Nutrition and management of the dairy calf to realize the growth and lactation potential

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For many years the rearing of calves has been viewed as a liability. Frequently the goal has been to wean them as early and as inexpensively as possible. However, market conditions, research and the experience of progressive dairy producers indicate that this is frequently not the best management decision for several reasons.

- Growth and lactation yield. Producers have found that feeding calves to achieve their growth potential has numerous benefits including reduced morbidity and mortality and positive impact on milk yield in their first and later lactations.
- Animal welfare. The calf program is an acutely visible indicator of standards for welfare of the dairy herd as evidenced by recent undesirable publicity. Properly designed and managed systems where calves are housed in pairs or groups has shown benefits to animal behavior and comfort, growth and later performance. Additional concerns exist where very young calves are transported long distances to rearing facilities.
- Economics. A survey by Karzes (2013) demonstrated that, although daily costs for the preweaned calf were highest ($3.13), they comprised less than 15% of total cost and 8% of the total growth cost. Reductions in rearing costs are improved more significantly by reducing the size of the replacement herd and managing the heifer to calve at an earlier age.

The net result of these conditions is that many dairies are raising fewer heifer calves, breeding lower ranking cows to beef, feeding and managing their calves in a more biologically normal manner and developing calf rearing systems which emphasize improved conditions for calves, enabling more effective and efficient use of labor resources.

The challenge in rearing the preweaned calf is that there a multitude of factors influencing success. Success can be defined from differently when evaluated from the perspective of calf health, labor efficiency, herd manager responsibilities, owner assessment and perception of dairy product consumers. Ideally the goal should be to rear calves to achieve maximum genetic potential for growth and lactation performance in an economical manner. Integral to this endeavor are favorable welfare of the animal, labor efficiency and effectiveness in a manner which is perceived desirably by the consumer. Unfortunately, our research conducted on the preweaned calf has been very segmented with little consideration given to the goals of the replacement program. This presentation will attempt to review the breadth of conditions affecting the successful rearing of calves.

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Maternal influence on the calf. We will make the assumption that effective feeding management of the lactating and dry cow is appropriate for development of the unborn calf.

- Production of high-quality colostrum can be compromised especially during the fall and early winter (Gavin et al, 2018). Affected cows (especially Jerseys) produce little to no colostrum prior to or after calving. Utilization of replacers should be considered essential adjuncts to passive transfer of immunity.
- Heat stress during the prepartum period results in premature calving and less efficient absorption of maternal colostrum by the calf. These calves are also less adapted to heat stress once they mature (Dahl et al, 2016).
- A diverse microbiome in the meconium of the newborn calf suggests that microbial colonization of the calf may begin in utero. It has been established that biome of the calf is influenced by the maternal vaginal, oral and fecal microbiomes. This active area of research indicates a strong relationship of the microbiome to calf health and productivity.

Maternity management. The first minutes or hours of the calf's life have immediate and long-term impacts on health and performance of the calf.

- In addition to the maternal influence on the developing microbiome of the calf, the birthing environment is a significant contributor. Ingestion of large quantities of bacteria prior to or during colostrum consumption has a negative impact on IgG absorption by the calf (Godden et al, 2012; James et al, 1978).

Colostrum management.

- The first requisite is sanitary harvesting of adequate quantities of high IgG colostrum in a timely fashion. Delays in feeding or in rapid cooling of colostrum result in excessive microbial growth which can impair IgG absorption.
- Colostrum is a source of both desirable and undesirable microbes and viruses. Where risk for disease is evident, timely pasteurization has been shown to improve efficiency of IgG absorption (Godden et al, 2012) and risk or disease transfer to the calf.
- Consumption of fresh colostrum from the dam which enabled absorption of immune cells from the dam had a positive impact on immune function of the calf. (Langel et al, 2016)
- There are positive influences of non-Ig and non-cellular components of colostrum on development of the digestive system of the calf. Consumption of bovine colostrum initially and for several feedings has been documented to improve growth of intestinal villi, absorption of glucose, support of insulin action and promotion of post-natal growth (Hammon, 2019)
- Consumption of adequate quantities of colostrum early in life has been a long-standing recommendation. Achieving 10 mg of IgG / ml of blood was once indicative of successful passive transfer of immunity to the calf. New standards as shown below have been proposed.

Category	Serum IgG g/L	Total protein g/dl	Brix %	Consensus % calves
Excellent	>25	>6.2	>9.4	40
Good	18.0-24.9	5.8 – 6.1	8.9-9.3	30
Fair	10.0 – 17.9	5.1 – 5.7	8.1 – 8.8	20
Poor	<10.0	<5.1	<8.1	<10

- Ideally successful colostrum management involves:
    - Timely harvest of colostrum post calving to optimize yield.
    - Birth environment to minimize potential contamination by undesirable microorganisms.
    - Prompt feeding of at least 4L high IgG colostrum (>50g/dl) with low bacteria count (<20,000 cfu/ml).
    - Ideally, 4L of fresh colostrum from the dam fed as soon as possible after birth.
    - When there is a risk of disease transfer, pasteurize colostrum to reduce undesirable bacteria.
    - Harvest and feed “transition” milk from fresh cows to the youngest calves as long as the supply lasts.
    - Implement use of effective colostrum replacers when sufficient colostrum resources are not available.

Nutrition and management. Historically, we have managed the preweaned calf with the goal of stimulating rumen development and early weaning. These practices were achieved by limiting milk or feeding milk replacers with lower fat content thereby reducing daily and total preweaning feed expenses. However, dairy is one of very few animal agriculture industries that follows this practice. Instead calves should be fed to meet their nutrient requirements for maintenance and growth while encouraging low morbidity and mortality.

The table below illustrates the impact of environment on maintenance requirements.

	Temperature °F			
Body weight	14	32	50	68
77	8.8	7.7	6.2	4.8
100	11	8.8	7.3	5.7

Research conducted at Virginia Tech (Bascom et al, 2007) indicated that maintenance requirements for Jersey calves are as much as 20% higher per unit of body weight than considered in this table. Additionally, maintenance requirements increase as temperature rise above the thermoneutral zone. It is not a common practice to increase nutrient intake when calves are exposed to conditions outside of the thermoneutral zone.

Traditionally milk replacers containing 20% protein and 20% fat were fed to preweaned calves. These replacers were developed to reduce cost and encourage starter intake and early weaning and not necessarily to meet the requirements of the growing calf. The table below demonstrates the energy allowable gain and cost per lb of gain at two different feeding rates for milk or milk replacer at different temperatures.

Calf	Whole milk		20:20 milk replacer	
	68F	32F	68F	32F
88 lb. calf – week 1 1 lb of DMI Cost = $1.49/day	.9 LB. ADG $1.65/lb gain	.3 lb. ADG $4.96/lb gain	.7 lb. ADG	Lose weight
88 lb. calf week 1 2.2 lb DMI Cost $2.98	2.6 lb. ADG??	2.1lb ADG $1.42/ lb gain	2.2 lb/day	1.7 lb/day

In viewing these tables, it is apparent that there is insufficient energy to meet the calf's requirements for maintenance and growth under cold environmental conditions. This is especially risky during the first weeks of life when the calf is incapable of consuming sufficient energy or protein from calf starter and likely impairs immune function during this time. These data also illustrate the impact of feeding rate on economic efficiency of gain. Although not as great a problem, excessive environmental temperatures also increase maintenance requirements. This can be problematic as calves typically have reduced appetites in this environment.

Traditionally, calves have been offered limited amount of milk (~2L/feeding) early in life and only gradually increased milk intake with the logic that their digestive systems were incapable of consuming more milk or that it would lead to more diarrhea. Use of ad lib milk feeding from autofeeders early in life has dispelled this theory but it was thought

that higher milk feeding was not feasible for 2x bottle or bucket-fed herds. In a field study with over 1,000 calves on 5 dairies, Knauer et al (2018) found that calves offered a fixed amount of milk post colostrum feeding consumed 14L more milk than calves in which milk was gradually increased over 7 to 14 days.

Estimated energy and protein available for growth for the average FIX (6.8L/day) and INC (5L) milk intake per enrolled calf. (Knauer et al, 2018)

Variable	Summer FIX	Summer INC	Winter FIX	Winter INC
Total DMI (kg)	0.85	0.63	0.85	0.63
DMI req for maintenance kg/day	0.29	0.29	0.44	0.44
DMI available for growth kg/day	0.56	0.34	0.41	0.18
Energy allowable ADG	0.99	0.65	0.76	0.39
Protein allowable ADG	0.74	0.52	0.74	.52

Over the first three weeks, calves receiving a FIX amount of milk or milk replacer weighed 1.35 kg more and were .3cm taller with no difference in morbidity or mortality.

Calf behavior research has yielded new information of significance to the dairy industry. Feeding behavior patterns are learned and develop early in life with long-term implications. More liberal milk feeding: reduces stress, improves immune function and feed conversion and appears to improve lactation performance. More liberally fed calves consume their solid feed at slower rate, in smaller meals with longer pauses between bouts of eating and a lesser response to feed delivery. Provision of chopped forages early in life appears to promote solid feed consumption and encourages development of a more stable developing rumen environment. Slug feeding eating patterns appear to be learned and persist later in life. Additionally, grouping calves promotes solid feed intake and growth. Research conducted at Guelph University (Miller-Cushon et al, 2016) has demonstrated that paired housed calves consumed more starter concentrate before and after weaning. They are less likely to experience the post weaning “slump” commonly observed in calves fed more liberally prior to weaning. These findings indicate that our system of housing calves individually and feeding twice day at irregular intervals enhance development of undesirable behaviors.

Calf starters: Probably the one of the most important characteristics of a starter would be its palatability. In most research conducted on calf starters, calves were housed individually, limit-fed milk replacer and/or were weaned abruptly at an early age (less than 6 weeks). We know that these conditions are a strong stimulus for dry feed intake and that these changes are probably very disruptive to the intestinal microbiome. More recent research with more liberally fed calves using step down weaning has shown

potential benefits of adding small amounts of chopped forage to aid in the development of the rumen and transition away from milk consumption (Terre et al, 2013, 2016).

Water: Although water quality is a critical component of calf rearing, it is often overlooked. Desired characteristics of water quality are shown in the table below. Water for calves should be tested twice a year.

Item	Expected	Borderline	Concern
pH	6.8 – 7.5	Under 6 and over 8.4	Under 5.5 and over 8.5
Total Dissolved Solids	<500 ppm	Over 500 ppm	Over 1000 ppm
Calcium	0-43 ppm	>100ppm	> 200ppm
Chloride	0-100ppm	>100ppm	>300ppm
Copper	0-0.2ppm	>0.2ppm	>0.5pm
Iron	0-0.2ppm	>0.2ppm	>0.3ppm
Manganese	0.05ppm	>0.05ppm	>0.05ppm
Magnesium	0-29ppm	>50 ppm	>125 ppm
Nitrate	0-44ppm	>50ppm	>100ppm
Nitrate-nitrogen	0 – 10 ppm	>11.4ppm	>22.7ppm
Sodium	0-3ppm	>55ppm	>200ppm
Zinc	0-5ppm	>5ppm	>25ppm
Total bacteria/ml	<2	>10	>10,000
Fecal coliform/100ml	Less than 0.1	Over 0.1	Over 1

Developed by Dr. Don Sockett, Dr. David Beede, Dr. Tim Johnson, and Mr. Bob Riesberg.

Successful calf rearing requires the development of systems which assure that all the desired components of calf management are addressed consistently. They are:

Prepartum dairy cow

- Nutrition to support desired calf growth and produce adequate amounts of colostrum with high IgG content.
- Heat stress remediation to promote efficient IgG absorption by the calf

Calving management

- A clean, well-bedded calving area to promote desired development of the biome in the calf.
- Convenient location for observation, timely harvest of colostrum with low bacteria count and further processing prior to feeding the calf.
- Timely feeding of either fresh or processed colostrum to supply at least 200g of IgG as soon as possible but within 6 hours of birth.

Nutrition of the pre-weaned calf

- Feed sufficient milk or milk replacer to meet nutrient requirements for maintenance and desired growth (double birth weight by 56 days). This may require as much as 2.0 lb. of DM from milk solids/day.
- Provision of a palatable calf starter grain within the first weeks of life with at least 20% protein. Provision of chopped palatable forage by the 4th week of life.
- Fresh water with desirable characteristics.
- Step-down weaning over at least 7 days.

Welfare friendly facilities

- Although individual housing systems will continue to be popular, the adoption of paired housing and or group housing systems should be considered as enabling social development and enhancing calf performance.
- Although there are no regulations concerning transportation of calves, it is likely that regulations will come in the future. In Canada after February of 2020, it will be forbidden to transport calves less than 8 days of age. In addition, calves over 8 days may not be transported more than 12 hours from their last feeding at the source farm. These policies may likely be considered in the US in the future.
- Labor will continue to be a challenge on dairies. Implementation of facilities which address comfort and efficacy of labor should be planned

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