

# THE EFFECT OF ARTIFICIAL DRYING ON THE AVAILABILITY OF THE NUTRIENTS OF ALFALFA HAY<sup>1</sup>

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## INTRODUCTION

Recently there have come into practical use a number of driers designed for the rapid desiccation of large quantities of green plant tissue. Naturally the question of the availability of the nutrients of such dried hays as compared with those of hays cured in the ordinary way becomes important.

One of the first driers used in this country for the desiccation of green plants was the Mason drier. In this machine the period of drying is from 30 to 35 minutes, and the temperature of the heated air as it passes from the furnace to the drying tunnel is 127° to 129° C. Later the Koon drier came into use. A Koon drier, established on the farm of Howard T. Green at Genesee Depot, Wis., was used there experimentally for a number of years. The maximum temperature to which plants were exposed in the process of drying and the time of exposure were definitely measured. The time consumed in the drying process was not more than one minute. The highest temperature recorded for fresh green material was 480° to 535° C. with an exposure of 40 seconds. Where the material had already been partly dried lower temperatures were used at the inlet. Such high temperatures of the drying gases must be used in the evaporation of the water without subjecting the dry matter itself to them. In spite of the high temperatures the hay comes out of the drier retaining a pea-green color. It was not known, however, whether these temperatures had rendered unavailable certain valuable constituents of the plants, and it was to determine the effects of this method of drying on the availability of important nutrients that the experiment herein reported was undertaken.

Studies have been carried out on the effect of the Mason drying process on the vitamin A and D content of alfalfa.<sup>3</sup> Russell found that alfalfa cured by the Mason process was seven times as potent in its vitamin A content as field-cured hay, but that it was very low in vitamin D—as would be expected when compared with alfalfa cured in the sun. Hauge and Aitkenhead<sup>4</sup> also found that alfalfa dried in artificial driers, at a much higher temperature than that used in the Mason drier, was still rich in vitamin A. They say: "Even a temperature as high as the hot flue gas used in one of the machines, or the sterilization temperature of the autoclave, was not destructive." No mention is made of the type of drier used.

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<sup>2</sup> The writers' thanks are due Howard T. Green, of Brook Hill Farms, Genesee Depot, Wis., for making this investigation possible.

<sup>3</sup> RUSSELL, W. C. THE EFFECT OF THE CURING PROCESS UPON THE VITAMIN A AND D CONTENT OF ALFALFA. *Jour. Biol. Chem.* 85: 289-297. 1929.

<sup>4</sup> HAUGE, S. M., and AITKENHEAD, W. THE EFFECT OF ARTIFICIAL DRYING UPON THE VITAMIN A CONTENT OF ALFALFA. *Jour. Biol. Chem.* 93: 663. 1931.

## EXPERIMENTAL PROCEDURE

Three lots of second-growth alfalfa hay, cut from the same field were prepared at the Brook Hill farm. The hays were cured in three different ways: Hay No. 1 was cut on August 1, 1930, and dried immediately in the Koon drier. Hay No. 2 was cut at 2.30 p. m., July 31, raked into a windrow late in the afternoon, hauled just before noon on August 1, and dried in the artificial drier. This hay had lost about 40 per cent of its moisture before it was actually dried in the drier. Hay No. 3 was field cured, cut on August 13, at 3 p. m., raked into windrows on August 14 about 1 p. m., and cocked about 4.30, August 14. This hay was hauled August 20, cut with a silage cutter, and blown into bags.

The hays, cut and bagged, were delivered to the experiment station. All were a rich pea-green color. Studies on the digestible dry matter, digestible protein, and available calcium were made with three high-producing Holstein cows that were in the early part of their third lactation period. The metabolism experiment was begun February 5, 1931. Cow No. 1 freshened January 15, 1931; cow No. 2 freshened December 22, 1930; and cow No. 3 freshened December 20, 1930. All developed into heavy milkers—that is, they produced 50 to 60 pounds of milk daily.

The ration used consisted of 10 pounds of the alfalfa hay, 25 pounds of corn silage, and for every 3 to 3½ pounds of milk 1 pound of a grain mixture made of 59 parts of yellow corn, 25 parts of wheat bran, 15 parts of oil meal, and 1 part of salt.

In the first period of three weeks the animals were fed hay 1 (dried immediately); in the second period of three weeks, hay 2 (partly field cured and then dried in the drier); and in the third period of three weeks, hay 3 (sun cured in the field).

Quantitative collection of the excreta and quantitative collection of the milk, with a complete analysis of income and outgo, particularly in reference to calcium, digestible dry matter, and digestible nitrogen, were made. During the course of the experiment the feed consumption by the animals was complete, except in the ninth week, when cow 2 left some residue.

## EXPERIMENTAL DATA

Table 1 gives the record of digestibility of the dry matter. A study of this table indicates that the coefficients of digestibility of the dry matter of the three hays were very much alike. Apparently drying at a high temperature for 40 seconds had in no way impaired the availability of the dry matter of alfalfa for the cow.

TABLE 1.—Data on digestibility of dry matter in alfalfa dried and cured in different ways

## PERIOD 1—HAY 1 (ALFALFA DRIED IMMEDIATELY)

Week No.	Cow 1				Cow 2				Cow 3			
	Dry matter intake	Dry matter in feces	Difference	Coefficient of digestibility	Dry matter intake	Dry matter in feces	Difference	Coefficient of digestibility	Dry matter intake	Dry matter in feces	Difference	Coefficient of digestibility
1.....	Grams 91, 286	Grams 26, 461	Grams 64, 825	Per ct. 71.0	Grams 88, 516	Grams 25, 558	Grams 62, 958	Per ct. 71.1	Grams 91, 286	Grams 27, 187	Grams 64, 099	Per ct. 70.2
2.....	91, 286	25, 530	65, 756	72.0	88, 516	24, 948	63, 568	71.8	91, 286	28, 093	63, 193	69.2
3.....	91, 286	27, 179	64, 107	70.2	88, 516	24, 617	63, 899	72.1	91, 286	28, 745	62, 541	68.5
Average.....	-----	-----	-----	71.0	-----	-----	-----	71.7	-----	-----	-----	69.3

## PERIOD 2—HAY 2 (ALFALFA PARTLY CURED)

4.....	90, 427	26, 713	63, 714	70.4	87, 662	26, 617	61, 045	69.6	90, 427	29, 731	60, 696	67.1
5.....	90, 427	25, 764	64, 664	71.5	87, 662	23, 976	63, 686	72.6	90, 427	28, 080	62, 347	68.9
6.....	90, 427	26, 235	64, 192	71.0	87, 662	26, 114	61, 548	70.2	90, 427	27, 044	63, 383	70.0
Average.....	-----	-----	-----	71.0	-----	-----	-----	70.8	-----	-----	-----	68.7

## PERIOD 3—HAY 3—(ALFALFA SUN CURED)

7.....	90, 538	24, 646	65, 892	72.7	87, 784	25, 017	62, 767	71.5	90, 538	27, 294	63, 244	69.8
8.....	90, 538	27, 113	63, 425	70.0	87, 784	26, 840	60, 944	69.4	90, 538	28, 482	62, 056	68.5
9.....	90, 538	26, 309	64, 229	70.9	87, 784	18, 688	69, 096	(*)	90, 538	28, 189	62, 349	68.9
Average.....	-----	-----	-----	71.2	-----	-----	-----	70.4	-----	-----	-----	69.1

\* Cow off feed.

Table 2 gives a record of the digestible nitrogen. A careful study of this table shows that the protein and other nitrogenous complexes of the hay were not rendered unavailable through the heat treatment of this particular drier. One might interpret the records of cows 1 and 3 as indicating a slightly lower availability of the protein in the hay that was immediately dried as compared with that in the sun-cured hay, but the differences are too slight to be of any real significance. In the case of cow 2 the availability of the nitrogen in the three periods was practically identical.

TABLE 2.—Data on digestibility of nitrogen in alfalfa dried and cured in different ways

## PERIOD 1—HAY 1 (ALFALFA DRIED IMMEDIATELY)

Week No.	Cow 1				Cow 2				Cow 3			
	Total nitrogen intake	Nitrogen in feces	Nitrogen digested	Coefficient of digestibility	Total nitrogen intake	Nitrogen in feces	Nitrogen digested	Coefficient of digestibility	Total nitrogen intake	Nitrogen in feces	Nitrogen digested	Coefficient of digestibility
1-----	Grams 2,315.95	Grams 642.60	Grams 1,673.35	Per ct. 72.2	Grams 2,229.85	Grams 666.60	Grams 1,563.25	Per ct. 70.1	Grams 2,315.95	Grams 773.14	Grams 1,542.81	Per ct. 66.6
2-----	2,315.95	612.70	1,703.25	73.1	2,229.85	631.80	1,598.05	71.6	2,315.95	719.96	1,595.99	68.9
3-----	2,315.95	639.00	1,676.95	72.4	2,229.85	640.80	1,589.05	71.3	2,315.95	827.68	1,488.27	64.3
Average--	-----	-----	-----	72.6	-----	-----	-----	71.0	-----	-----	-----	66.6

## PERIOD 2—HAY 2 (ALFALFA PARTLY CURED)

4-----	2,379.51	598.20	1,781.31	74.9	2,293.41	686.88	1,606.53	70.0	2,379.51	798.75	1,580.76	66.5
5-----	2,379.51	639.00	1,740.51	73.3	2,293.41	642.82	1,650.59	71.9	2,379.51	793.49	1,586.02	66.6
6-----	2,379.51	613.80	1,765.71	74.2	2,293.41	645.84	1,647.57	71.8	2,379.51	685.26	1,694.25	71.2
Average--	-----	-----	-----	74.1	-----	-----	-----	71.2	-----	-----	-----	68.1

## PERIOD 3—HAY 3 (ALFALFA SUN CURED)

7-----	2,363.62	564.60	1,799.02	76.1	2,277.52	652.15	1,625.37	71.3	2,363.62	772.74	1,590.88	67.2
8-----	2,363.62	591.00	1,772.62	75.0	2,277.52	637.81	1,639.71	72.0	2,363.62	773.26	1,590.36	68.9
9-----	2,363.62	552.60	1,811.02	76.6	2,277.52	395.14	1,882.38	(*) 72.0	2,363.62	748.50	1,615.12	68.3
Average--	-----	-----	-----	75.9	-----	-----	-----	71.6	-----	-----	-----	68.1

\* Cow off feed.

In Table 3 are given the records of the calcium metabolism of the cows during the three periods, as well as the weekly milk production. As is usually the case with cows in the early part of lactation, especially liberal producers, these animals are in negative lime balance. The results recorded here are in harmony with previous observations in calcium metabolism work with cows. There is no indication, however, that the different treatments to which the hays had been subjected materially influenced the availability of the calcium. The calcium in the immediately dried hay appears to have been a little more readily assimilated, but the difference is very slight.

TABLE 3.—Calcium balance and milk production of three cows when fed alfalfa hay which had been dried and cured in different ways

## COW 1—PERIOD 1—HAY 1 (DRIED IMMEDIATELY)

Week No.	CaO in feces	CaO in milk	CaO in urine	Total CaO excreted	Total CaO intake	CaO balance	Weekly milk production
1-----	Grams 708.29	Grams 251.57	Grams 7.59	Grams 967.45	Grams 895.28	-72.17	Pounds 432.8
2-----	699.93	246.49	15.61	962.03	895.28	-66.75	448.7
3-----	733.28	233.96	10.49	977.73	895.28	-82.45	422.4

## COW 1—PERIOD 2—HAY 2 (PARTLY SUN CURED)

4-----	677.06	251.39	9.96	938.41	803.71	-134.70	436.0
5-----	672.95	254.82	9.95	937.72	803.71	-134.01	412.7
6-----	669.17	250.43	6.50	926.10	803.71	-122.39	427.6

TABLE 3.—*Calcium balance and milk production of three cows when fed alfalfa hay which had been dried and cured in different ways—Continued*

COW 1—PERIOD 3—HAY 3 (SUN CURED)							
Week No.	CaO in feces	CaO in milk	CaO in urine	Total CaO excreted	Total CaO intake	CaO balance	Weekly milk production
	Grams	Grams	Grams	Grams	Grams		Pounds
7-----	623.51	233.57	16.04	873.12	753.50	-119.62	414.9
8-----	669.93	221.03	11.66	902.62	753.50	-149.13	405.7
9-----	636.63	193.41	15.44	845.48	753.50	-91.98	377.0
COW 2—PERIOD 1—HAY 1 (DRIED IMMEDIATELY)							
1-----	689.56	248.96	9.83	948.35	890.59	-57.76	340.6
2-----	661.23	248.01	10.70	919.94	890.59	-29.35	353.1
3-----	614.63	246.74	7.82	869.19	890.59	+21.40	323.5
COW 2—PERIOD 2—HAY 2 (PARTLY SUN CURED)							
4-----	628.21	243.83	8.49	880.53	798.43	-82.10	317.8
5-----	593.57	247.49	7.63	848.69	798.43	-50.26	313.3
6-----	611.58	231.43	9.82	852.83	798.43	-54.40	318.6
COW 2—PERIOD 3—HAY 3 (SUN CURED)							
7-----	637.53	231.40	10.71	879.64	748.22	-131.42	301.6
8-----	583.55	222.90	18.07	824.52	748.22	-76.30	294.0
9-----	400.78	149.28	6.65	556.71	748.22	+191.51	196.9
COW 3—PERIOD 1—HAY 1 (DRIED IMMEDIATELY)							
1-----	635.22	271.46	10.98	917.66	895.28	-22.38	427.1
2-----	634.68	249.07	8.55	892.30	895.28	+2.98	428.6
3-----	660.05	266.67	11.79	938.51	895.28	-43.23	435.1
COW 3—PERIOD 2—HAY 2 (PARTLY SUN CURED)							
4-----	662.44	239.28	5.47	907.19	803.71	-103.48	428.5
5-----	623.66	294.92	7.59	926.17	803.71	-122.46	430.2
6-----	553.28	271.31	7.75	832.34	803.71	-28.63	436.2
COW 3—PERIOD 3—HAY 3 (SUN CURED)							
7-----	601.28	263.70	5.41	870.39	753.50	-116.89	420.9
8-----	612.06	265.59	5.89	883.54	753.50	-130.04	414.9
9-----	582.63	229.05	7.35	819.03	753.50	-65.53	388.1

<sup>a</sup> Cow off feed.

### SUMMARY

Second-cutting alfalfa hays, (1) dried immediately in an artificial drier (Koon); (2) partly dried in the field and then dried in the artificial drier, and (3) completely dried in the field, were studied for the availability of their dry matter, protein, and calcium.

The availability of the dry matter, protein, and calcium was much alike in all three hays, as measured by metabolism experiments with heavy-milking cows.

Apparently the high temperature of 480° to 535° C. for 40 seconds, to which the green legume plants were exposed in the immediate-drying process, did not reduce the availability of the nutrients studied.

