# The Effect of Formaldehyde Treatment of Solvent and Mechanical Extracted Cottonseed Meal on the Performance, Digestibility and Nitrogen Balance in Lambs

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**ABSTRACT :** The effect of formaldehyde treatment of solvent and mechanical extracted cottonseed meal on the performance, digestibility and nitrogen balance was assessed in lambs. Four total mixed rations viz., A, B, C and D containing 40% untreated and treated solvent and mechanical extracted meal were prepared. Sixteen male lambs with average BW of 20-22 kg were randomly allocated to experimental rations and were fed individually during ninety days growth trial. The treatment of solvent extracted cottonseed meal resulted in a linear decrease in ruminal protein degradation. Maximum decrease (64%) in protein degradation was observed at 4 h incubation time with 0.3% formaldehyde treatment. Highest daily BW gain was observed in lambs fed on rations B and D compared to lambs fed on rations A and C. Daily BW gain was higher on rations having 0.3% for fromaldehyde treated cottonseed meals. Higher DM digestibility was observed on ration D compared to other rations. Higher ($p<0.05$) CP and CF digestibility was observed on rations B and D compared to rations A and C. Nitrogen retention as % age of nitrogen intake was ($p<0.05$) higher for lambs fed rations B and D compared to rations A and C. Similar pattern was observed for nitrogen retention as percent of nitrogen absorbed. The present study suggested that oil extraction methods of cottonseed did not alter their meal utilization in lambs, however, formaldehyde (0.3%) treatment of meals enhanced its efficiency for growth, digestibility and nitrogen balance in lambs. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 6 : 785-790*)

Key Words : Formaldehyde, Growth, Cottonseed Meal, Lambs

## INTRODUCTION

Oil seed by-products particularly form the cottonseed are used as a main protein supplement in dairy animals in Pakistan (NODP, 1995). Oil seed extraction in Pakistan is carried out by three main processes such as 1) undecorticated oil seed expeller extraction, 2) decorticated oil seed mechanical (expeller) extraction and 3) decorticated oil seed solvent extraction. The oil seed by-products thus produced are oil seed cake, mechanical extracted and solvent extracted meal; respectively. During the recent past, there has been major shift in the commercial oil extraction processing from mechanical to solvent extraction process. Resultantly, there is substantial increase in the availability of solvent extracted cottonseed meal. Feedstuffs processing methods have been suggested to influence the extent of ruminal escape of meals and later on its utilization in subsequent parts of intestine (Goetsch and Owens, 1985). Slowly degraded proteins in the rumen are utilised more efficiently when used to supplement diets (Hogan and Weston, 1967; NRC, 1985). Previously, various methods were tested to decrease ruminal degradation of supplemental proteins with chemicals which suggested that ruminal degradation of proteins in soybean meal was decreased by treating with formaldehyde and was useful for improving solvent extracted meal as a supplement for young cattle (Thomas et al., 1979a, b; Coenen and Trenkle, 1989). Formaldehyde treatment of soybean meal improved nitrogen utilisation and performance in growing lambs and improved feed efficiency in steers (Faichney, 1971; Barry, 1972 and Spears et al., 1980). Most of the cottonseed meal in Pakistan is used in the production of poultry rations and its utilization has been studied extensively in commercial birds. However, there is no information available on the comparative nitrogen utilization of local cottonseed meals and effect of formaldehyde treatment of meals on the performance of ruminants. Therefore, present study was conducted to quantify ruminal escape of dietary protein from untreated and treated solvent and mechanical extracted cottonseed meals and also to evaluate these as a protein source for growing lambs.

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## MATERIALS AND METHODS

### Formaldehyde treatment of cottonseed meal

Four levels i.e., 0.3, 0.6, 0.9 and 1.2% of formaldehyde were prepared to treat solvent extracted cottonseed meal. Different concentrations of formaldehyde solution were applied to treat 100 gm cottonseed meal by slowly pouring solution form a beaker and mixing the material thoroughly. After mixing, samples were stored in sealed polythene bags and kept at room temperature for 72 h as described by Thomas et al. (1979a). After the treatment period,

**Table 1.** Ingredients (%) and chemical composition of the experimental rations

| Parameter | Rations | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Ingredients | | | | |
| Cottonseed meal (solv. extracted) | 40.00 UT | 40.00 FT | - | - |
| Cottonseed meal (mech. extracted) | - | - | 40.00 UT | 40.00 FT |
| Maize | 15.00 | 15.00 | 15.00 | 15.00 |
| Wheat bran | 8.00 | 8.00 | 8.00 | 8.00 |
| Molasses | 10.00 | 10.00 | 10.00 | 10.00 |
| Salt | 1.00 | 1.00 | 1.00 | 1.00 |
| Premix[a] | 1.00 | 1.00 | 1.00 | 1.00 |
| Wheat straw | 25.00 | 25.00 | 25.00 | 25.00 |
| Cheminal composition (% DM) | | | | |
| Crude protein[b] | 16.00 | 16.42 | 16.00 | 16.42 |
| Crude fibre[b] | 14.00 | 14.00 | 14.00 | 14.00 |
| Total digestible nutrients[c] | 70.00 | 70.00 | 70.00 | 70.00 |

UT=Un-treated; FT=Treated with 0.3% formaldehyde by weight of cottonseed meal.
[a] Vitamin and mineral premix contains 19.2% P, 25.5% Ca, 2.3% Na, 1.2% Mg (300000 IU vitamin A, 50000 IU vitamin $D_3$, 100 Cu, Co, Se) (made by Bayer Leverkusen, Germany).
[b] Analysed values; [c] Calculated values.

the samples were placed in open trays to air dry for 48 h and then dried at 50℃ in oven. These dried treated samples were ground by willey cutting machine to 1 mm and used for *in situ* protein degradation study.

### *In situ* protein degradation

Four grams of untreated and treated solvent extracted cottonseed meal was weighed into dacron polyester bags having average pore size of 52 $\mu$m with dimensions of $7'' \times 4''$. After the bags were sewn. they were fastened to weighted rings before being placed into the rumen of two goats fitted with permanent ruminal cannula. About twenty days prior to and also during incubation period, the goats were fed on 80% concentrate diet containing 40% cottonseed meal at the maintenance level of feed. All bage including duplicate empty bags were simultaneously introduced into the rumen and the bags were removed after incubation periods of 4, 12, 24 and 48 h. After removal, bags were rinsed with tap water until the rinse fluid was clean. Bags were then dried at 60℃ and their contents were analysed for nitrogen (AOAC, 1990). Nitrogen disappearance was corrected for blank bag nitrogen content and then rumen protein degradation was calculated by the method described by Ørskov et al. (1980). Rates of degradation were calculated as the slope of regression between the natural logarithm of percentage protein remaining in nylon bags and time of incubation (Lynch et al., 1986).

### Rations preparation

Solvent and mechanical extracted cottonseed meals were purchased from their manufacturing plants. Both type of cottonseed meals were manually treated with 0.3% formaldehyde by weight. After 72 h of the treatment, treated cottonseed meals were used for rations preparation. Four iso-nitrogenous and iso-caloric total mixed rations (A, B, C and D) containing 40% untreated and treated solvent and mechanical extracted cottonseed meal were prepared at Feed Technology Unit, National Agricultural Research Centre. The ingredients composition and chemical analysis of the experimental rations are presented in table 1.

### Growth trial

Sixteen 5 to 6 months old fat tail salt range lambs with average body weight of 20 to 22 kg were stratified by weight and randomly allocated to four rations. The trial was conducted during ninety days period. Before starting the experiment, all the lambs were dewormed against internal parasites by administering recommended doses of Nilverm (ICI Pharmaceuticals, Pakistan) and were also provided with dips of Neguvon (Bayer, Leverkusen, Germany) to kill external parasites. Animals were fed individually ad-libitum and weighed quantities of rations were offered twice a day at 08:00 and 14:00 h to minimize sorting and wastage. Daily feed refusal was recorded prior to the 08:00 h feeding. Fresh and clean water was made available free-choice. Records on daily feed intake, feed refused and weekly weight gain of lambs were maintained for individual lamb.

### Digestibility and nitrogen balance trial

At the end of growth trial, a digestibility and nitrogen balance trial was conducted allocating 3

**Table 2.** *In situ* rumen protein degradation (%) from untreated and formaldehyde treated solvent extracted cottonseed meal

| Treatment | Incubation Time (h) | | | | Rate of degradation, %/h |
|---|---|---|---|---|---|
| | 0 | 4 | 24 | 48 | |
| Untreated cottonseed meal (CSM) | 4.13[a] | 19.57[a] | 42.00[a] | 58.50[a] | 1.65[a] |
| Formaldehyde treated CSM | | | | | |
| 0.30% | 3.04[b] | 12.58[b] | 27.50[b] | 37.00[b] | 0.85[b] |
| 0.60% | 3.53[b] | 12.97[b] | 22.57[b] | 35.09[bc] | 0.76[c] |
| 0.90% | 3.83[ab] | 10.53[b] | 22.45[b] | 33.53[c] | 0.74[c] |
| 1.20% | 3.10[b] | 7.37[c] | 20.31[b] | 32.53[c] | 0.74[c] |

Different superscripts on means in the same column show significant difference at $p<0.05$.

**Table 3.** Performance of lambs fed on untreated and formaldehyde treated cottonseed meal based rations

| Particulars | Rations | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Av. initial weight (kg) | 20.65 | 20.85 | 21.75 | 21.30 |
| Av. final weight (kg) | 35.05 | 37.10 | 36.71 | 38.22 |
| Av. weight gain (g/d) | 160 ±1.81[b] | 180 ±2.35[a] | 166 ±3.17[b] | 188 ±2.47[a] |
| Av. dry matter intake (g/d) | 1436 ±10.36[b] | 1567 ±9.63[a] | 1475 ±5.57[b] | 1587 ±6.63[a] |
| Feed:gain ratio | 8.97 ± 0.071[a] | 8.72 ±0.086[a] | 8.77 ±0.197[a] | 8.02 ±0.115[b] |

Different superscripts on means in the same row show significant difference at $p<0.05$.
Mean ± SE.

lambs to each ration. During this trial, lambs were placed individually in metallic cages (L=4′.2″, W=2′.5″ and H=3′.0″ raised by 2′.0″ from the ground) having the facility to collect faeces and urine separately. Animals were given 15 days to adjust and their voluntary feed intake (VFI) was recorded during this period. During five days collection period, animals were fed on 90% of their VFI to ensure minimum segregation and refusal. Samples of daily feed offered, orts and faeces voided for each lamb were weighed, mixed, subsampled, composited and stored at 5℃. Urine from each lamb was also collected daily in plastic bottles containing 100 ml 3N HCl to prevent N losses. Daily urine output was measured and immediately analysed for nitrogen (AOAC, 1990). The composited samples of feed, orts and faeces were analysed for dry matter, crude protein and crude fibre by AOAC (1990) methods.

### Statistical procedure

The growth performance, digestibility and nitrogen balance trial data was statistically analysed by using analysis of variance for completely randomised design. Upon significant treatment effects, Duncan's Multiple Range Test was employed to compare means (Steel and Torrie, 1980).

## RESULTS AND DISCUSSION

### *In situ* protein degradation

Results of *in situ* rumen protein degradation are presented in table 2. Treatment of solvent extracted cottonseed meal with formaldehyde resulted in highly ($p<0.05$) linear decrease in ruminal protein degradation as measured by N-disappearance from the dacron bags. The protein of formaldehyde treated cottonseed meal was not only less soluble during first 4 h in the rumen but was degraded at a slower rate throughout 48 h incubation period. No ($p>0.05$) difference in protein degradation was found in 0.6, 0.9 and 1.2% formaldehyde treated cottonseed meal after 24 hours incubation in rumen. Maximum decrease (64%) in protein degradation was observed at 4 h with 0.3% formaldehyde treatment. Formaldehyde treatment of cottonseed meal at the rate of 0.3, 0.6, 0.9 and 1.2% caused significant slow rate of degradation (0.85, 0.76, 0.74 and 0.74 %/h; respectively) compared to untreated cottonseed meal (1.65 %/h). However, formaldehyde treatment beyond 0.3% did not show any significant effect in rate of degradation among the treatments. Results of the present study are substantiated by Dutta et al. (1995) who found maximum depression in protein degradation with formaldehyde treatment at 4 h in cottonseed cake, groundnut cake, soybean meal, linseed meal and fish meal. These results are also in agreement with Prasad and Reddy (1998) who reported that formaldehyde treatment reduced (81%) in-situ ruminal degradation of protein of groundnut cake.

### Growth trial

1) Weight gain

The results of the growth performance trial such as BW gain, feed intake and feed efficiency are depicted in table 3. The average initial and final BW of lambs on rations A, B, C and D was recorded as 20.65, 20.85, 21.75 and 21.30 kg and 35.05, 37.10, 36.71 and 38.22 kg; respectively. Higher ($p<0.05$) daily BW gain was observed in lambs fed on rations B (180.50 g/day) and D (188.00 g/day) compared to lambs fed on rations A (160 g/day) and C (166.25 g/day). No difference ($p>0.05$) was noticed in daily BW gain of lambs fed on rations A and C and also on rations B and D. It was observed that the daily BW gain was ($p<0.05$) higher on the rations having 0.3% formaldehyde treated solvent and mechanically extracted cottonseed meal compared to untreated cottonseed meals. Increased body weight gain was probably a result of increased ruminal escape protein supplied to small intestine by formaldehyde treated cottonseed meal in rations B and D. However, there was no ($p>0.05$) difference in the solvent and mechanical extracted cottonseed meals. The results presented in this study support the finding of Wright (1971), Barry (1972) and Yao Ming et al. (1996) who found improved performance in growing lambs and heifers when fed on formaldehyde treated soybean and rapeseed meal.

2) Dry matter intake and feed efficiency

Average daily dry matter (DM) intake of lambs was 1436, 1567, 1475 and 1587 g on rations A, B, C and D, respectively. Higher ($p<0.05$) average DM intake was observed on rations B and D as compared to rations A and C. It elucidated that formaldehyde treatment of both the type of meals improved the intake of rations, however, types of meal did not ($p>0.05$) affect the intake.

Feed efficiency was calculated as 8.97, 8.72, 8.77 and 8.02 on rations A, B, C and D, respectively. Feed efficiency of ration D was ($p<0.05$) better as compared to all the other rations. Findings of the present study are substantiated by Spear et al. (1980) and Tapalaga et al. (1994) who reproted that formaldehyde treatment of soybean meal improved the feed efficiency in lambs and steers.

3) Digestibility and nitrogen balance

The digestibility of DM, CP and CF of the experimental rations in lambs are presented in table 4. Higher ($p<0.05$) DM digestibility was observed in ration D as compared to remaining three rations. No ($p>0.05$) difference was found in DM digestibility of the rations A, B and C. Higher ($p<0.05$) CP and CF digestibility was observed on rations B and D as compared to rations A and C. It was observed that the digestibility of CP and CF was higher for the rations having 0.3% formaldehyde treated cottonseed meal. No ($p>0.05$) difference was noticed in the digestibility of the untreated solvent and mechanically extracted cottonseed meal. These results are substantiated by Goetsech and Owens (1985) who reported that processing methods of cottonseed meal did not influence organic matter and fibre digestibility in steers. The results of the present study for nutrients digestibility are also in agreement with Ramachandra and Sampath (1995) and Yao Ming et al. (1996) who reported that formaldehyde treatment of groundnut cake and rape seed meal improved the nutrients digestibility in cattle heifers.

Results of nitrogen balance trial are presented in table 5. Nitrogen intake in lambs fed on rations A, B, C and D was 46.45, 46.29, 40.00 and 43.70 g/d. Nitrogen intake of rations A and B did not differ ($p>0.05$), however, the N intake was ($p<0.05$) less on rations C and D compared to rations A and B. Nitrogen excretion through faeces was similar for all the rations. Nitrogen excretion through urine was ($p<0.05$) less in lambs fed rations C and D as compared to rations A and B. Nitrogen retention as % age of nitrogen intake was ($p<0.05$) higher in lambs fed rations B (22.12%) and D (24.80%) having formaldehyde treated cottonseed meals compared to

**Table 4.** Effect of feeding untreated and formaldehyde treated cottonseed meals based rations on the nutrient digestibility in lambs

| Variable | Rations | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Intake (g/d) | | | | |
| Dry matter | 1345.67 | 1262.33 | 1357.00 | 1247.33 |
| Digestibility (%) | | | | |
| Dry matter | $68.92 \pm 1.05^{b}$ | $71.21 \pm 0.97^{a}$ | $70.42 \pm 0.66^{b}$ | $73.46 \pm 0.36^{a}$ |
| Crude protein | $75.41 \pm 0.73^{b}$ | $76.16 \pm 0.39^{a}$ | $74.64 \pm 0.52^{b}$ | $77.10 \pm 0.20^{a}$ |
| Crude fibre | $57.64 \pm 0.90^{b}$ | $59.22 \pm 0.46^{a}$ | $56.88 \pm 0.46^{b}$ | $60.79 \pm 0.09^{a}$ |

Different superscirpts on means in the same row show significant difference at $p<0.05$.
Mean $\pm$ SE.

**Table 5.** Nitrogen utilization of untreated and formaldehyde treated cottonseed meals in lambs

| Parameter | Rations | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Nitrogen intake (g/day) | 46.45 | 46.29 | 40.00 | 43.70 |
| Fecal nitrogen (g/day) | 11.41 | 11.34 | 10.02 | 10.16 |
| Absorbed nitrogen (g/day) | 35.23 | 34.62 | 30.00 | 33.13 |
| Urine nitrogen (g/day) | 25.34 | 24.71 | 22.26 | 22.70 |
| Retained nitrogen (g/day) | 9.70 | 10.24 | 7.27 | 10.84 |
| Retained | | | | |
| % intake | 20.88[b] | 22.12[a] | 19.30[b] | 24.80[a] |
| % of absorbed | 27.53[b] | 29.57[a] | 25.76[b] | 32.72[a] |

Different superscript on means in a row show significant difference at $p<0.05$.

rations A (20.88%) and C (19.30%) having untreated solvent and mechanical extracted cottonseed meal, respectively. Data suggested that treatment of solvent and mechanical extracted cottonseed meal with 0.3% formaldehyde improved overall protein utilization in growing lambs. This might be due to the increase in rumen escape protein of rations having formaldehyde treated cottonseed meal. It is also reported that formaldehyde treatment of protein rich feedstuffs increased the protein digestion in the intestine and also the nitrogen retention (Ferguson, 1975). Similar pattern was found in nitrogen retention as percent of nitrogen absorbed. These results are in agreement with Spears et al. (1985) who reported that nitrogen utilisation increased in steers when fed 0.3% formaldehyde treated soybean meal. Ramachandra and Sampath (1995) also observed higher nitrogen retention in heifers when fed on formaldehyde treated groundnut cake.

From the present findings, it may be concluded that oil extraction methods (solvent and mechanical) of cottonseed did not alter their meal utilization in lambs, however, formaldehyde (0.3%) treatment of meals enhanced its efficiency for growth, digestibility and nitrogen balance in lambs fed on total mixed rations.

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