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DIGESTIBILITY OF ALKALI TREATED CORN COBS

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The dry matter digestibility of corn cobs on treatment with sodium hydroxide, potassium hydroxide or calcium hydroxide increased from 23.5–55.88, 41.5 and 48.48% respectively. Successive treatment with 4.0% sodium hydroxide and 2.0% calcium hydroxide increased dry matter digestibility to 64.44%. Improvement in the digestibility of cellulose, minerals and organic matter was also observed with these treatments. Reduction in neutral detergent fibre especially in hemicellulose contents from 18.92–12.00% along with two fold increase in reducing sugars was noticed. A significant reduction in lignin contents was also observed due to the action of alkalies on corn cobs.

Key words: Corn cobs, Alkali treatment, Digestibility.

Introduction

Maize is one of the important cereal crops in Pakistan. The major by-products of this cereal are not being properly utilized due to their low digestibility as animal feed. A number of chemical methods have recently been suggested for improvement in the digestibility of crop residue [1-5].

The present work was undertaken to study the effect of different alkalies on the digestibility and chemical composition of corn cobs.

Material and Methods

Corn cobs, procured from the local market, were subjected to different alkali treatments after grinding to 20 mesh size.

Alkali treatments. Corn cobs were treated with a solution of sodium hydroxide and potassium hydroxide of different concentrations (1.0-5.0% w/w) at room temperature, keeping 20% moisture in the substrate. After 24 hrs, the treated material was dried at 100 ±5° for 4 hrs. Untreated and sodium hydroxide and potassium hydroxide treated corn cobs were also subjected to calcium hydroxide treatment. The material was treated with a solution of calcium hydroxide of different concentrations (0.5-2.5 w/w) at room temperature, keeping 20% moisture in the substrate. After 24 hrs, the treated material was dried at 100 ±5° for 4 hrs.

Digestibility trials. In vivo digestibility of the treated material was estimated in nylon bags as described by Orskove *et al.* [6]. A dry Sahiwal cow was rumen fistulated. The samples (in six replicates) were infused in the rumen of cow at the same time and taken out after 48 hrs. These were washed with water, followed by alcohol and finally with distilled water and then dried at 100 ±5° to constant weight. Results of the digestibility were analysed statistically according to Snedicor method [7].

Chemical analysis. Dry matter and ash contents were determined according to AOAC method [8]. Nitrogen was estimated by a micro-Kjeldahl method using $CuSO_4$-K_2SO_4-SeO_2 (1:9:0.02) mixture [9]. Cellulose was determined by Kurschner and Hanak method [10]. Neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose and lignin contents were determined according to the method described by Van Soest and Wine [11]. Reducing sugars in the extract of the sample were measured by DNS procedure as described by Miller [12].

Result and Discussion

Effect of sodium hydroxide on in vivo digestibility. In vivo digestibility of corn cobs was significantly enhanced by sodium hydroxide treatment (Table 1). Dry matter, cellulose, minerals and organic matter digestibility of untreated corn cobs was 23.05, 20.31, 48.1 and 22.74% respectively. Dry matter, cellulose, minerals and organic matter digestibility was 55.88, 55.97 and 49.96% respectively with 4% sodium hydroxide treatment (w/w). The increase in the digestibility of alkali treated corn cobs seems to be due to the breaking of bond between lignin and polysaccharides. Treatment with higher concentrations of sodium hydroxide resulted in a decrease in the digestibility of the corn cobs. It seems that the pH of the rumen of the animal was distrubed at higher concentration of NaOH due to the presence of unreached alkali. Many other workers [5,12] have already reported a decrease in the digestibility of various cellulosic materials beyond a certain concentration of sodium hydroxide.

Effect of potassium hydroxide on in vivo digestibility. Rumen digestibility of corn cobs after potassium hydroxide treatment was also considerably increased (Table 1). Dry matter digestibility of the corn cobs increased from 23.05–41.5% with 4% potassium hydroxide treatment. It is evident from these results that the digestibility of cobs treated with potassium hydroxide was less than sodium hydroxide treated substrate as potassium hydroxide is a weaker alkali than sodium hydroxide.

Effect of calcium hydroxide on in vivo digestibility. Results mentioned in Table 1 also indicate the effect of calcium hydroxide on the digestibility of corn cobs. Dry matter digestibility of corn cobs was 48.48% with 2.0% calcium hydroxide treatment. The digestibility of cellulose, minerals and organic matter was also improved by calcium hydroxide treatment. These results are in agreement with the findings of Shah *et al.*[13], who reported an increase in the digestibility of rice straw by calcium hydroxide treatment. Iwata [14] found an improvement in organic matter digestibility of straw with 1.0% lime treatment.

*Effect of calcium hydroxide on other alkali treated corn cobs.*The effect of calcium hydroxide on the digestibility of other alkali treated corn cobs is given in Table 2. *In vivo* digestibility of corn cobs was further improved when sodium hydroxide treated corn cobs were further treated with calcium hydroxide (2% w/w). Dry matter digestibility was 64.44% when corn cobs were successively treated with 4.0% sodium hydroxide and 2.0% calcium hydroxide whereas it was 55.9% when treated with sodium hydroxide alone (4%). An improvement in the digestibility of cellulose and organic matter was also found by the same treatment. However, no improvement in the digestibility of minerals was observed when sodium hydroxide and calcium hydroxide treated cobs were infused in the rumer of cow for 48 hrs. Our results regarding improvement in the dry matter digestibility are in agreement with the results of Soper *et al.* [15], who reported an increase in the weight gain of cattle by feeding them with 3.0% NaOH and 1.0% $Ca(OH)_2$ treated crop residues. Rounds *et al.* [16] also obtained a greater response in growing lambs fed on corn cobs treated with 3.0% NaOH and 1.0% $Ca(OH)_2$ than with 4.0% NaOH alone. It was suggested that feeding corn cobs treated with 4.0% NaOH resulted in alkalosis which was reduced by the replacement of NaOH by $Ca(OH)_2$. This resulted an increase in the energy availability and digestibility of the crop residues. Similar results were also obtained when potassium hydroxide treated corn cobs were subjected to calcium hydroxide treatment (Table 2).

Effect of different alkali treatments on the chemical composition of corn cobs. The effect of different alkalies on the chemical composition of corn cobs is given in Table 3. Treatment with different concentration of sodium hydroxide resulted an increase in ash contents from 1.69–8.07% but showed no effect on nitrogen contents. Increase in ash contents was also observed after potassium hydroxide and calcium hydroxide treatments. It is also apparent from the results mentioned in Table 4 that the ash contents were remarkable increased due to the combined action of calcium hydroxide with other alkalies. Maximum increase in ash contents was found to be 9.97% when corn cobs were successively treated with 5.0% sodium hydroxide and 2.0% calcium hydroxide. The increase in ash contents might be due to formation of complex salts of lower molecular weight phenolic compounds. Garret *et al.* [17] also reported an increase in ash contents after alkali treatment. Sodium hydroxide treatment was found to be quite effective in reducing the hemicellulose and lignin

TABLE 1. *IN VIVO* DIGESTIBILITY OF CORN COBS AFTER TREATMENT WITH DIFFERENT ALKALIES.

Treatments	Percentage digestibility after 48 hrs.			
	Dry matter	Cellulose	Minerals	Organic matter
Corn cobs as such	23.05±2.18	20.31±1.29	48.11±1.88	22.74±2.37
1.0% Sodium hydroxide	35.76±1.72	31.35±2.62	61.26±2.08	37.67±2.25
2.0% " "	44.66±2.44	35.21±1.34	65.85±4.63	41.26±2.26
3.0% " "	49.99±2.44	39.95±1.74	83.83±1.18	47.15±2.75
4.0% " "	55.88±1.76	55.97±1.38	90.28±1.68	49.96±2.73
5.0% " "	43.95±2.19	46.00±2.25	88.26±1.63	47.47±2.26
1.0% Potassium hydroxide	31.69±1.35	28.67±1.83	60.37±1.87	32.00±1.33
2.0% " "	40.70±2.26	37.55±1.11	69.35±1.22	37.63±2.68
3.0% " "	39.21±3.18	30.72±1.85	84.23±1.59	36.60±2.96
4.0% " "	41.51±2.17	33.73±2.22	90.44±2.53	35.64±3.42
5.0% " "	38.28±3.12	30.00±1.68	92.65±2.72	40.44±2.32
0.5% Calcium hydroxide	34.57±3.30	27.37±2.56	65.00±3.76	30.87±5.16
1.0% " "	41.27±3.40	32.88±1.69	70.48±1.28	40.31±3.46
1.5% " "	41.81±1.25	37.77±1.88	72.39±3.23	42.25±1.25
2.0% " "	48.48±2.20	45.98±3.23	75.52±3.46	45.56±5.69
2.5% " "	46.69±2.31	41.11±3.29	69.89±1.20	43.38±2.73

Average of six replicates alongwith standard deviation.

contents. Reduction in hemicellulose from 18.92–13.55% and lignin contents from 13.03–11.11% was observed as a result of sodium hydroxide treatments. Reduction in hemicellulose and lignin contents was also noticed due to the action of potassium hydroxide and calcium hydroxide. (Table 3). Negi and Kehar [18] reported a decrease in lignin after calcium hydroxide treatment. A slight decrease in neutral detergent fibre was also observed with these treatments. Sodium hydroxide treatment resulted an increase in reducing sugars from 1.83–2.79% which seems to be due to the conversion of polysaccharides into simple carbohydrates. It is evident from the results mentioned in Table 4 that combined treatments decreased neutral detergent fibre from 71.63–64.09% especially the hemicellulose contents from 18.92–12.0%. Lignin contents of sodium hydroxide treated corn cobs were further reduced after calcium hydroxide treatment. Similar results were also obtained when potassium hydroxide treated corn cobs were subjected to calcium hydroxide treatment. Morrison [19] found that when lignin carbohydrate complexes were subjected to alkaline conditions, lignin was decreased with the formation of low

TABLE 2. *IN-VIVO* DIGESTIBILITY OF SODIUM HYDROXIDE AND POTASSIUM HYDROXIDE TREATED CORN COBS AFTER CALCIUM HYDROXIDE TREATMENT.

Treatments	Percentage digestibility after 48 hrs.			
	Dry matter	Cellulose	Minerals	Organic matter
1.0% Sodium hydroxide + 2% Calcium hydroxide	36.56±1.73	36.18±2.98	56.33±4.12	36.26±1.92
2.0% " " + 2% " "	32.91±2.10	45.39±3.25	81.90±3.51	32.13±5.68
3.0% " " + 2% " "	49.28±1.11	87.48±1.40	86.32±1.30	45.15±1.40
4.0% " " + 2% " "	64.44±1.64	83.61±2.72	89.54±1.58	61.71±3.23
5.0% " " + 2% " "	52.93±0.81	52.10±1.10	89.01±3.85	45.16±4.58
1.0% Potassium hydroxide + 2% Calcium hydroxide	32.33±1.69	29.79±2.22	78.38±2.35	31.28±1.60
2.0% " " + 2% " "	35.15±2.11	32.17±3.21	83.15±3.37	28.31±4.19
3.0% " " + 2% " "	33.83±2.17	39.64±2.92	77.42±3.00	33.22±4.87
4.0% " " + 2% " "	44.68±2.45	44.61±1.62	85.29±2.95	34.39±4.02
5.0% " " + 2% " "	35.36±3.78	30.24±5.42	85.88±4.62	28.15±4.97

Average of six replicates alongwith standard deviation.

TABLE 3. EFFECT OF DIFFERENT ALKALIES ON THE CHEMICAL COMPOSITION OF CORN COBS.

Treatments	Percentage								
	Dry matter	Ash	Nitrogen	NDF	ADF	Hemi-cellulose	Cellulose	Lignin	Reducing sugars
Untreated	93.57	1.69	0.80	71.63	52.71	18.92	38.67	13.03	1.83
1% Sodium hydroxide	89.33	2.63	0.79	70.20	54.11	16.09	40.96	13.00	2.11
2% " "	88.67	3.12	0.79	68.81	54.70	15.11	41.15	12.81	2.34
3% " "	88.49	5.41	0.81	68.50	54.72	14.78	41.67	11.88	2.47
4% " "	88.53	6.71	0.84	67.14	54.69	13.55	42.05	11.35	2.87
5% " "	88.21	8.07	0.83	67.27	54.55	13.72	42.33	11.11	2.79
1% Potasium hydroxide	87.99	3.11	0.75	70.77	54.01	17.33	41.25	12.98	2.00
2% " "	88.05	3.40	0.78	71.42	54.37	16.80	41.71	12.91	2.09
3% " "	88.12	4.91	0.82	69.83	54.48	15.11	41.95	12.77	2.22
4% " "	87.93	6.39	0.80	68.91	54.46	14.09	42.27	12.55	2.40
5% " "	87.91	7.40	0.80	68.37	54.29	14.00	42.31	12.06	2.17
0.5% Calcium hydroxide	89.65	1.87	0.80	71.11	54.43	17.68	40.40	13.03	1.80
1.0% " "	89.73	2.53	0.80	71.22	55.22	17.00	41.29	12.93	2.08
1.5% " "	89.49	3.33	0.80	71.18	55.30	16.88	41.45	12.85	2.34
2.0% " "	89.67	4.71	0.80	69.86	55.54	15.32	41.88	12.66	2.30
2.5% " "	88.78	5.02	0.80	68.98	54.87	15.11	41.75	12.12	2.25

Average of three replicates

TABLE 4. EFFECT OF CALCIUM HYDROXIDE ON THE CHEMICAL COMPOSITION OF OTHER ALKALIES TREATED CORN COBS.

Treatments	Percentage								
	Dry matter	Ash	Nitrogen	NDF	ADF	Hemi-cellulose	Cellulose	Lignin	Reducing sugars
1.0% Sodium hydroxide + 2.0% Calcium hydroxide	88.63	4.58	0.80	67.64	52.00	15.70	39.75	12.25	2.30
2.0% Sodium hydroxide + 2.0% Calcium hydroxide	88.49	5.94	0.80	66.40	51.69	14.58	39.88	12.01	2.55
3.0% Sodium hydroxide + 2.0% Calcium hydroxide	88.05	8.35	0.84	66.00	51.60	13.69	40.67	11.77	2.70
4.0% Sodium hydroxide + 2.0% Calcium hydroxide	89.33	9.82	0.84	64.40	51.00	12.28	40.93	11.19	2.85
5.0% Sodium hydroxide + 2.0% Calcium hydroxide	89.37	9.97	0.84	64.09	50.90	12.00	41.27	10.89	2.95
1.0% Potassium hydroxide + 2.0% Calcium hydroxide	79.77	3.89	0.80	70.00	54.39	16.66	42.05	12.95	2.10
2.0% Potassium hydroxide + 2.0% Calcium hydroxide	80.59	5.01	0.80	69.49	53.60	15.87	41.79	12.83	2.40
3.0% Potassium hydroxide + 2.0% Calcium hydroxide	80.83	5.89	0.80	67.88	53.22	14.47	41.73	12.49	2.55
4.0% Potassium hydroxide + 2.0% Calcium hydroxide	80.83	6.77	0.80	67.09	52.96	13.89	41.91	12.01	2.70
5.0% Potassium hydroxide + 2.0% Calcium hydroxide	80.29	8.89	0.80	66.22	52.06	13.16	41.38	11.68	2.75

Average of three replicates.

molecular weight phenolic compounds. Treatment with different alkalies resulted a slight increase in acid detergent fibre and cellulose contents which might be due to partial removal of hemicellulose (Tables 3 and 4). A significant increase in reducing sugars from 1.83–2.95% was observed when sodium hydroxide treated corn cobs were further treated with 2% calcium hydroxide.

From these findings it is concluded that the reduction in lignin and hemicellulose contents seems to be due to the break down of covalent bonds between lignin and polysaccharides. Reduction in lignin and hemicellulose contents, probably created large spaces within the cellulose matrix, thus increasing the susceptibility of cellulolytic micro organisms in the substrate. This observation is supported by the increased digestibility of corn cobs after treatment with different alkalies.

On the basis of these findings it is suggested that easily digestible and nutritious feed can be prepared by the combined treatment of sodium hydroxide and calcium hydroxide. This combined treatment has the following advantages over the other.

(i). Dry matter digestibility becomes almost equivalent to good quality hay or coarse grain. (ii). Cellulose and organic matter digestibility improvement is better than the other treatments. (iii). It also helps in supplying more calcium to the animal which is beneficial for the production of meat and milk.

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