

Changes in the chemical composition of sugarcane crop residues treated with different levels of urea and moisture

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Abstract

Aim: To determine the optimum level of urea, moisture, period of treatments required to enrich the nutritive value of urea treated sugarcane crop residues.

Materials and Methods: Sugarcane bagasse and chopped green sugarcane tops were treated with 3, 4 and 5 % of urea at 40, 50 and 60 % levels of moisture and incubated for 2, 3 and 4 week periods at ambient temperature under polypacked condition for the ammonization purpose. The required amount of urea (30, 40 and 50g) was dissolved in 400, 500 and 600 ml of water, respectively and sprayed on both 1kg bagasse and tops. The treated materials were thoroughly mixed to be homogenous and the moisture content was adjusted to 65%, and then ensiled for 2, 3 & 4 weeks. At the end of incubation period, the treated bagasse and tops were taken out and aerated for 2 days to get rid of the free ammonia and smell. Then samples were ground and stored for further chemical analysis viz. OM, CP, AIA, NDF, ADF HC.

Results: The chemical composition of treated sugarcane bagasse showed that treating with 5 percent urea at 40 % moisture level for 4 weeks enhanced CP content from 2.17 to 14.35 % and hemicellulose content from 16.22 to 24.85 %. However in case of sugarcane tops treatment with 3 % urea at 40 % moisture level for 3 weeks was found to give maximum in terms of chemical composition with enhanced CP content from 4.91 to 13.76 % and NDF and ADF content from 72.44 to 80.39 % and 41.20 to 47.11 %, respectively.

Conclusions: Sugarcane bagasse treated with 5% urea at 40% moisture level for 4 weeks enhanced CP and hemicelluloses content, however sugarcane tops treated with 3% urea at 40% moisture level for 3 weeks was found to give maximum improvement in terms of chemical composition.

Key words: chemical composition, sugarcane bagasse, sugarcane tops, urea treatment

Introduction

Crop based animal production system is one of the three primary production systems followed across the world for livestock production. Under mixed farming scenario, ruminant production, to a large extent, is dependent on feeding practices based on crop residues [1]. The availability of various crop residues in our country is presently about 540 million tons per annum [2]. Among the various crop residues, sugarcane bagasse (SCB) and sugarcane tops are very good staple sources of dry and green fodders, respectively for large as well as small ruminants [3]. SCB is a secondary by-product of sugar cane factories where it is obtained after the extraction of sugarcane juice. It used in the manufacture of pressed fibrous woods, paper pulp and also as a fuel. The yield of bagasse depends upon the fiber content of the sugarcane, and generally represents 30-32 % of the yield in a sugarcane plant. Thus, there is a potential availability of about 79-80 million tones of SCB every year. Presently, most of the bagasse is used as fuel,

mainly at its production level. Bagasse consists of hard and soft fibers. The soft fiber is called pith. At the time of production in the sugar mills, bagasse contains approximately 50% moisture. Sugarcane tops include growing point of the sugarcane, a few upper nodes and accompanying leaves. Sugarcane tops are available in huge quantities in India and in many other developing countries. India stands second in sugarcane (*Saccharum officinarum* Linn) production in the world with an annual yield of about 355 million tons [4]. Since the tops form about 15-20% of total sugarcane [5], about 55-60 million tons of sugarcane tops are available every year in our country. If all the available SCB and tops are effectively utilized as a source of fodder in the diet of animals, it can largely alleviate the shortage of feeds. However, both of these residues are a poor source of protein but high in fiber content [6]. Moreover, raw bagasse is also not palatable and is less digestible because of its high lignin and very low N content. However, it can be a potential source of energy for ruminants if exploited with suitable processing techniques like physical/chemical treatments [7]. To improve the nutritive value of crop residues, it is important to breakdown the linkages among cellulose and lignin by mechanical, chemical and biological or

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Table-1. Chemical composition of SCB treated with different levels of urea and moisture for different incubation periods

Periods (weeks)	Urea (%)	Moisture(%)	OM	CP	NDF	ADF	HC	AIA	
Untreated bagasse			97.61	2.17	75.30	59.10	16.2	1.66	
2	3	40	96.91	9.64	93.40	64.20	29.2	2.00	
		50	96.42	6.74	93.94	60.78	33.16	2.30	
		60	97.02	7.14	92.08	61.29	30.79	2.13	
	4	40	97.26	10.46	92.31	60.29	32.02	1.97	
		50	97.01	7.74	93.68	61.04	32.64	1.99	
		60	97.04	8.29	93.72	62.27	31.45	1.85	
	5	40	96.72	11.83	91.51	63.32	28.19	2.10	
		50	96.83	8.16	92.69	60.49	32.20	1.98	
		60	96.85	8.72	93.31	61.83	31.48	2.06	
	3	3	40	97.28	5.68	92.19	61.86	30.33	2.09
			50	96.60	5.78	92.89	61.44	31.45	2.56
			60	97.04	5.93	93.05	64.76	28.29	2.23
4		40	97.22	8.09	92.75	63.55	29.2	2.03	
		50	96.92	7.38	91.89	63.47	28.42	1.83	
		60	97.60	10.11	91.63	66.67	24.96	1.75	
5		40	97.22	9.88	91.59	63.92	27.67	1.94	
		50	96.68	7.70	92.07	65.99	26.08	2.47	
		60	96.52	9.70	92.58	65.92	26.66	2.62	
4		3	40	95.70	9.37	89.21	64.24	24.97	3.31
			50	94.31	7.54	89.51	66.49	23.02	4.55
			60	94.89	9.72	89.06	67.04	22.02	3.98
	4	40	96.15	10.92	91.94	67.13	24.81	3.01	
		50	95.94	9.20	90.88	70.11	20.77	3.11	
		60	93.16	7.21	86.01	67.99	18.02	4.56	
	5	40	96.67	14.35	92.61	67.76	24.85	2.56	
		50	95.69	14.27	92.41	68.85	23.56	2.97	
		60	92.95	14.05	87.94	65.62	22.32	5.15	

All values are average of three replications, OM: organic matter, CP: crude protein (CP), NDF: neutral detergent fibre, ADF: acid detergent fibre, HC: hemicelluloses, AIA: acid insoluble ash.

by a combination of these treatments. Many studies suggested the use of ammonia and urea to increase the crude protein content of the poor quality residues [8, 9]. Urea as a source of ammonia seems to be a promising alternative for chemical treatment of ligno-cellulosic materials (straws, stovers and bagasse, etc.) to improve their protein content to meet the rumen microbial requirement and it also improves the energy availability due to increased digestibility of ingredients [10].

Therefore, the present study is undertaken to assess the changes in chemical composition of sugarcane crop residues treated with different levels of urea and moisture and for different incubation periods.

Materials and Methods

Different samples of SCB and sugarcane tops were collected from the nearby sugar mills and villages and representative samples were dried in a hot air oven at $70\pm 1^\circ\text{C}$ and ground using 2 mm sieve. Initial moisture content of bagasse and tops was 15%. The samples were analyzed for their organic matter (OM), crude protein (CP) and acid insoluble ash (AIA) as per methods of AOAC [11], fiber fractions i.e. neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemicelluloses (HC) by the method of Van Soest *et al.* [12]. SCB and chopped green sugarcane tops were treated with 3, 4 and 5 % of urea at 40, 50 and 60 % levels of moisture and incubated for 2, 3 and 4 weeks periods at ambient temperature (30°C) under poly-packed condition for the ammonization purpose. The required amount of urea (30, 40 and 50g) was dissolved in 400, 500 and 600 ml of water, respectively and

sprayed on 1kg of both bagasse and tops. The treated materials were thoroughly mixed to be homogenous and the moisture content was adjusted to 65%, and then ensiled for 2, 3 & 4 weeks. At the end of incubation period, the treated bagasse and tops were taken out to be aerated for 2 days to get rid of the free ammonia and smell. Then samples were ground and stored for later chemical analysis viz. OM, CP, AIA, NDF, ADF and HC.

Statistical analysis: Statistical analysis was done by use of simple correlation coefficient.

Results and Discussion

Data presented in Tables-1 and 2 show the effect of chemical treatments on the changes in chemical composition of sugar cane bagasse (SCB) and sugarcane tops as a result of chemical treatments with urea (3, 4 and 5 %) and moisture (40, 50 and 60 %) for different incubation periods (2, 3 and 4 weeks), respectively. The chemical composition of treated SCB showed that treating with 5% urea at 40% moisture level for 4 weeks enhanced CP content from 2.17 to 14.35% and hemicelluloses content from 16.22 to 24.85%. Ebrahimi *et al.* [13] reported lower CP value of raw SCB. Effect of different urease sources on cell wall constituents of SCB treated with 2.5 % urea for three weeks showed decreases in the value of NDF, ADF, hemicellulose and cellulose, compared to bagasse treated with urea alone [14]. Many of scientists reported intake of feed was increased after treatment of crop residues [15-18]. Pachauri *et al.* [19] reported higher CP value of treated wheat straw than untreated wheat straw.

CP content was increased by urea treatment

Table-2. Chemical composition of green sugarcane tops treated with different levels of urea and moisture with different incubation periods

Periods (weeks)	Urea(%)	Moisture(%)	OM	CP	NDF	ADF	HC	AIA
Initial		90.84	4.91	72.44	41.20	31.24	4.08	
3	3	40	90.47	13.76	80.39	47.11	33.28	4.42
		50	90.61	12.05	80.31	47.53	32.78	4.43
		60	90.65	12.91	79.91	48.79	31.12	4.22
	4	40	90.78	13.72	77.32	46.02	31.30	4.28
		50	91.12	12.21	77.02	45.45	31.57	3.90
		60	90.93	14.62	78.69	49.26	29.43	4.09
	5	40	91.27	15.53	76.95	43.87	33.08	3.61
		50	90.63	14.83	78.09	47.39	30.70	4.22
		60	89.73	13.57	78.47	47.44	31.03	5.03
4	3	40	90.66	7.25	80.04	45.99	34.05	4.15
		50	90.74	8.73	80.69	45.76	34.93	4.25
		60	90.10	9.51	79.69	46.82	32.87	4.79
	4	40	91.40	9.61	81.39	46.79	34.60	4.13
		50	91.22	7.53	83.30	48.73	34.57	4.12
		60	89.94	12.83	77.64	44.31	33.33	4.84
	5	40	91.06	9.85	77.74	46.56	31.18	4.66
		50	90.66	10.05	78.68	45.39	33.29	4.31
		60	88.73	8.51	76.41	45.44	30.97	5.44

All values are average of three replications, OM: organic matter, CP: crude protein (CP), NDF: neutral detergent fibre, ADF: acid detergent fibre, HC: hemicelluloses, AIA: acid insoluble ash (AIA)

because urea is a good source of nitrogen. It is of interest to point out that urea treatment as a chemical substances led to enrich the treated SCB and tops with N, besides its chemical role on the breakdown of lingo-cellulosic bonds. Pretreatment with aqueous ammonia of residues promote the removal of external fibers, which led to increased surface area, which may have made cellulose more accessible to enzymes [20, 21]. CP was increased and fiber fraction was decreased following chemical treatment for sesame residues [22], wheat straw (23, 24) and triticale straw [25]. Alkali and acid treatments increased ($P < 0.05$) CP of treated SCB may be due to its chemical role on the breakdown of cell constituents which may result later in releasing some harsh unavailable attached N in the cell walls and in turn led to increase the CP content of such treated material [26]. On the contrary, OM content in all treatments showed a decreasing trend as compared to untreated bagasse with the advances of time until the later phase of incubation period. The reductions in OM may be linked to the higher values of ash released as a result to chemical treatments. NaOH treatment of tree leaves had significant effect on the CP content in sesame residues [27]. Thus, there is a possibility of altering the chemical composition and improving nutritive value of SCB by chemical, biological and biochemical treatments in ration for lambs [28].

On the contrary, NDF and ADF content in all treatments tended to be increased as compared to untreated bagasse and sugarcane tops, however, in case of sugarcane tops treatment with 3% urea at 40% moisture level for 3 weeks was found to give maximum improvement in terms of chemical composition with enhanced CP content from 4.91 to 13.76% and NDF and ADF content from 72.44 to 80.39% and 41.20 to 47.11%, respectively. In another study, lower CP value of raw sugarcane tops was reported as compared to the present findings [29].

Conclusions

SCB treated with 5% urea at 40% moisture level for 4 weeks enhanced CP and hemicelluloses content, however sugarcane tops treated with 3% urea at 40% moisture level for 3 weeks were found to yield maximum improvement in terms of their chemical composition.

Authors' contributions

AKG and PS implemented the study design. PS and RKT carried out the work and RKT did the data analysis and wrote the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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