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Effects of Grain and Protein Sources on Diet Preferences, Milk Yield and Milk Composition of Choice-Fed German Fawn x Hair Crossbred Goats in Mid Lactation

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Abstract: The present study was conducted to determine the effects of grain (barley vs. corn) and protein sources (soybean meal (SBM) and Corn Gluten Meal (CGM)) on diet selection, milk yield and milk compositions of choice-fed Goats. A 2 by 2 factorial design was employed with 2 grain sources (barley or corn) and 2 protein sources (soybean meal; SBM or Corn Gluten Meal; CGM) as main effects. The groups received grain and protein sources besides wheat bran and alfalfa hay, which chopped in 1.5-2 cm length. Each group received feed stuff as free choice *ad libitum* in a special trough divided into 4 parts for grain and protein sources, wheat bran and alfalfa hay for a week training + an 8-weeks testing period. The results showed that type of grain (barley or corn) and protein (SBM or CGM) affected the nutrient contents of diets selected. The does offered barley as a grain source consumed higher amount of protein sources. The does offered SBM as protein source selected the diet having lower ADF, NDF and RUP contents and higher CP content than those offered CGM as a protein source. Grain×protein source interaction also affected ($p<0.05$) nutrient composition of the diets selected. In barley groups, the does offered CGM selected diets with higher NDF but lower ME content than those selected by the does offered SBM, however, no such a difference according to the protein source was observed in the groups receiving corn. Live weight change, dry matter intake (DMI), DMI/milk yield ratio and ME intake were lower ($p<0.05$) in the groups receiving barley than those having corn. Fat corrected milk yield, fat and protein yield and ADF intake were higher ($p<0.05$) for the does offered CGM than those offered SBM. ADF and NDF intakes and milk NPN contents were affected ($p<0.05$) by grain×protein source interaction. The does receiving SBM with barley consumed less ADF and NDF than the does receiving CGM with barley, but the does offered corn did not change their ADF and NDF intakes according to the protein sources. Milk NPN content was decreased by CGM with barley. The results suggest that lactating goats have a good nutritional wisdom that allowing them to select nutritionally balanced diet and to avoid feedstuffs causing nutritional discomfort when different grain and protein sources were supplied simultaneously and freely.

Key words: Goats, diet selection, grain, protein, milk yield and composition

INTRODUCTION

Microbial protein synthesis depends on synchronization of available fermentable energy and degradable protein in the rumen (Hoover and Stokes, 1991). Diets or feeding methods allowing nutrient supply in a synchronized manner to ruminal microorganism may improve microbial growth in the rumen and also improve the utilization of dietary energy and/or protein and animal performance. It is possible to create synchrony in supplying energy and nitrogen for ruminal microorganism by changing dietary ingredients or altering the relative times of feeding ingredients (Dewhurst *et al*., 2000). Choice feeding with feed ingredients could give an opportunity to animals to arrange the consumption time and level of individual feed ingredient. The present literature (Gorgulu *et al*., 1996; Fedele *et al*., 2002; Gorgulu *et al*., 2003; Yurtseven and Gorgulu, 2004) revealed that the animal (sheep and goats) offered multiple choice can select their diet to meet their nutrient requirements, corresponding to their physiological status and consume high amount of concentrate without suffering any digestive problem by balancing fiber intake and creating of a synchronicity among feed ingredients in respect to energy and nitrogen supply to the rumen.

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It has been speculated that diurnal feeding pattern could be changed by post ingestive factors (James *et al*., 2001) such as ruminal pH, release of energy and nitrogen, production of total and individual volatile fatty acids in the rumen. Yurtseven and Gorgulu (2004) reported that diet preferences of goats could be changed by grains, differing in degradation, offered to the animal as choice.

In practice, corn and barley are mainly used as grain sources in dairy goat rations. It is well known that corn starch is less degradable than barley starch (Petit, 2000). Thus, ruminal fermentation pattern may be changed by grain sources (Schmidely *et al*., 1999). Similarly, as protein sources, soybean and corn gluten meal have different properties in respect to protein solubility and rate of rumen degradability (Schingoethe *et al*., 1988). Therefore, energy and nitrogen availability and synchronicity of nutrient supply for rumen microorganism could differ according to the grain and protein sources included in ration or offered as a free choice. It has been reported that highly degradable starch and protein increased microbial protein synthesis, although no improvements in microbial protein synthesis due to synchrony between energy and nitrogen supply was reported in other studies (Henning *et al*., 1993; Kim *et al*., 1999).

The present literature, however, had no information whether diet preferences of goats would be changed according to grain and protein sources differing in degradability in order to maintain or improve ruminal environment and lactation performance. Therefore, the present study aimed to test whether lactating goats can select an adequate diet when offered an unrestricted choice among feed ingredients, to asses whether the goats change their diet preferences according to the grain or protein sources and determine whether choice feeding with different grain and protein sources may give a chance to create a synchrony in fermentable energy and nitrogen supply to rumen microorganism to increase milk quality and milk yield of German Fawn×Hair Crossbred Goats during mid lactation.

MATERIALS AND METHODS

Animals and management: This study conducted from May to July, 2003 in the Goat Unit (a semi open barn) of agricultural Faculty Farm, Universtiy of Cukurova, Adana-Turkey. In the study, 20 German Fawn×Hair first backcross does (B1), having twin kids, in the second lactation were used. The does having average 48±5 kg live weight, 100±3 days after postpartum and 1436±77 g daily milk yield were allocated into 4 experimental groups with 5 animals each. The animals were housed individually in a 1.5×1.5 m pen each. Each pen had one trough sizing 0.4 m width×1.2 m length × 0.4 m deep with 15-L bucket for fresh water. Feed troughs in length were divided into 4 equal parts to present feed ingredients separately. The goats were assigned to the treatments according to the live weight, days in milk and milk yield.

Treatments and measurements: In the experiment, a 2 by 2 factorial design was employed with 2 grain sources (barley or corn) and 2 protein sources (soybean meal; SBM or corn gluten meal; CGM) as main effects. So, 4 treatment groups were made as barley+SBM, barley+CGM, Corn+SBM and Corn+CGM. The groups received grain and protein sources besides wheat bran and alfalfa hay, which chopped in 1.5-2 cm length. Each group received feed stuff as free choice *ad libitum* in a special trough divided into 4 parts for grain (barley or corn) and protein (SBM or CGM) sources, wheat bran and alfalfa hay. Barley and corn were selected as grain sources as they differ in degradation rate for their nonstructural carbohydrate and protein. Barley had more rapidly degradable and fermentable nonstructural carbohydrate in the rumen and higher rumen degradable protein concentration compared to corn (Casper *et al*., 1999). Soybean and corn gluten meal are also quite different in soluble protein and degradable protein contents. Soybean meal have higher amount of soluble and more degradable protein than corn gluten meal (NRC, 2001).

The experiment, including 1 week training period at the beginning, lasted for 9 weeks. During the training period, grain source (barley or corn), protein source (SBM or CGM) and wheat bran were supplied in the 1st, 2nd and 3rd day, respectively. Alfalfa hay was provided all time. The same procedure was applied for the next 3 days and the last day of training period and following testing period (8 weeks), all ingredients (grain source + protein source + wheat bran + alfalfa hay) were offered *ad libitum* simultaneously according to experimental design. Each feed ingredients, except alfalfa hay, was mixed with 2.8 limestone, 1.2 salt and 0.1% vitamin-mineral mixture in order to ensure the micronutrients intakes of animals and also to prevent any possible effect of micronutrients on feed ingredient selection. Fresh water was available freely during the entire experimental period (training and testing) for all animals.

The compositions of feed ingredients were determined according to the standard AOAC procedures (1998). NDF and ADF were analyzed using the methods of Van Soest *et al*. (1991) using ANKOM fiber analyzer. Metabolizable energy contents of the diets were calculated based on the table values published by NRC (1981).

Live weight change, milk yield and feed intake were determined weekly after training period. Animals were milked by hand and milk samples were taken from morning milk and then milk fat were determined by Gerber method. Milk samples were also analyzed for dry matter, ash, milk protein, NPN, casein nitrogen according to AOAC (1998). The rest of the nitrogen fractions were determined by calculation. Lactose was obtained by subtracting fat plus protein from milk organic matter as described by Sanz Sampelayo *et al*. (1998).

Statistical analyses: Data obtained in the experiment were analyzed by GLM procedure of SPSS. The differences among treatments were separated by Duncan's Multiple Range Test. Difference between the diets selected by goats during the 1st (1-4th week) and 2nd part (5-8th week) of the testing period was separated by t-test.

RESULTS

Diet selection: The results obtained in the experiment showed that diet selections with respect to feed ingredient consumptions and nutrient intakes were affected by grain and protein sources. Type of grain (barley or corn) affected ($p<0.01$) crude protein, rumen undegradable protein (RUP), NDF and ether extract contents of the diet selected by does. The does offered barley as a grain source consumed higher amount of protein sources (SBM or CGM), so they made the diets containing higher ($p<0.01$) crude protein and NDF, but lower ($p<0.01$) rumen undegradable protein (RUP) and ether extract than the does offered corn as a grain source during all experimental period. Type of grain also affected wheat bran consumption in the second half of the study, the does receiving corn consumed wheat bran in higher ($p<0.01$) amount than those receiving barley.

Type of protein source (SBM or CGM) also affected feed ingredients selection and the nutrient contents of diets selected. Throughout the experiment, SBM was consumed more preferentially ($p<0.01$, Table 1) than corn gluten meal by does receiving barley. The does having corn gluten meal (CGM) tended to consume more grain ($p = 0.06$) and alfalfa hay ($p = 0.06$) in the 1st 4 weeks period and more alfalfa in the 2nd 4 (5-8) weeks period and also during the entire experimental period ($p<0.01$). The percentage of wheat bran in the diets chosen by the does receiving barley was not changed significantly by protein sources, but it was increased by SBM along with corn compared with CGM. The does offered SBM as protein source selected the diet having lower ADF, NDF and RUP contents and higher CP content than those offered CGM as a protein source.

The diets selected by does were affected by grain×protein source interaction in the second half of the study ($p<0.05$, Table 1) and also during the overall period ($p<0.01$). The groups receiving barley along with SBM or CGM consumed higher ($p<0.01$) amount of SBM than CGM, while the groups receiving corn consumed similar amount of SBM or CGM. Grain×protein source interaction also affected ($p<0.05$) nutrient composition of diets selected. In barley groups, the does offered CGM selected diets with higher NDF but lower ME content than those selected by the does offered SBM, however, no such a difference according to the protein source was observed in the groups receiving corn.

According to the diet preferences, ME ($p = 0.07$) and NDF ($p = 0.06$) contents of the diets in the 1st 4 weeks of the study, ME ($p = 0.08$), CP ($p = 0.08$) and NDF ($p = 0.10$) contents of the diets in the second 4 weeks of the study and ME ($p<0.05$) and NDF ($p<0.05$) contents of the diets selected by the does in the entire experimental period were influenced by the above mentioned interaction between grain and protein sources. The results also showed that experimental period changed the diet preferences of the does. The does receiving barley and SBM as choice increased the SBM content ($p<0.05$) in the diet in the second half of the study. Similarly, the does receiving barley and CGM consumed more barley ($p<0.05$) and the does receiving corn and CGM as choice consumed more CGM and wheat bran ($p = 0.07$), as the study was in progress. Depending on ingredient preferences of the does, ME contents of the diet selected in the barley-SBM ($p = 0.07$), barley-CGM ($p<0.05$) and corn-SBM groups ($p = 0.07$) were increased and ADF and NDF contents were decreased as the study was in progress. While the does in barley-SBM group increased CP level ($p = 0.07$) in the diet selected and the does in corn-CGM group decreased CP level in the diet selected, as the study was in progress, the others did not change CP level in their diets.

Performance and milk composition: Grain sources had significant effects on DMI, MEI, protein yield, milk production efficiency (DMI/milk yield) ($p<0.05$, Table 2) and live weight changes ($p<0.01$, Table 2). The does receiving barley as grain source had lower DMI, MEI ($p<0.05$), lower live weigh gain ($p<0.01$), higher milk protein yield ($p<0.05$) than those receiving corn. However, providing barley as a grain source tended to increase FCM ($p = 0.06$) and fat yields ($p = 0.08$) compared to Corn.

Table 1: Compositions of the diets selected by does offered different grain and protein sources

Grain Sources (GS)	Barley		Corn			Effects (p≤)		
Protein Sources (PS)	SBM	CGM	SBM	CGM	SE	GS	PS	Gs×PS
1-4 weeks:								
Barley/Corn	31.74ab	34.02ab	27.97b	44.05a	4.45	NS	0.06	NS
SBM/CGM	8.85a	3.04b	2.94b	0.54b	1.35	0.01	0.01	NS
Wheat Bran	28.24ab	25.24ab	36.03a	16.51b	4.24	NS	0.01	0.08
Alfalfa hay	28.21	35.02	30.18	36.27	3.06	NS	0.06	NS
Salt	0.86	0.78	0.84	0.76		NP	NP	NP
Limestone	2.01	1.82	1.95	1.78		NP	NP	NP
Vitamin min. premixϒ	0.07	0.06	0.07	0.06		NP	NP	NP
ME, Mcal/kg	2.56ab	2.53b	2.54ab	2.62a	0.03	NS	NS	0.07
CP%	17.18a	15.95a	13.70b	11.66c	0.50	0.01	0.01	NS
RUP, CP%	37.87c	41.25b	40.56bc	45.0a	0.98	0.01	0.01	NS
CF%	17.33	18.40	16.75	16.46	0.98	NS	NS	NS
ADF%	21.52	24.27	21.48	22.51	1.29	NS	NS	NS
NDF%	35.82ab	39.45a	34.0b	31.76b	1.37	0.01	NS	0.06
Ether extract%	2.22b	2.16b	2.92a	3.02a	0.07	0.01	NS	NS
5-8 weeks								
Barley/Corn	40.08	42.12*	35.03	36.08	5.49	NS	NS	NS
SBM/CGM	23.09a*	2.53b	8.05b	3.07b¥	3.28	0.05	0.01	0.05
Wheat Bran	11.86b	20.03ab	28.52a	25.83a¥	4.10	0.01	NS	NS
Alfalfa hay	21.75b	32.54a	25.33b	32.28a	1.97	NS	0.01	NS
Salt	0.94	0.81	0.90	0.81		NP	NP	NP
Limestone	2.19	1.88	2.09	1.89		NP	NP	NP
Vitamin min. premixϒ	0.08	0.07	0.07	0.07		NP	NP	NP
ME, Mcal/kg	2.70a¥	2.57b*	2.62ab¥	2.59b	0.03	NS	0.01	0.08
CP%	20.85a¥	15.70b	14.52b	13.44b*	1.07	0.01	0.01	0.08
RUP, CP%	37.37b	40.12b	39.91b	44.57a	1.02	0.01	0.01	NS
CF%	15.45	17.35¥	14.90	16.04	0.78	NS	0.08	NS
ADF%	18.38c	22.99a¥	18.96bc	21.75ab	0.91	NS	0.01	NS
NDF%	29.97b¥	37.83a*	29.78b¥	33.24b	1.23	0.08	0.01	0.10
Ether extract%	1.93b	2.07b	2.94a	3.07a	0.08	0.01	0.11	NS
Overall								
Barley/Corn	35.91	38.07	31.50	40.07	4.00	NS	NS	NS
SBM/CGM	15.97a	2.78b	5.49b	1.81b	1.73	0.01	0.01	0.01
Wheat Bran	20.05	22.64	32.28	21.17	3.78	NS	NS	0.10
Alfalfa hay	24.97b	33.78a	27.75ab	34.27a	1.98	NS	0.01	NS
Salt	0.90	0.79	0.87	0.79		NP	NP	NP
Limestone	2.10	1.85	2.02	1.84		NP	NP	NP
Vitamin min. premixϒ	0.07	0.07	0.07	0.07		NP	NP	NP
ME, Mcal/kg	2.63a	2.55b	2.58ab	2.61ab	0.02	NS	NS	0.05
CP%	19.02a	15.82b	14.11bc	12.55c	0.60	0.01	0.01	NS
RUP, CP%	37.63c	40.82b	40.25b	44.79a	0.76	0.01	0.01	NS
ADF%	19.95b	23.63a	20.22b	22.13ab	0.85	NS	0.01	NS
NDF%	32.89b	38.64a	31.89b	32.50b	1.04	0.01	0.01	0.05
Ether extract%	2.08b	2.12b	2.93a	3.04a	0.07	0.01	NS	NS

a, b, c: Denotes the difference among the diets selected by does in different groups in the same period ($p<0.05$); *: denotes the difference among the diets selected by the goats for the same groups in different periods ($p<0.05$); ¥: Denotes the difference among the diets selected by the goats for the same groups in different periods ($p<0.07$); SE: Standard error of the least square means; SBM: Soybean Meal; CGM: Corn Gluten Meal; ME: Metabolizable Energy; CP: Crude Protein; RUP: Rumen Undegradable Protein; ϒ: Each kg vitamin-mineral premix provides 8.000.000 IU vitamin A, 1.000.000 IU vitamin D3, 30 g vitamin E, 50 g Mn, 50 g Zn, 50 g Fe, 10 g Cu, 150 mg Co, 800 mg I and 150 mg Se; NS = Not Statistically significant ($p>0.10$); NP: Not performed statistical analysis

FCM, fat and protein yields ($p<0.05$) were increased markedly for the animals offered CGM compared to SBM. Milk yield ($p = 0.07$) and casein nitrogen to total nitrogen ratio ($p = 0.06$) were also tended to increase by CGM compared to SBM.

Grain and protein sources interaction had significant effects on ADF ($p<0.05$) and NDF ($p<0.01$) intakes and milk NPN ($p<0.05$). The does having CGM with barley consumed more ADF and NDF than those receiving SBM with barley, but the does receiving corn free choice did not change their fiber intakes according to protein sources. NPN contents of milk of the does receiving barley-SBM were higher than those receiving CGM together with barley; however, NPN content of milk was not differed according to the protein sources for the groups receiving corn as grain sources. Similar trend ($p = 0.07$) was also observed for the milk true protein nitrogen to total nitrogen ratio; true protein nitrogen to total nitrogen ratio was increased by CGM for the groups receiving barley as grain sources, but it was not changed by protein sources the selection groups receiving corn as a grain source.

Table 2: Dry matter and nutrient intakes, milk yield and composition of the does fed with different grain and protein sources during entire experimental period

Grain Sources (GS)	Barley		Corn			Effects (P≤)		
Protein Sources (PS)	SBM	CGM	SBM	CGM	SE	GS	PS	GsxPS
DMI, kg day^{-1}	1.91b	2.22ab	2.48a	2.34ab	0.14	0.05	NS	NS
MEI, Mcal day^{-1}	5.02b	5.67ab	6.42a	6.13ab	0.37	0.05	NS	NS
CPI, g day^{-1}	362.72	351.59	352.40	292.46	22.83	NS	NS	NS
ADFI, kg day^{-1}	0.38b	0.52a	0.50a	0.51a	0.03	0.10	0.05	0.05
NDFI, kg day^{-1}	0.63b	0.86a	0.79a	0.75ab	0.04	NS	0.08	0.01
Milk yield, g day^{-1}	1.04ab	1.31a	0.93b	1.11ab	0.11	NS	0.07	NS
FCM, g day^{-1}	0.95b	1.30a	0.86b	1.00ab	0.09	0.06	0.05	NS
Fat yield, g day^{-1}	35.31b	50.03a	32.57b	37.18b	3.89	0.08	0.05	NS
Protein yield, g day^{-1}	37.87ab	49.77a	32.62b	38.83ab	3.67	0.05	0.05	NS
MPE, DMI/milk yield	1.98ab	1.74b	2.69a	2.15ab	0.25	0.05	NS	NS
LWC, g day^{-1}	17ab	0b	75a	72ab	20	0.01	NS	NS
Milk composition								
Lactose%	4.30	4.08	4.43	4.40	0.13	NS	NS	NS
Protein%	3.59	3.63	3.45	3.48	0.18	NS	NS	NS
Fat%	3.34	3.66	3.40	3.36	0.23	NS	NS	NS
DM%	11.99	12.10	11.97	12.00	0.29	NS	NS	NS
Nitrogen fractions								
Total N, g L^{-1} (TtN)	5.63	5.68	5.40	5.45	0.28	NS	NS	NS
Prot. N, g L^{-1} (PrN)	5.10	5.31	5.20	5.24	0.28	NS	NS	NS
Casein N, g L^{-1} (CsN)	4.01	4.21	4.02	4.33	0.17	NS	NS	NS
Whey-N, g L^{-1}	1.09	1.10	1.17	0.91	0.16	NS	NS	NS
NPN, g L^{-1}	0.62a	0.46b	0.50b	0.49b	0.03	NS	0.05	0.05
TrN/TtN	88.65b	91.74a	91.38a	91.60a	0.70	0.10	0.05	0.07
CsN/TtN	69.90	72.94	71.03	76.27	1.89	NS	0.06	NS

a, b, c: denotes the difference among means (p<0.05); SBM: Soybean Meal; CGM: Corn Gluten Meal; SE: Standard Error of the least square means; LWC: Live Weight Change; FCM: 4% fat corrected milk; DMI: Dry Matter Intake; MPE: Milk Production Efficiency; MEI: Metabolizable Energy Intake; CPI: Crude Protein Intake; CFI: Crude Fiber Intake; ADFI: Acid Detergent Fiber Intake; NDF: Neutral Detergent Fiber Intake; NS= Not Statistically significant (p>0.10); DIM: Days In Milk

DISCUSSION

Diet preferences: The does receiving barley as grain sources made the diets having higher crude protein and lower rumen undegradable protein and ether extract than those receiving corn. The selection of high protein could be a reflection of the interaction between grain and protein sources with respect to protein source preferences, besides higher crude protein content of barley than corn. When the SBM presented as a choice with barley, the does consumed almost 6 folds higher amount of SBM than CGM (15.97 and 2.78%), but the does receiving corn consumed only 3 folds higher amount of SBM and CGM (5.49 and 1.81%, Table 2). RUP and ether extract percentage in the diet selected by the does fed with corn was higher than those fed with barley. These are a reflection of the RUP and fat contents of corn as it contains about 2 fold RUP and ether extract than barley (NRC, 2001). On the other hand, the does fed with barley had lower feed intake (2.07 kg day^{-1}) than those on corn (2.41 kg day^{-1}), thus they could have increased protein source consumption to meet crude protein requirement. The results also revealed that the does having free access to CGM made the diets containing higher RUP and ADF than those receiving SBM. Lower protein degradability of CGM (NRC, 2001) is responsible for the increase in RUP level in the diet of the does having CGM as protein sources compared SBM, which is known to be highly degradable protein source. Increased ADF level of the diet selected by the does consuming CGM was probably resulted from high preferences to alfalfa hay to overcome the deficiency in crude protein and/or rumen degradable protein due to reduced consumption of CGM, which was the sole protein source. It is well known that dairy goats having free access to multiple choice could make their diets to meet their nutrient requirements (Fedele *et al*., 2002; Gorgulu *et al*., 2003; Yurtseven and Gorgulu, 2004). In the present study, as the does received grain (barley or corn) and protein (SBM or CGM) sources as free choices, they could have a limitedchance to create better nutrient synchronizations to rumen microorganism and the host animal. The does receiving CGM, which is known to be low degradable (NRC, 2001) and lysin deficient protein source (Schwab *et al*., 1992), have probably searched alternative to avoid asyncrony (and/or nutrional disconfort) in nutriet supply to microorganism and/or host animal and they preferred alfalfa hay as degradable protein and/or amino acid sources without concerning food structure.

The less preference to CGM could also be attributed to its unpleasant flavour (Wu *et al*., 1994), high protein content supplying more amino acids to small intestine with less protein with lower ruminal degradability or unbalanced amino acid suply to small intestine due to lysin deficincy (Korhonen *et al*., 2002). The results obtained in the study caried out simultaneously (Yurtseven and Gorgulu, 2007) with the present study showed that the does having free access simultaneously to both grain (barley and corn) and both protein sources (SBM and CGM) consumed more CGM (9.03%) than those having free access to barley or corn and CGM (2.78% for barley-CGM and 1.81% for corn-CGM). These goats selected a diet containing 28.99 barley, 13.25 corn, 22.62 wheat bran, 1.91 SBM, 9 CGM and 3.09% (limestone, salt, vit-min premix). This result suggests that the inbalance of rumen undegradable protein and rumen degradable protein in the diet and/or rumen and/or amino acid supply to small intestine with CGM play more important role than the palatability of CGM for the CGM preferences in the present study. This finding was also supported by the effect of protein sources on alfalfa preferences in the present study. The does receiving CGM as protein sources consumed more alfalfa hay than those receiving SBM, this was probably resulted from the need for rumen degradable protein of the does receiving CGM, poor in rumen degradable protein (NRC, 2001). In the present study, alfalfa hay was used primarily as a fiber source or an energy diluting material, but the does receiving CGM consumed alfalfa as a fiber source, energy diluting material and also to meet protein and/or rumen degradable protein requirements due to its higher degradable protein value than those of CGM (NRC, 2001). Similarly, Tolkamp *et al*. (1998) revealed that dairy cow could exhibit preferences for dietary choices according to RDP content of the diet, but not its metabolizable protein content.

The does having free access to SBM as a protein source increased CP content of their diet due to high preferences to SBM compared to CGM as discussed before. The diet made by the does receiving CGM contained normally more RUP than the diet selected by the does having free access to SBM, as CGM is rich in RUP (NRC, 2001). The does receiving CGM as sole protein source in the present study suffered RDP defficiency and they tried to compensate or minimize the deficiency by consuming more alfalfa hay. Alfalfa hay is a good alternative for protein and/or rumen degradable protein amongst the available choice presented to the does in the present study. This preference for alfalfa resulted in increase in fiber content (ADF, NDF) of the diets selected by these does as well. Many researchers (Gorgulu *et al*., 1996; Forbes, 2001; Fedele *et al*., 2002; Gorgulu *et al*., 2003; Yurtseven and Gorgulu, 2004) pointed out that the ruminants learn the consequences of food ingestion physiologically and they can recognize feed ingredients offered as choice according to their postingestive effects. This has been also confirmed by the does diverting food preferences towards to alfalfa to rectify imbalances in RUP and RDP availability when sole protein source was CGM.

SBM contents of the diets selected by the does having barley as grain were higher than the diet selected by the does having corn as grain (15.97 and 5.49%, Table 1), but CGM content of the diet selected by the does was not changed according to the grain sources (2.78 and 1.81%, Table 1). The present literature (Petit, 2000; Vaughan *et al*., 2002) revealed that highly degradable starch (barley) and highly degradable protein sources (SBM) may match better in respect to microbial growth in the rumen. As discussed previously, main reasons of preferences for some special feed ingredients given as free choice likely depend on their nutrient contents and their effect on ruminal conditions, such as microbial growth, ruminal pH, ammonia nitrogen, proportion of VFAs, passage rate and rumen turnover rate. Furthermore, one of the objectives of ruminants for selecting a diet is to maintain the rumen environment within certain physiological range (James *et al*., 2001). The does receiving barley having highly degradable starch (Petit, 2000) could have, therefore, preferred more SBM containing highly degradable protein compared to the does receiving corn having less degradable starch (Petit, 2000) to have synchronization of fermentable organic matter and ammonia nitrogen availabilities in the rumen to improve ruminal condition and microbial protein yield. Fermentable organic matter and ammonia nitrogen coming from rumen degradable protein are the major nutrients supporting microbial growth (Hoover and Stokes, 1991). Kim *et al*. (1999) suggested that the degree of synchrony in ruminal release of energy and nitrogen is likely to influence microbial protein yield with the diet containing high level of readily fermentable carbohydrate. This has been also explained why the does preferred high level of SBM especially when barley was available as choice with SBM. Furthermore, high level of SBM in the diet of the does receiving free-choice barley could be associated with the buffering rumen pH (Soto-Navarro *et al*., 2003) due to highly degradable starch source (barley). It could also be associated with an increased need for amino acids due to highly degradable protein of SBM (Gorgulu *et al*., 2003).

ME and NDF contents of the diets selected by the does affected by interaction between grain and protein sources. The does having free access to barley and CGM made the diets having the lowest ME content than others as they have chosen the diets having highest NDF contents. NDF is the less digestible fraction in the feed; its concentration is, therefore, negatively correlated with dietary energy concentration (NRC, 2001) such as in the present study. The changes in NDF and ME contents of the diets selected by the does could be explain by the changes in diet preferences of the does fed with barley and CGM. The does receiving barley and CGM consumed less protein sources (CGM) than those receiving barley and SBM. The does receiving corn as grain source did not change their alfalfa preferences markedly by protein sources. However, the does receiving barley and CGM tried to compensate the lack of rumen degradable protein by diverting their preferences to alfalfa as protein sources (24 and 34% alfalfa for SBM and CGM, respectively) compare to those fed with barley and SBM as choices as discussed before.

It is well documented that farm animals can switch their feed preferences according to environmental temperature and they can prefer certain feed ingredients which induce less heat increment in their bodies. The results of the studies on cattle (Gorgulu *et al*., 1998) and goats (Yurtseven and Gorgulu, 2004) suggested that dairy cow could decrease roughage ratio in the diet as low as 10% during hot summer months, when concentrate and roughage are available as free choice, the goats having free access to feed ingredients increased concentrate preferences when ambient temperature was getting higher during the study carried out from May to July. In the present study, the does generally increased grain and decreased alfalfa contents (except corn-CGM group) of the diet selected, as experiment was in progress from the beginning of May to the end of June. Due to these preferences, ME content was increased and NDF content was decreased. In the 2nd half of the study, average ambient temperature and humidity (27°C and 66%) were higher than in the first half of the study (25°C and 51%). However, the does having corn and corn gluten meal as choice consumed less grain and high level alfalfa in the second half of the study, it was probably mediated by the availability and synchronicity of ruminal fermentable organic matter and ammonia nitrogen as discussed before.

The does having free access to feed ingredients in this study, set the ADF and NDF content of their diets to about 20-24 and 32-39% by choosing the diets containing about 25-34% alfalfa hay. However, the forage level in the diets is lower than the conventional goat diets; the does did not suffer any metabolic problem due to low dietary total NDF and/or forage NDF during experiment. Similar results were obtained by Yurtseven and Gorgulu (2004). This could be explained by the changes in feeding behaviour (order of feed ingredient consumptions, intermeal interval, meal size and meal length, etc.) (Görgülü *et al*., 2008) of the goats having free access to feed ingredients (Abijaoude *et al*., 2000; Gorgulu *et al*., 2003) and pectin content of alfalfa hay with high buffering capacity (Van Soest *et al*., 1991). NDF content of the diet selected by the does in our previos (Yurtseven and Gorgulu, 2004) and the present studies are lower than the diet selected by the goats in the study of Fedele *et al*. (2002), who reported that the goats selected the diets containing 74-85% concentrate with similar NDF content (40%) throughout the experiment. Santini *et al*. (1992) reported that high yielding dairy goats could have used energy more efficiently when ADF level in the diet were ranged between 18-22%. They also reported that dietary ADF level did not affect the performance of high yielding dairy goats when alfalfa was used as fiber source, as in this study.

Performance and milk composition: The does receiving corn as grain consumed more dry matter, ME, but had lower protein yield and milk production efficiency (higher dry matter intake per kg milk yield) than those receiving barley. Corn grain tended to decrease FCM and fat yield than those receiving barley as grain sources. Rapid ruminal degradation of carbohydrate in the rumen such as barley starch may affect ruminal environment and digestion of fiber adversely and depress DMI by decreasing rumen pH. Petit (2000) in lambs, Khorasani *et al*. (1994) and Casper *et al*. (1999) in cows observed that corn in the diet increased dry matter intake over barley. However, DePeters and Taylor (1985) in dairy cows and Hadjipanayiotu (2004) and Yurtseven and Gorgulu (2004) in goats did not observed any differences in dry matter intake of animals receiving corn or barley.

Grain sources had no effect on milk composition, but FCM yield, fat yield and milk production efficiency tended to increase with barley compared to corn. Schmidely *et al*. (1999) also reported that the goats receiving rapidly degradable diet based on wheat, barley and oat produced more raw milk than the goats the diet fed with slowly degradable diet based on soybean hull and beet pulp. Although the does receiving corn consumed more dry matter and ME than those receiving barley as grain, they

did not have a corresponding increase in milk yield. However, Casper and Schingoethe (1989) and Weiss *et al.* (1989) observed an increase in milk yield when cows fed with corn compared to barley. Corn has the higher starch content and the lower rumen degradability than barley has (Tothi *et al.*, 2003). Therefore, the corn based diets could supply more propionate and glucose resulting in increase in plasma insulin, which can increase body condition and fat accretion (Schmidely *et al.*, 1999), especially in mid lactation, such as in the present study. This hormonal change can also increase competition between body fat tissues and mammary gland for nutrients such as glucose and NEFA (Gaynor *et al.*, 1995). This could explain why the does having free access to corn had higher live weight gain and lower milk yield, although they consumed more dry matter and ME than those having free access to barley in the present study.

FCM, fat and protein yields were higher for the does receiving CGM than those receiving SBM. The does having CGM as protein sources also consumed high amount of ADF and NDF due to high preferences to alfalfa. As discussed before the goats having free access to CGM as sole protein sources suffered RDP deficiency and they tried to compensate or minimize the deficiency by consuming more alfalfa hay. Increase in FCM, fat and protein yield could be attributed to amino acid supply to small intestine by CGM. Korhonen *et al.* (2002) reported lowered milk yield response to SBM compared to fish meal and CGM and they suggested that this was related to mainly lower nitrogen and amino acid supplies due to high ruminal protein degradability of SBM. CGM has a good source for methionine, one of the first limiting amino acid in some condition for lactating animals (Cozzi *et al.*, 1995; NRC, 2001). Increasing dietary methionine may increase milk yield and milk fat content (Xu *et al.*, 1998). Increase in milk fat was attributed to increase in short and medium chain fatty acid synthesis in mammary tissues (Pisulevski *et al.*, 1996), the need to amino acids for intestinal chylomicrons, hepatic very low density lipoprotein and choline synthesis (NRC, 2001). It is also possible to suggest that CGM might have created better synchronization than SBM in the choice feeding conditions. Furthermore, CGM and alfalfa hay could have better complementary effect for amino acids used for milk protein synthesis. Van Horn and Powers (1992) reported that the response of milk yield to substitution of SBM with RUP sources were more positive for the diet based on alfalfa than for the forage containing lower protein.

Microbial protein synthesis, milk yield, milk composition and daily gain in dairy animal are generally connected with ruminal degradability of nonstructural carbohydrate and protein sources (Khorasani *et al.*, 1994; Casper *et al.*, 1999). However, there were not marked interactions between grain and protein sources for performance findings such as milk yield and feed intake in the present study. Lack of any interaction between feed ingredients in differing degradability of starch and protein for milk production could be attributed to the does having lower milk yield in mid lactation in the present study. High yielding goats in early lactation (over 3 kg day^{-1}) responded better to choice feeding with feed ingredients (Gorgulu *et al.*, 2003). Casper *et al.* (1999) also reported that the attempts to synchronize nonstructural carbohydrate and rumen degradable protein sources resulted in minimal benefits for dairy cows in mid lactation as they did not need additional nutrients at this production level. As noted before, goats have ability to choose their diet when proper feed ingredients were presented as choice. All treatments in the present study may cover all nutritional requirements as the does had lower yielding capacity in mid lactation. Yurtseven and Gorgulu (2004) reported that choice feeding could have supplied more nutrients for the same goats in similar lactation period than those recommended by NRC (1981). Therefore, choice feeding may be used more efficiently with the conditions, such as heat stress and high yielding, shifting nutrient requirement of animals.

ADF and NDF intakes, milk NPN and milk true protein were affected significantly by interaction between grain and protein sources. The diet selected by the does fed barley and SBM had less fiber than those receiving other dietary treatments (Table 2). The does having free access to SBM with barley had more milk NPN, although all does had similar protein intake. This is probably resulted from inefficient use of ammonia nitrogen released from highly degradable soybean protein. Ruminal nitrogen utilization by rumen microorganism strictly depends on availability (Shabi *et al.*, 1998) or synchronicity (Dewhurst *et al.*, 2000) of energy and nitrogen in the rumen. The goats fed having free access to barley and SBM had the least DM and ME intake amongst does. High degradable protein consumption (Table 1) and lower fermentable organic matter intake of these does might have been responsible from increase in milk NPN due to inefficient nitrogen use in the rumen in such conditions. Similarly, Schmidely *et al.* (1999) revealed that goats fed with the diet containing highly degradable starch and nitrogen had higher plasma urea compared to slowly degradable diets.

While, some researcher (Khorasani *et al.*, 1994) reported that starch sources had limited but protein

sources had marked effects on milk yield and composition, some others (Shabi *et al*., 1998) reported that available energy in the rumen is the most limiting factor for ruminal nitrogen utilization and milk protein content. The present results and the previous results suggest that synchronization of energy and nitrogen availability for microorganism in the rumen and/or host animal may be affected by animal materials, diets, feeding methods and environmental conditions.

CONCLUSION

The results suggested that dairy goats having free access to multiple choice giving opportunity to form balanced diets could match their nutrient requirements with their nutrient intakes by changing preferences and intake level. It could be concluded that lactating goats have a good nutritional wisdom that allowing them to select nutritionally balanced diet and to avoid feedstuffs causing nutritional discomfort when different energy and protein sources are supplied.

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REFERENCES

AOAC, 1998. Official Methods of Analysis. 16th Edn. 4th Revision Association of Official Agricultural Chemists, Washington, DC, USA.

Abijaoude, J.A., P. Moran-Fehr and J. Tessier *et al*., 2000. Diet effect on the daily feeding behaviour, frequency and characteristics of meals in dairy goats. Livest. Prod. Sci., 64: 29-37. DOI: 10.1016/S0301-6226(00) 00173-1.

Casper, D.P., H.A. Maiga and M.J. Brouk *et al*., 1999. Synchronization of carbohydrate and protein sources on fermentation and passage rates in dairy cows. J. Dairy Sci., 82: 1779-1790. PMID: 10480104.

Casper, D.P. and D.J. Schingothe, 1989. Lactational response of dairy cows to diets varying in ruminal solubilities of carbohydrate and crude protein. J. Dairy Sci., 72: 928-941. PMID: 2745813.

Cozzi, G. I. andrighetto, P. Berzaghi and C.E. Polan *et al*., 1995. *In situ* ruminal disappearance of essential amino acids in protein feedstuffs. J. Dairy Sci., 78: 161-171. http://jds.fass.org/cgi/content/abstract/ 78/1/161.

DePeters, E.J. and S.J. Taylor, 1985. Effects of feeding corn or barley on composition of milk and diet digestibility. J. Dairy Sci., 68: 2027-2032. PMID: 4044966.

Dewhurst, R.J., D.R. Davies and R.J. Merry *et al*., 2000. Microbial protein supply from the rumen. Anim. Feed Sci. Technol., 85: 1-21.

Fedele, V., S. Claps and R. Rubino *et al*., 2002. Effect of free-choice and traditional feeding systems on goat feeding behaviour and intake. Livest. Prod. Sci., 4: 19-31. DOI: 10.1016/S0301-6226(01)00285-8.

Forbes, J.M., 2001. Consequences of feeding for future feeding. Comparative Biochem. Physiol. Part A., 128: 463-470. PMID: 11246038.

Gaynor, P.J., D.R. Waldo and A.V. Capuco *et al*., 1995. Milk fat depression, the glucogenic theory and trans-C18: 1 fatty acids. J. Dairy Sci., 78: 2008-2015. PMID: 8550910.

Görgülü, M., Boğa, M.A. Şahin, Serbester, H.R. Kutlu and S. Şahinler, 2008. Diet selection and eating behaviour of lactating goats subjected to time restricted feeding in choice and single feeding system. Small Ruminant Research. DOI: 10.1016/j. smallrumres.2008.04.004.

Gorgulu, M., O. Güney and O. Torun *et al*., 2003. An alternative feeding system for dairy goats: Effects of free-choice feeding on milk yield and milk composition In early lactation of Damascus goats. J. Anim. Feed Sci., 12: 33-44. http://psjc.icm. edu.pl/psjc/cgi-bin/getdoc.cgi?AAAA005767.

Gorgulu, M., N. Kılıçalp and H.R. Kutlu *et al*., 1998. Influence of Roughage/concentrate Ratio on Milk Yield and Milk Composition. In: Van Arendonk, J.A.M. (Ed.). Book of Abstract of the 49th Annual Meeting of the European Association for Animal Production. Warsaw, Poland, 192: 24-27.

Gorgulu, M., H.R., Kutlu and E. Demir *et al*., 1996. Nutritional consequences of free choice among feed ingredients by Awassi lambs. Small Rumin. Res., 20: 23-29. DOI: 10.1016/0921-4488 (95)00777-6.

Hadjipanayiotou, M., 2004. Replacement of barley grain for corn in concentrate diets fed to dairy Damascus goats at different frequencies. Small Rumin. Res., 51: 229-233. http://linkinghub.elsevier.com/retrieve/ pii/S0921448803001998.

Henning, P.H., D.G. Steyn and H.H. Meissner *et al*., 1993. Effect of synchronization of energy and nitrogen supply on ruminal characteristics and microbial growth. J. Anim. Sci., 71: 2516-2528. PMID: 8407664.

Hoover, W.H. and S.R. Stokes, 1991. Balancing carbohydrates and proteins for proteins for optimum rumen microbial yield. J. Dairy Sci., 74: 3630-3644. PMID: 1744285.

James, S.M., I. Kyriazakis and G.C. Emmans *et al*., 2001. Diet selection of sheep: Effects of adding urea to foods with different protein contents. Anim. Sci., 73: 183-195. http://www.bsas.org.uk/Publications/Animal_Science/2001/Volume_73_Part_1/.

Khorasani, G.R., G. de Boer and B. Robinson *et al*., 1994. Influence of dietary protein and starch on production and metabolic responses of dairy cows. J. Dairy Sci., 77: 813-824. PMID: 8169289.

Korhonen, M., A. Vanhatalo and P. Huhtanen *et al*., 2002. Effects of protein source on amino acid supply, milk production and metabolism of plasma nutrients in dairy cows fed grass silage. J. Dairy Sci., 85: 3336-3351. PMID: 8861345.

Kim, K.H., J.J. Choung and D.G. Chamberlain *et al*., 1999. Effects of varying degrees of synchrony of energy and nitrogen release in the rumen on the synthesis of microbial protein in cattle consuming a diet of grass silage and cereal-based concentrate. J. Sci. Food Agric., 79: 1441-1447.

NRC, 2001. Nutrient Requirements of Dairy Cattle. 7th Revised Edn. National Academy Press Washington, DC, USA. www.nap.edu/openbook.php?isbn=0309069971.

NRC, 1981. Nutrient Requirements of Goat. National Academy Press, Washington, DC, USA. www.nap.edu/books/0309031850/html.

Petit, H.V., 2000. Effect of whole and rolled corn or barley on growth and carcass quality of lambs. Small Rumin. Res., 37: 293-297. PMID: 10867328.

Pisulewski, P.M., H. Rulquin and J.L. Peyraud *et al*., 1996. Lactational and systemic responses of dairy cows to postruminal infusions of increasing amounts of methionine. J. Dairy Sci., 79: 1781-1791. PMID: 8923249.

Santini, F.J., C.D. Lu, M.J. Potchoiba and J.M. Fernandez *et al*., 1992. Dietary fiber and milk yield, mastication, digestion and rate of passage in goats fed alfalfa hay. J. Dairy Sci., 75: 209-219. PMID: 1311727.

Sanz Sampelayo, M.R., L., Perez, J. Boza *et al*., 1989. Forage of different physical form in the diets of lactating Granadina Goats: Nutrient digestibility and milk production and composition. J. Dairy Sci., 81: 492-498. http: //jds.fass.org/cgi/content/abstract/81/2/492.

Schingoethe, D.J., D.P. Casper and C. Yang *et al*., 1988. Lactational response to soybean meal, heated soybean meal and extruded soybeans with ruminally protected methionine. J. Dairy Sci., 71: 173-180. PMID: 3372801.

Schmidely, P., M. Lloret-Pujol and P. Bas *et al*., 1999. Influence of feed intake and source of dietary carbohydrate on milk yield and composition, nitrogen balance and plasma constituents of lactating goats. J. Dairy Sci., 82: 747-755. http://jds.fass.org/cgi/content/abstract/82/4/747.

Schwab, C.G., C.K. Bozak and N.L. Whitehouse *et al*., 1992. Amino acid limitation and flow to duodenum at 4 stages of lactation. 1. Sequence of lysine and methionine limitation. J. Dairy Sci., 75: 3486-3502. PMID: 1474215.

Shabi, Z., A. Arieli and I. Bruckental *et al*., 1998. Effect of syncronization of the degradation of dietary crude protein and organic matter and feeding frequency on ruminal fermentation and flow of digesta in the abomasum of dairy cows. J. Dairy Sci., 81: 1991-2000.

Soto-Navarro, S.A., A.L. Goetsch and T. Sahlu *et al*., 2003. Effects of ruminally degraded nitrogen source and level in a high concentrate diet on site of digestion in yearling Boer Spanish wether goats. Small Rumin. Res., 50: 117-128. DOI: 10.1016/S0921-4488 (03)00120-2.

Tolkamp, B.J., R.J. Dewhurst and N.C. Friggens *et al*., 1998. Diet Choice by Dairy Cows. 1. Selection of Feed Protein Content During the First Half of Lactation. J. Dairy Sci., 81: 2657-2669. www.jds.fass.org/cgi/content/abstract/81/10/2657.

Tothi, R., P. Lund and M.R. Weisbjerg *et al*., 2003. Effect of expander processing on fractional rate of maize and barley starch degradation in the rumen of dairy cows estimated using rumen evacuation and *in situ* techniques. Anim. Feed Sci. Technol., 104: 71-94.

Van Horn, H.H. and W.J. Powers, 1992. The role of bypass protein in supplying amino acid needs of lactating dairy cows. In: Proc. 3rd Ann. Florida Rum. Nutr. Symp. Gainesville, Florida, pp: 19-30.

Van Soest, P.J., J.B. Robertson and B.A. Lewis *et al*., 1991. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 583-3597. http://jds.fass.org/cgi/content/abstract/74/10/3583.

Vaughan, J.M., J.A. Bertrand, T.C. Jenkins and B.W. Pinkerton *et al*., 2002. Effects of Feeding Time on Nitrogen Capture by Lactating Dairy Cows Grazing Rye Pasture. J. Dairy Sci., 85: 1267-1272. http://jds.fass.org/cgi/reprint/85/5/1267.

Weiss, W.P., G.R. Fisher and G.M. Erickson, 1989. Effect of source of neutral detergent fiber and starch on nutrient utilization by dairy cows. J. Dairy Sci., 72: 2308-2315. http://jds.fass.org/cgi/content/abstract/72/9/2308.

Wu, Y.V., J.W. King and K. Warner *et al*., 1994. Evaluation of corn gluten meal extracted with supercritical carbon dioxide and other solvents: Flavors and composition. Cereal Chemis., 71: 217-219.

Xu, S., J.H. Harrison and W. Chalupa *et al*., 1998. The effect of ruminal bypass lysine and methionine on milk yield and composition of lactating cows. J. Dairy Sci., 81: 1062-1077. http://jds.fass.org/cgi/reprint/81/4/1062.

Yurtseven, S. and M. Görgülü, 2007. The effects of multiple choices for grain and protein sources differing in ruminal degradability on diet selection and performance of lactating dairy goats. J. Anim. Prod., 48 (2): 7-14. http://www.zootekniderneği.org/dergi/makale/2007_48_2_07-14.pdf.

Yurtseven, S. and M. Gorgulu, 2004. Effects of grain sources and feeding methods, free-choice vs total mixed ration, on milk yield and composition of German Fawn x Hair crossbred goats in mid lactation. J. Anim. Feed Sci., 13: 417-428. http://www. cababstractsplus.org/google/abstract.asp.ACNO= 20043131883.