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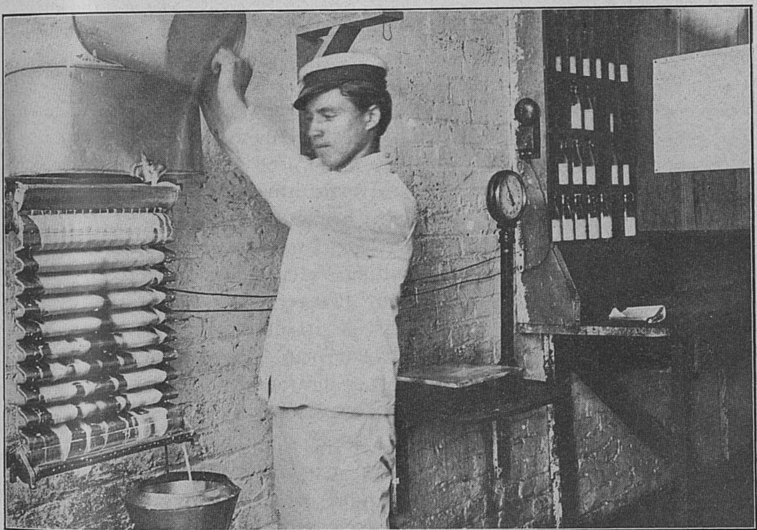

RECORDING THE WEIGHT AND SAMPLING THE MILK FOR THE FAT TEST AND TOTAL SOLIDS

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The Relative Value of Protein in Cotton Seed Meal, Cowpea Hay and Wheat Bran

A cooperative experiment between the Tennessee Experiment Station and the Bureau of Animal Industry U. S. Department of Agriculture.

KNOXVILLE, TENNESSEE

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The Relative Value of Protein in Cotton Seed Meal, Cowpea Hay and Wheat Bran

ANDREW M. SOULE AND S. E. BARNES

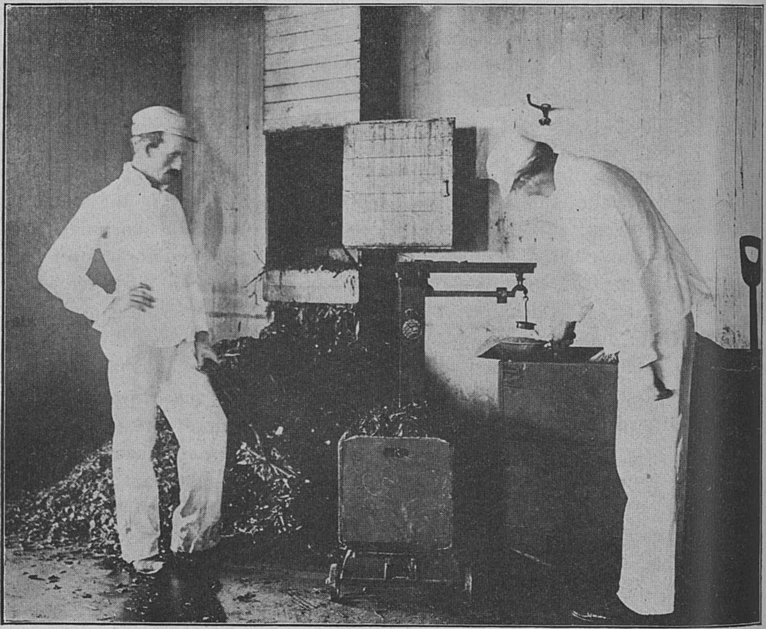
INTRODUCTION

Feeding the dairy cow would be a comparatively easy matter were it not for the difficulty experienced in securing a sufficient amount of protein to supply the heavy demands made on her system in the production of milk. Cheap and abundant fodder crops can be grown with comparative ease to supply the more bulky part of her ration, but the protein needed is much harder to provide in a desirable form at a price within the reach of the average dairyman. The abundance of cotton seed meal in the south should offer a happy solution of the difficulty, but there are many places where freight rates make cotton seed meal quite as expensive as in the states of the far northwest, and then it frequently happens that the dairyman does not see his way clear to pay out a large amount of money for cotton seed meal, for as the old axiom puts it, "A dollar saved is a dollar made." So it is to his interest to discover if possible a means by which he can produce the needed protein on his own farm and thus save the heavy drain on his resources required by the purchase of cotton seed meal or some other concentrate rich in protein.

Results of General Interest In the sections where cotton seed meal is particularly abundant and so comparatively cheap, the present investigation may seem to have but slight application, but the reader must remember that the best results in feeding dairy cows come from a combination of concentrates rather than from the exclusive use of one, no matter how rich that may be in the elements most needed for the economic production of milk. Cotton seed meal has now been fed long enough to establish its virtue as a feed for dairy cows, but it has also been shown that it is unwise to employ it exclusively for that purpose, as it is so rich, not only in protein but in fat and other constituents as well, that it has a tendency to produce various nervous derangements of the cow's system entailing serious losses that can easily be avoided if the meal were employed in a more rational manner. The present investigation, therefore, has a much wider application and a more general interest than would at first seem to be the case.

These statements are not meant to disparage the use of cotton seed meal, far from it, for it is the most highly concentrated foodstuff produced in the United States and it should be so completely used by the southern farmer that there would be no surplus for sale beyond the borders of the state producing it, but in order that it may be employed with satisfaction and with the greatest profit, its utilization must be along lines in harmony with the needs of the animal's system.

Protein=Producing Crops It now becomes important to discover what crops may be grown on the southern farm to supply protein abundantly and in an economic manner. Fortunately, the southern soil is adapted to the culture of several of the most important legumes known to mankind. Among these the one that stands out preeminently is the cowpea. It is well adapted to every section of the south and can be utilized to advantage in more ways than any other legume, and besides making a most excellent hay rich in protein, it has the power of materially improving the mechanical condition and the crop-producing power of the land, an item of the most profound concern to the southern farmer who has been somewhat careless with regard to such matters and has sold his cotton seed to the oil mill because of its ready cash value, though failing to return to the



PREPARING THE RATIONS

soil in some other form the equivalent of the plant food thus removed. As a result, the fertility of much of our land has been seriously impaired, and so it is a particularly happy coincidence that the cowpea can be employed to rehabilitate the soil, produce a hay rich in protein which combines most happily with cotton seed meal as a feed for dairy cows, and can even be used to advantage as a substitute for wheat bran or cotton seed meal under certain conditions.

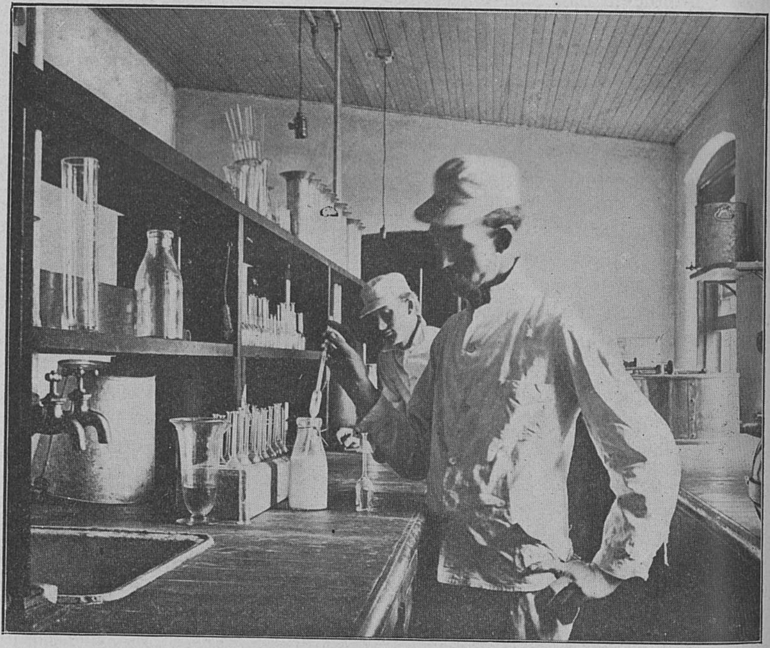
If the present experiment is a safe criterion, the southern dairyman can employ cotton seed meal and cowpea hay as grain feeds for his dairy cows, and thus grow all the concentrates needed on his own farm, a matter of the gravest importance. Milk being particularly rich in nitrogenous substances makes it essential that foods rich in these elements be employed as a part of the ration, for the dairyman in order to be successful must have an abundance of cheap food at his command, and this applies both to roughness and concentrates. It is generally conceded that some concentrate must be bought. The smaller the amount required and the less expensive the substance employed to secure the most profitable returns, the more material the advantage becomes.

Special Advantages for Dairying It appears from these statements that the southern dairyman has a phenomenal advantage in that he can so frequently utilize a home-grown ration. Wheat bran has long been considered one of the standard foods for the dairy cow. Its abundance, especially throughout the best known dairy sections of the country and in the wheat belt as well, has hitherto made it comparatively cheap and abundant, and its fine physiological action has tended to increase its favor. As the middle south is now a large wheat-producing section and the tendency is to increase the acreage of that important cereal, wheat bran is likely to remain in favor with the dairyman if the millers will make the price such as to warrant its employment on the dairy farm. The tendency of the times is to raise the price of bran until it becomes even more expensive than cotton seed meal, and under such circumstances it is doubtful if the dairyman can afford to employ it as extensively in the future as in the past if prices remain as at present. As cotton seed meal, cowpea hay and wheat bran are the most important protein-producing crops which can be employed to advantage in the south, the purpose of the present investigation was to compare as far as possible the utility of different combinations of these feeds, it being generally admitted that two concentrates must enter into the ration of the dairy cow to give the best results.

The Cowpea and Protein Production It will be interesting to learn how the cowpea ranks as a protein-producing crop, as several feeding experiments have shown that alfalfa is about equal pound for pound to wheat bran. In order to do so, the following table was prepared exhibiting the amount of dry matter, protein, carbohydrates and fat and the nutritive ratios of alfalfa, cowpeas and red clover, legumes which can be grown with the possible exception of alfalfa pretty generally over the south, when compared with some standard hays.

		DIGESTIBLE MATTER PER TON			
	Dry Matter Per Ton—Lbs.	Protein Lbs.	Carbohydrates Lbs.	Fat Lbs.	Nutritive Ratios
Hay from Legumes					
Alfalfa	1832	211.6	746.6	27.6	1:3.6
Cowpeas	1786	215.8	768.0	30.2	1:3.9
Red Clover	1694	131.6	707.0	33.2	1:5.9
Hay from					
Orchard Grass	1802	95.6	838.0	28.0	1:9.5
Timothy	1736	57.8	874.4	28.6	1:16.2
Kentucky Blue	1576	95.2	746.6	39.0	1:8.9

It is noteworthy that a ton of cowpea hay is slightly richer in protein, carbohydrates and fat than a ton of alfalfa hay, while it contains 83.2 more pounds of protein than red clover hay, 61 pounds more of carbohydrates, though 3 pounds less of fat. The nutritive ratio of alfalfa is 1:3.6; of cowpea hay 1:3.9, and of red clover 1:5.9. Compared with standard hays, such as orchard grass, timothy and Kentucky blue grass, any of the above legumes are seen to be infinitely richer in the food nutrients suitable to the production of milk. So it seems clear that by employing proper rotations and utilizing some one of the above legumes, probably the cowpea, owing to its being a practically sure crop and its wide adaptability, the southern farmer can by using cotton seed meal produce an abundance of protein foods for his dairy herd.



DETERMINING THE FAT BY THE BABCOCK METHOD

Plan of Experiment The experiment commenced on November 1, 1901, and closed March 1, 1902, a feeding period of 120 days. Twelve cows divided into three groups of four each were employed. The rations were fed in two equal parts and in proportion to the live weight of the animal. Aliquot samples of milk were drawn night and morning and preserved with corrosive sublimate tablets for the Babcock test. Corrections were made for the influence on specific gravity of the small amount of corrosive sublimate added as a preservative, and the solids not fat were determined by the use of the lactometer and the composite samples employed in making the fat tests. The results were satisfactory and comparatively simple as compared with the immense amount of labor involved in saving a sample of each cow's milk, cooling it down and attempting to make a lactometer reading of it twice a day. Indeed, that would have involved so much labor as to practically caused the abandonment of that part of the experiment, though our success with the present method leads us to believe that the results would not have been any more satisfactory if the older and more laborious method had been employed.

The Rations Fed The following table I shows a schedule of the rations fed. Silage was the principal roughness employed, though cowpea hay was also regarded as a roughness in these experiments. To determine the relative efficiency of the protein in cotton seed meal, cowpea hay and wheat bran, 4 pounds of cotton seed meal and 6 pounds of wheat bran were fed in group I; 4 pounds of cotton seed meal and 7 pounds of cowpea hay in group II; and 6 pounds of wheat bran and 13 pounds of cowpea hay in group III. Thus, in the two groups in which cotton seed meal was fed the same amount was employed; in the two groups in which wheat bran was

TABLE I—Rations Fed

Groups	Name of Cow	Rations per day	Amount Pounds	Remarks
I	Stophell	....	....	....
	Roonan's Lady	Silage	30	....
	Aggie	Cot. Seed Meal	4	....
	Nettie	Wheat Bran.....	6	....
II	Matilda.........	....	....	....
	Rosy	Silage	30	....
	Callie	Cot. Seed Meal	4	Pea Hay was
	Belle	Cowpea Hay	7	finely cut
III	Maggie Doon....	....	....	....
	Stanley	Silage	30	....
	Lucy	Wheat Bran.....	6	Pea Hay was
	Stachy	Cowpea Hay	13	finely cut

fed the same amount was employed; while in the two groups in which cowpea hay was fed, a sufficient number of pounds were used to take the place of the protein in the wheat bran for which the pea hay was substituted in group II, and to take the place of the 4 pounds of cotton seed meal for which the pea hay was substituted in group III. The pea hay was fed in a finely cut condition, being run through a Blizzard shredder to which cutting and shredding bars were both attached. It was believed that by substituting an amount of cowpea hay that would supply the protein contained in the wheat bran and cotton seed meal respectively that the relative efficiency of the protein in any two of the substances when combined could be determined with a fair degree of accuracy.

The Basis of Substitution The following statement showing the dry matter and digestible protein, carbohydrates and fat contained in the average analysis of cowpea hay, wheat bran and cotton seed meal will explain why the amounts of pea hay specified in groups II and III were employed.

THE RESTFUL HOUR

	Dry Matter per 100 lbs.	Digestible Matter per 100 lbs. Protein	Carbohydrates	Fat
Cowpea Hay	89.3	10.79	38.40	1.51
Wheat Bran	88.4	12.01	41.23	2.87
Cotton Seed Meal	91.8	37.01	16.52	12.58

The table indicates that one pound of wheat bran contains about as much protein as 1.16 pounds of cowpea hay, and 1 pound of cotton seed meal as much protein as 3.25 pounds of cowpea hay. It was on this basis that the substitution was made. The rations employed were all found satisfactory as the tables which follow indicate and they were all eaten with avidity and relished by the cows which kept in good health and condition throughout the experiment. The results obtained with pea hay would probably not have followed had it not been finely cut up. It is quite probable that if it had been ground, as was done in certain experiments with alfalfa, it would have been found even more satisfactory. The principal

TABLE II—History of Cows and Gain or Loss in Weight

GROUP I

Name of Cow	Breed	Weight—Pounds Initial	Final	Gain Pounds	Loss Pounds
Stophell	Grade	827	805		22
Roonan Lady	Jersey	782	825	43	
Aggie	Holstein	1125	1155	30	
Nettie	Grade	735	725		10

GROUP II

Name of Cow	Breed	Initial	Final	Gain Pounds	Loss Pounds
Matilda	Jersey	882	905	23	
Rosy	Jersey	777	760		17
Callie	Grade	867	825		42
Belle	Jersey	797	840	43	

GROUP III

Name of Cow	Breed	Initial	Final	Gain Pounds	Loss Pounds
Maggie Doon	Jersey	800	805	5	
Stanley	Grade	955	820		135
Lucy	Grade	950	905		45
Stachy	Jersey	900	885		15

objection that could be urged against the substitution of cowpea hay for cotton seed meal in a dairy ration would be the necessity of employing such a large amount that the cows would not be disposed to eat it. This was not a difficulty in the present investigation, though it might have been if 6 or more pounds of cotton seed meal had been employed, but our own experience in feeding cotton seed meal indicates that it is better to limit the amount of that concentrate to 4 or 5 pounds, and not to feed more than 6 pounds for long periods. While it is true that as much as 10 pounds of cotton seed meal or even more might be fed for a considerable period of time to cows, in the long run it will prove injurious and so it is much better to employ it in moderate quantities where it can be fed continuously rather than to attempt to feed it in large quantities for short periods. This is the candid opinion of men who have employed it for several years as a concentrate in feeding dairy cows.

The Cattle Used The cows employed were with one exception Jersey grades Table II. The average weight of group I was 872 pounds; group II, 831 pounds; and group III, 901 pounds. The animals were all in fair condition at the commencement of the experiment, but group III was probably in considerably the best condition. The four animals in group I gained 41 pounds in 120 days; in group II they gained 7 pounds; and in group III they lost 190 pounds. While the loss with group III was quite

Skim Milk Calves

marked, they closed the experiment in good condition, and so the variation in live weight could hardly be attributed solely to the foodstuffs employed.

Cost of the Foodstuffs at High Prices and Low Prices Realizing that the cost of foodstuffs has an important bearing on an experiment Table III, the results have been figured out on the basis of what are termed high prices and low prices. For example, in the case of high prices, wheat bran is figured at $26.00 a ton; at low prices, at $16.00 a ton. Cotton seed meal is figured at $24.00 and $20.00 a ton respectively; pea hay at $10.00 and $6.00 respectively; and silage at $2.50 and $1.70 a ton. Near the centers of population, as in the vicinity of the larger towns and cities where dairying is more largely developed than in the country sections, the price of bran and other foodstuffs is frequently much higher than in the country. The locality of the state also has a marked influence on the price of foodstuffs, for the past year when bran was ranging from $26.00 to $27.00 a ton in Knoxville and other large cities, it was being bought by farmers from country mills for from $14.00 to $16.00 a ton. The same is true of cotton seed meal. A fair average price for pea hay on the farm, according to the statistics of a number of dealers, is $6.00 or $7.00. A fair average market price according to these same men is about $10.00. It does not cost $4.00 to put pea hay on the market, but if the farmer remembers that it takes a man and a team all day to haul a load of pea hay to market over the common type of country roads, he will find that it costs him from $2.00 to $3.00 a ton to deliver baled hay. According to actual experiments made on the University farm, pea hay can be produced for from $4.00 to $5.00 a ton, leaving the farmer from $1.00 to $2.00 clear profit if his crop is employed at home, and of course, it is of the utmost importance for the farmer to ascertain whether it is better for him to keep his pea hay at home and

TABLE III—Cost of Food Stuffs

Kind of Food	High Prices	Cost per Pound	Low Prices	Cost per Pound
Wheat Bran	$26 00	1.3c	$16 00	.8c
Cotton Seed Meal	24 00	1.2	20 00	1.00c
Pea Hay	10 00	.5	6 00	.3
Silage	2 50	.125	1 70	.085

feed it, allowing himself a margin of profit over the cost of production, or rather to entail the labor and cost of baling and delivering the hay to the market for a very slightly increased profit, remembering that if he hopes to maintain the fertility of his farm, he must replace the plant food carried off in the hay through the medium of an expensive commercial manure, whereas if he feeds the hay intelligently, he should be able to make a further profit on it. While silage can be produced in Tennessee for less than $1.70 per ton, owing to the severe drought of the past season, it cost that to produce it on the University farm, and in order to have two sets of prices to compare, a sale price of $2.50 per ton has been placed on the silage somewhat arbitrarily, but still a price that is believed to fairly represent its sale value. It is important to set forth the profits on the experiment where two sets of prices are considered, owing to the great fluctuations in the market value of foodstuffs.

Food Consumed Table IV shows the roughness and concentrates consumed by the different groups and the cost of the same at high prices and low prices. It is worthy of note that the increased consumption of pea hay seemed to reduce the consumption of silage in group II, and especially in group III where the difference amounted, as compared with group I, to 9884 pounds. The table also shows the amount of roughness and concentrates consumed per gallon of milk and per pound of butter. It seems that it required almost double the amount of roughness and concentrates to produce a pound of butter that was required to produce a gallon of milk. The amount of roughness required to produce a gallon of milk was highest with group II, being 29.1 pounds, while the concentrates were the lowest, being 2 pounds, or less than half of that required in group I, thus the substitution of 7 pounds of pea hay for 6 pounds of wheat bran in group II while increasing the roughness slightly reduced the concentrates by one-half, and as the concentrates are more expensive to buy than the pea hay, the substitution was a very desirable one. The lowest amount of roughness eaten for a pound of butter was 43.8 pounds with group III in which 13 pounds of pea hay was substituted for 4 pounds of cotton seed meal. The highest amount of concentrates required was with group I, 9.2 pounds, or 3.2 pounds more than group II, and 5.3 pounds more than group III. The substitution of the pea hay while resulting in the decreased consumption of roughness for the production of a pound of butter with group III and a slight increase with group II, reduced the consumption of concentrates again very considerably.

TABLE IV—Food Consumed

Groups	ROUGHAGE CONSUMED		CONCENTRATES CONSUMED		FOOD CONSUMED PER GAL. MILK		FOOD CONSUMED PER LB. BUTTER	
	Silage Pounds	Pea Hay Founds	Wheat Bran	Cotton-seed Meal	Rough-age	Concen-trates	Rough-age	Concen-trates
I	25415	....	2880	1920	23.6	4.4	48.7	9.2
II	23795	3034	....	1920	29.1	2.0	54.9	3.9
III	15531	4935	2880	....	24.2	3.4	43.8	6.1

The Protein Equivalent In table V the amount of each foodstuff consumed per group is shown, also the amount consumed for each gallon of milk and each pound of butter. The amount of these foodstuffs has been reduced to the basis of 1000 pounds of live weight which will enable the reader to make a more careful comparison of the relative value of the different foodstuffs. The ratio between the different concentrates consumed for the production of a gallon of milk or a pound of butter did not vary materially. Group I consumed 5 pounds of concentrates for the production of a gallon of milk, made up for all practical purposes of 3 pounds of wheat bran and 2 pounds of cotton seed meal. Group II consumed 6.44 pounds of concentrates, made up for all practical purposes of 2.5 pounds of cotton seed meal and four pounds of pea hay. It was therefore necessary to feed about a pound and a quarter of pea hay to take the place of a pound of wheat bran. Group III consumed 10.52 pounds of concentrates, made up for all practical purposes in the ratio of 4 pounds of wheat bran and 7 pounds of pea hay. It therefore required the substitution of about 3 pounds or a little more of pea hay to provide the protein equivalent contained in a pound of cotton seed meal. Virtually the same ratio of substitution holds in the case of both milk and butter production. *These substitutions correspond very nearly with those indicated as being necessary in* *the earlier part of this bulletin, so that provided the palatability and the digestibility of the foodstuffs used are equal, the source from which the protein is derived has but little effect. The practical lesson to be drawn from these results is that in making a substitution of one food for another where the protein is the item of chief consideration, it must always be done on the basis of the protein equivalent.*

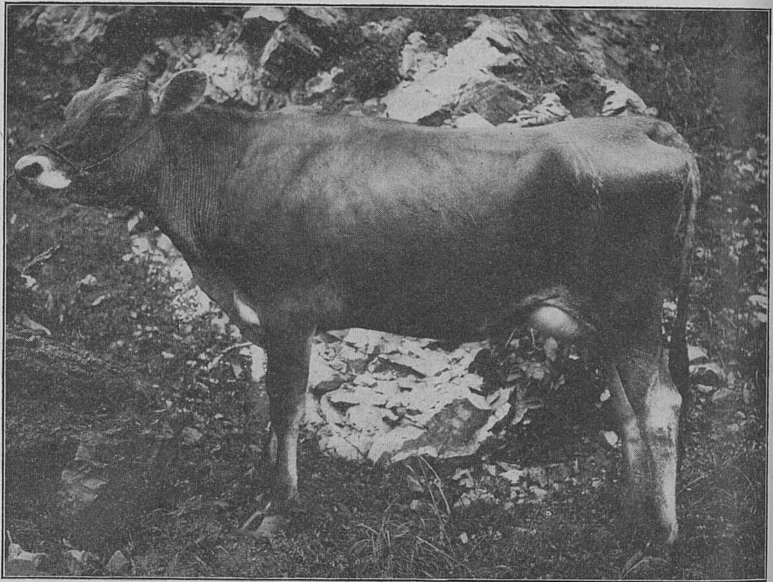
Should the Farmer Grow Pea Hay, Sell It or Feed It? Keeping in mind the basis of substitution which the experiments seem to justify, we can now proceed to discuss intelligently what disposition the farmer should make of his pea hay and whether he can afford to cultivate it as a concentrate for use in his dairy herd. A "second crop" of cowpea hay can be made for from $4.00 to $5.00 a ton after a crop of winter cereals seeded the previous autumn has been harvested for hay or grain. Where the land was fall plowed and the peas seeded earlier, a larger yield at a less cost per ton for the cured hay should be obtained. The average yield of pea hay on the

TABLE V—Effect of substituting Pea Hay for Cotton Seed Meal and Wheat Bran

FOOD CONSUMED		POUNDS OF FOOD		FOOD CONSUMED PER 1000 LBS. LIVE WEIGHT	
Kind of	Pounds of	Per Gallon Milk	Per Pound Butter	Per Gallon Milk	Per Pound Butter
GROUP I					
Silage	25415	23.60	48.7	27.04	55.80
Wheat Bran	2880	2.60	5.5	2.96	6.40
Cottonseed Meal	1920	1.78	3.68	2.04	4.20
GROUP II					
Silage	23795	25.8	48.7	29.04	48.4
Pea Hay	3034	3.29	6.20	3.96	7.44
Cottonseed Meal	1920	2.08	3.92	2.48	4.68
GROUP III					
Silage	15531	18.4	33.3	20.96	37.92
Pea Hay	4935	5.84	10.5	6.64	11.96
Wheat Bran	2880	3.41	6.17	3.88	7.00

University farm the past year was about 2.5 tons per acre. It cost, therefore, to put the crop in the barn some $12.50. The average farm price of pea hay for the state is about $6.00 or $7.00 per ton which would make the crop worth at the higher price, $17.50 on the farm. If baled and placed on the market, it would bring about $10.00 per ton, or $25.00. A ton of bran at low prices cost about $16.00, or $1.50 less than the farm value of 2.5 tons of pea hay, though 2.5 tons of pea hay has twice the feeding value of the wheat bran. To purchase an amount of wheat bran equivalent in feeding value to pea hay would cost at low prices $32.00, and at high prices, $52.00. The results are overwhelmingly in favor of the production of protein through the medium of pea hay on the farm rather than through the purchase of wheat bran. As soon as the farmer comes to realize the virtue of the pea vine and to utilize it properly, he can materially reduce the price of producing a gallon of milk or a pound of butter, and when that day comes southern dairying will rest on a safe basis for competition with the whole world.

According to the results obtained, it would take 3 tons of pea hay to equal in feeding value a ton of cotton seed meal. It would take 1.2 acres of land to yield that amount of hay according to the results of the past year. It would cost about $16.00 to make the cowpea hay; the farm value of the crop would be about $21.00 and the market value, $30.00. A ton of cotton seed meal at low prices costs $20.00, and therefore 1.2 acres of land would produce pea hay equal in feeding value to a ton of cotton seed meal at a cost of $16.00, leaving the farmer $4.00 of a margin without utilizing



Lady Tippen—A Promising Jersey Heifer

the pea hay for feeding. The roots, leaves and stubble of the peas left on the ground would supply some 40 pounds of nitrogen, which at 15 cents a pound would be worth $6.00, enough to more than compensate for the higher fertilizing value of the cotton seed meal. It thus appears that if the farmer can grow 2.5 or more tons of pea hay per acre, he could afford to use it as a substitute for cotton seed meal rather than purchase the latter, even at a cost of $20.00 per ton, and the higher the price of cotton seed meal, the more important the production of home-grown food rich in protein becomes. It is quite clear to the practical dairyman that one of the concentrates suggested must be purchased, and as a matter of economy this should always be cotton seed meal. There may be times, however, when it will pay him to buy wheat bran even if it does cost him a good deal more in proportion because of its fine physiological effect. But it seems perfectly clear that the southern farmer should never purchase more than one protein food for his dairy cows.

Food Nutrients Consumed Table VI shows the dry and digestible matter consumed in roughness and concentrates for the production of a

TABLE VI—Digestible Matter

Groups	LBS. CONSUMED OF		LBS. CONSUMED OF		LBS. CONSUMED PER GAL. MILK OF		LBS. CONSUMED PER LB. BUTTER OF		Nutritive Ratio
	Roughage	Concentrates	Dry Matter	Digestible Matter	Dry Matter	Dig. Matter	Dry Matter	Dig. Matter	
I	25415	4800	9827.48	6662.24	9.1	6.2	18.8	12.7	1—4.5
II	26829	1920	9611.98	6049.19	10.4	6.5	19.6	12.4	1—4.2
III	20466	2880	10353.63	6116.70	12.2	7.2	22.2	13.1	1—4.8

gallon of milk and a pound of butter, also the nutritive ratios of the rations fed. It is noteworthy that these were very nearly the same, all of them being narrow, ranging from 1:4.3 with group II to 1:4.8 with group III. Observe that the smallest amount of dry matter and digestible matter was consumed for both purposes by group I, and the largest by group II. While there was considerable variation shown in the amount of dry matter consumed by these two groups, very slight differences appear with regard to the digestible matter in the case of all groups. In the case of dry matter required for a gallon of milk, the amounts consumed by groups I, II and III were respectively 6.2, 6.3 and 7.2 pounds, an extreme difference between groups I and III of 1 pound per gallon of milk.

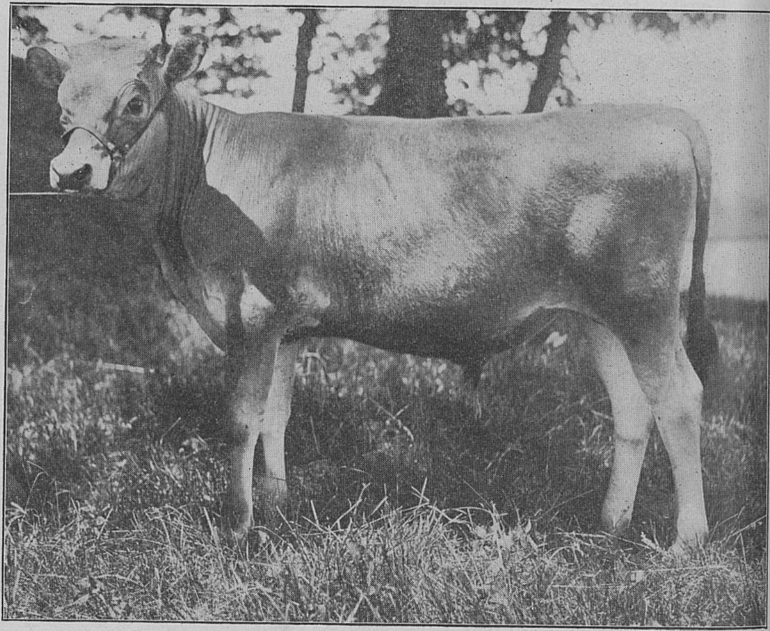
With regard to the digestible matter consumed for the production of a pound of butter, the difference was even less marked, the amounts consumed being 12.7, 12.3 and 13.1 pounds, or an extreme difference of .4 of a pound. The larger consumption of dry matter by group III was not a matter of so much importance, as this did not involve the outlay of any considerable amount of money. It is quite evident that the larger consumption of dry matter for the production of a gallon of milk and a pound of butter by group III was due to the 13 pounds of pea hay substituted for the 4 pounds of cotton seed meal.

Influence of Feed on the Composition of Milk Table VII shows the influence of the feed on the production of milk, fat and solids. The

TABLE VII—Influence of Feed on the Production of Milk, Fat and Solids

Groups	Milk Produced	Fat Test	Fat Produced	Butter Produced	Lactometer Test	Solids Not Fat	Total Solids	Pounds of Butter per 100 lbs. of Milk	Pounds of Solids not Fat per 100 lbs. of Milk	Pounds of Total Solids per 100 lbs. of Milk
I	9134	4.9	447.59	522.18	33.1	778.22	1225.81	5.7	8.4	13.4
II	7833	5.3	415.15	484.33	33.6	678.57	1083.71	6.2	8.6	14.0
III	7176	5.0	394.68	460.46	34.0	635.20	1029.88	6.4	8.8	14.3

largest amount of milk was produced by group I, 9134 pounds and the smallest by group III, 7176 pounds. These differences were probably as much due to individuality in the animals as to the feeds employed. The difference in the yield of milk was somewhat compensated for by the higher fat test of the milk of groups II and III, so that the fat and butter yield was more nearly equal than one would have anticipated. The highest lactometer test was shown by the milk of group III, being 34. The highest yield of solids not fat was made by group I, as was also the highest yield of total solids. The maximum yield of butter per 100 pounds of milk was made by group III with 6.4 pounds; group II followed with 6.2 pounds, and group I with 5.7 pounds. Figured out on the basis of 100 pounds, the



IUKA'S TORMENTER—A BULL CALF SHOWING FINE QUALITY, RAISED ON SKIM MILK

solids not fat and the total solids were more nearly equal than might have been expected, being with groups I, II and III, 13.4, 14 and 14.3 respectively. *It appears that all the foods were satisfactory in maintaining a good flow of milk, a high fat content and a high per cent of total solids, and the variations shown are not definite enough to attribute the results to any material influence of the respective feeds.*

Influence of Protein Consumption on the Yield of Milk and Butter Table VIII shows the total amount of protein consumed by the three groups. The largest amount was consumed by group I, 1294.20 pounds, while group III consumed much less or 1024.11 pounds. The protein consumed per 1000 pounds of live weight was highest with group II, 377.9 pounds, and smallest with group III, 284 pounds, a difference of 93.9 pounds of protein per 1000 pounds of live weight. Keeping in mind the two sets of prices already referred to, it appears that group II consumed the largest amount of protein per 1000 pounds of live weight, and made the cheapest gallon of milk and the cheapest pound of butter at low prices, being 5.2 and 9.9 cents respectively. Group III which consumed the smallest amount of protein produced a gallon of milk at a cost of 6 cents and a pound of butter at a cost of 10.9 cents; while group I produced a gallon

TABLE VIII—Relation of Protein Consumption to Cost of Milk and Butter

Groups	Protein Consumed	Protein Consumed per 1000 lbs. live wt.	Cost of a gal. of Milk at high prices of feed	Cost lb. butter at high prices of feed	Cost of a gal of Milk at low prices of feed	Cost lb. butter at low prices of feed
I	1294.20	373.0	8.5	17.6	5.9	12.2
II	1256.06	377.9	7.3	13.9	5.2	9.9
III	1024.11	284.0	9.6	17.4	6.0	10.9

of milk at a cost of 5.9 cents and a pound of butter at 12.2 cents. Thus, while group III produced a gallon of milk at practically the same cost as group I with a much smaller consumption of protein, it produced a pound of butter at a considerably smaller cost.

Where high prices are considered, the results favor group II and a high consumption of protein; that is, the ration which contained the cotton seed meal and cowpea hay. The cost of a gallon of milk was 7.8 cents and the cost of a pound of butter 14 cents with group II. Where high prices are considered, group I fed bran and cotton seed meal fared best and had a material advantage over group III, fed wheat bran and cowpea hay as a substitute for cotton seed meal.

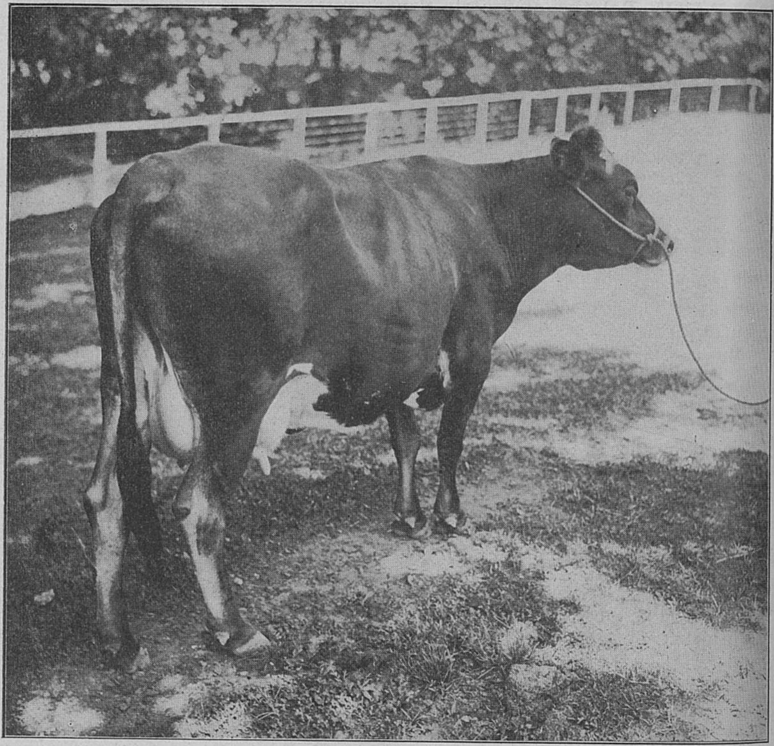
Fertilizing Value of the Food In summing up any feeding experiment with dairy cows Table IX, the fertilizing value of the food will have a definite influence on the results, and under no circumstances should its influence on the experiment be overlooked. It will also indicate to a certain extent what foodstuffs one could afford to purchase where their

TABLE IX—Fertilizing Value of the Food

Groups	FOOD CONSUMED		Pounds Nitrogen	Pounds Phosphoric Acid	Pounds Potash	VALUE OF MANURE	
	Roughage	Concentrates				Total Voided	60% of Am't Voided
I	25415	4800	278.41	166.47	157.09	45.67	34.25
II	26829	1920	256.14	97.23	149.93	40.21	30.16
III	20469	2880	216.60	125.97	176.36	37.53	28.16

utility for the mere production of milk and butter are practically the same. The fertilizing value of the food, that is, the nitrogen, phosphoric acid and potash contained in the foodstuff, is presented in the following table. The total value of all the fertilizing elements and the value of 60 per cent of the elements voided is likewise presented. The value of the excrements is estimated on the basis of 15 cents per pound for available nitrogen, 4.5 for available phosphoric acid and 5 cents for available potash. The total amount voided is estimated on the basis of 80 per cent of the mineral elements supplied in the ration, and while with the best of care and attention practically all of these elements would be conserved and utilized as plant food, even under indifferent management 60 per cent should be saved and so utilized.

The total value of the excrements voided was the largest with group I,



ROLILDA 2ND—A FINE TYPE OF JERSEY COW SHOWING A WELL DEVELOPED UDDER

doubtless due to the cotton seed meal fed, being $45.67. It was smallest with group III, being $37.53, a difference of $8.14. This disparity was due to the substitution of cowpea hay for cotton seed meal, and might lead many to suppose that one could afford to use cotton seed meal under any circumstances in preference to cowpea hay on account of its increased fertilizing value. The cowpea has a wonderful capacity for improving the mechanical condition of the soil, as the fallen leaves, roots, etc., which are left on the ground will supply anywhere from 35 to 40 pounds of nitrogen per acre, which offsets if it does not clearly over-balance the added fertilizing value of the mineral constituents in the cotton seed meal. According to these results the total manurial value of the excrements voided would be $123.41; if only 60 per cent were saved, it would be $92.57. The fertilizing value of the foodstuffs is a material factor in determining the profit on feeding dairy cows, and should always be so considered.

Financial Statement Table X presents the financial side of the experiment when both high prices and low prices are considered. The cost of attendance was figured at $14.40 per group, and the animals were credited with 60 per cent of the value of the excrements voided. It is perfectly clear that the cost of the care and attention given a cow will be offset by the value of the manure where it is properly utilized.

On the basis of comparison shown, the net cost of a gallon of milk at high prices varied from 5.6 cents with group II to 8 cents with group III. *Here as elsewhere the cheapest gallon of milk was made by the combination of the two protein foods, cotton seed meal and cowpea hay.* The net cost of a pound of butter was also lowest with group II when high prices are considered, being 10.7 cents, and highest with group III, being 14.5

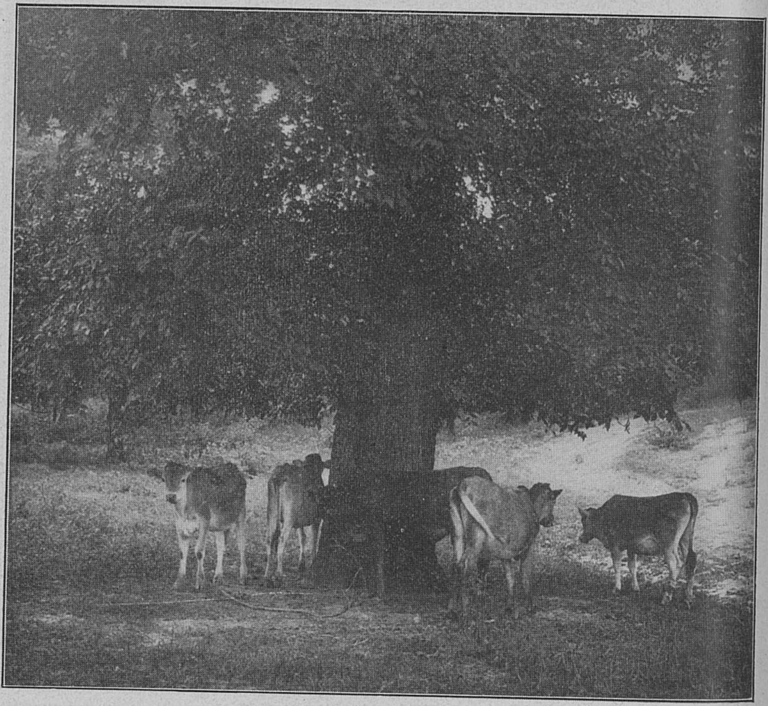
TABLE X—Financial Statement

Groups	COST OF FOOD		Attendance	Value of 60% of Manure Voided	Net Cost Gal. Milk at High Prices of Food	Net Cost lb Butter at High Prices of Food	Net Cost Gal. Milk at Low Prices of Food	Net Cost lb. Butter at Low Prices of Food
	High Prices	Low Prices						
I	$92.24	$63.84	$14.40	$34.25	6.7	13.8	4.0	8.4
II	67.95	48.52	14.40	30.16	5.6	10.7	3.5	6.7
III	81.52	51.04	14.40	28.16	8.0	14.5	4.4	7.9

cents. The combination of wheat bran and cowpea hay as a substitute for cotton seed meal was here unsatisfactory in every instance. On the other hand, when low prices for foodstuffs are considered, that is, where cowpea hay and silage are grown on the farm and fed at their farm value, the conditions with regard to groups I and III were reversed. Group II still stands first, however, making a gallon of milk at a net cost of 3.5 cents, and a pound of butter for 6.7 cents. Group I now comes second with the cost of a gallon of milk being 4 cents and a pound of butter 8.4 cents.

With regard to the cost of butter production the results are reversed, group III standing first with a cost of 7.9 *cents and group I last with a cost of* 8.4 *cents. The results throughout favor the combination of cowpea hay and cotton seed meal, two rich protein-containing foods, whether high prices or low prices are considered for milk and butter making. They indicate also that at low prices cowpea hay can be substituted for cotton seed meal with satisfactory results, whereas, this can not be done when high prices prevail. The results of the experiment indicate that it would be better for the farmer to purchase cotton seed meal at* $20.00 *to* $24.00 *per ton rather than buy wheat bran at prices ranging from* $16.00 *to* $26.00 *per ton.*

The figures presented in this table show that any one of the rations suggested may be fed with advantage and profit on the average farm in the south, and that the profit to be derived from the use of each will be influenced very considerably by the price of the foodstuffs, freight rates, distance from market, etc. The cheapness with which milk and butter can be produced is a subject for congratulation, for as milk ordinarily retails from 25 to 30 cents a gallon in the state, the farmer who uses a silo and feeds his cattle in a rational manner can certainly make a handsome profit over the cost of production, and the same is true of butter which retails at from 20 to 30 cents a pound, depending on its quality. There is a demand for much more 25 and 30 cents butter than is now available, and even at the high prices prevailing for foodstuffs the past year, the dairy-



UNDER THE SHELTERING OAK

man could have made a clear profit of from 10 to 15 cents a pound if he had good, average dairy cows in his herd. The dairy business can be made an unquestionable success in the middle south, as all the local conditions favor the development of giant enterprises of this character, but the business must be conducted intelligently and the greatest care exercised in the selection, breeding and management of the herd and also in the choice and combination of foodstuffs in order to secure the largest returns.

Profit or Loss Table XI gives a summary of the results showing the value of the milk and butter produced at high prices and at low prices.

It seems with such cows as were used in these tests that the profit on the milk at low prices for foodstuffs would have amounted in the case of group I to $201.95, and with group III to $157.78. In the case of butter the results were reversed, group II showing the greatest profit, $49.21, group III second with $42.22 and group I last. The profit on the butter would be greater because the skim milk would amount to very considerable, as it has been shown in experiments conducted on the station farm to be worth from 25 to 30 cents per 100 pounds for feeding to hogs and would also be valuable for the sustenance of calves intended for the dairy.

The profit at high prices for foodstuffs showed no material difference with regard to the relative standing of the groups so far as milk production

TABLE XI—Profit on Milk and Butter

Groups	Cost of Feed		Value of		Profit at High Prices on		Profit at Low Prices on	
	High Prices	Low Prices	Milk at 25c Gallon	Butter at 20c Pound	Milk	Butter	Milk	Butter
I	$92.24	$63.84	$265.79	$104.23	$173.55	$11.99	$201.95	$40.39
II	67.95	48.52	227.94	97.73	159.99	29.68	179.42	49.21
III	81.52	51.04	208.82	93.26	127.30	11.74	157.78	42.22

is concerned, except of course that the profit was considerably less. When butter is considered the results are strikingly different, and the ration most profitable was the one rich in protein, consisting of a combination of cotton seed meal with cowpea hay substituted for wheat bran. The profits on the butter with group II, few cotton seed meal and pea hay as substitutes for wheat bran, were $29.63; $11.74 with group III fed wheat bran and cowpea hay as a substitute for cotton seed meal; and $11.99 with group I fed on wheat bran and cotton seed meal. The profits on the butter with these two groups were thus about the same. *Pea hay has made a remarkably fine showing in these results and seems to be an excellent substitute for either wheat bran or cotton seed meal, though it can better supply the place of wheat bran than cotton seed meal. It is an exceedingly palatable substitute for bran and is greedily eaten by dairy cattle. As it can be produced cheaply and in abundance and improve the soil of the farm at the same time, the results are particularly gratifying to southern farmers as they can produce a home-grown ration of the highest excellence for dairy production.*

SUMMARY OF RESULTS

1 Only about one-half as much food is consumed in the production of a gallon of milk as is eaten to make a pound of butter.

2 The smallest amount of roughness consumed in the production of a pound of butter was 43.8 pounds with group III in which 13 pounds of pea hay was substituted for 4 pounds of cotton seed meal.

3 The highest amount of concentrates consumed was by group I, 9.2 pounds, or 3.2 pounds more than in group III and 5.3 pounds more than in group II. The substitution of pea hay for wheat bran in group II and for

cotton seed meal in group III thus resulted in materially reducing the consumption of the concentrates.

4 It seems clear that one and a quarter pounds of chopped pea hay can take the place of one pound of wheat bran, and about 3 pounds of chopped pea hay the place of 1 pound of cotton seed meal. The substitution of the pea hay for either of the concentrates mentioned must be made on the basis of the protein equivalent.

5 Some 2.5 tons of pea hay can be produced on an acre of average farm lands at a cost of $12.50. The farm price of the crop is about $7.00 per ton; the farm sale price would thus be about $17.50. Baled and placed on the market it would bring about $25.00.

6 The cost of a ton of bran at low prices is $16.00 or $1.50 less than the farm sale price of 2.5 tons of pea hay, though 2.5 tons of pea hay have twice the feeding value of wheat bran. It is certainly to the interest of the farmer to produce at least half of the protein needed for his cow through the medium of pea hay rather than by the purchase of wheat bran.

7 According to the yield of pea hay obtained at this station, it would require 1.2 acres of land to produce the protein equivalent contained in one ton of cotton seed meal. The cost of producing the hay would be about $16.00, its farm sale value would be about $21.00 and its market value some $30.00.

8 In addition, the pea crop would store in the soil some 40 pounds of atmospheric nitrogen worth $6.00, and as they would cost the farmer but $16.00, it would be better for him to grow and utilize the peas in place of cotton seed meal, unless he could buy it for $20.00 or less, though it would be to his interest to buy cotton seed meal at $20.00 to $24.00 a ton rather than wheat bran, as he would require to purchase some concentrate.

9 While the substitution of 7 pounds of pea hay for 6 pounds of wheat bran and 13 pounds of pea hay for 4 pounds of cotton seed meal on the basis of the protein equivalent was thus very satisfactory, it is evident that if it were desired to substitute pea hay for 6 or 8 pounds of cotton seed meal that it would be difficult if not impossible to get the cattle to consume all the pea hay satisfactorily.

10 The results indicate that at moderate prices and at even high prices for foodstuffs, pea hay can be substituted to advantage for wheat bran; that at high prices for cowpea hay and wheat bran, the latter would have the advantage; at low prices cowpea hay could be fed to advantage with bran as a substitute for cotton seed meal.

11 The net cost of a gallon of milk at high prices varied from 6.1 cents with group II to 8.9 cents with group III. Here as elsewhere the cheapest gallon of milk was made with a combination of the two protein foods—cotton seed meal and cowpea hay.

12 While cotton seed meal is the most highly concentrated foodstuff known and should be so completely utilized by the southern farmer that there would be none for sale beyond its borders, it frequently happens to be a great advantage to the farmer if he can utilize some protein-producing crop in its place, as the cowpea.

13 In round numbers the amount and ratio of meals consumed for the

production of a gallon of milk was as follows: Group I, 3 pounds of wheat bran and 2 pounds of cotton seed meal; Group II, 2.5 pounds of cotton seed meal and 4 pounds of pea hay; Group III, 4 pounds of wheat bran and 7 pounds of pea hay. The same ratio holds in the case of butter, though the amount of concentrates consumed was considerably more.

14 Providing the palatability and the digestibility of the foodstuffs used are equal, the source from which the protein is derived has but little effect if the substitution of one food for another is made on the basis of the protein equivalent.

15 The amount of dry matter consumed for the production of a gallon of milk was 6.2, 6.5 and 7.2 pounds with groups I, II and III respectively. The digestible matter consumed for a pound of butter was practically the same, being 12.7, 12.3 and 13.1 pounds with groups I, II and III.

16 All the rations fed were satisfactory in maintaining a good flow of milk, a high fat content and a high per cent of total solids.

17 Group II consumed the largest amount of protein for 1000 pounds of live weight and made the cheapest gallon of milk, 5.2 cents, and the cheapest pound of butter, 9.9 cents. Group III which consumed the smallest amount of dry matter produced a gallon of milk at a cost of 6 cents and a pound of butter at a cost of 10.9 cents. Group I produced a gallon of milk at a cost of 5.9 cents and a pound of butter at a cost of 12.2 cents.

18 As milk retails at from 25 to 30 cents a gallon and butter is in demand at 25 to 30 cents a pound, it is evident that the southern farmer who owns a herd of good cows can make large profits from the dairy business.