Paddy Straw as a Feed for Cattle

BY

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IN rice growing countries the grain is the staple food of the human population and the straw that of the cattle. Paddy being practically the only crop in these areas the utilization of both the grain and straw to the maximum possible extent is necessary for sound economy.

Cereal straws due to their nutritional poverty become particularly important only in times of war when feedingstuffs for animals become scarce. These straws in general are composed mainly of crude fibre and Nitrogen-Free-Extract, the two together forming the total carbohydrates. It is however unfortunate that these two constituents of straw are low in digestibility. The amounts of protein and fat digested are so small as to be negligible. The ash contains about 30 per cent. of silica and traces of calcium and phosphorus.

If therefore cereal straws are to be made useful the digestibility of the carbohydrate fraction should be considerably increased. In this fraction crude fibre constitutes more than half the soluble carbohydrates. Crude fibre itself is composed of complex polysaccharides, the most important being lignin and cutin which form a protective covering over the cellulose (1). This covering prevents the digestive juices or the rumen bacteria from breaking down the cellulose material. Cellulose however is largely digested by the bacteria in the rumen of cattle or caecum of horses.

Cereals like other grasses on maturity undergo lignification, and with age the lignin cellulose fraction increases. Further in the selection of cereals that do not lodge, varieties with high lignocellulose contents are selected and consequently straw from the improved strains of cereals will contain more of the lignocellulose fraction. If, however, a crop is cut in the early stages as in the case of oats, the crude fibre and lignin are low. Lignin contains in its molecule methoxy and acetyl groups which are easily split up by the action of heat and alkali. This treatment can completely remove the lignin from the straw.

The pioneer workers in this field subjected chopped or powdered straw to hot alkali under high pressure. It was however found by Beckman (2) that neither heat nor pressure was necessary to obtain an increase in the digestibility of lye treated straw. He adopted the simple method of steeping

chopped straw in 1·25 per cent. caustic soda solution in the cold and washed out the soda from the treated material. This method has the advantage of being as effective but much less expensive than the older ones. It is claimed that the starch equivalent of the straw is increased 50 per cent.

In the case of paddy straw however there is a further difficulty in its efficient utilization. The animal nutrition workers in India (3) were faced with the problem why cattle in the rice-growing tracts were unthrifty and in poor condition while those in the corresponding wheat-growing areas were vigorous and productive. This was all the more puzzling as the nutritive value of the two straws which constituted 80 per cent. of the roughage ration of cattle was almost identical. The digestible crude protein is 0·0 and the starch equivalent is 22 in both cases.

Indian animal nutrition workers (4) found that rice straw contained large quantities of oxalates, the major portion of which was in combination with potassium, while a small but appreciable amount was in the form of calcium oxalate insoluble in the gastric juices. This small quantity of calcium oxalate could not account for the negative balance. The potassium oxalate on the other hand was converted into potassium carbonate and bicarbonate in the fore stomach of the cattle and interfered with the assimilation of calcium. These decomposed products cause severe alkali symptoms or alkalosis which either inhibits the flow of gastric juice or neutralises its effective acidity as a result of which the solubility of calcium in the feeds preparatory to its absorption is adversely affected. The calcium passes out in the faeces unabsorbed leaving the animals in a deficit calcium balance.

Lye treatment of straw, i.e., steeping the straw in a 1·25 per cent. solution of caustic soda for 24 hours and washing it removes about 90 per cent. of the oxalates. The protein still remains totally indigestible but the carbohydrate fraction is increased in quantity and digestibility with a consequent increase in the total digestible nutrients. The adoption of lye treatment is however not feasible under normal village conditions. Steeping the straw in water for 24 hours was next tried and the Indian workers claim that the same beneficial effects as lye treatment are obtained but to a slightly less degree.

Ceylon with one million acres of paddy land produces about one million tons of straw annually, which is the largest source of feedingstuffs for cattle in the island. As nearly 80 per cent. of the cattle population is in a state of undernourishment the efficient utilization of the paddy straw assumes a problem of major importance. Investigations were accordingly made to determine the effects of water washing and lye treatment on the chemical composition and on the digestibility of the paddy straw.

THE EFFECT OF WATER WASHING AND LYE TREATMENT ON THE COMPOSITION OF STRAW

The first stage of this investigation deals with the effect of water washing and lye treatment on the chemical composition of some Ceylon paddy straws. For this purpose representative samples of straw were obtained from different paddy tracts of the Island.

The water washed straw was prepared by steeping the straw cut up into lengths of about 4 inches, in water for 24 hours. At the end of the steeping the material was washed with two changes of water and dried.

For lye treatment, the straw was cut to the same length and steeped in a solution of 1·25 per cent. caustic soda for 24 hours, the material was then washed free of caustic soda and dried.

Analyses of the different straws untreated, water-washed and lye treated were carried out. The results are given in Table 1. Averages of the ten samples of straw untreated, water-washed and lye treated are shown at the bottom of the table.

If the averages are considered the following trend in the change in composition of the straws may be noted :

(*a*) With water-washing the ash, protein, fat, carbohydrates, potash and oxalates are significantly decreased. The percentage losses calculated on the averages are : —12·5, 11·6, 14·4, 1·9, 62·9, and 49·6, respectively. On the other hand the fibre, lime and phosphates have increased by 11·19, 34·88, and 162·50 respectively,

(*b*) With lye-washing the ash, protein, carbohydrates, phosphates, potash and oxalates have suffered further decrease. The percentage loss of these constituents being 53·61, 23·68, 1·49, 10·84, 91·18, and 88·80 respectively. The fibre and lime have however increased by 45·96 and 58·12 respectively.

It is clear that both these treatments remove potassium oxalate in which form the major portion of the oxalates are present in the straw. Both treatments should accordingly enhance the feeding value of straw.

Examination of the individual percentage losses of potash and oxalate give a clearer picture. Table II gives the individual percentages of these two constituents under the different treatments and the corresponding losses. From this it will be seen that the quantity of both the potash and oxalates removed by lye treatment is high and more or less constant, while water washing removes less of these constituent and the lossess are more eratic. Lye treatment is evidently more effective.

TABLE I

Percentage Composition of Treated and Untreated Straws

(on dry matter basis)

No.	Locality	Variety	Season	Age	Treatment	Ash	Protein	Fibre	Fat	Carbohydrates	Lime CaO	Phosphate P_2O_5	Potash K_2O	Oxalates
				Mths.		%	%	%	%	%	%	%	%	%
1	Peradeniya	Balamawi	Yala	4½	Untreated	21·68	3·60	31·84	·65	42·23	·23	·32	1·36	·66
	Do.	,,	,,	,,	Water washed	19·84	3·76	33·61	·40	42·39	·43	·67	·70	·27
	Do.	,,	,,	,,	Lye washed	8·16	3·39	48·25	·73	3 47	·48	·08	·22	·06
2	Paranthan	Pachchaperumal	Maha	3	Untreated	16·45	3·43	34·70	·47	44·15	·58	·11	2·04	1·70
	Do.	,,	,,	,,	Water washed	12·17	3·17	38·92	·35	45·39	·60	·49	·49	·79
	Do.	,,	,,	,,	Lye washed	7·07	2·84	49·19	·47	40·43	·80	·04	·18	·33
3	Do.	Vellai-Illankalayan	Yala	4	Untreated	15·78	4·57	35·62	·50	43·53	·39	·30	2·19	1·34
	Do.	,,	,,	,,	Water washed	11·99	3·83	37·71	·38	46·09	·47	·72	·49	·43
	Do.	,,	,,	,,	Lye washed	5·86	3·49	51·42	·46	38·77	·59	·07	·25	·12
4	Batalagoda	Pachchaperumal	Maha	3	Untreated	17·96	3·11	35·39	·65	42·89	·38	·12	1·21	1·28
	Do.	,,	,,	,,	Water washed	15·18	2·46	38·23	·44	43·69	·63	·68	·57	·78
	Do.	,,	,,	,,	Lye washed	8·10	2·17	51·35	·51	37·87	·76	·03	·19	·17
5	Do.	,,	,,	,,	Untreated	15·60	3·42	33·61	·78	46·59	·54	·19	1·81	1·41
	Do.	,,	,,	,,	Water washed	14·70	3·84	36·25	·62	44·59	·64	·62	·81	·94
	Do.	,,	,,	,,	Lye washed	6·77	3·03	50·04	·63	39·53	·72	·03	·17	·19
6	Do.	Podowi	,,	5	Untreated	15·98	4·34	33·18	·75	45·75	·31	·12	1·64	1·01
	Do.	,,	,,	,,	Water washed	14·58	3·42	35·65	·55	45·80	·40	·62	·62	·57
	Do.	,,	,,	,,	Lye washed	8·96	3·13	47·81	·78	39·32	·52	·04	·13	·09
7	Do.	Vellai Illankaliyan	,,	4	Untreated	18·63	4·30	32·00	·80	44·27	·46	·24	1·81	1·54
	Do.	,,	,,	,,	Water washed	16·48	4·11	34·22	·34	44·85	·75	·60	·41	·97
	Do.	,,	,,	,,	Lye washed	10·31	3·42	49·19	·73	36·35	·71	·04	·17	·12
8	Mylagastenne	Godael	—	—	Untreated	17·79	5·60	36·41	·93	39·27	·53	·39	1·28	1·06
	Do.	,,	—	—	Water washed	16·69	4·49	43·57	·90	34·35	·59	·78	·61	·46
	Do.	,,	—	—	Lye washed	9·51	3·55	50·71	·86	35·37	·71	·06	·14	·11
9	Tissamaharama	Sulai	Maha	3½	Untreated	23·72	4·62	33·05	·66	37·95	·47	·33	1·78	1·23
	Do.	,,	,,	,,	Water washed	21·12	3·70	40·93	·90	33·35	·62	·61	·79	·52
	Do.	,,	,,	,,	Lye washed	10·58	3·14	50·58	·69	35·01	·77	·04	·18	·12
10	Hanguranketa	Heeneti	Yala	4	Untreated	22·23	2·74	34·66	·50	39·81	·44	·20	1·90	1·25
	Do.	,,	,,	,,	Water washed	19·88	2·35	39·51	·80	37·46	·62	·50	·77	·52
	Do.	,,	,,	,,	Lye washed	10·90	2·12	48·47	·69	37·82	·75	·04	·20	·12
	Average				Untreated	18·58	3·97	34·05	·67	42·72	·43	·24	1·70	1·25
	Do.				Water washed	16·26	3·51	37·86	·57	41·90	·58	·63	·63	·63
	Do.				Lye washed	8·62	3·03	49·70	·66	38·09	·68	·05	·18	·14
	Loss or Gain by Water Washing					—12·49	—11·59	+11·19	—14·93	— 1·92	+34·88	+162.50	—62·94	—49·60
	Loss or Gain in Lye Treatment					—53·61	—23·68	+45·96	— 1·49	—10·84	+58·14	+ 79.17	—91·18	—88·80

TABLE II

Percentages of Potash and Oxalates in the Straws under the Different Treatments and Losses Effected

		% *Potash*			% *Loss of Potash by*		% *Oxalates*			% *Loss of Oxalates by*	
		Untreated	*Water washed*	*Lye treatment*	*Water washed*	*Lye treatment*	*Untreated*	*Water washed*	*Lye treated*	*Water washed*	*Lye treated*
1.	Peradeniya (Balamawi)	1·36	·70	·22	48·53	83·82	·66	·27	·06	59·09	90·91
2.	Paranthan (P. P.)	2·04	·49	·18	75·98	91·18	1·70	·79	·33	53·53	80·59
3.	Paranthan (V. I.)	2·19	·49	·25	77·63	88·58	1·34	·43	·12	67·91	91·04
4.	Batalagoda (P. P.)	1·21	·57	·19	52·89	84·30	1·28	·78	·17	39·06	86·72
5.	Batalagoda (P. P.)	1·81	·81	·17	55·25	90·61	1·41	·94	·19	33·33	86·52
6.	Batalagoda (Podiwi)	1·64	·62	·13	62·20	92·07	1·01	·57	·09	43·56	91·09
7.	Batalagoda (V. I.)	1·81	·41	·17	77·35	90·61	1·54	·97	·12	37·01	92·21
8.	Mylagastenne (Godael)	1·28	·61	·14	52·34	89·06	1·06	·46	·11	56·60	89·62
9.	Hanguranketa (Heeniti)	1·90	·77	·20	59·47	89·06	1·25	·52	·12	58·40	90·40
10.	Tissamaharama (Sulai)	1·78	·79	·18	55·62	89·89	1·23	·52	·12	57·72	90·24

THE EFFECT OF WATER WASHING AND LYE TREATMENT ON THE DIGESTIBILITY OF STRAW

The second stage of this investigation was the determination of the effects of water washing and lye treatment on the digestibility of the straw.

In determining the digestibility of a feedingstuff the material is fed to animals for which it is meant under strict y controlled conditions and the amounts of the various constituents digested determined. For arriving at this figure the amount of each constituent actually eaten is determined and the amount of this constituent in the faeces deducted from it. The percentage digested is called the Co-efficient of digestibility for that particular constituent. In such a trial the ration fed should be balanced as far as possible for the maintenance requirements of the animal as regards the dry matter it can eat and the rough digestible protein and total digestible nutrients. Few feedingstuffs are so balanced in themselves. Roughages like grasses, grass hays, cereal straws, &c., are low in digestible protein while the concentrates e.g., oil cakes, grains, &c., on the other hand are not sufficiently bulky. It is therefore necessary to make up a balanced ration with the feedingstuffs under test and one or more other feedingstuffs to balance it.

Paddy straw contains 3–5 per cent. crude protein but has little or no digestible protein. In computing a ration it is therefore best to leave out any contribution of protein from paddy straw and provide for the necessary protein by the addition of an oil cake or other concentrate.

In this trial assuming that there is no protein in the straw sufficient coconut poonac was used to meet this need. There were three types of straw to be tested, namely untreated straw, water washed straw and lye treated straw, and three rations were worked out. The rations consisted of the straw together with the same amount of coconut poonac to make up the protein. These are shown below :—

Ration No. 1	1¾ lb. coconut poonac	.. 6 lb. untreated straw
Ration No. 2	1¾ lb. coconut poonac	.. 6 lb. water washed straw
Ration No. 3	1¾ lb. coconut poonac	.. 6 lb. lye treated straw

Six adult Sinhala bulls of the Karagoda Uyangoda strain of similar weight 455–493 lb. between 4–4½ years old were selected. The animals which were in good health and condition, were trained to the digestibility harness as shown in plate I for collecting faeces and urine. The six bulls were grouped into three batches of two each as follows :—

Batch No. 1	Bull No. 1
	,, No. 2
Batch No. 2	Bull No. 3
	,, No. 4
Batch No. 3	Bull No. 5
	,, No. 6

To eliminate the variation in the digestibility of the individual animals every animal batch received each treatment in rotation in the three periods.

During the preliminary period of 7 days each batch of animals was fed the ration they were to be put on, to get accustomed to it, to see whether there was any ill effect and to clear the digestive tract of the remains of the food taken previously. At the end of this period the actual trial was started and the collection of the faeces and the urine was made daily for ten days. The coconut poonac together with ½ ounce of common salt was given to the animals at 9 a.m. and when they had eaten this the straw was offered to them throughout the day. Water was offered frequently. The faeces were collected from time to time off the bags of each into a weighed bin bearing the number of the animal and containing a small quantity of formalin. The urine was similarly collected into bottles. The collections of both the faeces and the urine were made throughout the day and night. The collected faeces was weighed daily at 8.30 a.m., and samples taken for analysis. The urine was measured simultaneously and aliquots drawn for analysis.

When the collection period of ten days had terminated the animals were kept on their respective rations but without the digestibility harness and weighed on three successive days.

Between each period the animals assumed their normal life for about one and a half months before they were put on to the next test. The main reason for this procedure was that the animals were deprived of any green material during the period under trial. Incidentally it may be stated that this was the first time a digestibility trial was carried out in Ceylon.

The bulls when first brought were semi-wild and unapproachable. They had to be castrated, made docile and trained to the digestibility harness. When the preliminary trial of each period was started the bulls were put into the metabolism stalls so that the faeces and urine of each animal could be collected separately without any confusion and that each animal ate only the food given it and not from its neighbour. Plate 2 shows two metabolism

stalls. In one the animal is in place and the other is empty to show the partition, the feed trough and the stanchion. The stanchion is used to confine the animals feeding to its own trough. These stanchions can be dispensed with if the animals are trained to be tied to the supports on either side of the trough. Plate 3 shows all six animals in the stalls with full harness.

The preparation of the water-washed and lye-treated straw was done in the same way as in the laboratory but on a larger scale. The straw was cut up into 4–6 inch lengths and for lye-treatment was steeped in a concrete tank which held about half a cwt. of straw at a time, with 1·25 per cent. lye (sodium hydroxide solution) for 24 hours. The lye solution was then drained out and the straw washed free of the lye. The resultant straw was dried and stored. The water washing was done in a similar tank by steeping the straw in water for 24 hours, draining the water, washing it with two changes of water and drying. For each period fresh lots of these straws were prepared.

When the three types of straw were weighed for the animals each morning a sample of each was taken the moisture determined and the balance of the sample retained in a bin. At the end of the ten days the straw in each bin was mixed and a sample drawn for analysis. The same procedure was adopted in the case of the coconut poonac. It was thus possible to ensure an accurate measure of the straw and coconut poonac eaten by the animals.

The three types of straw and the coconut poonac from each of the ten-day collections together with the faeces from the six bulls were analysed separately for all the constituents. But the urine was analysed only for nitrogen, calcium and phosphorus. From these results the amounts of different constituents consumed from the straw and poonac and the amount of the different constituents in the faeces voided were calculated. The difference is taken as the amount digested and the percentage of this difference is the digestibility co-efficient for each constituent in the whole ration. The digestibility co-efficients of the three types of straw alone were calculated by deducting the amounts digested from the coconut poonac. The digestibility co-efficients of coconut poonac were taken from Morrison (1948)—(5).

TABLE III

Food Consumption (on dry basis) per all six Animals for each Treatment per day

Straw	*Consumed*		*Total Intake*	*Weight of Bulls*	*Consumption per 100 lb. live weight*	
	from Straw	*from Coconut Poonac*				
	Gms.	*Gms.*	*Gms.*	*lb.*	*Gms.*	*lb.*
Untreated Straw ..	19,570 ..	3,956·0 ..	23,536 ..	3,068 ..	767·1 ..	1·67
Water Washed Straw	17,469 ..	3,956·0 ..	21,425 ..	3,055 ..	701·3 ..	1·55
Lye Treated Straw ..	15,558 ..	3,956·0 ..	19,514 ..	3,046 ..	640·6 ..	1·45

The food consumption on dry basis is given in table III. The results are tabled as the total consumed by the six animals in one day and the total weights of the six animals for the three different types of straw. The data shows that the animals have eaten less than their normal intake of dry matter which is 2–2·5 lb. per 100 lb. of live weight. The consumption is highest in the untreated straw and lowest in the lye treated straw. It is however, not the gross consumption that is important but the actual amount digested. In this the lye treated straw is highest as will be seen later.

TABLE IV

Percentage Composition of the Straw and Poonac (on dry basis)

	Dry matter	*Mineral matter*	*Crude protein*	*Ether extract*	*Crude fibre*	*Nitrogen free extract*	*Total Carbo-hydrates*	*Cal-cium*	*Phos-phorous*
				UNTREATED STRAW					
1st Period ..	87·80	19·96	2·52	0·78	34·13	42·61	76·74	·24	·12
2nd Period ..	91·69	17·24	3·14	0·64	36·77	42·21	78·98	·23	·11
3rd Period ..	89·68	18·14	2·92	0·88	36·73	41·33	78·06	·20	·11
Average ..	89·32	18·45	2.86	0.77	35·88	42·05	77·59	·22	·11
				WATER WASHED STRAW					
1st Period ..	88·08	19·63	2·40	0·83	36·44	40·70	77·14	·38	·33
2nd Period ..	89·70	14·87	2·74	0·78	40·62	40·99	81·61	·31	·30
3rd Period ..	89·94	15·76	2·22	0·97	39·06	41·99	81·05	·28	·32
Average ..	89·24	16·75	2·45	0.86	38·71	41·23	79·93	·32	·32
				LYE WASHED STRAW					
1st Period ..	88·94	13·50	2·54	0·80	44·22	38·94	83·16	·50	·08
2nd Period ..	91·23	12·11	2·63	0·73	44·50	40·03	84·53	·41	·09
3rd Period ..	89·12	15·59	2·41	0·99	42·15	38·86	81·01	·38	·08
Average ..	89·76	13·73	2·53	0·84	43·62	39·28	82·90	·43	·08
				COCONUT POONAC					
1st Period ..	87·70	5·59	21·20	14·45	16·52	42·24	58·76	·06	·52
2nd Period ..	88·48	5·66	21·51	14·63	16·29	41·91	58·20	·07	·52
3rd Period ..	89·42	5·76	20·93	14·67	16·31	42·33	58·64	·07	·50
Average ..	88·53	5·67	21·21	14·58	16·37	42·16	58·53	·07	·52

The percentage composition of the three straws and of the coconut poonac on dry basis is given in table IV. Here too the averages for the three periods are given.

TABLE V

Digestibility co-efficients of Rice Straw and Coconut Poonac and Straw alone

1ST PERIOD

Untreated Straw

Consumed from :—	*Bull No. 1*						*Bull No. 2*					
	Dry matter gm.	*Crude Protein* gm.	*Ether extract* gm.	*Crude fibre* gm.	*N. free extract* gm.	*Total carbohydrates* gm.	*Dry matter* gm.	*Crude protein* gm.	*Ether extract* gm.	*Crude fibre* gm.	*N. free extract* gm.	*Total carbohydrates* gm.
Untreated Straw	2,812·0	70·95	21·80	959·8	1,198·0	2,157·8	2,828·0	71·33	21·93	965·2	1,205·0	2,170·2
Coconut Poonac	656·4	139·20	94·86	115·0	255·7	370·7	656·4	139·20	94·86	115·0	255·7	370·7
Total	3,468·4	210·15	116·66	1,074·8	1,453·7	2,528·5	3,484·4	210·53	116·79	1,080·2	1,460·7	2,540·9
Voided in faeces	2,100·0	114·90	31·59	460·3	877·0	1,337·3	1,944·9	110·00	27·83	392·4	766·1	1,158·5
Total digested	1,368·4	95·25	85·07	614·5	576·7	1,191·2	1,539·5	100·53	88·96	687·8	694·6	1,382·4
Digestibility co-efficient of whole ration	40	45	73	57	40	47	44	48	76	64	47	54
Digested from Coconut Poonac	538·2	118·30	94·86	52·90	209·7	262·6	538·2	118·30	94·86	52·9	209·7	262·6
Digested from Straw	830·2	—	—	561·60	367·0	928·6	1,001·3	—	—	634·9	484·9	1,119·8
Dig : co-efficient of Straw	30	0	0	59	31	43	35	0	0	66	40	52

Water Washed Straw

Consumed from :—	*Bull No. 3*						*Bull No. 4*					
Water washed straw	2,101·0	50·46	17·37	765·5	855·0	1,620·5	2,395·0	57·51	19·80	872·8	974·6	1,847·4
Coconut poonac	656·4	139·20	94·86	115·0	255·7	370·7	656·4	139·20	94·86	115·0	255·7	370·7
Total	2,757·4	189·66	112·23	880·5	1,110·7	1,991·2	3,951·4	196·71	114·66	987·8	1,230·3	2,218·1
Voided in faeces	1,714·5	104·20	25·31	354·3	703·5	1,057·8	1,915·2	104·10	27·43	414·0	810·0	1,224·0
Total digested	1,042·9	85·46	86·92	526·2	407·2	933·4	1,136·2	92·61	87·23	573·8	420·3	994·1
Dig : co-ef : of whole ration	38	45	77	60	37	47	37	47	76	58	34	45
Dig : from c : poonac	538·2	118·30	94.86	52·90	209·7	262·6	538·2	118·30	94·86	52·90	209·7	262·60
Dig : from Straw	504·7	—	—	473·30	197·5	670·8	598·0	—	—	520·90	210·6	731·50
Dig : co-ef. of straw alone	24	0	0	57	23	41	25	0	0	60	22	40

Lye Treated Straw

Consumed from :—	*Bull No. 5*						*Bull No. 6*					
Lye treated straw	2,321·0	58·97	18·48	1,026·0	1,903·6	1,929·6	2,580·0	65·56	20·53	1,141·0	1,005·0	2,146·0
Coconut poonac	656·4	139·20	94·86	115·0	255·7	370·7	656·4	139·20	94·86	115·0	255·7	370·7
Total	2,977·4	198·17	113·74	1,141·0	1,159·3	2,300·3	3,236·4	204·76	115·39	1,256·0	1,260·7	2,516·7
Voided in faeces	1,282·2	114·2	29·10	235·3	517·1	752·4	1,380·5	121·20	30·79	242·5	574·1	816·8
Total digested	1,695·2	83·97	84·24	905·7	642·2	1,547·9	1,855·9	83·56	84·60	1,013·5	686·6	1,700·1
Dig : co-ef of whole ration	57	42	74	79	55	67	57	41	73	81	55	68
Digested from c. poonac	538·2	118·3	94·86	52·90	209·7	262·6	538·2	118·3	94·86	52·90	209·7	262·6
Digested from lye tr. straw	1,157·0	—	—	852·8	432·5	1,285·3	1,317·7	—	—	960·6	476·9	1,437·5
Dig : co-ef, of straw alone	50	0	0	83	48	67	51	0	0	84	47	67

TABLE VI

Digestibility co-efficients of Straw and Coconut Poonac and Straw alone.

2ND PERIOD

Untreated Straw

	Bull No. 3						*Bull No. 4*					
Consumed from :—	*Dry matter* gm.	*Crude Protein* gm.	*Ether extract* gm.	*Crude fibre* gm.	*N. free extract* gm.	*Total carbohydrates* gm.	*Dry matter* gm.	*Crude protein* gm.	*Ether extract* gm.	*Crude fibre* gm.	*N. free extract* gm.	*Total carbohydrates* gm.
Untreated straw	2,847·0	89·48	18·25	1,047·0	1,096·0	2,143·0	3,587·0	112·80	23·00	1,319·0	1,514·0	2,833·0
Coconut poonac	652·3	140·30	95·44	106·2	273·3	379·5	652·3	140·30	95·44	106·2	273·3	379·5
Total	3,499·3	229·78	113·69	1,153·2	1,369·3	2,522·5	4,239·3	253·10	118·44	1,425·2	1,787·3	3,212·5
Voided in faeces	1,669·0	110·80	15·90	362·6	723·1	1,085·7	2,357·8	140·40	27·60	557·6	1,019·0	1,576·6
Total digested	1,830·3	118·98	97·79	790·6	646·2	1,436·8	1,881·5	112·70	90·84	867·6	768·3	1,635·9
Dig : co-ef. whole ration	52	52	86	69	47	67	44	45	77	58	43	51
Digested from coconut poonac	534·9	119·20	95·44	48·86	224·1	272·96	534·9	119·20	95·44	48·86	224·1	272·96
Digested from straw	1,295·4	—	2·35	741·74	422·1	1,163·84	1,346·6	—	—	818·74	544·2	1,362·94
Digestibility co-ef. of straw alone	46	0	12	70	39	54	38	0	0	62	36	48

Water Washed Straw

	Bull No. 5						*Bull No. 6*					
Consumed from :—												
Water washed straw	2,958·0	81·15	23·07	1,201·0	1,212·0	2,413·0	3,429·0	94·08	26·74	1,393·0	1,506·0	2,899·0
Coconut poonac	652·3	140·30	95·44	106·2	273·3	379·5	652·3	140·30	95·44	106·2	273·3	379·5
Total	3,610·3	221·45	118·51	1,307·2	1,485·3	2,792·5	4,081·3	234·38	122·18	1,499·2	1,779·3	3,278·5
Voided in faeces	1,952·8	120·60	18·59	464·4	832·7	1,297·1	2,264·0	137·00	34·91	543·2	975·2	1,518·4
Total digested	1,657·5	100·85	99·02	842·8	652·6	1,485·4	1,817·3	97·38	97·27	956·0	804·1	1,760·1
Digestibility co-ef : of who : ration	46	46	84	65	44	54	45	43	80	64	45	54
Digested from coconut poonac	534·9	119·20	95·44	48·86	224·1	272·96	534·9	119·20	95·44	48·86	224·1	272·96
Digested from straw	1,122·6	—	4·48	793·94	428·5	1,222·44	1,282·4	—	1·83	907·10	580·0	1,487·10
Digestibility co-ef. of straw alone	38	0	19	66	35	51	37	0	7	65	39	51

Lye Treated Straw

	Bull No. 1						*Bull No. 2*					
Consumed from :—												
Lye treated straw	2,387·0	69·84	17·39	1,063·0	955·8	2,018·8	2,686·0	70·68	19·55	1,195·0	1,075·0	2,270·0
Coconut poonac	652·3	140·30	95·44	106·2	273·3	379·5	652·3	140·30	95·44	106·2	273·3	379·5
Total	3,039·3	210·14	112·83	1,196·2	1,229·1	2,398·3	3,338·3	210·98	114·99	1,301·2	1,348·3	2,649·5
Voided in faeces	1,264·3	120·20	15·30	279·9	525·4	805·3	1,235·4	120·00	15·36	258·7	521·3	780·0
Total digested	1,775·0	89·94	87·53	889·3	703·7	1,593·0	2,102·9	90·98	99·63	1,042·5	827·0	1,869·5
Digestibility co. ef. of whole rt	58	43	86	76	57	66	63	43	87	80	61	70
Digested from coconut poonac	534·9	119·20	95·44	48·86	224·1	272·96	534·9	119·20	95·44	48·86	224·1	272·96
Digested from lye treated straw	1,240·1	—	2·09	840·44	479·6	1,320·04	1,568·0	—	40·19	993·64	602·09	1,596·5
Digestibility co.ef. of straw alone	52	0	12	79	50	65	58	0	21	83	56	70

TABLE VII

Digestibility Co-efficients of Rice, Straw and Coconut Poonac and Straw alone

3RD PERIOD

Untreated Straw

	Bull No. 5						*Bull No. 6*					
	Dry matter	*Crude Protein*	*Ether extract*	*Crude fibre*	*N. free extract*	*Tctal carbohy-drates*	*Dry matter*	*Crude protein*	*Ether extract*	*Crude fibre*	*N. free extract*	*Total carbohy-drates*
	gm.	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
Consumed from:—												
Untreated straw ..	3,590·0	83·25	31·54	1,319·0	1,505·0	2,824·0	3,906·0	90·58	34·31	1,435·0	1,638·0	3,073·0
Coconut poonac ..	669·3	140·10	98·22	109·2	277·8	387·0	669·3	140·10	98·22	109·2	277·8	387·0
Total ..	4,259·3	233·35	129·76	1,428·2	1,782·8	3,211·0	4,575·3	230·68	132·53	1,544·2	1,915·8	3,460·0
Voided from faeces	2,041·9	117·00	21·58	397·6	846·1	1,243·7	2,389·2	137·40	21·76	538·5	935·8	1,474·3
Total digested ..	2,217·4	106·35	108·18	1,030·6	936·7	1,967·3	2,186·1	93·28	110·77	1,005·7	980·0	1,985·7
Digestibility co-eff: of whole ration..	52	48	83	72	53	61	48	41	84	65	51	57
Digested from Coconut poonac	543·1	119·1	98·22	50·2	237·8	288·0	543·1	119·10	98·22	50·2	237·8	288·0
Digested from untreated straw	1,674·3	—	—	980·4	698·9	1,679·3	1,643·0	—	—	955·5	742·2	1,697·7
Digestibility co-eff. of straw alone	47	0	0	74	46	59	42	0	0	66	45	55

Water Washed Straw

	Bull No. 1						*Bull No. 2*					
Consumed from :—												
Water Washed straw	3,270·0	72·51	31·54	1,277·0	1,373·0	2,650·0	3,316·0	73·53	31·99	1,295·0	1,392·0	2,687·0
Coconut poonac ..	669·3	140·10	98·22	109·2	277·8	387·0	669·3	140·10	98·22	109·2	277·8	387·0
Total ..	3,939·3	212·61	129·76	1,386·2	1,650·8	3,037·0	3,985·3	213·63	130·21	1,404·2	1,669·8	3,074·0
Voided from faeces	2,302·2	116·10	39·80	562·1	937·4	1,499·5	2,070·1	123·70	36·44	506·3	879·2	1,385·5
Total digested ..	1,637·1	96·51	89·96	824·1	713·4	1,537·5	1,915·2	89·93	93·77	897·9	790·6	1,688·5
Digestibility co-eff: whole ration	42	45	69	60	43	51	46	42	72	64	47	55
Digested from Coconut poonac	543·1	119·1	98·22	50·2	237·8	288·0	543·1	119·10	98·22	50·2	237·8	288·0
Digested from straw	1,094·0	—	—	773·9	475·6	1,249·5	1,372·1	—	—	847·1	552·8	1,400·5
Digestibility co-eff: straw	33	0	0	61	35	47	41	0	0	65	40	52

Lye Treated Straw

	Bull No. 3						*Bull No. 4*					
Consumed from '—												
Lye treated straw ..	2,873·0	69·35	28·48	1,211·0	1,117·0	2,328·0	2,711·0	65·43	26·88	1,143·0	1,054·0	2,197·0
Coconut poonac ..	669·3	140·10	98·22	109·2	277·8	387·0	6,69·3	140·10	98·22	109·2	277·8	387·0
Total ..	3,542·3	209·45	126·70	1,320·2	1,394·8	2,715·0	3,380·3	205·53	125·10	1,252·2	1,331·8	2,584·0
Voided in faeces ..	1,557·3	128·48	23·05	302·3	623·4	925·7	1,485·8	128·20	19·49	308·8	610·8	919·6
Total digested ..	1,985·0	80·97	103·65	1,017·9	771·4	1,789·3	1,894·5	77·33	105·61	943·4	721·0	1,664·4
Digestibility co-eff: whole ration	56	39	82	77	55	66	56	38	84	75	54	64
Digested from coconut poonac	543·1	119·10	98·22	50·2	237·8	288·0	543·1	119·1	98·22	50·2	237·8	288·0
Digested from straw	1,441·9	—	5·43	967·7	533·6	1,501·3	1,351·4	—	7·39	893·2	483·2	1,376·4
Digestibility co-eff; Straw alone	50	0	19	80	48	64	50	0	27	78	46	63

TABLE VIII

Digestibitlity Co-efficients of the Whole Ration

UNTREATED STRAW

Period	*Dry matter* 1— 2— 3	*Crude Protein* 1— 2— 3	*Ether extract* 1— 2— 3	*Crude Fibre* 1— 2— 3	*Notrogen free extractives* 1— 2— 3	*Total carbohydrates* 1— 2— 3
	40—52—52	45—52—48	73—86—83	57—69—72	40—47—53	47—67—61
	44—44—48	48—45—41	76—77—84	64—58—65	47—43—51	54—51—57
Mean	46·67	46·50	79·83	64·17	46·83	56·17

WATER WASHED

Period	61— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3
	38—46—42	45—46—45	77—84—69	60—65—60	37—44—43	47—54—51
	37—45—46	47—42—42	76—80—72	58—64—64	34—45—47	45—54—55
Mean	42·33	44·50	76·33	61·83	41·67	51·00

LYE WASHED

Period	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3
	57—58—56	42—43—39	74—86—82	79—76—77	55—57—55	67—66—66
	57—63—56	41—43—38	73—87—84	81—80—75	55—61—54	68—70—64
Mean	57·53	41·00	81·00	78·00	56·17	66·83

Digestibility Co-efficients of the Straws alone

UNTREATED STRAW

Period	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3
	30—46—47	00—00—00	00—12—00	59—70—74	31—39—46	43—54—59
	35—38—42	00—00—00	00—00—00	66—62—66	40—36—45	52—48—55
Mean	39·69	00	2	66·17	39·50	51·83

WATER WASHED STRAW

Period	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3
	24—38—33	00—00—00	00—19—00	57—66—61	23—35—35	41—51—47
	25—37—41	00—00—00	00— 7—00	60—65—65	22—39—40	40—51—52
Mean	33·00	00	4	62·33	32·33	47·00

LYE WASHED

Period	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3	1— 2— 3
	50—52—50	00—00—00	00—12—19	89—79—80	48—50—48	67—65—64
	51—58—50	00—00—00	00—21—27	84—83—78	47—56—46	67—70—63
Mean	51·83	00	13	81·17	49·17	66·00

The digestibility co-efficients in the whole ration and in the straw alone are shown in tables V, VI and VII and in table VIII the digestibility co-efficients are summarised.

The digestibility co-efficients of the various constituents as shown in table VIII have been statistically analysed. The analysis of variance of these are shown in tables IX and X the whole ration and the straws alone being treated separately. It was not considered necessary to effect a transformation of the digestibility co-efficients before statistically analysing them.

TABLE IX

Whole Ration

Analysis of Variance of Digestibility Co-efficients

Total treatments :—	*df.*	*Dry Matter* S. S.	*Dry Matter* M. S.	*Dry Matter* Variance Ratio	*Crude Fibre* S. S.	*Crude Fibre* M. S.	*Crude Fibre* Variance Ratio	*Nitrogen-free extract* S. S.	*Nitrogen-free extract* M. S.	*Nitrogen-free extract* Variance Ratio
Animal batches and straw	8	931·45	116·43	15·08*	1,028·00	128·50	8·76*	869·12	108·64	17·47*
Straw	2	767·45	383·73	49·70*	916·33	458·17	31·23*	648·12	324·06	52·10*
Animal batches	2	40·45	20·23	2·62	82·33	41·17	2·81	98·78	49·39	7·94†
Interaction	4	123·55	30·89	4·00†	29·34	7·34	·50	122·22	30·56	4·91†
Error	9	69·50	7·72	—	132·00	14·67	—	56·00	6·22	—
Total	17	1,000·95	—	—	1,160·00	—	—	925·12	—	—

	Dry Matter Untreated Straw	*Dry Matter* Water Washed Straw	*Dry Matter* Lye treated Straw	*Dry Matter* Sig. diff.	*Crude Fibre* Untreated Straw	*Crude Fibre* Water Washed Straw	*Crude Fibre* Lye treated Straw	*Crude Fibre* Sig. diff.	*Nitrogen-free extract* Untreated Straw	*Nitrogen-free extract* Water Washed Straw	*Nitrogen-free extract* Lye treated Straw	*Nitrogen-free extract* Sig. diff.
Total for 6 animals	280	254	347	—	385	371	468	—	281	250	337	—
Mean per animal	46·67	42·33	57·83	3·63	64·17	61·83	78·00	5·00	46·83	41·67	56·17	3·26
Percentage	100	90·70	123·91	7·78	100	96·35	121·55	7·79	100	88·98	119·94	6·96

Analysis of Variance of Digestibility Co-efficients—*contd.*

Total treatment :—	*df.*	*Total carbohydrate* S. S.	*Total carbohydrate* M. S.	*Total carbohydrate* Variance Ratio	*Protein* S. S.	*Protein* M. S.	*Protein* Variance Ratio	*Ether Extract* S. S.	*Ether Extract* M. S.	*Ether Extract* Variance Ratio
Animal batches and straw	8	964·78	120·60	6·00*	137·00	17·83	2·23	473·39	59·17	8·66*
Straw	2	782.11	391·06	19·45*	93·00	46·50	6·06†	70·72	35·17	5·18†
Animal batches	2	42·78	21·39	1·06	4·00	2·00	26	33·39	16·70	2·45
Interaction	4	139·89	34·97	1·74	40·00	10·00	1·30	369·28	92·32	13·52*
Error	9	181·00	20·11	—	69·00	7·67	—	61·50	6·83	—
Total	17	1,145·78	—	—	206·00	—	—	534·89	—	—

	Total carbohydrate Untreated Straw	*Total carbohydrate* Water Washed Straw	*Total carbohydrate* Lye treated Straw	*Total carbohydrate* Sig. diff.	*Protein* Untreated Straw	*Protein* Water Washed Straw	*Protein* Lye treated Straw	*Protein* Sig. diff.	*Ether Extract* Untreated Straw	*Ether Extract* Water Washed Straw	*Ether Extract* Lye treated Straw	*Ether Extract* Sig. diff.
Total for 6 animals	337	306	401	—	279	267	246	—	479	458	486	—
Mean per animal	56·17	51·00	66·83	5·86	46·50	44·50	41·00	3·62	79·83	76·33	81·00	3·41
Percentage	100	90·80	118·98	10·43	100	95·70	88·17	7·78	100	95·62	101·47	4·27

* Sig. at 1 per cent.

† Sig. at 5 per cent.

TABLE X.

Analysis of Variance of Digestibility Co-efficients—Straw Alone

	df.	*Dry Matter*			*Crude Fibre*			*Nitrogen-Free-Extract*			*Total Carbohydrates*		
		S. S.	*M. S.*	*Variance Ratio*	*S. S.*	*M. S.*	*Variance Ratio*	*S. S.*	*M. S.*	*Variance Ratio*	*S. S.*	*M. S.*	*Variance Ratio*
Total treatments :—													
Animal batches and straw	8	1,502·00	187·75	15·57*.	1,316·00	164·50	13·22*.	1,303·00	163·00	16·86*.	1,410·44	176·31	17·15*
Straw	2	1,094·33	547·17	45·37*.	1,189·00	594·50	47·79*.	856·50	428·25	44·29*.	1,170·11	585·06	56·91*
Animal batches	2	85·33	42·67	3·54	90·30	45·15	3·63	201·30	100·65	10·41*.	133·44	66·72	6·49†
Interaction	4	322·34	80·59	6·68*.	36·70	9·18	0·74	245·20	61·30	6·34†.	106·89	26·72	2·60
Error	9	108·50	12·06	—	112·00	12·44	—	87·00	9·67	—	92·50	10·28	—
Total	17	1,610·50	—	—	1,428·00	—	—	1,390·00	—	—	1,502·94	—	—

	Untreated Straw	*Water Washed Straw*	*Lye Treated Straw*	*Sig. diff.*	*Untreated Straw*	*Water Washed Straw*	*Lye Treated Straw*	*Sig. diff.*	*Untreated Straw*	*Water Washed Straw*	*Lye Treated Straw*	*Sig. diff.*	*Untreated Straw*	*Water Washed Straw*	*Lye Treated Straw*	*Sig. diff.*
Total for 6 animals	238	198	311	—	397	374	487	—	237	194	295	—	311	282	396	—
Mean per animal	39·67	33·00	51·83	4·53	66·17	62·33	81·17	4·61	39·50	32·33	49·17	4·06	51·83	47·00	66·00	4·19
Percentage	100	83·19	130·65	11·42	100	94·20	122·67	6·97	100	81·85	124·48	10·28	100	90·68	127·34	8·08

* Sig. at 1 per cent.

† Sig. at 5 per cent.

The results of the statistical analysis show that in the *whole ration* the lye treated straw is significantly superior to both the untreated and the water washed straw in dry matter, crude fibre, nitrogen-free-extract and total carbohydrates. In ether extract lye treated straw is significantly better than water washed straw but there is no significant difference between it and the untreated straw. It is however noteworthy that the protein in the untreated straw is significantly superior to that in the lye treated straw. There is no significant difference between the lye treated and water washed. Untreated straw is significantly better than water washed straw in dry matter, nitrogen-free-extract and ether extract but there is no significant difference between untreated and water washed straw in the other three constituents.

In the *straw-alone-figures* the lye treated is significantly superior to both water washed and untreated straw in dry matter, crude fibre, nitrogen-free-extract and total carbohydrates. The untreated straw is significantly better than the water washed straw in dry matter, nitrogen-free-extract and total carbohydrates, but in the case of crude fibre there is no difference.

The differences in the animal batches are eliminated by the design of the experiment and therefore the effect of water washing and lye treatment on the digestibility of the straw can be clearly gauged. In the digestibility of the straw alone which really is of primary importance, the protein and fat may be considered totally undigested for all purposes. The carbohydrate fraction is therefore all that has to be considered in the nutritive value of the straws. The total digestible carbohydrate content of the untreated, water washed and lye treated straws are 40·22 per cent., 37·57 per cent. and 54·71 per cent. respectively. This means that lye treated straw has increased the digestibility of the total carbohydrate fraction by 36 per cent. Here it is abundantly evident that lye treatment has significantly improved the straw while water washing has significantly decreased the value of the straw.

TABLE XI

Balance for Nitrogen

UNTREATED STRAW

	Intake from		*Total Intake*	*Output from*		*Total output*	*Balance*
	Straw	*Poonac*		*Faeces*	*Urine*		
Bull No. 1	11·24	22·27	33·51	18·38	22·64	41·02	— 7·51
Bull No. 2	11·41	22·27	33·68	17·60	18·70	36·30	— 2·62
Bull No. 3	14·32	22·45	36·77	17·73	19·00	36·73	— 0·04
Bull No. 4	18·05	22·45	40·50	22·46	18·96	41·42	— 0·92
Bull No. 5	13·32	22·42	35·74	18·72	16·18	36·90	— 1·16
Bull No. 6	14·49	22·42	36·91	21·98	18·43	40·41	— 3·50

WATER WASHED

	Intake from		Total Intake	Output from		Total output	Balance
	Straw	Poonac		Faeces	Urine		
Bull No. 3	8·07	22·27	30·34	16·67	21·05	37·72	— 7·38
Bull No. 4	9·20	22·27	31·47	16·66	21·07	37·73	— 6·26
Bull No. 5	12·98	22·45	35·43	19·30	18·54	38·17	— 2·74
Bull No. 6	15·05	22·45	37·50	21·92	18·17	40·09	— 2·59
Bull No. 1	11·60	22·42	34·02	18·58	18·43	37·01	— 2·99
Bull No. 2	11·76	22·42	34·23	19·79	20·02	39·81	— 5·58

LYE WASHED

Bull No. 5	9·44	22·27	31·71	18·48	12·53	31·01	+ 0·70
Bull No. 6	10·49	22·27	32·76	19·39	12·69	32·08	+ 0·68
Bull No. 1	11·17	22·45	33·62	19·23	13·30	32·53	+ 1·09
Bull No. 2	11·31	22·45	33·76	19·20	12·31	31·51	+ 2·25
Bull No. 3	11·10	22·42	33·52	20·56	9·87	30·43	+ 3·09
Bull No. 4	10·47	22·42	32·89	20·51	10·95	31·46	+ 1·43

TABLE XII

Balance for Calcium

UNTREATED STRAW

	Intake from		Total Intake	Output from		Total output	Balance
	Straw	Poonac		Faeces	Urine		
Bull No. 1	6·22	0·39	6·61	11·76	0·20	11·96	— 5·35
Bull No. 2	6·25	0·39	6·64	11·86	0·36	12·22	— 5·58
Bull No. 3	6·58	0·46	7·04	10·02	0·46	10·48	— 3·44
Bull No. 4	8·29	0·46	8·75	12·31	0·46	12·77	— 4·02
Bull No. 5	7·04	0·45	7·49	9·82	0·09	9·91	— 2·42
Bull No. 6	7·66	0·45	8·11	11·40	0·09	11·49	— 3·38

WATER WASHED STRAW

Bull No. 3	7·94	0·39	8·33	10·46	0·94	11·40	— 3·07
Bull No. 4	9·05	0·39	9·44	11·11	0·56	11·67	— 2·23
Bull No. 5	9·02	0·46	9·48	12·73	0·71	13·44	— 3·96
Bull No. 6	10·46	0·46	10·92	14·09	0·71	14·80	— 3·88
Bull No. 1	9·02	0·45	9·47	10·39	0·48	10·87	— 1·40
Bull No. 2	9·15	0·45	9·60	10·86	0·78	11·64	— 2·04

LYE TREATED STRAW

	Intake from: Straw	Intake from: Poonac	Total Intake	Output from: Faeces	Output from: Urine	Total output	Balance
Bull No. 5	11·51	0·39	11·90	10·51	0·50	11·01	+ 0·89
Bull No. 6	12·80	0·39	13·19	10·49	0·60	10·09	+ 2·10
Bull No. 1	9·84	0·46	10·30	8·41	0·71	9·12	+ 1·18
Bull No. 2	11·08	0·46	11·54	8·36	0·71	9·07	+ 2·47
Bull No. 3	10·83	0·45	11·28	10·30	0·13	10·43	+ 0·85
Bull No. 4	10·22	0·45	10·67	6·65	0·16	6·81	+ 3·86

TABLE XIII

Balance for Phosphorus

UNTREATED STRAW

	Intake from: Straw	Intake from: Poonac	Total Intake	Output from: Faeces	Output from: Urine	Total output	Balance
Bull No. 1	3·37	3·49	6·86	6·72	0·16	6·88	+ 0·02
Bull No. 2	3·39	3·49	6·88	6·22	0·19	6·41	+ 0·47
Bull No. 3	3·13	3·38	6·51	7·68	0·11	7·79	— 1·28
Bull No. 4	3·95	3·38	7·33	8·96	0·10	9·06	— 1·73
Bull No. 5	3·95	3·33	7·28	7·35	0·15	7·50	— 0·22
Bull No. 6	4·30	3·33	7·63	7·89	0·17	8·06	— 0·43

WATER WASHED STRAW

Bull No. 3	6·93	3·49	10·42	5·32	0·08	5·40	+ 5·02
Bull No. 4	7·90	3·49	11·39	5·17	0·09	5·26	+ 6·13
Bull No. 5	8·87	3·38	12·25	6·45	0·11	6·56	+ 5·69
Bull No. 6	10·28	3·38	13·66	9·96	0·10	10·06	+ 3·60
Bull No. 1	10·46	3·33	13·79	8·52	0·15	8·67	+ 5·12
Bull No. 2	10·61	3·33	13·94	7·04	0·11	6·79	+ 7·15

LYE TREATED STRAW

Bull No. 5	1·76	3·49	5·25	4·36	0·13	4·49	+ 0·76
Bull No. 6	2·06	3·49	5·55	4·01	0·13	4·14	+ 1·41
Bull No. 1	2·15	3·38	5·53	5·29	0·12	5·41	+ 0·12
Bull No. 2	2·41	3·38	5·79	5·80	0·10	5·90	— 0·11
Bull No. 3	2·30	3·33	5·63	4·67	0·16	4·83	+ 0·80
Bull No. 4	2·17	3·33	5·50	4·90	0·15	5·05	+ 0·45

Tables XI, XII, and XIII show the nitrogen, calcium and phosphorus balances. The results show that the lye treated straw has a positive balance for all three constituents while in the water washed and untreated straw the nitrogen and calcium are negative in both. The phosphorus is negative in the untreated straw but positive in the water washed straw. This may be expected as there is a big increase in the phosphorus of the water washed straw.

TABLE XIV

Excretion of Urine per Day

Untreated		*Water Washed*		*Lye Treated*	
Bull No. 1 ..	2785	Bull No. 3 ..	1354	Bull No. 5 ..	2201
Bull No. 2 ..	2431	Bull No. 4 ..	1512	Bull No. 6 ..	2456
Bull No. 3 ..	2405	Bull No. 5 ..	1144	Bull No. 1 ..	2657
Bull No. 4 ..	3186	Bull No. 6 ..	1453	Bull No. 2 ..	2948
Bull No. 5 ..	2693	Bull No. 1 ..	1186	Bull No. 3 ..	3493
Bull No. 6 ..	3364	Bull No. 2 ..	1678	Bull No. 4 ..	3476
Average ..	2810		1389		2872

There is no excessive urination under any of the three straw treatments nor were the animals emaciated due to the deficiency in the retention of Calcium and Phosporus. The author (6) had noticed a very marked emaciation in the experimental animals in a trial he carried out at Izatnagar on the digestibility of maize husk where the ration fed was deficient in phosphorus. When in the next trial the deficiency of phosphorus was made good no such emaciation was noticed. Further whereas in the first trial the nitrogen calcium and phosphorus were all negative in the absence of sufficient phosphorus with the addition of the phosphorus the retention of all three of these constituents were positive. Cabery (7), also did not notice any excessive urination or diuresis, in his trials with paddy straw.

Table XIV shows the amounts of urine excreted daily under the three different treatments. The average for each treatment is given at the bottom of the table. The amount of urine excreted under the untreated straw treatment, which cannot be considered excessive, is practically the same as that under lye treatment. But the urination under the water washed treatment is almost half of the others which indicates that water washing of the straw depresses the excretion of urine.

TABLE XV

Percentage Moisture in Faeces

Untreated		*Water Washed*		*Lye Treated*	
Bull No. 1 ..	77·15	Bull No. 3 ..	73·60	Bull No. 5 ..	79·15
Bull No. 2 ..	77·05	Bull No. 4 ..	75·17	Bull No. 6 ..	79·88
Bull No. 3 ..	79·96	Bull No. 5 ..	76·71	Bull No. 1 ..	81·85
Bull No. 4 ..	79·11	Bull No. 6 ..	77·15	Bull No. 2 ..	80·47
Bull No. 5 ..	73·60	Bull No. 1 ..	77·70	Bull No. 3 ..	75·10
Bull No. 6 ..	76·05	Bull No. 2 ..	79·02	Bull No. 4 ..	80·34
Average ..	77·15		76·54		79·47

Table XV gives the percentage moisture in the faeces under the three different treatments and it is seen that the faeces from the lye treated straw treatment has the highest moisture.

It is possible that Sinhala cattle living on a lower mineral intake for centuries had attained a lower equilibrium for these minerals. Thus the experimental animals were not adversely affected as animals bred at a higher mineral level would have been.

TABLE XVI

Utilization of Carbohydrates in Straw—per all six Animals for each Treatment per Day

	Total straw consumed	*Total carbohydrates in the straw consumed*	*Total carbohydrates Digested*
	gms.	*gms.*	*gms.*
Untreated straw ..	19,570 ..	15,184 ..	6,107
Water washed straw ..	17,469 ..	13,963 ..	5,246
Lye treated straw ..	15,558 ..	12,897 ..	7,056

Table XVI gives the amounts of straw consumed from the three treatments, the equivalent of the straw consumed in total carbohydrates and the amount of carbohydrate digested. It is seen that although the untreated straw is consumed the most, the highest amount of digestible carbohydrates has been derived from the lye treated straw. It is not the amount consumed but the actual amount digested that is the criterion by which a feedingstuff can be judged.

Unfortunately, although the lye treatment of straw significantly increases its nutritive value, it is not a method that can be adopted by the average Ceylon villager. But when the plant for the large scale processing of animal food is established the production of lye treated straw economically

Plate 1.—A Bull with the digestibility harness on.

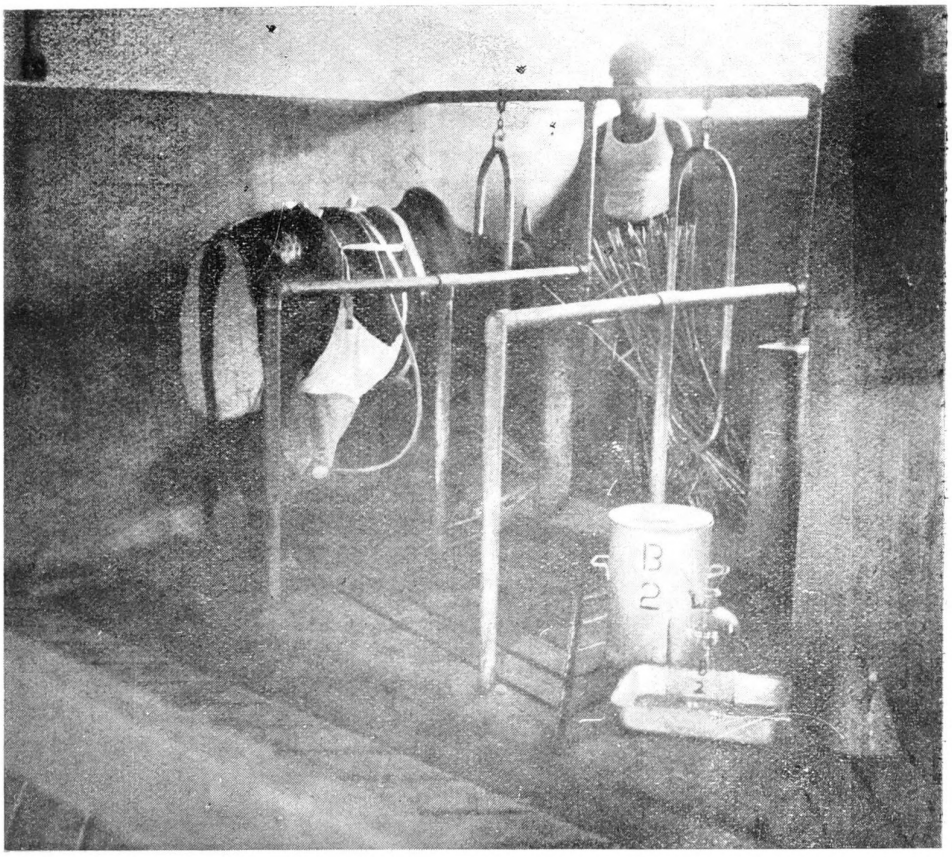

Plate 2.—Two Metabolism Stalls.

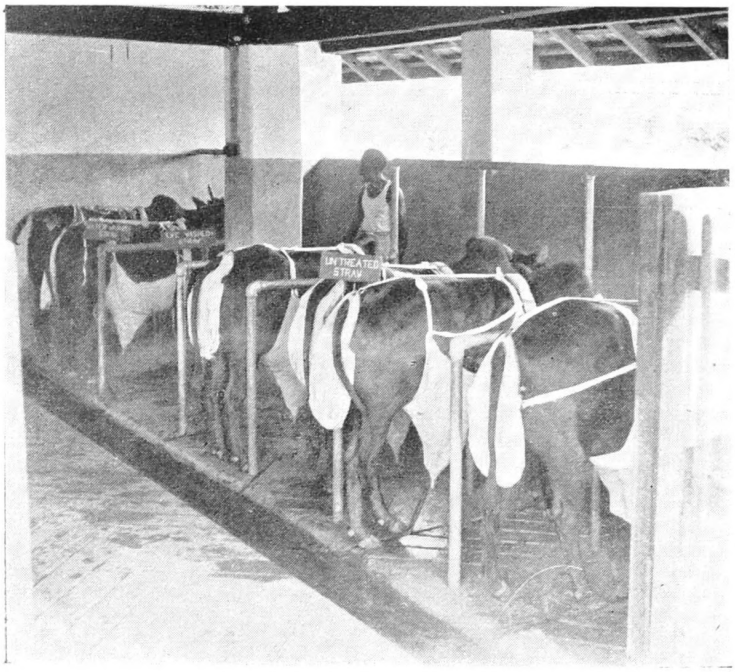

Plate 3.—The Trial in Progress

should be possible. It may be worthwhile investigating the production of a lye treated straw fortified with a nitrogen rich material like urea. A product of this nature will go a long way to ease the scarcity of animal feedingstuffs in the Island.

SUMMARY

Both lye treatment and water washing remove the excessive amounts of potassium and oxalates which hinder the assimilation of calcium. But while lye treatment removes almost 90 per cent., water washing removes only about 50 per cent. and that too not consistantly.

The carbohydrate fraction which is the most valuable portion of the straw is significantly increased by lye treatment.

Lye treatment significantly increases the digestibility of the carbohydrate fraction of paddy straw while water washing decreases it. The increase of the total digestible carbohydrates by lye treatment is 36 per cent.

No diuresis was noticed under any of the three straw treatments adopted in this trial.

Though the consumption was highest in the untreated straw and lowest in the lye treated the amount of the carbohydrates actually digested was highest in the lye treated straw.

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