Iran Agricultural Research 13:49-66 (1994)

STUDIES ON THE FEEDING VALUE OF *GLYCYRRHIZA GLABRA* L. PULP FOR SHEEP

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(Received May 9, 1993)

ABSTRACT

Glycyrrhiza glabra L. (GG) pulp is a by-product which remains after extracting the roots of the plant for pharmaceutical purposes. The feeding value of GG pulp for sheep was investigated in two experiments.

The overall results from these experiments indicated that GG pulp contained (all dry matter basis; DM) 3.35-8.90% crude protein, 36.0-43.3% crude fiber, 36.4-47.7% nitrogen-free extractives (NFE), 3.51-3.60% crude fat and 7.80-9.47% ash; total digestible nutrients (TDN) value, measured on 11 rams, varied from 17.2 to 50.6. Digestion coefficients were also variable in both experiments. Levels of Ca and Mg (experiment 2) were 1.80% and 3.92%, respectively, but P was not detectable. The concentrations (micrograms per g DM) of K (200), Na (125), Fe (6.05), Mn (4.2), Zn (5.8) and Cu (5.0) in GG pulp were also measured. In the first experiment, rations containing 0, 15, 25 and 35% GG pulp were fed to 17-18 months old Mehraban and Ghezel ewes (n=7-8 per breed; n=15 per ration) for 80 days. Mean slaughter weight (P=0.056), total gain (P=0.0023) and gain:feed ratio (P=0.002) were lower at higher levels of GG pulp; however, mean feed intake did not differ amongst the experimental groups. Breed and ration interaction effects were not significant. The amount of cavity fats was lower, but empty stomach weight was greater for the sheep on GG pulp rations.

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In the second experiment, GG pulp was ensiled with urea, wet sugar beet pulp and molasses and the silages were fed to 17-18 months old Mehraban (n=35) and Ghezel (n=35) rams in a feedlot for 100 days. Each silage formed 40% DM of a fattening ration. Feedlot performance and carcass characteristics of GG pulp fed sheep were not different from the control sheep.

The results of these experiments show that GG pulp can be included in the ration of sheep, especially if ensiled with urea, molasses and sugar beet pulp; however, further longer-term experiments are recommended.

تحقیقات کشاورزی ایران

(۱۳۷۳) ۶۶-۴۹:۱۳

بررسی ارزش غذایی تفاله شیرین بیان برای گوسفند

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چکیـــده

تفاله شیرین بیان محصولی است که پس از عصاره گیری از ریشه شیرین بیان برای مصارف دارویی، بر جای می‌ماند. ارزش غذائی تفاله شیرین‌بیان برای گوسفند در دو آزمایش بررسی شد.

تفاله شیرین بیان مربوط به دو کارخانه در آزمایشهای هضمی که با قوچ انجام شد، به کار گرفته شد. نتایج این دو آزمایش نشان داد که تفاله شیرین‌بیان (براساس ماده خشک) دارای ۸/۹۰-۳/۳۵ درصد پروتئین خام، ۴۳/۳-۳۶/۰ درصد فیبرخام، ۴۷/۷-۳۶/۴ درصد NFE، ۳/۶۰-۳/۵۱ درصد چربی خام و ۹/۴۷-۷/۸۰ درصد خاکستر بود. مقدار TDN اندازه گیری شده بوسیله ۱۱ رأس قوچ بین ۱۷/۲ و ۵۰/۶ درصد متغیر بود. ضرائب هضمی نیز در دو آزمایش متغیر بودند. تراکم برخی از مینرالها در تفاله شیرین بیان مورد استفاده در یکی از آزمایش‌ها (آزمایش دوم)، نیز اندازه گیری شد. میزان کلسیم و منیزیوم به ترتیب ۱/۸۰ و ۳/۹۲ درصد بود ولی فسفر در تفاله شیرین بیان قابل

اندازه گیری نبود. غلظت (میکروگرم در گرم ماده خشک) پتاسیم (۲۰۰)، سدیم (۱۲۵)، آهن (۶/۰۵)، منگنز (٤/۲)، روی (۵/۸) و مس (۵) نیز اندازه گیری شد. در آزمایش اول جیره‌هایی که صفر، ۱۵، ۲۵ و ۳۵ درصد تفاله شیرین بیان داشتند برای ۸۰ روز به میش‌های ۱۸-۱۷ ماهه قزل و مهربان (۸-۷ میش از هر نژاد و ۱۵ میش برای هر جیره) تغذیه شدند. میانگین وزن کشتار (P=۰/۰۵٦) افزایش وزن روزانه (P=۰/۰۰۲۳) و نسبت افزایش وزن به خوراک مصرفی (P=۰/۰۰۲) برای سطوح بالای تفاله کمتر بود، اما میانگین مقدار غذای مصرفی بین گروهها تفاوتی نداشت. اثر متقابل نژاد - جیره معنی‌دار نبود. در گوسفندانی که با جیره‌های دارای تفاله شیرین بیان تغذیه شده بودند، مقدار چربی حفره‌های داخلی بدن کمتر ولی وزن معده خالی بیشتر از گروه شاهد بود.

در آزمایش دوم، تفاله شیرین بیان با اوره، تفاله‌تر چغندرقند و ملاس سیلو شد. سیلاژ تولید شده در یک دوره پرواری ۱۰۰ روزه به قوچ‌های ۱۸-۱۷ ماهه مهربان (۳۵رأس) و قزل (۳۵رأس) تغذیه شد. هر سیلاژ ٤۰ % از جیره پرواری را تشکیل می‌داد (براساس ماده خشک). عملکرد پرواربندی و ویژگیهای لاشه بین گوسفندان گروه شاهد و گروهی که با سیلاژ تغذیه شده بودند تفاوتی نداشت.

نتایج این آزمایش‌ها نشان می‌دهد که می‌توان تفاله شیرین بیان را در جیره‌های گوسفند، به ویژه وقتی با اوره، تفاله چغندرقند و ملاس سیلو شده باشد، به کار گرفت. به هرحال، انجام آزمایشهایی با دوره‌های طولانی‌تر توصیه می‌شود.

INTRODUCTION

Chronic feed shortage is a major limitation to animal production in many developing countries, including Iran, resulting in poor animal performance (4). Because conventional roughages such as alfalfa are relatively expensive in Iran, crop residues, especially wheat straw, are fed to ruminants in an increasing amount. Identification and use of potential non-conventional plant residues may partly alleviate the problem.

Glycyrrhiza glabra L. (GG), locally known as "shirin-bian" or "maak", is a natural vegetation in Iran, particularly in the Fars province. The roots of the plants have pharmaceutical usages. Large scale cultivation of GG is currently carried out in southern Iran. The roots were used to be exported to Europe in the past; however, at present three processing plants, all located in the Fars province, are involved with the extraction of the roots and exporting the extracted material as powder. The powder is used in pharmaceutical, confectionary and soft drink industries. The by-product of root extraction is referred to as GG pulp and contains a considerable amount of moisture. The pulp is generally piled in the factory yard where it creates storage problems. Some pulp is used as fuel by a number of brickyards and some is used as soil amendment. The monthly production of GG pulp is estimated at 12000 tons (as is) and is sold at 500 Rls per ton.

The purpose of the present experiments was to study the feeding value of GG pulp for sheep. In the first experiment, effects of GG pulp in the ration of ewes with a theoretical weight gain of about 100 g day^{-1} was investigated.

Urea treatment of wheat straw improves its nutritive value (2) and is practised by some farmers in Iran. Composition of GG pulp was found to be similar to wheat straw (Experiment I); therefore, urea treatment might similarly improve its feeding value. High quality agro-industrial by-products such as molasses and sugar beet pulp are not available in many parts of Iran on a year-round basis. On the other hand, there is a problem with storage of wet by-products if these are bulk-purchased. Ensiling of fibrous by-products with molasses, wet sugar beet pulp and urea, if

successful, will not only increase their nutritive values but it might also solve the problem of storage of wet sugar beet pulp and molasses. The second experiment was therefore conducted to study the possibility of ensiling wet sugar beet pulp, molasses and urea with GG pulp and wheat straw , and to investigate the effect of ensiling on the feeding value of these fibrous by-products for fattening sheep.

MATERIALS AND METHODS

Experiment I

Digestion trial: Chemical composition of GG pulp was determined according to AOAC methods (1). Digestion coefficients for crude protein (CP), crude fiber (CF) and crude fat or ether extract (EE), and the TDN value were determined by using five intact rams of a fat-tailed sheep breed. Concentrations of calcium (atomic absorption) and phosphorus (spectrophotometry) in GG pulp were determined by our colleagues in the Dept. of Soil Science by atomic absorption and spectrophotometric methods, respectively. The rams were fed a 1:1 mixture of alfalfa hay and GG pulp for a preliminary period of 14 days followed by a collection period of seven days. Digestion coefficients and TDN values were calculated as described by Crampton (3). Results are shown in Table 1.

Feeding trial: Sixty individually caged 17- to 18-month old ewes belonging to two fat-tailed breeds of local sheep (Mehraban and Ghezel) were allotted to four experimental groups on the basis of their body weights

Table 1. Composition of *Glycyrrhiza glabra* L. pulp (dry matter basis) in experiments I and II.

	Exp.I	Exp.II
Dry matter (%)	61.2	95.6
Crude protein (%)	8.90	3.35
Crude fiber (%)	43.3	36.0
NFE (%)	36.4	47.7
Ether extract (%)	3.60	3.51
Ash (%)	7.80	9.47
TDN (%)		
Mean ± SD	42.2 ± 6.7	22.5 ± 4.6
Range	35.1 - 50.6	17.2 - 29.9
Digestibility (%)		
Crude protein	34.0	3.6
Crude fiber	72.6	26.2
NFE	54.6	34.4
Ether extract	41.8	19.3
Minerals		
Ca (%)	1.80	1.92
P (%)	Not detected	Not detected
Mg (%)	ND	3.92
K (ug g^{-1})	ND	200
Na (ug g^{-1})	ND	125
Fe (ug g^{-1})	ND	6.05
Mn (ug g^{-1})	ND	4.2
Zn (ug g^{-1})	ND	5.8
Cu (ug g^{-1})	ND	5.0

ND : Not determined

(7-8 ewes per breed). Mean body weights of the ewes in the experimental groups were not statistically different and varied between 42.8-43.5 kg. Using data on chemical composition and TDN value of GG pulp from the digestion trial, four rations were prepared to give a theoretical weight gain of about 100 g/day. Ration 1 which contained 35% wheat straw (as fed; 90.0% dry matter) was chosen to serve as control. In ration 2, wheat straw was substituted by equal proportion of GG pulp. Ration 3 contained 25% GG pulp and 10% wheat straw, and ration 4 contained 15% GG pulp and 20% wheat straw. The common ingredients of the rations were: 35% alfalfa hay, 14% dried sugar beet pulp and 16% barley grains. All rations were adjusted to a common dry matter of 90.0%. The composition of the rations is shown in Table 2.

A generous amount of each ration was weighed and delivered to the feed trough at 8.00 a.m. Daily orts were removed and weighed before daily feed was added to the trough. The experimental rations were fed for 80 days and water and salt-lick were freely available during the feeding trial.

At the end of the trial, five Mehraban ewes were slaughtered from each experimental group and carcass characteristics were determined as described by Farid (6).

Experiment II

Digestion trial: Eventhough the composition of GG pulp had been determined in Exp. I, this digestion trial was conducted because GG pulp which was used in Exp. II had been obtained from a different processing plant. It was therefore necessary to evaluate it before

feeding. The trial was carried out with six rams as described in Exp. I. In addition to calcium and phosphorus (Exp. I), the levels of several other minerals in GG pulp were also determined by atomic absorption (Kindly performed by Dept. of Soil Sci.).

Feeding trial: Wheat straw and/or GG pulp were ensiled with wet sugar beet pulp, molasses and urea in ground silos. The DM content was adjusted to 30% for all silages and the ingredients were mixed thoroughly before ensiling. Four silages contained 68.7, 61.5, 52.4 and 40.5% DM wheat straw, respectively (S-1 to S-4). One silage contained 20.25% DM straw and an equal amount of GG pulp (S-5) and the last one contained 40.5% DM GG pulp (S-6). The composition of the silages is shown in Table 3.

Seven weeks after ensiling, the silages were fed during a 100-day fattening period to 17- to 18-month old Mehraban (n=35) and Ghezel (n=35) rams. Equal numbers of sheep were assigned to seven rations (six with silages and one with alfalfa hay). Each ration consisted of two parts which varied slightly during the first and second 50 days of the fattening period; the control sheep received 42% DM alfalfa hay (TDN=51 ;CP=14.7%) and the experimental sheep received an equivalent amount of the appropriate silages (S-1 to S-6). The other portion of the ration consisted of 22% alfalfa hay, 35% barley grains, 0.5% common salt, 0.45% steamed bone meal and 0.05% vitamin supplement (all DM basis).

During the second 50 days of the fattening period, 40% DM of each ration consisted of either alfalfa hay (control) or silages, and 60% of the ration contained 19% alfalfa hay, 40% barley, 0.5% common salt, 0.45%

Table 2. Composition (DM %) of the rations in experiment I†.

	Ration No.			
	1	2	3	4
TDN	58.7	55.0	56.1	57.1
Crude protein	10.0	10.5	10.3	10.0
Calcium	0.61	0.95	0.85	0.70
Phosphorus	0.15	0.12	0.12	0.13

† : For description of rations, please see the text.

Table 3. Silage (S-1 to S-6) ingredients and composition (DM %) in experiment II†.

Ingredients	S-1	S-2	S-3	S-4	S-5	S-6
Wheat straw	68.7	61.5	52.4	40.5	20.25	-
GG pulp	-	-	-	-	20.25	40.5
Sugar beet pulp	9.0	13.6	19.4	27.0	27.0	27.0
Molasses	19.8	22.2	25.2	29.2	29.2	29.2
Urea	2.5	2.7	3.0	3.3	3.3	3.3
Composition						
TDN	50.0	52.0	55.5	58.5	54.5	51.0
Crude protein	12.0	13.0	14.3	15.8	15.8	15.7

† : For description of rations, please see the text.

steamed bone meal and 0.05% vitamin supplement.

The sheep were fed gradually in an increasing amount with the appropriate ration for two weeks, followed by a 100-day fattening period. During the gradual feeding phase, four control sheep died, one due to suffocation and three due to overeating.

Weight gain, daily dry matter intake (DMI) and feed costs were determined at the end of the fattening period. Four Mehraban sheep from each ration group were slaughtered and several carcass traits were studied. The carcass traits considered were the weights of cold carcass, legs, shoulder, back joint, flap, neck and fat content (including the fat-tail). The length and width of the cross section of the *Longissimus dorsi* muscle and the backfat depth at 12/13th rib were also measured. The dissection procedure is described elsewhere (6).

Statistical Procedures

The data were analyzed by ANOVA procedure of SPSS-PC with the body weight as covariate. Mean separation was performed by Tukey's procedure (7).

RESULTS AND DISCUSSION

Composition of GG Pulp

The chemical composition, digestion coefficients and TDN values of GG pulp in both digestion trials are shown in Table 1. The CP content and TDN value of the pulp used in Exp. II were 40 and 50%, respectively, of the values in Exp. I. There were marked individual variations in the ability

of sheep to utilize the GG pulp as shown by the ranges of TDN values (50.6 in Exp. I to 17.2 in Exp. II). Mean TDN value was 42.2 in Exp. I and 22.5 in Exp. II. As far as TDN values are concerned, GG pulp may at best be compared with straw. Further studies are required to obtain a more accurate estimate of TDN value. There may also be species variation in their ability to utilize GG pulp, and it is thus recommended to use other species, such as goats and cattle, in similar experiments. It is suggested that acid and neutral detergent fiber levels be determined in order to obtain a more accurate estimate of the usefullness of the structural carbohydrates.

The concentration of several minerals, whichever possible, were also determined (Table 1). Calcium contents were similar for the two batches of the GG pulp. Phosphorus was undetectable in these samples. It is likely that various batches may differ considerably in mineral contents, and it is necessary to analyze more samples to obtain a more reliable estimate of the concentrations of these and other minerals that were not measured in the present work.

The pulp must also be investigated for the presence of deleterious substances, since it has been shown that several non-conventional feeds contain toxic substances (5). The relatively high content of ash in GG pulp may contain undesirable elements concentrated from the soil. It is therefore essential to investigate the ash composition.

Performance Data

Experiment I

Table 4 shows the means ± SD for slaughter weight, total feed intake, total gain and gain-to-feed ratio (kg gain kg^{-1} feed) for the experimental

Table 4. Slaughter weight, feed intake, gain, empty-stomach weight and internal fat content† of the sheep fed with diets containing *Glycyrrhiza glabra* pulp (mean ± SD) in experiment I.

	n	Ration			
		1	2	3	4
Slaughter weight (kg)	15	50.9±3.5[a§]	48.5±3.1[a]	47.9±3.5[a]	50.0±3.2[a]
Feed intake (kg)	15	131.3±5.6[a]	103.7±4.9[a]	133.6±7.2[a]	132.3±5.7[a]
Weight gain (kg)	15	6.87±2.34[a]	5.05±1.56[ab]	4.52±1.82[b]	6.54±1.02[a]
Gain-to-feed ratio	15	0.052±0.017[a]	0.039±0.012[b]	0.034±0.013[b]	0.050±0.016[a]
Empty stomach weight (kg)	5	1.18±0.09[bc]	1.36±0.18[ac]	1.49±17[a]	1.55±0.09[a]
Internal fat depot (kg)	5	2.92±0.75[a]	1.45±0.23[b]	1.57±0.61[b]	2.10±0.31[ab]

† Other carcass parameters were not different amongst rations.

§ Within each row, means followed by same letter(s) are not statistically different (P>0.05, Tukey's test).

groups. The slaughter weight was influenced by the type of ration fed (P=0.056). Sheep receiving rations containing 25 to 35% GG pulp had smaller slaughter weights compared with those containing 0 and 15% GG pulp. Total weight gain during the experimental period was affected by the type of ration (P=0.003). Sheep fed ration with 25% GG pulp gained less compared with those fed 0 and 15% GG pulp. Total feed intake did not differ amongst various groups, but gain-to-feed ratio significantly decreased for rations with 25 and 35% GG pulp compared with rations containing 0 and 15% GG pulp (P=0.002). The observed feed efficiency was lower than expected; this might have been caused partly by the exceptionally cold weather during the conduct of the experiment, resulting in higher feed consumption. However, mean daily gain of the control group was about 85 g as compared with the theoretical value of 100 g used to formulate the ration. For all above parameters, the effects of breed and breed × treatment interaction were not significant.

Most carcass characteristics were not different amongst experimental rations (data not shown); however, the weights of internal fat depot (thoracic, peritoneal and pelvic cavities; P=0.05) and the empty-stomch weight (P=0.002) were affected by the treatment. The sheep fed with GG pulp rations had a smaller internal fat depot compared with those receiving the control ration (Table 4). Higher levels of GG pulp resulted in a 50% reduction in the size of the internal fat depot.

The empty-stomach weights of the sheep fed with rations containing GG pulp were in general heavier than those of the sheep which received straw ration. The fiber or other unknown substances in GG pulp might have

had a stimulatory effect on the stomach.

It can be concluded that decreased slaughter weight and daily gain in sheep which received GG pulp were mainly due to lower fat deposition in the body. Considering the gradual decrease in body weight with increasing levels of GG pulp, along with the relatively short period of the experiment (80 days) it seems that GG pulp as such can not be fed to sheep for long periods. However, during the periods of feed shortages some GG pulp can be fed, since only the body fat was reduced when it was included in the ration.

Experiment II

Data presented in Table 5 show the daily dry matter intake (DMI), DMI per 100 kg body weight (BW) and daily feed cost (in Rials) for sheep fed with the control ration and various silages. Daily DMI (P=0.002), DMI per 100 kg BW (P=0.001) and daily feed cost (P=0.001) differed with the ration, but daily gain was not different amongst ration (P>0.05). Mean daily gain (±SD) was greater (P=0.025) for Ghezel compared with Mehraban sheep (140.3± 38.9 vs 122.2± 35.9). Gain-to-feed ratio was also higher (P=0.006) for Ghezel breed (0.068± 0.022 vs 0.063±0.019).

The sheep fed ration S-3 consumed more DM compared with the control and S-6 rations; however, the differences amongst other rations were not significant (P>0.05). The reasons for such differences are not clear. Daily feed cost was higher for sheep receiving the control ration compared with silage containing rations. Daily feed cost for the sheep on wheat straw containing silage was generally higher than the feed cost for sheep fed with GG-pulp-containing silages. This mainly reflects the lower

Table 5. Dry matter intake (DMI) and feed cost for sheep fed in the control and silage-based rations† (mean±SD)§ in experiment II.

Ration	n	Daily DMI (kg)	DMI per 100 kg BW	Daily feed Cost (Rials)	Daily gain (g)	Gian:feed ratio
Control	6	1.94 ± 0.35^{b}	4.24 ± 0.36^{a}	171.4 ± 31.3^{a}	136 ± 33^{a}	14.9 ± 3.9^{a}
S-1	10	2.11 ± 0.22^{ab}	4.02 ± 0.33^{ab}	156.2 ± 17.1^{b}	134 ± 44^{a}	17.5 ± 6.6^{a}
S-2	10	2.01 ± 0.23^{ab}	3.65 ± 0.18^{b}	148.6 ± 16.6^{b}	109 ± 32^{a}	21.4 ± 12.7^{a}
S-3	10	2.16 ± 0.29^{ab}	4.00 ± 0.39^{ab}	152.2 ± 16.4^{b}	130 ± 34^{a}	17.8 ± 5.6^{a}
S-4	10	2.04 ± 0.22^{ab}	3.74 ± 0.18^{b}	145.6 ± 16.0^{bc}	122 ± 35^{a}	18.7 ± 8.2^{a}
S-5	10	1.99 ± 0.19^{ab}	3.77 ± 0.19^{b}	137.6 ± 13.1^{cd}	153 ± 53^{a}	14.4 ± 4.7^{a}
S-6	10	1.92 ± 0.30^{b}	3.70 ± 0.11^{b}	129.6 ± 20.0^{d}	136 ± 24^{a}	14.4 ± 2.7^{a}

† For description of rations, please see the text.

§ Within each column, means followed by same letter(s) are not statistically different (P>0.05, Tukey's test).

prices of GG pulp and wheat straw in comparison with that of the alfalfa hay. DMI per 100 kg BW did not differ amongst sheep fed silage rations, but the sheep on control ration consumed more DMI per 100 kg BW compared with S-2, S-4, S-5 and S-6 rations. DMI and feed cost were not different between Ghezel and Mehraban breeds ($P>0.05$). None of the breed × ration interactions was significant ($P>0.05$).

Carcass traits (absolute value or as a percentage of the cold carcass weight) were not different amongst rations ($P>0.05$). Since only four sheep in each group were slaughtered for this purpose, there may be a need for using more sheep to detect any real differences which may exist. The cold carcass consisted of 23.2% leg, 15.2% shoulder, 16.6% back joint, 16.5% flap, 6.0% neck and 23.0% fat (including fat-tail). Mean back-fat depth was 7.2 mm, and the length and width of the cross section of *Longissimus dorsi* muscle, measured at 12/13 rib, were 6.4 and 3.4 cm, respectively.

The results of this experiment showed that low quality roughages such as wheat straw and GG pulp could successfully be ensiled with urea, wet sugar beet pulp and molasses. The feeding value of the silages for fattening sheep was similar to alfalfa hay as far as weight gain and carcass composition were concerned. Due to low prices of these roughages, the feed costs were lower for the rations containing these feedstuffs. The cost of livestock feed has become prohibitive in Iran, and the ensiling procedure described in this experiment might help solve problems associated with storage of wet sugar beet pulp and molasses, as well as increasing the nutritive value of these low quality roughages. Further experiments are required to determine if different processing practices would improve GG

pulp feeding quality, as described for many non-conventional feed resources (2, 4, 8, 9) for sheep, goats and cattle.

ACKNOWLEDGEMENT

Financial support was provided by the Research Council of Shiraz University (contract # 67-AG-476-246) and Animal Husbandry Committee of the Shiraz Branch of Jahad Sazandegi. The authors thank the staff of the Sheep Unit, Animal Research Station, for the care of animals and the technicians of the Department of Animal Science for help with data collection. We sincerely thank our colleagues in the Department of Soil Science for performing mineral analyses.

LITERATURE CITED

1. Association of Official Analytical Chemists. 1975. Official Methods of Analysis, 12th ed. Association of Official Analytical Chemists. Washington, D.C., U.S.A. 129-136.
2. Cantner, E.W. 1987. Utilization of agricultural waste products in animal nutrition. Anim. Res. Develop. 26:56-69.
3. Crampton, E.W. 1969. Applied Animal Nutrition, 2nd ed. W.H. Freeman, San Francisco. U.S.A. 111-115.
4. Devendra, C. 1988a. Non-Conventional Feed Resources and Fibrous Agricultural Residues. Intern. Develop. Res. Centre/Indian Council of Agric. Res. 194 p.

5. Devendra, C. 1988b. Strategies for the intensive utilization of cereal straws and fibrous agricultural residues in South Asia. In: Devendra, C. (ed). Non-Conventional Feed Resources and Fibrous Agricultural Residues. Intern. Develop. Res. Centre/Indian Council of Agric. Res. 1-20.
6. Farid, A. 1989. Direct, maternal and heterosis effects for slaughter and carcass characteristics in three breeds of fat-tailed sheep. Livest. Prod. Sci. 23:137-162.
7. Sokal, R.R. and F.J. Rohlf. 1981. Biometry, 2nd ed. W.H. Freeman, N.Y., U.S.A. 146-247.
8. Sundstol, F. and E. Owen. 1984. Straw and other Fibrous by-products as Feed. Elsevier, Amsterdam, The Netherlands. 640 p.
9. Van Der Meer, J.M., B.A. Rijkens and M.P. Ferrranti. 1987. Degradation of Lignocellulosics in Ruminants and in Industrial Processes. Elsevier Applied Science, London, England. 120 p.