Journal of Animal and Veterinary Advances 7 (7): 825-829, 2008
ISSN: 1680-5593

The Effect of Sorghum Grain on Ruminal Fermentation and Some Blood Parameters in Beef Cattle

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Abstract: In this research, the effect of sorghum in beef cattle mixture feeds as energy source instead of wheat on ruminal fermentation and some blood parameters was investigated. In the experiment, 20 Holstein beef cattle of 1.5 years old, each weighing average 330 kg were used. The trial was done in 2 stages: the first stage was pre-experimental period for 2 weeks and the second stage was the main experimental period for 10 weeks, totally lasting twelve weeks. During the whole experimental period, isocaloric and isonitrogenic 2 diets were used. In control group, mixtures involved 27% wheat, but in experimental group 27% sorghum was used instead of wheat. Dried alfalfa hay was used as roughage. Both rations consisted of 80% concentrated feed and 20% roughage. The differences between the groups for ruminal fermentation parameters; rumen fluid pH, ammonia concentrations, total volatile fatty acids, acetate, propionate, butyrate levels were not significant ($p>0.05$). In both groups differences, at the beginning and middle of the trial period for blood serum parameters (total protein, glucose, albumin, Ca, Na, P, K, Zn, Cu, Fe, Mg), were not significant, but at the middle and end of the trial, the differences between the groups was significant for blood serum Se levels ($p<0.05$). Trial results indicated that sorghum grain could be used instead of wheat as an economical energy source in beef cattle rations.

Key words: Sorghum, beef cattle, ruminal fermentation, blood parameters

INTRODUCTION

Sorghum is a special plant that provides 2 times as much roughage as corn and wheat; its nutritional value is closer to corn and wheat and it can also be silaged well without additives. It can be named as the camel of field crops because of its economical water consumption (Baran and Kocabaglı, 2000).

Galloway *et al.* (1993) by using on average 400 kg live weight beef cattle, found that ruminal pH was 6.12 and 6.21 for wheat and sorghum groups, respectively. Total volatile fatty acids were found higher in wheat group than sorghum group; however, for ruminal fermentation parameters, there were not statistically significant differences. Axe *et al.* (1987) investigated the effects of using wheat and high moisture grain sorghum diets on ruminal fermentation and feeding performance of approximately 341 kg live weight beef cattle. Increase in wheat percentage in diets decreased ruminal pH levels ($p<0.05$); differences between the groups for ruminal parameters despite increasing levels of propionic acid and total volatile fatty acids were not significant. Zinn *et al.* (2008) used dry-rolled and steam-flaked sorghum grain in feedlot cattle and they found that grain processing did not affect ruminal pH and volatile fatty acids concentrations.

Köster *et al.* (2002) reported that use of different amounts of sorghum and urea in beef cattle diets did not affect ruminal pH, total volatile fatty acid concentrations in terms of diets. In this trial, 13.6 mmol L^{-1} propionic acid and 8.01 mmol L^{-1} butyric acid were found in sorghum diet. Sunvold *et al.* (1991) used grain sorghum and wheat in beef cattle diets and found higher ruminal ammonia nitrogen in wheat group than sorghum group. Acetic,

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propionic and butyric acid levels were; 70.9-75.3; 17.3-15.9; 9.7-7.3 mmol L^{-1}, respectively for wheat and sorghum groups. Miron *et al.* (1996) investigated the effects of sorghum-wheat ratios/percentages on carbohydrate digestibility in dairy cow diets and they found that ruminal pH (6.15-6.13), total volatile fatty acid concentrations (133-136 mmol L^{-1}) and rumen ammonia concentrations (210-230 mg L^{-1}) were similar according to groups. In many studies in which grain sorghum and wheat were used, differences for ruminal fermentation and blood parameters according to applications were not significant (Abdelgadir and Morrill, 1995; Al-Suwaiegh *et al.*, 2002; Dalke *et al.*, 1997; Hermesmeyer *et al.*, 2002; Krysl *et al.*, 1989; Mowrey *et al.*, 1999; Miller *et al.*, 2007). Belibasakis and Tsigogianni (1996) found that giving high humidity grain wheat and corn in dairy cow diets did not affect blood plasma concentrations, (glucose, total protein, albumin, sodium, potassium, calcium, phosphorus and magnesium).

The aim of this research is to compare grain sorghum and wheat which is used in Turkey in beef cattle diets as an energy source for considering live weight gain, feed conversion ratio and the digestibility of nutrition.

Table 1: Feedstuff contents and nutrient of diets (DM basis)

Feed stuffs (%)	Wheat (%)	Sorghum (%)
Dried alfalfa	20.00	20.00
Sorghum	-	27.00
Wheat	27.00	-
Wheat bran	18.50	18.50
Cotton seed meal. (29.27% CP)	20.00	20.00
Molasses	11.00	11.00
Marble flour	2.05	1.80
Salt	1.20	1.20
Urea	-	0.25
Vitamin and min. mixture (Vimarmix BR1+M)*	0.25	0.25
Total	100.00	100.00
Calculated and analyzed values		
Dry matter (%)	89.99	90.38
Metabolisable energy, Mj kg^{-1} (calculated)	11.08	11.16
Crude protein (%)	17.55	17.56
Ether extract (%)	3.36	3.77
Crude fiber (%)	11.71	11.30
Nitrogen free extract matter (%) (calculated)	51.87	52.53
NDF (%)	27.12	26.71
ADF (%)	17.15	16.82

*Vimarmix BR1+M: In each kg: 4.800.000 IU Vitamin A, 1.200.000 IU.D_3, 12.000 mg Vitamin E, 1.500 mg Vitamin K_3, 1.200 mg Vitamin B_1, 2.400 mg Vitamin B_2, 2000 mg B_6, 8 mg B_{12}, 16.000 mg Niacin, 4000 mg Cal-D-Pantotenat, 400 mg Folic acid, 20 mg D-Biotin, 200.000 mg Colin Chloride, 32.000 mg Mn, 24.000 mg Zn, 24.000 mg Fe, 2000 mg Cu, 400 mg I, 200 mg Co, 60 mg Se

MATERIALS AND METHODS

In this trial, 20 Holstein male beef cattle of 1.5 years old were used. Animals were assigned to 2 groups, considering similar average live weight after they were kept hungry for 24 h. Every group had 10 animals. Initial weights of animals were approximately 330.9±18 and 329.8±16 kg in sorghum and wheat groups, respectively. Prior to trial, all of the animals were medicated for internal and external parasites.

Mixed feeds to be given were prepared according to NRC (2000) beef cattle nutrient requirements as isocaloric and isonitrogenic in a private feed mill. Dried alfalfa hay (15.85% CP) was used as roughage. In control group, wheat comprised 27% of the mixed feed; in treatment group, the same rate of sorghum was used instead of wheat. Control (wheat) and treatment (sorghum) groups' diets consisted of 80% concentrated feed + 20% dried alfalfa. Feedstuffs and nutrient contents of feeds and metabolisable energy levels are given in Table 1. Feeds were given twice a day (at 08: 00 and 16: 00 o'clock) by weighing daily consumption as ad libitum, after pretrial period for 2 weeks. Daily feed consumption was determined by weighing excess feed the following day. Water was supplied freshly and ad libitum.

Rumen fluid samples were taken by rumen sounding line 3 times (at the beginning-1st day, middle-42 day and end-84 days of trial) during trial. Rumen fluids were taken before morning feeding and 2 days following in order to reduce mistake. Average 500-600 mL rumen fluids were taken each time from each animal and placed into bottles as. The pH values of rumen fluids were instantly measured by using digital pH meters. After measuring pH, samples were filtered by using 2 folded muslin and centrifuged in 3000 rpm for 10 min in Nüve centrifuge. Then, 4.5 mL samples were taken from the upper of tubes and 0.5 mL formic acid were added for volatile fatty acid analysis. These prepared samples were centrifuged again in 3000 rpm for 10 min and kept at -20°C until the samples were analyzed. In order to prepare ammonia analysis, 0.5 mL centrifuged rumen fluid was taken and 4.5 mL distillated water was added.

The nutrient contents of feedstuffs, dried alfalfa and trial diets were analyzed according to AOAC (1990) method. Crude fiber contents were analyzed according to Crampton and Maynard (1938). Ammonia concentrations of rumen fluids were analyzed by using spectrophotometer according to Annino (1964) and volatile fatty acids were analyzed by gas chromatography according to Leventini *et al.* (1990).

Blood samples were taken from vena jugularis into vacuum tubes, centrifuged for 45 min and serum was separated. Serum samples were kept at -20°C in deep freeze until they were analyzed. Total protein, sodium and potassium concentrations in blood serum were determined in auto analyzer and element levels were determined in Shimadzu AA-6401F atomic absorption spectrophotometer.

Statistical analysis: All of data in tables were presented as arithmetical mean (x) and standard deviation (SD). The independent-samples t test was performed in order to compare between sorghum and wheat groups for each evaluated parameters (1980). All statistical analyses were performed with statistics package SPSS version 10.0 (SPSS Inc., Illinois, USA).

RESULTS AND DISCUSSION

Ruminal fermentation products of sorghum and wheat groups are seen in Table 2. Differences between sorghum and wheat groups for ruminal fermentation products were not significant ($p>0.05$) as shown in Table 2.

Blood analysis results of wheat and sorghum groups are seen in Table 3. In sorghum and wheat groups, there were not statistically significant differences at the beginning of trial, but there were statistically important differences between groups for blood serum selenium content at the middle and end of trial ($p<0.05$). Blood serum selenium content in sorghum group was found higher than wheat group (Table 3).

The differences between sorghum and wheat based diets for ruminal fermentation products were not significant ($p>0.05$) (Table 3).

Axe *et al.* (1987) reported that use of wheat and high humidity grain sorghum in beef cattle diets changed ruminal fermentation products. Increasing wheat percent in diets reduced ruminal pH ($p<0.05$); however propionic acid and total volatile fatty acid percentages increased. In our study, because of less fiber content of sorghum group, acetic acid content of ruminal fluid was less than that of wheat based diets (Table 2). This finding is consistent with the findings reported by Krysl *et al.* (1989).

In sorghum based diet, ruminal fluid pH value was slightly higher than that of wheat diets; however, ammonia and volatile fatty acid content were measured lower. It was reported that there was negative relationship between volatile fatty acids and ruminal fluid pH values (Baran and Kocabagli, 2000). Galloway *et al.* (1993) found that ruminal pH values were 6.12 and 6.21 in wheat and sorghum based diets, respectively. Although total volatile fatty acids were higher in wheat groups, differences between grains for ruminal fermentation parameters were not significant.

Sunvold *et al.* (1991) used grain sorghum and wheat in beef cattle diets and found higher ruminal ammonia nitrogen in wheat group than sorghum based group. Acetic, propionic and butyric acid levels were; 70.9-75.3; 17.3-15.9; 9.7-7.3 mmol L^{-1} for wheat and sorghum diets, respectively. In this research, higher acetic acid content of sorghum group may be attributed to different diet contents. Köster *et al.* (2002) reported that different levels of grain sorghum and urea containing beef cattle diets did not affect ruminal pH and total volatile fatty acids in terms of diets. There researchers' findings (in sorghum group, propionic acid and butyric acid levels 13.6 and 8.01 mmol L^{-1}) are similar to our findings (Table 2).

Zinn *et al.* (2008) used dry-rolled and steam-flaked sorghum grain in beef cattles and they found that grain processing did not affect ruminal pH and volatile fatty acids concentrations. Miron *et al.* (1996) investigated the effects of sorghum-wheat ratios/percentages on carbohydrate digestibility in dairy cow diets and they found that ruminal pH (6.15-6.13), total volatile fatty acid concentrations (133-136 mmol L^{-1}) and rumen ammonia concentrations (210-230 mg L^{-1}) were similar in terms of groups, respectively. Our findings are similar to those reported by Miron *et al.* (1996). Miller *et al.* (2007) used grain sorghum and barley in beef cattles and they have found that grains did not affect ruminal fermentation parameters. At the same time, our results are similar with some other researchers' findings (Baran and Kocabagli, 2000, Al-Suwaiegh *et al.*, 2002; Dalke *et al.*, 1997; Mowrey *et al.*, 1999).

As in Table 3, in both groups differences, at the beginning and middle of the trial period, for blood serum parameters (total protein, glucose, albumin, Ca, Na, P, K, Zn, Cu, Fe, Mg) were not significant ($p>0.05$), but at the middle and end of the trial, the differences between of the groups was significant for blood serum Se levels ($p<0.05$). Blood serum selenium level was found higher in sorghum groups than that of wheat groups (Table 3). This result can be attributed to higher selenium contents of sorghum (sorghum has 0.5 ppm, wheat 0.3 ppm selenium).

Abdelgadır and Morrıll (1995) reported that processed grain sorghum did not affect blood parameters of calves. In addition, Belibasakis and Tsirgogianni (1996) maintained that giving humidity grain wheat and corn to dairy cows did not affect blood plasma glucose, total protein, albumin, sodium, potassium, calcium and phosphorus and magnesium contents. Our findings seem to be consistent with findings of other researchers (Abdelgadır and Morrıll, 1995; Al-Suwaiegh *et al.*, 2002; Dalke *et al.*, 1997; Mowrey *et al.*, 1999).

As a result, use of sorghum instead of wheat in beef cattle diets did not change ruminal fermentation and affected blood analysis results positively.

Table 2: Ruminal fermentation products of wheat and sorghum groups (n = 10)

	Wheat					
	At the beginning of trial (1 day)		At the middle of trial (42 day)		At the end of trial (84 day)	
Ruminal fermentation products	x	S.D.	x	S.D.	x	S.D.
pH	6.66	0.25	6.85	0.14	6.93	0.12
NH_3, mg L^{-1}	121.20	9.20	105.00	10.50	108.20	8.30
Acetic acid, mmol L^{-1}	68.50	2.00	69.00	1.10	70.00	1.50
Propionic acid, mmol L^{-1}	13.80	1.50	14.20	1.50	13.60	0.90
Butyric acid, mmol L^{-1}	8.90	0.90	8.00	1.00	9.10	1.00
Total volatile fatty acids, mmol L^{-1}	91.20	6.50	91.30	3.60	92.70	2.10
Acetic acid (%)	75.10	0.80	75.50	0.90	75.50	1.50
Propionic acid (%)	15.30	0.90	15.50	1.00	14.70	0.80
Butyric asid (%)	9.70	0.50	8.70	1.20	9.80	0.60
pH	6.49	0.31	6.87	0.20	7.04	0.22
NH_3, mg L^{-1}	118.70	6.00	103.40	9.80	106.30	6.60
Acetic asid, mmol L^{-1}	67.70	1.80	68.60	0.90	69.30	1.00
Propionic asid, mmol L^{-1}	13.00	1.20	13.60	0.80	13.10	1.30
Butyric asid, mmol L^{-1}	8.60	1.30	7.80	0.80	9.00	0.80
Total volatile fatty acids, mmol L^{-1}	89.30	5.80	90.70	5.00	92.60	1.30
Acetic asid (%)	75.80	1.30	75.60	1.10	74.80	1.20
Propionic asid (%)	14.50	1.30	15.00	0.70	14.10	0.90
Butyric asid (%)	9.60	0.70	8.60	0.90	9.70	0.50

Table 3: Blood analysis results of wheat and sorghum groups (n = 10)

	Wheat					
	At the beginning of trial (1 day)		At the middle of trial (42 day)		At the end of trial (84 day)	
Blood parameters	x	S.D.	x	S.D.	x	S.D.
Na, mmol L^{-1}	144.40	15.40	139.30	2.63	138.88	4.37
K, mmol L^{-1}	4.57	0.53	4.40	0.27	4.41	0.15
Ca, mg dL^{-1}	9.80	1.23	9.56	0.26	9.44	0.31
P, mg dL^{-1}	7.19	1.54	7.54	0.81	7.61	0.88
Mg, mg dL^{-1}	19.66	1.69	21.00	2.36	23.93	1.99
T.protein, g dL^{-1}	7.31	0.59	6.57	0.43	6.64	0.37
Glikoz, mg dL^{-1}	82.10	11.50	80.50	8.58	80.44	8.31
Albumin, g dL^{-1}	1.18	0.30	1.09	0.11	1.11	0.09
Fe, ppm	22.91	2.24	25.57	1.55	26.77	1.70
Cu, ppm	0.92	0.16	1.00	0.14	1.06	0.11
Zn, ppm	0.86	0.13	0.97	0.12	1.00	0.14
Se, ppb	59.30	3.97	63.40	3.95*	67.90	2.56*
Na, mmolL^{-1}	143.55	29.70	137.44	7.60	139.44	2.65
K, mmolL^{-1}	4.56	1.00	4.34	0.28	4.36	0.28
Ca, mg dL^{-1}	9.31	1.24	9.27	0.82	9.23	0.74
P, mg dL^{-1}	7.20	1.15	7.58	0.67	7.60	0.51
Mg, mg dL^{-1}	18.37	1.49	22.11	2.53	25.17	1.93
T.protein, g dL^{-1}	7.28	1.42	6.56	0.52	6.73	0.48
Glikoz, mg dL^{-1}	88.10	14.10	82.00	6.87	81.55	8.38
Albumin, g dL^{-1}	1.20	0.21	1.04	0.17	1.08	0.10
Fe, ppm	23.00	1.88	25.65	2.07	27.16	1.61
Cu, ppm	0.95	0.13	1.09	0.12	1.17	0.09
Zn, ppm	0.82	0.07	0.90	0.05	0.92	0.07
Se, ppb	61.40	2.91	68.20	3.58*	71.50	3.37**

$p<0.05$

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