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REGULAR ARTICLES

The nutritional value of peanut hay (*Arachis hypogaea* L.) as an alternate forage source for sheep

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Abstract The aim of this study was to evaluate the nutritional and feeding value of peanut hay (*Arachis hypogaea* L.) produced under tropical environment as an alternate forage resource for sheep. Peanut hay was appreciably high in crude protein [CP; 105 g/kg dry matter (DM)] and lower in neutral detergent fiber (NDF; 466 g/kg DM). Moreover, peanut hay was rich in Ca (12 g/kg DM) and P (1.7 g/kg DM). A feeding trial was conducted to investigate the effect of substituting wheat straw with peanut hay on nutrient intake, digestibility, and N utilization. Four adult Ramghani (Kaghani × Rambouillet) wethers (60±2.5 kg body weight) were randomly assigned to the four dietary treatments according to a 4×4 Latin square design. The four rations were formulated on isonitrogenous and isocaloric bases and differed in the proportion (in grams per kilogram DM) of wheat straw/peanut hay, i.e., 700:0, 460:240, 240:460, and 0:700. The replacement of wheat straw with peanut hay increased the intakes of DM ($P<0.001$), NDF ($P<0.01$), and N ($P<0.001$). Moreover, apparent in vivo digestibility of DM, NDF, and CP increased ($P<0.001$) with the increasing proportion of peanut hay in the ration. Nitrogen retention in the body increased ($P<0.01$; 3.2 to 8.1 g/day) with the replacement of wheat straw with peanut hay. These findings showed that substitution of wheat straw with peanut hay can improve DM and nutrients intake, digestibility, and N retention in sheep.

Keywords Peanut hay · Wheat straw · Digestibility · N retention

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Introduction

In the tropical arid and semi-arid regions of many developing countries such as Pakistan, there is severe shortage of good quality forages for ruminant livestock. Sheep, for example, are predominantly grazed on low-quality natural pastures and stall fed on crop residues such as wheat straw, rice straw, and maize stovers, with very little or no concentrate supplementation (Khan and Habib 2012). These low-quality forage-based diets impede sheep productivity due to their low nutritive value, dry matter (DM) intake, and digestibility (Khan and Habib 2012). Therefore, recent research is focused on the efficient utilization of nonconventional feed resources to sustain the productivity of the large population of sheep (Khan et al. 2009b; Khan and Habib 2012).

Annual peanut (*Arachis hypogaea* L.) is widely grown (82,900 ha) in both arid and irrigated regions of Pakistan (ASP 2011). Annual peanut is a multipurpose crop; the nuts are used as dry fruit for human consumption, whereas the vegetative part is used as forage (hay) for ruminant livestock. Peanut hay is rich in crude protein (CP; 100–180 g/kg DM) and had high organic matter (OM) digestibility (660–770 g/kg) in sheep (Blümmel et al. 2005). This background provides an impetus to efficiently utilize indigenous peanut hay in sheep ration during the pasture scarcity periods to optimize growth and profitability of the smallholders. The present experiment was therefore designed to investigate the nutritional value of indigenous peanut hay and evaluate the affect

of replacing wheat straw with peanut hay on DM and nutrient intake, digestibility, and N utilization in sheep.

Materials and methods

Study area

Peanut hay was produced from a mature crop after harvesting of peanut in a private farm facility at Gadoon Amazai area of District Swabi (34°14′ N latitude, 72°68′ E longitude, and 426 m altitude). The crop was harvested at a stubble height of 10 cm, wilted, and transported to the Agricultural University Peshawar, Pakistan. The hay was stored in fully enclosed barn. The feeding trail was conducted during October–November 2010, at the animal research facilities of Agricultural University Peshawar (34°00′ N latitude, 71°30′ E longitude, and 350 m altitude), when ambient temperature varied from 20–30 °C.

Experimental design and rations

Four adult Ramghani (Kaghani × Rambouillet) wethers (60± 2.5 kg body weight) were randomly assigned to four experimental diets according to a 4×4 Latin square design. The diets were switched over to the four wethers at the end of each 15-day experimental period. Each period consisted of 10-day adaptation and 5-day data collection period. Animals were housed in individual metabolic chambers in the same shed. Each chamber had a device for separate collection of feces and urine. The experimental rations were formulated on isonitrogenous and isocaloric bases and mainly differed in the proportion of wheat straw/peanut hay (Table 1). The dietary requirements of the sheep were calculated according to NRC (2001). The four experimental rations were prepared daily according to their ingredient composition and fed twice daily ad libitum. The animals had 24 h/day access to fresh water

Data collection and sampling

During the last 5 days of each period, data on feed offered, feed refused, and feces and urine output were recorded daily on individual animals. Samples of the feed offered and feed refused were collected daily in labeled polythene bags and immediately stored in a freezer. The feces excreted by individual animal during the 24-h period were weighed and mixed, and representative samples equivalent to 20 % of the total weight were collected in labeled polythene bags and transported to the laboratory. From each bag, subsamples (~50 g) were taken for DM analysis and immediately stored in a freezer. Urine excreted by individual animal during the 24-h period was collected in labeled bottles containing 150 ml of 2.5 N H_2SO_4. Urine volume was measured and mixed, and representative sample equivalent to 20 % of the total volume was collected. At the end of each experimental period, the feed, feces, and urine samples were thawed, pooled for each animal, and mixed thoroughly, and subsamples were stored in the freezer for chemical analysis.

Table 1 Ingredients and nutrients composition of the experimental rations

	Rations[a]				Wheat straw	Peanut hay
	Ration A	Ration B	Ration C	Ration D		
Ingredient (g/kg dry matter)					–	–
Wheat straw	700	460	240	0	–	–
Peanut hay	0	240	460	700	–	–
Mustard seed cake	70	49	25	0	–	–
Urea	10	06	03	0	–	–
Molasses	40	60	70	70	–	–
Maize fodder	40	79	109	164	–	–
Wheat bran	67	50	44	30	–	–
Wheat flour	67	50	43	30	–	–
Sodium sulfate	05	5	5	5	–	–
Salt	0.5	0.5	0.5	0.5	–	–
Mineral mix	0.5	0.5	0.5	0.5	–	–
Nutrients (g/kg dry matter)						
Organic matter	899	896	908	908	928	900
Neutral detergent fiber	609	547	481	421	771	467
Acid detergent fiber	497	444	379	338	573	358
Crude protein	103	104	104	100	30	105

[a]Rations A, B, C, and D were formulated on isonitrogenous and isocaloric bases

Table 2 Effect of substituting wheat straw with peanut hay on the nutrient intake and nitrogen retention in Ramghani sheep

	Rations (wheat straw/peanut hay)				SEM	Significance
	Ration A (70:0)	Ration B (46:24)	Ration C (24:46)	Ration D (0:70)		
Intake (g/day)						
Dry matter	680 a	819 b	1,126 c	1,383 d	57.1	*
Organic matter	611 a	734 b	1,022 c	1,256 d	53.6	*
Neutral detergent fiber	414 a	448 a	542 b	582 b	44.0	**
Acid detergent fiber	338 a	364 a	427 b	467 b	43.4	**
Nitrogen (N)	11.2 a	14.0 b	19.3 c	22.1 d	0.84	*
N excretion (g/day)						
Feces	4.5 a	5.6 a	8.8 b	9.6 b	1.12	***
Urine	3.5	3.8	3.7	4.3	0.81	NS
Total	8.0 a	9.4 a	12.5 b	14.0 b	1.50	***
N retention (g/day)	3.2 a	4.6 a	6.8 b	8.1 b	1.70	**

Mean within rows with different small letters differ ($P<0.05$)

SEM standard error of the mean, *NS* not significant

*$P<0.001$; **$P<0.01$; ***$P<0.05$

Chemical analysis

Samples of feed and feces were oven dried at 70 °C, grounded in Thomas–Willey laboratory mill to 1-mm particle size, and analyzed for DM, N, acid detergent fiber (ADF), and neutral detergent fiber (NDF). Dry matter content was determined by oven drying at 103 °C (ISO 6496; ISO 1999), ash after incineration at 550 °C (ISO 6496; ISO 2002), and N content, whereas CP=N×6.25) was determined using the Kjeldahl method (ISO 5983; ISO 2005). Neutral detergent fiber was analyzed according to Van Soest et al. (1991), with some modification as described by Khan et al. (2009a). Acid detergent fiber was determined according to Van Soest (1973).

Statistical analysis

Data on the intake, digestibility, and N retention in sheep were analyzed for the fixed effect of ration composition and random effects of experimental period and sheep, using PROC MIXED procedure of the statistical analysis system (SAS Institute 2003).

$$Y_{ijkl} = \mu + R_i + P_j + S_k + \epsilon_{ijkl}$$

where Y_{ijkl} is the dependent variable; μ, the general mean; R_i is the fixed effect of ration i (i=1, 2, 3, 4); P_j is the random effect period j (j=1, 2, 3, 4); S_k is the random effect of sheep k (k=1, 2, 3, 4); ϵ_{ijkl} is the residual.

Results

Peanut hay had a higher content (in grams per kilogram DM) of CP (105 vs 30) and lower content of NDF (467 vs 771) compared with wheat straw (Table 1). Moreover, peanut hay was rich in Ca (12 g/kg DM) and P (1.7 g/kg DM).

Intake and nitrogen retention

The replacement of wheat straw with peanut hay in the sheep ration resulted in increased intake of DM ($P<0.001$), OM ($P<$

Table 3 Effect of substituting wheat straw with peanut hay on in vivo and in vitro digestibility

Digestibility	Rations (wheat straw/peanut hay[a])				SEM	Significance
	Ration A (70:0)	Ration B (46:24)	Ration C (24:46)	Ration D (0:70)		
In vivo						
Dry matter	0.434 a	0.512 b	0.618 c	0.744 d	0.0285	*
Organic matter	0.467 a	0.543 b	0.649 c	0.769 d	0.0265	*
Neutral detergent fibre	0.355 a	0.435 b	0.515 c	0.638 d	0.0219	*
Acid detergent fibre	0.261 a	0.316 b	0.407 c	0.523 d	0.0208	*
Crude protein	0.396 a	0.503 b	0.645 c	0.758 d	0.0190	*
In vitro						
Dry matter	0.370	0.437	0.491	0.583	0.0103	**

Mean within rows with different small letters differ ($P<0.05$)

[a]Rations A, B, C, and D were formulated on isonitrogenous and isocaloric bases

*$P<0.001$; **$P<0.01$

0.001), and NDF ($P<0.01$) (Table 2). With the complete replacement of wheat straw with peanut hay, the intake of DM increased on average by 703 g/day. In general, the intake of all nutrients increased consistently with the increasing proportion of peanut hay in the ration. Although the content (in grams per kilogram DM) of NDF was much lower (467 vs 771) in peanut hay as compared to wheat straw, the intake of NDF also increased (by 168 g/day) with the replacement of wheat straw with peanut hay. Nitrogen intake increased (11.2 to 22.1 g/day; $P<0.001$) with the substitution of wheat straw with peanut hay (Table 2). The quantity (in grams per day) of N retained in the body increased ($P<0.01$) from 3.2 to 8.1 g/day with the substitution of wheat straw with peanut hay (Table 2).

In vivo digestibility

Data on the effect of substituting wheat straw with peanut hay on in vivo and in vitro digestibility is summarized in Table 3. Apparent in vivo digestibility of DM, OM, NDF, ADF, and CP increased ($P<0.001$) with the inclusion of peanut hay in the sheep ration. Although in vitro DM digestibility showed lower values (0.370–0.583) than in vivo (0.434–0.744), it showed a similar increase in DM digestibility ($P<0.01$) with the inclusion of peanut hay in the ration.

Discussion

The results on nutrients composition of peanut hay are consistent with earlier studies (Blümmel et al. 2005; Foster et al. 2009). Owing to the higher CP and lower NDF content, the inclusion of peanut hay in the straw-based ration improved the rumen fermentation process as reflected in the increased digestibility (Table 3). Legumes have greater rates of ruminal particle size reduction than tropical grasses. Because the cell walls of legumes are more fragile and easily broken down during mastication, the surface area increases for attachment of fibrolytic microbes (Foster 2008). Moreover, the additional supply of essential nutrients, such as CP, fermentable carbohydrates, and minerals by peanut hay, could have enhanced microbial growth and fermentation, as reflected in the higher digestibility. Collectively, the greater degradation and quicker rumen outflow rates increased DM intake with the inclusion of peanut hay in the sheep ration. The DM intake increased by 103 % (703 g/day) with the replacement of wheat straw with peanut hay in the ration.

The intake of N doubled (11.2 vs 22.4 g/day) with the replacement of wheat straw with peanut hay was mainly due to the greater DM intake of the peanut hay-based rations by sheep. In addition to the high N intake, N digestibility also increased with the substitution of wheat straw with peanut hay. These findings suggest that the additional N supplied by the increasing proportion of peanut hay was efficiently utilized and resulted in a greater N retention. The high N retention with peanut hay is consistent with the findings of Foster et al. (2009). Most of the protein in peanut hay is in the form of soluble protein or rumen degradable protein. Therefore, the replacement of wheat straw with peanut hay increased the supply of ruminal NH_3–N. The high NH_3–N concentration, together with high fermentable cell walls in peanut hay, increases microbial protein synthesis (Foster et al. 2009), which could further explain the high N retention on peanut hay-based diets. These findings suggest that incorporation of peanut hay into the low-quality diets of sheep can maintain sheep productivity throughout the year and enhance the profitability of sheep farmers under the smallholding subsistence production systems. Future research should determine the optimal inclusion rates of peanut hay in the diets of growing lambs.

Conclusions

Peanut hay was appreciably high in CP and Ca, and lower in NDF. Due to the high nutritional value, replacement of wheat straw with peanut hay significantly increased intake, digestibility, and N retention in sheep. These findings demonstrate that incorporation of peanut hay in the straw-based rations of sheep can maintain sheep productivity and minimize the production losses during the prolonged feed scarcity periods in the tropics.

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References

ASP, 2011. Agricultural Statistics of Pakistan, Ministry of Agriculture, Islamabad, Pakistan, pp. 61–62.

Blümmel, M., Vellaikumar, S., Devulapalli, R., Nigam, S.N., Upadhyaya, H.D. and Khan A., 2005. Preliminary observations on livestock productivity in sheep fed exclusively on haulms from eleven cultivars of groundnut. International Arachis Newsletter, 25, 55–57.

Foster, J.L., 2008. Improving the productivity of livestock with warm-season legumes. PhD thesis, University of Florida, Gainesville, FL, USA.

Foster, J.L., Adesogan, A.T., Carter, J.N., Blount, A.R., Myer, R.O. and Phatak, S.C., 2009. Intake, digestibility, and nitrogen retention by sheep supplemented with warm-season legume hays or soybean meal. Journal of Animal Science, 87, 2891–2898.

ISO, 1999. Animal Feeding Stuffs. Determination of moisture and other volatile matter content. ISO 6496:1999. International Organization for Standardization, Geneva, Switzerland.

ISO, 2002. Animal feeding stuffs. Determination of crude ash. ISO 5984. International Organization for Standardization, Geneva, Switzerland.

ISO, 2005. Animal Feeding Stuffs. Determination of nitrogen content and calculation of crude protein content–Kjeldahl method. ISO 5983:1997. International Organization for Standardization, Geneva, Switzerland.

Khan, N.A. and Habib, G., 2012. Assessment of *Grewia oppositifolia* leaves as crude protein supplement to low-quality forage diets of sheep. Tropical Animal Health and Production, 44, 1375–1381.

Khan, N.A., Cone, J.W. and Hendriks, W.H., 2009a. Stability of fatty acids in grass and maize silages after exposure to air during the feed out period. Animal Feed Science and Technology, 154, 183–192.

Khan, N.A., Habib, G., and Ullah, G., 2009b. Chemical composition, rumen degradability, protein utilization and lactation response to selected tree leaves as substitute of cottonseed cake in the diet of dairy goats, Animal Feed Science and Technology, 154, 160–68.

NRC, 2001. Nutrient requirements of cattle. National Research Council, Washington, DC, USA.

SAS Institute, 2003. Statistical Analysis System, Version 9.2. SAS Institute Inc., Cary, NC, USA.

Van Soest, P.J., 1973. Collaborative study of acid detergent fiber and lignin. Journal of the Association of Official Analytical Chemists, 56, 781–784.

Van Soest, P.J., Robertson, J.B., and Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition, Journal of Dairy Science,74, 3583–3597.