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Diagnosis of Subacute Ruminal Acidosis: A Review

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ABSTRACT

Subacute Ruminal Acidosis (SARA) may be a common and economically important problem in well managed dairy herds. Although, the complex etiology of SARA necessitates its routine monitoring, diagnosis of SARA in a dairy herd based only on clinical signs is very difficult. Rumenocentesis is the only recommended method for SARA diagnosis in dairy herds, however, numerous methods are proposed for the diagnosis of SARA, which have been reviewed in this study.

Key words: Subacute ruminal acidosis, diagnosis, dairy cattle

INTRODUCTION

Subacute Ruminal Acidosis (SARA) is the consequence of feeding high grain diets to dairy cows, which are adapted to digesting predominantly forage diets. SARA is characterized by daily episodes of low ruminal pH between 5.5 and 5.0 (Krause and Oetzel, 2006). Field studies revealed the presence of SARA in 11-29.3% of the early lactation cows and in 18-26.4% of the mid-lactation cows (Garrett *et al*., 1997; Kleen, 2004; Tajik *et al*., 2009). Even in well managed dairy farms SARA may be a common and economically important problem and some authors believe that SARA is the most important nutritional disease affecting dairy cattle (Enemark, 2008; Mohebbi Fani *et al*., 2010). Also, SARA has been proposed as the predisposing factor for some diseases, such as hemorrhagic bowel syndrome (Tajik *et al*., 2010).

Although, the complex etiology of SARA necessitates its routine monitoring, evidence of the sequelae associated with SARA are often varied and subtle and can be easily overlooked, which precludes a definitive diagnosis of SARA in a dairy herd based only on clinical signs. Additionally, some of the probable clinical signs may appear several weeks after the episodes of ruminal acidosis.

Although, numerous methods are proposed for the diagnosis of non-acute ruminal acidosis, rumenocentesis is the only recommended method for SARA diagnosis in dairy herds. The use of rumenocentesis to sample digesta fluids and its effects on the health of the sampled cows are currently controversial topics in veterinary medicine. This study provides a review of the main signs associated with SARA and those which are proposed for its diagnosis. Available and proposed methods for the diagnosis of SARA in affected herds and the benefits and problems of each method have also been described.

CLINICAL SIGNS OF SARA

SARA affected cows have no typical clinical sign of illness (Krause and Oetzel, 2005; Mutsvangwa *et al*., 2002), however, some clinical signs have been associated with it. The

proposed clinical signs for SARA diagnosis and probable challenges in the diagnosis of SARA by each sign are presented.

Decreased dry matter intake: Decrease in dry matter intake is often presented as a consistent sign and sensitive indicator of SARA. A 25% decrement in Total Mixed Ration (TMR) intake has been observed during induced SARA periods (Kleen *et al*., 2003). Decrease in dry matter intake is cyclic and a high intake on one day is followed by a low intake the following day (Gozho *et al*., 2005). However, several studies showed no decrease in the dry matter intake during experimentally induced SARA (Khafipour *et al*., 2009a). Khafipour *et al*. (2009a) proposed the difference in plasma insulin, insulin secretion or endotoxin tolerance among individual cows as well as differences in the contents of fiber and ensiled forages in particle size and in starch fermentability among the diets used to induce SARA as the probable causes of this discrepancy.

Furthermore, when animals are fed individually, such changes in feeding behavior are detectable. However, intake fluctuations are hardly detectable when 20 or more cows are fed in a loose stall unless all animals experience SARA at the same time (Owen *et al*., 1998).

Laminitis: Laminitis, an aseptic inflammation of the hoof dermal layers, is the major source of lameness for dairy herds (Shaver, 2005). Nutrition, especially acute and subacute ruminal acidosis, is associated with laminitis. Although, the exact relationship between SARA and laminitis is not known (Stone, 2004), subacute or chronic laminitis has been described in SARA affected cows and its clinical signs are discoloration of the hoof, sole hemorrhages, sole ulceration and misshapen hooves (Nordlund *et al*., 1995). Some authors believe that chronic laminitis is the most consistent and significant clinical sign of a herd with SARA and a prevalence of more than 10% is maintained as being indicative of a SARA problem in a herd (Nordlund *et al*., 1995; Enemark *et al*., 2002). However, the causes of laminitis and associated claw horn lesions are multi-factorial in nature (Nordlund, 2004) and a combination of many factors, such as genetics, conformation characteristics, manure handling system and the presence or absence of some infectious diseases affect the prevalence of SARA triggered laminitis in a herd (Shaver, 2005; Cook *et al*., 2004). On the other hand, often there is a long time lapse between the SARA occurrence and the appearance of signs of laminitis. Also, in herds with multiple rations, although, SARA may occur in some subgroups of cows, the herd prevalence of laminitis may be less than 10%.

Milk-fat depression: The relationship between SARA and milk fat depression is controversial and complex. Several factors, such as lactation state, breed and composition of feed rations affect the fat percentage of milk (Enemark *et al*., 2002). A depression of milk fat percentage in SARA affected cows has been documented by some authors and alterations in the ruminal fermentation pattern has been introduced as the cause of the depression (Kleen *et al*., 2003). In a case study of 500 dairy cows, a decrease in milk production of 3 kg/cow/day and decreased milk fat from 37 to 34 g kg^{-1} were calculated (Stone, 1999).

However, it is believed that a decrease of milk fat usually occurs in individuals and remains undetectable in bulk tank testing (Kleen *et al*., 2003). In herds with multiple rations, some subgroups may experience SARA and the effect may be masked by pooling their milk with the rest of the herd. Nordlund (2004) believe that a milk fat percentage below 2.5% in 10% of the cows in a Holstein herd is possible evidence for SARA.

On the other hand, low milk fat content was not observed during some of the experimental inductions of SARA (Enjalbert *et al.*, 2008) and some researches have shown that SARA affected cows had no milk fat depression in farm condition (Tajik *et al.*, 2009; Oetzel, 2005). Some authors have suggested that the inconsistent response in milk fat in experimentally-induced SARA may be related to the duration of the bouts of SARA (Krause and Oetzel, 2005) and Oetzel (2005) believes that short-term SARA challenges have no effect on the milk contents.

Enjalbert *et al.* (2008) observed that the experimental induction of SARA affects the milk fatty acid profile and believe that the fatty acid profile can be used as a diagnostic tool for SARA. Future researches are needed to evaluate the milk fatty acid profile in the diagnosis of SARA.

Alterations in faeces: Changes in faecal consistency, structure and the pH of SARA affected cows have been described. In a SARA affected group, variable faecal consistency and many cows with loose faeces are seen. It is believed that the pH of faeces in SARA affected cows is lower than normal and the size of ingesta particles may be larger than normal (Kleen *et al.*, 2003; Grove-White, 2004). However, as the faecal alterations are usually transient and only a few animals have loose faeces at one time, these animals are usually not noticed (Kleen *et al.*, 2003; Nordlund *et al.*, 1995). Additionally, our study showed that in the SARA affected groups, there were no significant differences between individuals experiencing SARA and the rest of the population in faecal consistency and faecal undigested feed particles. We conclude that perhaps faecal changes apply to rather more severe states of ruminal acidosis than to SARA (Tajik *et al.*, 2008). Gakhar *et al.* (2008) found that experimental SARA induction had no effect on faecal pH. Nordlund (2004) believes that because dietary fiber had no effect on faecal consistency and faecal pH is an indicator of small intestinal pH but not necessarily ruminal pH, faecal evaluation has very limited value in monitoring or diagnosing SARA in dairy herds.

High-culling rate: In SARA affected herds the culling rate and number of inexplicable deaths are exceptionally high (Enemark *et al.*, 2002). In these herds the annual herd turnover rate is greater than 45% and the annual cull rate is greater than 31%. The culling reasons are indistinct and unexplained death, lameness, loss of body condition and non-responsive pathological conditions are probably the most important causes (Oetzel, 2003; Kleen *et al.*, 2003; Nordlund *et al.*, 1995). However, similar to lameness, a high culling rate in an affected dairy herd may be unuseful in SARA diagnosis when only some subgroups of cows experience it.

Loss of body condition: It is often believed that in SARA affected dairy herds there are a number of thin cows despite a high energy diet (Kleen *et al.*, 2003; Nordlund *et al.*, 1995). However, body condition score could not be used to differentiate between SARA affected and non-affected cows in a dairy herd (Kleen, 2004; Tajik *et al.*, 2009).

Other signs: Some of the SARA attributed clinical signs such as rumenitis, rumen parakeratosis, liver abscesses and pulmonary bacterial emboli are detectable at the time of autopsy and show previous periods of acidosis. Other clinical signs that have been noted by some authors are the presence of fibrin casts in faeces, excessive body faecal soiling, continuous tail swishing, dropping the cud while ruminating, poor reproductive performance and environmental mastitis (Grove-White, 2004).

Also, rumen hypomotility has been considered as a probable clinical sign of SARA affected cows (Duffield *et al*., 2004), but, no difference was observed between the SARA affected and the non-affected cows in the number and quality of rumen contractions (Tajik *et al*., 2009).

SARA DIAGNOSTIC TECHNIQUES

The signs of SARA are not completely known and the diagnosis is often difficult in the field due to the variable and subtle signs. Additionally, some of the SARA signs may appear several weeks or months after SARA occurrence. Lack of pathogonomic signs and the delayed appearance of some clinical signs cause SARA to remain unrecognized in some dairy herds. On the other hand, SARA occurrence in herds which are suspected to be SARA affected by the appearance of some clinical signs needs to be confirmed.

Use of rumen fluid: Diagnosis of SARA based on the rumen fluid has been recommended by several authors, as it gives direct information about the rumen condition (Kleen *et al*., 2003).

Rumen pH: Although, there is no general agreement on the pH threshold that is definitive of SARA and a rumen pH of ≤5.5, between 5.2 and 5.5, <5.6 and <6 have been suggested as the threshold for SARA (Khafipour *et al*., 2009b), the current definition of SARA is based on rumen pH. The methods of obtaining rumen fluid for the measurement of rumen pH are:

Stomach tubing: It is generally accepted that sampling and evaluation of rumen fluid using a stomach tube is not a reliable technique in the diagnosis of SARA. Stomach tubing is time consuming and the pH of the sampled rumen fluid is questionable because the pH may vary depending on the intra-ruminal localization of the stomach tube, saliva contamination and time of sampling in relation to feeding (Enemark *et al*., 2002).

Indwelling electrode: After eating, ruminal pH has enormous changes and continuous monitoring of the ruminal pH by an indwelling electrode provides the most information about these changes. This method is often used in research studies and contamination and clogging of the electrodes are the major problems in prolonged use (Enemark *et al*., 2003). On the other hand, there is no general agreement on the definition of SARA in different experiments and subacute ruminal acidosis has been defined as repeated bouts of depressed ruminal pH below 5.6 for 3 to 5 h day^{-1} (Al-Zahal *et al*., 2007), between 5.2 and 5.6 for more than 3 h day^{-1} (Gozho *et al*., 2005) and below 5.6 for 506 min day^{-1} (Krause and Oetzel, 2005). In the Gozho *et al*. (2007) experiment the ruminal pH below 5.6 for 187 min day^{-1} has been mentioned as none affected, while the ruminal pH below 5.6 for 309 min day^{-1} has been mentioned as affected cows. Although, continuous monitoring of the rumen pH is advantageous due to its high diurnal variation (Plaizier *et al*., 2008), providing a similar definition of SARA seems to be necessary.

An indwelling wireless data transfer system for monitoring the rumen pH has been assembled. In this system an indwelling and wireless data transmitting unit allows real-time monitoring of the rumen pH, which could help in the prevention and detection of SARA in cows. It is less invasive compared to other methods of the ruminal pH measurement. Several studies on the relationships between the data recorded by this system and the actual data recorded by independent devices were conducted (Gasteiner *et al*., 2009; Xiaoxiao, 2009) and it seems that by improving the limitations found in the experiments, this system could become very useful for monitoring rumen pH during both scientific research and under commercial conditions.

Ruminal cannulation: Ruminal cannulation is the preferred method of obtaining representative samples of ruminal fluid (Nocek, 1997), however, this method is limited to research proposes. In this method the repeated removal and replacement of the cannula cover disturb the animal and may allow digesta to escape.

Rumenocentesis (rumen puncture): In the mid 1990s, rumenocentesis was presented by Nordlund *et al.* (1995) for SARA diagnosis in dairy herds (Nordlund *et al.*, 1995). In this method, rumen fluid is obtained using percutaneous needle aspiration from the caudoventral rumen. Duffield *et al.* (2004) reported rumenocentesis as a better field test in comparison to the oro-ruminal probe for the measurement of rumen pH. The pH of ruminal fluid that was collected by rumenocentesis had a positive linear relationship with the pH of that collected through a ruminal cannula and rumenocentesis samples were about 0.28 pH units lower than the samples collected simultaneously through rumen cannula (Garrett *et al.*, 1999).

The puncture site is located 12 to 15 cm caudal to the costochondral junction of the last rib, on a horizontal line level with the top of the patella. Before rumenocentesis the puncture site should be clipped, disinfected (scrubbing with povidone-iodine or chlorhexidine) and locally anesthetized (with S.C. and I.M. injection of lidocaine). The puncture can be carried out by an 18 gauge, 100-120 mm long, stainless steel needle and 3-5 mL of ruminal fluid can be aspirated using a 10 mL syringe (Garrett *et al.*, 1999; Nordlund, 2003).

A randomly selected subsample of 12 cows from a herd or diet group should be sampled. A pH of 5.5 has been identified as the cut-point between normal and abnormal cows and cows with a rumen pH of 5.5 or less at the time of rumenocentesis have been considered as experiencing SARA; a ruminal pH ≥5.8 considered as a non affected cow. If three or more cows in either group have a rumen pH of 5.5 or less, the group is considered to be experiencing SARA (Nordlund *et al.*, 1995; Garrett *et al.*, 1999).

If the number of cows with ruminal pH ≤5.5 was less than 3 or one-third or more of cows had values between 5.6 and 5.8, the group is considered borderline or marginally affected. If all of the sampled cows have ruminal pH ≥5.8, the group is definitively classified as negative for SARA (Enemark *et al.*, 2002; Stone, 1999). Some authors believe that a group is affected if more than one-third of the animals tested have a rumen pH less than 5.8 (Stone, 1999).

In a dairy herd, each group of cows which is suspected can be sampled. Two groups of cows are more susceptible to SARA, early lactation and mid lactation cows. Periparturient cows that have been introduced to the lactation ration within the previous 20 days and usually have 1-20 days in milk and mid lactation cows with 45-150 days in milk are recommended to be sampled (Kleen *et al.*, 2003; Nordlund *et al.*, 1995).

The time of sampling after feeding is important and depends on the type of ration fed. In component fed herds, samples should be collected two to 4 h following the concentrate meal and in TMR fed herds they should be collected 4-8 h after feeding (Kleen *et al.*, 2003; Nordlund *et al.*, 1995).

Although, rumenocentesis is the only recommended protocol for SARA diagnosis in dairy herds, there is some doubt about its effects on the health and productivity of sampled cows. Haematomas and abscess formation at the puncture site and septic peritonitis have been reported in different proportions of sampled cows (Kleen *et al.*, 2004). Strabel *et al.* (2007) reported abscess formation in 7 out of 12 cows after one to three rumemenocentesis. Aceto *et al.* (2000) reported rumenocentesis causes a 16% decrease in the milk production of sampled cows. On the other hand, Morgante *et al.*

(2007) and Enemark (2008) performed rumenocentesis on 480 and 58 cows, respectively. None of the sampled cows in these studies had problems during and subsequent to the sampling. According to results of our unpublished study, following rumenocentesis in 196 dairy cows, a small local reaction and abscess formation were observed in 24 (12.24%) and 1 (0.5%) of the sampled cows, respectively and no case of haematomas formation or general health impairment was observed. It seems small needle size, deep local anesthesia, local disinfection and a small volume of collected fluid can decrease the rate of post puncture complications (Garrett *et al.,* 1999). According to our results, the occurrence of skin reaction to the rumenocentesis was different between the fresh and mid lactation cows and between primiparous and multiparous cows. Therefore, other factors such as the immune system condition (under stress or not) and the level of the cow's resistance during rumenocentesis (this was usually higher in primiparous cows) may affect the occurrence of rumenocentesis complications.

Although, the use of this technique seems straightforward, in small and medium sized dairy herds, selection of sufficient early lactation cows could be difficult. Time, the heavy resistance of some cows and blood contamination of samples are other probable problems in the use of rumenocentesis as a diagnostic procedure. Furthermore, the recommended protocol for SARA diagnosis, the collection of ruminal fluid by rumenocentesis from a sub-sample of 12 cows from a diet group, applies to groups with either a high (>30%) or low (<15%) prevalence of low ruminal pH (Enemark, 2008).

Rumen lipopolysaccharide: It has been proven that SARA induction increases the rumen content of free lipopolysaccharide (LPS), which is due to the increase in lysis of gram negative bacteria (Gozho *et al.*, 2005; Plaizier *et al.*, 2008). Gozho *et al.* (2005) suggested refining the definition of SARA based on the free rumen LPS concentration. However, the reported range of free LPS in the rumen fluid of affected cows varied between the different studies. Khafipour *et al.* (2009a) proposed using different methods of LPS determination as the probable cause of this discrepancy between the different studies.

Rumen microbial composition: The rumen pH is a major determinant of the type of digestion that occurs in the rumen and rumen digestion influences rumen pH. There is a paucity of data on changes in ruminal bacterial species that occur due to SARA (Plaizier *et al.*, 2008). In general, a decrease in rumen pH causes the decrement of cellulolytic bacteria and predomination of gram-positive cocci and rods, even though the number of gram-negative bacteria also increases (Nagaraja *et al.*, 1978; Goad *et al.,* 1998). Khafipour *et al.* (2009c) found that microbial composition of the rumen is different between SARA affected and non affected cows, between mild and severe induced SARA and between grain induced and alfalfa pellet induced SARA. Complete detection of the change patterns in the rumen microbial community during SARA may help in finding new methods for SARA detection.

Rumen fluids temperature: Al-Zahal *et al.* (2008) showed that ruminal pH has a negative relationship with ruminal temperature (R2 = 0.77) and proposed that ruminal temperature may aid in the diagnosis of SARA. This experiment showed that the temperature range 39 to 41°C corresponds to the ruminal pH range of 5 to 5.6, which is critical for the detection of SARA. However, the consumption of water and diet may interfere with the diagnosis (Al-Zahal *et al.*, 2008). Gasteiner *et al.* (2009) reported that rumen temperature was influenced significantly by drinking water but it is not connected with feeding time.

Prediction of ruminal pH using ration analysis: The systems of ruminal pH prediction described are mainly on the proportion of ration effective fiber, non fiber carbohydrates, added fat and crude protein and their usage requires reliable data about the chemical component of the ration (Kleen *et al*., 2003; Nordlund, 2003). These systems have limited applications because their results were not repeated across different types of diets (Allen, 1997). Therefore, SARA diagnosis cannot be based upon the ration analysis alone. There are three problems in the diagnosis based on the ration analysis: A: the ration printout may be different from the ration that the cows consume. B: the nutrient analysis does not fully predict what will happen in the rumen. C: in addition to the nutrient content of the ration, some other factors such as total intake, particle size, moisture and consumption patterns affect the rumen pH (Nordlund, 2003). Therefore, assessment of the ration should be based on the evaluation of the chemical and physical properties of the diet and evaluation of the ration chemical properties such as dry matter, digestibility, energy, non fiber carbohydrate, crude protein and neutral detergent fiber (NDF), as well as evaluation of the physical properties of quality, including particle size and both forages and grains, which may improve the prediction of the rumen pH by ration analysis. Additionally, because the fermentation rates of grains carbohydrates are different, the grain type and degree of processing should be noted in the ration evaluation (Krause and Oetzel, 2006). Unfortunately, no standard method for the evaluation of these factors is available.

Urine pH: Positive relation between rumen pH and urine pH has been established and some authors believe that routine monitoring of the urine acidity is the most efficient parameter in SARA diagnosis (Enemark *et al*., 2002). However, the results of other researches showed no diagnostic value for urine pH in the detection of SARA affected cows and the use of urine pH in the diagnosis of SARA has been doubted (Kleen, 2004; Tajik *et al*., 2009; Gakhar *et al*., 2008).

Assessment of cows: Grove-White (2004) believes that assessment and scoring of some factors, such as changes in the body condition score in early lactation cows, rumen fill, rumination, body dirt score, faecal score, production and fertility parameters, lameness prevalence, the overall health and appearance of the cows and cow comfort can be used in the diagnosis of SARA occurrence in a dairy herd. However, the method of detection of a SARA affected herd has not been illustrated.

Assessment of chewing activity indicating the presence or lack of adequate fiber in the diet, can be used as an indication of sub-clinical acidosis in a herd. It is believed that rumination promotes much chewing activity and therefore causes the secretion of much saliva into the rumen. Saliva contains inorganic buffers that neutralize the organic acids produced during rumen fermentation. Ruminal pH increases during bouts of rumination (Oetzel, 2005; Plaizier *et al*., 2009). At least 40% of cows at rest should be ruminating and with fewer than 40%, the potential for SARA should be considered (Allen, 1997).

Faecal sieving: Faecal sieving has been proposed as a diagnostic method for SARA. In each group of cows 6-12 faecal samples should be collected and sieved under running water using a standard sieve. The presence of large particles of fiber (greater than 2.5 cm), undigested grains and fibrin casts are suggestive of the presence of ruminal acidosis (Grove-White, 2004; Hall, 1999). However, no scoring method has been illustrated and we found no experiment regarding the evaluation of this method in the detection of SARA affected cows.

Faecal lipopolysaccharide: Gakhar *et al.* (2008) found that experimental induction of SARA increases the LPS concentration in faeces. Plaizier *et al.* (2009) reported that dairy farms with low dietary NDF had higher faecal LPS, about 2 times greater, than farms with a high dietary NDF. They proposed that faecal LPS could aid in the diagnosis of SARA.

Blood parameters: Although, a slight decrease in blood pH and bicarbonate, as well as a slight change in the base excess have often been reported following the experimental induction of SARA, in some cases a more significant marked decrease in the blood bicarbonate and base excess during subacute acidosis have been observed (Bevans *et al.*, 2005; Brown *et al.*, 2000; Goad *et al.*, 1998). Kleen *et al.* (2003) believes that blood pH and base excess may be of use in diagnosis of SARA.

Following experimental induction of SARA serum lactate, non esterified fatty acids, cholesterol, albumin, urea, Na, Cl, K, Ca, P, insulin, triiodothyronine, thyroxine, growth hormone and cortisol as well as blood packed cell volume, gas parameters, white blood cells and plasma glucose have no significant change (Bevans *et al.*, 2005; Brown *et al.*, 2000; Enemark *et al.*, 2002; Gakhar *et al.*, 2008; Goad *et al.*, 1998).

Brown *et al.* (2000) proposed that some factors such as serum amylase may be of use in the diagnosis of SARA affected cows, however, our study showed no difference between affected and non affected cows in serum amylase and alkaline phosphatase. We conclude that there may be some differences between the experimentally controlled studies of SARA and the farm condition and the results of the experimental studies may be different from what is happening in dairy farms (Tajik and Tahvili, 2011).

It has been shown that the experimental induction of SARA causes inflammation, which is shown by the increase in acute phase proteins, Serum Amyloid A (SAA) and haptoglobin (Hp), in peripheral blood (Gozho *et al.*, 2005; Plaizier *et al.*, 2008). Measurement of these proteins in the blood has been suggested as an aid in the diagnosis of SARA (Plaizier and Krause, 2009). However, Khafipour *et al.* (2009a) observed that Grain-based induction of SARA increases the concentrations of these acute phase proteins, but SARA induction by feeding alfalfa pellets was not accompanied by an inflammatory response (Khafipour *et al.*, 2009b). On the other hand, the elevation of SAA and Hp is a nonspecific reaction to different external or internal challenges such as infection and stress (Mohebbi *et al.*, 2009). Unlike SAA and Hp, the experimental induction of SARA did not affect the serum concentration of other inflammation indicators, such as ceruloplasmin, fibrinogen and lipid associated sialic acid and assessing their serum concentration may help in the differential diagnosis of serum SAA and Hp increment caused by SARA or other conditions such as stress (Mohebbi *et al.*, 2009).

Although, it is proven that the induction of SARA increases free rumen LPS, no evidence of LPS in peripheral blood circulation has been found (Gozho *et al.*, 2005). Some studies have occasionally detected LPS in peripheral circulation during experimentally induced acute ruminal acidosis (Khafipour *et al.*, 2009a). Khafipour *et al.* (2009a) reported, for the first time, that a grain-based SARA challenge increased the peripheral blood LPS. Despite greater free rumen LPS in alfalfa pellet-induced than grain-induced SARA, LPS has not been detected in the peripheral circulation of affected cows (Khafipour *et al.*, 2009b). Therefore, the use of an LPS measurement in peripheral blood for the diagnosis of SARA needs more research.

CONCLUSIONS

Khafipour *et al.* (2009a-c) showed that grain and alfalfa pellet induced SARA have different features. Therefore, a suitable method for the diagnosis of each of them may be different. Some

authors have proposed refining the definition of SARA (Gozho *et al.*, 2005). In a new definition these differences should be considered.

At this time, the diagnosis of SARA in a herd should be based on a combination of supporting clinical signs, production records, diet characteristics and ruminal fluid pH (Nordlund, 2004).

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