Mortality, compared to 1	100%	132%	192%
Culling Rate, %	1.4	2.7	0.7
Culling Rate, compared to 1	100%	193%	50%
Milk Replacer, lb	629.8	616.0	630.5
Weight at 8 days, lb	104.1	112.9	106.3
Carcass Weight, lb	274.2	273.6	270.5
Theoretic ADG, lb	2.50	2.70	2.62
Feed Conversion (FC)	1.71 ± 0.07	1.73 ± 0.05	1.75 ± 0.09
FC compared to 1	100%	101%	102%

Source: BERTRAND, G. and C. MARTINEAU. 2002. Institut de l'Elevage, Le Rheu, France.

What's Most Important?
In order to attain the most benefit from expensive milk replacer, accurately mixing milk replacer and accurately delivering the prescribed amount of milk replacer during feeding is most important.

Producers considering investing in new technology for mixing and/or feeding equipment should carefully consider features and benefits of such equipment before buying. There are vast differences in the capabilities of different makes and models, but remember that all of these systems are currently available and have been in use now for decades in the U.S. and Europe. There are several different manufacturers of this type of equipment and within given manufacturers there are often several different models to choose from. Producers should ask questions and explore options when considering buying this type of technology.

What are the most important features? Systems that mix and feed by weight require much less frequent calibration than systems that mix and feed volumetrically. Machines that have the ability to adjust mixing temperatures and feeding temperatures to accommodate different types of milk replacer create more opportunities for calf producers when buying milk replacers than machines that only have temperature adjustment for the water heater but no other adjustments. Many producers want machines that can mix milk replacer powder and/or pasteurized milk. Very few machines have this capability, but there are some.

Facilities should be designed to enable producers to handle calves within group pens for vaccinations, treatments, etc. without moving calves to a central location. Most European large group feeding facilities have some gates built into the pens to work calves within the pens.

Cross-sucking and bully behavior such as riding is a fact of life for calves in groups. BERTRAND has found that the dilution rate of milk replacer influences the cross-sucking behavior so feed schedules with automatic machines tend to be more dilute than hand-feeding feed schedules. But, chronic offenders often wear plastic buckets attached to a halter with a hole which the nipple can fit through, but which prevents cross-sucking.

Calf health and sanitation go hand-in-hand so it is important to have automatic cleaning cycles built into the machine if sanitation is to be maintained. Washing the nipple between calves is important to limit disease transfer, as well. Figure 7 shows a nipple feeding station from a system without a nipple cleaning system and Figure 8 shows a nipple being automatically washed by a machine with this capability.

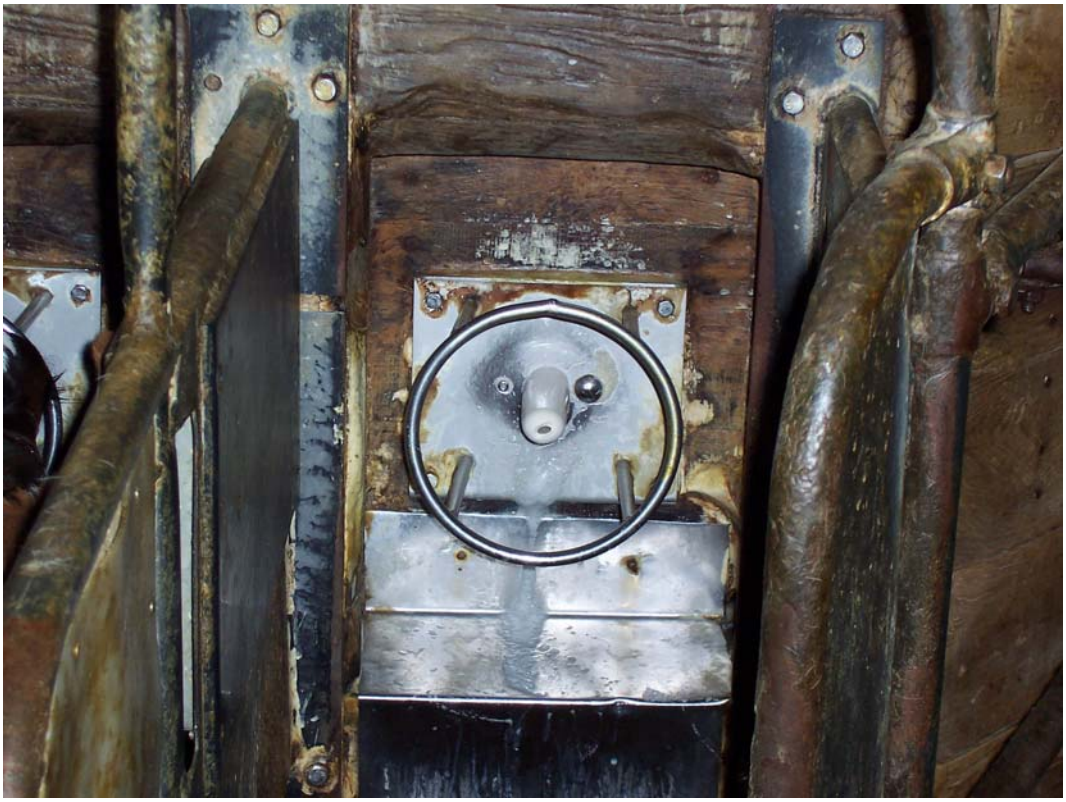

Figure 7. Nipple Feeding Station without Nipple Washing System

Figure 8. Nipple Being Washed in Feeding Station with Automatic Nipple Washing

What about service? All things mechanical will break at some point. Some machines are designed to be self-serviced, while others require a technician to make repairs. Some machines have the capability of computer updates via the internet. Ask how service will be provided if the machine breaks down because someday it will break down.

Another consideration for producers is the energy usage of different machines because power usage varies tremendously from machine to machine. Initial price is only one component of the ultimate cost of ownership. Like a car, initial sticker price is very important, but gas mileage may be a deal maker or a deal breaker.

Consistently providing properly mixed milk replacer to each calf at every feeding is the goal we are trying to achieve for both hand-fed and machine-fed calves. Even the oldest, most basic machines can raise a good calf with diligent producers and good management. With new technology, some machines offer programming features to individually recognize calves, follow precise feed schedules, gradually wean calves over 10-20 days, allow remote monitoring via the internet, blend multiple additives into milk replacer and/or pasteurized milk, and graph daily consumption patterns on the computer screen. These systems replace traditional bottle washing with calf management and can be effective tools to raising calves.