FEEDING MANAGEMENT AS A KEY FOR IMPROVING HEALTH AND PRODUCTIVITY OF CALVES

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Abstract. Calf health and early development have major impact on the economic viability of cattle operations, with nutrition playing a pivotal role. A high proportion of deaths of pre-weaned calves can be attributed to diarrhea mainly because of the failure of passive transfer of immunity. Reaching the breeding age also depends on early development of the calves. Thus, the successful calf nutrition starts with appropriate colostrum management of the neonatal calf. This suggests that dairy producers have only one first chance to lay down the tracks of a well growing calf and successful breeding animal, which is a successful colostrums management. The latter event starts with the feeding and care of the pregnant cow. After a period where the calf relies almost entirely on liquid feeds, intake of starter feeds induces ruminal development. Although various approaches are used to rear calves and recommendations for feeding concepts differ between countries, they all have to cope with the unique physiology of the calf born as a pre-ruminant and transitioning to a functioning ruminant. The main goal of this paper is to provide an overview of the nutritional needs and feeding strategies of calves in terms of optimizing health and production.
Keywords: calf production, rearing calf, rumen development, feeding plan

Introduction. Calf health is one of the most important animal health issues facing all ruminant production sectors as the morbidity and mortality of pre-weaned calves remains higher compared to the rest of the herd. Due to the strong interplay between disease agents, environmental stressors and nutrition, appropriate feeding management of young calves is of utmost importance for calf health and the profitability of cattle operations. Although various approaches can be used, all systems include the key aspects of the composition and amount of liquid feed, water availability, and the first solid feeds offered (Drackley, 2008). In general, the postnatal development of the digestive system of calves can be divided in three phases: The “pre-ruminant phase” persists until the first 2 to 3 weeks of age. During this time the nutrition of the calf relies almost entirely on liquid feeds. The so called “transitional phase” comprises of the time when the calf begins to eat some starter feed until the calf is weaned. In this period, fermentation of starter feed induces a rapid expansion of volume and differentiation of the rumen epithelium, to enable absorption of volatile fatty acids (VFA). When the calf is weaned the third phase (“ruminant phase”) begins. From this time on, the ruminant depends mainly on VFA from the fermentation of carbohydrates until the rest of the animal`s life (Davis and Drackley, 1998). However, while the chief target in calf raising for milk or beef production is to achieve the third phase as soon as possible, veal calf production aims at the opposite. This article focuses on the nutrition and care of calves with primary emphasis on the pre-ruminant and transitional phase.

Secrets of colostrum feeding

Because of the lack of vertical transfer of immunoglobulins (Ig) from the dam to the neonate (bovine placenta does not permit the passive transfer of antibodies to the fetus) and the fact that the immune system of the newborn calf is inefficient in its ability to produce antibodies, the horizontal transfer of Ig from the dam to the neonate, termed passive transfer of immunity via colostrum, is of paramount importance for the protection from infectious diseases. It has been estimated that as many as one third of dairy calves suffer from failure of passive transfer (FPT), a condition that predisposes the neonate to the development of disease syndromes (Heinrichs and Elizondo-Salazar, 2009). In general, adequate passive transfer is subject of the quality and quantity of colostrum as well as the timing of colostrum feeding with respect to the calf`s ability to absorb Ig. The quality of colostrum is influenced by lactation number, breed of the cow, vaccination status as well as the length of the dry period. Although some studies report about higher IgG concentrations in multiparous cows, this was not observed in all studies (Lorenz et al., 2011). Thus, lactation number and even the color of colostrum is not a guarantee for good quality of colostrum. In general, the risk for poor colostrum quality (<50 g IgG/L) seems to be higher if the non-lactating period is less than 3 weeks or even omitted (Verweij et al., 2014). As the efficiency of Ig absorption in the small intestine of the neonatal calf decreases rapidly after birth in a linear manner until 24 h, timely intake of sufficient amounts of colostrum is essential for developing a strong passive immune level in the calf (Lorenz et al., 2011). It is currently recommended that normal sized calves are given a total of 4 l of colostrum within 12 h from birth to ensure adequate passive immunity in almost all calves (Kaske et al., 2005). It is important to emphasize that the initial concentration of Ig as well as proteins and peptides diminishes quickly after the onset of lactation. Furthermore, initial Ig levels and specificity can be modified through maternal vaccination programs. Besides providing passive immunity, colostrum also contains bioactive and growth-promoting substances, which support the development of the neonatal intestine. Certainly, colostrum is also an important source of nutrients for the calf after birth that contains markedly higher amounts of energy, protein and some minerals and vitamins than mature milk (Heinrichs and Elizondo-Salazar, 2009), thus, being the best "life insurance" of the young calf.

Besides providing sufficient amounts of high-quality colostrum timely after birth, preventing bacterial contamination during the harvest, storage and feeding process is an important aspect of a colostrum program. The same is true for thermal (too cold or hot) and environmental (bedding, surface, contamination) stress of the calves, which should be reduced at maximum. In general, for controlling the spread of infectious diseases within a herd only colostrums from non-infected dams should be fed. An alternative may be the use of on-farm pasteurization of non-salable milk (Drackley, 2008; Lorenz et al., 2011). Besides reducing the risks of ingestion of potentially pathogenic organisms, it has been also reported that pasteurizing colostrums at 60°C for 30 min enhances IgG absorption, thereby reducing the percentage of dairy calves that experience FPT (Heinrichs and Elizondo-Salazar, 2009).

Feeding until weaning period

During the pre-ruminant phase the calf relies almost entirely on milk or milk replacer for its nutrients, which are digested by the enzymes in the animal`s abomasum and small intestine (Drackley, 2008). During the first week the amount of colostral milk can be increased daily up to an amount of 5-6 kg fed with a frequency that decreases from 3 to 2 times per day. After the first week calves can be fed either whole milk or milk replacers, whereby different feeding systems, in terms of feeding frequency and milk temperature, can be used (Kamphues et al. 2014). In general, milk replacers are fed on a majority of dairy farms, as they are usually less expensive per unit of nutrient supplied than whole salable milk. A further advantage is the consistency of the product from day to day, the flexibility of storage and most importantly disease control (Drackley, 2008). The amount, type and the nutrient content should be matched to the desired calf growth rates and production type. Nutrient content is summarized in Table 1.

The ingredient composition of the milk replacers plays a pivotal role. As the digestive enzymes present at birth are highly specialized towards milk constituents, the inclusion of non-milk proteins or polysaccharides such as starch has to be stringently limited in calf milk replacers (Drackley, 2008), especially during the first 4 weeks after birth (Kamphues et al., 2014). Milk protein sources used in milk replacers (mainly dried skim milk or whey) are highly digestible by calves. However, due to economic constraints, up to 50% of alternate proteins instead of milk proteins can be included in conventional milk replacers; however, during the first 4-5 weeks the use of plant proteins should be minimized to avoid digestive disorders. For successful usage, alternate proteins have to be well used by the calf and have to possess acceptable mixing and solubility properties, making soy protein concentrates and modified whey proteins the most popular alternative protein sources. Furthermore, while whey is rich in lactose as a carbohydrate source, being the main carbohydrate source in milk replacers, whey need partial demineralization to be used in the feed. Too high lactose content due to high whey inclusion causes diarrhea. Instead of milk fat, also coconut fat and palm oil can be used in milk replacers (Drackley, 2008). As coconut oil can cause fatty liver in calves, the most common replacement is a mixture of 80% palm oil and 20% coconut oil. Furthermore, the ash content should not exceed 8-9% in milk replacers as a high ash content (>10%) coupled with high osmolality is more likely to cause digestive problems in calves (Drackley, 2008; Kamphues et al., 2014).

Table 1. **Concentration of nutrients recommended for milk replacer for calves (Kamphues et al., 2014)**

Production Type		**Calf Rearing**	**Veal Calf**	
Nutrient			≤ 80 kg BW	>80 kg BW
Crude Protein, g	min.	200	220	170
Lysine, g	min.	16	17.5	15
Meth+Cys, g	min.	7	7	6
Ether Extract, g		130-200	150-200	180-300
Crude Fiber, g	max.	2	1.5	2
Ash, g	max.	90	90	100
Fe, mg	min.	60	40	-

It is possible to rear calves in various ways, and recommendations for milk amount and weaning time differ among countries. Traditionally, the calves are fed limited amounts of milk replacers and encouraged to start eating dry feeds at an early age. Table 2 outlines recommendations for different feeding concepts during the transitional phase, depending on the time of weaning (conventional vs. early). Independent of the feeding system water – as the most critical nutrient – must be provided to all calves at all times beyond what is consumed as part of the liquid diet (Lorenz et al., 2011).

Table 2. **Feeding concept (kg/d) for calf rearing during the transitional period (Kamphues et al., 2014)**

Weaning method		**Conventional**			**Early**		
Age (week)	BW (kg)	Milk replacer (12.5%)	Starter	Hay	Milk replacer (12.5%)	Starter	Hay
2.	40	6-7	*ad libitum*	*ad libitum*	6	*ad libitum*	*ad libitum*
3.-6.	45-65	8	*ad libitum*	*ad libitum*	7	*ad libitum*	*ad libitum*
7.-8.	65-75	8	*ad libitum*	*ad libitum*	4-6	*ad libitum*	*ad libitum*
9.-12.	75-100	8	≤1.5 kg	*ad libitum*	–	≤ 2.0 kg	*ad libitum*
13.-16.	100-120	6->0	≤ 1.5 kg	*ad libitum*	–	≤ 2.0 kg	*ad libitum*

The onset of the transitional phase is characterized by the consuming of starter concentrates, which induce the production of VFA via microbial fermentation of carbohydrates (Davis and Drackley, 1998). Mainly butyric acid stimulates the establishment of functional papillae, which facilitate absorption of VFA, finally enabling an increase of the pH which is the prerequisite for cellulolytic bacteria to thrive (Yáñez-Ruiz et al., 2015). The main nutritional challenge in calf rearing is therefore to encourage the calves to eat the dry feed at an early age, provided that the starter is formulated with easily degradable ingredients. Therefore, palatability and acceptability of the starter formulation to the calves remains of paramount importance (Drackley, 2008). As outlined in Table 2 the starter feed should be provided from the second week onwards, being offered *ad libitum* at the beginning and kept constant at 1.5 or 2 kg/d, respectively, from week 9 on (Kamphues et al., 2014). High-quality starter feed during this period should contain at least 18% Crude Protein and not more than 10% Crude Fiber, whereby pellets are consumed preferably (Kamphues et al., 2014). Feeding of forage to young calves during the transition period appears to primarily stimulate the rumen muscularization and volume (Yáñez-Ruiz et al., 2015). Although low-quality forages low in sugars and high in poorly fermentable fiber has clearly to be limited (Drackley, 2008), some fiber (especially high-quality forage) is needed to maintain an abrasion factor (Kamphues et al., 2014).

While the nutrition to raise calves for milk or beef production aims at supporting the transition of the non-ruminant newborn calf to a ruminant and reailizing only moderate daily gains (about 750 g), veal production has a contradictory interest (Kamphues et al., 2014). The goal is to achieve high daily gains (up to 1500 g) and pale veal by restricting intake of structured feed. Thus, production of veal is mainly based on milk or milk replacers right through slaughter (Moran, 2002; Kamphues et al., 2014). After the first week of feeding colostrum, the concentration and amount of the milk replacer is gradually increased, and will be provided almost *ad libitum* until a weight of about 80 kg is reached. Thereafter, a milk replacer with lower protein content and less expensive ingredients is commonly fed until the slaughter weight is reached (Table 1). Although feeding mainly milk replacers increase growth rates and the dressing percentage (Moran, 2002), veal production solely based on liquid feeds has been prohibited in European Union. More, specifically, at least 100 g structured feed per day from the second week after birth on and of 250 g per day from week 8 on, respectively, has to be offered to all calves. Nowadays this structured feed is mainly provided via maize silage, coarse grain or chopped straw, due to their low iron content. Also concentrates low in iron can be provided up to about 0.5 kg per calf and day (Kamphues et al., 2014).

Ad libitum feeding system of calves

During the last years the feeding system of rearing calves in many dairy production systems has moved towards an ad libitum supply of milk or milk replacers. This feeding method brings several advantages especially in gaining weight at a faster rate than the conventionally fed calves before weaning (Jasper and Weary, 2002), most probably as a result of the higher intake of milk. This feeding method intents to simulate the physiological feeding of young calves with their dams, encouraging increased meal number and reduced amount of milk per meal. However, although sound in theory, the application of ad libitum feeding on the practice requires consideration of several rules to avoid disturbances that may come from the use of milk in high amounts and during extended periods of time with changing weather and hygienic conditions. Below are some practical recommendations of ad libitum feeding of calves:

- Feed ad libitum from the first day on – until 3 wk
- Calves should not recognize hunger feeling during this period
- Always some milk should be left in the bucket
- Use buckets with strong nipples to guarantee slow milk intake
- Milk or milk replacers should be offered as sour milk (pH 5.5)
  - Use feed-grade organic acids to produce sour milk
  - Sour milk should be offered from the second milk supply (colostrum not)
  - Fill the bucket 2 x day (winter 4 x day)
  - Clean the buckets every day
  - Use one bucket per calf
  - Remove the bucket shortly in main meals to stimulate milk intake

Conclusions

Appropriate nutrition of calves is essential to improve health as well as growth. Overall, timely provision of sufficient amounts of high-quality colostrum is the prerequisite to protect the newborn calf from infectious diseases. Depending on the production type and feeds available, several strategies are available for raising young calves. Altogether, appropriate selection of feeds for the given production purpose is important to optimize calf performance as well as health.

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