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Determination of rumen degradability of some oilseeds and meals using nylon bag technique

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Summary: The present experiment was carried out to determine the rumen dry mater (DM) and crude protein (CP) degradability of poppy seed meal, poppy seed, canola meal, sesame seed, hemp seed and groundnut meal. Three ruminally cannulated Merino rams weighing approximately 60 kg were used in the present experiment. Two nylon bags were used for each feed and each time of incubation per sheep. The bags were incubated in the rumen of each animal for 2, 4, 8, 16, 24 or 48 h. Significant ($p<0.001$) differences were obtained among the oilseeds and meals for DM and CP degradability according to feed samples and incubation times. Dry matter degradabiliy of canola meal was found slower than those of the other feeds up to 16 h incubation time. Hemp seed had the slowest dry matter degradability from 16 h to 48 h of incubation. Among the test materials poppy seed reached the lowest CP degradability at 24 h of incubation. Sesame seed was seen to have highest CP degradation at end of the 48 h of incubation. Although hemp seed protein degraded sharply at 2 h incubation period it showed a stabile degradation by the time. Dry matter 'a' fractions of feeds ranged from 12.18 % (canola meal) and 36.89 % (poppy seed). Although the effective dry matter degradability value for canola meal (49.62 % for 0.06 h^{-1}) was the lowest, sesame seed (64.37 %, 0.06 h^{-1}) dry matter P_e was determined as the highest value. The lowest effective crude protein degradability value was seen for poppy seed (54.05 %, 0.06 h^{-1}).

Key words: Meal, nylon bag technique, oilseed, rumen degradability,

Bazı yağlı tohumların ve küspelerin rumen parçalanabilirliklerinin naylon kese tekniği kullanılarak belirlenmesi

Özet: Bu çalışma haşhaş tohumu küspesi, haşhaş tohumu, kanola küspesi, susam tohumu, kendir tohumu ve yerfıstığı küspesinin rumendeki kuru madde ve ham protein parçalanabilirliğini belirlemek amacıyla gerçekleştirilmiştir. Çalışmada canlı ağırlığı yaklaşık 60 kg gelen rumenlerine 3 adet kanül yerleştirilmiş erkek merinos koyunlar kullanılmıştır. Koyunların her birinde yem çeşidi ve inkübasyon zamanı için 2 adet naylon kese kullanılmıştır. Naylon keseler her hayvanda 2, 4, 8, 16, 24 ve 48 saatlik süreler için inkübasyona bırakılmıştır. Yem maddeleri arasında yem örneklerine ve inkübasyon sürelerine göre kuru madde ve ham protein parçalanabilirliği bakımından istatistik önem ($p<0.001$) taşıyan farklılıklar elde edilmiştir. Kanola küspesinin 16 saatlik inkübasyon süresine kadarki dönemde kuru madde parçalanabilirliği diğer yem örneklerinden düşük bulunmuştur. Kendir tohumu, 16-48 saatlik inkübasyon süreleri arasında kuru madde parçalanabilirliği en düşük olan yem maddesi olmuştur. İncelenen test materyalleri arasında haşhaş tohumu ilk 24 saatte en düşük ham protein parçalanabilirliğine sahip yem maddesi olmuştur. Kırk sekiz saatlik inkübasyon dönemi sonunda susam tohumunun en yüksek protein parçalanabilirliğine sahip olan yem maddesi olduğu görülmüştür. İlk iki saatte çok hızlı parçalanma göstermesine rağmen kendir tohumu proteini daha sonraki saatlerde oldukça stabil bir parçalanma seyri göstermiştir. Yem maddelerinin kuru madde 'a' fraksiyonu % 12.18 (kanola küspesi) ve % 36.89 (haşhaş tohumu) arasında değişiklik göstermiştir. Kanola küspesinin efektif (P_e) kuru madde parçalanabilirliği (% 49.62, 0.06 h^{-1}) en düşük olmasına karşılık, susam tohumunun kuru madde P_e değeri en yüksek (% 64.37, 0.06 h^{-1}) olarak belirlenmiştir. En düşük ham protein P_e değerine sahip yem maddesinin haşhaş tohumu olduğu (% 54.05, 0.06 h^{-1}) görülmüştür.

Anahtar sözcükler: Küspe, naylon kese tekniği, rumen parçalanabilirliği, yağlı tohum.

Introduction

The nylon bag technique is a simple means of obtaining estimates of potential degradability of supplements and feedstuffs for ruminants. Inclusion of values for fractional clearance of undigested feed residues from the rumen degradability provides estimates the rate of degradation of the various components of the test material which more closely approximate true degradability of the material in the rumen (4).

Protein requirements for ruminants are satisfied from microbial protein, synthesised in the rumen from degradable protein (RDP) and from rumen undegradable dietary protein (UDP) which is unaffected by the rumen microorganisms prior to entering the abomasum and

small intestine. The acknowledgement that the ruminant has a requirement for both RDP and UDP has given rise to the importance of investigating the degradability of feedstuffs in the rumen. Hence, considerable attention has been placed in recent years on determining the degradability of feedstuffs. The *in sacco* DM and CP degradabilities will be useful in identifying the best materials for use in practical ruminant diets.

Little is known about the nutritive value of feedstuffs such as poppy seed, poppy seed meal, hemp seed and sesame seed and very limited data for some of them have been found in the literature regarding their rumen degradability. Annual production of poppy seed in Turkey exceeds 11 564 t (12). Because large quantities of these crops (especially poppy seed and sesame seed) are present in Turkey, it is needed to study their rumen degradability characteristics due to possible usage of them as alternative animal feed.

Hemp is an annual herbaceous plant. Traditionally, hemp is grown as a fiber crop in areas with temperate climates. Hemp seeds are also a valuable alternative commodity for animal nutrition. The seed contains 30 to 35% oil, 80% of which is polyunsaturated fatty acids(15). No data have been also found for degradability of hem seed.

Canola press-cake is an intermediate product in the manufacturing process of canola oil after cooking and screw pressing stages and just before the solvent extraction of oil fraction. With partial removal of oil from seeds during screw pressing, oil concentration in resultant press-cake is turned out to be about 21% (11, 16). Canola meal is receiving increased attention as a feed ingredient and considered to be a premium ingredient owing to the high quality of its protein with respect to requirements for milk production. With these high level of fat and protein, press-cake can be utilised as both protein and high energy sources similar to canola seed. Groundnut meal is also a safe feed for all classes of livestock because of its good protein balance. Rumen dry matter and crude protein degradability of canola meal and groundnut meal widely used in cattle rations has been studied. Comparatively little work has been published evaluating the degradability characteristics of seeds and meals used in the current experiment. This prompted us to perform the present study to determine the degradability of poppy seed, poppy seed meal, hemp seed, sesame seed, canola meal and groundnut meal.

Material and Method

Animals and diet: Three ruminally cannulated Merino rams weighing approximately 60 kg about three years of age were housed individually in metabolism cages and given free access to drinking water and fed twice daily in two equal meals (at 9:00 and 16:00 h) consisting alfa alfa hay (900 g) and concentrate (200 g) after 15 days adaptation period as a pre-experimental period. The concentrate consisted of barley (50 %), sunflower meal (25 %), wheat bran (21 %), salt (1 %), dicalcium phosphate (1 %), $CaCO_3$ (1 %) and vitamin-mineral premix (1 %). Premix per kilogram provided 1 333 335 IU vitamin A, 133 333 IU vitamin D_3, 1 g vitamin E, 185.8 g Ca, 120.6 g P, 5 g Fe, 1 g Cu, 30 g Mg, 6 g Mn, 25 mg Se, 82 mg I, 60 mg Co, 36 g N and 7.2 S.

Feed samples: Poppy seed, poppy seed meal, canola meal, sesame seed, hemp seed and groundnut meal were evaluated *in sacco*. Oil seeds were placed in to nylon bags after milling process. Meals obtained mechanically extraction were also used in the present experiment as test materials. Feed samples had the suitable particle size (approximately 3 mm) for nylon bag procedure.

Nylon bag incubation: All samples were incubated using the nylon bag procedure as outlined by Orskov and Mcdonald (19). The bags with 9 × 14 cm inner dimensions and a pore size of 40 µm were filled with approximately 3 g of sample and incubated in the rumen of each animal for 2, 4, 8, 16, 24 or 48 h. Bags were attached to polyvinil string 30 cm long and 0.6 cm diameter and suspended in the rumen. Nylon bags were used in duplicate for each feed at each time of incubation per sheep. After rumen incubation individual bags with contents were washed in running tap water until the rinse water flowing through the bags was free of rumen matter. Bags were then dried to a constant weight at 60ºC until constant weight. After drying all bags were weighed individually.

Analyses: Samples were analysed for dry matter (DM), ash, crude protein (CP), crude fiber, ether extract by procedures of Association of Official Analytical Chemists (1). The nylon bag residues were subjected to nitrogen determination by the Kjeldahl method multiplied by a factor of 6.25 (7). The CP disappearance was determined on the basis of six values obtained for each treatment.

Rumen degradability calculation and statistical analysis: The degradabilities of material in the nylon bags were calculated by the formula described by Orskov and Mcdonald (19) using a "Naway" program. The equation used for calculating rumen DM and CP degradability was as follows:

$$P = a + b\,(1 - e^{-ct})$$

Where 'P' is the amount degraded at a time, *a* the rapidly soluble fraction (g/kg), *b* the potentially degradable fraction (g/kg), *c* the constant rate of disappearance of *b*, *t* the time of incubation (h),

The equation used for calculating the effective degradability of feeds was as shown below where 'P_e' was defined as effective degradability of nutrients, '*k*' was the fractional ruminal outflow rate. The variables '*a*', '*b*' and '*c*' were as defined above. Effective

degradability was calculated with an estimated solid outflow rate from the rumen (*k*) of 0.02, 0.04, 0.06, 0.08 and 0.10 h^{-1} (4).

$$P_e = a + \frac{bc}{k+c}$$

Data for all response variables were subjected to analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS, Inc., Chiago, II, USA) and significant differences between treatments means were determined by Duncan's Multiple Range Test (8) with a 5 % level of probability.

Results

Nutrient analysis of oilseeds and meals: The chemical composition of the feed samples used in the present experiment and values reported in the literatures are presented in Table 1. *In sacco* DM and CP disappearances values are given in Table 2 and Table 3, respectively. Table 4 illustrates dry matter and crude protein degradability characteristics and effective degradability values of feed samples**.** Dry matter content of the samples ranged from 91.7 % (poppy seed meal) to 96.2 % (poppy seed). Groundnut meal had the highest level ash. Substantial differences in ether extract and crude protein were noted among samples. Meal samples included relatively high level oil (from 9.3 % for groundnut meal to 18.3 % for poppy seed meal) when compared to meals produced by solvent extraction. Crude protein of poppy seed meal was the highest (31.4 %) followed by canola meal (25.9 %).

*In sacco disappearances and degradability characteristics of feed samples***:** Dry matter degradability significantly ($p<0.001$) differed between several feeds. In addition, significant variations ($p<0.001$) were also determined among the feeds according to incubation times. Dry matter degradability value changed between 24.65 % (Canola meal) (2 h incubation) and poppy seed (86.66 %) (48 h incubation). Dry mater degradation of canola meal was slower than those of the other feeds until 16 h incubation time. The slowest degradation was observed for hemp seed from 16 h to 48 h. Hemp seed

Table 1. Chemical composition of oilseeds and meals and values reported in the literatures (% DM)
Tablo 1.Yağlı tohumların ve küspelerin kimyasal bileşimleri ve literatürde bildirilen değerler (% KM)

	Reference	Dry matter	Ash	Crude fiber	Ether extract and oil extraction	Crude protein
Poppy seed meal		91.7	11.4	11.2	18.3*	31.4
	17	92.9	12.2	4.80	11.9*	44.0
	10	91.1	17.5	6.90	6.30*	43.7
	18	90.7	13.3	8.90	6.60*	46.4
Poppy seed		96.2	6.20	9.70	49.9*	19.9
Canola meal		93.4	6.10	12.7	19.5*	25.9
	9	92.0	-	-	1.20 SE	44.0
	9	90.0	-	-	-	35.6
	19	-	7.40	-	5.40 ME	37.8
	16	-	-	-	ME	30.0
Sesame seed	-	94.3	4.80	16.0	51.2*	17.3
Hemp seed	-	93.0	5.80	13.4	30.3*	23.3
Groundnut meal	-	93.8	25.5	10.7	9.30*	22.8
	9	92.0	-	-	1.40 SE	52.3
	9	92.0	-	-	- ME	43.2
	3	90.0	5.02	8.30	2.47 SE	45.6

SE: Solvent extraction, ME: Mechanical extraction, *: Extraction method is unknown

Table 2. Dry matter degradability levels (%) of feed samples.
Tablo 2. Yem örneklerinin kuru madde parçalanabilirlik düzeyleri (%).

n=6

	Time of incubation in the rumen (h)						
	2	4	8	16	24	48	SEM
Poppy seed meal	41.82^{dA}	45.11^{bAB}	49.36^{bB}	58.15^{abC}	69.86^{bD}	77.20^{bE}	2.25
Poppy seed	40.54^{cdA}	48.87^{bB}	54.27^{cC}	60.95^{bD}	73.38^{bcE}	86.66^{cF}	2.65
Canola meal	24.65^{aA}	28.52^{aB}	38.02^{aC}	60.66^{bD}	72.38^{bcE}	75.03^{bE}	3.48
Sesame seed	37.08^{bA}	48.64^{bB}	63.45^{dC}	69.15^{cC}	82.65^{dD}	86.28^{cD}	3.05
Hemp seed	43.25^{dA}	49.28^{bB}	52.81^{bcC}	53.28^{aC}	57.65^{aD}	58.29^{aD}	0.94
Groundnut meal	37.92^{bcA}	46.55^{bB}	61.10^{dC}	63.17^{bcC}	75.76^{cD}	82.11^{cD}	2.79
SEM	1.11	1.48	1.52	1.21	1.40	1.78	

Means for feedstuffs on the same column followed by different letters (small letter) differ significantly ($p<0.001$)
Means for feedstuffs on the same line followed by different letters (big letter) differ significantly ($p<0.001$)

Table 3. Crude protein degradability levels (%) of feed samples.
Tablo 3. Yem örneklerinin ham protein parçalanabilirlik düzeyleri (%).
n=6

	Time of incubation in the rumen (h)						
	2	4	8	16	24	48	SEM
Poppy seed meal	51.29^{dA}	56.92^{bB}	62.45^{bC}	66.39^{bcD}	77.68^{bcE}	83.50^{aF}	1.93
Poppy seed	23.94^{aA}	45.48^{aB}	49.50^{aBC}	52.95^{aC}	68.89^{aD}	88.44^{bE}	3.42
Canola meal	49.37^{dA}	57.30^{bB}	61.11^{bC}	75.95^{dD}	81.84^{dE}	84.19^{aE}	2.23
Sesame seed	35.35^{bA}	50.36^{aB}	62.54^{bC}	72.32^{cdD}	86.50^{eE}	89.63^{bE}	3.32
Hemp seed	68.33^{eA}	71.80^{cB}	78.01^{dC}	77.39^{dC}	80.46^{cdD}	82.71^{aE}	0.85
Groundnut meal	39.77^{cA}	48.61^{aB}	67.80^{cC}	63.46^{bC}	76.17^{bD}	88.88^{bE}	2.93
SEM	2.38	1.65	1.52	1.64	1.04	0.65	

Means on the same column followed by different letters (small letter) differ significantly ($p<0.001$)
Means on the same line followed by different letters (big letter) differ significantly ($p<0.001$)

Table 4. Dry matter and crude protein degradability characteristics and effective degradability values of feed samples.
Tablo 4. Yem örneklerinin kuru madde ve protein parçalanabilirlik karakteristikleri ve efektif parçalanabilirlik değerleri.
n=6

Feedstuffs	Dry matter				Crude protein			
	a* %	b* %	c** Fraction/h	P_e* % 0.06	a* %	b* %	c Fraction/h	P_e* % 0.06
Poppy seed meal	36.57 ^{b}	46.03 ^{b}	0.0503 ^{a}	56.40 ^{c}	48.37 ^{c}	39.73 ^{b}	0.0519	64.92 ^{b}
Poppy seed	36.89 ^{b}	55.07 ^{bc}	0.0451 ^{a}	59.96 ^{d}	25.04 ^{a}	69.39 ^{d}	0.1348	54.05 ^{a}
Canola meal	12.18 ^{a}	67.30 ^{d}	0.0766 ^{a}	49.62 ^{a}	42.68 ^{bc}	43.35 ^{b}	0.0871	68.17 ^{c}
Sesame seed	27.64 ^{b}	60.09 ^{cd}	0.1014 ^{a}	64.37 ^{e}	25.83 ^{a}	66.51 ^{d}	0.1001	65.95 ^{b}
Hemp seed	35.48 ^{b}	25.87 ^{a}	0.2181 ^{b}	52.28 ^{b}	64.38 ^{d}	17.87 ^{a}	0.1435	76.40 ^{d}
Groundnut meal	29.05 ^{b}	55.67 ^{bc}	0.1024 ^{a}	61.09 ^{d}	35.25 ^{b}	55.52 ^{c}	0.1349	64.68 ^{b}
SEM	1.97	2.59	0.0164	0.92	2.60	3.18	0.0142	1.11

Means for feedstuffs on the same column followed by different letters differ significantly (* $p<0.001$, ** $p<0.01$)

had very low DM degradability (58.29 %) at the end of last incubation when compared to other test materials.

CP degradability values of feed samples ranged from 23.94 % (poppy seed) (2 h incubation) to 89.63 % (sesame seed) (48 h incubation). Similar trend was seen for CP degradability. Significant differences ($p<0.001$) among the some feeds and incubation times were also obtained for CP degradability. Poppy seed reached the lowest CP degradability in all incubation periods with exception 48 h incubation period. Although crude protein of hemp seed degraded sharply in the first incubation phase the lowest CP degradability (82.71 %) was seen at the end of 48 h incubation. However sesame seed reached the highest CP degradation at the 48 h incubation period.

The '*a*' fraction values of dry matter ranged from 12.18 % (canola meal) to 36.89 % (poppy seed). Although the effective DM degradability for canola meal (49.62 % for 0.06 h^{-1}) was the lowest, sesame seed (64.37 %, 0.06 h^{-1}) dry matter P_e was the highest. The lowest effective CP degradability value was that for poppy seed (54.05 %, 0.06 h^{-1}). Hemp seed also had the lowest CP '*b'* fraction *(*25.87 %). The lowest DM '*a'* fraction and the highest DM '*b'* fraction were determined for canola meal. Crude protein '*a*' fraction of poppy seed was much lower than that of poppy seed meal.

Discussion and Conclusion

Nutrient composition of oilseeds and meals: The chemical composition of the seeds and meals were variable among the studies. Dry matter of poppy seed meal (91.7 %) and ash content (11.4 %) determined by the present investigation are nearly similar to literature values reported by Friesecke (10) (91.1 %), Naik (17) (92.9 % -12.2 %). However higher crude fiber (11.2 %), ether extract (18.3 %) and lower CP (31.4 %) were observed when compared the findings of the researchers. The lower level CP of poppy seed meal could be attributed to higher level of ether extract and crude fiber. Canola meal DM content (93.4 %) was approximately similar to data reported in the literatures. However, crude protein level of the canola meal (25.9 %) obtained in the present experiment was the lowest than values of NRC (18) (37.8 %) and Mustafa et al. (16) (30.0 %) obtained as a result of mechanical press. Ether extract in the canola meal was (19.5 %) high probably due to insufficient mechanical press to dissociate oil in the sample. This also caused a decrease in CP level (25.9 %) in the feed. Differences were determined for crude protein level in groundnut meal. Lower CP (22.8 %) was observed for groundnut meal. Lower ether extract level (2.47 %) and higher protein level (45.6 %) in the groundnut meal (3) are probably the result of solvent

extraction method used to remove oil. Groundnut meal had the highest level ash. Ash content of groundnut meal might probably be due to high level of soil content of groundnut. Available data show evidence of a great variability for feeds. Variations in nutrient composition among the feed materials might be attributed to differences in sample origin and analysis methods.

In sacco disappearances and degradability characteristics of feed samples: The present study was designed to investigate the ruminal degradation of the oilseeds and meals. Data for *in vitro* degradabilitiy of these feed samples are limited and there is inadequate information on the nutritive value of these seeds for ruminants. More comprehensive experiments using the nylon bag procedure should be conducted using these oilseeds to determine their degradability properties.

Dry matter degradability of poppy seed was high and data show that prolongation of incubation time might probably have caused more degradation. Hemp seed had the lowest DM and CP degradability at the end of 48 h incubation. This result might be attributed its high ether extract level. High values for '*a'* are usual for canola meals (11). The result obtained for the soluble DM fraction '*a*' in canola meal (12.18 %) was much lower than that reported by Seoane et al. (20) (31.4 % for canola meal), Liu et al. (13) (29.4 % for canola meal), Arif (2) (18.8 % for canola meal) and Tuncer et al. (22) (36.6 %). Canola meal DM '*b*' potentially degradable fraction (67.30 %) obtained in the present study was close to values reported by Seoane et al. (20) (62.6 %). The high values P_e of DM and CP are indicative of a high rumen microbial activity. Result for P_e at an outflow rate of 0.06 h. (68.17 %) is close the value indicated by Boila and Ingalls (6) (67.3%) for canola meal at an outflow rate of 0.05 h. As far as our knowledge no data have been for poppy seed, poppy seed meal, hemp seed and sesame seed degradability. Results obtained in the current study serve as table values for these feeds. Crude protein '*a*' fraction of poppy seed was much lower than that of poppy seed meal. This result could perhaps be explained by ether extract level of poppy seed resulting in a protective effect on crude protein degradability, mainly at the start of the incubation. Indeed the crude protein '*b*' fraction of poppy seed was greater than that of poppy seed meal. The degradation profile could be changed by feed processing methods. Higher temperature treatment during the feed manufacturing could increase the amount of nitrogen permanently bound to the fibre in feeds causing decreases the content of available nitrogen for rumen microorganisms. Canola meal used in the studies noted in this paper was mostly obtained by solvent extraction method resulting lower ether extract. It is well known that higher ether extract intakes by ruminants adversely affects microbial functions (5, 14) and in a feeding experiment in which canola seed ether extract was incorporated in the diet of bulls, a depression in rumen fermentation and a reduction in apparent cell wall digestibility was found (21). Discrepancies in reported in situ disappearance values can be attributed to varietal differences in the meal incubated, bag por size (in the loss of fine particles through the bag pores rather than to differences in true solubility), in situ technique, basal diet or variation in the extent of microbial contamination of the incubated samples, amount of sample (the loss of particles from the bag is mainly related to sample preparation).

With the advances in modern livestock production, it is importance for farmers to be able to predict as accurately as possible the amount of feed and true feed required to formulate an optimal diet to sustain a desirable level of production. Availability of feed databases for as many locally available feeds as possible are highly desirable due to the fact that most feedstuff tables portray data derived from different countries. The variation present in the chemical composition and dry matter and crude protein degradability characteristics of feedstuffs examined in this paper should be taken into consideration and established the need for adequate analysis prior to being included into any ruminant diet. Data here in serve the table values to researchers about these feeds. However, more studies are needed to improve its accuracy.

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