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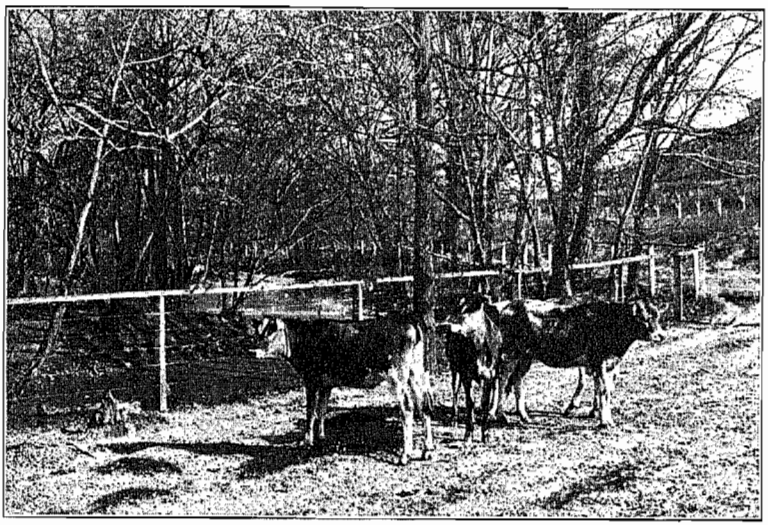

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REPLACING GRAIN WITH ALFALFA IN A RATION FOR DAIRY COWS

BY

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KNOXVILLE, TENNESSEE

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REPLACING GRAIN WITH ALFALFA IN A RATION FOR DAIRY COWS

INTRODUCTION

Feeding the dairy cow in the most economic manner hinges on the reduction of the concentrates necessary for maximum yields to the lowest possible point. The reason for this is that the concentrates are by far the most expensive part of the ration. The comparative cheapness of concentrates rendered this part of the ration comparatively cheap in years gone by. With an increasing population and a greater demand for animal products in general, the price of concentrates is steadily advancing and food stuffs that were commonly used a few years ago have now almost reached prohibitive prices from the dairyman's standpoint.

To discover some means by which the amount of concentrates required by the dairy cow can be reduced has become a momentous problem to all persons interested in the dairy business. This question is of greater interest to the dairy farmers of the South than to those of any other part of the country, because wheat, oats and barley are not extensively cultivated in the South, and hence these grains, or the by-products derived from them, are unusually high. And as cotton-seed meal does not give as good satisfaction when fed alone as when fed in combination with some of these more expensive concentrates, the cost of maintaining the dairy cow has been steadily increasing. For a long time there seemed to be no solution to this difficult question, and the dairyman has blindly pursued the old policy of feeding high-priced concentrates at break-neck prices, endeavoring to cover the increased cost of production through a corresponding rise in the price of milk and butter. This might have gone on indefinitely but for the fact that the buying ability of the people has a final limit and this limit seems to have been reached in many sections.

Experiment station workers in many parts of the country have endeavored to find some substitute for a part of the expensive concentrates in a ration for the dairy cow. Investigations in the field of feeds and feeding have shown that food stuffs, whether in the form of roughness or of concentrates, may be appropriately divided into two classes—those rich in protein and those rich in carbohydrates. A ration rich in protein gives the best results with the dairy cow, because the product of the cow is rich in that substance, and she requires a large amount of it for the proper nourishment of her body. Under the circumstances it was natural to look for a roughness among those plants that yield the largest amount of digestible protein. It was found that there was a whole family of these plants, known as legumes, suited to a wide range of culture. Among the number especially adapted for Southern conditions were the cowpea, red clover, soy bean, velvet bean and alfalfa.

A systematic series of experiments was commenced at the Tennessee Experiment Station in 1902 for the purpose of ascertaining to what extent the substitutions suggested could be made and which of the several crops rich in protein could be grown and utilized to the best advantage. The cowpea, being well adapted for culture throughout the South, was the first considered. It was shown in the experiment of 1902 that this plant could be substituted with profit for a part of the cotton-seed meal or wheat bran required by the cow. These results were so interesting that a second experiment was planned to compare the merits of alfalfa for the same purpose with the cowpea. Owing to the importance of this problem plans have now been developed for a most thorough investigation of this very interesting question, and the coming winter the plan is to feed red clover, and the following year soy beans. Then some other crop, such as crimson clover, may be considered.

At the present time the experiments indicate that the cost of a ration for the dairy cow can be greatly reduced by the use of one or more of these well-known leguminous crops in place of a part of the concentrates. Thus, the greatest difficulty in the way of lowering the cost of milk and butter seems to have been removed; for while the South has not grown the leading cereals as freely as the naturally favorable conditions would warrant, the leguminous crops have been freely used and make not only large yields of soft grain but a rich quality of hay as well. These crops are not more difficult to cure into hay than red clover where the process is understood. The compensating influences of nature have rendered it possible for the dairyman to substitute these excellent crops for a part of the expensive concentrates which he has hitherto fed and so reduce the cost of production in a gratifying degree. Thus, the most serious problem of the Southern dairyman, namely, cheap grain, bids fair to be solved through the utilization of some of the crops mentioned. These crops have the great advantage also of improving the soil through the assimilation of atmospheric nitrogen, rendered possible by their association with certain forms of bacteria which thrive in the nodules growing on their roots.

Up to the present time the investigations have been confined entirely to the feeding of these food stuffs in a dry condition in the form of hay, although, if the crops are fairly well matured when used for soiling purposes, there is no evident reason why they can not be substituted for a portion of the grain, even when fed in a green condition. This question opens up another field of investigation that has been considered to some extent in the past and will receive more careful consideration in the future; for of course the hay is best fed in conjunction with silage during the winter season, and it frequently becomes necessary to feed soiling crops during a part of the summer.

CAN ALFALFA BE UTILIZED?

Before passing to the general consideration of the results of the experiments, it will not be inappropriate to say a few words with reference to the cultivation of alfalfa. This crop has been a great success in the Western country, but a large number of failures have been recorded in the Eastern and Southern States. It was believed for a long time that the crop

was not suited to our climatic conditions, but recent investigations seem to indicate that the trouble was not so much due to the climate as to the soil, which did not contain the necessary bacteria. The soils of the South are as a rule deficient in vegetable matter, and hence low in available nitrogen. When the alfalfa plant is not inoculated it draws on the nitrogen supply in the soil. When this is exhausted the crop dies out and disappears. Such, at least, has been the experience of many persons who have endeavored to cultivate it. On many upland farms, where the soil has been inoculated properly—a very simple operation—and enriched with vegetable matter in the form of farmyard manure or cowpeas plowed under, good stands of alfalfa have now been obtained, and the crop has been successfully utilized for hay for several years past.

Alfalfa likes a rich soil and will give its best results on bottom lands that are not subject to prolonged overflows, but on thoroughly prepared clay uplands, carefully subsoiled, cultivated and enriched, as indicated, there is no reason why it can not be grown under a great variety of conditions. It is more likely to succeed on stock farms because of the abundance of farmyard manure available for the enrichment of the soil and the growing crop.

One of the chief difficulties experienced by alfalfa growers has been the destruction of the stand while young through the encroachment of crab-grass. This difficulty can be obviated by preparing the land and seeding early in the fall. Greater care must be exercised in the preparation of the soil and the general management of the crop than has been accorded the lands which grow red clover fairly well, or failure is almost certain to follow. Alfalfa is so rich in digestible protein and so valuable a food that every effort should be made to secure a stand of it where live stock growing is a matter of any considerable interest. The soil may be inoculated through the use of 200 pounds of earth from a field where alfalfa has grown successfully for several years. Use 20 pounds of well-cleaned, tested seed per acre, mix with the soil and distribute uniformly over the ground, and cover with some light surface-working implement. Do not sow with a nurse crop.

The results of trials on the Station farm of spring and fall seeding do not show any marked difference in yield, but fall seeding has an advantage in that the crop may be cut for hay the following spring; whereas, if the seeding is done in the spring, crab-grass and noxious weeds are likely to destroy the stand, and the crop must be simply clipped the first year and not cut for hay.

Our investigations have now proceeded far enough to warrant us in making the statement that under the system of treatment outlined alfalfa can be grown with fair success on upland soils and with satisfactory results on rich first and second bottoms. Of the two plats grown on the Station farm, No. 1 made a yield of 7810 pounds of hay and 4010 pounds of green feed; No. 2 made 6365 pounds of hay and 15,015 pounds of green feed, in the notably dry summer and autumn of 1903. The alfalfa looks well at the present time and promises to yield as well as last year if not better.

COMPARATIVE VALUES OF COWPEAS AND ALFALFA

Alfalfa and cowpeas resemble each other in composition very closely. A ton of alfalfa contains 1832 pounds of dry matter, 211.6 pounds of digestible protein, 746.6 pounds of carbohydrates, and 27.6 pounds of fat. A ton of cowpeas contains 1786 pounds of dry matter, 215.8 pounds of digestible protein, 768 pounds of carbohydrates, and 30.2 pounds of fat. Thus, it is not surprising that the results of substituting these two foods for cotton-seed meal and wheat bran should be practically the same when the composition shown in the following statement is considered:

	Dry matter	Protein	Carbo-hydrates	Fat
One ton cotton-seed meal	1836 lbs.	744.0 lbs.	338.0 lbs.	244.0 lbs.
One ton wheat bran	1762 lbs.	244.0 lbs.	784.0 lbs.	54.0 lbs.
One ton cowpea hay	1786 lbs.	215.8 lbs.	768.0 lbs.	30.2 lbs.
One ton alfalfa	1832 lbs.	211.6 lbs.	746.6 lbs.	27.6 lbs.

A ton of wheat bran contains practically the same amount of carbohydrates as a ton of alfalfa and about twice as much fat and some 30 pounds more protein. Cowpea hay is slightly richer in protein and fat than alfalfa, and hence more nearly approaches the composition of wheat bran. Cotton-seed meal is the richest concentrate known. It is not a well-balanced food, as shown by its composition; and though it contains more than three times as much protein and more than eight times as much fat as alfalfa, from 5 to 10 pounds of the latter can be used with satisfactory results to replace from 3 to 4 pounds of cotton-seed meal in a ration for dairy cows. This is due to the appetizing nature of the alfalfa hay and to the variety it gives to the ration. Theoretically it would seem reasonable that the substitution of alfalfa and cowpea hay for wheat bran and cotton-seed meal could be effected within certain limits, and our practical tests confirm this theory.

SILAGE AS A COMPANION FOOD

One of the best ways to feed alfalfa hay is with silage, unless it is in a region where alfalfa is very cheap—a contingency that is not likely to arise in the Southeastern States, because the crop will hardly grow with the luxuriance characteristic of it in the West. Alfalfa hay in the Southeastern States, by reason of its higher price, must be utilized more carefully than in the West, where it can be fed in the most wasteful fashion and still give profitable returns. It is a great advantage to feed alfalfa, or any other of the leguminous crops that may be substituted for a portion of the concentrates in a ration for the dairy cow, with some such succulent and palatable food as silage. In our experiments the alfalfa was chopped up and sprinkled over the silage with the meal fed, and the whole ration was readily consumed. If the alfalfa hay were fed by itself, even in larger quantity, it would not be so completely consumed, the waste would be much greater, and its effectiveness in the ration would be reduced to that extent. In our judgment the gratifying results following the substitution of alfalfa and cowpea hay for a certain amount of concentrates were due in

a large measure to the feeding of these crops with a fine quality of silage, which is generally admitted to be the best form of roughness for the dairy cow. Of course, silage by itself is not so satisfactory as when fed in conjunction with a small amount of dry roughness.

The ration containing the largest amount of protein was eaten with the greatest relish. In other words, the best results were obtained in the experiments of 1902 and 1903 when cotton-seed meal was fed in conjunction with cowpea and alfalfa hay. The other rations were also eaten with relish, and the animals were in good condition throughout the experiment, but in both years the best results were obtained from the high protein ration.

PLAN OF EXPERIMENTS

The plan of this experiment was very simple and was based on the lines followed in 1902. The animals were placed on feed November 1 and the experiment closed March 1, giving a feeding period of 120 days. Twelve cows were used—four to each group. The ration was fed in two equal parts, morning and night. Samples of milk were taken from each milking and preserved with corrosive sublimate and tested weekly for fat by the Babcock method. Lactometer readings of this milk were also made, so that the amount of solids not fat and the total solids could be determined. The cows were out of the stable during the greater part of the experiment, because the mild winter climate made it unnecessary to house them. Water was available at all times. The animals did not receive any special treatment that could not be accorded them on any farm where a sanitary stable, a silo, and a feed cutter for chopping up the hay are available.

The cost of the foods used was as follows:

Wheat bran	$20.00 per ton
Cotton-seed meal	24.00 per ton
Alfalfa hay	10.00 per ton
Silage	2.00 per ton

After several years' experience in the purchase of food stuffs and in the feeding of cows, these prices have been adopted as fairly representative of local market conditions. They are higher than those prevailing in country districts and lower than those which sometimes prevail in the larger towns and cities; but as these investigations are expected to cover a period of several years, it seems advisable to adopt uniform prices for food stuffs to make the investigations of the different years comparable. It would be of little service to the average farmer if the prices were changed every year according to the fluctuations of the market, because they would then not be more applicable to his local conditions than the prices selected. It will not be a difficult matter for the reader to apply the results obtained to his conditions if he will take a lead pencil and a piece of paper and do a little figuring for himself, and this he must do if he is a successful farmer, for experimental results at best, while invaluable, can never be more than guides to the feeder, who must adapt them to his local environment and use judgment and discretion in combining them to secure the most economic returns.

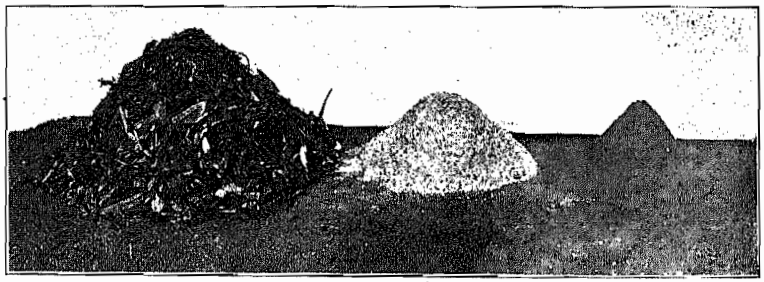
THE RATIONS FED

The rations fed per 1000 pounds of live weight are shown in Table I. Group I received silage, wheat bran and cotton-seed meal; Group II silage, alfalfa hay and cotton-seed meal; Group III silage, alfalfa hay and wheat bran. For Group II alfalfa hay was substituted for wheat bran, and for Group III alfalfa hay was substituted for cotton-seed meal. The largest

TABLE I—*Rations fed*

Group	Name of cow	Ration per day	Food per cow per 1000 lbs. live weight				Remarks
			Silage	Alfalfa	Wheat bran	Cotton-seed meal	
			Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	
I	Rolilda.....	Silage	62	.....	9.8	3.2	
	BluePrincess	Wheat bran.....	54	.....	10.5	3.5	
	Mary Moore	Cotton-seed meal	44	.....	9.0	3.0	
	Viola	.....	56	.....	7.5	2.5	
II	Lucy.....	Silage	50	8.3	.....	4.4	Alfalfa hay was finely cut
	Rosy.....	Alfalfa hay.....	56	9.2	.....	4.2	
	Nettie.....	Cotton-seed meal	36	8.5	.....	4.8	
	PhyllisKnox	.....	73	11.9	.....	6.1	
III	Lady Tippen	Silage	49	12.0	10.8	.....	Alfalfa hay was finely cut
	Belle.....	Alfalfa hay.....	30	8.1	9.3	.....	
	Sadie	Wheat bran.....	30	4.8	9.6	.....	
	Winnie.....	.....	49	11.5	8.6	.....	

amount of silage was naturally consumed by Group I, which received no dry roughness. This group also consumed the largest amount of wheat bran and cotton-seed meal. The amount of alfalfa hay fed to replace the wheat bran fed to Group I varied from 8.3 to 11.9 pounds, depending on



Silage Wheat bran Cotton-seed meal

RATION FED GROUP I—SHOWING BULK WHEN CONCENTRATES WERE FED WITH SILAGE. COMPARE WITH RATIONS FED GROUPS II AND III

the individuality of the cows. The basis of substitution was made on the relative amounts of protein contained in wheat bran and alfalfa hay.

Notice in the case of Group I that from 7.5 to 10.5 pounds of wheat

bran were consumed according to the individuality of the cows, while in the case of Group II from 8.3 to 11.9 pounds of alfalfa hay were consumed in the place of wheat bran. In the case of Group I from 2.5 to 3.5 pounds of cotton-seed meal were eaten, while in the case of Group III from 4.8, which was remarkably low, to 12 pounds of alfalfa were eaten in the place



Silage Alfalfa hay Cotton-seed meal

RATION FED GROUP II—SHOWING CHANGE IN BULK EFFECTED BY SUBSTITUTING ALFALFA HAY FOR WHEAT BRAN. COMPARE WITH RATIONS FED GROUPS I AND III

of the cotton-seed meal fed to Group I. The amounts of alfalfa consumed in the place of wheat bran and cotton-seed meal were just about sufficient to replace the amount of protein contained in these two concentrates.

The method of feeding the animals will have an important influence on the success of substituting any roughness, no matter how favorable it may be, for a certain amount of grain. Care should be taken to see that the

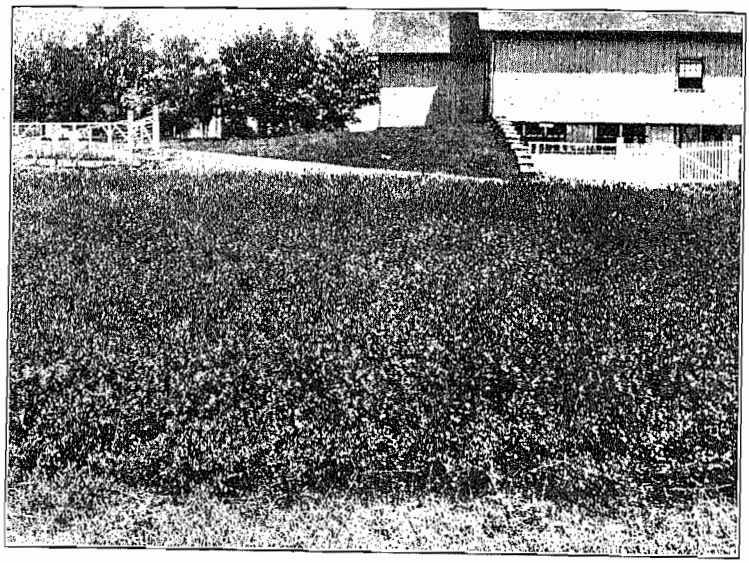


Silage Alfalfa hay Wheat bran

RATION FED GROUP III—SHOWING EFFECT ON BULK WHEN ALFALFA WAS SUBSTITUTED FOR COTTON-SEED MEAL. COMPARE WITH RATIONS FED GROUPS I AND II

roughness is placed before the animals in a palatable form—that it is of good quality. Of course the substitution can not be carried on indefinitely. It seems almost needless to say this, and yet correspondence would indicate that some farmers have the idea that provided they have a roughness rich

in protein they need feed practically no concentrates. This notion extends even to silage. Some persons argue that as corn is put into the silo with the stalk, no grain is necessary. A ration of silage and a roughness rich in protein will rarely if ever prove satisfactory. Some concentrate is necessary, and the substitution of a home-grown food stuff for a high-priced one that must be bought will be limited by the individual capacity of the cow to consume a large amount of roughness.



ALFALFA GROWING ON RED CLAY UPLAND

The hay used in the experiment was cut from this plat

RELATION OF INDIVIDUALITY TO RESULTS

This brings us to the point of considering the individuality of the animals, which is set forth in Table II. It was thought at first that this might have a marked influence on the results, and hence this table was prepared, which gives the history of the animals in the experiment as far as seems advisable. It is proper to state that the greatest care was exercised in selecting the animals for the respective groups, to have them as nearly balanced as possible. The selection of the cows is not taken up a few days before the experiment, but is considered for a long time in advance. An individual record is kept of each animal, which enables us to make a comparison of the yield of milk and butter obtained, the cost of food consumed, etc., from year to year. This not only makes it possible to keep an accurate record of the cow, but permits the comparison of her work in the herd with those of other individuals, so that animals of approximately uniform capacity for dairy work can be selected for experimental purposes. This method has been practiced in selecting the animals used in the present test.

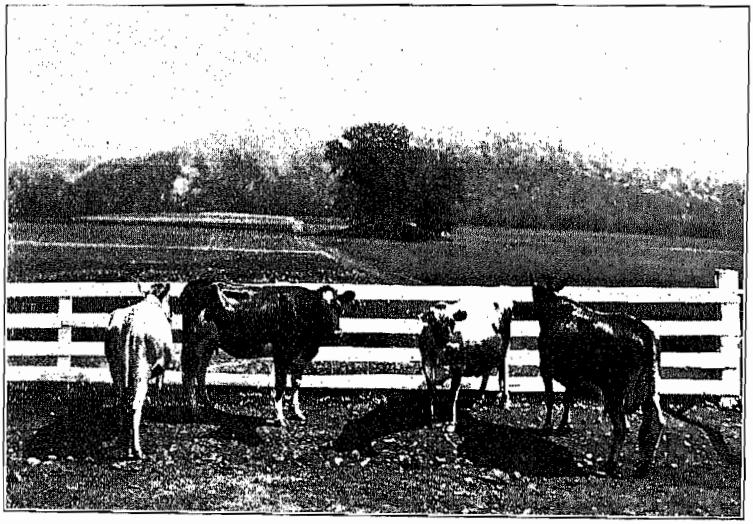
TABLE II—*History and individual record of cows*

Name of cow	Breed	Initial weight	Loss or gain in weight	Food consumed per day per 1000 lbs. live wt.		Cost of food per day	Average amount of—		Cost per—	
				Roughage	Concentrates		Milk	Butter	Gallon milk	Pound butter
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Cts.*	*Lbs.*	*Lbs.*	*Cts.*	*Cts.*
GROUP I										
Rolilda	Jersey	910	+ 5	62	13.0	18.0	23.6	1.62	6.6	11.1
BluePrincess	Jersey	810	+ 5	54	14.0	17.0	12.1	1.10	12.1	15.4
Mary Moore	Jersey	635	+ 50	44	12.0	11.3	13.0	.81	7.5	13.9
Viola	Grade Holstein	765	+100	56	10.0	13.0	13.8	.72	8.1	18.0
Average		780	+ 40	54	12.2	14.8	15.6	1.06	8.5	14.6
GROUP II										
Lucy	Grade	880	+ 40	57	4.4	13.0	18.6	1.17	5.9	11.1
Rosy	Grade	835	+ 20	66	4.3	13.0	17.4	.97	6.3	13.4
Nettie	Grade	775	+ 85	45	4.8	11.3	11.9	.98	8.0	11.5
PhyllisKnox	Jersey	640	+ 25	85	6.1	13.5	16.0	1.00	7.5	13.5
Average		782	+ 42	63	4.9	13.4	15.9	1.03	6.9	12.8
GROUP III										
Lady Tippen	Jersey	810	+ 45	61	10.8	18.0	16.2	1.10	9.4	16.3
Belle	Grade	845	+ 25	38	9.3	14.1	13.0	.79	9.4	17.8
Sadie	Grade	830	+ 5	34	9.6	12.5	10.9	.72	9.7	17.3
Winnie	Grade	695	.....	60	8.6	13.4	13.2	.76	8.6	17.6
Average		795	+ 18	48	9.5	14.5	13.3	.84	9.2	17.2

The table fails to indicate that the results obtained from substituting a given amount of alfalfa hay for cotton-seed meal and wheat bran were due to individuality. The data show that the groups were well-balanced so far as weight is concerned and that they all gained slightly during the experimental period. The difference in the amounts of roughness and concentrates consumed throughout the experimental period per 1000 pounds of live weight is due to the fact that the alfalfa hay was calculated as a roughness. The cost of the feed was also very nearly uniform, so that the results are not due to that factor. In our opinion the larger amount of butter made by Group II as compared with Group III was due to the feed rather than to the individual differences in the animals. It is true that Group III did not yield quite so much milk, and hence would not be expected to make quite as much fat, but the difference should be attributed to the ration rather than to the cows, considering their previous records.

The cows have always seemed to eat the ration in which alfalfa or cowpea hay was substituted for wheat bran to better advantage than where the roughness was substituted for cotton-seed meal. This is not hard to understand, because a larger amount of roughness must be consumed to replace a given amount of cotton-seed meal in a ration than of wheat bran, and the capacity of the cow being limited the results are not so satisfactory.

Evidently an economic ration for the Southern farmer is one consisting of some leguminous crop rich in digestible protein fed in conjunction with cotton-seed meal, a product almost universally available in the South and at much less cost, when the protein and fat are considered, than any other concentrate that can be used. Wheat bran is not produced in large quantities in the South. It is quite as expensive in many sections, and often costs more per ton than cotton-seed meal. Hence it seems foolish to use

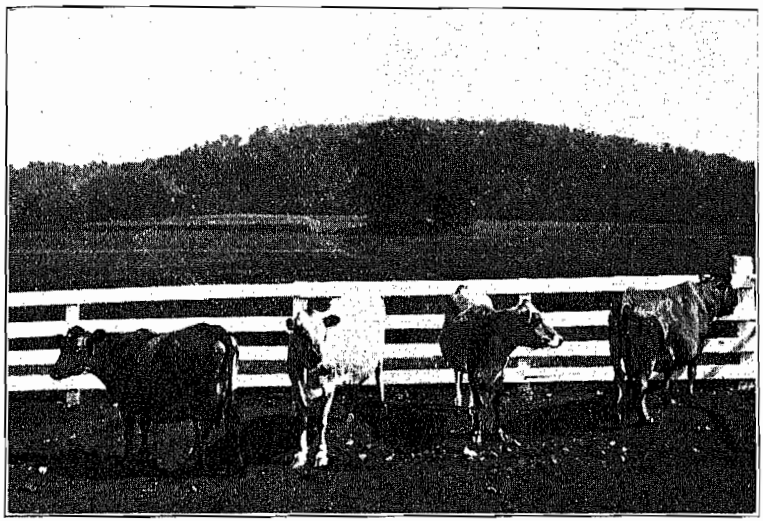


GROUP I—FED SILAGE, COTTON-SEED MEAL AND WHEAT BRAN

wheat bran when other food stuffs that can be grown on the farm at a moderate cost can take its place with satisfactory results if fed in conjunction with the great staple concentrate of the entire region. Cotton-seed meal by itself is not satisfactory for the dairy cow. It is too rich and is not sufficiently well balanced to give the most profitable returns; and when wheat bran is not available at a reasonable price other crops can be utilized in its place. This makes cotton-seed meal the cheapest and most satisfactory food stuff available and materially reduces the cost of producing a gallon of milk and a pound of butter, and so solves the most serious problem of the dairyman. While individual animals will have an influence on the utility of these different rations, experience does not incline us to the belief that the differences observed are attributable to the animals used.

FOOD CONSUMED

The amounts of the various foods consumed are set forth in Table III. Group II consumed the largest amount of silage—over 4000 pounds more than Group III—while Groups I and II consumed each about the same amount. Group I consumed 3624 pounds of wheat bran and Group II 3638 pounds of alfalfa hay. The latter group, however, consumed over 664 pounds more cotton-seed meal than Group I, which accounts for the fact that practically the same number of pounds of alfalfa hay and wheat bran were consumed by these two groups. In the case of Group III there was a falling off in the consumption of alfalfa hay as compared with Group II,



GROUP II—FED SILAGE, COTTON-SEED MEAL AND ALFALFA HAY

though they consumed a slightly larger amount of bran than Group I. Figuring alfalfa hay as a roughness, it appears that from 24 to 27 pounds of roughness was consumed, and from 2.06 to 5.3 pounds of concentrates,

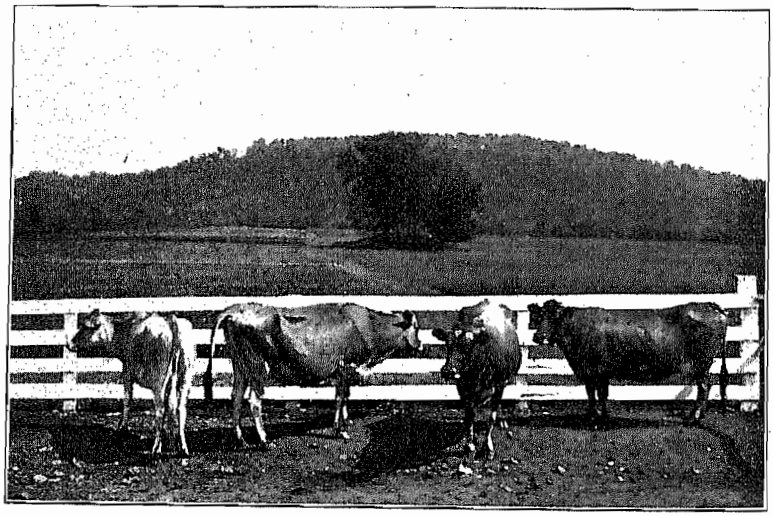
TABLE III—*Food consumed*

Group	Roughage		Concentrates		Food consumed per gallon of milk		Food consumed per pound of butter	
	Silage	Alfalfa hay	Wheat bran	Cotton-seed meal	Roughage	Concentrates	Roughage	Concentrates
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
I	21376	.....	3624	1207	24	5.30	41	9.40
II	20558	3638	.....	1871	27	2.06	48	3.80
III	16139	3350	3725	.....	25	4.90	42	9.10

for the production of a gallon of milk. The substitution of alfalfa hay for wheat bran in the case of Group II resulted in a saving of 3.24 pounds of grain or 33.9 pounds of concentrates for each 100 pounds of milk yielded,

which would mean a great saving in the cost of the concentrates for a year with even a moderately large herd of cows. From 41 to 48 pounds of roughness was consumed for the production of a pound of butter, and from 3.8 to 9.4 pounds of concentrates. Thus, the substitution of alfalfa hay for Group II effected a saving of 5.6 pounds of concentrates for the production of each pound of butter, or 560 pounds of concentrates for each 100 pounds of butter yielded.

The substitution of alfalfa hay for cotton-seed meal did not give as satisfactory returns as the substitution of alfalfa hay for wheat bran. With alfalfa hay at $10.00 and wheat bran at $20.00, the saving effected by substituting alfalfa for wheat bran would be $2.80 for every 100 pounds of butter and 19.8 cents for every 100 pounds of milk. In other words, the farmer could afford to sell his milk for 19.8 cents a hundred less than he now receives, if he fed alfalfa hay, as compared with wheat bran, and



GROUP III—FED SILAGE, WHEAT BRAN AND ALFALFA HAY

his butter for about 22 cents as compared with 25 cents a pound. Then, it is well to remember that the production of alfalfa on the farm has certain advantages which make it even more valuable. In the first place, it is a permanent crop and when well established will remain on the land for several years. Instances are recorded where it has been grown on the same land for more than fifty years in succession and still yields good crops. It is a soil renovator, and in figuring it at $10.00 per ton, a fair market value has been accorded it. It will not cost the farmer anything like $10.00 to produce it on his own land, and hence his profits from the use of alfalfa hay to replace wheat bran will be very much larger than those indicated here. He should certainly be able to produce alfalfa from a well established field at the same cost as he can grow red clover, which will not exceed from $2.00 to $4.00 per ton.

SUBSTITUTING ALFALFA FOR CONCENTRATES

The effect of substituting alfalfa hay for cotton-seed meal and wheat bran is presented in Table IV. Group I ate 30 pounds of silage, 5 pounds of wheat bran and 1.7 pound of cotton-seed meal for each gallon of milk. Practically speaking, it seems that when an equal amount of alfalfa hay is substituted for wheat bran about one-third more cotton-seed meal will be eaten; and when alfalfa hay is substituted for cotton-seed meal about three times as much alfalfa hay will be required, pound for pound, to replace the cotton-seed meal. In other words, 3624 pounds of wheat bran and 1207 pounds of cotton-seed meal were fed with silage to Group I; 3638 pounds

TABLE IV—*Effect of substituting alfalfa hay for cotton-seed meal and wheat bran*

Food consumed		Food consumed per—		Food consumed per 1000 lbs. live weight per—	
Kind	Am't.	Gallon milk	Pound butter	Gallon milk	Pound butter
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
GROUP I					
Silage	21376	24.00	41.0	30.0	51.0
Wheat bran.....	3624	4.00	7.7	5.0	9.6
Cotton-seed meal	1207	1.37	2.3	1.7	2.8
GROUP II					
Silage	20558	22.00	41.0	27.0	51.0
Cotton-seed meal	1871	2.06	3.8	3.2	4.7
Alfalfa hay.....	3638	4.02	7.3	5.0	9.0
GROUP III					
Silage	16139	21.0	39.0	26.0	48.0
Alfalfa hay.....	3350	4.4	8.2	5.4	10.2
Wheat bran.....	3725	4.9	9.1	6.0	11.3

of alfalfa hay and 1871 pounds of cotton-seed meal were fed to Group II; and 3725 pounds of wheat bran and 3350 pounds of alfalfa hay were fed to Group III—indicating that about 3 pounds of alfalfa hay would be required to replace 1 pound of cotton-seed meal, and about 1½ pound of alfalfa hay to replace a pound of wheat bran. Thus, the actual experiments indicate that the theoretical basis of substitution is practically correct.

The limit of substitution that can be permitted will depend on the individual capacity of the animals to consume alfalfa hay. When alfalfa hay is cheap and abundant it can be fed in what might be termed a wasteful manner. It should be placed before the animals in larger quantities than might seem advisable from a purely economic standpoint, for the purpose of inducing them to eat as much of it as possible, because it provides digestible protein in the cheapest form in which it can be obtained, at a less cost,

in other words, than it can be supplied in the form of wheat bran and cotton-seed meal. Ordinarily, not more than from 10 to 12 pounds of alfalfa hay will be consumed with silage. On the other hand, where no silage is fed this amount may be increased to from 15 to 20 pounds per day.

DIGESTIBLE NUTRIENTS EATEN

The amount of digestible matter consumed is shown in Table V. The largest amount of dry matter for the production of a gallon of milk and a pound of butter was eaten by Group III—13 pounds; Groups I and II consumed 10.7 and 10.2 pounds, respectively. Group III also ate the largest amount of digestible matter, 7.9 pounds, as compared with 6.6 pounds in the case of Group II and 6.9 pounds in the case of Group I. The same ratio held in the consumption of dry and digestible matter required for the production of one pound of butter. These conditions may be due in a measure to individuality, but are more likely attributable to the fact that a roughness, though rich in digestible protein, can not be used so effectively in replacing a concentrate as rich in that constituent as cotton-seed meal. It also seems that whenever a roughness is substituted for a concentrate the amounts of dry and digestible matter required to produce a pound of butter and a gallon of milk increase, though when the food stuffs substi-

TABLE V—*Digestible matter*

Group	Amount consumed of—		Amount consumed of—		Amount consumed per gallon milk of—		Amount consumed per lb. butter of—		Nutritive ratio
	Roughage	Concentrates	Dry matter	Digestible matter	Dry matter	Digestible matter	Dry matter	Digestible matter	
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
I	21376	4831	9079.11	5792.19	10.2	6.5	17.7	11.3	1-4.5
II	24196	1871	9692.78	6040.21	10.7	6.6	19.5	12.1	1-4.2
III	19489	3725	9889.78	5986.07	13.0	7.9	24.2	14.7	1-5.6

tuted for one another are more nearly equal in composition, as in the case of alfalfa and wheat bran, there is not a marked increase in the consumption of digestible matter. On the other hand, when the difference is marked, as in the case of alfalfa hay and cotton-seed meal, the consumption of dry and digestible matter will increase very considerably.

The facts set forth indicate that in the substitution of a roughness rich in protein for a concentrate, satisfactory results are most likely to follow when the two most nearly approach each other in composition. Ground alfalfa has been satisfactorily used as the basis of many artificial food stuffs that have been placed on the market. It is easy to see how satisfactory it would prove as the basis of such food stuffs when fed in a finely ground condition, permitting it to be more thoroughly masticated and digested. It is also easy to see that when thoroughly ground up and mixed with cotton-seed meal and some other rich concentrate how readily it may be made to take the place of food stuffs which it resembles in composition. The condition in which the roughness is placed before the

animal, so far as fineness, palatability and ease of digestion are concerned, will affect the degree of substitution that can be practiced with success.

The results of two years' work indicate that from 6 to 8 pounds of digestible matter will be required for the production of a gallon of milk, and from 11 to 15 pounds for the production of a pound of butter. In other words, just about twice as much digestible matter will be required for the production of a pound of butter as for a gallon of milk. The dry matter will vary in about the same degree.

EFFECT OF FOOD ON COMPOSITION OF MILK

In Table VI the influence of food on the yield of milk, fat and solids is shown. The smallest amount of milk was given by Group III, though the fat test of all the groups was more nearly equal than would have been anticipated. The largest amount of milk was made by Group II, 7689 pounds, and the largest amount of butter by Group I, 512.22 pounds. The lactometer test was highest in the case of Group II, being 34.7. This group also yielded the largest amount of solids, 714.07 pounds, and naturally the largest amount of total solids, 1138.73 pounds, though in this respect Group I was a close second with 1120.24 pounds. The number of pounds of

TABLE VI—*Influence of food on production of milk, fat and solids*

Group	Milk produced	Fat test	Fat produced	Butter produced	Lactometer test	Solids not fat	Total solids	Butter per 100 lbs. milk	Solids not fat per 100 lbs. milk	Total solids per 100 lbs. milk
	Lbs.	*Per ct.*	*Lbs.*	*Lbs.*	*Per ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
I	7521	5.8	439.05	512.22	33.7	671.13	1120.24	6.76	8.9	14.7
II	7689	5.5	424.89	495.70	34.7	714.07	1138.73	6.41	9.3	14.8
III	6414	5.4	347.99	405.98	34.1	589.11	937.10	6.30	9.1	14.5

butter made per 100 pounds of milk was close, being 6.76 pounds by Group I, which was the highest, and 6.30 pounds by Group III. In pounds of solids not fat per 100 pounds of milk, Group II led, with 9.3 pounds; Group III was a close second with 9.1 pounds; and Group I third with 8.9 pounds. The total solids yielded per 100 pounds of milk were remarkably uniform, being 14.7 pounds by Group I, 14.8 by Group II, and 14.5 by Group III. Thus, the foods did not appear to affect the composition of the milk, though the solids from Groups II and III were slightly higher than from Group I. It is fair to conclude that the rations used were all satisfactory so far as the fat content and total solids of the milk were concerned and that there should be no hesitancy in feeding any of them on that account. The authors are of the opinion that Group II would have done better if fed the ration given to either Group I or Group II, and the fact that they did not yield so much milk, butter and total solids is not attributable solely to a difference in individuality, but at least partly to the character of the ration fed.

CONSUMPTION OF PROTEIN

The relative amounts of protein eaten by the several groups are shown in Table VII. The largest amount of protein was consumed by Group II, 1240.09 pounds; Group I was second with 1139.98, and Group III third with 935.92. Group III thus consumed 304.17 pounds less protein than Group II, which goes to prove the statement already made that the showing of Group III is not attributable to a difference in individuality so much as to the character of the ration fed and the inability of the cows to assimilate a relatively coarser ration to the same advantage as a more concentrated one. On the other hand, there are cases when it would be advisable to feed Group III as it was fed in this instance rather than as Group II was fed. If the farmer were in a position to make larger quantities of alfalfa hay, and cotton-seed meal and wheat bran were both extremely high, he could afford to feed a larger quantity of roughness and a comparatively small amount of concentrates, and reduce the purchase of expensive concentrates to a minimum. He might not obtain quite so much milk and butter as under a different system of feeding, but this difference would be more than compensated for in the smaller cost of his ration and in the fact that he was utilizing a home-grown product.

TABLE VII—*Relation of protein consumption to cost of milk and butter*

Group	Protein consumed	Protein consumed per 1000 lbs. live weight	Cost of—	
			Gallon milk	Pound butter
	Lbs.	*Lbs.*	*Cents*	*Cents*
I	1139.98	356.2	8.5	14.6
II	1240.09	386.7	6.9	12.3
III	935.92	291.0	9.2	17.2

In the experiments of both 1902 and 1903 the consumption of the largest amount of protein resulted in the production of the cheapest gallon of milk and pound of butter. Notice that Group II, consuming 386.7 pounds of protein per 1000 pounds of live weight, made a gallon of milk at a cost of 6.9 cents and a pound of butter at a cost of 12.3 cents. Group I, consuming 356.3 pounds of protein for 1000 pounds of live weight, made a gallon of milk at a cost of 8.5 cents and a pound of butter for 14.6 cents. Group III, which consumed 291 pounds of protein per 1000 pounds of live weight, made a pound of butter for 17.2 cents and a gallon of milk for 9.2 cents.

These results clearly indicate the necessity of a liberal supply of digestible protein in the ration of the dairy cow, and are rather opposed to the theories of some investigators that too much protein is fed to the cow and that the amount can be cut down to advantage. Group I consumed 30.5 pounds less protein for 1000 pounds of live weight than Group II, and the rise in the cost of a gallon of milk and a pound of butter is marked. Group III consumed 95.7 pounds less protein for 1000 pounds

of live weight than Group II, and the rise in the cost of a gallon of milk and a pound of butter is very marked. The source of the protein is thus shown to be a matter of importance. It must be provided in sufficient quantity and not in a form that renders it hard to digest and assimilate. No matter where the dairyman may be located he should first determine all the possible sources from which he may obtain protein in the largest quantity at the least cost. Then, it would seem that by the adoption of a suitable ration he should be able to utilize to advantage the cheapest form of protein available in his community. There are limits to the sources from which the necessary protein may be obtained, and these will be determined largely by the ability of the animals to eat a large amount of roughness rich in protein as compared with protein obtained from concentrates rich in the same. The fact that some leguminous crop rich in digestible protein can be grown in almost every section of the country and substituted to a very considerable extent for some form of concentrate which is likely to be high, is of vital interest to the dairyman, and will effect a vast saving to the industry when its application is more generally recognized.

MANURIAL VALUE OF FOODS

There are many persons who still fail to realize the value of farmyard manure, and there are many more who think it unnecessary and unwise to consider the fertilizing value of the food stuffs consumed by the animals in a feeding experiment. In some sections of the country this may possibly be true, but in the South it is not sound philosophy. The greatest need of the soil today is an ample supply of available plant food. Provide the elements in which it is deficient and it will yield as large crops as can be raised anywhere. Farmyard manure is doubly important to our people because millions and millions of dollars are annually expended for the purchase of commercial fertilizers, while farmyard manure and

TABLE VIII—*Fertilizing value of foods*

Group	Food consumed		Nitrogen	Phosphoric acid	Potash	Value of manure	
	Roughage	Concentrates				Total voided	60 pr. ct. of amt. voided
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*		
I	21376	4831	231.01	162.48	137.24	$39.05	$23.43
II	24196	1871	256.04	94.01	143.16	39.82	23.87
III	19489	3725	211.64	141.67	167.90	37.20	22.32

other useful by-products of the farm, which could be utilized to improve the mechanical condition of the soil and add useful forms of food for plant nutrition, are utterly disregarded. The fertilizing value of the food stuffs consumed by the animals constitutes one of the assets of the farmer and provides one of the profits he should derive from the maintenance of live stock. The value of the plant food has been figured in this experiment on the basis of 15 cents per pound for available nitrogen, 4.5 cents for available phosphoric acid and 5 cents for available potash. These

figures are probably not so high as those current for commercial fertilizers at the present time, but are fair prices for commercial plant food.

The total value of the nitrogen, phosphoric acid and potash in the food eaten by the different groups did not vary widely. A very large per cent of the nitrogen, phosphoric acid and potash consumed in the food stuffs is voided by the animal, and theoretically about 80 per cent should be returned to the soil. This is hardly possible under the best of conditions, but where farmyard manure is cared for as it should be at least 60 per cent should be saved. On this basis Group I should be credited with $23.43, Group II with $23.87, and Group III with $22.32, a total of $69.62 for the three groups. The animals should justly be credited with this amount of money, which is a part of their net earnings, if properly utilized, the same as the milk and butter. Letters of inquiry are daily received asking, "What is wrong with my soil?" The owner does not seem to appreciate the fact that there is nothing wrong with the soil except that it is worn-out and needs rest and additional supplies of plant food. There is an alarming waste of animal manures going on in the South today, and in spite of the oft-repeated warnings the lesson does not seem to be readily taken to heart. There is a remedy for this difficulty in the hands of the dairy farmers, and it is simply this: to grow and utilize the leguminous crops more freely and conserve the farmyard manure. Then, if the animals are credited with what justly belongs to them, it will be more common to hear that dairying is a profitable business.

FINANCIAL ASPECT OF THE EXPERIMENT

The financial statement shown in Table IX is, of course, only tentative owing to the wide variation in the market prices of food stuffs from year to year, but it may be safely followed. The table shows that the concentrates in the case of Group I cost more than twice as much as the roughness; in the case of Group II the roughness cost considerably more than the concentrates, owing to the substitution of alfalfa hay for wheat bran. This

TABLE IX—*Financial statement*

Group	Cost of food			Attendance	Value of 60 pr. ct. of manure	Net cost of—	
	Roughage	Concentrates	Total			Gallon milk	Pound butter
						Cents	*Cents*
I	$21.37	$50.72	$72.09	$14.40	$23.43	7.1	12.3
II	38.74	22.45	61.19	14.40	23.87	5.7	10.4
III	32.88	37.25	70.16	14.40	22.32	8.2	15.3

shows in itself an important fact, namely, that the source of the food will have a marked influence on the economy of production. This matter is of so much importance and is brought out so clearly in this table that it is well worthy of more careful consideration than it generally receives. It is quite possible, as shown by these results, to make a gallon of milk and a pound of butter at a cost of 5.7 cents for the former and 10.4 cents

for the latter, when crediting the cows with 60 per cent of the manurial value of the food stuffs and charging them for the labor and care involved in looking after them. Notice that by the use of a different ration, as in the case of Group I, the cost of a gallon of milk and a pound of butter was increased considerably. The ration in the case of Group III did not seem to be so well adapted to the economic production of milk and butter as that fed to Group II. As a result it cost 2.5 cents more to make a gallon of milk and 4.9 cents more to make a pound of butter than with Group II. While any of the rations fed were fairly satisfactory, there is a marked difference between the best and the poorest, and the matter of chief concern to the farmer is the fact that the best ration is one that he can largely grow at home. The difference in favor of this ration is due chiefly to the fact that it costs less, which is further proof, if additional proof is necessary, of the importance of utilizing alfalfa hay in the place of more expensive concentrates.

PROFIT ON MILK AND BUTTER

The profit on the milk at 25 cents a gallon and on butter at 20 cents a pound for the several groups is shown in Table X. In this case the cows are not credited with the value of the manure, nor is the cost of labor and attendance charged to them. The value of the manure should more than offset the item of attendance, according to our observation. The largest profit on milk and butter—$164.81 for the former and $37.95 for the latter—was made by Group II, as would naturally be expected. It also made the largest profit per cow. The profits were lowest from Group III, being $118.34 for milk and $11.03 for butter. This made an individual profit for the cow of $29.58 for milk and $2.75 for butter, which was not a satis-

TABLE X.—*Profit on milk and butter*

Group	Cost of food	Value of—		Profit on—		Average profit per cow on—	
		Milk @ 25c. per gallon	Butter @ 20c. per lb.	Milk	Butter	Milk	Butter
I	$72.09	$221.25	$102.44	$149.16	$30.35	$37.29	$7.59
II	61.19	226.00	99.14	164.81	37.95	41.20	9.48
III	70.16	188.50	81.19	118.34	11.03	29.58	2.75

factory showing for this ration. Group II made an average profit per cow of $41.20 for milk and $9.48 for butter, which was $11.62 more per cow for milk and $6.73 more for butter than with Group III. Group II thus made over 25 per cent more profit on milk and 33 per cent more profit on butter, which, even after allowing for considerable individual difference between the cows in Groups II and III, indicates that alfalfa can not be substituted to the same advantage for cotton-seed meal as for wheat bran. In other words, when some of the coarse protein-yielding forage crops are utilized in the place of concentrates, it would be an advantage to feed them with a concentrate particularly rich in protein, such as cotton-seed meal.

COMPARATIVE VALUES OF ALFALFA AND COWPEA HAY

Remarkably uniform results are shown in the substitution of alfalfa and cowpea hay for a portion of the concentrates in feeding the dairy cow. Notice the results presented in Table XI, which gives a summary of the experiments to determine the relative merits of alfalfa and pea hay. Though different animals were used in the two experiments, practically the same amount of food was consumed for a gallon of milk in the two cases. The cattle fed pea hay ate a little more roughness for a pound of butter than those fed alfalfa. The real test of the comparative merits of the two feeds is shown by the net cost of producing a gallon of milk and a pound of butter. It seems that the one food can be substituted for the other with the greatest satisfaction. Observe that the cheapest gallon of milk and pound of butter were made by Group II in both instances. Where alfalfa hay was fed the cost of a gallon of milk was 5.7 cents, and of a pound of butter 10.4 cents; when pea hay was fed the net cost of a gallon of milk was 5.6 cents and of a pound of butter 10.7 cents. In localities where pea

TABLE XI—*Comparison of alfalfa experiment and pea hay experiment*

	ALFALFA EXPERIMENT							PEA HAY EXPERIMENT						
	Food consumed			Food consumed per—		Net cost of—		Food consumed			Food consumed per—		Net cost of—	
Group	Roughage	Concentrates	Cost of food	Gallon milk	Pound butter	Gallon milk	Pound butter	Roughage	Concentrates	Cost of food	Gallon milk	Pound butter	Gallon milk	Pound butter
	Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Cts.*	*Cts.*	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Cts.*	*Cts.*
I	21876	4881	$72.09	29.37	51.0	7.1	12.3	25415	4800	$92.24	27.98	57.88	6.7	13.8
II	24196	1871	61.19	28.62	52.1	5.7	10.4	26829	1920	67.95	31.17	59.22	5.6	10.7
III	19498	3725	70.16	30.30	56.8	8.2	15.3	20466	2880	81.52	27.65	49.97	8.0	14.5

hay grows well and alfalfa can not be grown the former can be used with satisfaction, and vice versa. It is a well-known fact that the cowpea grows satisfactorily all over the South. On the other hand in many places where cowpeas will grow well alfalfa can not be grown. In sections where alfalfa thrives it can be substituted with equal satisfaction for the cowpea and it has the advantage of being a permanent crop and remaining on the land for several years, and yielding if anything larger returns in the way of forage than the cowpea. The cowpea can be grown in between crops or as a catch crop and utilized under conditions where it would be impracticable to use alfalfa. It is certain that either one of these crops can be utilized to the greatest advantage on the Southern farm, for the tables show conclusively that either one makes a splendid companion food for cotton-seed meal in feeding the dairy cow, and that it cheapens the ration very considerably. This solves the most difficult problem with which the Southern dairyman has to contend; namely, the production of cheap concentrates for his cattle. It is quite evident that he can discard the use of wheat bran, which is now so costly. It is not so certain from these results that alfalfa or pea hay can be substituted satisfactorily for cotton-seed meal; but this will hardly ever become necessary as cotton-seed meal is the cheapest con-

centrate raised by the Southern farmer, and owing to the high percentage of protein it contains, it is likely to remain so for a long time to come. Under certain conditions it is very evident that such food stuffs as wheat bran or others of equal feeding value, if they can be bought at a reasonable price, can be used to advantage in the place of cotton-seed meal; and these results will of course have a wider application in sections of the country where cotton-seed meal is not a by-product on the majority of farms.

CONCLUSIONS

1 The cost of producing milk and butter can be greatly reduced by replacing a part of the concentrates in the daily ration of the cow with some roughness rich in protein, such as alfalfa or cowpea hay.

2 Alfalfa can be grown successfully on upland soils. 6365 pounds of hay and 15,015 pounds of green feed have been raised on an acre of upland soil on the Station farm in a dry season, a yield approximating 5 tons of cured hay per acre.

3 It is an advantage to feed a dry roughness which is intended to replace a part of the concentrates in a ration with silage, because of its succulent and palatable nature.

4 A ton of alfalfa or pea hay can be produced at a cost of from $3.00 to $5.00, whereas, wheat bran costs from $20.00 to $25.00. From 2 to 3 tons of pea hay and from 3 to 5 tons of alfalfa can be obtained from an acre of land; hence there is a great advantage in the utilization of these roughnesses in the place of wheat bran.

5 Alfalfa and pea hay can not be substituted to the best advantage for cotton-seed meal, as this food stuff is so very rich in protein that a larger bulk must be consumed than the capacity of the average cow will permit.

6 The substitution of a roughness rich in protein for an expensive concentrate will enable the dairyman to make milk and butter at a less cost and will thus solve one of his most serious problems.

7 In substituting alfalfa hay for wheat bran it will be best to allow 1½ pound of alfalfa to each pound of wheat bran; and the results are likely to prove more satisfactory if the alfalfa is fed in a finely chopped condition.

8 These tests indicate that with alfalfa hay at $10.00 a ton and wheat bran at $20.00, the saving effected by substituting alfalfa for wheat bran would be $2.80 for every 100 pounds of butter and 19.8 cents for every 100 pounds of milk. The farmer could thus afford to sell his milk for 19.8 cents a hundred less than he now receives, and his butter for about 22 cents as compared with 25 cents a pound.

9 These experiments show why alfalfa has been frequently used as a basis of manufactured food stuffs, and indicate that the farmer who can grow it makes a mistake in purchasing artificial food stuffs of which it forms the basis.

10 The best results from the standpoint of economic production of a gallon of milk and a pound of butter were obtained with Group II, which consumed 386.7 pounds of protein per 1000 pounds of live weight and made a gallon of milk at a cost of 6.9 cents and a pound of butter at a cost of

12.3 cents. Group I consumed 356.2 pounds of protein per 1000 pounds of live weight and made a gallon of milk at a cost of 8.5 cents and a pound of butter at a cost of 14.6 cents. Group III consumed 291 pounds of protein per 1000 pounds of live weight and made a gallon of milk for 9.2 cents and a pound of butter for 17.2 cents, indicating the necessity of a liberal supply of digestible protein in the ration of the dairy cow.

11 When alfalfa was fed under the most favorable conditions a gallon of milk was obtained for 5.7 cents and a pound of butter for 10.4 cents. When pea hay was fed the lowest cost of a gallon of milk was 5.2 cents and of a pound of butter 9.4 cents. In localities where pea hay grows well it can be utilized to replace wheat bran and in sections where alfalfa can be grown this crop can be substituted for pea hay with satisfaction.

12 These results, covering two years' tests with different sets of cows, furnish proof that certain forms of roughness rich in digestible protein can be substituted with satisfaction for the more expensive concentrates, and should thus lend great encouragement to dairy farmers.