EFFECTS OF MONENSIN, SARSAPONIN™ AND VFA ON IN VITRO DIGESTION OF WHEAT FORAGE

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Story in Brief

Wheat forage digestion was studied using semi-continuous rumen cultures with or without monensin, a mixture of ammonium salts of volatile fatty acids and Sarsaponin™. Monensin at 27.5 ppm reduced nitrogen disappearance by 12 percent, increased digestion of acid detergent fiber by 25 percent, reduced gas production and reduced production of microbial nitrogen by 21 percent. Sarsaponin™ at 66 ppm had effects generally similar to monensin though of slightly lower magnitude. Ammonium salts of volatile fatty acids increased acid detergent fiber digestion slightly and tended to increase nitrogen disappearance but did not improve microbial yield or efficiency. The increases in fiber digestion and decreases in nitrogen disappearance with Sarsaponin™ and monensin are desirable changes with wheat forage diets. Monensin and Sarsaponin™ tended to decrease true digestion of organic matter. However, depressed microbial protein production is undesirable if the total amino acid supply to the intestine limits performance. Hence, these additives would appear most useful to improve protein status if dietary protein is extensively degraded in the rumen. With very low protein diets, these two additives may prove detrimental to protein status contrary to the suggestion of a protein sparing effect of monensin with low protein diets.

(Key Words: In Vitro, Fermentation, Digestion, Wheat Forage, Monensin, Sarsaponin™, Minor Volatile Fatty Acids.)

Introduction

At periods of rapid growth, wheat forage exceeds 20 percent crude protein, and a large proportion of this protein is soluble and rapidly degraded to ammonia in the rumen (Zorrilla-Rios et al., 1985). Supply of fermentable energy in wheat forage may be inadequate to fully use this ammonia, and ammonia losses can be high. Supplementation of wheat forage with a high energy, low protein feed like ground corn should increase capture of ammonia in microbial protein. Recently, rate of gain of cattle grazing wheat was reported to be increased by 0.2 lb/day with supplementation of 0.23 lb/head daily of a high-bypass protein feed (meat meal; Lee, 1985). This suggests that amino acid flow to the intestines may limit performance of cattle grazing wheat and that increased protein escape may prove useful.

Certain feed additives are useful for cattle grazing wheat pasture. Ionophores depress protein and amino acid breakdown in the rumen (Schelling, 1984), and may increase fiber digestion in the rumen and even reduce wheat pasture bloat (Branine et al., 1985). Likewise, sarsapogenins may alter microbial degradation of protein and fiber in the rumen. Branched-chain volatile fatty acids (BCVFA) are essential

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for certain fiber digesting bacteria and have increased milk production of dairy cows fed silage-based diets. This trial was conducted to ascertain the effects of the monensin, Sarsaponin™ and a mixture of BCVFA on fermentation of wheat forage in an in vitro system which simulates digestion in the rumen.

Materials and Methods

Wheat forage to feed the fermenter flasks was hand-clipped on April 21, 1984, dried at 50 C and ground through a 2-mm screen. Wheat forage dry matter contained 17.8 percent protein, 25.6 percent acid detergent fiber and 8.6 percent ash. Treatments consisted of wheat forage alone (CON), CON with 27.5 ppm monensin (MON) added, and CON with either 66 or 99 ppm Sarsaponin™ (trademark of Distributors Processing Inc., Porterville, CA 93257) added (SAR-L and SAR-H) and CON with 1 percent of a mixture of BCVFA added (MFA). The MFA mix consisted of 24 percent ammonium isobutyrate, 17 percent ammonium isovalerate, 17 percent ammonium 2-methylbutyrate, 17 percent ammonium valerate and 26 percent water.

Three semi-continuous in vitro rumen microbial fermentation flasks were fed each diet twice daily for 16 days. After 6 days for culture adaptation, effluent samples were collected for 10 days and analyzed for bacterial and protozoal numbers, dry matter (DM), ash, acid detergent fiber (ADF), nitrogen (N), ammonia-N and nucleic acid-N.

Results and Discussion

Treatments had little effect on bacterial numbers, though numbers of protozoa tended to be lower ($P<.01$) in flasks with MON and SAR-H than in CON cultures (Table 1). Monensin has been reported to inhibit growth of protozoa and certain types of bacteria. Culture pH was lower ($P<.05$) for MON than for the CON diet, possibly because of higher concentrations of VFA from more extensive fiber digestion (Table 2) with added monensin. In vivo, another ionophore, lasalocid also decreased ruminal pH (Andersen and Horn, 1985) due to an increase in total VFA concentration. With other diets, ionophores more typically increase ruminal pH due either to reduced feed intake or reduced acetate production. Culture pH was slightly lower than ruminal pH values previously measured (6.6 to 7.2) in heifers grazing wheat forage (Andersen and Horn, 1985).

Added monensin tended to decrease ($P<.10$) gas production from 6 to 9 h after flasks were fed and total production of gas during the 12-hour feeding interval. This may be associated with decreased production of methane or reduced microbial activity. MFA also tended to decrease total gas production ($P<.06$), mainly during 6 to 9 ($P<.09$) and 9 to 12 hour periods ($P<.05$) after feeding. The low level of Sarsaponin™ also tended to reduce gas accumulation at 6 and 9 hours of fermentation. Changes in gas production observed with MFA and Sarsaponin™ do not appear related to measured changes in digestion and may be partly associated with pH of the fermenter. Lower culture pH values drive more of the CO_2 produced out of solution.

Ammonia-N concentration in all flasks was very low considering the high protein content of the wheat forage. In the rumen, much higher values (8 to 17 mg ammonia-nitrogen per 100 ml) have been reported (Andersen and Horn, 1985). Ammonia was higher ($P<.05$) for MON than for

Table 1. Fermentation characteristics.

Item	Treatments				
	Control	Monensin	Minor fatty acids	Sarsaponin-low	Sarsaponin-high
Bacteria numbers, $x10^{10}$	2.9	2.5	2.7	2.9	3.4
Protozoa numbers, $x10^{4}$	1.3	.6	.9	.8	.6
pH	6.38^{a}	6.34^{b}	6.37^{ab}	3.36^{ab}	6.36^{ab}
Gas production, ml water displaced					
3 h, cumulative	15.4	14.0	14.6	15.3	16.5
6 h, cumulative	25.1	23.6	23.7	23.9	25.7
9 h, cumulative	29.8	27.2	27.4	27.7	29.5
12 h, cumulative	32.4	29.5	28.9	29.6	31.2
3-6 h, interval	9.7	9.5	9.2	8.7	9.2
6-9 h, interval	4.7	3.6	3.6	3.8	3.8
9-12 h, interval	2.6^{a}	2.3^{ab}	1.6^{b}	1.9^{ab}	1.7^{ab}
Ammonia-nitrogen, mg/dl					
.5 h	2.4^{a}	3.1^{b}	3.2^{b}	2.4^{ab}	2.8^{ab}
1 h	2.4^{a}	2.9^{ab}	3.1^{b}	2.4^{a}	2.9^{b}
4 h	1.8^{a}	2.6^{b}	2.8^{b}	2.1^{ab}	2.3^{ab}
12 h	2.9^{a}	3.3^{ab}	3.6^{b}	2.9^{ab}	3.4^{ab}
Mean	2.4^{a}	3.0^{b}	3.2^{b}	2.4^{ab}	2.9^{ab}

^{ab}Means in a row with different superscripts differ significantly ($P<.05$).

CON cultures, with larger differences at .5, 1 and 4 h after substrate addition similar to observed effects with lasalocid in the rumen (Andersen and Horn, 1985). With most other diets, ruminal ammonia concentrations are decreased by added monensin. Because MON depressed microbial protein synthesis in our system, the increased ammonia-N in these cultures may reflect decreased utilization of ammonia-N by microbes.

MFA addition increased ammonia-N concentration at all collection times ($P<.05$). This would be expected since these fatty acids were added as ammonium salts. MFA also tended to increase digestion of wheat forage N (Table 2). In previous research with diets lower in N than wheat forage, MFA has either depressed or not altered ruminal ammonia-N levels in vitro and in vivo. Mean ammonia-N concentration as well as concentration at 1, 4 ($P<.05$) and 12 h ($P<.10$) after substrate addition was higher for SAR-H than for CON. Differences in rate of protein degradation or of incorporation of ammonia-N into microbial protein may be responsible.

True organic matter (OM) digestion tended ($P<.11$) to be lower for MON than for CON cultures though extent of ADF digestion was increased (Table 2). Synthesis of microbial N and microbial efficiency tended to decrease ($P<.08$) with added MON as is often observed with monensin in vivo.

Organic matter digestion was not altered by MFA, though again digestion of ADF tended to increase ($P<.09$). Neither microbial N production

Table 2. Digestion measures (for 8 day collection periods).

Item	Treatment				
	Control	Monensin	Minor fatty acids	Sarsaponin-low	Sarsaponin-high
Organic matter					
Input, mg	6815	6815	6806	6815	6815
Outflow, mg					
Total	3514	3515	3530	3519	3470
Feed	2619	2807	2628	2774	2671
Microbial	895	708	902	745	798
Apparent digestion, %	48.4	48.4	48.1	48.4	49.1
True digestion, %	61.6	58.8	61.4	59.3	60.8
Nitrogen					
Input, mg	212.4	212.4	215.7	212.4	212.4
Outflow, mg					
Total	175.2	179.1	170.0	179.6	176.1
Feed	59.6	78.4	47.3	79.0	66.0
Microbial	91.3[a]	72.2[ab]	92.0[b]	76.0[ab]	81.4[ab]
Ammonia	24.3[a]	28.4[ab]	30.7[b]	24.6[ab]	28.6[ab]
Apparent digestion, %	17.5	15.7	21.2	15.4	17.1
True digestion, %	71.9	63.1	78.1	62.8	68.9
Acid detergent fiber					
Input, mg	1907	1907	1904	1907	1907
Outflow, mg	934	694	875	855	907
Digestion, %	51.0[a]	63.6[b]	54.0[ab]	55.2[b]	52.4[ab]
Microbial efficiency, g microbial-N/kg OM fermented	27.7	21.9	28.0	23.1	24.4

[ab]Means in a row with different superscripts differ significantly (P<.05).

or microbial efficiency was altered by MFA. MFA may have altered types of microbes in the fermentation flask but not microbial efficiency. Whether addition of MFA could alleviate the reduced microbial efficiency which occurs with monensin feeding is unknown.

True OM digestion decreased linearly (P<.07) as Sarsaponin™ level increased. Effects of Sarsaponin™ on digestion in other trials have varied with type of diet and level of Sarsaponin™. Sarsaponin™ at 66 ppm increased (P<.03) ADF digestion by 8.2 percent and decreased (P<.07) disappearance of feed N by 12.7 percent but the higher Sarsaponin™ level had less effect on these measurements. Increasing the Sarsaponin™ level tended to reduce the effect of Sarsaponin™ on fermentation. Similar decreases in microbial efficiency with added Sarsaponin™ have been observed in some (Goetsch and Owens, 1984; Valdez et al., 1985) but not all (Goetsch et al., 1985; Zinn et al., 1986) trials with cattle.

In summary, monensin and Sarsaponin™ modulated in vitro fermentation of wheat forage. Both compounds elevated extent of digestion of fiber but reduced both catabolism of feed protein and microbial protein synthesis and efficiency. Based on these results, either monensin or Sarsaponin™ would appear to increase ruminal escape of dietary protein and thereby spare dietary protein. But if animals must rely fully or primarily upon microbial matter as a source of protein, either compound may be detrimental to protein status. Increased protein escape may be associated with the decreases in protozoal numbers in the fermentation flask. Whether these additives have similar effects on fermentation of wheat pasture in the rumen needs to be examined, since in vivo, pH is much lower and passage rate is much faster than in these culture flasks.

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