Rumen Health Care for Sustained Productivity

Kamran Sharifi

Associate professor, Department of Clinical Science, School of Veterinary Medicine, Ferdowsi University of Mashhad, Mashhad, IRAN.

Address all correspondence to Dr. Kamran Sharifi (DVM, DVSc), E-mail: shariffp@um.ac.ir

Introduction

Veterinary surgeons frequently confront situations that need a variety of surgical or medical interventions in dairy farms; e.g. displacement of the abomasums, abscess in the soles, milk fever, retained fetal membranes, etc. In a short time interval a high prevalence of such diseases may mean receiving a golden egg per day (i.e.a high monetary income).Eventually, this process may send the golden-egg-laying hen to the slaughterhouse; that is, the veterinary surgeon might confront delayed payments followed by total bankruptcy of the farm. Thus, it is prudent to try to see the jungle in addition to trees.

In a broader view, veterinary surgeons are at the front line of ensuring sustained productivity of dairy farms. Sustainability relates to the proper balancing between economic issues (the dairy operation must be profitable to the farmer), society-related issues (e.g., demands related to landscape, food quality and safety, production methods), ethics (husbandry methods including animal welfare) and ecological issues (e.g., resources use, emissions of ammonia and greenhouse gases into the air; pollution of soil and waters with nutrients, pesticides, metals, antibiotics and hormone residues).It is generallyaccepted now that the basis for sustainability within the dairy farm is formedby the combination of:

(1) The genetic potential of the herd,
(2) A fine-tunednutrition,
(3) Optimal health/welfare conditions,
(4) Good housing facilities,and
(5) High management quality.

When one of these five key factors is suboptimal,sustainability will be at risk. Other relevant factors are: interactionsbetween farmer and society, ethical issues, and environmental aspects offarming.Noordhuizen et al, 2012).

Because, frome a nutritional viewpoint, Rumen health care has a key role in sustained productivity of dairy farms, the remainder of this manuscript will focus on this topic.

Interrelationships of diseases that endanger sustained productivity

It has been shown that several disease situations occur concurrently and most of them tend to occur around calving. For example, milk fever predisposes the occurrence of the downer cow syndrome, ketosis, abomasal displacements, retained fetal membranes, uterine prolapse, metritis and poor fertility, mastitis and failure in immune system.(Massey et al, 1993, Curtis et al, 1983; DeGaris and Lean, 2008; Goff, 2008). Moreover, besides of negative effectson herd productivity, subacuteruminal acidosis (SARA) is considered an etiological orat least predisposing factor for a number of common disordersin dairy and beef cattle such as feed intake depression,milk fat depression, rumenitis, laminitis, diarrhea, liverabscess formation, caudal vena cava syndrome, abomasaldisplacement or abomasal ulceration. SARA thereforepresents a major risk for animal health and well-being incattle (Dirksen et al. 1984; Enemark 2008; Plaizier et al.2008).for some production diseases, such as displacement of the abomasum (Ingvartsen et al, 2003), and SARA, the etiology is not directly related to milk yield per se, but to other variables, such as feed intake and feeding errors. The corner stone of controlling of our golden-egg-laying henis providing an appropriate rumen ecosystem.

Rumen ecosystem

Rumen is a fermentative constant continuous ecosystem and its efficiency is a prerequisite for an efficient function of both the cow and the herd. As a large fermentative chamber, it provides 50% to 70% of amino acid supply, (Polan 1988, Hoover and Miller, 1991) as well as an efficient environment for fiber digestion.

1. Role of fiber in rumen ecosystem

Without an internal skeleton, rumen relies solely on its fiber contents for full expansion. An efficient fiber mat provides the structure for rumen expansion as well as rumen motility. However, the fiber should have a high digestibility.

Cellulose and hemicellulose are incompletely fermented to volatile fatty acids and the extent of fermentation is limited by the degree of lignification.A reduction in rate of passage that increases digestibility will also tend to increase gut fill, possibly decreasing dry matter intake.Cows in early lactation generally loose more energy than they are able to receive and must mobilize body energy reserves for the production of milk. Unhesitant increasein the energy density of the diet by feeding more grains often results in decreased energy intakes and further condition loss as the consequence of less than optimal energy intake. Insufficient fiber and excess nonstructural carbohydrate prevent the animal from maintaining optimal rumen motility (Allen, 1991).

To ensure feeding high quality forages with proper digestibility, proper timing of harvesting of forages' fields is crucial. Following criteria provide clues to provide materials for an efficient rumen fiber mat that not only expands and motivate the rumen capacity and motility, but departs the rumen in an acceptable time period to maximize dry matter intake and ruminal dry matter turnover.

- Alfalfa should be harvested at bud stage and not later that early bloom stage (5% of the stems contain blooms).
- Grasses (immature) should be harvested at boot or soft dough stage. (Collar and Aksland, 2001)
- Corn forage should be harvested when milk line passed the midline and not exceeded the ⅔ of the length of the kernel. (Linn et al. 1988)

2. Role of concentrates in rumen ecology

A cow's milk production over her lactation is largely dependent on her peak production (VandeHaar and Black, 1991). Regression analysis of the Wisconsindata shows each additional kilogram at peak is associated with an increasedrolling herd average milk yield of 290 to 380 kg (Nordlund and Cook, 2004). Without concentrates achieving high production levels is impossible.

Let's look as an example. Theoretically, let's suppose that we want to provide the energy required by an early lactating mature cow producing 54.4 kg of milk(requires 30 kg of DMI and 1.6 mcal/kg of ration, NRC, 2001) with ground barley grain and alfalfa hay. It a trade-off among different combinations of ground barley grain and alfalfa hay, approximately, a ration that contains about 80% of ground barley grain and 20% of alfalfa hay matches the target of 1.6 mcal/kg of DMI (Figure 1). On the other words, the cow should consume a ration containing 24 and 6 kg of ground barley grain and alfalfa hay, respectively (DMI basis). Too unlealistic!

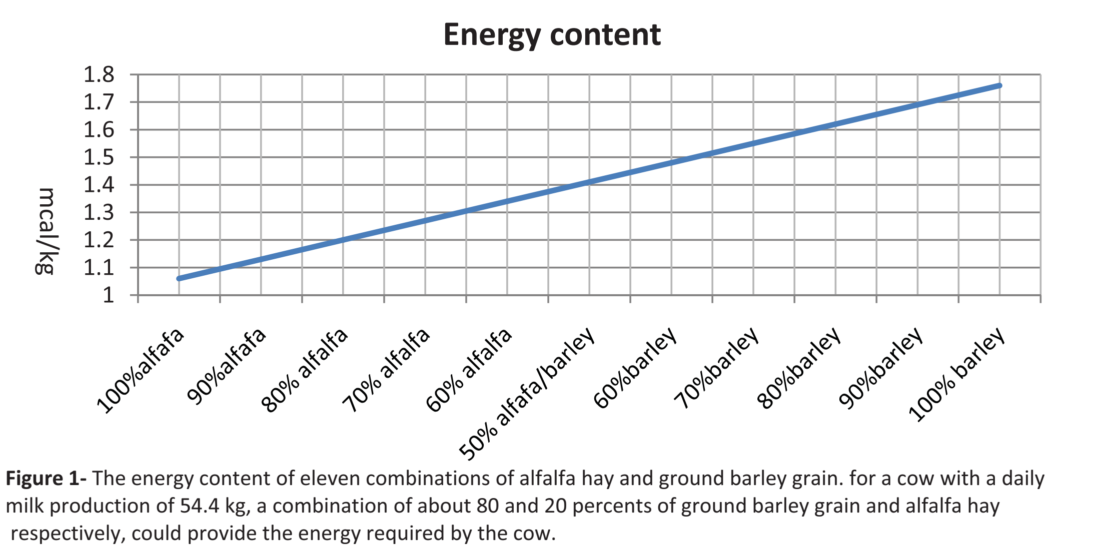

Figure 1- The energy content of eleven combinations of alfalfa hay and ground barley grain. for a cow with a daily milk production of 54.4 kg, a combination of about 80 and 20 percents of ground barley grain and alfalfa hay respectively, could provide the energy required by the cow.

There is a systematic error in Figure 1; it has been taken for granted that there is a linear relationship between increasing concentrates in the ration and efficiency of the rumen to digest and capture the energy content of the ration.

There is a nonlinear relationship between concentrate content of the ration and rate of starch digestion (Allen, 1991). Figure 2 depicts the relationship. Because of complex interactions among ration fiber content, particle size, nonstructural carbohydrates (NSC), rate of starch digestion, fiber digestibility, and meal frequency on energy intake (Allen, 1991), it is still impossible to make specific fiber and/or concentrate recommendations. Thus, designing the nutritional policy of every farm is a matter of both art and science, which claims the keen observational potencies of veterinarians.

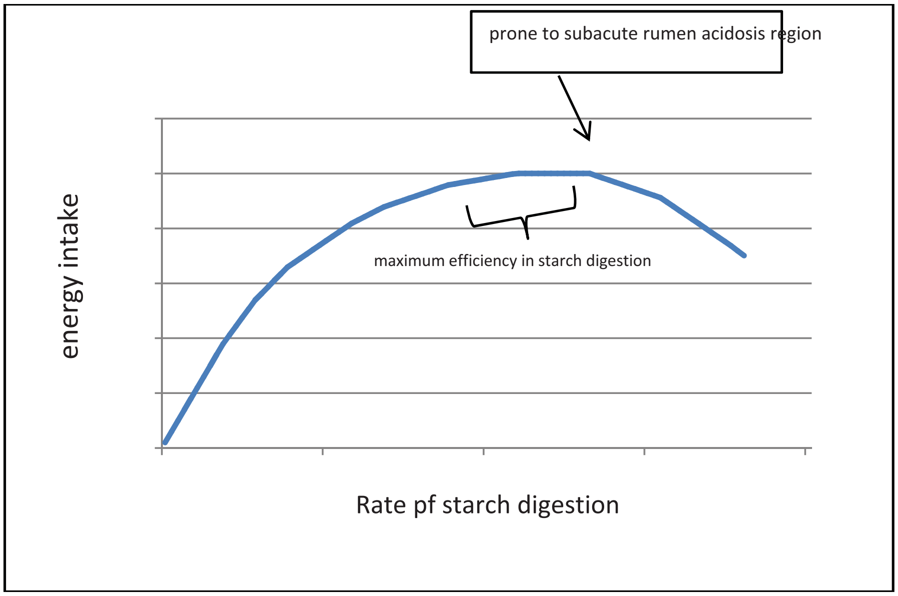

Figure 2. Effect of rate of starch digestion on energy intake. (Inspired from, Allen, 1991)

Rumen health Monitoring

Until the early 1960s, veterinarians in food animal practice devoted most of their time to treat and manage sick animals. However, a new trend has been emerged; dairy practitioners have been exploring ways to prevent diseases rather than taking the time- and effort-consuming process of prescription and treatment (Jarret, 1988). Veterinarians increasingly play an important contributory role to the profitability of dairies by providing nutritional advices. (Sharifi, K, 2006).

It is a long time that many large dairy herds used to be conducted by a teamwork that consists of a veterinarian, a nutritionist and multiple outside consultants, and a team approach provides high level of expertise. In many herds the veterinarian is best suited to be the "team leader" (Gerloff, 2001). So, the veterinarian must be equipped with a reliable source of information to perform his leadership role satisfactorily, and minimize the level of conflict and overlap with nutritionists and consultants in a teamwork setting (Sharifi, K, 2006).

1. Exploring the on farm information:

- **General information of the farm**:Look at some general information in the farm. For example, when average days in milk (DIM) are beyond the desirable interval (160-180 D), then, feeding excessive concentrates to increase the overall milk yieldis not warranted; it may be caused by failure to gain reproductive goals that caused a considerable population of cows to be in their late lactation period.
- **Milk yield information:**The pathologies associated with nutritional imbalances or deficiencies are often correlated with changes in milk components (Bouchard et al, 2012) . Looking at individual milk yield, fat and protein records may be useful.
    - Generally, but not specifically, low butter fat <3 may indicate acidosis, while high butter fat>5 in fresh cows may indicate excessive fat mobilization. Feeding a fat supplement containing C16 fats may mask the presence of SARA by increasing the fat content of milk to normal levels (for Holsteins about 4). (Atkinson, 2009)

- It is estimated that about 70% of ingested protein is degraded into ammonia, which is then used by the rumen microbiota for microbial protein production. The surplus of ammonia will be transferred to the liver, where it is detoxified in urea. Thus, blood urea nitrogen (BUN) or milk urea nitrogen (MUN) isa good indicator of nutritional status. If BUN or MUN are too high, it seems that the herd is possibly wasting feed protein. Otherwise, the rumen bacteria yield can be reduced, followed by limited milk and protein yield. The generally accepted ideal range for MUN is between 8 and 14 mgN/dl (Bouchard et al, 2012)
- **Protein vs Urea:** comparing milk protein percentageversus urea concentration in a scatterplot gives a good indication of protein intake and energy balance. It is recommended to stratify the data by lactation stage (<60 DIM, 61-120 DIM, >120 DIM). Interpret it as follows:1) low urea, normal protein: generally associated with deficient protein or energy intake; 2) high urea, low protein: deficient or poor synchronization of energy intake ; 3)high urea, high protein: excess protein intake (Bouchard et al, 2012).
- **Fat/Protein (F/P) ration**: is useful for detecting ketosis and acidosis of the rumen. High F/P ration is suggestive of lipomobilisation. In normal conditions, the F/P ratio value should be around 1.2. A ration below 1 for a large proportion of cows in lactating group means an action or further investigation is needed. A low ration caused by low butter fat may indicate rumen acidosis caused by insufficient fiber (Bouchard et al, 2012).

2. **Visiting farm:**select at least six cows from each group of 1)close-up cows with <2 weeks to parturition; 2) recently calved cows (between 2-4 weeks postcalving) and 3)peakyealder cows. Determine the body condition score (BCS) (1-5), the rumen fill score (1-5) and fecal sieve score (1-5) and compare them with the target scores in Table 1.

	BCS	Rumen fill score	Fecal sieve score
Close-up cows	2.5-3	4	1-3
Fresh cows	2.5	3-3.5	1-2
Cows in peak lactation	2.5	3-3.5	1-2

- **Metabolic profile test:** there are some overlap between metabolic profile testing and rumen health care. Briefly, non-esterified fatty acid concentrations for all cows should be less than 0.6 mmol/L and betahydroxybutyrate less than 0.9 mmol /L, especially for fresh and peak yielder cows are desirable. Urea nitrogen less than 6 mmol/L (~17 mg/dl) is desirable. Because this subject is out of context of the aims of the current article, it is advisable to follow the topic of metabolic profile testing in relevant articles and books.

3. **Evaluating the ration:** the ration should be evaluated according to:

- Availability in the matter of enough feeding space (0.75 meter bunk space per cow)
- Trough management
- Water availability
- Actual dry matter intake
- The quality of total mixed ration (TMR) and ability of the cows to sort it.
- Any evidence of rotting and spoilage feeds and forages
- Availability of enough physically effective NDF or scratch factor in the ration based on the behavior of the cows (rumination, lying down and overall comfortability)
- The availability of up-to-date facilities and machinaries,e.g. horizontal mixers and vertical feeders are preferable to vertical mixers and horizontal feeders. (Atkinson, 2009).

The subject of SARA diagnosis and rumen health care

current definition of SARA are based on ruminal fluid pH measured between 4 and 8 hours after feeding, when the lowest pH values in ruminal fluid are expected, the confirmed diagnosis requires ruminal fluid collection (Nordlund et al. 1995; Garrett et al. 1999). practically, Ruminal fluid collection either orally by stomach tube or transcutaneously via rumenocentesis has to this day not become routine procedure in veterinary practice because the former is considered as too time consuming and the latter is often perceived as too invasive by animal owners and veterinarians alike (Kleen et al. 2003; Duffield et al. 2004). Moreover, asample obtained at a specific timerelative to feeding only represents a snapshot in time of ahighly dynamic parameter. (MirMazhari-Anwar, et al.) Since the definition of SARA is based on the lowest ruminal fluid pH measured at any time during the day

rather than the mean ruminal pH or the pH at a specific time, the number of false negative results for the diagnosis of SARA when based on a single sample was found to be considerable (Duffield et al. 2004).
several alternative promising approaches to substitute rumenocentesis has been developed, which need further investigation as follows:

1. pH sensors administered orally as a bolus have been used for long-term ruminal pH measurements for research purposes. These devices minimize the risk of false negative results by providing continuous data over time, but costs per unit preclude their use in daily veterinary practice (Sato et al. 2012).
2. Ruminal fermentation pattern tolerate changes during episodes of SARA. Consequently, the synthesis of unique odd and branched-chain fatty acids that are incorporated into milk lipids tolerate some changes. Therefore, it has been proposed using them as markers (C17:0 plus C17:1 cis-9 and a decrease in iso C14:0 concentrations in milk) for estimating microbial protein synthesis and VFA profiles. Their pattern has been proposed to have the ability of diagnosing SARA (Vlaeminck et al., 2005, 2006, Fievez et al., 2012).
3. It is proposed that the ruminal epithelia in the peri-parturient cow responds in a coordinated manner to rapid dietary changes which is of high significance to maintain normal rumen function (Bannink et al., 2012). To investigate the reaction of rumen epithelia to increasing levels of concentrate in 5 cannulated dairy bulls, MirMazhari-Anwar et al. (2013) showed that ultrasonography of the rumen epithelia was able to detect the increase in epithelial thickness. Base on a cut-off point of 5.5 for ruminal pH, the ultrasonographic procedure was able to diagnose bulls suffering from SARA [partial $R2=0.669$, $P<0.0001$, sensitivity=0.9, specificity=0.77]. This procedure needs further investigation.

Conclusion

In nutrition of a ruminanat animal, actually, it is the microbiota of the rumen that is fed and received the allegedly balanced ration. The challenge in feeding cattle is to provide feeds with rapid, intermediate, and slow degradabilities in order to maintain a constant supply of nutrients required to optimize microbial growth. The combined proteolytic activities of protozoa, fungi, and bacteria, along with synergism among different species of the latter, result in rapid degradation of most feed proteins in the rumen. As degradation proceeds, peptides appear in the rumen contents. The rate of peptide hydrolysis is rapid, resulting in the appearance of free amino acids and ammonia within minutes after feeding peak ammonia production at about 1 hour postfeeding. Thus, the major N sources required for microbial growth, including peptide-bound amino acids, free amino acids, and ammonia, all become available at high concentrations within 1 to 2 hours postfeeding. Then decline in concentration until next feeding.The challenge in feeding cattle is to provide feeds with rapid, intermediate, and slow degradabilities in order to maintain a constant supply of nutrients required to optimize microbial growth. (Hoover and Miller, 1991). Rumen health visit is one of the procedures to ensure provision of constant building blocks to the rumen microbiota, synchronize the availability of carbohydrates and crude protein to have a constant rumen turn over and sustained productivity of dairy farms.

References

Noordhuizen,J., Oenema,OBoersema,S.J., Cannas da Silva,J.(2012) Sustainable dairy production & veterinary ad visory practice. In Proceedings of XXVII world buiatrics congress. Lisbon, Portugal, 3-8 June, PP. 48-53.
Curtis C, Erb H, Sniffen C, Smith R, Powers P, Smith M, et al. (1983) Association of parturient hypocalcemia with eight periparturient disorders in Holstein cows. JAVMA.183:559.
Massey C, Wang C, Donovan G, Beede D. (1993) Hypocalcemia at parturition as a risk factor for left displacement of the abomasum in dairy cows. JAVMA. 203:852-3.
DeGaris, P.J and Lean, I.J. (2008) Milk fever in dairy cows: a review of pathophysiology and control principlesVet J. 176:58–69.
Goff, J.P. (2008) The monitoring, prevention, and treatment of milk fever and subclinical hypocalcemia in dairy cows. The Veterinary Journal 176:50–57.
Dirksen G, Liebich HG, Brosi G, Hagemeister H, Mayer E. (1984) Morphology of the rumen mucosa and fatty acid absorption in cattle-important factors for health and production. ZentralblVeterinarmed A. 31:414–430.
Enemark JMD. 2008. The monitoring, prevention and treatment of subacuteruminal acidosis (SARA): a review. Vet J.176:32–43.
Plaizier JC, Krause DO, Gozho GN, McBride BW. (2008) Subacuteruminal acidosis in dairy cows: the physiological causes, incidence and consequences. Vet J. 176:21–31.
Ingvartsen, K.L., Dewhurst, R.J., Friggens, N.C. (2003). On the relationship between lactational performance and health: is it yield or metabolic imbalance that cause production diseases in dairy cattle? A position paper. Livestock Production Science 83, 277-308.
Allen, M., (1991) Carbohydrate Nutrition. Vet. Clin. Food Anim. 7(2), 327-340.

Collar, C.; Aksland, G. (2001). Harvest stage effects on yield and quality of winter forage. In Proceedings, 31st California Alfalfa and Forage Symposium: 12-13 December, 2001, Modesto, CA, UC Cooperative Extension University of California, Davis. (See http://alfalfa.ucdavis.edu). Accessed October 2014.
Linn, JG; Hutjens, MF; Howard, WT; Kilmer,LH and Otterby, DE (1988).Feeding the dairy herd.North centralregional extension.Publication No. 346. 32ndEdn., University of Minnesota ExtensionService.
VandeHaar,M.J, Black, J.R.(1991) Ration Formulation using linear programming, Vet. Clin: Food Anim. 7(2),541-556,.
Nordlund,K.V, Cook, N.B. (2004) Using herd records to monitor transition cow survival, productivity and health. Vet. Clin: Food Anim. 20, 627-649.
National Research Council (2001). Nutrient requirements of dairy cattle. 7th Edn., Washington, DC., Academies press.
Jarret, JA (1988). Highlights and horizons indairy nutrition management. Comp. Cont.Educ. Pract. Vet. Food Anim., (Suppl.), 21:S208-S209, S232.
Sharifi, K. (2006) Veterinarians and dairy nutrition management: basic concepts and design-it-yourself—a veterinary-oriented ration evaluation program Iranian Journal of Veterinary Research, University of Shiraz, 7:60-68.
Gerloff, BJ (2001). Dairy cattle nutrition. In: Radostits, OM (Ed.), Herd health. (3rd. Edn.), W. B. Saunders Co., PP: 435-473.
Bouchard,E., Des Côteaux L., Dubuc, J. (2012). Herd health: beyond reproduction. In Proceedings of XXVII world buiatrics congress. Lisbon, Portugal, 3-8 June, PP. 42-46.
Atkinson, O. (2009) Guide to rumen health visit. In Practice, 31: 314-325.
Nordlund KV, Garrett EF, Oetzel GR. 1995. Herd-based rumenocentesis – a clinical approach to the diagnosis of subacuterumen acidosis. CompenContinEducPract Vet. 17:S48–S56.
Garrett EF, Pereira MN, Nordlund KV, Armentano LE, Goodger WJ, Oetzel GR. 1999. Diagnostic methods for the detectionof subacuteruminal acidosis in dairy cows. J Dairy Sci. 82:1170–1178.
Duffield T, Plaizier JC, Fairfield A, Bagg R, Vessie G, Dick P, Wilson J, Aramini J, Mcbride B. 2004. Comparison of techniques for measurement of rumen pH in lactating dairy cows. J Dairy Sci. 87:59–66.
Kleen JL, Hooijer GA, Rehage J, Noordhuizen JPTM. 2003. Subacuteruminal acidosis (SARA): a review. J Vet Med A. 50:406–414.
Mirmazhari-Anwar, V., Sharifi, K., Mirshahi, A., Mohri, M., Grünberg, W. (2013)Transabdominal ultrasonography of the ruminal mucosa as a tool to diagnose subacuteruminal acidosis in adult dairy bulls: a pilot study. Vet Q. 33:139–147.
Sato S, Kimura A, Anan T, Yamagishi N, Okada K, Mizuguchi H, Ito K. 2012. A radiotransmission pH measurement system for continuous evaluation of fluid pH in the rumen of cows. Vet Res Commun. 36:85–89.
Vlaeminck, B., Dufour, C., van Vuuren, A.M., Cabrita, A.R.J., Dewhurst, R.J., Demeyer, D., Fievez, V., 2005. Use of odd and branched chain fatty acids in rumen contents and milk as a potential microbial marker. J. Dairy Sci. 88, 1031–1042.
Vlaeminck, B., Fievez, V., Tamminga, S., Dewhurst, R.J., van Vuuren, A.M., De Brabander, D., Demeyer, D., 2006. Milk odd and branched-chain fatty acids in relation to the rumen fermentation pattern. J. Dairy Sci. 89, 3954–3964.
Fievez, V., Colman, E., Castor-Montoya, J.M., Stefanov, I., Vlaeminck, B. (2012). Milk odd- and branched-chain fatty acids as biomarkers of rumen function-An update. Anim. Feed Sci. and Tech. 172, 51-65.
Bannink, A.,Gerrits, W.J.J., France, J.,Dijkstra, J. 2012 Variation in rumen fermentation and the rumen wall during the transition period in dairy cows. Anim. Feed Sci. and Tech. 172, 80-94.
Hoover, W.H., Miller, T.K., 1991.Rumen digestive physiology and microbial ecology. Vet Clin: Food Anim. 7311-325.