CHEMICAL COMPOSITION OF WHEAT STRAW AS INFLUENCED BY UREA AND ALKALI TREATMENTS AT DIFFERENT MOISTURE LEVELS

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Summary

To improve the nutritive value of wheat straw it was treated with 0, 3, 4 and 5 percent levels of urea, 0 and 4 percent level of alkali at 40, 50 and 60 percent moisture levels and stored at room temperature. Total nitrogen contents of the straw increased significantly, from 0.77 percent with no urea treatment to 0.87, 1.16 and 1.19 percent with 3, 4 and 5 percent urea levels, respectively. Percent retention of nitrogen was 63.73 percent. Alkali treatment at 4 percent level, lowered significantly the crude fibre contents of the straw from 41.86 percent in control to 40.21 percent in the treated straw. Moisture level of 40 percent significantly lowered ($p < 0.05$) the crude fibre contents. Total ash content of straw increased significantly by urea and alkali treatment. Alkali treatment improved significantly the sodium contents also. The results of the study indicated that most beneficial results were obtained with 4 percent urea, 4 percent alkali at 50 percent moisture level.

(**Key Words**: Wheat Straw, Treatment, Urea, Alkali, Moisture)

Introduction

Chronic feed deficit represents a major constraint to the animal production in Pakistan. Good quality green fodders are not available in sufficient quantity through out the year. Livestock therefore has mainly to depend upon the straws of the cereals and other crop residues. These being poor in nutritive value do not provide sufficient nutrients to the livestock population for the exploration of their maximum potential. Wheat straw is most abundantly used crop residue in the livestock feeding as it is commonly available at each farm house-hold. It is considered to be a potential source of energy for ruminants. Lack of protein is often the most important limiting factor in the feeding of straw. Low cell contents and limited nitrogen of wheat straw make it nutritionally poor. A study had therefore been conducted to determine the effect of different levels of moisture, urea and alkali treatments on the quality of wheat straw in terms of nitrogen, crude fibre, total ash and sodium contents.

Materials and Methods

The samples of wheat straw (250 g each) were treated with 7.5 (3%), 10.0 (4%), and 12.5 g (5%) of fertilizer grade urea and 10 g (4%) of sodium hydroxide. The weighed quantities of urea and sodium were dissolved in 175, 250 and 375 ml of tap water to obtain the moisture level of 40, 50 and 60 percent, respectively. The dissolved material was sprinkled evenly on each sample of 250 g of wheat straw and stored at room temperature (30-34℃) in polythene bags in triplicates. The bags were pressed to remove the air as for as possible and were made air tight with rubber bands to create anaerobiasis. The samples of wheat straw treated neither with urea nor sodium hydroxide were kept as control. However, these were treated with simple water at 40, 50 and 60 percent moisture levels similar to urea and alkali treated straw. The treated samples of straw were exposed open after two weeks storage period and were chemically analyzed for total nitrogen, crude fibre, total ash and sodium contents (AOAC, 1984). Five grams of each sample was put in petri dish and was placed in oven at 105℃ for 24 hours to determine the dry matter percentage in the treated straw.

Nitrogen was determined by micro Kjeldahl method. Half a gram of oven dried sample was digested in the presence of a catalyst and concentrated sulphuric acid.

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Digested sample was diluted to 250 ml with distilled water. A 10 ml of diluted sample was used for distillation. The ammonia collected in flask was titrated against N/10 sulphuric acid to calculate the nitrogen in the sample. To assess the crude fibre contents, 1.25 percent sulphuric acid was added into 2 g of dried straw sample. The contents were heated for 30 minutes and then filtered. The residue was heated with 1.25 percent NaOH and then filtered. The sample was put in oven and then in muffle furnace for ignition to get ash. The weight of ash was recorded to determine the crude fibre in the sample.

Sodium was determined from the sample ash by flame photometer. A stock solution of NaCl was prepared by dissolving 250 mg of NaCl/100 ml to get 1 mg Na/ml concentration. Various concentrations of Na were prepared. These were fed to flame photometer and a graph was constructed. Sample ash treated with concentrated HCl and ignited for one hour in muffle furnace was diluted to 100 ml with distilled water and filtered. Filtrate was fed to the flame photometer and its reading was recorded to calculate sodium contents in the sample. The data on various nutrients were tabulated. The analysis of variance technique was used to test the significance of variables according to completely randomized block design with 4 × 3 × 2 factorial arrangement (Steel and Torrie, 1982).

Results

Wheat straw used in the experiment was analyzed chemically before and after the treatments. It contained moisture 4.53%, nitrogen 0.56%, crude fibre 43.18%, total ash 9.17% and sodium contents 0.16%. During storage, colour of the treated wheat straw was keenly examined and it was found to be changed from yellow to brown due to Millard action as reported by Herrera-Saldana et al. (1983). Slight fungal infestation was observed in straw treated at 60 percent moisture level. Wheat straw treated with urea and alkali at 40, 50 and 60 percent moisture levels, retained moisture 40.77, 50.54 and 60.84 percent, respectively, with an average value of 50.72 percent. Different levels of moisture did not show any effect on nitrogen, ash and sodium contents.

The total nitrogen contents were increased from 0.77 percent with no urea treatment to 0.87, 1.16 and 1.19 percent with 3, 4 and 5 percent urea levels, respectively. Statistical analysis of the results revealed significant ($p < 0.01$) effect of different levels of urea on nitrogen contents of treated straw (table 1).

Percent retention of urea nitrogen into straw sample treated with varying levels of urea was computed and it was observed that 65.95, 67.94 and 57.54% of urea nitrogen were retained when treated with 3, 4 and 5 percent levels of urea, respectively. It was also found that oven drying of treated straw also caused some loss of nitrogen. The results showed that the losses in nitrogen content of straw treated with 3, 4 and 5 percent levels of urea were 4.39, 7.20 and 9.84 percent, with an average value of 7.14 percent (table 2).

TABLE 1. EFFECTS OF UREA TREATMENT ON NITROGEN, ASH, CRUDE FIBRE AND SODIUM CONTENTS OF WHEAT STRAW

Urea levels (%)	% Composition			
	Nitrogen	Crude fibre	Total ash	Sodium
Control	0.77 ±0.03[c1]	42.74 ±0.68	8.68 ±0.30	0.22 ±0.02
3	0.87 ±0.05[b]	41.67 ±0.81	9.58 ±0.66	0.22 ±0.03
4	1.16 ±0.03[a]	41.42 ±1.04	9.84 ±0.66	0.19 ±0.02
5	1.19 ±0.02[a]	39.80 ±0.59	9.27 ±0.44	0.20 ±0.02

[1] All values are reported in means ± SE.
[abc] Means in the same coloumn with different superscripts differ ($p < 0.01$).

TABLE 2. RETENTION AND LOSS IN NITROGEN CONTENTS OF WHEAT STRAW DURING TREATMENT AND OVEN DRYING

Urea levels (%)	Nitrogen added (%)	Before oven drying (%)		After oven drying (%)	
		Actural nitrogen	Nitrogen retained	Nitrogen content	Loss of nitrogen
3	1.38	0.91	65.95	0.87	4.39
4	1.84	1.25	67.94	1.16	7.20
5	2.30	1.32	57.40	1.19	9.84

Urea treatment did not affect crude fibre contents of wheat straw. It was also observed from the data that crude fibre contents of straw treated with alkali decreased significantly at different moisture levels. However, at 60 percent moisture level, the crude fibre content of straw was significantly higher than at 40 percent moisture levels. The wheat straw contained 40.24, 40.86 and 41.98 percent crude fibre at 40, 50 and 60 percent moisture levels,

respectively.

Urea and alkali treatments showed a significant effect with regards to ash contents. However different levels of moisture did not show any significant effect. The data showed that average total ash contents were increased from 9.32 percent in control to 14.29 percent with alkali treatment (table 3). The results indicated that alkali treatment increased significantly the ash content of straw ($p < 0.01$).

TABLE 3. EFFECT OF ALKALI TREATMENTS ON THE CRUDE FIBRE, ASH AND SODIUM CONTENTS OF THE STRAW

Alkali levels (%)	% Composition		
	Total ash	Crude fibre	Sodium
Control	09.34 ± 0.27^{b1}	41.86 ± 0.38^{a}	0.21 ± 0.06^{b}
4	14.29 ± 0.38^{a}	40.21 ± 0.35^{b}	0.98 ± 0.02^{a}

[1] All values are reported in means ± SE.
[ab] Means in the same coloumn with different superscripts differ ($p < 0.05$).

The data showed that average sodium contents of control and 4 percent alkali treated wheat straw were 0.21 and 0.98 percent, respectively. The sodium content of straw was increased by 84.6 percent. The analysis of variance of data revealed a non-significant effect due to different levels of urea and moisture. The interaction between urea and alkali, and alkali and moisture levels also showed non-significant differences.

Discussion

Several chemical (Homb et al., 1976), physical (Donfer, 1976) and microbiological treatments (Linko, 1976) have been practiced to improve the nutritive value of wheat straw. Nitrogen content of wheat straw was increased by treatment with urea (Ali and Naseer, 1986). Based on these findings, Athar (1988) conducted laboratory trials to assess the effect of urea and alkali treatments on the chemical composition of wheat straw. He suggested that further studies should be conducted to improve the nutritive value of wheat straw through urea and alkali treatments at different moisture levels.

Wheat straw was treated with different levels of urea and 4 percent alkali at various moisture levels. Urea treatment at 4 percent level increased the crude protein content of wheat straw more than twice its content when untreated. Similar findings were reported by Benahmed and Dulphy (1985), Ali and Naseer (1986) and Singh and Gupta (1987). The urea was hydrolysed under anaerobic condition by bacterial urease and the ammonia released was incorporated into straw. About 32 percent of urea nitrogen added for straw treatment could not be trapped by straw particles under the polythene bag environment. In this way about one third of the urea nitrogen was retained in the straw. At 4 percent level of urea treatment more than 7 percent of the nitrogen was heat liable and was lost at 100°C temperature exposure reducing the retention from 67.94 to 57.40 percent. Similar results were reported by Horn et al. (1983), Ali and Naseer (1986) and Kumase et al. (1984). They reported that almost one third of added nitrogen was bound to the straw. Wheat straw seems to have good capability of nitrogen incorporation by urea treatment. It was found that oven drying of treated straw also caused some loss of nitrogen. It may be inferred that treatment of straw may be done preferably at 4 percent level to attain more nitrogen. Lower levels have been observed to have more fungal growth in the straw treatment and the higher levels reduce the nitrogen retention. Straw treatment was successfully done at 40 to 50 percent moisture levels. The breakdown of urea within the range of moisture levels used in this study was almost similar. The crude fibre content of straw remained unaffected by either urea or moisture levels. However, 4 percent alkali treatment significantly lowered the crude fibre content partly due to the solublizing effect of hemicellulose and to a major extent due to addition of alkali. The results confirm the findings of Ali and Naseer (1986). The average ash content of straw used in the study was 9.17 percent. When straw was treated with urea and alkali at different moisture levels, it attained 5.9 to 18.85 percent ash with an average of 11.81 percent. This may be noted that total ash and sodium contents of straw increased significantly by alkali treatment. This is mainly due to the sodium content added during alkali treatment.

The effect of different levels of urea on ash content of straw was found to be significant. However Duncan's Multiple Range test for significant interaction between urea × alkali revealed that different levels of urea did not affect the ash content of the straw. It further revealed that there was a non-significant difference in ash content of straw treated with 4 and 5 percent urea at 4 percent alkali level. Herrera-Saldana et al. (1983) treated wheat straw with 5 percent anhydrous ammonia and stored for 44 days and reported an increase in ash content from 8.42 percent to 9.47 percent.

The results of the study indicate that moisture level between 40 and 60 can be used for the treatment of wheat straw. Urea levels of 3, 4 and 5 percent showed and increase in the nitrogen content of wheat straw. However,

4 percent urea is better due to its being economical as the loss during the treatment was less compared to 5 percent level.

Literature Cited

Ali, A. and Z. Naseer. 1986. Nutritional evaluation of wheat straw treated with urea and NH_4HCO_3 using cattle manure as urease source. NARC, Islamabad. Proceedings of 3rd AAAP Animal Science Congress, Seoul, Korea.

AOAC. 1984. Official Methods of Analysis of Association of Official Analytical Chemists. 14th Ed. Arlington, Virginia.

Athar, M. 1988. Effect of urea treatment on the chemical composition and digestibility of wheat straw. M. Sc. thesis. University of Agriculture, Faisalabad, Pakistan.

Benahmed, H. and J. P. Dulphy. 1985. Note on the nitrogen values of the poor forages treated with urea or ammonia. Annals de Zootechnie, 34(3):335-346. 2908, 1986.

Donefer, E. 1976. Physical treatment of poor quality roughages at commercial and farm levels. New Feed Resources. FAO Animal Production and Health Paper. Proceeding of a technical consultation held in Rome.

Homb, T., F. Sundstol and J. Arnason. 1976. Chemical treatment of straw at commercial and farm levels. New Feed Resources. FAO Animal Health and Production Paper. Proceedings of a technical consultation held in Rome.

Herrera-Saldana, R., D. C. Church and R. O. Kellems. 1983. Effect of ammoniation treatment of wheat straw on *in-vitro* and *in-vivo* digestibility. J. Anim. Sci. 56 (4):938-942.

Horn, G. W., D. G. Batchelder, G. Manor, C. L. Streeter and G. L. Mehanglin. 1983. Ammoniation of wheat straw and native grass hay during baling and bales. Anim. Feed Sci. and Technol. 8:35-46.

Kumase, N., M. Suzuki, J. Y. Zhao and H. Fujita. 1984. Effect of anhydrous ammonia treatment on nitrogen distribution chemical composition, nutritive value and intake of wheat straw by sheep. Research Bulletin of Obihiro University Japan. 14(1):81-87. 2(4):3108, 1984.

Linko, M. 1976. Biological treatment of lignocellulosic materials. New Feed Resources. FAO Animal Health and Production Paper. Proceedings of a technical consultation held in Rome.

Singh, S. P. and B. N. Gupta. 1987. Ammonia treatment to improve the nutritive value of wheat straw. Indian J. Anim. Sci. 4(2):129-131.

Steel, G. D. and J. H. Torrie. 1982. Principles and Procedures of Statistics. 2nd Ed. McGraw Hill Book Company, Inc. New York.