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Effects of the Supplementation of Yeast, Molasses and Barley to Barley Straw Diets on the Intake, Digestibility and Ruminal Fermentation in Sheep

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Abstract: The effects of the supplementation of yeast, molasses and barley to barley straw diets on the dry matter intake, digestibility and ruminal fermentation in sheep were investigated.

Ten male merino sheep were used in a changeover design trial of five 30-day periods. Baker's yeast (50 g/kg straw), molasses (100g/kg straw) and barley grain (100 g/kg straw) were given either separately or in combination as supplements to barley straw.

Supplementation increased the total dry matter intake by 18.2-36.8 %. Supplements given alone or in combination had no effect on dry matter and organic matter digestibility of the diet. Crude protein digestibility was decreased with molasses supplementation. Crude fiber digestibility was not affected by baker's yeast supplementation but decreased with other supplements. The digestibility of nitrogen free extract was increased with carbohydrate supplementation.

Rumen pH, total volatile fatty acids and ammonia-nitrogen values were not influenced significantly ($p>0.05$) by supplementation.

As a conclusion, when urea to meet the requirements for rumen degradable N and vitamin-mineral premixes were mixed throughly with barley straw, usage of moderate levels of baker's yeast, molasses, barley grain or the mixture of them increased total dry matter and crude protein intake, but didn't affect the digestibilities of dry matter and organic matter of diets and rumen parameters in sheep.

Key Words: barley straw, supplementation, intake, digestibility, ruminal fermentation.

Arpa Samanlı Rasyonlara Maya, Melas ve Arpa İlavesinin Koçlarda Yem Tüketimi, Sindirilebilirlik ve Rumen Fermantasyonu Üzerine Etkileri

Özet: Arpa samanlı rasyonlara, maya, melas ve arpa ilavesinin koçlarda kuru madde tüketimi, sindirilebilirlik ve rumen fermentasyonu üzerine etkileri incelenmiştir.

On baş merinos koçu, 30 günlük dönemler halinde 5 değişimli deneme düzeninde kullanılmıştır. Arpa samanına, ekmek mayası (50 g/kg saman), melas (100 g/kg saman) ve arpa danesi (100 g/kg saman) ayrı ayrı ve kombinasyon halinde ilave edilmiştir.

İlave yapılması toplam kuru madde tüketimini % 18.2-36.8 düzeyinde arttırmıştır. Tek başına veya karışım halinde ilave edilen yem maddeleri, rasyonun kuru madde ve organik madde sindirilebilirliğini etkilememiştir. Ham protein sindirilebilirliği, melas ilavesiyle azalmıştır. Ham selüloz sindirilebilirliği, ekmek mayası ilavesiyle etkilenmemiş, fakat diğer yem maddelerinin ilavesiyle azalmıştır. Azotsuz öz madde sindirilebilirliği, karbonhidrat ilavesiyle artmıştır.

İlavelerden rumen pH, toplam uçucu yağ asitleri ve amonyak azotu değerleri önemli ölçüde ($p>0.05$) etkilenmemiştir.

Sonuç olarak, vitamin-mineral premiksi ile rumende parçalanabilen azot gereksinimini karşılamak için üre, arpa samanına homojen bir şekilde karıştırıldığı zaman, orta düzeylerde ekmek mayası, melas ve arpa danesinin ayrı ayrı veya karışım halinde ilavesi, koçlarda toplam kuru madde ve ham protein tüketimini arttırmış fakat rasyon kuru madde ve organik madde sindirilebilirliği ile rumen parametre değerlerini etkilememiştir.

Anahtar Sözcükler: Arpa samanı, ilave, tüketim, sindirilebilirlik, rumen fermantasyonu

Introduction

Nearly 33.7 million tonnes of cereal straws are produced in Türkiye (1). Most of this are given to livestock. However they are of limited nutritional value because of their low nitrogen and high ligno-cellulosic contents.

In recent years there has been much interest in developing methods improving straw and other low-digestibility roughages by physical, chemical, physicochemical and biological treatments. Energy and protein supplements have been also used to increase the feeding value of

straw. However many studies show that rumen conditions for fibrolysis can become adverse when the level of energy supplement in the diet increases, depending on the type of supplement (2, 3), the level of supplementation (2, 4-6) and the quality of the basal roughage (7, 8). Barley grain or molasses supplementation would result in a rumen pH owing to the presence of soluble carbohydrate (5, 9) whilst cotton seed meal, fish meal supplementation would increase the nitrogen supply to rumen microorganisms (10, 11). The effect of these supplements would be to alter the population of bacteria and protozoa which vary in their ability to adhere and to digest plant cell walls (12).

The present experiment was designated to evaluate the effects of the supplementation of yeast, molasses and barley to barley straw diets on the intake, digestibility and ruminal fermentation in sheep.

Materials and Methods

Animals and feeds

In experiment ten male merino sheep aged 6 months were used. Their average weight was about 35.7 kg (s.e. 0.67 kg). All the animals were dewormed and indoors in individual pens and had free access to water.

Straw was shredded through a bale grinder with a 40 mm screen. Urea was added to meet requirements for rumen-degradable N (13). The straw was supplemented with 5 g salt, 3 g vitamin-mineral premix, 5 g dicalcium phosphate, 10 g limestone, 25 g urea and 3.5 g Na_2SO_4 per kg (air dry) straw. The vitamin-mineral premix provided per kg 1.333.335 IU vit A, 133.333 IU vit D_3, 1 g vit E, 185,8 g Ca, 120,6 g P, 30 g Mg, 25 mg Se, 82 mg I, 60 mg Co, 5 g Fe, 1 g Cu, 6 g Mn, 36 g N, 7,2 g S. Baker's yeast (*Saccharomyces cerevicia*), molasses and barley grain were given as supplements for straw diets. They were given either alone or in combination to form the following diets:

Diet	Dietary costituents
1	basal straw (S)
2	1 kg basal straw+50 g baker's yeast (Y)
3	1 kg basal straw-100 g molasses (M)
4	1 kg basal straw+100 g barley grain (B)
5	1 kg basal straw+50 g baker's yeast+100 g molasses+100 g barley grain (YMB)

The term basal straw is here defined as straw supplemented with urea, vitamins and minerals.

The composition of the straw and supplements is shown in Table 1.

Experimental procedures

Ten sheep were used in a changeover design trial of five 30-day periods. Five experiments were conducted using 10 sheep per experiment. Animals were allocoted into five groups of two, each group receiving either basal straw or basal straw with each supplements throughout the experiment.

The animals were given basal straw and supplements in two equal amounts twice daily at 9^{00} and 16^{00} h. Straw and supplements were given together. Diets were offered ad libitum with the new feed being given at each feeding time and to allow at least 15% refusals, Residues were collected before the morning feed, bulked and weighed.

Each experimental period lasted 30 days, comprising 22 days adaptation, 7 days of total collection of faeces and 1 day for sampling rumen content.

Total collection of faeces was facilitated by harnenesses and collection bags which were emptied daily. Daily aliquots of faeces were weighted. A 10 % of each was sampled, bulked for each animal over 7 days and stored at -18^0C for analysis. Residues of feeds were also sampled, bulked for each animal over collection period and stored for analysis.

Rumen fluid samples were obtained by stomach tube after 4 h feeding. Rumen fluid pH was determined immediately using a pH meter. Total volatile fatty acids (TVFA) and ammonia nitrogen (NH_3-N) of rumen fluid were determined by Markham distillation method (14).

All feed, orts and faecal samples for chemical analyses were ground to pass through a sieve size of 1 mm. Crude protein (CP) content were determined using the macro-Kjeldahl method as outlined by the Association of Official Analytical Chemists (15). The dry matter (DM), organic matter (OM), crude fibre (CF) and ether extract (EE) were also determined according to the procedures described by AOAC (15).

Statistical analysis

All data were analysed by using latin squares design on repeated measurements (16). Significant differences

Table 1. Chemical composition of experimental feeds (g/kg dry matter)

	Dry matter	Organic matter	Crude protein	Crude fibre	Ether extract	Nitrogen free extract
Barley straw	922	937	63	414	7	453
Baker's yeast	912	949	506	4	8	431
Molasses	774	910	127	-	-	783
Barley grain	891	965	141	42	19	763

between treatment means were determined by Duncan's multiple range test (17).

Results

The effects of supplementation on total DM intake, chemical components of orts and apparent digestibility of nutrients in total diet are shown in Table 2. Supplementation increased the DM intake. Supplementation of 50 g baker's yeast per head per day increased DM intake by 18.2 % although the difference was non-significant (p>0.05). Supplementation increased crude protein intake significantly (p<0.01). A signigicant increase (p<0.01) in CP content and a significant decrease ((p<0.05) in CF content of the orts was observed in 3. and 5. diets containing molasses. The ratio of CP of orts to CP of diet 3 supplemented with molasses was significantly (p<0.05) higher than that of other diets.

Supplementation did not affect digestibility of DM or OM of the diet. The digestibility of CP and CF of the diet was decreased (p<0.01) with molasses supplementation. Baker's yeast supplementation did not affect (p>0.05) digestibility of nutrients.

Carbohydrate supplementation (molasses and/or barley grain) decreased apparent digestibility of CF but increased of nitrogen free extract.

The effects of treatments on ruminal pH, TVFA and NH_3-N concentration are shown in Table 3. Rumen pH, TVFA and NH_3-N values were not influenced significantly (p>0.05) by supplementation with yeast and/or carbohydrate.

Discussion

Supplementation increased the total DM intake by 18.2-36.8 %. Total DM intake were significantly higher (p<0.01) when molasses or barley or the mixture of molasses, barley and yeast were given than when the straw was not supplemented. Nakanishi et al. (5) reported that the effect of addition of molasses up to 6 % levels to urea-treated rice straw is mostly increasing the intake. Total DM consumption in sheep fed NaOH treated oat or wheat straw was significantly increased (p<0.01) by the addition of cottonseed meal or barley grain supplements (18). Addition of cottonseed cake to the diet significantly (p<0.05) improved the DM intake of straw from all varieties tested (10). Silva et al. (19) reported

Table 2. Effect of supplementation on total dry matter intake, crude protein intake, chemical components of orts and apparent digestitibility nutrients (mean±standard error of the mean)

Diet	Basal straw		Basal straw + baker's yeast		Basal straw +molasses		Basal straw + barley grain		Basal straw + baker's yeast +molasses+ barley grain		Level of significance[1]
Total dry matter intake (g/day)	670.8^{b}	40.8	792.9^{ab}	33.3	847.5^{a}	41.0	833.1^{a}	36.0	917.9^{a}	33.4	**
Total crude protein intake (g/day)	95.7^{d}	3.9	125.0^{b}	3.8	109.0^{c}	5.2	115.8^{bc}	3.6	137.4^{a}	4.6	**
Chemical components of orts (% of DM)											
Crude protein (CP)	9.5^{b}	0.4	9.8^{b}	0.5	11.5^{a}	0.4	8.9^{b}	0.4	11.6^{a}	0.3	**
Crude fibre (CF)	39.1^{a}	0.7	39.1^{a}	0.7	36.9^{b}	0.8	39.1^{a}	0.6	36.4^{b}	0.7	*
(CP of orts/diets)x100	74.8^{bc}	3.2	67.7^{c}	3.4	89.5^{a}	2.7	69.4^{c}	3.2	80.7^{b}	2.3	*
(CF of orts/diets)x100	99.5^{c}	1.8	103.6^{bc}	2.0	100.4^{c}	2.3	107.1^{ab}	1.8	110.8^{a}	2.0	**
Apparent digestibility of total diet (%)											
Dry matter	48.3	0.7	49.4	1.0	49.0	0.5	48.2	0.7	51.3	1.0	NS
Organic matter	51.5	0.9	52.6	1.0	50.7	0.6	51.1	0.7	53.4	1.0	NS
Crude protein	75.1^{a}	1.0	77.2^{a}	0.8	69.1^{b}	1.1	73.1^{ab}	0.5	73.4a^{b}	0.6	**
Crude fibre	59.8^{a}	0.8	59.1^{a}	1.0	54.7^{b}	1.1	54.2^{b}	1.0	50.8^{b}	1.4	**
Nitrogen Free extract	34.7^{c}	1.6	36.8^{c}	1.3	42.0^{b}	1.0	41.6^{b}	0.9	48.7^{a}	1.1	**

1: Means within treatments with the same superscripts in the rows are not significantly different (p>0.05).
NS: non-significant; *p<0.05; **p<0.01.

Table 3. Effect of supplementation on ruminal pH, TVFA (mmol/l) and NH3-N (mg/100 ml) concentration (mean±standart error of mean)

Diet	Basal straw	Basal straw +baker's yeast	Basal straw + molasses	Basal straw + barley grain	Basal straw + baker's yeast +molasses+ barley grain	Level of significance[1]
pH	6.4 0.1	6.4 0.1	6.4 0.1	6.5 0.1	6.5 0.1	NS
TVFA	87.0 4.9	88.3 6.1	86.0 7.4	86.0 5.1	88.8 4.8	NS
NH_3-N	12.1^{ab} 0.7	13.1^{a} 0.6	11.7^{b} 0.8	10.8^{b} 0.4	11.5^{b} 0.5	*

1: Means within treatments with the same superscripts in the rows are not significantly different (p>0.05).
NS: non-significant; *p<0.05.

that both fish meal (50 g/kg) and sugar beet pulp (150 g/kg), given alone or in combination significantly increased the total DM intake of sheep. Kellaway and Leibholz (20) reported that when rumen degradable nitrogen is non-limiting, dietary protein supplements, fed at moderate levels have negligible effects on roughage intake.

Supplementation increased crude protein intake significantly ($p<0.01$). Total crude protein intake was the highest when the mixture of baker's yeast, molasses and barley grain was added to basal straw.

The addition of barley supplements or the combination of baker's yeast, molasses and barley grain to barley straw caused a significant increase ($p<0.01$) in the ratio of CF content of orts to CF contents of diet.

Barley grain, molasses and baker's yeast when given either alone or in combination did not affect the DM and OM digestibility of the diet. CP digestibility was decreased with molasses supplementation. CF digestibility was not affected by baker's yeast supplementation but decreased with other supplements. The digestibility of nitrogen free extract was increased with carbohydrate supplementation.

Stewart et al. (21) concluded that high amounts of starch have detrimental effects on the digestion of roughages, but small amounts of readily available carboyhdrates stimulate bacterial digestion of straw. Zorilla-Rios et al. (3) reported that whole shelled corn supplementation increase ($p<0.03$) digestibilities of diet OM and strach but did not affect ($p>0.05$) digestibility of CP or cell wall fractions.

Huhtanen (22) reported that the inclusion of molasses in the diet improved the digestibility of DM ($p<0.01$), ash ($p<0.001$) and nitrogen free extractives ($p<0.01$) in cattle given a silage diet, but Nakanishi et al. (5) observed that molasses addition did not affect the digestibility of DM, OM, CP and cellulose. Williams (6) concluded that supplementation of ammonia treated straw with either fish meal, cassava or molasses tended to increase the digestibility of ADF and the apparent DM digestibility of the straw when the supplement constituted approximately 5 % of the DM of the diet. Similarly Silva et al. (19) reported that both fish meal (50 g/kg) and sugar beet pulp (150 g/kg) supplements, when given either alone or in combination, increased the DM and OM digestibility of total diet and straw in sheep.

Ruman pH, TVFA and NH_3-N were not influenced signigicantly ($p>0.05$) by supplementation in our experiment. Ruminal NH_3-N levels of group fed with baker's yeast were found to be higher than that of other groups. However, ruminal NH_3-N values were significantly higher ($p<0.05$) when baker's yeast was given than molasses, barley and the mixture of baker's yeast, molasses and barley grain were given. Huhtanen (22) and Combellas et al. (11) also observed no significant differences between the diets in rumen pH and TVFA. Amaning-Kwarteng and Kellaway (18) reported that cottonseed meal and barley grain supplements marginally lowered rumen pH and marginally decreased rumen NH3 concentrations but these differences were not statistically significant ($p>0.05$). They also concluded that these supplements increased significantly ($p<0.05$)TVFA concentrations in the rumen. Fondevila et al. (23) observed that supplementation of barley straw with rolled barley or pelleted sugar beet pulp depressed rumen pH and enhanced TVFA concentration but supplementation with meadow grasshay did not have any great effect. Ruminal NH3-N concentrations decreased ($p<0.01$) with whole shelled corn supplementation (3) but increased slightly with fish meal (11).

As a conclusion, when urea to meet the requirements for rumen degradable N and vitamin-mineral premixes were mixed throughly with barley straw, usage of moderate levels of baker's yeast, molasses, barley grain or the mixture of them increased total dry matter and crude protein intake, but didn't affect the digestibilities of dry matter and organic matter of barley straw diets and rumen parameters in sheep.

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