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The Composition and Digestibility of Sudan Grass Hay

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INTRODUCTION.

The introduction of Sudan grass (*Andropogon sorghum* var.) into the United States took place less than nine years ago, but since then this crop has become widely known and its popularity is rapidly increasing. Sudan grass, being an annual, does not make a good pasture plant, but gives excellent results as a hay or soiling crop; it might also be successfully made into silage if mixed with a legume.

RESUME OF PREVIOUS WORK.

A considerable amount of work has been done on the production of Sudan grass, and, though the yields of hay obtained varied considerably, they were as a rule satisfactory.

TABLE I.

AVERAGE YIELDS OF SUDAN GRASS HAY.[1]

State Experiment Station	Dry Hay Per Acre
	Tons
Virginia	3.4
Tennessee	2.6
Mississippi	5.5
Louisiana	3.3
Georgia	3.6
Arkansas	1.1
Texas	3.9
Oklahoma	2.9
[2]Ohio	4.3
[3]Kansas	3.1
Average	3.4

The average yields of Sudan hay, as stated in Table I, have not all been calculated by the same method but the results show that as a rule a yield of three to four tons of field cured hay per acre can be expected.

The material available to show the composition of Sudan grass hay is limited but a compilation of the published analyses is included here. There is a wide variation in the moisture contents

[1]Farm Bul. 677; U. S. Dept. Agric.
[2]Monthly Bul. Vol. 1, No. 3; Ohio Sta.
[3]Bul. 212, Kans. Sta.

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of hays, due to a considerable extent to the lack of uniformity in the conditions under which curing takes place, so in Table II the various constituents are expressed as percentages of the total dry matter present in the samples of hay analyzed.

TABLE II.

COMPOSITION OF DRY MATTER OF SUDAN GRASS HAY.

	Maryland 4	Virginia 5	Texas 6	Oklahoma 7	Average
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Total Dry Matter ...	90.12	96.49	.	92.80	93.14
Protein	6.57	4.83	12.42	8.56	8.10
Nitrogen-free-extract	51.99	51.09	45.56	48.98	49.41
Crude Fiber	34.83	36.92	29.93	34.01	33.92
Ether Extract	1.88	1.32	1.93	2.42	1.89
Ash	4.74	5.85	10.16	6.03	6.70

The analyses of Sudan grass hay that have been reported are fairly uniform in all their constituents except protein and ash, which show rather wide variations due perhaps to the conditions under which the crops were grown, and the stage of growth at the time of cutting.

It is generally understood that the majority of crops alter materially in composition as ripening progresses. This change is due not only to the increase in the amount of dry matter and the decrease in the amount of water but also to a variation in the relative proportions of the individual constituents of the dry matter. These changes usually go on until the crop is practically ripe but that this is not so in the later stages of ripening in the case of Sudan grass has been shown by Piper.

TABLE III.

COMPOSITION OF DRY MATTER OF SUDAN GRASS HAYS[8] MADE AT VARIOUS STAGES OF RIPENESS.

Stage of Cutting	Before Heading	Heads Appearing	Beginning to Bloom	In Full Bloom	Seeds Fully Mature
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Protein	8.08	6.28	5.34	4.83	4.38
Nitrogen-free-extract	51.23	53.41	53.76	51.09	55.85
Crude Fiber	32.00	33.11	34.42	36.92	36.02
Ether Extract	1.79	1.44	1.27	1.32	1.55
Ash	6.89	5.75	5.20	5.85	5.85

[4]Bul. 194; Md. Sta.
[5]Circ. 125; Bur. Plant Ind., U. S. Dept. Ag.
[6]Bul. 172; Tex. Sta.
[7]Bul. 103; Okla. Sta.
[8]Circ. 125; Bur. Plant Ind., U. S. Dept. Ag.

As would be expected there is a decrease in the protein and a slight increase in the crude fiber content. These changes are marked in the case of the protein but the other constituents are fairly constant. The significance of this is that from the time Sudan grass heads out until it is fully ripe there is very little change in the fiber content of the dry matter and consequently the time of cutting can be delayed without much risk of the hay becoming too coarse. This suggests a distinct advantage if the haying season is wet—the cutting of the Sudan grass may advantageously be postponed for a week or ten days if there is a prospect of the weather improving.

In spite of the fact that Sudan grass is now grown in quite an extensive territory it has been fed but little experimentally. Large amounts of Sudan hay are consumed annually yet only in one or two cases have accurate records been kept of the results it produced.

So far only one digestion trial has been conducted with Sudan grass hay. This work consisted of a five day test period with a two-year-old bull and the results of it are given below.

TABLE IV.

DIGESTIBILITY OF SUDAN GRASS HAY.[9]

CONSTITUENT	DIGESTION COEFFICIENT
	Per Cent
Dry Matter	60.6
Crude Protein	35.4
Nitrogen-free-extract	63.3
Crude Fiber	67.1
Ether Extract	41.2

The digestion coefficients for Sudan grass hay obtained at the Maryland Experiment Station compare well with those for other nonleguminous roughages.

At the Kansas Experiment Station Sudan grass hay was compared with alfalfa hay as a roughage for dairy cows. Two lots of three cows each were used. There were two thirty-day test periods. In the first period Lot I received alfalfa hay and Lot II Sudan grass hay, while in the second test period the roughages for the two lots were reversed.

[9] Bul. 194, Md. Sta.

TABLE V.

SUDAN GRASS HAY VS. ALFALFA HAY[3] FOR MILK PRODUCTION

	Roughage		Gain due to Alfalfa
	Sudan Grass	Alfalfa	
	lbs.	lbs.	lbs.
Milk Produced	4022	4112	90
Fat Produced	168	178	10
Average Body Weight	1053	1077	24

This shows a difference in production of 0.5 pound of milk per head per day in favor of the alfalfa hay. This is not a large difference but if the experiment had been run for another thirty-day period so as to facilitate the elimination of the decrease in production due to advance in lactation, there is little doubt but what the Sudan grass hay would have shown up even less favorably. The fact that the cows increased in weight when receiving the alfalfa is significant.

The Kansas records also show that when the herd of milking cows was turned from a native pasture on to a Sudan pasture the average daily production of milk was increased 3.2 pounds per head even though Sudan grass is not a first class pasture plant. In addition they also found that for wintering work horses and mules and young beef cattle Sudan grass hay was of considerably less value than alfalfa hay.

EXPERIMENTAL WORK.

The Sudan grass used in the work reported in this paper was grown on the College dairy farm. During the two years this crop has been grown there it has given good results as a soiling crop, the average yield being eleven tons of green feed per acre for one cutting. In 1916 a small amount of second growth was made into hay. Sudan grass seems to be palatable and much relished by the stock and good results have been obtained in the feeding of both the soiling and the hay.

In 1915 analyses were made of the crop at various stages of growth. The samples were all taken from one small plot in the centre of the area grown for soiling and the results of the analyses are expressed as percentages of the total dry matter present.

[3] Bul. 212, Kans. Sta.

TABLE VI.

COMPOSITION OF DRY MATTER OF SUDAN GRASS AT VARIOUS STAGES OF GROWTH.

	Before Heading	Headed Out	Full Bloom	Half Ripe	Ripe
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Total Dry Matter ..	20.80	20.96	25.74	30.08	31.92
Protein	8.80	9.78	6.57	5.02	4.29
Nitrogen-free-extract	48.12	46.04	50.19	53.32	53.73
Crude Fiber	32.98	35.50	32.36	32.98	33.83
Ether Extract	2.31	2.62	3.53	2.10	1.66
Ash	7.79	6.06	7.35	6.58	6.49

As the moisture decreases and the dry matter content increases in the later stages of growth of Sudan grass, a few minor changes take place in the relative proportions of the individual constituents of the dry matter. In the earlier stages of ripening the protein seems to increase while it decreases in the later stages. The changes in the fat content are very similar to but lag behind those of the protein content. The changes in the proportions of nitrogen-free extract and ash are in the opposite direction to those of the protein and ether extract. Peculiarly, the relative proportion of the crude fiber to the other constituents of the dry matter appears to be greater when the plants have headed out than when the crop is ripe. The difference is not great, however, and can probably be explained by the fact that the seed, of which the yield is quite heavy, is very low in crude fiber. It has been found at the Maryland Station[4] that cleaned Sudan grass seed contains only 1.19 per cent of crude fiber. Considering the changes broadly it is evident that from the time the crop heads out until it is ripe no very marked alterations take place in the relative proportions of the various constituents of the dry matter present and consequently Sudan grass does not materially deteriorate in feeding value on ripening.

The hay used in the digestion trial was from a plot yielding 2.94 tons of field-cured hay per acre at one cutting. It was cut on August 5, 1916, when in full bloom and was harvested in good condition. It was kept in the mow till used for the digestion trial in December, 1916.

The animals used were two three-quarter blood Guernsey heifers about a year and a half old and averaging 600 pounds in live

[4]Bull. 194; Md. Sta.

weight. These animals were of 75 per cent the same breeding, being sired by Rouge of Ames, 24405, a son of Rouge II's Son, while their dams were sired by Rouge II's Son, 18587. From birth until the start of the digestion trial these heifers received the same care and feed. Both were pregnant and in fair condition at the beginning of the experiment, and though No. 298 was rather larger than No. 301, they were a very uniform pair in all other ways.

TABLE VII—ANIMALS USED IN TRIAL.

	Herd No. 298	Herd No. 301	Average
Age	1 yr. 6 mo. 17 da.	1 yr. 5 mo. 27 da.	1 yr. 6 mo. 7 da.
Days Bred ...	63	152	108
Weight, lbs. .	650	550	600

The digestion trial was run for a period of five days preceded by a preliminary period of seven days during which Sudan grass was fed as the only source of nutriment to the heifers. In the preliminary period it was found that 20 pounds per head per day of the hay would be a convenient amount to feed, so this allowance was used throughout the experiment and the material left was weighed back daily.

It has been found that the animals had no special need of being watered twice daily so the watering was done at the beginning of each twenty-four hour period and the animals were weighed before and after watering. The attendant collected the feces with a scoop and deposited them in tarred galvanized iron vessels which were provided with covers.

A composite sample of the hay fed and one of the orts were made at the end of the trial period. The feces from each heifer were mixed thoroughly and sampled at the end of each twenty-four-hour period and these samples air-dried. At the end of the trial an aliquot composite sample was made for the feces produced by each of the heifers during the five-day trial period.

The composite samples of feces, together with those of hay and orts were chemically examined according to the official methods.

In Table VIII is given a summary of the hay and water consumed and the feces produced daily by each of the heifers. Only the net consumption of hay is given and the feces production recorded opposite a daily consumption of hay is the weight of feces

produced in the twenty-four hour period following the day during which the recorded amount of hay was consumed.

TABLE VIII—SUMMARY OF FEED AND FECES.

	Hay Consumed		Water Consumed		Feces Produced	
Heifer No.	298	301	298	301	298	301
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Day 1	14.2	13.4	24	27	19.1	14.9
2	17.0	16.7	39	29	21.8	20.9
3	13.0	11.6	31	17	24.6	18.4
4	7.9	10.5	28	27	21.4	21.8
5	12.4	14.1	24	26	23.9	19.8
Total	64.5	66.3	146	126	110.8	95.8

The heifers had very similar capacities for hay consumption, the difference in their average daily consumption being only about one-third of a pound. Their capacities for water consumption were also very much alike; the heifer which consumed the smaller amount of hay drank on the average four pounds more water per day than did the other heifer. The feces production followed the water consumption very closely and the heifer which consumed the smaller amount of hay and the greater quantity of water produced the greater weight of feces.

TABLE IX. COMPOSITION OF HAY.

	Hay Offered	Hay Refused	Hay Consumed
	Per Cent	Per Cent	Per Cent
Moisture	13.19	11.64	14.01
Dry Matter	86.81	88.36	85.99
Protein	5.97	4.10	6.96
Nitrogen-free-extract	43.63	42.85	44.04
Crude Fiber	28.65	34.50	25.55
Ether Extract	1.62	1.08	1.91
Ash	6.94	5.83	7.52

As was to be expected the hay refused was a little more fibrous than the whole sample. The difference is so small, however, that the digestion coefficients found for the hay consumed will apply equally well to the whole sample.

TABLE X. COMPOSITION OF FECES.

Heifer No.	298	301
	Per Cent	Per Cent
Moisture	82.39	79.13
Dry Matter	17.61	20.87
Protein	2.13	2.54
Nitrogen-free-extract	8.32	9.74
Crude Fiber	4.35	5.24
Ether Extract	.47	.54
Ash	2.34	2.81

The analyses given for the feces represent their composition when moist. Heifer No. 301, which consumed less hay and more water than did heifer No. 298, produced the feces with the higher moisture content. The bulk of the feces evidently depends to a large extent on the amount of water consumed.

TABLE XI.

SUMMARY OF NUTRIENTS CONSUMED AND DEFECATED.

Heifer No.	298		301	
Nutrients	Consumed Total	Defecated Total	Consumed Total	Defecated Total
	lbs.	lbs.	lbs.	lbs.
Dry Matter	55.44	19.51	57.03	19.99
Protein	4.51	2.36	4.59	2.43
Nitrogen-free-extract	28.42	9.22	29.19	9.33
Crude Fiber	16.40	4.82	17.02	5.02
Ether Extract	1.24	.52	1.26	.52

This table again demonstrates the similarity between the powers of the two heifers for using roughage and also indicates that their powers of digestion are very nearly equal.

TABLE XII.

COEFFICIENTS OF DIGESTIBILITY.

Heifer No.	298	301	Average
	Per Cent	Per Cent	Per Cent
Dry Matter	64.8	65.0	64.9
Protein	47.7	47.1	47.4
Nitrogen-free-extract	67.6	68.0	67.8
Crude Fiber	70.6	70.5	70.6
Ether Extract	58.1	58.7	58.4

This shows that the nutrients in Sudan grass hay are all fairly easily digested. The digestion coefficients range from 47.4 per cent in the case of the protein to 70.6 per cent in the case of the crude fiber, while that for the total dry matter is 64.9 per cent.

A comparison of the work done at this Station with that done at the Maryland Station shows that the coefficients of digestibility obtained agree fairly closely for most of the nutrients present in Sudan grass hay.

TABLE XIII.

COMPARISON OF DIGESTION TRIALS WITH SUDAN GRASS HAY.

	Digestion Coefficients[4]		
	Maryland	Iowa	Average
	Per Cent	Per Cent	Per Cent
Dry Matter	60.6	64.9	63.5
Protein	35.4	47.4	43.4
Nitrogen-free-extract	63.3	67.8	66.3
Crude Fiber	67.1	70.6	69.4
Ether Extract	41.2	58.4	52.7

The Iowa results are in all cases higher than those obtained at the Maryland Station but only in the case of the crude protein and ether extract is there a very marked difference. This may perhaps be due to differences in the conditions under which the hays were grown, though they are very similar in composition, or more probably to variations in the digestive powers of the animals used. Whatever the factor or factors are that bring about this difference they apparently are selective in their action.

TABLE XIV.

SUMMARY OF WORK ON SUDAN GRASS HAY
NUTRIENTS IN 100 POUNDS OF HAY.

	Nutrients	
	Total	Digestible
	lbs.	lbs.
Dry Matter	91.6	58.2
Protein	7.7	3.3
Nitrogen-free extract	48.3	32.0
Crude Fiber	30.9	21.4
Ether Extract	1.8	.9

[4]Bul. 194; Md. Sta.

A comparison of Sudan grass hay with timothy and millet hay shows that these feeds are very similar in composition. The digestible nutrients in 100 pounds of dry matter of the various feeds have been calculated from Henry & Morrison's tables[8] while the digestible true protein and net energy value of 100 pounds of dry matter have been obtained from Armsby's work.[9]

TABLE XV.

DIGESTIBLE NUTRIENTS IN 100 LBS. OF DRY MATTER.

	Timothy Hay	Millet Hay	Sudan Grass Hay
	lbs.	lbs.	lbs.
Protein	3.4	5.8	3.6
Carbohydrates	48.4	53.6	58.3
Fat	1.4	2.1	1.0
Total	54.0	64.2	64.2

This shows that Sudan grass hay provides considerably more nutrients than does timothy hay and though it contains rather less digestible protein than does millet hay it appears to furnish about the same amount of total nutrients. These comparisons are made on the dry matter basis so as to eliminate variations due to changes in the moisture contents of the feeds.

TABLE XVI.

DIGESTIBLE TRUE PROTEIN AND NET ENERGY. VALUES PER 100 POUNDS OF DRY MATTER.

	Timothy Hay	Millet Hay	Sudan Grass Hay
Digestible True Protein, lbs.	2.5	4.6	2.7
Net Energy Value, Therms..	48.67	54.80	64.42

The net energy value of the Sudan grass hay has been calculated according to Armsby's method. While the digestible true protein is taken as 75 per cent of the digestible crude protein. These figures show that Sudan grass hay, though deficient in protein, provides more net energy, per 100 pounds of dry matter. than does hay from timothy or millet.

[8] Bul. 73; Wis. Feeding.
[9] Bul. 142; Pa. Sta.

SUMMARY.

1. The dry matter of Sudan grass changes slightly in composition from the time of heading until the crop is ripe.

2. The content of fat and protein increases in the early stages of ripening and decreases later while the changes in the nitrogen-free-extract and ash content are in the opposite direction.

3. Either as a green feed or as hay, Sudan grass is very palatable.

4. Sudan grass hay has a comparatively high apparent digestibility.

5. Sudan grass hay supplies energy to cattle much more efficiently than it does protein.

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