Broadening Horizons

N°19, July 2015

Feedipedia

www.feedipedia.org

Nutrition of cattle: The foundation for animal wellness

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Introduction

Throughout the last decades and around the world, genetic selection has produced cattle with a high productive (meat and milk) potential. These high-producing animals need to be fed and housed under optimum conditions to ensure that the expression of their genetic potential does not undermine their health and biological functioning and thus compromise welfare. Domesticated cattle depend completely on the skills of the producers to provide a balanced and adequate ration that will meet their nutrition and physiological needs within an environment that supports productivity and welfare. Next, I address the most relevant nutritional aspects that may be linked with the wellness of young and adult cattle.

Calves

Nutrition during the first few weeks of life of any animal is particularly important. A low plane of nutrition for calves, for example, will contribute to both short- and long-term health and welfare consequences. Specifically, inadequate nutrition may impair immune function, and calves fed low volumes of milk often struggle to meet their nutrient requirements. **Investing in ensuring adequate nutrient supply and proper welfare early in life** results in more economic rearing costs (Bach and Ahedo, 2008) and improved yielding ability (Bach, 2012; Soberon *et al.,* 2012) and longevity (Bach, 2011).

Rearing calves properly should start by adequately providing colostrum. The result of inadequate colostrum intake is a low concentration of circulating immuno-globulin (Ig) in the blood of the calf, a condition known as 'failure of passive transfer' (i.e., a blood-serum concentration of IgG =10.0 g/L; McGuirk and Collins, 2004) can lead to serious welfare concerns and poor productive performance. The next step, is to provide sufficient amounts of good quality milk or milk replacer. A number of studies have demonstrated that calves fed more milk actually have the same or lower incidence of diarrhoea than limit-fed calves. **A good objective would be to provide about 750 g/d of solids via the milk or milk replacer during the first 2 months of life. In addition, to encourage solid feed intake, a palatable starter feed (in pellet form preferably) should be offered from the first day of life along with chopped forage starting as early as possible, and preferable before the 2^nd^ week of age** (Castells *et al.,* 2012; Khan *et al.,* 2012; Castells *et al*., 2013). These practices should be able to maintain growth rates of *ca.* 900 g/d.

Dairy cattle

The high demand for nutrients at the onset of lactation is one of the main factors leading to diseases at this particular time. Despite decades of nutritional and epidemiological work, the incidence of disease around the calving period in lactating dairy cattle remains high, showing the need for better tools for identifying which cows are ill or are most likely to become ill after calving. Growing concerns regarding insulin resistance and loss of body condition; and the failures to identify these cows from reductions in milk production or associated metabolic problems (Janovick *et al.*, 2011) are alarming, as these cows may be feeling sick but go unnoticed. When the mobilization of body reserves is exaggerated (due to either excessive insulin resistance or inadequate nutrient supply) the risk of cows succumbing to sub-clinical or clinical ketosis increases (Vickers *et al.,* 2013). Patterns of feed intake have been shown to differ for healthy cows and cows diagnosed with metritis. Furthermore, Bach *et al.* (2006) reported that the time devoted to eating decreased, and dry matter intake and milk production also decreased, with increasing severity of lameness, and Yunta *et al.*, (2012) have shown that the time elapsed between fresh feed delivery time and attendance to the feedbunk could be a good proxy for identifying moderately lame cows.

To minimize transition problems in dairy cows, since the early 90s (and especially after the release of the NRC model in 2001, which recommends energy densities around 1.60 Mcal of NEl (net energy of lactation)/kg during this period) late pregnant cows have been fed high-energy rations in the immediate pre-calving period to 1) compensate for the assumed decrease in feed intake as calving approaches, 2) minimize body fat mobilization, ketosis, and fatty liver after calving, 3) adapting the rumen microflora towards a high nutrient-dense ration (that cows will be presented with after calving), and 4) foster the growth of rumen papillae to minimize the risk of rumen acidosis during lactation through an improved absorption (and removal) of volatile fatty acids from the rumen.

However, in the past years, several authors have provided evidence that suggests that feeding low-energy diets to dry cows is actually a better strategy than overfeeding energy during the dry period. An average pre-partum cow requires about 15 Mcal of NEl/d, and feeding a ration with an energy density of 1.60 Mcal of NEl/kg ration would readily provide more than 19 Mcal of NEl/d. Consequently, lower energy rations (approx. 1.32 Mcal/kg of NEl) should be sufficient to meet the energy requirements of dry cows. Cereal straw represents an excellent source of fiber in such rations as well as an important energy diluent provided the ration is well mixed to avoid ingredient selection by the cows. With respect to dietary protein, feeding rations of approximately 13% crude protein are recommended, possibly marginally greater when a significant numbers of first-calving heifers are part of the dry pen. **Recent evidence (Huang *et al.*, 2014) supports feeding low energy diets (~1.30 Mcal of NEl/kg) prepartum as they result in increased dry matter intake postpartum, milk yield, and alleviate negative energy balance.**

Dairy cows have between 2 and 4 g of calcium in blood, half of which is in the ionized form. On the first day of lactation, synthesis and secretion of colostrum impose major losses of calcium equivalent to 7 to 10 times the amount of calcium present in blood (Horst *et al.*, 2005). Cows with milk fever are at increased risk of developing other periparturient problems, including dystocia and ketosis (Curtis *et al*., 1983), displaced abomasum (Massey *et al*., 1993), uterine prolapse (Risco *et al.*, 1984), and retained placenta (Melendez *et al*., 2004). Furthermore, hypocalcemic cows have increased plasma concentrations of cortisol (Horst and Jorgensen, 1982), reduced proportion of neutrophils with phagocytic activity (Ducusin *et al*., 2003; Martinez *et al*., 2012), and impaired mononuclear cell response to an antigen-activating stimulus (Kimura *et al*., 2006). This reduction of immune response has linked hypocalcemia to metritis (Martinez *et al*., 2012) and mastitis (Curtis *et al*., 1983). Thus, preventing or minimizing the incidence of hypocalcemia should be a priority when feeding prepartum dairy cattle. Strategies to minimize hypocalcemia consist of 1) feeding anionic salts (such as ammonium chloride, calcium chloride, magnesium chloride, ammonium sulfate, calcium sulfate, and magnesium sulfate), or 2) feeding low calcium diets. When supplementing pre-calving rations with anionic salts, urine pH should be monitored. In Holstein cows, effective anion addition should reduce urine pH to 6.8 (Oetzel and Goff, 1998). The second strategy to minimize hypocalcemia, as stated above, consists on limiting the amount of dietary calcium pre-calving to force the cow to initiate calcium mobilization mechanisms well before parturition. Diets providing less than 15 g/d of calcium and fed for at least 10 days before calving reduce the incidence of hypocalcemia

(Goings *et al*., 1974).

Last, during lactation, rumen health needs to be preserved by ensuring that rapidly fermentable carbohydrates do not lead to rumen acidosis and consequent decreases dry matter intake, which would ultimately expose the cow to other metabolic afflictions.

Beef cattle

The digestive system of cattle evolved to enable efficient digestion of forage diets. However, in many beef feedlot production systems these diets do not support the growth potential or profitability of finishing cattle for slaughter. As a result, heavy grain feeding has become normal in feedlots. For example, most North American feedlot finishing diets comprise 95% grain, which has been shown to maximize cattle performance, and ultimately profitability (Russell and Rychlik, 2001). However, despite improved cattle performance and advantages in terms of profitability, the digestion of these concentrate-based diets creates distinct challenges in terms of cattle health and welfare (Nagaraja and Lechtenberg, 2007a). These high-starch rations result in a rapid and extensive ruminal fermentation that produces high amounts of volatile fatty acids, which cause a reduction of ruminal pH. In many cases the unfortunate consequence of high grain feeding is ruminal acidosis, a predisposing factor to liver abscesses that arise when rumen bacteria enter the portal vein and travel to the liver (Nagaraja and Lechtenberg, 2007b). When feeding large amounts of starch, it is important to 1) transition the animals towards these rations, 2) consider the rate of fermentation of starch sources used. Typically, starch from corn, sorghum and oats is more slowly fermented than starch contained in wheat, manioc, and barley (Offner et al., 2003). Transitioning of cattle from low to high starch diets should be done over a 2-week period, and it is recommended to begin with the inclusion of slowly fermentable starch sources.

Pasture-based systems

There is the believe that animals on pasture have a greater level of welfare because they may be closer to their natural environment. However, under extensive production systems, animals are exposed to prevailing climate conditions. For extensive production systems in hot climates, the most important issues become access to shade and water, whereas for cold climates the insufficient provision of nutrients to sustain performance and maintain body temperature is a common threat to welfare. Moreover, as stocking density increases, often coinciding with the rainy season, cows are exposed to mud. Also, the nutrition provided by pasture-based systems is not always in line with the requirements of cattle. Typically, lush pastures tend to provide an excess of protein relative to their energy content. Furthermore, some pastures may contain weeds and toxic plants containing different degrees of secondary compounds such as alkaloids, terpenes, phenolics, saponins, and tannins. These compounds, when consumed in small amounts may actually play beneficial roles for the animal (Makkar et al., 2007; Provenza et al., 2007), but are negative at high doses (Mueller-Harvey, 2006).

Take home message

Providing the right combination of nutrients in the adequate amounts is the foundation for ensuring good animal performance, health, and welfare.

For calves

A low plane of nutrition during the first 8 weeks of life will contribute to alleviation of both short- and long-term health and welfare negative consequences. Calves must be supplied with adequate amounts of good quality colostrum, and then fed at least 750 g/d f solids via milk or milk replacer and offered a palatable starter feed along with some high-fiber chopped grass on the side.

For cows

The high nutrient demands early during lactation coupled with a metabolic status dominated by varying degrees of insulin resistance renders the dairy cow in a bridle position (exposed to an under-controlled fat mobilization coupled with a shortage of carbohydrates to facilitate the full oxidization of the mobilized fat). Attempts to minimize metabolic afflictions during this phase (typically ketosis) have focused on providing high-energy diets before calving. However, recent evidence suggests that feeding low energy diets (~1.30 Mcal of NEl/kg) prepartum is a more effective strategy.

Calcium levels during prepartum should be either kept below 15 g/d or supplement anionic salts for at least 2 weeks preceding calving.

Rations for lactating cows should ensure that the animal absorbs all acids produced in the rumen before rumen pH decreases excessively. Thus, nutritionist should take into account the amount and rate of starch degradation in the rumen along with passage rate (dictated by intake).

For beef

Similar to the situation with lactating cows, high-starch rations result in a rapid and extensive ruminal fermentation that produces high amounts of volatile fatty acids, which cause a reduction of ruminal pH. Rumen acidosis can be minimized by transitioning the animals towards high-starch diets and using slowly-fermentable starch sources such as corn, sorghum, or oats.

For pasture-raised livestock

Take into account weather conditions to estimate nutrient yield of the fields and ensure adequate supplementation.

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