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Vitamins D and A in Alfalfa Hay

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Cover Picture

The farmer shown on the cover of this bulletin is using the best methods of handling hay in order to secure the largest amounts of vitamins D and A. Results of experiments at the South Dakota Agricultural Experiment Station show that curing in the small windrow saves the greatest *total amount* of these two vitamins. However, more vitamin A is saved when the hay is cured in the cock, and more vitamin D is secured when the hay is cured in the swath.

Contents

Vitamins D and A in Alfalfa Hay

By G. C. Wallis, Associate Dairy Husbandman

Every farmer knows that adequate amounts of vitamins D and A are needed in order to maintain vigorous health, good growth, and efficient production in his livestock.

This need has been well established by carefully controlled experimental work and by farm observations. It brings into sharp focus the problem of finding the most economical means of providing these important nutrients.

During the summer season, sunshine supplies much of the required vitamin D which is necessary for the utilization of calcium and phosphorus. Green pasture plants are rich sources of carotene, which is responsible for the vitamin-A activity of most green plants and the dried roughages made from them. The real problem of supplying vitamins D and A comes during the winter seasons.

Present knowledge of the vitamin content of feeds indicates that sun-cured roughages (those exposed to sunshine after harvesting, such as fodder and straw) are the main natural-feed sources of vitamin D for farm livestock during the winter months.

Most silages contain generous amounts of carotene (vitamin-A precursor), but on many farms silage is not available. When silage is not on hand, dry roughages are the major source of carotene for meeting the vitamin-A requirements of animals. (Some of the grains, especially yellow corn, also contain appreciable amounts of carotene.)

It is important for the farmer to know the best methods of curing and handling hay to secure the largest amounts of vitamin D and carotene.

For the past 3 years, work has been carried on at the South Dakota Agricultural Experiment Station to determine the effect of different hay-making practices on the vitamin-D and carotene content of alfalfa hay. The same field was used throughout the experiment.

Emphasis was placed on discovering the conditions or curing practices which favored the development of vitamin D. The effect of each practice on the carotene content and the rate of drying (moisture loss) was also noted.

For meeting the needs of farm animals it is desirable to have a leafy hay of good quality that is high in both vitamin D and carotene. The research work of the South Dakota Station reveals some principles and practices for producing hay of this type. They are discussed in this circular.

Developing Vitamin D

Hay exposed in a small windrow to the action of sunshine develops vitamin D as rapidly as when it is exposed in the swath. But there is only a small increase in the vitamin-D content of cocked hay.

These conclusions are based on the results of 2 years' work in which one portion of hay in a small field was left to cure in the swath, a second portion was placed immediately into small windrows by the use of a side-delivery rake, and a third portion was placed immediately into cocks.

The reason for putting some of the hay immediately into windrows and cocks was to get more accurate information on the rate and amount of vitamin D that would develop under these conditions of curing. By starting with the fresh material, any changes in vitamin-D content that occurred could be attributed to a particular curing method.

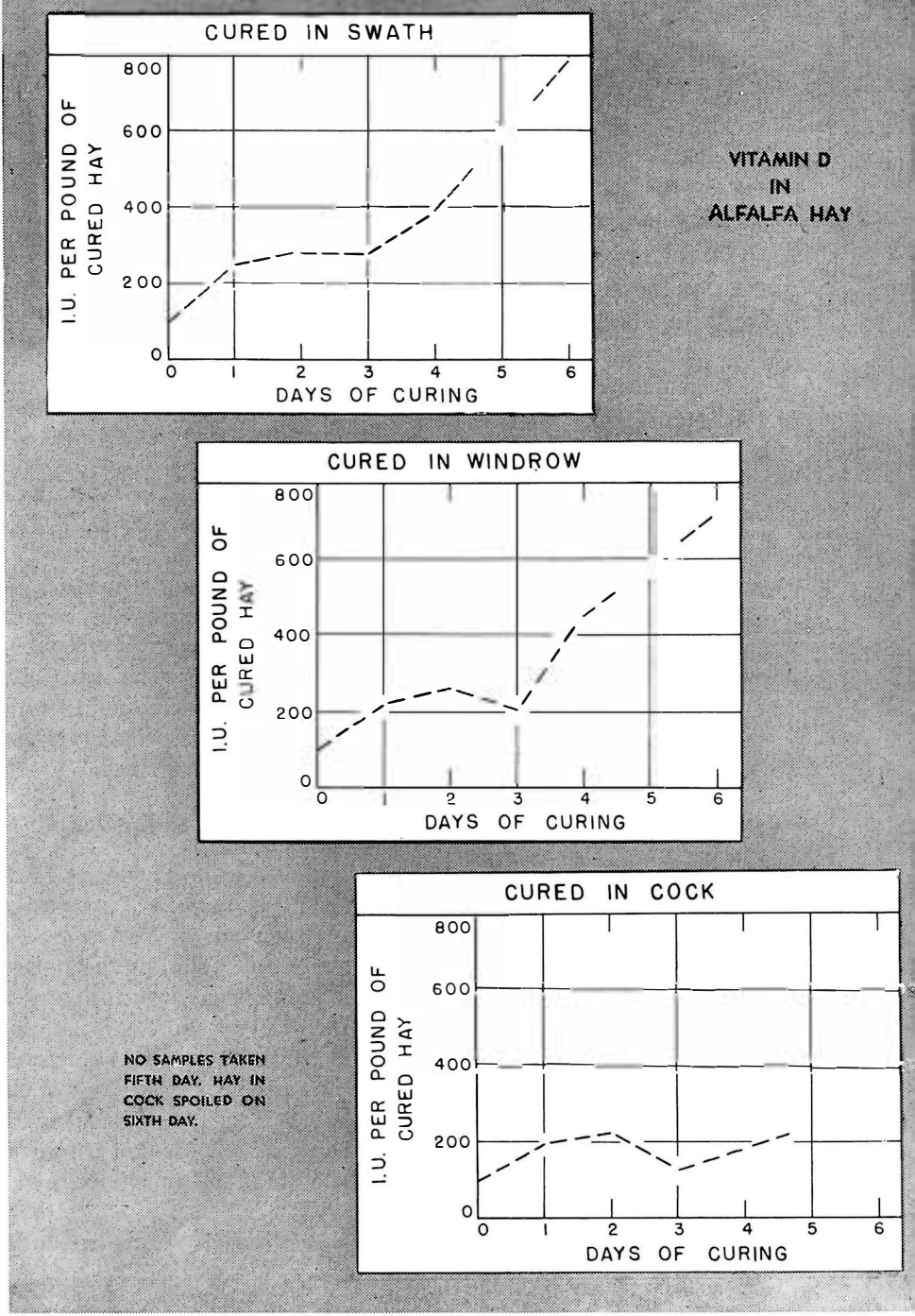
Samples of the hay were obtained at frequent intervals to determine what changes were taking place in the vitamin-D content of the hay as it cured side-by-side under these three conditions (see graphs on page 5). The hay was left in the field and sampling was continued for some time after it was dry enough to haul in order to find out what changes would ultimately take place with continued sunshine exposure.

Vitamin D increased at almost the same rate in the swath and small windrow, whereas there was only a small increase in the cock-cured hay.

A second important point shown in the graphs on page 5 is that vitamin D develops rather slowly in alfalfa hay no matter which method of curing is used. This means, of course, that the highest amounts of vitamin D obtainable in any particular batch of hay are not reached during the usual curing period.

For swath and windrow curing the hay was dry enough to haul by the end of the second day, but at this time the vitamin-D content was only 277 International Units per pound in the swath and 262 in the windrow. These are less than half the amount that was finally reached when sampling was discontinued at the end of 6 days.

By the time the higher amounts were reached, the hay was very dry and brash. The leaves were shattering badly and the green color was bleached out except for the hay in the bottom of the windrows. These losses in nutrients and quality far exceed any benefits derived from the higher vitamin-D potency obtained.



Vitamin D increased almost as rapidly in hay cured in small windrows as in hay cured in the swath.

When hay was placed immediately into large windrows, it was found that the increase in vitamin-D potency was slower than in small windrows and swath but faster than in cocks. Hay put immediately into cocks showed an increase of only 50 to 100 International Units of vitamin D even after several days of curing.

Most of the increase occurred in the hay on the outside of the cock. The results of several trials showed that the outside hay was about twice as high in vitamin D as hay in the bottom of the cock.

Wilting in the Swath

On the farm, hay is often left to wilt in the swath for a half day or so before it is raked into windrows or possibly put into cocks. In studying this practice it was found that the vitamin D continued to develop as fast in hay raked into small windrows as in hay left in the swath. But when the hay was raked into a large windrow, the rate of increase was retarded.

For instance, hay which was ready to haul after curing for a day and a half was found to have 327 International Units of vitamin D per pound when it was left continuously in the swath or raked into small windrows after wilting a half day in the swath. It had only 277 units when it was raked into large windrows after the first half day in the swath.

Hay placed into cocks after a half day of curing in the swath showed no further increase in vitamin-D content even after standing for 8 days.

These results are in good agreement with those previously obtained when each curing practice was studied separately. Curing in the swath continuously and in the combination of swath and small windrow gave the same final potency, indicating that vitamin D develops equally well under these two conditions. The combination of swath and large windrows gave a lower final potency.

Turning the Windrows

The vitamin-D content of the hay was increased by turning the windrows. An average of six trials including both large and small windrows showed an increase of about 100 Internaal Units of vitamin D per pound for a final day or full day of curing in the turned windrow as compared with the unturned portion of the same windrow.

Sunshine Not Only Influence

In one season two different batches of third-cutting hay were made. The hay was left in the swath for a short time and then raked into windrows. One batch was out in showers and

cloudy weather so it was 4 or 5 days before it was ready to haul. The other batch had good curing weather so was dry in about 2 days.

These samples contained 1,000 to 1,200 International Units of vitamin D per pound by the time they were ready to haul. After portions of the windrows were left in the field for an additional day or two, one sample developed 2,413 International Units per pound and the other 1,950 units. These are the highest values that were observed in this study.

Second-cutting samples having a curing history fairly comparable to the third-cutting hay were taken another season from the same field. They contained only 300 to 500 International Units per pound when ready to haul and developed only 900 to 1,200 units after exposure in the swath and windrow for 8 or 9 days.

These results indicate that there are influences other than the amount of sunshine received which greatly affect the vitamin-D content of the resulting hay.

The stage of maturity of the plants, the time of the year, seasonal differences, climatic differences from year to year, or other similar factors might be concerned. It will take more study to get definite information on this point.

Conserving the Carotene (Vitamin-A Value)

A high vitamin-D content is not the only desirable quality of alfalfa hay. It is important to save as much of the carotene as possible in the finished hay.

In general, the greener the color the more carotene in the hay and the greater value it has for meeting the vitamin-A requirements of livestock. There is continual destruction of carotene during the curing of hay, and it is important to keep these losses at a minimum.

The results of carotene determinations made on the same samples as taken for vitamin-D determination from hay curing side-by-side in the swath, windrow, and cock, are shown in Table 1.

For the first day, carotene was lost at about the same rate from all three methods of curing. Beginning with the second day the loss of carotene was appreciably greater in the swath than in the windrow. It was least in the cocked hay where only a slow gradual destruction was indicated.

Hay cured in the swath and windrow was ready to haul by the end of the second day. At

this time the swath-cured hay had 40 milligrams of carotene per pound of dry matter while that cured in the windrow contained 72 milligrams (Table 1).

Table 1. Losses in the Carotene Content of Alfalfa Hay Cured By Different Methods

Curing period	Carotene per pound in dry matter when hay was cured in		
	swath	windrow	cock
days	*mgm.*	*mgm.*	*mgm.*
0*	145	145	145
1	108	91	107
2	40	72	111
3	15	43	109
4	7	41	92
6	1	21	... †

*Fresh material taken when cut.
†Hay spoiled. No sample taken.

In general these results are quite favorable to the use of windrows for curing as an aid to the preservation of carotene under practical conditions.

Controlling the Rate of Drying

It is obvious that information about the rate of moisture loss under the different curing practices studied is useful for determining the best method of handling hay that is high in both vitamin-D and carotene content.

Moisture determinations were made on all samples taken. Drying was most rapid from the swath and small windrow and at practically the same rate under these two conditons.

With larger windrows the rate of drying was decreased, and with cocked hay it was slowest of all. Turning large windrows hastened drying appreciably but turning small windrows had only a limited effect unless the windrows were damp or packed from rain.

Hay-Curing Suggestions

The results of the experiments discussed afford valuable suggestions for making alfalfa hay high in both vitamin D and carotene.

Leaving the hay in the swath for a few hours after cutting favors rapid drying and the development of vitamin D without carotene loss, since this loss is no greater in the swath than in the windrow for the first few hours.

During most of the curing time the hay should be in small to medium-sized windrows, for carotene losses after the first few hours are much less from the windrow than from the swath, while the development of vitamin D continues almost as rapidly as when the hay is left in the swath.

This general procedure is already being followed on many farms and undoubtedly gives as good results as any in securing both vitamin D and carotene.

More vitamin D could be obtained by continuing the curing somewhat longer than usual, but this would result in a further loss of carotene and encourage the shattering of leaves from overdrying. Larger windrows might be used to lengthen the curing time, but since the rate of vitamin-D formation decreases in larger windrows, the final potency might not be increased.

The carotene content could be increased by finishing the curing in cocks, but this involves considerably more time and labor and would lower the vitamin-D content.

It is unfortunate that vitamin-D formation is not more rapid in the swath and small windrow so that maximum carotene values could be attained in the length of time required to cure hay under these conditions.

More information is needed to establish definite figures for the vitamin-D content of alfalfa hay. Undoubtedly many samples contain between 300 and 1,000 International Units per pound with an average of around 500 to 600 units.

Considerable information is available as to the carotene content. However, the variations are so great that an average figure has little value. Many samples have between 10 and 60 milligrams per pound at the time of harvest.

There will be appreciable losses of carotene after the hay has been stored. Vitamin D is more stable and will not show much loss during a winter storage period.

The results of vitamin-D and carotene determinations on five samples of alfalfa hay taken from the regular field operations during one season give

TABLE 2. VITAMIN D AND CAROTENE IN DIFFERENT CUTTINGS OF FIELD-CURED ALFALFA HAY

Cutting and sample number	Curing notes	Carotene per pound	Vitamin D per pound
First Cutting		*mgm.*	*I. U.*
98	4 days, mostly windrows, showers	28	603
100	2 days, most swath, showers	12	653
Second Cutting			
102	4 days, mostly windrow, showers	28	299
104	½ day swath, 1 day windrow, no rain	24	227
Third Cutting			
106	1½ days swath, 1½ days windrow, no rain	10	612

some idea of the values which may occur under customary handling (Table 2).

How much these values could be increased by carefully following curing methods designed to obtain the best results in producing hay with high vitamin D and carotene values cannot be stated definitely at the present time.

However, the very fact that wide variations have been observed provides encouraging evidence for the possibility of securing higher amounts of vitamins D and A on the average if the proper curing methods are used.

Vitamin Needs of Calves

Rough calculations have been made to indicate the possibility of meeting the suggested vitamin-D and vitamin-A needs of calves. When 400 International Units of vitamin D per 100 pounds of live weight is the requirement, a 400-pound calf requires 1,600 units daily. About 3 pounds of average alfalfa hay containing 600 units per pound meets this requirement.

If the hay has only 300 units per pound, it takes 6 pounds of hay which is about the limit of consumption for a 400-pound calf.

The vitamin-A requirement is not difficult to meet when alfalfa hay is available. The same calf requires about 25 milligrams of carotene as a source of vitamin A. This amount is furnished by 2½ pounds of hay containing 10 milligrams per pound.

Meeting the vitamin-A requirements is a much more difficult problem when the only roughages available are those that contain much less carotene, such as prairie hay, corn fodder, or sorghum.

The vitamin-D requirement would also probably be harder

to meet if alfalfa hay was not fed, for there is some evidence that alfalfa hay may be one of the best natural-feed sources of vitamin D. The frequent occurrence of rickets and vitamin-A deficiency in calves and other livestock under farm conditions indicates that these vitamins are often not present in adequate amounts and emphasizes the importance of providing feeds rich in vitamin D and carotene.

Summary

The more important results of this study as they affect the making of alfalfa hay high in both vitamin D and carotene under South Dakota conditions may be summarized as follows:

Vitamin D develops as rapidly in small windrows as in the swath. Less vitamin D develops in large windrows than in the swath and small windrows, and still less in cocks. Most of the increase in cocks takes place in the outside layers.

Carotene losses are much less from the windrow than from the swath. Losses are still less from cocks.

Allowing the hay to wilt in the swath for a few hours and then raking it into small to medium-sized windrows provides for rapid drying of the hay, encourages the development of as much vitamin D as the particular plants are capable of producing, and conserves a fair amount of carotene.

Finishing the curing in cocks after partial drying in the swath and windrow tends to conserve more of the carotene but takes more time and labor and provides less vitamin D.

Turning the windrows for the last half day or full day of curing increases the vitamin-D content by about 100 International Units per pound as compared with unturned windrows.

The devolpment of vitamin D in alfalfa hay by sunshine exposure is a comparatively slow process which continues gradually over a period of at least 6 or 8 days. The vitamin-D content of hay could be increased by continuing the curing beyond the length of time necessary for proper drying, but the losses in carotene and other valuable properties would more than offset.the gains.

Alfalfa hay probably varies between 300 and 1,000 International Units of vitamin D per pound, averaging about 500 to 600 units.

Alfalfa varies from time to time in the amount and rate of vitamin D development induced by sunshine exposure. The reasons for such variations are not known.

Good growth, efficient production and vigorous health can be promoted in livestock by harvesting methods which secure a high vitamin-D and carotene content in roughages.

Other Farm Publications

For a list of farm publications that can be obtained from the South Dakota Agricultural Experiment Station, send a postal card to—

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