Sub Acute Ruminal Acidosis (SARA) In High Concentrate Ration Fed Calves

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ABSTRACT

Subacute ruminal acidosis (SARA) is a significant production disease of fattening calves. Highly concentrate rations contains high concentrations of rapidly fermentable carbohydrate and low concentrations of physical effective fiber that may result in SARA. This study was conducted to investigate prevalence survey of rumen health status in high concentrate ration-fed calves. The survey assessed rumen fluid(SCFA and pH), daily weight gain, serum biochemical parameters(total protein, glucose, AST, GGT, GLDH,BHB and NEFA) and prevalence of SARA . A total of 185 fattening calves in Sharkia and Ismailia governorates in beginning and finishing phase of fattening were selected from 7 farms. 21.7% of calves were classified as affected with SARA (pH $\leq$ 5.5), 53.5% were marginal (pH 5.6–5.7) and 24.8% were normal (pH $\geq$5.8). The study showed that low rumen pH is prevalent in high concentrate ration-fed farms with the highest prevalence in the farms depended on wheat flour as a source of energy. The ruminal pH is the accurate method for detection of SARA in the farm then the SCFA estimation while the serum parameters had no value in detection of SARA.

INTRODUCTION

Mortality and morbidity rates associated with digestive disturbances in feedlot cattle are only the second to those from respiratory diseases. Among the digestive disorders of feedlot cattle, acidosis is one of the most common and has been well known ever since grain feeding became a widespread practice. Acidosis in feedlot calves results when cattle consume fermentable carbohydrates in amounts sufficient to cause a non-physiologic accumulation of organic acids in the rumen, with a concurrent reduction in pH *(1)* In beef cattle fed on high-concentrate diets, the ability of the animal to buffer the rumen is minimal because of limited mastication and rumination and hence, insufficient salivary secretion *(2)* Additionally, if the absorptive capacity of the ruminal wall is impaired by abnormal ruminal papillae or rumenitis, the animal's ability to maintain a stable ruminal pH is affected.

Britton and Stock (3) were the first to recognize that "Acidosis is not one disease, but rather a continuum of degrees of ruminal acidity," and for simplicity, it is categorized as acute or subacute based on ruminal pH, type of acid responsible for low pH, and whether clinical signs are evident. Ruminal pH of 5.6 or lower is generally considered the benchmark for ruminal acidosis; a pH range of 5.0 to 5.5 is regarded as subacute or chronic acidosis; and pH below 5.0, approaching 4.5 or lower, is considered acute acidosis *(4,5)*. The critical time for the occurrence of acidosis is during the period of step-up to high-grain diets when cattle enter feedlots and during the late finisher phase, when intakes are greatest and the rumen wall is maximally compromised from months of high-acid environments*(1)*. The signs of acidosis are most evident with acute acidosis *(6)*. Several studies have linked SARA to conditions of dairy cattle such as laminitis *(7,8)* decreased dry matter intake (DMI) *(9)* poor body condition score *(7),* loose faecal consistency *(7,10)*, low milk fat syndrome *(7,10)*, caudal vena cava syndrome *(10)* and abomasal displacement/ulceration *(11)*. Some of the telltale signs of acidosis in a feedlot include fecal consistency scores with more than 20% loose stool or more than 5% watery indicate acute acidosis in some of the cattle, more than 10% of cattle are apparently tender (sore) on the front feet, Smeared (wet) areas lateral to anus, because of the irritating effect of acidotic feces and Increased respiratory rate *(1)*.

Nordlund et al. (10) recommended that a pH of less than 5.5 for more than 30% of the cows in a subgroup (minimum of 10 cows),

selected from a high-risk group during the first 60 days postpartum, should be considered indicative of subacute acidosis. Similar studies have not been conducted in feedlot cattle. Traditionally, increased dietary concentrate is fed in incremental amounts of grain over a 3 to 4 week period to minimize the risk of acidosis *(12).* However, acidosis could happen even when cattle are gradually adapted to a grain diet *(13).* Ruminal acidosis is associated with many other feedlot ailments that can significantly impact animal performance. ***Brent*** *(14)* discussed rumenitis, liver abscesses, laminitis, and polioencephalomalacia as problems related to SARA *(15).* ***Britton and Stock*** *(3)* added sudden death syndrome, grain bloat, clostridial infections, and malabsorption to the list of problems associated with an episode of acidosis.

MATERIALS AND METHODS

Materials

1.Animals

In the present study seven fattening farms in Sharkia and Ismailia governorate were selected according to history that reported repeated cases of laminitis , diarrhoea and liver abscesses after slaughtering. This study carried in the period from Feb. 2007 to Aug. 2007 . Production data and herd features were recorded and a first selection of animals to be examined was made. In cooperation with the farmers, the groups of animals per farm were definitely built. All farms cooperating in this study were fattening farms. In average, the farms had a herd size of 180 fattening calves, with a range from 80 to 400 animals. On all farms the animals were kept on concentrated ration during the period of fattening with addition to hay or silage (8% & 12%) in starting and finishing rations respectively. The animals were fed *ad. Lib.* For this study, in total 185 fattening calves were selected randomly from the seven farms. Sixty five in the beginning of fattening and 120 in the last month were examined to detect the prevalence of SARA in each farm. Animals experiencing disease or being in recovery were excluded from further examination.

On the basis of decreased body gain , presence of laminitis , diarrhea or bloat as well as decreased feed consumption ,these affected calves grouped separately and sampled to detect either those signs related to ruminal pH or not, and either those signs were disappeared by correction of pH or not. The mean daily gains of the farms were ranged from 0.9 to 1.3 kg / head / day.

2.Samples

A.Ruminal fluid samples were collected using stomach tube, 2.2 meter length with suction machine designed locally to help the collection of ruminal juice, samples from caudoventral sac ,first jets of sample were discarded to avoid effect of saliva, then about 250-500 cc samples were collected for detection of pH immediately using pH meter and applying physical examinations. Then the rest of samples were prepared for estimation of Short Chain Fatty Acid (SCFA).According to ruminal pH reading ,animals were divided to three groups; affected ($pH \leq 5.5$), marginal (pH5.6-5.7), and normal ($pH \geq 5.8$).

B.Blood samples (coagulated blood sample): Sera were gained after blood collection by vein puncture from jugular vein, into a clean dry centrifuge tubes. Blood samples were lifted to clot at room temperature till the clot retracted, then the sera were removed by Pasteur pipette and clarified by centrifugation at 3000 rpm for 15 minutes to remove residual red cells. The obtained clear non haemolyzed sera were transferred into sterile, clean glass vials and then stored at -20^0C for determination of total serum protein, beta-hydroxybutyrate, non estratified fatty acid (NEFA) while glucose, AST, GGT and GLDH were examined immediately after collection of sera.

Methods

1.Clinical examination and general health assessment to exclude diseasesd calves *(16).*

2.Ruminal fluid sampling using stomach tube *(17)*. The stomach tube sampling was carried out 3 to 4 hours after the last concentrate meal *(9)*. The mean difference in rumen pH using the two methods (stomach tube and rumenocentesis) varies from 0.28 *(18)* to 0.76 *(19)*. However, the relationship appears weak (r2 = 0.11) *(19)*.

3.Rumen fluid pH was measured immediately after the sample was drawn using a portable pH-meter ***(Hanna Instruments, Italy; HI 9025/1230)***. A calibration using standard buffers of pH 4.01 and pH 7.01, respectively was carried out on each visit before measuring began.

4. Blood serum samples: The methods used can be taken from this table .

Parameter	Reference	Unit	Source
Total serum protein	*Trinder (20)*	Mmol/l	Sigma Diagnostics, Deisenhofen, Germany
Glucose	*Trinder (20)*	Mmol/l	ABX Diagnostics, Montpellier, France
Beta-hydroxybutyrate	*Young et al (21)*	Mmol/l	Randox Laboratories, Krefeld, Germany
NEFA	*Young et al (21)*	Mmol/l	Wako Chemicals, Neuss, Germany
AST	*Young et al (21)*	U/l	mti diagnostics, Idstein, Germany
Gamma-GT	*Young et al (21)*	U/l	Roche Diagnostics, Mannheim, Germany
GLDH	*Young et al (21)*	U/l	Roche Diagnostics, Mannheim, Germany

5.Laboratory determination of short chained fatty acids (SCFA):From each sample of ruminal fluid, an amount of 8 to 10 ml was mixed with the amount of 0.4 ml of formic acid for conservation and immediately deep-frozen for further analysis. A laboratory determination of SCFA (Acetic acid, Propionic acid, Butyric acid and Valeric acid) was done by gas chromatography *(22)*.

RESULTS

Table 1. Prevalence of SARA , affected, marginal and normal animals in the examined farms and the judgment of each farm.

Farmnumber and population		No of exam calves	Ruminal pH			Prevalence Of SARA	Prevalence Of marginal	Prevalence Of normal	Judgment of the herd
			≤5.5	5.6-5.7	≥5.8				
1	140	22	6	8	8	0.272	0.363	0.363	Affected
2	220	32	4	18	10	0.125	0.562	0.312	At risk
3	80	10	4	4	2	0.40	0.40	0.20	Affected
4	200	20	7	4	9	0.35	0.20	0.45	Affected
5	160	20	6	8	6	0.30	0.40	0.30	Affected
6	100	10	5	5	0	0.50	0.50	0.00	Affected
7	400	71	8	52	11	0.112	0.732	0.154	At risk

Affected farms classified as containing ≥25% of sampled calves with a rumen pH of ≤5.5. High-risk farms classified as containing ≥33% of the cows with a rumen pH < 5.8. Normal herds classified as containing <33% of cows with a rumen pH < 5.8.

Table 2. The percent of SARA affected, marginal and normal animals in all examined animals.

All examined animals	% of affected animals	% of marginal animals	% of normal animals
185	21.7%	53.5%	24.8%

Table 3. Number and percent of SARA, affected, marginal and normal animal in the beginning and finishing period of fattening

Ruminal pH	SARA affected< 5.5	Marginal 5.6&5.7	Normal 5.8&more
Group1 (beginning of fattening)	14/65 (21.54 %)	41/65 (63.08 %)	10/65 (15.38 %)
Group2(finishing period)	26/120 (21.67%)	58/120 (48.33%)	36/120 (30.00%)

Table 4. The mean pH and daily gain in the seven farms

Farm	pH(mean±SD)	Daily gain(kg)
1	5.61 ±0.05 ^{b}	1.18 ±0.01 ^{b}
2	5.56 ±0.10 ^{b}	0.99 ±0.02 ^{b}
3	5.51 ±0.12 ^{b}	0.97 ±0.03 ^{b}
4	5.70 ±0.05 ^{a}	1.30 ±0.01 ^{a}
5	5.51 ±0.10 ^{b}	0.96 ±0.02 ^{b}
6	5.44 ±0.15 ^{c}	0.91 ±0.01 ^{c}
7	5.76 ±0.06 ^{a}	1.33 ±0.01 ^{a}

Table 5. Showed Correlation matrix between pH and daily weight gain

PH	WEIGHT GAIN
	- 0.98 **

** Correlation is highly significant.

Table 6. The average values of total serum protein, blood glucose, betahydroxy butyrate, non esterified fatty acid, AST, GGT, GLDH and pH in the examined farms.

Farm	TP g/l	Glucose. Mmol/l	Beta-hydroxybutyrate Mmol/l	(NEFA). Mmol/l	(AST). u/l	(GGT). u/l	(GLDH). u/l	PH
1	63.6	2.95	1.08	433.75	36.9	29.4	41.8	5.61
2	65.1	2.85	1.09	429.5	38.2	30.8	38.3	5.56
3	62.4	3.05	1.03	455.85	39.5	54.8	34.8	5.51
4	62.7	3.01	1.03	448.3	39.7	19.8	19.3	5.7
5	63.2	3.00	1.07	453.45	36.8	55.3	34.6	5.51
6	64.5	2.88	1.09	438.66	40.4	58.6	32.9	5.44
7	62.9	2.84	1.02	430.7	41.16	56.5	33.1	5.76

Table 7. The average values of total serum protein, blood glucose , betahydroxy butyrate, non esterified fatty acid, AST, GGT and GLDH in SARA affected, marginal and normal animals.

parameter / Samples	TP g/l	(AST). u/l	(GGT). u/l	(GLDH). u/l	Glucose. Mmol/l	(NEFA). Mmol/l	Beta-hydroxybutyrate Mmol/l
All samples	65.12	37.2	25.75	22.10	2.30	325.7	1.01
Affected PH<5.5	63.31	32.7	65.25	32.55	2.40	270.6	0.88
Marginal PH5.6-5.7	64.25	34.6	30.50	41.50	2.25	338.9	0.91
Normal PH>5.8	62.95	38.8	15.15	15.75	2.20	329.4	1.07

Table 8. The mean values of acetate, propionate, acetate/propionate ratio, butyrate, valerate, total VFA concentration and total lactate in ruminal juice in SARA affected, marginal and normal animals.

Animal group	Affected (ruminal pH≤5.5)	Marginal(uminal pH 5.6-5.7)	Normal (uminal pHmore≥5.8)
Rumen acetate (mmol/L)	89.64 ± 5.10^{b}	96.88 ± 3.87^{a}	78.51 ± 2.59^{c}
Rumen propionate (mmol/L)	29.85 ± 2.56^{a}	26.64 ± 1.70^{b}	21.34 ± 1.97^{c}
Acetate: propionate	3.13 ± 0.25^{c}	3.68 ± 0.41^{b}	3.72 ± 0.62^{a}
Iso-butyrate (mmol/L)	0.95 ± 0.30^{b}	1.14 ± 0.47^{a}	0.59 ± 0.05^{c}
N-butyrate (mmol/L)	18.30 ± 2.99^{a}	15.00 ± 1.00^{b}	12.92 ± 1.06^{c}
Iso-valerate (mmol/L)	1.97 ± 0.14^{b}	2.38 ± 0.17^{a}	1.45 ± 0.13^{c}
N-valerate (mmol/L)	2.91 ± 0.27^{b}	3.03 ± 0.31^{a}	1.66 ± 0.25^{c}
Total volatile fatty acid concentration (mmol/L)	133.63 ± 4.84^{b}	147.07 ± 3.90^{a}	116.48 ± 5.73^{c}
Total lactate	0.05%	0.05%	0.05%

Mean within the same row carrying different litters are significant at $P \leq 0.05$.

DISCUSSION

1. farms participated in the survey

Selection of the farms participated in the survey was done according to history of presence of cases of laminitis, diarrhoea, decreased daily gain, bloat and liver abscesses after slaughter . These signs were approved as indication of SARA in the herds ***(10,23,24)***.

2. Ruminal pH and prevalence of SARA

Table 1 showed that five farms (1,3,4,5&6) from the seven farms were affected with SARA (≥25 % of samples pH ≤5.5) and the farm (2,7) were at high risk (≥ 33 % of samples pH< 5.8) . This classification of herds was designed previously ***(25)***. Table 2 showed that the whole percent of affected animals (pH≤5.5) was 21.7 % , marginal animals (pH 5.6 & 5.7) was 53.5 % and the normal animals (pH ≥ 5.8) were 24.8 %.In the present study the prevalence of SARA were higher than 11% ***(26)*** and 26 % ***(27)***. The two studies were carried on dairy herds but similar study is not present in fattening herds ***(1)***. The high prevalence in the present study may be due to the high concentrated ration used that contain only 8-12 % roughage in all farms , also all farms were selected according to history of signs indicated SARA .

Table 3 showed the percentage of affected, marginal and normal animal in beginning and end of fattening period. The results were 21.54%, 63.08%, 15.38 % in the beginning period and 21.67%, 48.33%and 30% in the finishing period respectively which indicate nearly equal prevalence in the two periods for SARA, while the marginal animals were higher in the beginning than finishing, this may due to incomplete adaptation. ***Bevans et al.*** *(12)* noted that increased dietary concentrate is fed in incremental amounts of grain over 3-4 weeks period to minimize the risk of acidosis. However acidosis could happen even when animals were gradually adapted to a grain diet *(13).*, which indicates that the ability of cattle to withstand grain challenges is highly variable *(12,28).* Our results pointed out that the most dangerous periods in the fattening calves were the beginning and finishing weeks. This agreed with the fact that the critical time for occurrence of acidosis is during the period of step up to high grain diets when cattle enter feedlots , also during the late finisher phase when intakes were greatest and the ruminal wall was maximally compromised from months of high acid environments *(1).* Furthermore SARA had the potential to transition into lactic acidosis if the pH of 5.0 is sustained for a period of time; however the length of time necessary for this to happen has not been determined *(29).* This may discuss why all pH samples below 5.0 in our study were in the finisher phase.

3.Daily gain

Table 4 showed the relation between ruminal pH and the average daily gain in each farms. The results revealed highly significant changes in body gain between the farms. Table 5 appeared highly significant negative correlation between pH and daily gain .

Similar results in one American report showed that reduced feed intake alone caused by SARA led to reduced growth in beef calves , estimated to result in a loss of 10 – 13 US $ / animal plus additional losses from liver abscess formation *(30).* Several studies have shown a lower feed intake during SARA periods *(31, 32).* This may due to the changes of osmolality of the rumen fluid because values that are considerably greater than 300 mOsm / L restrict feed intake and reduce the bacterial and protozoal fermentation of fiber and starch. Also ruminitis and parakeratosis which are a frequent sequel to SARA may affect VFA absorption in the long term leading to decreased daily gain *(23, 33).*

5- Serum biochemical parameters and its relation to SARA.

Table 6 revealed no changes between all measured parameters in different herds also Table 7 showed no variations in the serum parameters in different group of affected; marginal or normal animals. Also the correlation between serum parameters and ruminal pH is very week. These results in accordance with the results which found that except GLDH none of the parameters proved to be related with the presence of SARA or being correlated with ruminal pH decreasing. The correlation of GLDH, however, was week and any significance between levels in SARA affected individuals and other animal was not detectable. These seems that determination of these parameters as tool of detection of SARA is values less *(17 ,34).*

Other parameters to be estimated but not included in the present study as blood pH and gases. Although some researchers found that the blood gas parameters were not notably in case of chronic metabolic acidosis *(35)*, whereas others demonstrated decreased blood pH and bicarbonate as well as base excess (Metabolic acidosis) in steers having SARA *(28 , 29 ,36).*

6. SCFA and SARA

Table 8 showed that TVFA. and acetate increased significantly with decreased pH then began to increase again in the SARA group . Propionate shows significant increase with decreased ruminal pH so acetate propionate ratio significantly decreased in SARA group . Butyrate continuously increased with decreased pH while valerate had the highest value in the marginal group and in SARA

group decreased significantly but still significantly higher than normal.

The total VFA concentration generally increases at the onset of acidosis but with progression of acidosis VFA concentration declined dramatically because of destruction of the normal bacterial flora and ruminal dilution as a result of an influx of fluids to compensate for increased osmolality *(37).* Although lactic acid is produced in SARA, it doesn't accumulate because lactate fermenting bacteria remain active and rapidly metabolize it to VFA *(29).*Also lower acetate to propionate ratio was numerically founded in a high risk herds *(25).*

Recent studies *(19, 27, 38)* have indicated that the presence of high concentration of velerate may be correlated with SARA as valerate is produced by lactolytic bacteria in the presence of lactate *(39 ,40).* This discussed why valerate was increased in marginal group.

Lactate not detected in all measured samples as the lactic acid accumulation is typical of acute acidosis when pH decreased towards 4.5 and lower *(1 ,30).*

Conclusion

The present results concluded that the ruminal pH must be examined regularly as the only accurate diagnosis of SARA; also preventive measures must be applied to reduce the prevalence of SARA.

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الملخص العربى

حموضة الكرش تحت الحادة فى عجول التسمين التى تتغذى على العلائق المركزة

عبدالكريم منصور، وفاء محمود عبدالرازق ، عزيزة محمد السيد ، عبدالخالق رمضان الشيخ
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تعتبر حموضة الكرش تحت الحاده واحده من اهم الأمراض التى تواجه عجول التسمين خاصه التى تعتمد فى تغذيتها على العلائق المركزه التى تحتوى على تركيزات عاليه من الكربوهيدرات سريعة التخمر و كذلك تحتوى على نسب منخفضه من الألياف . و لهذا المرض اهميه كبيره حيث يؤثر بشكل ملحوظ على معدل الزياده اليوميه فى الأوزان بجانب تأثيراته على الحاله الصحيه للحيوان و تكمن خطورته فى عدم ظهوره حقليا بإستثناء بعض الملاحظات داخل المزرعه مثل النفاخ و الأسهالات و نقص الأستهلاك اليومى للعلائق . لذا تهدف هذه الدراسة لعمل مسح شامل لعدد ٧ مزارع بمحافظتى الشرقيه و الأسماعليه يتم من خلاله تعيين الأس الهيدروجينى لعصارة الكرش وربطها بمعدلات الزياده اليوميه للأوزان و كذلك ربطها بتغيرات فى قياسات السيروم مثل الجلوكوز و البروتين و . AST , GGT , GLDH , BHB , NEFA وكذلك قياس الاحماض الدهنية الطيارة بالكرش للوقوف على استخدام احد هذه المتغيرات فى التشخيص و لبيان نسبة حدوث هذا المرض فى المزارع التى تم بها المسح. اظهرت النتائج ارتفاع نسبة حدوث حموضة الكرش تحت الحادة فى هذه المزارع وارتباطها المباشر بانخفاض معدل الزيادة اليومية فى الاوزان. كما اوضحت النتائج عدم ارتباط قياسات السيروم بتغيرات الاس الهيدروجينى للكرش بينما كانت بعض التغيرات فى الاحماض الدهنية الطيارة بالكرش مرتبطة بدرجة حموضة الكرش.