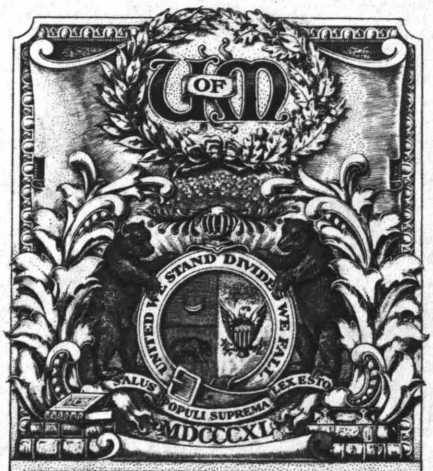

Approved by C. H. Eckles

THE EFFECT OF COTTON SEED MEAL UPON THE CHURNABILITY OF CREAM AND THE MARKET QUALITIES OF THE BUTTER

by

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INTRODUCTION.

Cotton seed meal, a by-product of the cotton industry, has become our cheapest concentrated food for dairy cows.

Armsby, in his work on feeding stuffs, gives the dry matter, digestible protein and energy values of cotton seed meal per hundred pounds as follows:-

Dry matter.	Digestible protein.	Energy value Therms.
91.8	35.15	84.20

Compare with this the values of wheat bran and oil meal, two of our most common feed stuffs.

	Dry matter.	Digestible protein.	Energy value.
Wheat bran	88.1	10.21	48.23
Oil meal	90.1	29.26	74.67

Cotton seed meal has slightly more dry matter per hundred pounds than wheat bran or oil meal; 71% more digestible protein, and 43% more energy value than bran; 17% more digestible protein and 12% more energy value than oil meal.

The prices of bran, cotton seed meal, and oil meal laid down in Columbia, Mo., in car load lots have averaged, for this winter 1911 - '12, for bran, $27.00 a ton, or $1.35 a hundred; for cotton seed meal, $30.00 a ton, or $1.50 a hundred; for oil meal, $40.00 a ton, or $2.00 a hundred.

The following computations show the comparative values of these feeds of one therm energy value and one pound digestible protein at the prices quoted above.

	Cost 100 lbs.	Energy value 100 lbs.	Cost of 1 therm energy value	Digestible Protein 100 lbs.	Cost of 1 lb. digestible protein
		Therms	Cents	Pounds	Cents
Wheat bran	1.35	48.23	2.79	10.21	13.22
Cotton S. M.	1.50	84.20	1.78	35.15	4.26
Oil meal	2.00	74.67	2.67	29.26	6.83

This shows us that cotton seed meal is considerably cheaper, for both energy value and protein, than oil meal or bran.

If the energy value of bran were sold at the same price per therm at which we buy cotton seed meal, it would cost us only 85 cents a hundred or $17.16 a ton as compared with $27.00, its present price. If we are bought energy value in cotton seed meal at the rate we are paying for it in bran, it would cost us $2.34 per hundred pounds or $46.98 per ton. Again, if we purchased bran for its protein value at the rate protein costs us in cotton seed meal, our bran would cost us only 53 cents a hundred, or $10.68 a ton. Cotton seed meal

purchased for its protein value at the rate we pay for protein in bran would cost $4.64 a hundred or $92.92 per ton.

In the same way it may be shown that the energy value of oil meal purchased at the cotton seed meal rate, would cost $1.32 a hundred or $26.58 a ton instead of $40.00 a ton. Or, its protein value, at the cotton seed meal rate would be $1.24 per hundred pounds of feed or $24.92 per ton. A mixture of corn meal and cotton seed meal is the cheapest grain ration, at the present time, that the farmer can feed the dairy cow. Many people, however, feel afraid to feed cotton seed meal for fear of injuring the quality of their products. It has long been a prevailing opinion that cotton seed meal has a detrimental effect on dairy products, especially butter. Butter in the South is usually of very poor quality, and a good deal of the cause of it has been attributed to the general use of cotton seed meal as a dairy food.

Butter from a cotton seed meal ration is said to have a harder, firmer body and does not melt at as low a temperature as butter produced from a ration without this feed. Some investigators have found that butter made from a cotton seed meal ration has a tallowy, salvy taste, is lighter in color, and the cream is more difficult to churn. Other investigators report the quality of the butter not injured by feeding cotton seed meal. Some of the experiments show the constants of the fat to be marked-

ly influenced by this ration while other experiments show that the same constituents are either not influenced at all or else influenced in the opposite direction by the use of this feed.

A large per cent of the cotton seed meal produced in this country is fed in the dairy countries of Europe. In many of the leading dairy states of the United States cotton seed meal is almost an unknown feed. The economy of using cotton seed meal in place of some of our more commonly used feeds has already been pointed out. Then why is cotton seed meal not more generally used in this country, where it is produced, when it is so universally used among the dairy men of Europe? One of the reasons has been given, namely, the fear of injuring the quality of the product. Another reason is the fear of injuring the health of the animal. While it is not the purpose of this paper to take up this side of the question, cotton seed meal is probably not injurious to the health of animals when not fed in excessive amounts. One Jersey cow has just completed a year's record at this station, in hwich she received six pounds of cotton seed meal per day with no apparent injury to her health. In the South it is not an uncommon thing for dairy men to feed their cows from 8 to 10 pounds of cotton seed meal a day, and their animals suffer no ill effects.

However, from an economical standpoint, it is seldom wise to use so much of this highly nitrogenous feed, especially where it is possible to secure corn.

Obviously these are the two principal reasons why cotton seed meal has not found a wider use as a dairy feed in this country. Though from the view point of economy it seems that it should be one of our most commonly used feeds, As stated previously the results of the investigations already carried out along the line of the effect of this feed upon butter have been marked by a lack of uniformity of results. In view of this it seems desirable to conduct this experiment with the object of ascertaining the effect of cotton seed meal on the churnability of cream and its influence upon the market qualities of butter.

LITERATURE.

Effect of cotton seed meal in the ration on the constants of butter fat.

Lindsey,[1] of the Massachusetts station, has carried on some extensive experiments with different feeds and oils in regard to their effects upon butter fat. He found that cotton seed meal with a minimum oil content of eight per cent, produced little change in the composition of butter fat. But the addition of .5 of a pound of cotton seed oil, daily, to the ration increased the melting point and the iodine number. He found that a rise in the iodine absorption (increase in olein) is a reasonably sure indication of a soft bodied butter, which will lack in firmness at a temperature of 70° F. A high melting point is not a sure indication of a hard, firm butter. It seems that the proportions of the several fats are more or less changed by an excess of oil in the feed and that this change varies the melting point.

Harrington,[2] of the Texas station fed four cows varying amounts of cotton seed meal with the following results: A marked increase in the saponification equivalent, an increase in iodine absorption, a very large decrease in the per cent of volatile acids, and

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(1) Annual Report Massachusetts Exper. Sta. 1907.

(2) Annual Report Texas Exper. Sta. 1891.

an increase in the melting point of 8° C. Harrington calls attention to the fact that a pure butter derived from a cotton seed meal ration might be mistaken for a butter adulterated with other fats, if judgment is based upon the common assumption that a natural butter may be safely distinguished from oleomargerine by estimating the volatile acids present. The amount of these acids is ordinarily much higher in pure butter than in the fats used in the manufacture of oleomargerine.

Doctor Wiley,(1) of the United States Department of Agriculture tested some samples for Harrington and found that the per cent of volatile acids were raised and also the iodine absorption number. Later in an experiment at the Maryland Station Doctor Wiley found the iodine number and the volatile acids both decreased.

At the New Hampshire Station,(2) F. W. Morse carried on several experiments with cotton seed meal, and cotton seed oil. With a grain ration of seven pounds of cotton seed meal and two and one fourth pounds middlings, he lowered the Reichert Meissl number and the iodine absorption number. Morse concludes that a low Reichert Meissl number means a low flavored butter and a decrease in the iodine absorption number means a

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(1) Proc. Soc. Prom. Agl. Sci., 1889.

(2) Annual Report New Hampshire Station, 1892.

harder butter. Morse fed eleven ounces of cotton seed oil daily and lowered the Reichert Meissl number and raised the iodine absorption number. Both the meal and the oil lowered the Reichert Meissl number but the oil raised the iodine absorption number and the meal lowered it.

The Mississippi[1] Station reports that crude cotton seed oil has a quantity of so-called vegetable stearin which is separated from the refined oil in the process of refining. The fatty acids of this vegetable stearin have a high melting point and its general character is not unlike that of other oils that have been found to produce a hard butter.

In experiments by Jordan[2] at the Maine Station in 1891, the butter produced on a ration of cotton seed meal, bran, and corn meal was harder; contained a larger amount of volatile acids, and showed a higher iodine number than that produced on a ration of linseed meal, bran, and corn meal, or of pea and barley meal; but in experiments in 1893, in which a ration of 2 pounds of corn meal, 2 pounds of cotton seed meal, and two pounds of gluten meal was compared with one of 6 pounds of corn meal, there was no difference in the butters shown by chemical tests.

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(1) Farmers Bulletin, United States Dept. Agr., 119 .

(2) Annual Rpt. Maine Exper. Station, 1891.

The Alabama Station[1] in experiments with ten cows found the melting point uniformly raised and the Reichert Meissl number lowered.

The Ontario Station[2] observed a marked increase in both the melting point and the iodine absorption number, by feeding cotton seed meal.

In several experiments at the Missouri Station (not in print), the saponification number was lowered, the iodine absorption number uniformly raised, and the Reichert Meissl number in most cases lowered. The melting point was raised.

In summing up the experiments on the effect of cotton seed meal on the constants of butter fat a lack of uniformity in results is evident.

Lindsey got but little change in the composition of fat with cotton seed meal, while all the other investigators got marked changes.

Most of the results show a decrease in volatile acids, from both the meal and the oil. Also an increase in the melting point, although it would seem that cotton seed, having a large per cent of olein which is liquid at ordinary temperatures, would decrease the melting point of butter. But the opposite seems to be true.

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(1) Bul. # 25, Alabama Station.

(2) Annual Rpt. Ontario Agricultural College, 1891.

Morse and Wiley get a lower iodine number. Harrington[1], the Maine Station, the Ontario Station, and the Missouri Station (not in print) report the iodine number raised. As stated before Morse and Lindsey think an increase in the iodine number an indication of a soft bodied butter while the Missouri Station takes the view that a high iodine number does not necessarily mean a soft butter. The Texas Station[2] got an increase in the saponification equivalent while the Missouri Station got a decrease.

It has been the general opinion that the oil in the cotton seed meal is in some way responsible for the firmer body of the butter from that feed. Morse and Lindsey fed cotton seed oil and got a soft bodied butter. A table follows showing the results of some of these experiments.

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(2) Bulletin # 39, Texas Station.

TABLE 1.

Effects of Cotton-Seed products on Butter.

Ration	No. of Cows.	Days on Feed before sampling	Melting point (°C.)	Reichart Meissl No.	Iodine No.
ALABAMA STATION (1)					
5# Oats, 5# Corn, 5# Bran	10	7	35.6	29.8	
3# Cotton Seed Meal, 4# Oats, 5# Bran, 11# Silage	10	7	36.1	30.5	
4# Cotton Seed Meal, 9# Cotton Seed Hulls, 4½# silage	10	7	37.4	27.5	
Raw Cotton Seed and Cotton Seed Hulls	10	7	43.6	22.1	
Cooked Cotton Seed and Cotton Seed Hulls	10	7	42.7	22.5	
NEW HAMPSHIRE STATION (2)					
40# Silage, 5½# Hay, 2.05# each of middlings, corn meal, cotton seed meal, and gluten meal	4			29.9	38.8
40# Silage, 5½# Hay, 2.05# middlings, 7.25# cotton seed meal	4	19		24.9	34
40# Silage, 5½# Hay, 2.05# middlings, 6.25# raw cotton seed	4	20		20.3	33.8
40# Silage, 5½# Hay, 205# middlings, 3.5# gluten meal, 13.5 oz. cotton seed oil	1			19.7	37.8

TABLE 1-, Cont.

Ration	No. of Cows	Days on Feed before sampling	Melting Point (°C.)	Reichart Meissl No.	Iodine No.
ONTARIO STATION (3)					
Pasture	2	21	32.3		24.4
30# hay, 9# linseed meal,	2	21	32.3		37
20# hay, 4# linseed meal 5# cotton seed meal	2	21	34.6		—
30# hay, 9# cotton seed meal	2	21	36.5		35
TEXAS STATION (4)					
Corn & cob meal, oats, bran, silage, sorghum, pea vine hay, & pasture	6	8	35	28.82	
Cotton seed hulls and Cotton seed meal	6	8	40.8	20.3	
Raw or Cooked whole cotton seed	6	8	40.4	15.7	
1 Part Cotton Seed Meal, 3 Parts Oats, Sorghum Hay, and Scant Pasture	6	8	37.3	26.28	
Equal Parts cooked cotton seed and Oats, scant pasture	6	8	36.6	26.78	
Corn Meal Wheat Bran, and Silage	4	{33 {16	33.2	26.9	30.22
$\frac{1}{4}$ Ration Cotton Seed Meal	4	25	36.5	23.72	32.38

TABLE 1—Cont.

Ration	No. of Cows.	Days on Feed before sampling	Melting Point (°C.)	Reichart Meissl No.	Iodine No.
½ Ration Cotton Seed Meal — — —	4	17 14	39.1	20.65	33.04
¾ Ration Cotton Seed Meal — — —	4	16 14	40.6	16.24	35.39
Cotton Seed Hulls and Cotton Seed Meal —	2	17	41.4	12.15	42.34
WILEY'S RESULTS (4) Pasturage — — — —	3	10	35.4	22.4	38.9
10# Cotton Seed Meal Per Day, and Light Pasture — —	3	10	41.9	21.1	34.7

(1) Bulletin #25, Alabama Station
(2) Bulletin #16, New Hampshire Station.
(3) Annual Report, Ontario Agr. College, 1891.
(4) Annual Report, Texas Station, 1889, Bulletins 11 & 29.
(5) Proc. Soc. Prom. Agl. Sci., 1889.

Effect of Cotton seed meal in the ration on the churnability of cream.

Curtis[1] at the Texas Station has done more work than any one else on the churnability of cream from a cotton seed meal ration.

Curtis made six churning tests on cream from cows fed exclusively on cotton seed or cotton seed meal. The temperature at starting was 68° to 70° F. and at closing 74° to 76° F. An average time of one hour and fifty six minutes was required to bring butter in granules the size of quail shot. With cream from the same cows on the same ration, three churnings were made with temperature at starting, 73° to 78° F., and at closing, 75° to 80° F. Butter was obtained in the average time of thirty three minutes. With cows fed a ration made up largely but not entirely of cotton seed meal, two tests were made with the temperature of the cream at starting, 64° F. and closing at 68° F. The average time of the churnings was one hour and eighteen minutes. Six tests were made with cream produced on this ration with temperature at starting 68° to 71° F. and at closing 70° to 75° F. The average time was thirty eight minutes. Curtis concludes that where cotton seed meal is used largely in the ration a temperature of four to eight degrees higher is required than for cream pro-

(1) Bulletin # 11, Texas Station.

duced on rations without this feed. Mayer[1] found milk from cotton seed cake rations to be harder to churn than from peanut, linseed or poppy seed cake rations.

Effects of cotton seed meal in the ration on butter.

As stated before, it is generally believed that where cotton seed meal is used to any extent in the ration the butter will have a harder, firmer body and a higher melting point. The butter is likely to be lighter in color, lacking in salt, and poor in quality.

Lindsey[2] of the Massachusetts Station, found that cotton seed meal with a high oil per centage (12.6%) produced a butter that was rather crumbly when hard, and slightly salvy to the taste. Cotton seed meal with a low per cent of oil (8%) likewise produced a hard, firm butter. The addition of a half pound of cotton seed oil a head, daily, to a ration containing three pounds of cotton seed meal low in oil, produced a softer, more yielding butter than that produced by the ration with the oil omitted.

Hunt[3], at the Pennsylvania Station, made butter from fat produced by two lots of cows. One lot was fed four pounds of corn chop and six pounds of bran, and the

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(1) Landw. Vers. Stat., 41 (1893).

(2) Annual Rpt. Mass. Exper. Sta., 1907.

(3) Bulletin # 13, Pennsylvania Station.

other lot received four pounds of corn chop and six pounds of cotton seed meal. Both lots received the same amounts of ensilage, green rye, or timothy and clover, and as much corn stover as they would eat.

The butter made from the cotton seed meal ration was rated appreciably lower than the bran butter by the New York Commission men. The average score of the bran butter was 91, and the cotton seed butter 72. The cotton seed butter was scored on both body and flavor. Hunt observes that cotton seed butter seems to require more salt than butter produced from rations with other grains.

At the Mississippi[1] Station the herd was fed on the following ration: ten pounds cow pea hay, twenty pounds silage, four pounds bran, and five pounds of cotton seed meal. This ration was fed for two weeks, when six pounds of cotton seed was substituted for the five pounds of cotton seed meal, and in two weeks following six pounds of corn and cob meal was substituted for the cotton seed. The milk of the last two days of each period was separated, churned, and the butter shipped to St. Louis Commission firms to be scored. The cotton seed meal butter scored 95½, the cotton seed butter, 96, and the corn and cob butter, 96. The conclusion is drawn that the quality of butter is not injured by feeding as much as five pounds of cotton seed meal or six pounds of cotton seed.

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(1) Farmers Bulletin # 119, U. S. Department of Agriculture.

Vanderford, of the Tennessee Station, says: "We do not consider it advisable to feed more tan five pounds of cotton seed meal daily to milch cows. For butter making it is not advisable to exceed three pounds daily".

Curtis[1], at the Texas Station has probably done more work on the effect of the cotton seed feeds on butter than any other investigator. It is his opinion that the cotton seed feeds have a more detrimental effect on the quality of the butter when fed with a dry ration than when fed with grass or other green stuff. To illustrate this he fed one group of cows bran, corn meal, and linseed meal and the cows had access to pasture. To a second group he fed bran, corn meal, and four pounds of cotton seed meal, and the cows had access to pasture. Five samples of the butter made from group one received an average score of 87. Five samples of butter from group two, receiving four pounds of cotton seed meal daily, received an average score of 85.7, being graded off slightly in flavor.

To get the effect of the same amount of cotton seed meal on the butter, when fed on a dry ration, he fed one group of cows eleven pounds of oats and four pounds of cotton seed meal and cows ran on dry pasture. The average score of three samples of butter from this ration was 75.8. The amount of cotton seed meal fed in this ration was the

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(1) Bulletin # 11, Texas Station.

same as that fed with the cows on grass, but the score is about ten points lower, the texture and flavor suffering most. Curtis says this bears out their practical experience at the station, they finding it necessary to decrease the amount of cotton seed meal fed in the winter and dry part of the summer.

The effect of the meal on the texture of the butter is that of overworking. Curtis says that the cotton seed butter sent to commission firms in the North was reported as "over worked" when in fact it was hardly worked at all, not nearly so much as butter produced without cotton seed meal in the ration, and which received a great deal better score on texture.

The Alabama (1) Station reports that feeding cotton seed meal to cows on pasture increases the melting point from 1° to 3°, Centigrade, and that three pounds of cotton seed meal and one pound of bran gave as hard a butter as eight pounds of cotton seed meal and one pound of bran.

The results of these experiments vary a great deal, The most marked difference being in the amount of cotton seed meal that may be fed without injuring the quality of the butter. The Mississippi Station says five pounds of cotton seed meal may be fed without injuring the quality of the butter. The Texas Station finds that four pounds injures the quality, if fed in a dry ration. At the Pennsylvania Station the quality of butterwas injured with

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(1) Bulletin # 25, Alabama Station.

six pounds of cotton seed meal, with which cows got some green feed. The Tennessee Station does not advise the use of over three pounds of cotton seed meal daily where butter is to be made.

The results of these experiments vary so, and the conditions under which they were worked out are so unlike, that it is impossible to ascertain what the effects on the churnability of cream and quality of the butter from feeding cotton seed meal really are. As to what the effect on the quality is, salvy, over worked texture, firmer body, etc., the results agree fairly well, but as to how much can be fed and under what conditions without getting these effects, cannot be told from the varying results. No two of these experiments were carried out in the same way. Temperature, acidity or the other factors that might influence the quality or churnability were apparently not uniformly controlled by many of the investigators. At least they are not mentioned in the reports of the experiments. Only one experiment has been made on churnability and that on rather an abnormal ration, containing either all cotton seed meal and hulls or a ration made up largely of cotton seed meal. In the chemical work there seems to be no agreement as to the influence of cotton seed meal in the ration upon the physical and chemical constants of the fat, or what these variations mean in their relation to the market qualities of butter.

For instance, one investigator thinks a rise in the iodine absorption number may go with a harder butter, while another thinks an increase in the iodine absorption number always indicates a softer bodied butter.

THE PLAN OF THE EXPERIMENT.

Object.

The two main objects in view in planning these tests are:

(1) The effect of cotton seed meal upon the churnability of cream.

(2) Influence of the same ration upon the market qualities of the butter.

Time for making Experiments--- It is planned to carry these tests on during the fall and winter season when silage is on hand and when butter can be shipped readily without injury from the heat. This season is more favorable also on account of keeping the animals in better condition. It will also be necessary to make a few tests during the pasturing season in order that the influence of feeding cotton seed under these conditions can be obtained.

General Plan--- The general plan is to feed a certain number of cows on a basil ration and compare the product with that of a second lot fed varying amounts of cotton seed meal. It is proposed to carry on two distinct series of tests using different basil rations in this way.

Animals Used--- The animals to be used will be selected at the time. They should represent at least two breeds and preferably three or four, and the animals should be mature cows. A sufficient number will be selected to produce from 12 to 15 pounds of butter per day.

Feeding--- The basil ration to be used will be the one heretofore used largely, namely, corn silage, alfalfa hay, and a grain mixture of corn 4 parts, bran 2 parts, and linseed meal 1 part. In using this basil ration the cotton seed meal will be substituted pound for pound for the grain. The amount of cotton seed meal to be fed will be from two to six pounds a day. The experiment will have five parts as illustrated in the diagram of which two will be basil ration and three will contain cotton seed meal in varying amounts.

The amount of each ration to be fed each individual animal used will be determined by calculating the amount required for maintenance plus the amount estimated as necessary for supplying the nutrients for milk production after the standard as proposed by Armsby.

Plans for Handling the Milk--- The samples used for the churning and for making the butter for examination are to be taken during the last three days of each period only, making two churning tests and two lots of butter for examination, from each group of animals. The milk produced by the two groups of animals used in this experiment will be kept separate in cans suitably labeled and brought with the other milk to the creamery room. The milk produced during one day is to be taken with that of the following morning and the analysis and tests made from this mixture. The morning milk is to be separated and the cream cooled to a temperature of 50 degrees or

lower, the night's milk likewise. In the morning the cream from the morning and evening are to be mixed with that from the morning's milk.

Plan for Determining the Churnability of the Cream---- A portion of the cream equal to about 600 c.c. secured in the above manner representing the morning and evening is to be used for this purpose. Five per cent of pure culture acid starter is to be added at once after the evening milk is separated, the cream then reduced by the addition of skim milk until it shows exactly 25% of fat. With the exception of the substitution of natural ripening for the addition of lactic acid the method to be followed will be the same as that used in our previous experiments, details of which are to be found in Mr. Rinkle's Thesis. The cream is to be kept at 70 degrees until morning, then cooled until afternoon and churned. It must be handled in the same way each time. The butter secured in making these churnings tests is to be taken as soon as the churning is completed and delivered to the Chemical Laboratory with proper labels.

Chemical Analyses--- The chemical work to be done with these samples is to include the Iodine, Saponification, and Reichert Meissl Numbers, the Melting Point, and the color measurements, and the hardness test.

Relation to the Market Value of the Butter.

The cream from the morning milk is to be secured in the manner previously described and added to the cream of the previous day. Five % pure culture acid starters

are to be added and the cream ripened at a temperature of 70° until an acidity o f .6% is developed. The churning should in every case be done at the end of 24 hours, the cream having been cooled down the previous evening to the churning temperature. The churning temperature to be used will be the same in all cases unless the results as found are such that it is necessary to make some change. This churning temperature will be the same as that employed in the general creamery work, 56° F. Sufficient color is to be used to make the color normal. Each lot of cream is to be churned until the butter granules are slightly larger than grains of wheat. The time of churning, the per cent of fat in the cream in the beginning, the per cent of fat remaining in the butter milk are to be recorded. The two lots of butter are to be completed in the ordinary manner and packed in ten pound tubs, and reserved for our examination. This examination should include such points as are usually taken into account in scoring butter, and such other observations as may be made including the test for hardness. The ten pound tub o f butter is to be sent to Professor M. Mortenson, of the Iowa State College, who is capable of rendering expert judgment and will be asked to give his opinion concerning it without knowing the nature of the experiment.

The "standing up" quality of each lot is to be determined under carefully controlled temperature conditions.

The keeping qualities are to be tested at the temperature of the cooling room and ordinary room temperature.

Arrangement of Experimental Periods.

Period 1 8 days.	Period 2 13 days.	Period 3 13 days.	Period 4 13 days.	Period 5 15 days.
Lot 1 & 2	Lot 2 2#C.S.M.	Lot 2 4#C.S.M.	Lot 2 6#C.S.M.	Lots 1 & 2
Basil Ration	Lot 1 Basil Ration	Lot 1 Basil Ration	Lot 1 Basil Ration	Basil Ration

The experiment was divided into five periods as shown in the diagam. During the first period both cows received the same basil ration, the constituents of which are stated in the plan. Lot 1 received the same ration during the whole experiment. During period 2, 2 pounds of the grain mixture, in the basil ration fed to lot 2, was replaced with 2 pounds of cotton seed meal; in period 3, 4 pounds of the grain mixture was replaced by 4 pounds of cotton seed meal, and during period 4, 6 pounds of the grain mixture was replaced by 6 pounds of cotton seed meal. In period 5, lot 2 was put back on the same basil ration they received during period 1. Lot 2 received the same roughness, alfalfa and corn silage, as lot 1 received thruout the experiment.

TABLE 2.

The Cows Used for the Experiment.

Lot 1.

No. Cow	Breed	Age. (Years)	Period of Lactation (days)	Average Amt. of Milk per Day during Exp. (POUNDS)
124	Jersey	14½	22	34
14	"	3	86	14
11	"	3½	228	10
211	Holstein	7	108	34
223	"	3½	156	32
227	"	3	82	22
217	"	5	72	30
Average		5½	108	25

* This group produced about 6½ pounds of fat per day.

Lot 2.

No. Cow	Breed	Age (years)	Period of Lactation (days)	Average Amt. of Milk for a day during Exp. (POUNDS)
317	Jersey	14½	290	23
301	Ayrshire	9	187	26
403	Shorthorn	10	119	28
406	"	2½	99	14
57	Jersey	5	101	14
16	"	12½	83	28
53	"	5½	33	22
215	Holstein	4½	119	23
Average		8	129	22

*This group produced about 7½ pounds of fat per day.

TABLE III.

Average Ration Feed. Lot 1

No. COW	FEED	PERIOD 1 (POUNDS)	PERIOD 2 (POUNDS)	PERIOD 3 (POUNDS)	PERIOD 4 (POUNDS)	PERIOD 5 (POUNDS)
211	Silage	44	44	42	42	42
	Alfalfa	11	11	11	11	11
	Grain	11	11	11	11	11
11	Silage	30	30	30	25	25
	Alfalfa	7	7	7	7	7
	Grain	3	3	3	3	3
14	Silage	30	30	30	30	30
	Alfalfa	7	7	7	7	7
	Grain	4	4	4	4	4
124	Silage	35	35	35	35	35
	Alfalfa	11	11	11	11	11
	Grain	11	11	11	11	11
223	Silage	35	35	35	35	35
	Alfalfa	10	10	10	10	10
	Grain	10	11	11	11	11
227	Silage	30	30	30	26	26
	Alfalfa	9	9	9	9	9
	Grain	6	6	6	6	6
217	Silage	35	35	35	35	35
	Alfalfa	11	11	11	11	11
	Grain	9	9	9	9	9

TABLE 4

Average Ration Fed. Lot 2.

No. of COW	FEED	PERIOD 1 (pounds)	PERIOD 2 (pounds)	PERIOD 3 (pounds)	PERIOD 4 (pounds)	PERIOD 5 (pounds)
406	Silage	35	25	25	25	25
	Alfalfa	7	6	6	6	6
	Grain	3	4	2		6
	Cotton Seed Meal		2	4	6	
403	Silage	40	40	40	40	40
	Alfalfa	10	10	10	10	10
	Grain	9	7	5	3	9
	Cotton Seed Meal		2	4	6	
57	Silage	30	25	25	25	25
	Alfalfa	7	6	6	6	6
	Grain	4	5	3	1	7
	Cotton Seed Meal		2	4	6	
317	Silage	30	30	36	36	36
	Alfalfa	9	9	9	9	9
	Grain	8	6	4	2	8
	Cotton Seed Meal		2	4	6	
301	Silage	30	31	31	31	31
	Alfalfa	9	9	9	9	9
	Grain	9	7	5	3	9
	Cotton Seed Meal		2	4	6	
53	Silage	35	35	35	35	35
	Alfalfa	8	8	8	8	8
	Grain	8	6	4	2	8
	Cotton Seed Meal		2	4	6	
16	Silage	30	30	30	30	30
	Alfalfa	9	9	9	9	9
	Grain	10	8	6	4	10
	Cotton Seed Meal		2	4	6	
215	Silage	35	33	33	33	33
	Alfalfa	7	7	7	7	7
	Grain	7	5	3	1	7
	Cotton Seed Meal		2	4	6	

Table 3 gives the average ration fed each animal in lot 1, in each period. The ration for each animal was computed by the Armsby feeding standard. The amount fed each cow varying with the body weight and the flow of milk. The animals in lot 1 received the same ration and practically the same amount of feed thruout the experiment. The grain ration was composed of corn 4 parts, bran 2 parts, and oil meal 1 part.

Table 4 gives the average ration fed each animal in lot 2, in each period. In period 1, the cows in this group received the same ration as lot 1; in period 2, 2 pounds of cotton seed meal was substituted for 2 pounds of grain mixture, in period 3, 4 pounds of cotton seed meal was substituted for 4 pounds of the grain mixture, and in period 4, 6 pounds of cotton seed meal was substituted for 6 pounds of the grain mixture. In period 5, lot 2 was taken off cotton seed meal and received the same ration as in period 1. None of the cows in this group suffered any ill effects from the consumption of cotton seed meal.

Churnability of the Cream.

In order to get an accurate comparison of the churnability of the cream from the two lots an experimental churn was used, which was devised for this purpose by Professor Eckles, and used by Mr. Rinkle in his thesis work. This churn consisted of an ordinary steel hand barrel churn. On either side of the inside of this churn, half way between the top and the bottom, was attached a bracket. Two specimen jars fitted into these brackets and fastened so that they were stationary. 300 c.c. of 25% cream was placed in each jar at a temperature of 64° F. The churn was then filled with water at the same temperature. In this way the jars containing the cream were surrounded with water and there was little change in the temperature of the cream during the churning. By placing the same amount of cream in the jars for each lot, the jars were filled to the same fullness and the same amount of agitation was secured, giving a more accurate comparison than if the comparison was made with the large churnings. In the large churnings one lot usually contained more cream than the other, which filled the churn to a greater fullness and consequently the cream in that lot would receive less agitation. This churn was attached to a small motor which kept the churn revolving at a uniform speed. A record of the number of revolutions of each churning was kept. As stated in the plan of the experiment the cream churned in the experimental churn was taken from the mixed

milk of each group representing one day. The cream was standardized to 25% and the samples of both lots ripened at the same temperature and for the same length of time. Two different churnings for each lot in each period, representing three milkings, were made, and the figures given in the table are averages of these two churnings. The time taken for each of the large churnings was also recorded and is given in the table below. These figures also represent the average of two churnings as do all the other determinations presented, excepting the scores on flavor and body, in this paper. No attempt is made to compare the churnability of the small churnings with the large churnings as the small churnings take somewhat longer. All that is attempted is an accurate comparison of the churnability of the cream in lot 2 with that in lot 1, and the opportunity is presented in the two methods of churning.

TABLE IV

	Large Churning (barrel)		Experimental Churn	
	Lot 1	Lot 2	Lot 1	Lot 2
	(minutes)	(minutes)	(revolutions)	(revolutions)
Period 1	39	45.5	1850	1855
Period 2	44.5	53.5	2388	2701
Period 3	67.5	81.9	2392.5	3085.2
Period 4	38.5	80	1850	2549
Period 5	61	46	2200	1868.5

There is a very noticeable difference in the difficulty with which the cream from lot 1 and lot 2 is churned. Both methods of churning show this quite distinctly. The greatest difficulty in churning in both lots was in period 3, when the cows in lot 2 were receiving four pounds of cotton seed meal per day. In lot 2 there is a uniform increase in the difficulty in churning, up to period 3, both in time and the number of revolutions. In period 4, with 6 pounds of cotton seed meal, there is a decrease in the time of the large churning of almost 2 minutes and a decrease of 536 revolutions with the experimental churn. In period 5 the time of the large churning dropped 34 minutes, and the number of revolutions of the experimental churn dropped 681.5 revolutions, returning to almost the same time and number of revolutions as were required in period 1.

In lot 1 the time and number of revolutions required for churning varied considerably. There was a gradual increase in the time and number of revolutions up to period 3. In period 4 the length of time and the number of revolutions returned to the same level as in period 1, but in period 5 there was a decided increase again.

The greatest difference in the time and number of revolutions required for churning in the two lots was in period 4, when lot 2 was receiving 6 pounds of cotton seed meal per day. In this period lot 2 required 37.5 minutes longer and 699 more revolutions than did lot 1, to complete the churning.

While this experiment shows an increased difficulty in the churning of cream, produced from a ration in which cotton seed meal was used, it does not show the marked results obtained by Curtis, at the Texas Station. However Curtis fed rather an abnormal ration.. Part of his experiments were conducted on a ration made up entirely of cotton seed meal or cotton seed, and part of them on a ration made up largely, but not entirely, of cotton seed meal. The average time required for churning on the latter ration at 64° F. was one hour and eighteen minutes while the time required for the large churning in this experiment, to which his results are comparable, in periods 3 and 4, was one hour and twenty two and one hour and twenty minutes, respectively. However these churnings were made at a temperature of 56° F., 8° F. lower than the temperature at which Curtis made his churning. This would make a large difference in the time required for the churning.

The per cent of fat left in the buttermilk from both lots was very low and the per cent of fat in the buttermilk from the cotton seed meal ration averaged as low as that in the buttermilk from the basil ration, showing that the cream from the cows receiving the cottin seed meal churned as exhaustively as that from the cows receiving the ration without this feed.

Flavor of Butter or Market Qualities.

In the first period, when both lots of cows were on a basil ration, there was no noticeable difference in the flavor or body of the butter from the two lots.

In the second period, when lot 2 received 2 # cotton seed meal per day, there was no difference in flavor or body of butter that could be traced to the influence of cotton seed meal in the ration. All the butter was mottled some, and slightly underworked, causing the butter to be rather short in grain and crumbly. All the butter had a fairly good flavor excepting the first churning of lot 1, which was a little off.

The butter made in this period was given the following scores on flavor and body, by Professor Eckles and Mr. Rinkle.

	First Churning		Second Churning	
	Lot 1	Lot 2	Lot 1	Lot 2
Flavor	39	41	41½	41
Body	24	23	23	23

In period 3 when lot 2 received 4 pounds of cotton seed meal per day, there was a very noticeable difference both in flavor and in body, between the butter produced by the cows receiving the basil ration and those receiving the cotton seed meal.

The body of the cotton seed butter seemed much firmer, it also seemed more brittle than the butter from lot 1. And though brittle, it was also sticky, adhering to the metal trier. When placed in the mouth the cotton seed meal butter was very slow to melt. The melting point, seeming ly, being almost as high as that of the mouth. In flavor the cotton seed butter had a peculiar flat, greasy taste, with a suggestion of lard. The flavor of this butter was not especially objectionable but when placed in the mouth lacked the quick characteristic butter flavor which the butter from lot 1 had. The cotton seed butter also seemed to lack salt.

This butter was scored by Professor Eckles and Mr. Rinkle as follows:

	First Churning.		Second Churning.	
	Lot 1	Lot 2	Lot 1	Lot 2
Flavor	41½	40	41½	40
Body	23½	23	24	23

It will be noticed that in the first churning the butter from lot 2 received the highest score in flavor, while in the second churning the butter from lot 1 received a slightly higher score, so that there was really no marked difference in the flavor of the butter from the two lots. The butter from lot 1 in the first churning received a score of 1 point higher than that received by the other three samples.

Both the flavor and the body of the butter from lot 1 were scored slightly higher than that from lot 2, by Professor Eckles and Mr. Rinkle.

This butter was shipped to Professor M. Mortenson, of the Iowa State College, to be scored. It was thought desirable to get the opinion of an expert on this butter, who was unfamiliar with the experiment or the conditions under which the butter was made. Unfortunately the butter produced by the cows on the basil ration developed an oily flavor beforebeing examined by Professor Mortenson.

Professor Mortenson scored the butter from this period as follows:

	First Churning		Second Churning	
	Lot 1	Lot 2	Lot 1	Lot 2
Flavor	38	37	37	39.5
Body	25	25	25	25

It will be noticed that the butter from lot 2, of the second churning received the highest score of the four samples on flavor. This is probably due to the oily flavor, spoken of above, developing in the butter from lot 1. The body of the butter of all four samples was pronounced perfect in body. The peculiar flat, lardy taste attributed to the cotton seed meal, by Professor Eckles and Mr. Rinkle, was characterized by Professor Mortenson as an unclean or metallic flavor, which he thoughtmight be due to some method of pastuer-

ization, showing that he detected a peculiar flavor in the butter from the lot receiving cotton seed meal, but was mistaken as to its cause, as none of the cream in this experiment was pasteurized at all. In Another reason that might be advanced, for the cotton seed meal butter receiving a higher score than the butter from the basil ration, is that it is very probable that the peculiar cotton seed meal flavor described above tends to moderate somewhat with age.

During period 4, lot 2 received 6 pounds of cotton seed meal a day.

Practically the same differences in the butter produced by lot 1 and lot 2 occured in this period as were described in period 3. The characteristics attributed to the cotton seed meal butter in period 3, seemed even more noticeable in this period.

The butter seemed more firm, brittle, and sticky than when the cows were receiving 4 pounds of cotton seed meal, and the peculiar flat, lardy taste seemed more strong and noticeable. There also seemed to be a greater difference in the readiness with which the two butters melted in the mouth than in the previous period. Also in this period the cotton seed butter seemed to lack salt. There was no difference in color that might be attributed to cotton seed meal.

The cotton seed butter seemed to lack the characteristic butter flavor and aroma which the butter produced by

lot 1 had.

Professor Mortenson scored this butter as follows:

	First Churning		Second Churning	
	Lot 1	Lot 2	Lot 1	Lot 2
Flavor	38.5	39	36.5	37
Body	25	25	25	25

As in the previous period Professor Mortenson gave the body of all samples perfect scores and in both churnings gave the cotton seed meal butter a higher score in flavor than that produced on the basil ration. Unfortunately the butter from lot 1 developed an oily flavor as it did in period 3 before it was examined by Professor Mortenson. This probably accounts largely for his scoring lot 2 higher in flavor than lot 1. Professor Mortenson incriticizing the butter spoke of the flavor of the butter in lot 2 not being so quick as that in lot 1. He also spoke of the body of the butter in lot 1 being a trifle weak and melting too readily in the mouth. This conclusion was probably reached from comparing with lot 2, which was very firm and melted very slowly in the mouth, as stated before. It is very possible that the body of the butter of lot 1 was not weak but only seemed so on account of the unusual firmness of lot 2.

In period 5 the cows in lot 2 were taken off cotton seed meal and put on basil ration again. The butter made during this period was very good, both in body and flavor. There was no noticeable difference in flavor

or body between the two lots of butter. No trace of the peculiar flavor or body characteristics present when the cows in lot 2 were receiving 4 and 6 pounds of cotton seed meal were distinguishable.

It is hard to draw a comparison of the effect of the cotton seed mean on the flavor and body of butter , as described in this experiment, with that obtained by other investigators, for lack of the uniformity of control of the many factors that might influence the quality of the butter. It seems apparent that the effect of the cotton seed meal on the quality of thebutter, in this experiment was not so harmful as that experienced by Curtis of Texas, Hunt of Pennsylvania Station, and others.

While the cotton seed meal did not have a peculiar effect on the flavor and the body of the butter, as described previously, yet this effect is probably not such as would hurt the market qualities of the butter, when cotton seed meal is fed with alfalfa hay and corn silage for roughness. This is readily shown by the fact that an expert judge of butter like Professor Mortenson scored the butter produced on the cotton seed meal ration higher than that produced on a ration without this seed, though he was entirely ignorant of the kind of feed fed to the cows that produced this butter.

One of the peculiar qualities that butter made from a cotton seed meal ration seems to have, is that of

having insufficient salt. Salt tests were run on these samples of butter showing this characteristic and the results showed them to have as high a per cent of salt as samples having a normal taste in this respect. This same characteristic was noted by Hunt in his experiments on cotton seed butter at the Pennsylvania Station.

Four pounds of cotton seed meal in the ration gave almost as marked an effect on the flavor and body of the butter, as six pounds.

Effect of cotton seed meal on the constants of butter fat.

With reference to the effect of cotton seed meal on the fat, determinations were made of each churning in each period for the melting point, Reichert Meissl number, saponification equivalent, iodine number, and color readings.

The results of the determinations are given in the table.

The melting point of the butter fat from lot 2 increased quite uniformly from period 1 to period 3, when the cows in this lot were receiving four pounds of cotton seed meal a day. The melting point was raised from 31.86° C. in period 1 to 33.5° C. in period 3, a gain of 1.64° C. In period 4, however, when the cows were receiving six pounds of cotton seed meal, the melting point dropped 0.16° C. When the cows were put back on basil ration in period 5, the melting point dropped to 31.7° C., 0.1° C. lower than in period 1, showing that whatever effect the cotton seed meal may have had in raising the melting point, had disappeared within seven days after they had been taken off cotton seed meal, seven days being the length of time lot 2 was on full basil ration in period 5 before samples were taken.

The melting point of the fat from lot 1, on

TABLE V

Showing influence of cotton seed meal on sonstants of butter fat.

Period	Melting Point		Reichert - Meissl	
	Lot 1	Lot 2	Lot 1	Lot 2
1	32.63	31.86	30.93	29.66
2	32.30	32.81	31.08	30.01
3	31.00	33.50	32.11	30.92
4	32.15	33.34	30.21	30.80
5	32.26	31.70	30.99	29.47

Per.	Saponification		Iodine Number		Color (yellow)	
	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
1	233.6	232.3	30.40	30.78	50	50
2	232.3	231.9	29.86	30.06	48	47
3	232.2	231.3	32.12	33.50	45	45
4	231.9	231.1	32.81	32.71	46	43
5	233.0	232.0	30.72	30.80	45	47

basil ration thru-out the five periods, remained quite constant at 32.63 to 32.15° C., with the exception of period 3 when it dropped to 31.0° C.

The results of these determinations do not show the marked increase in the melting point obtained by the other investigators. Harrington(1), of the Texas Station, by feeding a ration, three fourths of which was cotton seed meal, increased the melting point 7.4° C. over that secured when the cows were on a basil ration. The cows in the Texas experiment received no more cotton seed meal, when on three fourths cotton seed meal ration, than did the cows in this experiment when they were receiving six pounds of cotton seed meal a day.

Wiley (2) increased the melting point 6.5° C. by feeding cows ten pounds of cotton seed meal a day with light pasture, over that secured when the cows were on full pasture ration.

The Ontario (3) Station increased the melting point 4.2° C. over that secured on pasture by feeding 30 # hay and 9 # of cotton seed meal.

The Alabama (4) Station obtained results more similar to those obtained in this experiment. The melting point was increased only 1.8° C. over that secured on basil ration, by feeding 4 pounds of cotton seed meal, 9 pounds of cotton seed hulls, and 4½ pounds silage.

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(1) Texas Bulletin, # 29. (2, 3, 4) Already given.

Linsey (1) of the Massachusetts Station got no increase in the melting point with cotton seed meal, but the addition of .5 of a pound of cotton seed oil, daily, increased the melting point.

Very little can be drawn from the results of the determinations on the Reichert Meissl number. It may be said that the cotton seed meal in the ration, in this experiment, had no influence on the Reichert Meissl number. While there was a slight increase in the Reichert Meissl number of the butter from lot 2, period 1 to period 3, there was almost as great an increase in the butter from lot 1. Suggesting that some factor, other than cotton seed meal, influenced the Reichert Meissl number of the butter from both lots.

In other investigations, a marked decrease in the Reichert Meissl number has generally resulted from the feeding of cotton seed meal. In the experiment reported by Harrington, at the Texas Station, the volatile acids decreased in proportion to the amount of the cotton seed meal fed. On ¼ ration of cotton seed meal the Reichert Meissl number was decreased 3.18, on ½ ration of cotton seed meal, 6.25 and on ¾ ration of cotton seed meal, 10.65. At the New Hampshire Station, on a ration of 40 # silage, 5½ # hay, 3.05 # middlings , and 7.25 # cotton seed meal, the Reichert Meissl number was decreased 5. Morse

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(1) Reference given before.

concludes from the results that a low Reichert Meissl number means a low flavored butter. This is not always the case as in this experiment it might be said that the Reichert Meissl number increased slightly and yet the butter from the cows receiving cotton seed meal was of a lower flavor that the butter from cows not receiving this feed. Jordan at the Maine Station produced butter from a ration containing a cotton seed meal which had a higher Reichert Meissl number. Wiley in one experiment reported the volatile acids raised by feeding cotton seed meal. In another experiment with cows, on light pasture, receiving 10 # cotton seed meal a day,,the Reichert Meissl number was lowered 1.3 under that obtained from butter produced on pasture alone. There was a slight uniform decrease in the saponification number of the butter from lot 2, from period 1 to period 4. In period 5 the saponification number returned to almost the same level as in period 1. The total decrease was only 1.2. However, the saponification number of the butter from lot 2 also decreased uniformly from period 1 toperiod 4 and returned to normal in period 5. The decrease was greater in the butter from lot 1 than in lot 2, being 1.7. As in the Reichert Meissl number some unknown factor influenced the saponification number of the butter from both lots. As lot 1 received the same ration thruout the experiment, it is not known what would cause it to

decrease from period 1 to period 4 and increase again in period 5.

The Texas Station saponification number was uniformly increased in proportion to the amount of cotton seed meal fed. The increase, when on ¾ ration cotto n seed meal, over that obtained on a basil ration being as high as 18.

It may be said that the iodine number of the butter was increased by the feeding of cotton seed meal. The maximum increase in the iodine number of the butter from lot 2 was obtained in period 3, the total increase over that in period 1 being 2.72. The iodinenumber of the butter fro m lot 1 also increased some, but the maximum increase was not obtained till period 4, and the total increase over period 1 was only 1.81.

Lindsey at the Massachusetts Station, reported the iodine number as not disturbed from feeding cotton seed meal but upon the addition of the cotton seed oil to the ration, the iodine number was raised. Morse also raised the iodine number by feeding cotton seed oil but decreased it 4.8 by feeding 7.25 # cotton seed meal. At the Ontario Station the iodine number was raised 10.6, over that secured from a pasture ration, by feeding 9 pounds of cotton seed meal. Harrington increased the iodine number in proportion to the amount of cotton seed meal fed. With a ration of ¾ cotton seed meal the iodine number was increased 5.19 over that

secured from a basil ration.

As may be seen in the table, the color readings of the butter from both lots decreased quite uniformly. It can hardly be said from these results that cotton seed meal when fed with alfalfa hay makes a lighter colored butter.

The results of the determinations do not show the marked changes, in the constants of the butter fat, obtained by many investigators by feeding cotton seed meal. The maximum increase in the melting point was 1.64° C. as compared with an increase of 7.4° C. obtained by Harrington at the Texas Station. There was practically no change in the Reichert Meissl number that could betraced to the influence of cotton seed meal, while many of the investigations showed a marked decrease. The saponification number was lowered slightly while Harrington obtained a marked increase. The iodine number increased 2.72 as compared with an increase of 5.17 obtained by Harrington, a decrease of 4.8 obtained by Morse, and an increase of 10.6 by the Ontario Station.

It is quite possible that the influence of the cotton seed meal on the butter fat in this experiment may have been off-set by some constituent or property of the alfalfa hay fed. So far as can be determined alfalfa hay was not fed with cotton seed meal in any of the other experiments.

The question may well be raised as to what relation the so-called constants of the fat, Reichert

Meissl number, the iodine number, and the saponification number, bear to the flavor and body of the butter. In the Reichert Meissl number determinations on the butter from lot 1 and lot 2 there was practically no difference and yet there was a wide difference in the flavor and body of the butter from these two lots.

Apparatus for Determining the Hardness of Butter and Butter Fat.

This apparatus was devised and perfected by A. E. Perkins (1) and consists of a firm upright support and a separate light frame carrying the penetrating needle and weight. At the top of the support, and in the center, is suspended an electro magnet. Attachments are on the support by which a battery is connected to operate the magnet. A key served for making and breaking the current through the magnet. Attached to the support is an adjustable platform for carrying the sample whose hardness is to be tested. On the top of the separate light frame is a piece of soft Swedish iron to be acted on by the magnet, directly beneath this, inside the frame, is a socket and set screw to hold the penetrating needle in place. At the opposite end of this frame, is a small platform for carrying the weights. This frame with needle weighs about 200 grams and in addition a 300 gram weight was used, in making these tests. The penetrating needles are cylindrical in shape and 10 cm. long , and graduated. In making these determinations the frame carrying the needle and the weight is suspended from the electro magnet. The sample to be tested is placed on the platform and, is adjusted until the surface of the sample

(1) Thesis by A. E. Perkins for M. S. Degree, U. of M., 1911.

is 10 cm. below the end of the needle. The distance of fall before reaching the surface of the butter is, then, always 10 cm. The weights on the frame now hang directly beneath the sample of butter, so that when th e frame is released from the magnet, the needle strikes the sample in a vertical position, and the needle being graduated, the depth of penetration is readily ascertained.

The following table shows the results of the test s for hardness on butter with this apparatus.

Table VII.

Hardness of Butter.

Period	Lot 1	Lot 2
	m.m. penetration	m.m. penetration
Period 1	230	230
" 2	225	190
" 3	300	250
" 4	305	230
" 5	210	205

These tests were made on samples that had been kept at a uniform temperature of $15\frac{1}{2}^{\circ}$ C. for 24 hours previous to making the determinations as a difference of 1° C will make a great difference in

the reading. The results given are the averages of three penetrations on each sample.

A study of table VII shows the hardest butter from lot two to be in period 2, when this group of cows received 2 pounds of cotton seed meal a day. The dept of penetration shows the butter in period 3, to be softer than that in any other period from lot 2. The butter in period 4, when this group of cows received 6 pounds of cotton seed meal per day is slightly firmer than that in period 3. In period 5 the depth of penetration is slightly less than in period 1. For some unknown reason the depth of penetration shows the butter from lot 1 to have increased uniformly in softness from period 1 to period 4, with the exception of period 2 when it remained practically the same as in period 1. In period 5 the depth of penetration was 95 mm. less than in period 4, and slightly less than in period 1. As showed by the depth of penetration there was a great difference in the firmness of the butter from the two lots in periods 2, 3, and 4. The greatest difference between the two lots being in period 4. Our practical observations and inspections by pressure with a knofe blade, when making and handling the butter corroborates the determination with the hardness apparatus. These results were contrary with our expectations as it was expected that the firmness of the butter would increase in proportion to the amount of

cotton seed meal fed. An explanation may be found for this in the observations of Morse and Lindsey. on the effect of cotton seed oil on the butter. They found that butter from a cotton seed meal rationwwas firm but the addition of a half pound of cotton seed oil to the ration caused the butter produced on this ration to be soft. Thus when 4 to 6 pounds of cotton seed meal is fed the amount of oil contained may be sufficient to cause the butter to be soft.

These results agree with those of the Alabama (1) Station in that the smaller amounts of cotton seed meal in the ration gave as firm a butter as a larger amount.

Moisture tests were run on these samples to see if any difference in the per cent of moisture in the butter from the two lots could be responsible for the difference in the depth of penetration. The table below shows the penetration and moisture determinations compared.

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(1) Bulletin 35, Alabama Experiment Station.

Table VIII.

	Moisture		Hardness	
	Lot 1	Lot 2	Lot 1	Lot 2
	%	%	m.m.	m.m.
Period 1	12	14.1	230	230
Period 2	12	10.35	225	190
Period 3	8.5	9	300	250
Period 4	10.9	12.15	305	230
Period 5	11.8	10.6	210	205

There seems to be no correlation between the percent of moisture present and the depth of penetration. Let us look at the results under lot 2. The depth of penetration is decreased 40 m.m. in the second period, and the percent of moisture present in these two samples is decreased 3.75 %. In the next period the depth of penetration increases 60 m.m. , but instead of the per cent of moisture increasing, as it would if there were any correlation between these two factors, it decreases 1.35 %. Again, under lot 1, in periods 2 and 3,the per cent of moisture decreases while the depth of penetration increases and in the fourth and fifth periods the per cent of moisture increases while the depth of penetration decreases.

Lindsey and Morse state that an increase in the iodine number indicates a softer butter. The following table shows a comparison of these two factors.

Table IX

	Iodine Number		Hardness	
	Lot 1	Lot 2	Lot 1	Lot 2
			m.m.	m.m.
Period 1	30.40	30.78	230	230
Period 2	29.86	30.06	225	190
Period 3	32.12	33.50	300	250
Period 4	32.21	32.71	305	230
Period 5	30.72	30.80	210	205

While the depth of penetration does seem to follow, to some extent, the iodine number, yet the iodine number cannot be the only factor that is responsible for the hardness or the softness of the butter, as a marked change in the iodine number is not followed to the same extent in the depth of penetration. For instance, in the second period the iodine number of lot 1 drop s .54 and the depth of penetration decreases 5 m.m. while under lot 2 in the same period, the iodine

number decreases .73, while the depth of penetration decreases 40, showing that while there was very little difference in the total decrease in the iodine number of the two lots during this period, there was a big difference in the lessened depth of penetration. The amount of decrease in the depth of penetration in lot 2 being eight times as great as that in lot 1.

Standing up Qualities of Cotton Seed Meal Butter.

One of the undesirable characteristics of most butters, is its property when placed in awarm room of losing all semblance of its former shape, and rapidly spreading out into a shapeless mass. When this has happened the consumer can usually take a helping of butter more gracefully with a tea spoon than with the knife intended for that purpose.

In order to see if cotton seed meal in the ration improves this condition any, it was decided to take samples of the two lots of butter, from the various periods, and place them on separate dishes in a warm jacketed oven, in which a temperature approaching summer conditions could easily be maintained. The results are given below. It will be recalled that in period 2, lot 1 received the basil ration and lot 2, 2 pounds of cotton seed meal per day. Slices of butter about two inches square and three quarters of an inch thick were taken from lot 1 and lot 2 and placed in the oven at a temperature of 70° F. and held there for an hour. Both lots softened some at this temperature. The temperature was then raised to 75° and maintained for an hour. Both lots softened appreciably. Between 80° and 85° F. both lots commenced to spread out and lose shape. There was no difference in the standing up qualities in the butter from the two lots during period 2.

In period 3, lot 1 received the basil ration

and lot 2, 4 pounds of cotton seed meal per day. At 70° the butter from the basil ration was noticeably softer than the butter from the lot receiving 4 pounds of cotton seed meal. At 80° F. the butter from the basil lot was very soft and commencing to spread at the bottom of the slice. The cotton seed meal butter while softer than at 70° F. was still, quite firm and was holding its shape well. At 85° F. the butter from the basil ration had almost lost its shape and was spreading badly, while the cotton seed meal butter, though soft, was still holding its shape well, the edges of the slice remaining clear cut. At 88° F. the butter from the basil ration had lost all semblance of its former shape and was melting at the edges. The cotton seed meal butter commenced to spread at the bottom of the slice at a temperature of 93° F. After remaining at that temperature for some time the top edges of the slice still remained clear cut. The butter from the cows receiving 4 pounds of cotton seed meal was a great deal firmer all the way through than the butter from the cows receiving the basil ration.

It will be remembered that in period 4, lot 1 received the basil ration and lot 2 six pounds of cotton seed meal per day. The experiment with the samples from period 4 were similar to period 3 in the lower temperatures. The butter from the basil ration completely lost its shape at 86° F. while the cotton seed meal butter did not lose its shape until

it had stood for some time at a temperature of 94° F., two degrees higher than the temperature at which the cotton seed meal butter in period 3 commenced spreading.

Thebutter from the two lots in period 5, showed no difference in the rate of softening. In this period, lot 1 and lot 2 received the basil,ration. The cotton seed meal butter seemed to have the property of keeping its shape until its temperature had almost reached its melting point, while the butter from the basil ration grew very soft and mushy and would commence to spread from 5° to 10° F. before its melting point was approached. This characteristic of cotton seed meal butter is a very important one as next nothing is more objectionable to both the shipper and the consumer than a soft butter, for it is hard to handle and has a most unpalatable appearance.

Keeping Quality of Cotton Seed Meal Butter.

In order to determine if butter made from the meal ration had any greater keeping quality than butter made from the basil ration, samples of each churning, weighing about a pound and a half each, were wrapped in parchment paper, placed in open glass jars, so that the butter was in contact with the air. They were then placed in a room where the temperature was kept at about 70° F. Other samples, weighing about two pounds each, were wrapped in parchment paper, and placed in closed ten pound butter tubs which were kept in the refrigerator, where the temperature averaged about 45° F. These samples were examined at irregular intervals and comparisons made of the deterioration in the flavor of corresponding lots.

Notes on butter held at 70° F.

Butter made in period 2, was placed in the warm room about 17 days after being made. At this time the butter from both lots was in good shape. When examined two weeks afterward, the butter from lot 1 had developed an oily flavor, while the butter from lot 2 had not changed any. It will be recalled that lot 2 received 2 pounds of cotton seed meal during this period. When examined 18 days later, the butter from lot 1 was strongly oily. The butter from lot 2 was off flavor somewhat but not nearly to the

extent of that from lot 1. When examined again 16 days later the butter from lot 2 had developed as bad a flavor as that from lot 1. Within a month after being made, the butter from lot 1 had an oily flavor. When a month and a half old this butter was strongly oily while in the same length of time lot 2 had only become slightly off flavor.

Within 16 days after being made, the butter from lot 1, in period 3, had developed an oily flavor, and a month afterward had a strong oily flavor while the butter from the cows receiving 4 # of cotton seed meal had gone only very slightly off flavor in the same length of time. Seven weeks after making, the butter from lot 2 had not yet become so rancid as the butter from lot 1, and two weeks later there was still quite a difference between these two lots of butter.

The butter from period 4 was placed in the warm room March 5th, almost a half month after it had been made. Lot 1 had a mild, oily flavor at this time, while the sample from lot 2 had not changed any. When examined 2 weeks later the butter from lot 1 had a very noticeable rancid taste while the butter from lot 2 did not appear to have changed. When examined again after seven weeks after being made there was a big difference in the flavor of the butter from the two lots, the butter from lot 1 having a strong rancid flavor. The butter from lot 2 had an off flavor but was not bad.

The butter from the two lots in period 5 seemed to deteriorate at about the same rate. Very little difference could be distinguished at any time.

Notes on butter held at 45° F.

Both lots of butter kept fairly well in the refrigerator. Two months after making, the butter from lot 1, in period 2, had a strong flavor, while lot 2 of the same period did not seem to have changed. The butter from lot 1 in periods 3 and 4 developed an oily flavor within two weeks after being made.

When the butter in period 2 was 3 months old, the butter from lot 1 was still considerably stronger than the butter from lot 2. The butter from lot 1 in period 3, when two and a half months old had a strong rancid, cheesy taste while the butter from lot 2 had a slight moldy taste but not nearly so bad as that from lot 1. The butter from lot 1 in period 4, also had a cheesy flavor when two months old, while the butter from lot 1 was off flavor only very slightly. All this butter was examined again on May 12th when the age of the butter in periods 2, 3, and 4 ranged from 3 to 4 months, the butter in period 2 being the oldest. When the sample of butter to be tasted was taken from the center of the piece of butter, there was quite a difference in flavor between the butter from the two lots in each period, but not nearly

such a pronounced difference as when the sample to be tasted was taken from the surface. The butter from lot 1 of periods 2, 3, and 4, showed a strong, moldy, rancid taste on the surface. While the butter from lot 2 had a moldy taste, there was no rancidity. The indications were that the rancid flavor in lot 1 went from the outside in.

These observations show that there is a decided difference in the keeping quality of the butter from the two lots. In the butter kept at 70° F., that from lot 2 was from 1 to 2 months older than the butter from lot 1, before going off flavor. The butter from the ration containing a larger proportion of cotton seed meal seemed to keep better than butter from the ration containing a small portion of cotton seed meal. The butter kept at 45° F. showed the same property, excepting of course that the butter from both lots was slower in going off. In every one of the twelve samples of butter, held at both temperatures, the butter from the basil ration developed an off flavor some time in advance of the butter from cotton seed meal ration. After a time the butter from the cotton seed meal ration would become as bad as the butter from the basil ration.

SECOND EXPERIMENT

INTRODUCTION

The results obtained in the first experiment were not nearly so pronounced as those obtained by other investigators. It was concluded that the influence of the cotton seed meal was in some way counteracted by the character of the roughness fed. Acting upon this supposition a short experiment was conducted with three cows. in which timothy hay was fed for roughness in place of alfalfa and corn silage fed in the first experiment.

The Plan of the Experiment.

The object in conducting this experiment was to discover if possible, if a grain ration composed largely of cotton seed meal fed with timothy hay for roughness would have a greater influence on the churnability of cream, the market qualities of butter, and the constants of the fat, than when fed with alfalfa hay and corn silage.

The general plan of this experiment was the same as that used in the first experiment with the exception of the following points: only one group of cows was used; the experiment had only two periods; one churning was made each period instead of two; the cream for each churning represented six milkings instead of three. The basil grain ration used was the same as that in the first experiment, namely:

corn 4 parts, bran 2 parts, and oil meal 1 part.

Arrangment of Experimental Periods.

Period 1 16 days.	Period 2 18 days.
Basil Ration	4 # Cotton Seed Meal

During period 1 the three cows received the basil grain ration and timothy hay. Then in period 2, 4 pounds of the grain ration was replaced pound for pound with cotton seed meal. The milk from the last three days of each period was used for the determinations.

TABLE X.

The Cows Used for the Experiment.

No. of Cow	Breed	Age (YRS.)	Period of Lactation (days)	Av. Am't. Milk a day
53	Jersey	5	103	21
301	Ayrshire	9	257	23
406	Shorthorn	3	169	12
Average:-		$5\frac{2}{3}$	176	19

This group produced about 2 pounds of butter fat a day.

TABLE XI.

Average Rations Fed.

No. of Cow	FEED	PERIOD 1 (pounds)	PERIOD 2 (pounds)
53	Timothy	15	15
	Grain	12	8
	Cotton Seed Meal		4
301	Timothy	15	15
	Grain	13	9
	Cotton Seed Meal		4
406	Timothy	15	15
	Grain	8	8
	Cotton Seed Meal		4

Table XI gives the average ration fed each animal in periods 1 and 2. The rations were computed according to the Armsby standard.

Churnability of the Cream.

The churnings in this experiment were made in the same way in every particular as those in the first experiment, of which a description may be found on page 31. The results are given below.

	Large Churning (minutes)	Experimental churn (revolutions)
Period 1	21	875
Period 2	30	1975

It will be recalled that 4 pounds of cotton seed meal was fed in period 2. While the time of churning in period 2 was longer than in period 1, it may be said that the churnings in each period were easy. Comparing the time of the churning in period 1 with the time of the churning in period 1 in the first experiment, (found on page 32) it will be seen that the time of the churning of the cream from the basil ration was about half that of the cream from the basil ration with alfalfa hay. While the cotton seed meal fed in period 2 seemed to increase the difficulty of churning the increased difficulty was not so great as was

found in the first experiment with 4 pounds of cotton seed meal. The butter in both churnings came in soft flaky granules, but came considerably softer in period 1 than in period 2.

Flavor of Butter, or Market Qualities.

The butter made in this experiment was not scored. However the butter from period 1 of this experiment seemed softer and was considerably poorer in flavor than the butter from the basil ration in the first experiment. The butter from period 2 was firmer than the butter from period 1, but seemed to have a greasy flat taste and was very low in flavor. This butter was a great deal poorer in quality than any of the butter produced on the cotton seed meal ration in the previous investigation. The body was very sticky and had an over worked appearance. The flavor and body of this butter was so poor as to have seriously injured its market quality. Although the butter from period 2 seemed firmer than the butter from period 1 it did not seem as hard and firm as the butter from the cotton seed meal ration in the first experiment.

Effect of Cotton Seed Meal on the Constants of Butter Fat.

TABLE XII

	Melting Point	Reichert Meissl		
Period 1	33	26.56		
Period 2	38.3	26.03		
	Saponification number	Iodine number	Color (yellow)	
Period 1	226.5	36.13	21	
Period 2	222.3	38.53	28	

The influence of the cotton seed meal on the sonstants of the butter fat in this experiment is far more pronounced than in the first experiment. The melting point went up 5.3° C. as compared with a rise of 1.64° C. in the previous experiment. The Reichert Meissl number dropped .53, while in the first experiment there was a very slight increase. The Reichert Meissl number of the butter from both periods in this experiment was considerable lower than in the previous investigation.

The saponification number dropped 4.2 in period 2 as compared with a drop of 1.2 in the first experiment. As in the Reichert Meissl number the saponification number was lower in both periods in this experiment than in the other experiment.

The iodine number was raised 2.4 which was not as great an increase as was secured with 4 pounds of cotton seed meal with alfalfa and silage. The iodine number was higher than in the first experiment.

The color reading increased from 21 in period 1 to 28 in period 2. This shows an increase in the color when fed cotton seed meal while the general tendency of both lots of butter in the other experiment was to decrease in color. The color reading of the butter in period 1 is 29 lower than that of the butter in period 1 of the previous experiment. This may be due to the alfalfa hay containing more coloring matter than the timethy hay.

Hardness Test.

Depth of Penetration.

Period 1 m.m.	Period 2 m.m.
320	290

This penetration test shows the butter from the ration containing cotton seed meal to be firmer than the butter from period 1. However both butters were very soft. The penetration test indicates that the butter from the cotton seed meal ration was softer than any of the butter produced by lot 2 in the previous experiment.

As the "standing up" quality of butter depends to some extent upon the melting point, the butter made in period 2 held its shape and firmness at

a temperature of several degrees higher than any butter made in the first experiment. The butter made in period 1 lost its shape at a comparatively low temperature.

SUMMARY AND CONCLUSIONS.

Cream from animals reeeiving cotton seed meal in their ration is more difficult to churn than that from animals receiving a ration without this feed. The churning is as difficult when the animals are receiving four pounds of cotton seed meal in their ration as it is when six pounds are fed.

A distinct flavor is imparted to the butter by feeding cotton seed meal. This flavor is hardly noticeable when only two pounds of this feed is fed in connection with alfalfa hay and silage for roughness, but it is very pronounced when as much as four or six pounds per day is fed. The body of the butter produced on this feed is firm, sticky, brittle, and has an overworked appearance. The influence of this feed on the flavor and body of butter when fed with the roughness mentioned above, is probably not such as to injure its market qualities.

More salt should be used in a butter made from a ration in which cotton seed meal is used.

The influence of cotton seed meal on the constants of the butter fat was only slightly noticeable, probably due to the character of the roughness fed with the ration, [illegible]. The melting point was raised 1.64° C; the Reichert Meissl number

was not affected; the saponification number was lowered slightly, and the iodine number raised 2.72. The colar was apparently not affected. A harder butter was produced from the cotton seed meal ration than from the basil ration. A firmer butter was produced from a ration containing 2 pounds of cotton seed meal than from a ration containing four or six pounds. The hardness was not influenced by the per cent of water in the butter but varied to a limited extent with the iodine number. These results correspond to some extent with those of the Alabama station where 3 pounds of cotton seed meal gave as firm a butter as 8 pounds of cotton seed meal. The firmest butter did not have the highest melting point.

The butter from the ration containing cotton seed meal had the property of standing up and holding its shape at a much higher temperature than the butter from the basil ration. The firmer butter did not have the greatest standing up quality.

The cotton seed meal butter was of far better keeping quality than the butter from the basil ration, the latter going off flavor from 1 to 2 months sooner than the cotton seed meal butter, when held at a temperature of 70° F.

Apparently timothy hay produces a softer butter than alfalfa hay.

The butter produced from the ration containing cotton seed meal and timothy hay was poorer in flavor and in body than butter produced from a ration containing cotton seed meal, alfalfa hay, and corn silage.

There was a pronounced difference in the influence of the cotton seed meal on the flavor of the butter and on the constants of the butter fat in this experiment, from that in the previous one.

The effects of the cotton seed meal on the quality of the butter and the constants of the butter fat, correspond more closely with the results of other investigators than do the results of the first experiment.

From the results of these experiments it seems that 2 pounds of cotton seed meal in the ration, when fed with alfalfa hay, would be beneficial to butter rather than harmful. The firmness, the keeping quality, and the melting point would increase while the flavor would not be noticeably affected.