Sağlık Bilimleri Dergisi
Yüzüncü Yıl Üniversitesi

Yüzüncü Yıl Üniversitesi, Sağlık Bilimleri Dergisi, 7 (1-2): 126-130, 2001

Comparison of protein fractions of hazelnut-meal with soybean –meal by using in situ technique

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Abstract: The aim of this study was to compare ruminal dry matter (DM) and crude protein (CP) degradation kinetics, and protein fractions of hazelnut-meal with soybean-meal by using in situ technique. To determine the chemical compositions of samples, oven-dried samples of hazelnut-meal (HZM) and soybean-meal (SBM) were ground through a 1-mm screen and then, analyzed for DM, organic matter (OM), ether extract (EE), crude fiber (CF), CP, and acid detergent insoluble nitrogen (ADIN) concentrations. To estimate in situ degradation kinetics and fractions of CP, three mature fistulated rams fed ground alfalfa hay plus barley were used for incubation of samples in this study. Samples were incubated in the rumen of rams for periods of 0, 3, 6, 12, 24, and 48 h. The concentrations of DM, OM, EE, CF, CP, and ADIN-N were 89.6, 93.5, 1.60, 7.28, 42.45, 8.45 for SBM and 92.2, 94.1, 4.43, 7.33, 40.09, 5.52 for HZM, respectively. Hazelnut-meal had significantly higher ($P< 0.05$) in situ ruminal DM and CP degradability compared with SBM at all incubation times,except 48-h incubation time. The rate of CP degradation (k) and water soluble protein (WSP) concentration were higher, but concentrations of potantially degradable (PDP), non-digestible (NDP), and escape protein (EPP) were lower in HZM compared with SBM ($P< 0.05$). It was concluded that hazelnut-meal may be substituted with soybean-meal as a protein supplement for ruminants as long as supplemented with protein sources which is high in undegradable intake protein (UIP) when fed to high producing dairy cows or fast growing beef steer and bulls.

Keywords: Hazelnut-meal, Soybean-meal, In situ degradability, Escape protein.

In situ yöntemle fındık küspesinin protein fraksiyonlarının soya küspesi ile karşılaştırması

Özet: Bu çalışma, fındık küspesinin naylon kese tekniğiyle kuru madde (KM), ham protein (HP) yıkılabilirliliği ve protein fraksiyonlarının soya küspesi ile karşılaştırma amacıyla yapılmıştır. Besin madde içeriklerinin belirlenmesi amacıyla, etüvde kurutulmuş fındık ve soya küspesi örnekleri 1-mm büyüklüğünde öğütüldükten sonra KM, organik madde (OM), eter extraktı (EE), ham selüloz (HS), HP ve ADIN-N içerikleri belirlenmiştir. Naylon kese yıkılım kinetiği ve protein fraksiyonlarının belirlenmesi için, öğütülmüş yonca- arpa karışımı tüketen üç erişkin rumen fistüllü koç örneklerin inkubasyonu için kullanılmıştır. Örnekler koçların rumeninde 0, 3, 6, 12, 24 ve 48 saat süreyle inkube edilmiştir. KM, OM, EE, , HP ve ADIN-N içerikleri sırasıyla soya küspesi için 89.6, 93.5, 1.60, 7.28, 42.45 ve 8.45; fındık küspesi için 92.2, 94.1, 4.43, 7.33, 40.09 ve 5.52 olarak tespit edilmiştir. Fındık küspesinin, 48 saat inkubasyon hariç, tüm inkubasyon saatlerinde soya küspesinden daha yüksek KM ve HP yıkılım değerlerine sahip olduğu gözlemlenmiştir ($P< 0.05$). Fındık küspesinin rumen HP yıkılım hızı ve suda kolay eriyebilen HP içeriği soya küspesine oranla daha yüksek, fakat potensiyel olarak rumende yıkılabilir ve yıkılamayan protein oranları daha düşük olarak bulunmuştur ($P< 0.05$). Fındık küspesi UIP kaynağı proteinlerle desteklendiği sürece, yüksek verimli süt ineği veya hızlı gelişen öküz ve boğa rasyonlarında soya küspesi yerine kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Fındık küspesi, Soya küspesi, In situ yıkılabilirlik, By-pass protein.

INTRODUCTION

One of the most expensive feed source in ruminant nutrition is known to be protein. Feedstuffs high in protein are especially lacking in Turkey. Thus, Turkish feed industry has been paying considerable amount of money to import protein source, such as soybean-meal (SBM) (1). This dependency on protein source creates some problems for Turkish feed industry and consequently, Turkish farmers every year. In order to avoid being dependent on the imported soybean-meal, alternative protein sources has to be created. Hazelnut-meal may provide an opportunity to reduce this protein shortage, at least locally.

Hazelnut has been grown in Black Sea region for years. Nowadays, hazelnut-meal (HZM) has been

introduced as a by-product of hazelnut-oil industry. Crude protein concentration of HZM has been reported to be similar to that of SBM (2). Thus, HZM can be substituted with SBM in this region as protein source in animal diet.

Protein requirement of ruminants has been determined based on crude protein concentrations of diets. However, studies have shown that addition of escape protein into diets of fast growing ruminants (3) and high producing dairy cows (4) have resulted in an improvement in animal performance, indicating that crude protein system is lacking in terms of meeting the protein requirements of animals. Therefore, metabolizable protein system was introduced (4, 5) to more accurately and precisely meet the protein requirements of ruminants.

Plant protein serves as a source of metabolizable protein to the ruminants by providing both ruminally degradable protein for microbial growth and some ruminally undegradable protein for intestinal digestion (6). Therefore, protein fractions of similar protein sources may differ.

The objective of this study was to compare ruminal dry matter and nitrogen degradation kinetics, escape protein concentrations and protein fractions of soybean-meal with hazelnut-meal by using in situ technique.

MATERIALS AND METHODS

Because HZM has produced only in the city of Ordu, HZM samples were brought only from Ordu, but from three different distributors. SBM samples used in this study were collected from three different areas.

To determine the chemical compositions of samples, oven-dried samples of HZM and SBM were ground through a 1-mm screen and then analyzed for DM, OM, EE, CP, CF (7) and ADIN (8) concentrations.

To estimate in situ degradation kinetics and fractions of CP, oven-dried samples of HZM and SBM were ground through a 2-mm screen. Approximately 3.5 g of each meal sample was weighed into a Dacron bag. Bags used were constructed of Dacron polyester having an average pore size of 50 microns. Suspension of bags in the rumen was accomplished by tying of bags onto tygon tubing with a nylon string. Eight bags were affixed to each tygon tubing for each suspension time.

Three mature fistulated Morkaraman rams (averaging 55 kg) fed ground alfalfa hay-ground barley (900 and 400 g/d, respectively) were used for incubation of samples in Dacron bags in this study. Samples in Dacron bags were placed in the rumen and incubated for periods of 0, 3, 6, 12, 24, and 48 h. Two bags of sample for each protein sources were inserted into the rumen of each rams for each incubation time. After the removal of bags from the rumen, bags were washed under running water in a small washing machine for about 15 min. Then, all bags were dried for 24 h at 65 °C in a drying oven and DM recovery was determined. Undigested HZM and SBM residues were analyzed for nitrogen by the micro-Kjeldahl procedure (7).

Kinetic parameters associated with the disappearance of N from bags were estimated from a one-pool version of Mertens' (9) discrete lag model of CW digestion.

Modifications of the model by Wechsler (10), which allows estimation of both digestion and lag functions from a single formula, were also incorporated. Model estimates of rate constant (k) and discrete lag time of the potentially digestible N in each sample were obtained by fitting recovery data to model, using nonlinear regression analysis (11).

Loss of DM from bags caused by exposure of substrates to the digestive action of the rumen and the washing process that followed resulted in the partitioning of CP in each of the meals into three fractions: 1) soluble fractions of CP (WSP) were determined as the differences between initial CP content and amounts of CP recovered in 0 time-incubation; 2) potentially digestible fractions of CP (PDP) were determined as 100 - (non-digestible fraction and water soluble fractions of CP); 3) non-digestible fractions of N (NDP) were determined as the differences between initial CP content and amount of CP recovered after 48 h incubations of samples in the rumen (12)

A modified technique reported by Mullahey et al. (13) was used to determine the percentage of SBM and HZM protein that escaped ruminal degradation.

The proportion of total protein which would escape ruminal digestion were calculated as total residual N remaining following 12-h incubation, adjusted for the indigestible N (ADIN) using following equation:

Escape Protein Percentage (EPP), % of total protein = (Total residual N - ADIN of total residue) / (Total plant-N) x 100

Statistical Analysis of Data

Results were subjected to analysis of variance using General Linear Model procedure of SAS (11). Mean treatment differences were determined by Duncans t-test with a level of statistical significance of 5% (14).

RESULTS AND DISCUSSION

The chemical compositions of SBM and HZM are presented in Table 1. The concentrations of DM, OM, EE, CF, CP (% of DM), and ADIN-N (% of total N)

were 89.6, 93.45, 1.60, 7.28, 42.45, 8.45 % for SBM and 92.2, 94.08, 4.43, 7.33, 40.09, 5.52 % for HZM, respectively.

Table 1. Chemical composition of Soybean-meal and Hazelnut-meal.

Items	Soybean-meal	Hazelnut-meal
DM	89.6	92.2
Ash, % DM	6.55	5.92
OM, % DM	93.45	94.08
EE, % DM	1.60	4.43
CF, % DM	7.28	7.33
CP, % DM	44.45	40.09
ADIN-N, % of total N	8.45	5.52

Dry matter, OM, EE, and CF concentrations of SBM and HZM used in the study were in the range of data reported in the literature (2, 15, 16). Crude protein concentration of SBM was less than the data reported in the literature (5, 16, 17). CP content of HZM was in the range of data reported in the literature (2, 15, 16). The ADIN-N concentration of SBM was somewhat higher than those of the value reported in the literature (5, 18). However, CP concentrations of SBM used in those studies were higher compared with the current study, which could cause the difference among studies.

In situ ruminal DM degradabilities of SBM and HZM are shown in Table 2 and Figure 1. Hazelnut-meal had significantly greater ($P<0.05$) DM degradabilities compared with SBM at all incubation times, except 48-h incubation time. Dry matter digestibilities of SBM and HZM were 91.05 % and 92.41 %, respectively after 48-h incubation in the rumen. Dry matter degradability of SBM was lower than that of Weakley et al. (19), but DM degradabilities of both SBM and HZM were in the range of value reported in the literature (2, 16, 17).

Table 2. In situ DM degradation of Soybean-meal and Hazelnut-meal (% DM).

Incubation Times, h	Soybean-meal	Hazelnut-meal
0	34.99 ^{b}	41.76 ^{a}
3	43.72 ^{b}	61.73 ^{a}
6	52.85 ^{b}	65.22 ^{a}
12	74.55 ^{b}	88.75 ^{a}
24	86.22 ^{b}	88.75 ^{a}
48	91.05 ^{a}	92.41 ^{a}

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

Similar to DM degradability, in situ ruminal CP degradability of HZM was significantly greater ($P<0.05$) than that of SBM at all sampling times (Table 3 and Figure 2).

In situ digestion measurements revealed that HZM has a highly soluble nitrogen. Percentage of protein degraded after 48-h incubation in the rumen ranged from 95.6 to 97.2 % for HZM and from 85.4 to 91.4 % for SBM, which were in agreement with the values reported by Yalçın et al. (2), Akyıldız (15) and Sarıçiçek (16).

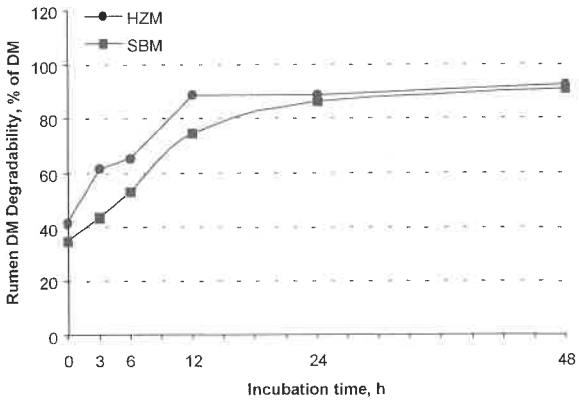

Figure 1. Asymptote of DM degradation curve for SBM and HZM.

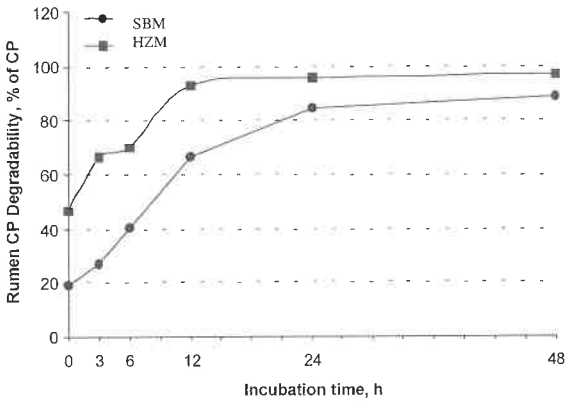

Figure 2. Asymptote of CP degradation curve for SBM and HZM.

Table 3. In situ CP degradation of Soybean-meal and Hazelnut-meal (% of CP).

Incubation Times, h	Soybean-meal	Hazelnut-meal
0	18.96 ^{b}	46.88 ^{a}
3	27.20 ^{b}	66.42 ^{a}
6	40.23 ^{b}	70.08 ^{a}
12	66.25 ^{b}	93.17 ^{a}
24	84.39 ^{b}	95.60 ^{a}
48	88.61 ^{b}	96.43 ^{a}

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

As evidenced from CP degradation in Table 3, the rate of CP degradation was significantly higher (P<0.05) in HZM compared with SBM (.167 and .138 h^{-1}, respectively) (Table 4). Proportion of protein that was removed due to the washing procedure (46.88 and 18.96 %, respectively) was higher, but proportions of protein that were insoluble but potentially digestible (49.56 and 70.04 %, respectively) or non-digestible (3.56 and 11.00 %, respectively) in the rumen were lower in HZM compared with SBM (P<0.05). The time required for initiation of protein degradation (lag time) was also significantly lower in HZM than in SBM (1.15 and 2.70 h, respectively) (P<0.05). Proportion of CP escaping the ruminal degradation was significantly greater in SBM than in HZM (31.93 and 6.58 %, respectively).

Table 4. In situ ruminal CP degradation kinetics and fractions of CP in Soybean-meal and Hazelnut-meal.

Items	Soybean-meal	Hazelnut-meal
K, h^{-1}	.1380 [b]	.1665 [a]
Lag time, h	2.70 [a]	1.15 [b]
WSP, % of total CP	18.96 [b]	46.88 [a]
PDP, % of total CP	70.04 [a]	49.56 [b]
NDP, % of total CP	11.00 [a]	3.56 [b]
EPP, % of total CP	31.93 [a]	6.58 [b]

[ab] Means in rows with different superscripts differ (P<.05).

High in situ ruminal DM degradability and soluble CP content of HZM has resulted in a greater rate of CP degradability compared with SBM. The rate of CP degradability for SBM was in range of the rate of CP degradability reported in the literature (16, 20). The rate of CP degradability for HZM was greater than that of Sarıçiçek (16), but lower than that of Yalçın et al. (2). HZM has been reported to be very rich in WSP content (2). Water soluble protein content of SBM was similar to those of NRC (5), Krishnamoorthy et al. (18), and Wolth et al. (21). NDP content of SBM and HZM were in agreement the literature (2, 16). Because soluble CP content of HZM was almost 50 %, only about 50 % of CP left for other fractions. In addition to higher rate of DM degradation, considerably high soluble CP content of HZM has resulted in an extremely lower percentage of escape protein (EPP) compared with SBM . Escape protein content of SBM was in agreement with the value reported in NRC (5).

Implications

Like soybean meal, hazelnut-meal is high in CP and highly digestible. Therefore, hazelnut-meal may be substituted with soybean-meal as a protein supplement for ruminants. Unlike soybean-meal, hazelnut-meal is very low in CP escaping ruminal degradation. Thus, It should be supplemented with protein sources, which is high in UIP when fed to high producing dairy cows or fast growing beef steer and bulls.

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