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Effects of Sorghum on Nutrient Digestibility and Some Milk Parameters in Dairy Cow Rations

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Abstract: In this study, effects of sorghum used instead of corn as an energy source on nutrient digestibility and some milk parameters in dairy cow rations were investigated. During the 20 weeks trial period, four Holstein cows at their first lactation stage were used in 4×4 Latin square design. The trial was consisted of four periods. Each period lasted five weeks of which consisted two weeks pre-experimental period and three weeks main experimental period. Dairy cows were fed with four different rations. Good quality alfalfa was given as roughage to animals. Digestibility of nutrients were determined according to rations, as follows, respectively; dry matter: 69.16, 69.49, 69.74, 70.10%, crude ash: 26.04, 26.31, 26.42, 26.49%; organic matter: 70.35, 70.43, 70.33, 70.48%; crude protein: 69.77, 69.96, 70.20, 70.43%; ether extract: 70.74, 70.86, 71.02, 71.15%; crude fiber: 59.56, 59.75, 59.96, 60.17; Neutral Detergent Fiber (NDF): 45.92, 46.03, 46.11, 46.15% and Acid Detergent Fiber (ADF): 43.06, 43.17, 43.36, 43.45%. The differences for the digestibility of dry matter, crude ash, organic matter, ADF and NDF among rations were not significant ($p>0.05$). However, digestibility of crude protein, ether extract and crude fiber were found significant among rations ($p<0.05$). According to rations percentages of milk parameters were determined as follows, respectively; dry matter: 13.23, 13.02, 13.05, 13.10%, crude ash: 0.57, 0.56, 0.58, 0.60%, pH: 6.65, 6.65, 6.66, 6.68, density: 1030, 1031, 1031, 1031 and fat-free dry matter: 9.46, 9.29, 9.33, 9.37%. Differences among milk parameters, according to rations were not significant ($p>0.05$). Trial results indicated that grain sorghum can be used instead of corn as an economical energy source in dairy cow rations.

Key words: Sorghum, dairy cow, nutrient, digestibility, milk parameters

INTRODUCTION

Sorghum is one of the alternatives in order to supply good quality roughage and grain feed requirements of animals. Sorghum can be used successfully in dairy cow nutrition. Grain sorghum is cheaper approximately 10-15% than energy sources such as corn and wheat grain and it has 2-3% higher crude protein than corn. Sorghum has a special status that its green forage yield approximately twice more than corn and wheat in similar cropping conditions. In addition, energy content of sorghum is nearly to corn and wheat grain. It can be ensilaged easily without adding any supplement. It can be named as the camel of plant family because of its economical water consumption (Baran and Kocabaglı, 2000).

Chen *et al*. (1995) were investigated effects of sorghum on lactation and digestibility, by using 35 dairy cows with 5 different rations. Basal ration (40% steam rolled corn, 13% milled barley, 20% wheat and 27% sugar beet pulp), 0, 15, 30 and 45% of dry matter steam rolled sorghum grain rations were used in the trial. When sorghum content was increased, dry matter intake and fat-free dry matter percentages were increased. Theurer *et al*. (1999) stated that giving steam grinded sorghum, corn or steam rolled wheat, barley to in lactating dairy cows, grain sources did not affect the digestibility of crude protein and crude fiber.

Mitzner *et al*. (1994) compared the effects of sorghum and corn grains on milk yield and milk composition in beginning and mid lactating Holstein breed dairy cows. They found that grain species and feeding methods affected similarly milk composition and fat-free dry matter content. Santos *et al*. (1999b) in lactation dairy cows, using 37-39% steam ground sorghum, corn or steam rolled

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corn; digestibility of dry matter, organic matter, NDF and crude protein were not affected by the grain processing method. In a similar research (Santos *et al*., 1999a) in the beginning of lactation dairy cows were fed by steam rolled sorghum or steam rolled corn with somatotropin hormone; digestibility of crude protein, ADF, NDF and milk composition did not affected by applied practices. Al-Suwaiegh *et al*. (2002) and Lodge *et al*. (1997) have found similar results for digestibility of dry matter, organic matter and NDF by using sorghum and corn in dairy cows and beef cattles. Miron *et al*. (2007) giving grain sorghum, corn and their silages according to 3×3 Latin square design to in lactating dairy cows, dry matter digestibility were found similar in amongst rations.

Madibela *et al*. (2005) were investigated that the effects of sorghum on milk yield, live weight and dry matter intake in lactating 34 dairy cows. They have found a similarity amongst rations for fat-free dry matter and milk composition. Miller *et al*. (2007) investigated the effects of sorghum on milk yield and composition and stated that milk composition did not affect by grain sorghum or barley. Gaebe *et al*. (1998) were investigated effects of grain sorghum and corn on digestibility in finishing beef cattle rations. There were not significant differences between groups for digestibility of dry matter, organic matter, crude fiber, ADF and NDF. Köster *et al*. (2002) reported that by using different levels of grain sorghum in beef cattle rations, digestibility of organic matter and dry matter increased by the increasing level of sorghum; however digestibility of NDF was not affected by trials.

Benefield *et al*. (2006) and Kleinschmit *et al*. (2006) according to 4×4 Latin square method giving corn grain to lactating dairy cows, they have found that there were not significant differences between rations for milk parameters. Silveira *et al*. (2007) by using 3×3 Latin square design giving grain barley and corn to lactating Holstein dairy cows. They reported that corn grain affected positively dry matter contents and fat-free dry matter contents of milk. On the other hand, there were some research results that milk composition have not affected by grain corn in dairy cow (Krause *et al*., 2002; Nennich *et al*., 2007; Rezamand *et al*., 2007; Yang and Beauchemin, 2005). Crocker *et al*. (1998) investigated the effects of processed corn grain on digestibility of nutrients and milk composition in dairy cows and found that there were similarities among rations for digestibility of dry matter, organic matter, cellulose, ADF, NDF and milk composition. Similar results were observed by some researchers (Alvarez *et al*., 2001; Burkholder *et al*., 2004; Cao *et al*., 2008; Omara *et al*., 1997; Weimer *et al*., 2003).

The aim of this research, was to investigate effects of using different levels of grain sorghum instead of corn as an energy source in dairy cow rations on nutrient digestibility and some milk parameters (dry matter, crude ash, pH, density and fat-free dry matter).

MATERIALS AND METHODS

Animals: In the experiment, 4 Holstein dairy cows which have first lactating and mean 550 kg live weight each one were used as animal material. Animals have taken to trial in sixteenth weeks of their lactation. Prior to trial, all of the animals were medicated for internal and external parasites.

Feed material: During research, considering in NRC (1989) requirements, 4 different mixed feed were given to dairy cows and dried alfalfa hay which contained 15.60% crude protein was used as roughage. Concentrated feed was consisted of wheat bran, molasses, cotton seed meal, marble flour, salt, vitamin and mineral mixtures. Control ration involved 16% corn as energy source meanwhile, in first trial group 8% corn + 8% sorghum, in second trial group, 4% corn + 12% sorghum and in third trial group 16% sorghum contained as an energy source. The constitution and nutrient contents of rations were given in Table 1. Control and experimental rations were prepared using 50% dried alfalfa and 50% mixed feed, considering isocaloric and isonitrogenic. Nutrient contents of rations were determined by chemical analysis but net energy lactation values of rations were determined by calculation.

Table 1: The constituents and nutrient contents of rations , % (DM basis)

		Treatment groups		
Feed stuffs, (%)	Control group	I	II	III
Dried alfalfa	50	50	50	50
Corn	16	8	4	-
Sorghum	-	8	12	16
Wheat bran	14	14	14	14
Molasses	5	5	5	5
Cotton seed meal (% 30.15 CP)	12.5	12.5	12.5	12.5
Marble flour	1.25	1.25	1.25	1.25
Salt	0.75	0.75	0.75	0.75
Vit + min. Premix (Vilsamin - 0)*	0.5	0.5	0.5	0.5
Total	100	100	100	100
Analytic and calculated values				
Dry matter,%	90.25	90.21	90.35	89.95
NEL, MJ kg^{-1} (calculated)	6.36	6.35	6.34	6.35
Crude protein, (%)	16.30	16.60	16.79	17.01
Ether extract, (%)	2.98	2.89	2.81	2.76
Crude fiber, (%)	18.41	18.33	18.25	18.16
Crude ash, (%)	6.74	6.82	6.78	6.81
Nitrogen free extract matter,% (calculated)	45.33	45.07	45.23	44.72
NDF,(%)	32.24	32.28	32.33	32.38
ADF, (%)	22.98	23.02	23.06	23.12

* Vilsamin - 0: In each kg; 1.500.000 IU Vit. A, 300.000 IU Vit. D_3, 5000 mg Vit. E, 50 mg Vit. B_1, 200 mg B_2; 10 mg B_6, 100 mg K_3, 100 mg Vit. C, 400 mg Cal-D-Pantotenat, 500 mg Niacin, 10 g Fe, 5 g Mn, 1 g Cu, 30 mg Se, 30 mg Co, 5 g Zn, 100 g Na, 80 mg I, 50 g P, 205.578 g Ca and 10 g BHT

The experiment was consisted of 4 periods, total 20 weeks. Each period lasted five weeks of which consisted two weeks pre-experimental period and three weeks main experimental period. Dairy cows were fed according to 4×4 Latin square design. In this design, cows, periods and feeds were used as column, rows and application, respectively.

Animals were fed 3 times (at 07:00, 14:00 and 20:00 o'clock) in a day. Each cow were fed similarly, in each ration change, animals were fed for two weeks pre-experimental period and after for three weeks main experimental period. Roughage and mixed feed amounts were arranged by considering pre-experimental consumption. Animals consumed all of the given feeds in each period. Maintenance requirements of cows were met by good quality dried alfalfa. In order to determining of milk quality (dry matter, crude ash, density, pH, fat-free dry matter), milk was collected once a week (approximately 1 L, mixturing daily production) and analyzed.

Determining of crude nutrients: The nutrient contents of feed stuffs, dried alfalfa, trial rations, feces and crude ash contents of milk were analyzed according to AOAC (1995) method. ADF and NDF values according to Van Soest (1987) and crude fiber contents according to Crampton and Maynard (1938) were analyzed. Fat-free dry matter content and density of milk was determined by refrectometer and densitometer, respectively. pH values of milk were measured with pH meter by putting electrode directly into milk samples.

Digestibility analysis: Feces samples were collected clearly at last 7 days of trial periods in order to determine in vivo digestibility values of nutrients. Feces samples were dried at 60°C during 36-48 h. Indicator method was used because of difficulty in collecting all of cattle feces (Sarı and Crici, 1993). Digestibility rates of nutrients were calculated by following equation which is stated by Sarı and Crici (1993).

$$\text{Digestibility rate}(\%) = 100 - 100 \times \frac{\text{Indicater level in food}(\%)}{\text{Indicater level in food}(\%)} \times \frac{\text{Nutrients in feces}(\%}{\text{Nutrients in feces}(\%)}$$

Statistical analysis: All of data in tables were presented as arithmetical mean (x) and standard deviation (Sx). Variance Analysis Method was used for statistical analysis of data. Duncan's Multiple Range Test was used to determine of differences amongst groups. For this purpose SAS (1985) pocket program was used.

RESULTS AND DISCUSSION

According to rations, digestibility rates of nutrients and dry matter content, crude ash, pH, fat-free dry matter and density rates in milk were presented in Table 2 and 3, respectively.

As seen in Table 2, differences among rations for dry matter, crude ash, organic matter, ADF and NDF digestibility were not significant ($p>0.05$), however there were statistically significant differences among rations for digestibility of crude protein, ether extract and crude fiber contents ($p<0.05$).

Köster *et al.* (2002) reported that by using different levels of grain sorghum in beef cattle rations, digestibility of organic matter and dry matter increased by the increasing level of sorghum, however digestibility of NDF was not affected by trials. Our results seem to be consistent with this research results (Köster *et al.*, 2002) which increasing sorghum ratio; some increase the digestibility of dry matter, organic matter and crude protein.

Al-Suwaiegh *et al.* (2002) and Lodge *et al.* (1997) comparing sorghum and corn grain in dairy cows and beef cattles, they found that there were similarities between the digestibility of dry matter, organic matter and NDF. Santos *et al.* (1999b) used steam grinded sorghum, corn and steam rolled corn in lactation dairy cows and they have found that grain processing didn't affect the digestibility of dry matter, organic matter, crude protein and NDF. In a similar research (Santos *et al.*, 1999a) stated that steam grinded sorghum or steam rolled corn + somatotropin hormone digestibility of crude protein, ADF and NDF were not affected by rations in lactating dairy cows.

Gaebe *et al.* (1998) used grain sorghum and corn in finishing rations of beef cattle and have found that there were not significant differences on the digestibility of dry matter, ADF and NDF. Crocker *et al.* (1998) have investigated the effects of processed corn grain on digestibility of nutrients and milk composition in dairy cow rations and found that there were similarities among rations for digestibility of dry matter, organic matter, crude fiber, ADF, NDF and milk composition. In addition, our findings are similar with some researchers results (Miron *et al.*, 2007; Krause *et al.*, 2002; Alvarez *et al.*, 2001; Burkholder *et al.*, 2004), which have supported the finding of sorghum did not affect statistically significant the digestibility of dry matter, crude ash, organic matter, ADF and NDF.

Theurer *et al.* (1999) have investigated effects of steam grinded sorghum, corn or steam rolled barley and wheat in lactating dairy cows and have found that the

Table 2: Digestibility rates of crude nutrients according to rations, (%)

Rations	Dry matter x±Sx	Crude ash x±Sx	Organic matter x±Sx	Crude Protein x±Sx	Ether extract x±Sx	Crude fiber x±Sx	ADF x±Sx	NDF x ± Sx
Control	69.16±0.20	26.05±0.14	70.35±0.07	69.77^{d}±0.13	70.74^{d}±0.13	59.56^{d}±0.14	43.06±0.17	45.92± .10
Treatment –I	69.49±0.12	26.31±0.15	70.43±0.08	69.96^{c}±0.16	70.86^{c}±0.12	59.75^{c}±0.14	43.17±0.22	46.03±0.18
Treatment -II	69.78±0.18	26.42±0.17	70.33±0.05	70.20^{b}±0.16	71.02^{b}±0.14	59.96^{b}±0.14	43.36±0.17	46.11±0.15
Treatment –III	70.10±0.19	26.49±0.14	70.48±0.07	70.43^{a}±0.14	71.15^{a}±0.15	60.17^{a}±0.15	43.45±0.16	46.15±0.25

Explanation: a, b, c, d-means in the same column with different superscript letters are different significantly at $p<0.05$. Control (16% corn), Treatment – I (8% corn + 8% sorghum), Treatment – II (4% corn + 12% sorghum), Treatment - III (16% sorghum)

Table 3: Some milk parameters according to rations

Rations	Dry matter content, (%) x±Sx	Ash content, (%) x±Sx	pH values x±Sx	Fat free dry matter content, (%) x±Sx	Density values x±Sx
Control	13.23±0.56	0.57±0.05	6.65±0.06	9.46±0.42	1030±1.30
Treatment -I	13.0±0.520	0.57±0.04	6.65±0.04	9.29±0.21	1031±0.50
Treatment -II	13.05±0.43	0.58±0.04	6.66±0.02	9.33±0.14	1031±0.50
Treatment –III	13.10±0.37	0.60±0.05	6.68±0.04	9.37±0.16	1031±1.00

Control (16% corn), Treatment – I (8% corn + 8% sorghum), Treatment – II (4% corn + 12% sorghum), Treatment – III (16% sorghum)

digestibility of crude protein and crude fiber were not affected by grain sources. These results are not consistent with our results and using of different rations can cause these differences. In our research when crude fiber content was decreased and sorghum content was increased in rations, the digestibility of crude protein, ether extract and crude fiber were increased. According to our results, the highest crude protein, ether extract and crude fiber digestibility were obtained from treatment-III ration (with sorghum, 16%) and this was followed by treatment-II, I and control rations, respectively and there were statistically significant differences control ration with between treatment rations ($p<0.05$) (Table 2).

Madibela *et al.* (2005) have investigated effects of sorghum on milk yield and dry matter intake in lactating dairy cows and they have found that there were similarities between rations for fat-free dry matter and milk composition. Mitzner *et al.* (1994) compared the effects of sorghum and corn grains on milk yield and milk composition in beginning and mid lactating Holstein dairy cows. They have found that grain species and feeding methods affected similarly milk composition and fat-free dry matter content. Miller *et al.* (2007) investigated the effects of sorghum on milk yield and composition and stated that milk composition did not affected by grain sorghum or barley.

In our research, for milk compositions (dry matter, crude ash, pH, density and fat-free dry matter content) differences between sorghum and corn groups were not significant ($p>0.05$) (Table 3). The highest dry matter percentage was obtained from control ration and this difference was not statistically significant. Trial III, II and I rations were followed control ration (Table 3). Dry matter contents of dairy cows which were fed with sorghum were less than control diet. The reason of this is higher oil content of corn than sorghum grain.

Chen *et al.* (1995) investigated effects of sorghum on lactation and digestibility in lactation dairy cow rations and have found that when sorghum ratio was increased, fat-free dry matter content have increased. In our trial when sorghum content of treatment rations increase, fat-free dry matter content increased, however there were not significant differences between rations (Table 3). Benefield *et al.* (2006) and Kleinschmit *et al.* (2006) according to 4×4 Latin square design giving corn grain to lactating dairy cows, they found that for milk parameters differences between rations were not significant. On the other hand, our results are similar with the findings of some researchers (Krause *et al.*, 2002; Rezamand *et al.*, 2007; Yang and Beauchemin, 2005; Alvarez *et al.*, 2001) which they have stated that grain sorghum and corn did not affect milk composition in dairy cows.

CONCLUSION

As a result of this research, using of different levels of sorghum instead of corn grain in dairy cow rations has a positive effect on the digestibility rates of crude nutrients and milk composition. In addition, sorghum is cheaper than other energy source grains such as corn and barley, it contains higher crude protein level and its yield is greater than other alternatives per unit area. So, using of sorghum in dairy cow rations can lead to less milk production cost and its thought become advantageous. Sorghum species and varieties have important role in supporting good quality roughage and mixed feeds for animal production. Therefore, it is highly essential that increasing of sorghum cropping areas for local and country economy and stockbreeding.

REFERENCES

Al-Suwaiegh, S.K., C. Fanning, R.J. Grant, C.T. Milton and T.J. Klopfenstein, 2002. Utilization of distillers grains from the fermentation of sorghum or corn in diets for finishing beef and lactating dairy cattle. J. Anim. Sci., 80: 1105-1111.

Alvarez, H.J., F.J. Santini, D.H. Rearte and J.C. Elizalde, 2001. Milk production and ruminal digestion in lactating dairy cows grazing temperate pastures and supplemented with dry cracked corn or high moisture corn. Anim. Feed Sci. Technol., 91: 183-195.

AOAC., 1995. Official Methods of Analysis. 16th Edn. Association of Official Analytical Chemists, Washington, DC.

Baran, M.S. and N. Kocabaglı, 2000. Effects of grain sorghum on ruminal fermentation, milk yield and milk composition in dairy cows. Istanbul Univ., Fac. Vet. Med. J., 26: 113-128.

Benefield, B.C., M. Lineiro, I.R. Ipharraguerre and J.H. Clark, 2006. Nutridense corn grain and corn silage for dairy cows. J. Dairy Sci., 89: 1571-1579.

Burkholder, K.M., A.D. Guyton, J.M. McKinney and K.F. Knowlton, 2004. The effect of steam flaked or dry ground corn and supplemental phytic acid on nitrogen partitioning in lactating cows and ammonia emission from manure. J. Dairy Sci., 87: 2546-2553.

Cao, Z.J., S.L. Li, J.J. Xing, M. Ma and L.L. Wan, 2008. Effects of maize grain and lucerne particle size on ruminal fermentation, digestibility and performance of cows in midlactation. J. Anim. Physiol. Anim. Nut., 92: 157-167.

Chen, K.H., J.T. Huber, C.B. Theurer, J. Simas, F. Santos, S.C. Chan and R.S. Swingle, 1995. Effect of substituting steam-flaked sorghum for concentrate on lactation and digestion in dairy cows. J. Dairy Sci., 78: 362-367.

Crampton, E.W. and L.A. Maynard, 1938. The relation of cellulose and lignin content to nutritive value of animal feeds. J. Nutr., 15: 383-395.

Crocker, L.M., E.J. DePeters, J.G. Fadel, H. Perez-Monti, S.J. Taylor, J.A. Wyckoff and R.A. Zinn, 1998. Influence of processed corn grain in diets of dairy cows on digestion of nutrients and milk composition. J. Dairy Sci., 81: 2394-2407.

Gaebe, R.J., D.W. Sanson, I.G. Rush, M.L. Riley, D.L. Hixon and S.I. Paisley, 1998. Effect of extruded corn or grain sorghum on intake, digestibility, weight gain and carcasses of finishing steers. J. Anim. Sci., 76: 2001-2007.

Kleinschmit, D.H., D.J. Schingoethe, K.F. Kalscheur and A.R. Hippen, 2006. Evaluation of various sources of corn dried distillers grains plus solubles for lactating dairy cattle. J. Dairy Sci., 89: 4784-4794.

Köster, H.H., B.C. Woods, R.C. Cochran, E.S. Vanzant, E.C. Titgemeyer, D.M. Grieger, K.C. Olson and G. Stoka, 2002. Effect of increasing proportion of supplemental N from urea in prepartum supplements on range beef cow performance and on forage intake and digestibility by steers fed low-quality forage. J. Anim. Sci., 80: 1652-1662.

Krause, K.M., D.K. Combs and K.A. Beauchemin, 2002. Effects of forage particle size and grain fermentability in mid lactation cows. I. Milk production and diet digestibility. J. Dairy Sci., 85: 1936-1946.

Lodge, S.L., R.A. Stock, T.J. Klopfenstein, D.H. Shain and D.W. Herold, 1997. Evaluation of corn and sorghum distillers byproducts. J. Anim. Sci., 75: 37-43.

Madibela, O.R., W. Mahabile and W. Boitumelo, 2005. Effects of sorghum stover as replacement basal diet on milk yield, live weight and dry matter intake of Friesian cows in Botswana. J. Anim. Vet. Adv., 4: 197-201.

Miller, D.R., B.C. Granzin, R. Elliott and B.W. Norton, 2007. Effects of an exogenous enzyme, Roxazyme® G2 Liquid, on milk production in pasture fed dairy cows. Anim. Feed Sci. Technol., pp: 1-15.

Miron, J., E. Zuckerman, G. Adin, R. Solomon, E. Shoshani, M. Nikbachat, E. Yosef, A. Zenou, Z.G. Weinberg, Y. Chen, I. Halachmi and D. Ghedalia, 2007. Comparison of two forage sorghum varieties with corn and the effect of feeding their silages on eating behavior and lactation performance of dairy cows. Anim. Feed Sci. Technol., 139: 23-39.

Mitzner, K.C., F.G. Owen and R.J. Grant, 1994. Comparison of sorghum and corn grains in early and mid-lactation diets for dairy cows. J. Dairy Sci., 77: 1044-1051.

National Research Council, 1989. Nutrient Requirements of Dairy Cattle. National Academy Press, Washington, D.C.

Nennich, T.D., J.G. Linn, D.G. Johnson, M.I. Endres and H.G. Jung, 2007. Comparison of feeding corn silages from leafy or conventional corn hybrids to lactating dairy cows. J. Dairy Sci., 86: 2932-2939.

O'mara, F.P., J.J. Murphy and M. Rath, 1997. The effect of replacing dietary beet pulp with wheat treated with sodium hydroxide, ground wheat, or ground corn in lactating cows. J. Dairy Sci., 80: 530-540.

Rezamand, P., S.M. Andrew and T.A. Hoagland, 2007. The feeding value of extruded corn grain in a corn silage-based ration for high-producing Holstein cows and heifers during mid lactation. J. Dairy Sci., 90: 3475-3481.

Santos, J.E., J.T. Huber, C.B. Theurer, L.G. Nussıo, C.B. Nussıo, M. Tarazon and R.O. Lima, 1999a. Performance and nutrient digestibility by dairy cows treated with bovine somatotropin and fed diets with steam-flaked sorghum or steam-rolled corn during early lactation. J. Dairy Sci., 82: 404-411.

Santos, J.E., J.T. Huber, C.B. Theurer, L.G. Nussıo, M. Tarazon and F.A.P. Santos, 1999b. Response of lactating dairy cows to steam-flaked sorghum, steam-flaked corn, or steam-rolled corn and protein sources of differing degradability. J. Dairy Sci., 82: 728-737.

Sarı, M. and I.H. Çerçi, 1993. Feeds, Animal Nutrition and Nutrition Diseases, Fırat Univ. Faculty of Veterinary Medicine Journal, Elazıg.

SAS, 1985. Sas User's Guide. Statistics (Version 5 Ed.). SAS Inst., Inc. Carry, NC.

Silveira, C., M. Oba, K.A. Beauchemin and J. Helm, 2007. Effect of grains differing in expected ruminal fermentability on the productivity of lactating dairy cows. J. Dairy Sci., 90: 2852-2859.

Theurer, C.B., J.T.A. Huber and R. Wanderley, 1999. Summary of steam-flaking corn or sorghum grain for lactating dairy cows. J. Dairy Sci., 82: 1950-1959.

Van Soest, P.J., 1987. Nutritional Ecology of the Ruminant. Second Edn. Comstock Publishing Associates, Cornell University Pres, Ithaca and London.

Weimer, P.J., D.R. Mertens, E. Ponnampalam, B.F. Severin and B.E. Dale, 2003. Fıbex-treated rice straw as a feed ingredient for lactating dairy cows. Anim. Feed Sci. Technol., 103: 41-50.

Yang, W.Z. and K.A. Beauchemin, 2005. Effects of physically effective fiber on digestion and milk production by dairy cows fed diets based on corn silage. J. Dairy Sci., 88: 1090-1098.