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In Situ Ruminal Crude Protein and Starch Degradability of Some Grains and By-Product Feeds in Turkey

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ABSTRACT

The objective of this study was to evaluate in situ ruminal crude protein and starch degradabilities of some grains and by-product feeds in sheep. Ingredients evaluated were corn (C), wheat (W), hazelnut meal (HM), corn gluten feed (CGF), and sunflower meal (SFM). Three ruminally cannulated 3 years of age male Merino sheep with an average initial body weight of 50±5 kg, 3 years of age, were housed in 1.22 x 1.70 m. Each sheep was fed with 1.0 kg/day alfalfa hay and 0.6 kg/day mixed concentrates containing 29% C, 22% W, 20% SFM and 29% soybean meal on dry matter (DM) basis and 25.0 g $CaCO_3$, 1.0 g vitamin-mineral premix and 10.0 g NaCL. The bags were placed into the ventral rumen after morning feeding in quadruplicate at each time point in each sheep for 2, 4, 6, 8, 12, 24, and 48 h. The crude protein (CP) of HM was 21.6 and 27.87 percentage units higher than for CP of SFM and CGF, respectively. Ruminal effective degradability of crude protein calculated as a percentage of nutrients were 88.3%, 85.2%, 78.3%, 60.6% and 55.9% for W, CGF, HM, SFM and C, respectively and of starch were 92.8%, 67.9% and 61.6% for W, C and CGF, respectively. This study provides estimates of kinetics of ruminal degradation of feeds for using the accuracy of formulation of sheep diets.

Key Words: in situ, organic matter degradability, protein degradability, starch degradability, grains, by-product feeds

INTRODUCTION

Cereal grains and by-product feeds are used extensively in ruminant ration in many parts of the world. Cereal grains are the most common sources of readily available energy for ruminant (Herrera-Saldana et al. 1990). The energetic value of a ration or a feed depends on organic matter digestion in the rumen and in particular on starch digestion (Cerneau and Michalet, 1991). Dynamic models of carbohydrate and protein digestion rely on estimates of kinetics of ruminal degradation of feeds (Russell et al. 1992). Several *in situ* (Arieli et al. 1996; Batajoo and Shaver, 1998; Cerneau and Michalet-Doreau, 1991; Harstad and Prestlokken, 2001; Herrera-Saldana et al.1991; Kamalak et al.2005) studies have determined starch digestibility of different grains. However, little information is available on degradation of starch in the rumen of wheat (W) and corn grain (C) used for ruminant in Turkey (Gulmez et al. 2010). On the other hand, there is increasing interest in the nutritive value of by-product feeds in ruminant rations (Batajoo and Shaver, 1998). Feedstuffs high in protein are especially lacking in Turkey. Thus, the Turkish feed industry incurs considerable expense to import protein sources, such as soybean meal. In order to avoid being dependent on imported soybean meal, alternative protein sources should be studied. In this regard, hazelnut meal (HM) was introduced as a by-product feedstuff just a few years ago in Turkey (Kamalak et al. 2005; Karsli et al. 2006). Batajoo and Shaver (1998) suggested that to optimize the feeding value of by-product feeds, knowledge of their ruminal degradation properties is needed for proper inclusion in the diet through formulation programs. The in situ nylon bag technique (Orskov and Mcdonald, 1979) is a simple means to estimate the ruminal degradation kinetics. The information related to degradability of nutrients in rumen is limited. Therefore, many feed factories in Turkey use tabulated values obtained from experiments carried out in different countries. It is not advisable for researchers and advisers to use absolute figures for protein degradability determined in another laboratory (Madsen and Hvelpund, 1994).

The objective of this study was to evaluate in situ ruminal crude protein and starch degradabilities of some grains and by-product feeds in sheep.

MATERIALS AND METHODS

Three ruminally cannulated 3 years age male Merino sheep with an average initial body weight of 50±5 kg, 3 years of age, were housed in 1.22 x 1.70 m individual pens equipped with a feeder, a water pot and wheat straw bedding.

Each sheep was fed with 1.0 kg/day alfalfa hay and 0.6 kg/day mixed concentrates containing 29% C, 22% W, 20% SFM and 29% soybean meal on dry matter basis and 25.0 g $CaCO_3$, 1.0 g vitamin-mineral premix (Vitamin A; 15 000 000 IU/kg, Vitamin D_3; 3 000 000 IU/kg, Vitamin E; 30 000 mg/kg, Mn; 50 000 mg/kg, Fe; 50 000 mg/kg, Zn; 50 000 mg/kg, Cu; 10 000 mg/kg, Co; 150 mg/kg, I; 800 mg/kg, Se; 150

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mg/kg) and 10.0 g NaCl. The ration was formulated at level of 1.25 x maintenance energy requirements according to NRC (1985) recommendations and given in two equal meals at 08,30 am and 04,30 pm.

A standard in situ method (Orskov and Mcdonald, 1979) was used to determine the degradation of concentrates. Dacron bags were purchased (5x15 cm, 40 µm pore size: Ankom, Fairport NY, USA). The feedstuffs experienced in this study were W, C, SFM, HM and CGF (Table 1). Feedstuffs samples were ground to pass through a 2.5 mm screen. Through the study, bags contained approximately 4 to 5 g sample of dry matter. The bags were placed into the ventral rumen after morning feeding in quadruplicate at each time point in each sheep and removed after 2, 4, 6, 8, 12, 24, and 48 h of incubation in the rumen of sheep. Immediately following incubation, the bags were washed in cold running water for 12 h (until the washing ran clear and colorless). Two quadruplicate sets of each sample were not incubated in the rumen but were washed in cold water as above to determine solubility at 0 h. After washing, the all bags were dried at 60°C for 48 h in an oven and residual dry matter of each bag was reweighed. The dried residues of bags for each sheep at each time point were combined, mixed and ground through a 1 mm screen. Each composite sample was analyzed for residual CP (AOAC, 1990). Ash was determined by combustions at 550 ^{0}C for 6h. The neutral detergent fiber (NDF) was determined using the method described by Van Soest et al. (1991) with heat-stable amylase (Sigma No: A-3306, Sigma Chemical Co, St Louis, MO, USA) and sodium sulfite. Starch contents for the samples except for SFM, HM were determined by the method of Bal et al. (2000).

Table 1. Chemical composition of the feedstuffs experienced in the study

	DM, (%)	CP, (% of DM)	EE, (% of DM)	NDF, (% of DM)
Wheat	89.40	14.20	2.30	13.40
Corn grain	88.10	9.10	4.20	9.50
Sunflower meal, 30%	92.21	30.03	1.40	40.30
Corn gluten feed	89.40	23.80	3.51	35.50
Hazelnut meal	88.98	51.67	3.72	21.56

The degradability coefficients were calculated by fitting the data obtained for starch and CP to the order model of Orskov and McDonald (1979):

$d = a + b (1-e^{-ct})$

Where d is the proportion degraded at time, a is the readily soluble fraction, b is the fraction potentially degraded in the rumen, c is the fractional rate of degradation of b and t is incubation time (hours).

The parameters, a, b and c, were obtained by fitting the data using a non-linear regression procedure, based on Marquardt's method, performed by the NONLIN procedure of SPSS software (version 13.0, SPSS Inc, Chicago, USA). The effective starch and CP degradability values were calculated with fractional rumen outflow rates (k) according to the equation (Orskov and Mcdonald, 1979):

Effective degradability = a + [(b * c)/(c + k)]

Where k is a mean particle passage rate taken as 5% h^{-1}.

RESULTS AND DISCUSSION

Chemical compositions of feedstuffs are presented in Table 1. The five feedstuffs CP content ranged from 9.1 to 51.6%, EE from 1.4 to 4.2%, and NDF from 9.5 to 40.3%. The HM was of good quality averaging 51.6% CP, 3.7% EE, and 21.6% NDF on DM basis. The CP of HM was 21.6 and 27.87 percentage units higher than for CP of SFM and CGF, respectively. The CP concentration of HM has been reported to be similar to that of soybean meal (Karsli and Nursoy, 2001).

Predicted parameters of rumen degradation of starch and CP in the five feedstuffs and their effective degradability are shown in Table 2. Ruminal effective degradability of CP calculated as a percentage of nutrients were 88.3%, 85.2%, 78.3%, 60.6% and 55.9% for W, CGF, HM, SFM and C, respectively and of starch were 92.8%, 67.9% and 61.6% for W, C and CGF, respectively.

Table 2. In situ degradation kinetics of the five feedstuffs

	Corn grain	Wheat	Corn gluten feed	Hazelnut meal	Sunflower meal 30%	SEM
Starch						
a, % of DM	20.0	47.2	22.2	NA	NA	0.005
b, % of DM	77.7	50.2	74.3	NA	NA	0.004
c, per h	0.06	0.72	0.05	NA	NA	0.007
ED, at 5%/h	67.9	92.8	61.6	NA	NA	1.4
Crude Protein						
a, % of DM	10.0	52.5	59.9	29.2	11.9	0.005
b, % of DM	75.3	41.2	32.7	67.4	67.2	0.006
c, per h	0.08	0.401	0.109	0.156	0.112	0.009
ED, at 5%/h	55.9	88.3	85.2	78.5	60.6	1.3

In situ degradability; a: the readily soluble fraction, b: the fraction potentially degraded in the rumen, c: the fractional rate of degradation of b, ED: Effective degradability, k: fractional outflow rate of 0.05/h.
NA: Not Analyzed

Large differences were observed among the feed ingredients in the rate and potential extent of starch and CP degradation. The C and CGF contained lowest proportion of starch in the soluble fraction (20, 22%, respectively), supporting the findings of other researchers who found 21% Herrera-Saldana et al. (1990) and 26.5% Cerneau and Michalet (1991). In this study, the soluble fraction of starch of W was lower than that reported by Herrera-Saldana et al. (1990) (47.2 vs. 78.2). Variation in the soluble fraction among feeds might be due to the various in feed particle size. Small feed particles could be physically expelled from the bag during washing which would overestimate the amount leaving the bag due to solubility. In addition, the starch was degraded more slowly, probably encapsulating by prolamin-zein in C and CGF. Hamaker et al. (1995) reported that prolamin proteins are named zein and comprise 50-60 % of total protein in whole corn. On the other hand, ruminal starch digestion depends on the intrinsic characteristics of ration or feed and on the intensity and duration of bacterial activity in the rumen (Cerneau and Michalet, 1991).

The values of CP degradation for W and C were consistent with those reported by Turgut et al. (2004). The degradability values of the CP for CGF were similar to those reported in several other studies (Batajoo and Shaver, 1998; Harstad and Prestlokken, 2001). However, C and SFM were defined as having lower soluble CP fraction than the W, CGF and HM. The SFM and CGF had similar rates of degradability of the potentially degradable fraction. By contrast, the in situ CP degradation kinetics and the effective protein degradability of SFM, CGF and HM obtained in this study were considerably higher than those obtained by Kamalak et al. (2005) and others (Batajoo and Shaver, 1998; Harstad and Prestlokken, 2001). Variation in the degradation parameters among experiments might be due to the differences in protein sources, bag surface area, pore size of nylon bag, feed particle size and degree of heating or differences in analytical techniques. In this study, the pore size of nylon bags and the particle size of feed samples were 40 μm and 2.5 mm, respectively. In the study carried out by Kamalak et al. (2005), the similar pore size (35-40 μm) and particle size (3 mm) were used. Nocek (1985) observed that feed sample particle size did not affect rates of N degradation although (Figroid et al. (1972) have observed large differences in disappearance of substrate with different particle size.

In situ CP disappearance of feedstuffs was presented in Figure 1. More than 85% of total protein in W disappeared during the first 4 h of rumen incubations, suggesting W contained a highly degradable CP fraction. The HM contained a medium degradable fraction which 50% of total protein disappeared during first 2 h; but by 48 h, C, W, CGF and HM were degraded to a similar extent. Karsli and Nursoy (2001) reported that HM has higher rate and extent of protein degradation, a greater soluble protein concentration but a lower level of ruminally undegraded protein compared with soybean meal in the rumen.

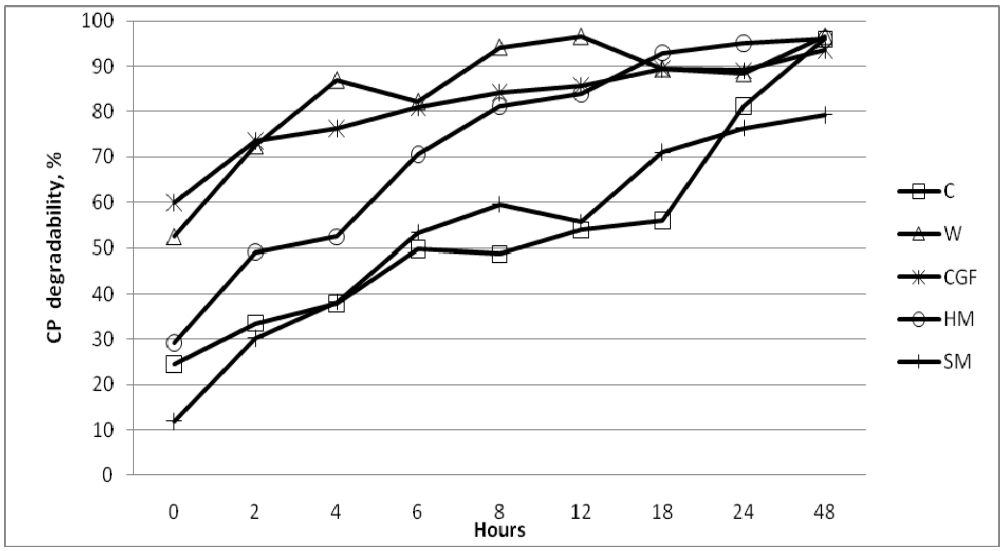

Figure 1. In situ CP disapperance of five feedstuffs
C: Corn grain, W: Wheat, CGF: Corn gluten feed, HM: Hazelnut meal, SFM: Sunflower meal 30% CP

CONCLUSIONS

The results show that this study provides estimates of kinetics of ruminal degradation of feeds for using the accuracy of formulation of sheep diets and HM can be substituted for SFM and CGF.

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