Approved by
C. H. Eckles

THE USE OF SILAGE TO COUNTERACT THE EFFECT OF COTTONSEED MEAL ON THE COMPOSITION AND MARKET QUALITIES OF BUTTER.

by

Dura Prescott Crockett, B. S.

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Index.

INTRODUCTION.

Since the value of cottonseed meal as a feed for farm animals was first demonstrated, its use has gradually become more general, both in the United States and in foreign countries. For many years after the culture of cotton was started, and, in fact, as late as the middle of the last century,[12] the seed was considered a waste product and allowed to rot on the ground near the gin house with absolute disregard for its fertilizer or feeding value.

When the cottonseed oil industry became established, it was discovered that the cake which remained was an excellent source of protein for both beef and dairy animals. Its use gradually spread, until the entire output of the American mills, amounting in 1909 to over one and a half million tons,[5] is sold to cattle feeders in the United States and Europe.

The reason for the tremendous consumption of this product is largely an economic one. Even at the increased price at which the meal is sold, it continues to be the cheapest protein carrier in most sections where concentrates must be purchased. A comparison of grains based on current price is only of passing value; yet, the following table illustrates the relation which ordinarily exists in regard to the cost of protein in the form of the more common feeds.

Table I.

Cost of a Pound of Digestible True Protein in Different Feeds

Feed	Price per cwt.	Dig.True Prot. per cwt. #	Cost per lb. Dig.True Prot.
	Dollars	Pounds	Cents
Cottonseed Meal	2.25	35.4	6.35
Gluten Feed	1.85	20.1	9.20
Linseed Meal	2.75	28.5	9.65
Wheat Bran	1.85	10.8	17.10

Analyses by Armsby.[1]

An examination of this table indicates that the composition of cottonseed meal is such that its relative price may be considerably increased before it will cease to be the cheapest source of protein.

Aside from its economic importance, the palatability of cottonseed meal increases its value as a feed. In the South where the cottonseed products are easily available, the meal frequently constitutes the principal part of the grain ration; while the hulls are sometimes fed as roughage. Under this method of feeding, the animals receive a large amount of the oil bearing substance, and yet they apparently suffer no ill effects.

It was early noticed, however, that the butter produced from cows fed liberally on cottonseed products, exhibited certain peculiar characteristics. Among these, a firm, hard body, a salvy, greasy taste, and lack of flavor and aroma were reported. Analyses of these samples proved that the chemical and physical constants of the fat were also changed. It is natural that these reports have come from those sections in which the cottonseed products are fed most heavily. In the North little trouble is experienced, for cottonseed meal is used as one of several concentrates in a ration, and is ordinarily fed in quantities of less than five pounds per day. On the other hand, in the South, where large amounts of the meal and hulls are constantly fed, these characteristics have become so well established that southern butter is regarded with suspicion. This has led the northern markets to discriminate against butter from the South; so that it can now be sold only in the region where it is produced. Such conditions prove to be a handicap to the dairy interests. Many natural conditions favor the production of butter in those states, but the lack of a market limits the extension of the industry.

Early observations indicate that the effect of cottonseed meal on the butter is less pronounced when the cows are kept on some kind of green roughage.[4] It has been demonstrated at the Missouri Station[9] that a liberal feeding of corn silage serves the same purpose as other succulent feeds. If the introduction of such a valuable feed as silage will improve the quality of the butter produced when cottonseed meal is used in large amounts, it can readily be seen that there is a possibility of providing an entirely different future for the dairy industry in the South.

The purpose of this investigation is to review the available data pertaining to the problem, and to present the results of an experiment to determine the extent to which the feeding of corn silage will counteract the effects of cottonseed meal on the composition and market qualities of butter.

REVIEW OF LITERATURE.

General Effects of Cottonseed Meal.

Quality of Butter:-

Curtis[4] obtained striking results from feeding cottonseed products as a complete substitute for a ration consisting of corn and cob meal, oats, bran, silage, pea vine and sorghum hay. With the cottonseed ration the melting point of the butter was raised 5 degrees Centigrade and the volatile acids were decreased from 14.4 to 10.1. The conditions which produced these results were of course extreme. When cottonseed meal was fed with oats, in the proportion of one to three, the melting point was raised only two degrees. He considered that the increased hardness due to cottonseed meal feeding would be of value in connection with the handling and shipping of butter. In hot weather, he thought that it might be detrimental to the health of the animals to feed a heavy ration of cottonseed meal, and yet a small amount would produce a butter sufficiently hard to possess a distinct advantage for shipping purposes. In conclusion he states: "It is the practical experience that if green feeds in any form make up a part of the ration, more cottonseed meal can be fed without destroying the quality of the butter than if cows are kept on dry feed." Table II. shows the average score given by five separate judges to the butter produced on different rations of cottonseed products in the experiment conducted by Curtis.

Table II.

Effect on Score of Feeding Cottonseed Products.

Roughage	Grain	Cottonseed Product lbs.	No. of Samples	Score
Millet, pea vine hay, pasture.	Bran, corn, bean and linseed meal		5	87.7
Same	Bran, corn meal	Meal 4	5	85.7
Poor pasture	Oats	Whole seed 11	3	76.8
Same	Oats	Meal 4	3	75.8
		Whole seed	3	70.6

This shows that when the animals were on good pasture the addition of four pounds of cottonseed meal had only a slight effect on the quality of the butter. With dry roughage, or an increased amount of cottonseed products, however, the quality of the butter was seriously injured.

Harrington[11] fed increasing amounts of cottonseed meal with bran to cows fresh in milk. They were given pasture or hay and fed 10 to 16 lbs. of silage. With

2 lbs. of meal there was a decided increase in the melting point and iodin absorption, and a decrease in the volatile acids. As the amount of cottonseed meal was increased to 4 and later to 6 lbs. a day, the effect on the constants became more prominent. He sent samples of the butter to Wiley,[28] whose examinations corroborated Harrington's results. A second set of samples received by Wiley did not show as marked effects. Wiley subsequently investigated the matter in co-operation with the Maryland Station, and found that cottonseed meal caused an elevation of the melting point and a lowering of the volatile acids. The iodin number, contrary to previous investigations, was diminished by feeding cottonseed meal.

Wood and Parsons[26] fed cottonseed meal with a heavy silage ration and secured a butter with a low iodin absorption and per cent of volatile acids, but with a high melting point. The meal produced an unusually hard quality of butter. They concluded that: "The melting point of butter fat is not a good index of its commercial hardness. While in general a soft butter melts at a lower temperature than a hard butter, there is no definite relation between melting point and hardness."

Lindsey[17] fed 4 lbs. of cottonseed meal with hay and 20 lbs. of silage as roughage. His results show a decrease in the saponification value and Reichert-Meissl number accompanied by a rise in the iodin value and melting point. The butter produced was of about the same condition and quality as that produced on the standard ration. Mr. Guide of New York in scoring the samples spoke of the cottonseed meal butter as, "Lacking aroma, having a slight taint, and being spongy when soft, and crumbly when hard." The following season, Lindsey[18] repeated his experiment, using dry roughage. The changes in the fat constants were not as great as those secured when silage was fed. The effect of the cottonseed meal on the quality of the butter was also less noticeable. He stated that cottonseed meal with a minimum of oil produces a firm butter, and when fed in liberal amounts causes only a slight change in the composition. As scored by Mr. Guide, a very slight preference was shown in favor of the cottonseed meal butter; although from both rations the samples were somewhat hard and crumbly. So far as the observation of practical judges was concerned, little difference was noted in the flavor and body of the butter from the different rations.

Hunt[14] found that when six pounds of cottonseed meal was substituted for an equal weight of bran, that the butter produced was much inferior in quality to that produced on the basal ration. The roughage consisted of silage, green rye, clover, and corn stover. New York commission men in judging the butter cut the score for both body and flavor. The butter from the basal ration was scored 91 and that from the cottonseed meal ration 72. The lot from the cottonseed meal required more salt and had a higher melting point.

Jordan[15] concluded that the investigation up to that date indicated, "That the presence of cottonseed meal in the grain ration gives the butter a higher melting point, or increases its resistance to hot weather, and that large quantities tend to lower the percentage of volatile acids."

Michels and Burgess[20] fed 3 lbs. of cottonseed meal with 3 lbs. of bran, and later 5 lbs. of meal, to a group of 21 cows in the station herd. The butter made during the period of heavy feeding was appreciably firmer than that made during the bran and meal period. In other respects the butter was the same throughout, being of uniformly good quality.

At the Mississippi Station,[21] 5 lbs. of cottonseed meal and 6 lbs. of seed were fed without injuring the butter, as judged by M. M. McKeen and Company of St. Louis. The very slight difference indicated that commercial judges would not discriminate against butter produced on this ration.

Clark,[3] after feeding increasing amounts of cottonseed meal on pasture, concluded that the butter secured was only slightly harder than that on the basal ration, the melting point being raised one to three degrees.

Three pounds of cottonseed meal gave as hard a butter as eight pounds. The volatile acids were not materially affected.

Graves[10] found that cottonseed meal in quantities of 2, 4, and 6 lbs., with alfalfa hay and silage, produced only a slight change in the fat constants. The melting point and iodin number were raised and the saponification value lowered; while the Reichert-Meissl number was not affected. Throughout the experiment, one lot of cows was kept on the basal ration of corn 4 lbs., bran 3 lbs., and linseed meal 1 lb., with the same roughage; and the butter from this lot used for a check. As scored by Professor Mortensen, Chief in Dairying at Iowa State College, a slight preference was shown for the flavor of the cottonseed meal butter, no cut being made in either case for the body. At the Missouri Station, Eckles and Rinkle detected no difference in the samples when 2 lbs. of meal were fed, but on the 4 lbs. ration they characterised the cottonseed meal butter as firm in body, flat and greasy in taste, with a suggestion of lard. They observed that it melted in the mouth more slowly and lacked the typical butter flavor. There seemed to be a pronounced lack of salt; although an analysis proved that a normal amount was present. When 6 lbs. of meal were fed, the characteristics attributed to the cottonseed butter were the same as in the preceding period, but slightly increased in intensity.

Standing Up Temperature:-

Graves determined the standing up quality of the butter, and found that that produced by the cottonseed feeding had the property of keeping its shape until the temperature had almost reached its melting point; while the butter from the basal ration grew very soft and mushy and commenced to spread from two to five degrees before its melting point was reached. The following table shows his results:

Table III.

Relation of Amount of Cottonseed Meal in Ration to Melting Point and Standing Up Quality of Butter.

Period	Ration	C.S.Meal lbs.	Temp. at which shape was lost Deg. Cent.	Melting Pt. Deg. Cent.
	Basal	0	27 - 29	32.4
2	Exp.	2	27 - 29	32.8
	Basal	0	29	31.0
3	Exp.	4	33	33.5
	Basal	0	30	32.2
4	Exp.	6	34	33.5

Graves conducted one experiment in which he used cottonseed meal and timothy hay. Four pounds of meal with this roughage produced more pronounced effects on the butter than the same amount of meal when fed with silage and alfalfa. The fat constants varied through a wider range-the melting point being raised five degrees as compared with one and seven-tenths degrees; while the flavor and body became much more objectionable.

McNulty[22] fed 4, 6, and 8 lbs. of cottonseed meal with timothy hay. The change from the basal ration resulted in a butter with a flat, salvy, tallowy taste and a body that melted slowly in the mouth. He stated that after tasting the sample, an oily product tended to remain on the palate. This property was much less prominent with the four pound ration than with the heavier feeding of meal. He concluded that the butter made in the four pound periods would not meet with any serious objection from the consumer, but the butter from the six pound period had such a flat tallowy taste as to be quite objectionable. The butter had a much higher melting point than that produced by Graves with equal amounts of meal fed with corn silage. In testing the standing up quality, McNulty found that the cottonseed meal samples withstood over five degrees higher temperature without losing shape than did the basal samples. The standing up temperatures followed the melting points quite closely and exhibited a corresponding increase over those secured by Graves. McNulty concluded that his investigation failed to show any relation between the increase in the iodin number and the oily flavor so prevalent in butter made from cows fed cottonseed meal. He stated that, "The quality of the butter produced by feeding cottonseed meal is much more dependent on the fluctuations in the melting point and the saponification value than upon the variations in the iodin and Reichert-Meissl numbers."

The statement quoted above would, no doubt, be correct for physical quality, but it is not in agreement with the belief of Lewkowitsch, who suggests that the flavor and aroma of butter depends largely on the content of volatile acids. It would be expected from this view that the Reichert-Meissl number, which serves as a measure of the volatile acids, would have a direct relation to the commercial value.

It is possible, too, that the increased oily flavor developing in cottonseed meal butter under certain conditions of storage depends, in part, on a change in the olein which is known to be present in this butter in more than ordinary quantities. Sayer[23] states that: "The decomposition of the unsaturated oleic acid is due to oxidation brought about more by the action of light than by organisms and caused not so much a rancid as a tallowy taste." Lewkowitsch[16] speaks of the "tallowy, lardy taste and smell" which butter acquires when exposed to light. Oleic acid is known to absorb oxygen very rapidly, but no evidence can be presented to show that there is any oxidation of olein of butter fat under ordinary storage conditions. Dyer[6] states that, "The flavors which develop in butter held in cold storage are not due to any oxidation of the fat itself, but may be attributed to changes accompanying an oxidation of the non-fatty substances." Since butter is ordinarily stored in the dark, it is not probable that any oxidation of the olein takes place. Cottonseed meal butter exposed to the light, however, might suffer more actual decomposition of the olein and this may be the cause of the abnormal tallowy taste which develops under such conditions.

Keeping Quality:-

Graves[10] seems to have been the first to observe any relation between the feeding of cottonseed products and the keeping qualities of butter. He tested samples both at room temperature and in the refrigerator. The results indicate that the butter secured from the animals fed cottonseed meal had a decided advantage in keeping quality. These samples held at room temperature went off in flavor from one to two months later than the ones from the ration containing no cottonseed products. Samples held at eight degrees Centigrade exhibited the same relation; although both lots were slower in going off in flavor. He stated that after a time the butter from the cottonseed meal ration would become as bad as the butter from the basal ration, but in every case the better quality was possessed by the cottonseed meal butter.

Eckles and Palmer[9] compared the keeping quality of butter produced on pasture, with and without cottonseed meal in the ration. The samples were packed in glass jars, sealed with paraffin, and held in the refrigerator at eight to twelve degrees Centigrade. After five weeks in storage the butter from the groups fed cottonseed products was of good quality, but the other samples had suffered considerable deterioration. The difference was more pronounced at the end of five months in storage. At this time the samples from the lots which received no cottonseed products while on pasture were very bad, being absolutely unfit for use. On the other hand, the butter from the groups fed cottonseed products was still of fair quality and would at least have satisfied the requirements for table butter. It was observed that the oily taste was considerably more pronounced than when the butter was fresh. In general it was concluded that the butter from the cottonseed products rations possessed decidedly better keeping qualities than that from the basal ration.

Effect of Corn Silage on the Fat Constants.

Hunziker[13] found that the presence of corn silage in the ration exerts a pronounced influence on the chemical composition of the butter fat. When silage was withdrawn there was an immediate drop in the percentage of volatile acids which continued until the cows were put back on the silage ration, when the volatile acids increased again. The olein increased rapidly as soon as the silage was withdrawn and dropped again abruptly as soon as it was replaced. The melting point fluctuated but slightly. This suggests that the influence of the increase of the olein to lower the melting point was offset by the decrease of the volatile acids. He attributed the tendency of silage to increase the percentage of volatile acids to the fact that the starches and sugars, in which silage is relatively rich, when subjected to the physiological and digestive processes logically yield products of low molecular weight.

Wood and Parsons[26] found that by replacing hay with 44 lbs. of silage that the melting point of the butter produced was lowered from 33.9 to 31.5, and the volatile acids were increased from 34.2 to 36.4. They concluded that the silage produced a somewhat softer butter than good hay, but was favorable to the flavor and texture.

Lindsey[17] conducted a test on linseed meal, which produced the same general changes in the fat constants as cottonseed meal. He found that the effect of the meal was much less pronounced when the roughage was made up of silage than when it consisted entirely of hay. The use of silage seemed to counteract the tendency for the melting point to rise and the Reichert-Meissl number to sink under the conditions of linseed meal feeding. The iodin number, however, was actually depressed on the silage ration.

The most complete data in regard to the effect of roughage on the constants of butter fat is that presented by Eckles and Palmer.[9] They compare silage with alfalfa hay and also with a ration of timothy and corn stover. The same experiment shows the effect of cottonseed oil when fed with the different roughages. Previous work shows that oil fed alone gives the same or slightly greater effects than an equal amount in the form of cottonseed meal. Two groups of three animals each were given rations as indicated in Table IV. For three days at the close of each period all the milk from each group was saved for churning. The butter from these samples was analysed. Figures I., II., III., and IV. show the results obtained. From a study of these graphs it is clear that the effect of silage, when replacing dry roughage, is to decrease the iodin value and to raise the Reichert-Meissl number and saponification value. The melting point was not materially influenced. These results were in exact accord with those reported by Hunziker. It is seen, then, that silage causes a change in the fat constants directly opposite to that produced by cottonseed meal or oil. In the case of Group I., which received oil in the second to fifth periods inclusive, the uniform effect of the silage ration was to cause the constants to return toward normal; thus counteracting the effect of the cottonseed oil. With the lighter ration there was a tendency for the constants to turn away from normal again, which would suggest that the counter-acting influence of silage varies directly with the amount fed.

Table IV.

Rations Fed in Cottonseed Oil Versus Roughage Experiment.

Period	Group I.	Group II.
1	Alfalfa hay and grain.	Alfalfa hay and grain.
2	Alfalfa hay, grain, cottonseed oil.	Alfalfa hay and grain.
3	Timothy hay, corn stover, grain, cottonseed oil.	Timothy hay, corn stover, grain.
4	Alfalfa hay, corn silage, 30 to 40 lbs., grain, cottonseed oil.	Alfalfa hay, corn silage, 30 to 40 lbs., grain.
5	Alfalfa hay, corn silage 20 to 30 lbs., grain, cottonseed oil.	Alfalfa hay, cornsilage, 20 to 30 lbs., grain.
6	Alfalfa hay and grain.	Alfalfa hay and grain.

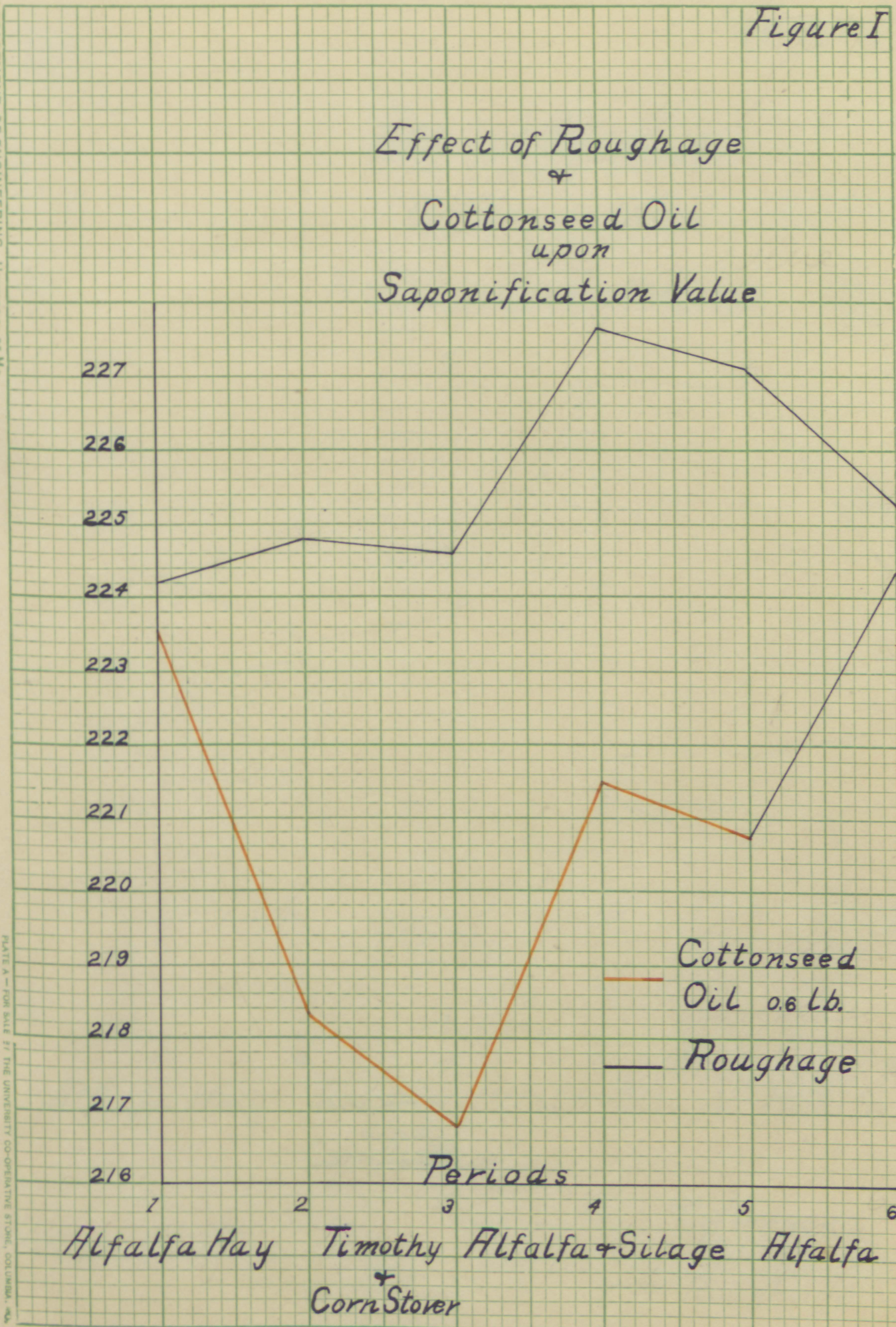


Figure I
Effect of Roughage
&
Cottonseed Oil
upon
Saponification Value
227
226
225
224
223
222
221
220
219
218
217
216
Cottonseed
Oil 0.6 lb.
Roughage
Periods
1
2
3
4
5
6
Alfalfa Hay
Timothy
+
Corn Stover
Alfalfa + Silage
Alfalfa

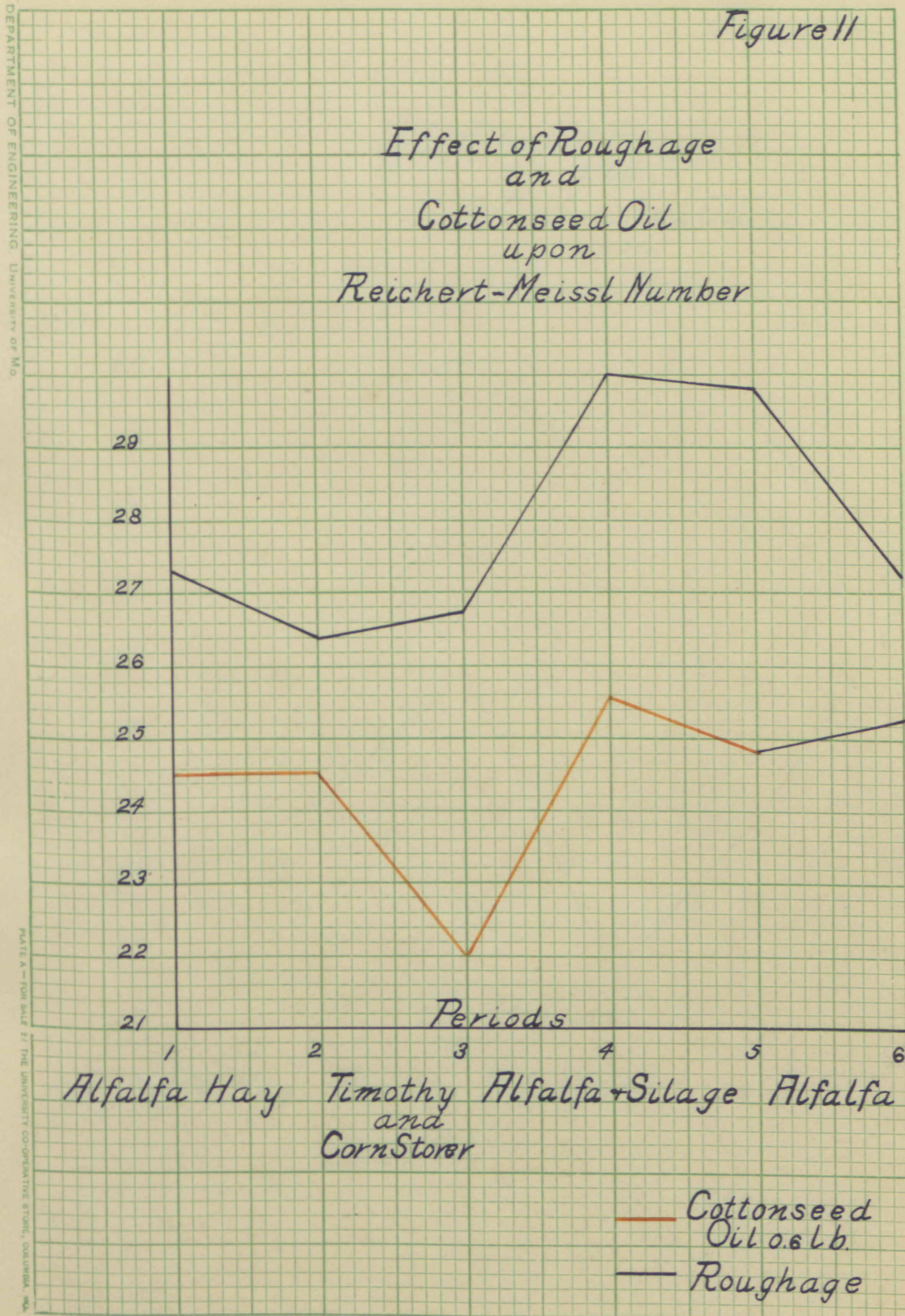


Figure 11
Effect of Roughage and Cottonseed Oil upon Reichert-Meissl Number
29
28
27
26
25
24
23
22
21
Periods
1
2
3
4
5
6
Alfalfa Hay
Timothy and Corn Stover
Alfalfa + Silage
Alfalfa
Cottonseed Oil 0.6 lb.
Roughage
DEPARTMENT OF ENGINEERING UNIVERSITY OF MO.
PLATE A — FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.

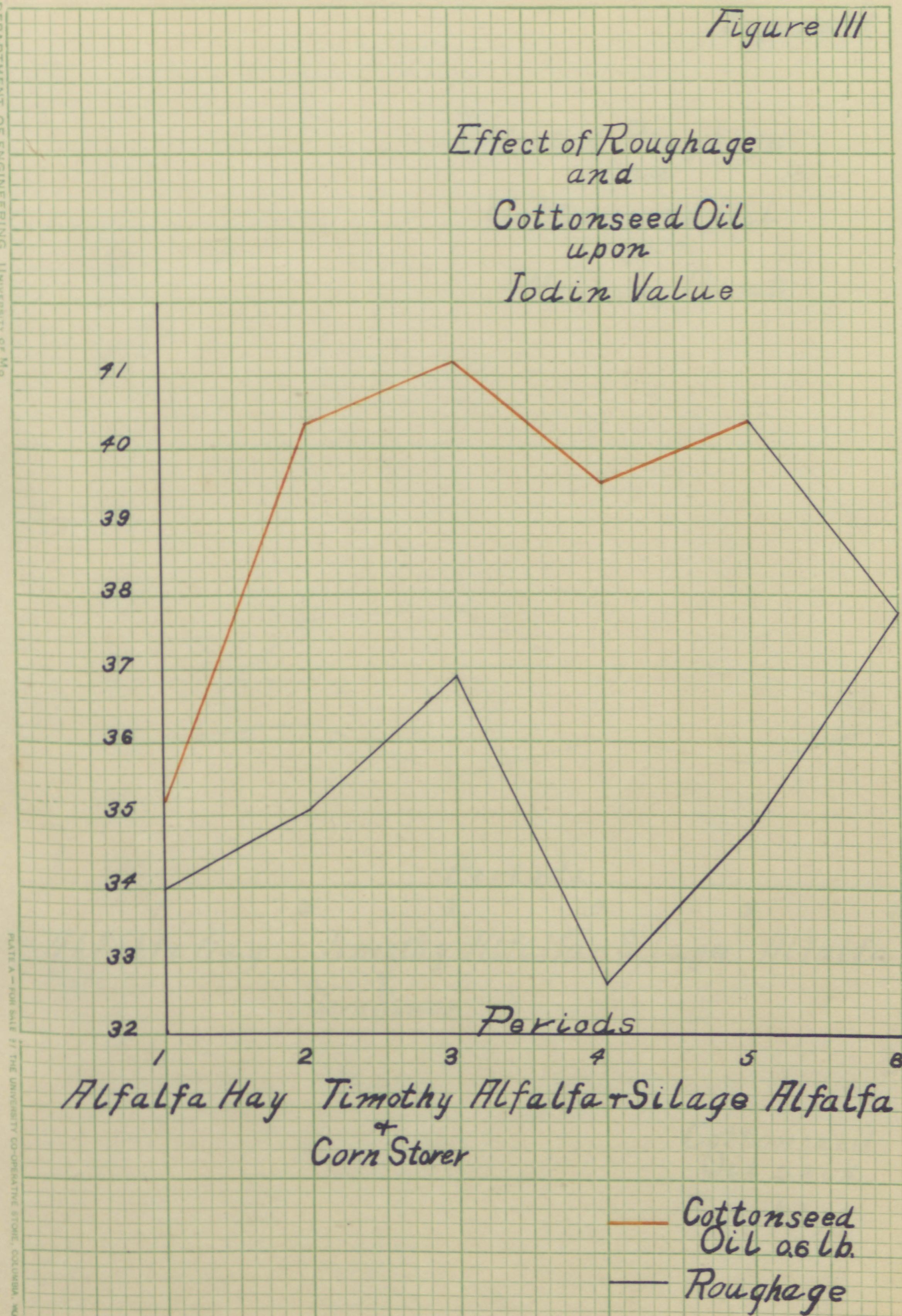
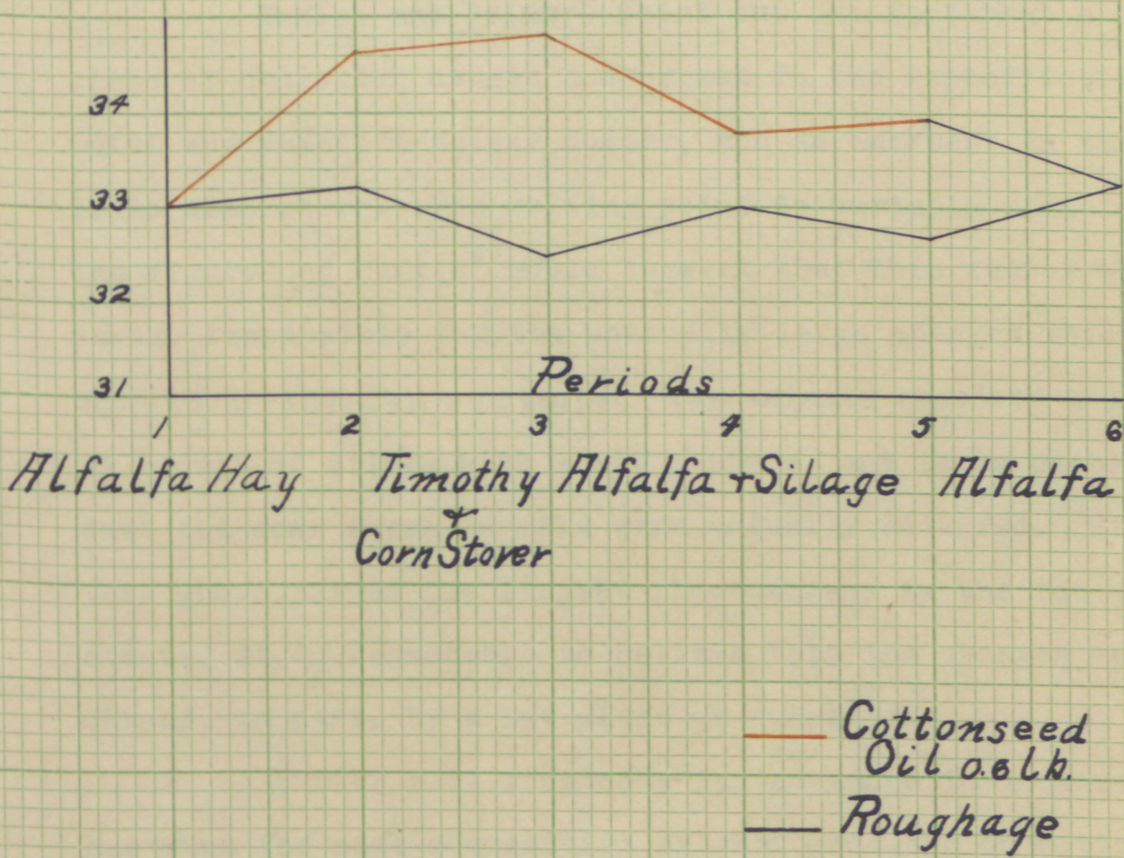


Figure III
Effect of Roughage
and
Cottonseed Oil
upon
Iodin Value
41
40
39
38
37
36
35
34
33
32
Periods
1
2
3
4
5
6
Alfalfa Hay
Timothy
+
Corn Storer
Alfalfa + Silage
Alfalfa
Cottonseed
Oil 0.6 lb.
Roughage

Figure IV

Effect of Roughage and Cottonseed Oil upon Melting Point



Other Factors Affecting Composition.

In making a study of this kind, all the more important factors affecting the composition of fat should be considered; for some of them are apt to influence experimental results, and unless accounted for, may lead to erroneous conclusions. Idiosyncracy and breed,[25] although of some importance, will not ordinarily introduce any large error when a group of animals is used. Underfeeding and stage of lactation, on the other hand, are of considerable importance.

Eckles and Palmer[8] point out the fact that a low plane of nutrition causes a decrease in the saponification value and Reichert-Meissl number, and an increase in the iodin absorption. The melting point is variably affected. The figures of Curtis[4] would suggest that this factor was partly responsible for the unusually large changes which he secured in the fat constants. The animals received a limited amount of silage with scant pasture, and it is probable that the cows fresh in milk were actually underfed. Since this group showed the largest fluctuations in the fat constants, it is reasonable to believe that the changes were caused, in part, by a low plane of nutrition.

Butter made from cows far advanced in lactation has much the same composition as that produced on cottonseed meal feeding. Eckles and Shaw[7] found that the

Reichert-Meissl number and saponification value show a gradual decline from the beginning to the end of the lactation period. After the first few weeks there is a slight but regular increase in the iodin number. The melting point remains nearly constant during the major part of the period. The results of the experiment are shown in Table V. It gives the average fat constants of eleven cows, by four-week periods. Mayer[19] corroborates the work reported on the Reichert-Meissl number.

Table V.

Influence of the Stage of Lactation Upon the Fat Constants.

Period	Saponification Value.	Reichert-Meissl Number	Iodin Value	Melting Point
1	233.7	29.13	33.28	31.73
2	230.4	27.49	31.58	32.96
3	231.0	27.06	32.22	32.82
4	229.6	26.45	30.85	33.08
5	229.2	26.58	31.36	33.28
6	228.9	26.40	31.72	33.25
7	225.7	25.52	32.96	33.32
8	226.7	25.20	33.26	33.41
9	225.6	24.23	34.56	33.51
10	223.4	22.48	35.41	33.94
11	223.8	22.18	35.48	34.68
12	220.6	20.29	35.17	33.85

SUMMARY OF PREVIOUS INVESTIGATIONS.

General Effect of Cottonseed Meal on Butter.

A study of the available literature reveals a remarkable lack of uniformity in the effects on butter attributed to the feeding of cottonseed meal. The results of different investigators are frequently conflicting, and the amount and direction of the changes secured are by no means consistent. It is very natural, however, that such a situation should be found. The conditions under which the different experiments were conducted were by no means comparable, and several factors whose importance was not recognized at the time may have entered to vitiate the results. By making allowance for the disturbing influence of these factors, it is possible to outline rather definitely the general effects of cottonseed meal on butter.

The effect of cottonseed meal first becomes evident in the changed body of the butter. It is uniformly hard and resistant. When cold it is brittle and crumbly, and when warm it is spongy or gummy. Some butter has been reported as actually rubbery.

The flavor imparted to butter by cottonseed meal is described as oily, salvy, tallowy, or in some instances as flat, then the product seems to lack flavor. Frequently the butter appears to be lightly salted; although a normal amount is present. There is a general absence of the quick, fresh taste characteristic of normal butter, and a lack of aroma is often more pronounced than any taint or off flavor. Two characteristics which are quite prominent when the butter is sampled are its hardness and high melting point. The butter resists pressure and melts very slowly in the mouth. Both the flavor and the body are subject to criticism and may be cut in the score by a commercial judge.

Standing Up Quality.

Some importance is attached to the heat resisting property and keeping quality of cottonseed meal butter. Its consistency is such that it will withstand a temperature close to its melting point before it loses its shape. This is a distinct advantage in butter used for table purposes in a warm climate. It has been reported, too, that the butter has a superior keeping quality and under similar conditions will remain in marketable condition much longer than other butter.

All these effects are more or less pronounced, depending on the amount of cottonseed meal fed. A ration containing five pounds ordinarily produces a butter which is not objectionable in any way, but if more than this is fed, the results become quite noticeable.

Composition.

The fat constants offer an accurate means of comparing the effect of cottonseed meal in varying amounts. Since it has been shown that the composition of butter fat is subject to the influence of the roughage, the previous work has been classified on this basis, and Table VI. shows the effects of cottonseed meal fed with dry roughage.

Table VI.

Effect on Fat Constants of Cottonseed Meal with Dry Roughage.

Meal fed per day	Roughage	Grain	Difference caused by change from basal to experimental ration expressed by + or -			
			Saponification Value.	Reichert-Meissl Number.	Iodin Value	Melting Point
Lbs.						
2[9]	Alfalfa hay	Corn 4 Bran 2 Oilmeal 1	+ 0.7	- 0.88	+ 0.15	+ 0.90
3[9]	Do.	Do.	- 0.4	- 1.80	+ 1.64	+ 0.93
3[18]	Hay Rowen	Oats 5 Bran 3 C.Seed 5 Gluten 5	- 1.5	- 0.22	+ 0.29	+ 1.64
3.6[9]	Alfalfa hay	Corn 4 Bran 2 Oilmeal 1	- 4.4	- 1.04	+ 5.52	+ 0.50
4[9]	Do.	Do.	- 3.0	- 3.14	+ 2.17	+ 2.04
4[9]	Do.	Do.	- 5.7	+ 0.30	+ 1.53	+ 1.37
4[22]	Timothy Corn Stover		- 2.0	+ 2.09	+ 0.07	+ 3.15
4[10]	Timothy	Bran 2 Corn 4 OilMeal 1	- 4.2	- 0.53	+ 2.40	+ 5.30
5[9]	Alfalfa	Corn 4 Bran 2 Oilmeal 1	- 1.4	- 0.17	+ 1.51	+ 2.23
6[22]	Timothy Corn Stover		- 4.7	- 1.77	+ 1.58	+ 6.20
7.5[9]	Alfalfa	Corn 4 Bran 2 Oilmeal 1	- 6.2	- 0.27	+ 5.98	+ 2.14
8[22]	Timothy Corn Stover		- 2.3	+ 0.86	+ 0.65	+ 5.55

Note: Figures in parentheses refer to like numbers in the bibliography.

A study of this table shows that the effect of cottonseed meal is to lower the saponification value; although there is no consistency in the amount of depression. In different experiments with four pounds of meal the total fall varied from 2.0 to 5.7. Neither was the change proportional to the amount fed, for seven and one-half pounds gave only slightly more depression than four pounds; while eight pounds showed less effect than three and six-tenths pounds. Even when the roughage was kept constant there was a large variation.

The Reichert-Meissl number shows less regularity in fluctuation than the saponification value. In the majority of cases, however, the addition of cottonseed meal was accompanied by a decrease in the number.

The iodin value in every case was increased, the amount ranging from 0.7 to 5.88. With the same kind of roughage almost equal amounts of meal caused variations of 1.55 and 5.52 respectively.

The melting point was raised in all the experiments, but followed neither the Reichert-Meissl number nor the iodin value in its variations. In two cases the changes in these two constants were practically equal; yet in one, the melting point rose 0.93 degree, and in the other, 6.20 degrees.

The changes in the fat constants are practically the same when cottonseed meal is added to a ration containing silage. Table VII. includes the results from a group of experiments of this nature. In each case the constants were depressed or raised in the directions commonly resulting from the use of cottonseed meal, but the amount of fluctuation was slightly less than that secured on dry roughage. This is particularly true of the melting point. It was raised consistently throughout, but the difference between the basal and experimental rations for equal amounts of cottonseed meal was less when silage was fed.

When comparing the results shown in Tables VI. and VII., it is to be pointed out that the fat constants on the basal rations were not the same. For example, the saponification value was higher on the basal ration containing silage than on the basal ration containing dry roughage only. The addition of cottonseed meal, then, tended to cause this constant to return toward the point it would occupy with the dry roughage. In this way the silage and cottonseed meal, acting to move the saponification value in opposite directions, would tend to keep it normal if both were used at the same time. The general effect on the other constants is like that on the saponification value.

It is seen then, that cottonseed meal causes a rise in the melting point and iodin value and a drop in the saponification value, and to some extent, in the

Reichert-Meissl number. Although the general direction of the change is constant, the degree of variation is by no means uniform, and tends to be less when silage is fed.

Table VII.

Effect on Fat Constants of Cottonseed Meal with Corn Silage.

Meal fed per day	Roughage	Grain	Difference caused by change from basal to experimental ration expressed by + or -			
			Saponification Value.	Reichert-Meissl Number.	Iodin Value:	Melting Point
Lbs.						Degrees C.
2 (10)	Alfalfa, Silage, 35 lbs.	Corn 4 Bran 2 Oilmeal 1	-0.4	+ 0.35	- 0.72	+ 0.95
4 (10)	Do.	Do.	- 0.9	+ 1.35	+ 0.96	+ 1.72
4 (17)	Hay, Silage, 20 lbs.	Oats 5 Bran 3 C. Seed Gluten	- 5.0	- 1.66	+ 2.57	+ 1.66
5 (21)	Hay, Silage 20 lbs.	Bran				+ 1.85
6 (10)	Alfalfa, Silage, 20 lbs.	Corn Bran Oilmeal	- 0.9	+ 1.33	+ 1.91	+ 1.64
7.2 (25)	Hay, Silage 40 lbs.	Corn Middlings Gluten C.S.Meal		- 6.4	- 4.0	

Note: Figures in parentheses refer to like numbers in the bibliography.

Effect of Silage on the Fat Constants.

No evidence is at hand to show any distinct effect on the market quality of butter due to the feeding of silage. There are, however, some data showing its influence on the fat constants. These are included in Table VIII. The results therein presented are surprisingly uniform throughout, and give some substantial evidence of the effects which may be expected from feeding silage. There was a uniform increase in the saponification value and Reichert-Meissl number, together with a decrease in the iodin value. The melting point was not affected to any considerable extent, except in one case, when it was lowered 2.4 degrees Centigrade. It appears that the changes represented by the iodin number and Reichert-Meissl number offset each other. There was a tendency in each series of experiments for the effect of the silage to vary directly with the amount fed.

It is important to observe the direction of the change brought about in the constants by the feeding of silage. It is in each case directly opposite to that caused by cottonseed meal.

Table VIII.

Effect on Fat Constants

Due to Adding Corn Silage to the Ration.

Silage fed per day	Roughage in basal period	Grain	Difference due to change from basal to silage ration expressed by + or -: Saponification Value	Reichert-Meissl Number	Iodin Value	Melting Point
Lbs.						Degrees C.
44 [25]	Hay	Corn meal Middlings Gluten		+ 2.2		- 2.4
30 to 40 [9]	Timothy Corn Stover	Corn 4 Bran 2 Oilmeal 1	+ 3.1	+ 3.31	- 4.17	+ 0.58
20 to 25 [9]	Do.	Do.	+ 1.8	+ 2.46	- 2.92	- 0.65
35 [13]	Alfalfa	Corn 3 Oats 2 Bran 2 Oilmeal 1		+ 3.3	- 5.1	0.00
30 to 40 [9]	# Timothy, Corn Stover	Corn 4 Bran 2 Oilmeal 1	+ 4.7	+ 3.7	-1.6	- 0.95
20 to 25 [9]	Do. #	Do.	+ 3.9	+ 2.84	- 0.81	- 0.93

\# .6 lb. cottonseed oil fed in all periods.

Note: Figures in parentheses refer to like numbers in the bibliography.

It would be expected, then, that when the two feeds are used together that the effect of neither one would be as prominent as when used alone. Each would in a way neutralize the effects of the other. That such a condition has been observed is shown by the following:

Curtis[4] concluded from practical observation that any green feed in the ration would make possible the feeding of more cottonseed meal without injury to the quality of the butter. Eckles and Palmer[9] conclude from their experiments, "That corn silage contains a specific substance, or substances, which counteract the effects of feeding cottonseed products upon the composition and properties of butter." These statements are substantiated by the work of other investigators, which is summarized in Table VII.

The data presented in Figures I. to IV. are the best available to show the actual results obtained by adding both silage and cottonseed meal to a ration. These plates indicate very clearly that silage tends to bring the constants affected by cottonseed feeding back toward normal. By inducing the change in the opposite direction, silage counteracts the effects of cottonseed meal on the constants of butter fat. There is a belief among practical men that a better quality of butter is produced on cottonseed meal if silage forms a part of the ration. The relation between the constants and market quality has not been established, but if one exists it is to be expected that any substance which neutralizes the effect of cottonseed meal on the constants would also counteract its effect on the quality of butter.

Conclusions.

The work of previous investigators indicates the following:

(1) Cottonseed meal, when fed in liberal amounts, produces a butter with a hard, brittle body, oily flavor, and increased resistance to heat and the processes causing deterioration. These characteristics accompany a change in the composition indicated by a high melting point, and iodin value, and a low saponification value and Reichert-Meissl number.

(2) The effect of silage is to produce changes in the fat constants directly opposite to those caused by cottonseed products.

(3) When cottonseed meal is fed with silage its effect on the body, flavor, heat resistance, and composition of butter are not as pronounced as when it is fed with dry roughage.

EXPERIMENTAL.

Outline of Problem.

The object of this experiment was to determine the extent to which corn silage counteracts the effects of cottonseed meal on the composition and market qualities of butter.

Twelve pure-bred cows were selected from the university herd and divided into two lots of six cows each. At the beginning of the third period it became necessary to drop cow No. 238 on account of the rapid decrease in her milk flow, and the experiment was completed with only five animals in Lot I. Table IX. gives a description of each animal.

Table IX.

Description of Cows Used.

Number of cow	Breed	Age Years	Weight Lbs.	Date of Breeding	Days in milk prior to Nov.5
Lot I.					
64	Jersey	6	1000	Jan. 20	70
67	Jersey	5	950	Nov. 16	127
101	Jersey	2	700	Oct. 25	207
304	Ayrshire	10	1050	Jan. 20	85
311	Ayrshire	5	1000	Feb. 17	57
238	Holstein	4	1050	June 15	179
Lot II.					
11	Jersey	8	950	Oct. 19	175
93	Jersey	3	800	Nov. 14	136
301	Ayrshire	13	1000	Jan. 27	37
305	Ayrshire	9	1050	Dec. 9	103
315	Ayrshire	3	900	Feb. 13	20
227	Holstein	7	1150	Dec. 23	66

The basal ration consisted of silage, equal parts of alfalfa and timothy hay, and a grain mixture of two parts of corn meal, one part of distillers' grains, and one part of bran. This was fed to all animals through the first and fourth periods. During the second and third periods, cottonseed meal in amounts of three and five pounds respectively, was substituted for equal weights of the grain mixture. The cottonseed meal used tested ten per cent ether extract. Lot 2 during the second and third periods received an increased amount of hay in place of silage. The nutrient content of all rations was adjusted to meet the requirements of the animal for maintenance and milk production, care being taken in all cases to avoid underfeeding. The plan of feeding, and the average ration fed each lot, are shown in Table X.

All the milk produced by the two groups during the last three days of each period was separated and the cream ripened with a commercial starter. The conditions were controlled as closely as possible throughout the process of separating, holding, and churning the samples. To provide against loss or accidant, the cream from both groups in each period was handled in duplicate, the first three milkings constituting the "A" churning, and the last three milkings the "B" churning. The cream was churned in a semi-commercial way, and as soon as the butter was salted and worked, samples were prepared for scoring and analysis, for a study of the keeping quality, and for the determination of the physical and chemical fat constants. The official methods of the American Association of Official Agricultural Chemists were used for the analysis of the butter for moisture, fat, ash, curd, and salt; the indirect method for fat being used.[24]

Table XI. gives the yield of milk and fat for the last three days of each period.

Table XII. gives the record of each churning.

Table XIII. gives the analysis of the butter from each churning.

Table V.

Rations Fed During the Experiment.

Period	Date	Lot I.	Lbs.	Lot II.	Lbs.
1 Basal	Nov. 5 to Nov. 23	Silage	29	Silage	28
		Hay (1)	9	Hay (1)	9
		Grain (2)	8	Grain (2)	9
2 Experimental	Nov. 23 to Dec. 15	Silage	29	Hay (1)	18
		Hay (1)	9	Grain (2)	7
		Grain (2)	6	Cottonseed Meal	3
		Cottonseed meal	3		
3 Experimental	Dec. 15 to Jan. 1	Silage	29	Hay (1)	18
		Hay (1)	9	Grain (2)	4
		Grain (2)	4	Cottonseed Meal	5
		Cottonseed Meal	5		
4 Basal	Jan. 1 to Jan. 21	Silage	29	Silage	28
		Hay (1)	9	Hay (1)	10
		Grain (2)	7	Grain (2)	9

(1) Equal parts alfalfa and timothy hay.

(2) Corn meal 2 parts, distillers' grain 1 part, and bran 1 part.

Table XI.

Yield of Milk and Fat During Each Sampling Period.

Number of cow	Period I. Nov. 20, 21, and 22.			Period II. Dec. 14, 15, and 16.		
	Milk	Fat	Fat	Milk	Fat	Fat
	Lbs.	Per cent	Lbs.	Lbs.	Per cent	Lbs.
Lot I.						
64	80.0	6.0	4.8	72.5	6.1	4.4
67	55.9	4.3	2.4	53.7	4.7	2.5
101	38.4	6.0	2.3	35.2	6.2	2.2
304	61.7	4.0	2.5	60.7	4.0	2.4
311	82.7	3.8	3.1	81.0	4.0	3.2
238	50.0	4.1	2.0	17.3	3.6	0.6
Total	368.7		17.1	320.4		15.3
Lot II.						
11	49.3	5.0	2.5	37.3	5.1	1.9
93	56.7	5.8	3.3	46.5	5.9	2.7
301	99.4	3.4	3.4	84.7	3.6	3.0
305	77.9	4.1	3.2	71.0	3.9	2.8
315	93.0	4.3	4.0	82.8	4.1	3.4
227	116.3	3.0	3.5	97.5	3.0	3.0
	492.6		19.9	419.8		16.8

Number of cow	Period III. Dec. 29, 30, and 31			Period IV. Jan. 18, 19, and 20.		
	Milk	Fat	Fat	Milk	Fat	Fat
	Lbs.	Per cent	Lbs.	Lbs.	Per cent	Lbs.
Lot I.						
64	61.9	6.3	3.9	55.0	6.5	3.6
67	46.2	4.9	2.3	43.5	5.3	2.3
101	32.9	6.3	2.1	32.4	6.3	2.0
304	60.0	4.0	2.4	55.1	4.0	2.2
311	73.0	4.1	3.0	70.2	4.2	2.9
238	---	---	---	---	---	---
Total	274.0		13.7	256.2		13.0
Lot II.						
11	33.4	5.3	1.8	31.8	5.6	1.8
93	49.4	6.0	3.0	47.9	6.0	2.9
301	86.5	3.6	3.1	82.7	3.0	2.5
305	60.4	3.9	2.4	54.1	3.8	2.1
315	78.2	4.3	3.4	75.3	4.5	3.4
227	96.0	3.0	2.9	83.4	3.0	2.5
Total	403.9		16.6	375.2		15.2

Table XII.

Churning Record.

Period	Lot	Churning	Fat in Cream	Acid in Cream	Churning Temp.	Time Churning	Fat in Butter Milk
			Per cent	Per cent	Deg.F.	Minutes	Per cent
	I.	A	30	0.60	62	50	0.50
		B	29	0.70	60	45	0.13
1							
	II.	A	30	0.60	62	35	0.28
		B	30	0.70	60	25	0.15
	I.	A	24	0.50	60	60	
		B	30	0.75	58	15	0.38
2							
	II.	A	29	0.50	60	25	0.45
		B	30	0.65	58	25	1.10
	I.	A	30		58	25	
		B	30		60	25	
3							
	II.	A	30		60	30	
		B	30		60	30	
	I.	A	30	0.56	58	20	0.24
		B	30	0.63	57	60	0.40
4							
	II.	A	27	0.43	58	25	0.21
		B	30	0.60	58	30	0.11

Table XIII.

Analyses of Butter.

Period	Lot	Churning	Moisture	Fat	Ash	Curd	Salt
			Per cent	Per cent	Per cent	Per cent	Per cent
1	I.	A	11.8				
		B	10.6				
	II.	A	12.0				
		B	13.0				
2	I.	A	15.68	81.50	1.73	1.12	1.72
		B	15.57	80.80	2.61	1.19	2.75
	II.	A	14.90	80.50	2.77	2.08	2.75
		B	15.90	79.30	3.36	1.14	3.42
3	I.	A	14.97	81.70	2.16	1.19	2.17
		B	15.52	80.95	2.54	1.06	2.05
	II.	A	15.22	81.35	2.46	0.99	2.59
		B	16.62	80.15	2.21	1.07	2.26
4	I.	A	15.79	81.35	2.05	0.96	2.03
		B	17.40	77.90	3.31	1.63	3.24
	II.	A	15.47	79.90	3.48	1.31	3.34
		B	14.70	82.50	2.31	0.93	2.26

Score.

Samples of butter from each churning were packed in paraffined cartons and shipped directly to M. Mortensen, Chief in Dairying at Iowa State College, Ames, Iowa. Table XIV. gives the scores which he assigned to each sample.

Table XIV.

Comparative Score of Butter.

Period	Lot	Churning	Feed: Cottonseed Meal Lbs.	Feed: Silage Lbs.	Score
1	I.	A	0	29	
		B	0	29	
	II.	A	0	28	
		B	0	28	
2	I.	A	3	29	91.0
		B	3	29	92.0
	II.	A	3	0	92.0
		B	3	0	92.5
3	I.	A	5	29	91.0
		B	5	29	91.5
	II.	A	5	0	92.0
		B	5	0	92.0
4	I.	A	0	29	91.0
		B	0	29	90.5
	II.	A	0	28	90.5
		B	0	28	91.0

An examination of Table XIV. shows that the butter made during the periods when cottonseed meal was fed, was scored higher than that from the last basal period. Samples of the first basal period were not sent to Professor Mortensen; so no comparison of these can be made in this study. There was no outstanding defect, however, in the butter from the last basal period, as shown by the fact that all samples received a score above 90. Neither can it be considered that the butter made during the cottonseed meal periods was markedly superior in quality; yet its uniformly higher score indicates that the butter was not injured by feeding these products. It is to be further noted that the score is slightly in favor of the butter from the group receiving hay instead of silage, when cottonseed meal was fed. In the three pound period, the "A" churning from the group receiving silage was characterized as "greasy and flat"; while in the five pound period, both the "A" and "B" churnings on this roughage were referred to as "a trifle oily." This shows that the characteristic effect of cottonseed meal in imparting an oily flavor was noticed, and that it was more pronounced on the silage ration.

In judging the butter, Professor Mortensen made all his cuts for flavor, and yet he pointed out some slight defects in body. From the three pound period both samples produced on silage and the "A" churning on hay were referred to as having a "hard, brittle body"; while that of the fourth sample was "good." In the five pound period both churnings from the group receiving silage resulted in a butter with a "hard body." On the other hand, he stated that the basal butter had no defects in body and that it was perfect in everything except flavor.

Such results indicate that the cottonseed meal produced a harder butter, and that silage increased, rather than decreased, the effect. Although Professor Mortensen criticised the body of these samples, he stated that the defect was not objectionable, and a commercial judge would not deduct for it.

All samples were examined by Professor Eckles and the writer and the following observations made. The butter produced from the first basal ration was of good quality. More difference was noticed between the "A" and "B" churnings from each lot than between the two "A" churnings, or between the two "B" churnings. It seems that the conditions under which the samples were handled had varied enough to produce a perceptible difference in the two samples from the same group, for the two "A" churnings which were ripened together were very similar, and likewise the two "B" churnings. Each of the "A" churnings contained more curd than the others. There was, however, no distinction between the butter from the two groups.

In the second period when both lots received three pounds of cottonseed meal, there could be distinguished a slight taste of oil. This was more pronounced in the butter from the "A" churnings; yet even in these samples it might easily pass unnoticed. A high melting point was observed in the two samples having the oily flavor. They seemed to remain firm on the palate longer than the other samples. However, there appeared to be no difference in the butter due to the character of the roughage; although it may be recalled that Professor Mortensen spoke of the oily flavor only in the butter from that group which received silage.

An oily flavor and a high melting point were more noticeable in the third period, when five pounds of meal were fed, than in the second period. All samples possessed these characteristics to some extent; yet they would not be observed except on a close examination. The oily taste was more distinct in the butter from Lot I., as referred to by Professor Mortensen. The butter from Lot II. was characterised more by a lack of flavor than by any noticeable off flavor. None of the effects were sufficiently pronounced to decrease the market value of the butter. The effect of the cottonseed meal, as in the three pound period, in giving an oily flavor, appeared to be stronger on the silage feed than on the dry roughage.

At the close of the last basal period the butter seemed to be perfectly normal. It melted quickly in the mouth and had no trace of the oily flavor found in the previous periods; in fact, there were no indications of the effect of cottonseed feeding. All samples in this period were uniform in quality. These observations correspond very closely to those of Professor Mortensen on the samples of the same butter.

From a study of the scores and criticisms, the following conclusions would be drawn in regard to the market quality of the butter from this experiment:

(1) Cottonseed meal, when fed in quantities of three to five pounds, imparted a slight oily flavor, and produced a hard body in the butter.

(2) These effects were fully as pronounced when silage was fed with the meal as when hay constituted the sole roughage.

(3) The results of the cottonseed meal feeding were not sufficiently pronounced in the fresh samples to detract from the market value of the product.

Standing Up Temperature:-

The degree of heat which butter will withstand before it loses its shape is of some economic importance. It is common to see a cake of butter soften at room temperature and assume a semi-liquid consistency, especially in summer weather, when small amounts are kept for immediate consumption. Under these conditions considerable inconvenience is experienced in serving it for table use. Previous work indicates that the feeding of cottonseed meal gives the butter an increased resistance to heat. To test this quality of the butter it was heated until the temperature was reached at which it began to lose its shape and spread. For convenience this point was designated by the term "standing up temperature."

The method used in determining the standing up temperature of the butter consisted in taking a rectangular piece, one and one-half inches square and three-quarters of an inch thick, from each churning. These cakes were placed in shallow metal dishes and kept at a temperature below ten degrees Centigrade for at least twelve hours before the test. They were then transferred to an electric oven and held during a preliminary period of half an hour at a temperature of thirty degrees Centigrade. A small electric fan was used to maintain a uniform distribution of heat throughout the oven. At the close of each subsequent thirty minute period the temperature was raised one degree, until all samples had lost their shape. Frequent observations were made and the spreading temperature determined for each sample. In every case the "A" and "B" churnings which were heated separately lost shape at the same temperature. Thus, the results shown in Table XV. represent duplicate tests.

Table XV.

Effect of Cottonseed Meal on Standing Up Temperature.

Period	Lot	Ration		Standing Up
		Silage	Cottonseed Meal	Temperature
		Lbs.	Lbs.	Degrees Centi.
1	I.	29	0	34
2	I.	29	3	34 to 35
3	I.	29	5	35 to 36
4	I.	29	0	34
1	II.	28	0	33
2	II.	0	3	34 to 35
3	II.	0	5	35 to 36
4	II.	28	0	33

It will be remembered that Periods 1 and 4 were basal in which silage was received by both lots but no cottonseed meal was included in the ration. Both basal samples from each group lost shape at the same temperature, but this was one degree lower for Lot II. than for Lot I. Such a relation shows that a difference existed between the samples under normal conditions. The butter from both lots on the three pound ration lost its shape at a temperature between thirty-four and thirty-five degrees; while on the five pound period the temperature for both groups was between thirty-five and thirty-six degrees. This represents a rise of from one to three degrees over the basal ration periods. Since Lot II. was one degree lower than Lot I. in the basal periods, and the same in the experimental periods, it is evident that its standing up temperature was increased more than that of Group I. As they both received the same amount of cottonseed meal, the results would indicate that the silage which was fed to Group I. had prevented the effect of the meal from becoming so prominent. Such results were expected, for all previous experiments indicate that the melting point of butter is lowered when silage replaces dry feed in the ration.

This test confirms the belief that cottonseed meal increases the standing up temperature of butter, and indicates that silage counteracts this effect to a slight degree. It is evident, then, that the best results in increasing the standing up quality of butter by the use of cottonseed products will be obtained on dry roughage; although the effects are sufficiently pronounced to be of some commercial value when silage is fed.

Keeping Quality:-

For the test on keeping quality, six 2-1/2 oz. glass jars were packed with the butter from each churning. The samples of the "B" churnings were immersed in strong brine and kept in the refrigerator, at a temperature of eight to twelve degrees Centigrade. One jar could thus be examined at any time without disturbing the other samples. The jars of the "A" churnings were kept at room temperature (twenty-six to thirty-five degrees Centigrade). After the samples had been kept for some weeks, the tops were dipped in paraffin to prevent the entrance of molds. Some of the samples had already become contaminated, but the fresh butter which was treated in this manner showed no effect of mold growth during the entire period in storage.

The butter from both basal periods developed a strong flavor and a slight rancidity within a month, at room temperature. A peculiar lardy, greasy taste was even more pronounced than in the cottonseed meal butter. Such a property Sayer[23] and Lewkowitsch[16] attribute to oxidation.

Since the butter had been kept in the light at a fairly high temperature, the conditions were such as to favor that process. The oily flavor was very pronounced when the butter was compared with the corresponding samples held in the cooler. Such observations indicate more clearly that the change is brought about by the influence of light and a higher temperature. The salvy taste and the rancidity increased with the length of time that the butter was stored.

Much trouble was experienced with molds in the samples made on the experimental rations. Five samples, however, were held for two months or more free from contamination. The chief characteristic of this butter produced on the cottonseed meal ration was an oily, lardy flavor, similar to that observed in the check samples; except that it was not rancid. There seemed to be a lack of flavor instead of any distinct off flavor. It is not probable, however, that the development of the oily flavor in the samples of cottonseed meal butter kept at room temperature is associated with the peculiar properties of fresh cottonseed meal butter, which has also been described as "oily." The basal butters developed the same characteristics in an even more pronounced degree, as has already been pointed out.

It is uncertain how long the cottonseed meal butters would have retained their superiority over the basal samples, but after two months in storage, the butter made at the close of the second and third periods was superior to that from the first and fourth periods. No definite conclusions can be drawn from this part of the experiment, for too few samples remained in a condition such that the relative keeping qualities could be judged. Where comparisons could be made, however, the results corresponded to those secured by Graves,[9] who found that cottonseed meal butter went off in flavor from one to two months later than basal butter.

The samples held under brine in the refrigerator were slower in showing a change than those held at room temperature. At the end of two months the basal samples lacked the quick flavor of fresh butter. It possessed a strong, old taste, which was not very marked, but this was more pronounced after three months; in fact, at that time it was so noticeable that the butter would not have been acceptable for table purposes.

The butter made on the cottonseed meal rations was judged to be in as good condition after two months as when put in storage. A slight butter-milk flavor was noticed in one sample, and another was rather oily; yet this was characteristic of the butter when fresh. After three months it was far from being objectionable. A little more pronounced oily flavor existed in all samples, and one was somewhat strong, but this property was not sufficiently pronounced to seriously detract from its value. Thus, at the end of three months all the butter made in the periods when cottonseed meal was fed was superior to that from the basal periods, and was judged to be of about the same quality as the basal butter at two months. After four months the butter from Lot I. was in very fair condition, showing that this had an advantage in keeping quality of fully two months. Lot II., however, was much inferior at this time.

It was not possible to compare samples of equal age from different periods, but as a general check on the work, two classes of butter were made up of a sample from both lots in each period. At that time the butter from Period I. had been stored for five months and that from Period IV. three months. The age of the other samples was between these limits. When judged comparatively, the oldest basal butter stood lowest, as would have been expected; next came the samples from the ration of cottonseed meal and hay. These had already been regarded as inferior to the corresponding samples from the silage group. The butter from the other groups was not placed consistently, but tended to show, however, that the last basal butter at three months was in about the same condition as the cottonseed meal butter three to six weeks older.

There was also an opportunity to compare the influence of silage on the effect which cottonseed meal exerts upon the keeping quality of butter. The samples were held for equal periods and judged at the same time. Contrary to expectations, the keeping quality was improved by the silage. All the other effects of cottonseed meal on butter are commonly decreased when silage is included in the ration. Since this is true of the composition of the fat, it appears that no direct relation exists between the keeping quality and the fat constants. Some factor other than the nature of the fat must control the deterioration of the butter. This was observed by Dyer[6] after studying the effects of oxidation. There also seemed to be no relation between the amount of meal fed and the influence on the keeping quality, for three pounds of meal produced as much effect as five pounds.

The degree of difference in the keeping quality of the samples was not as large as that reported by Eckles and Palmer[9] but the experiment shows that the addition of cottonseed meal to the ration tends to decrease the rate of deterioration in butter and that this effect is increased by the feeding of silage.

Fat Constants:-

A portion of the butter from each churning was rendered and the fat used for determining the following physical and chemical constants: Reichert-Meissl number, iodin number, saponification value, and melting point. The methods of the Association of Official Agricultural Chemists were followed.[24] The results are given in Table XVI. The same data are shown graphically in Figures V. and VI.

Table XVI.

Effect of Silage and Cottonseed Meal on Constants of Butter Fat.

Period	Lot	Saponification Value	Reichert-Meissl Number	Iodin Value	Melting Point
				Hübl.	Deg. Centi.
1	I.	234.9	31.66	28.00	32.90
	II.	236.8	33.27	29.70	32.38
2	I.	232.9	30.95	29.01	34.18
	II.	229.2	29.63	34.69	34.35
3	I.	233.4	31.08	28.88	34.00
	II.	227.4	30.01	34.42	33.98
4	I.	232.2	29.63	30.22	33.03
	II.	232.5	30.73	32.11	32.45

A study of Figures V. and VI. shows that all the constants fluctuated during the experiment and were not the same at the close of the two basal periods. The Reichert-Meissl number and saponification values were lower at the end of the experiment than at the beginning, and the iodin value and melting point were higher; although the last constant rose only slightly. This at once suggests the question whether the difference can be attributed to the advance in lactation or to the residual influence of the experimental ration. In this connection it may be recalled that Eckles and Shaw[6] found a gradual change in the constants accompanying the advance in the milking period, and that this change in each case was in the direction described above. So, it may be considered that the trend of the fluctuation in this experiment was normal. A comparison of the results shown in Figures V. and VI., with the data presented in Table V., indicates, however, that the amount of fluctuation was somewhat greater than would be expected for a group of cows at this stage of lactation. It is possible that the effect of the cottonseed meal was still influencing the constants to prevent their return to normal at the end of the experiment. In as much as the fat constants of the two groups, shown in figures V. and VI., occupy the same relative position at the close of the second basal period as at the

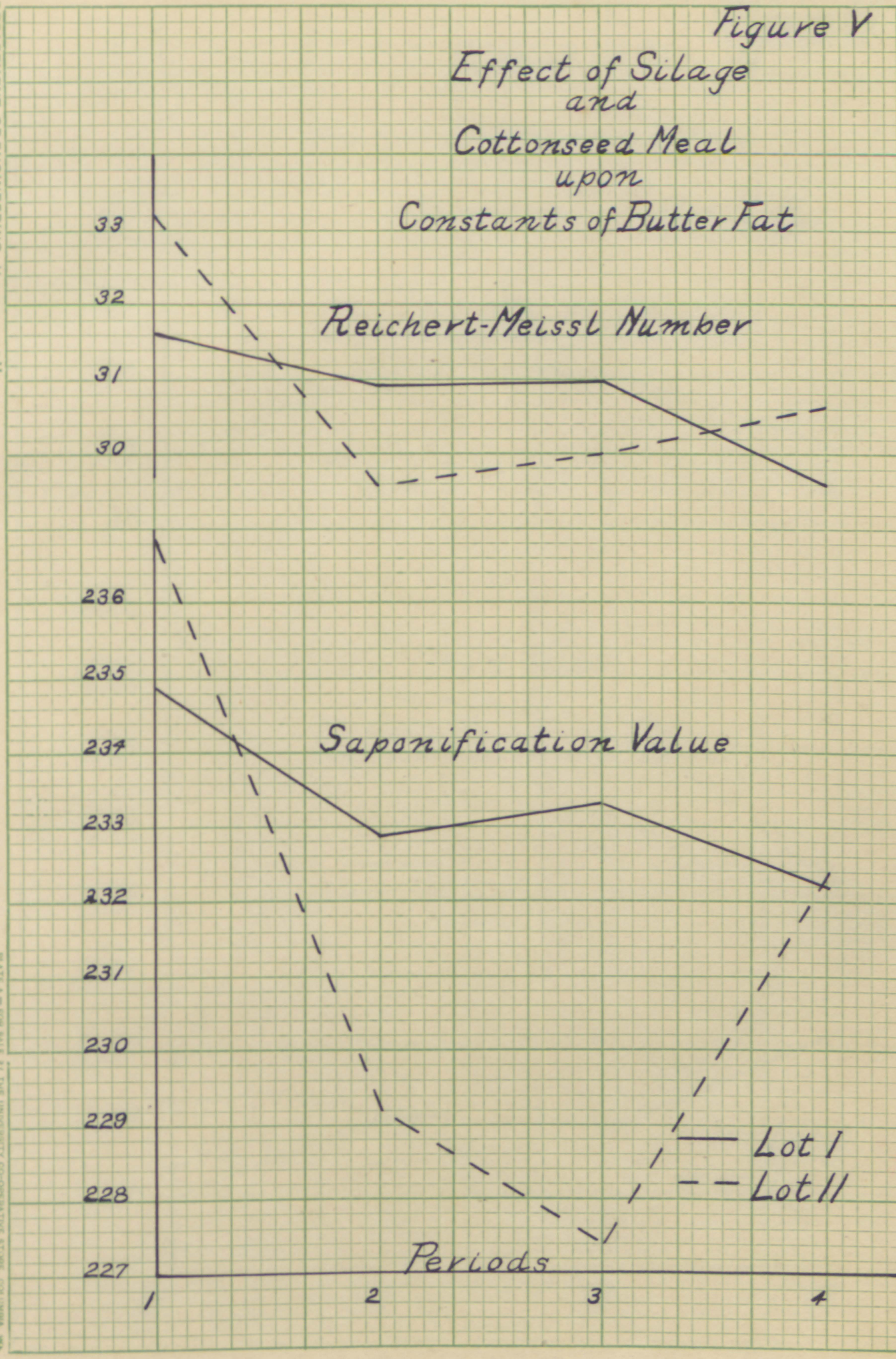


Figure V
Effect of Silage
and
Cottonseed Meal
upon
Constants of Butter Fat
Reichert-Meissl Number
33
32
31
30
Saponification Value
236
235
234
233
232
231
230
229
228
227
Lot I
Lot II
Periods
1
2
3
4

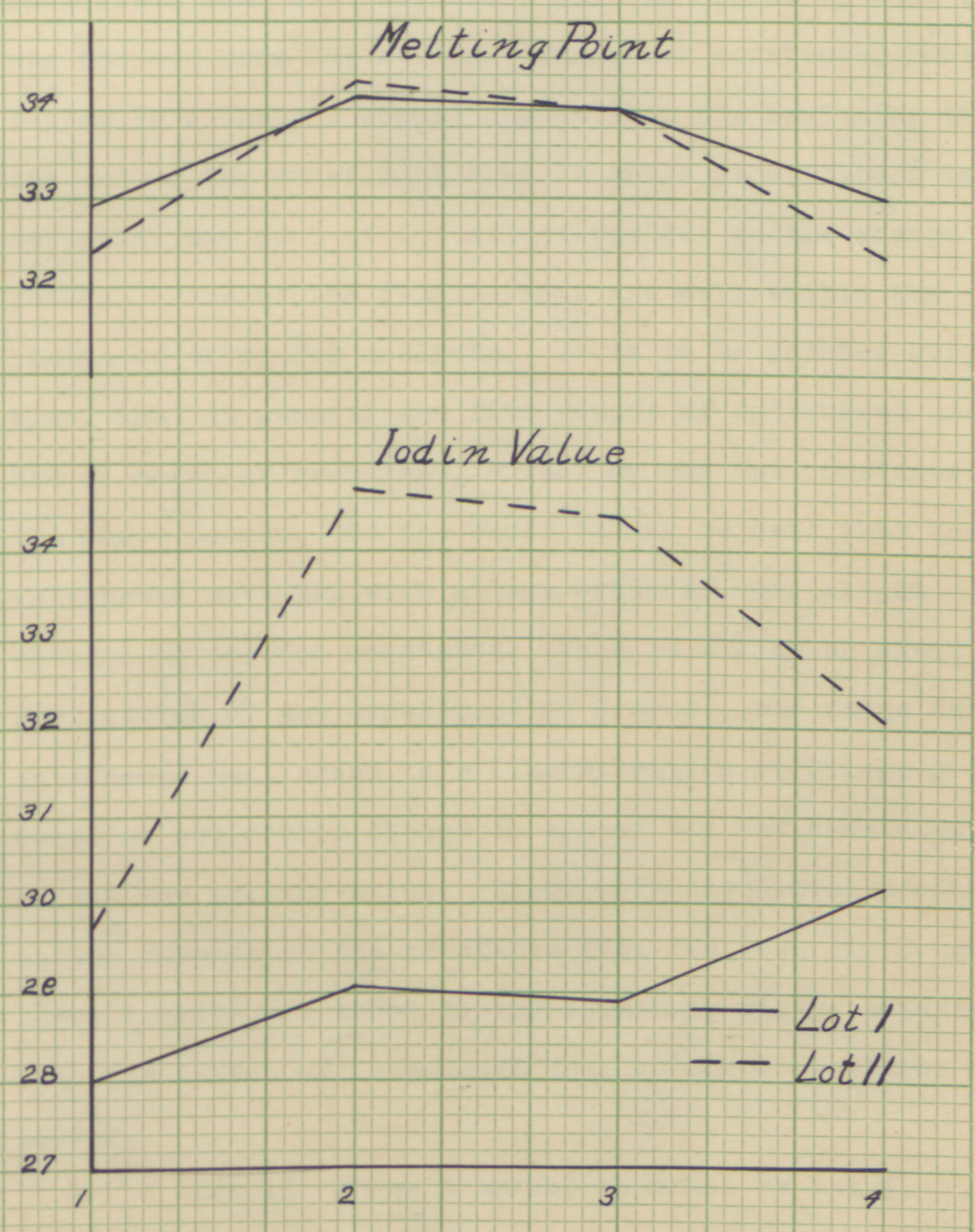


Figure VI
Effect of Silage and Cottonseed Meal upon Constants of Butter Fat

close of the first, the data serve for comparing the effect of the experimental ration.

The next noticeable feature is the small range of fluctuation in the constants for Lot I. The melting point shows a characteristic rise in Periods 2 and 3, when cottonseed meal was fed, and a fall in Period 4, when it was removed from the ration. The other constants, however, follow so closely a normal change from the beginning to the end of the experiment that it would be difficult to determine how much of the effect was due to the change in ration. Some of the fluctuations are well within the limits of error for analysis. It is to be pointed out, also, that in general the five pounds of cottonseed meal had no more, or even less, effect on the fat constants than the three pounds. On the whole it may be said that the cottonseed meal fed with silage produced very slight changes in the fat constants. This is almost an exact duplication of the experiment of Graves[9], who found that cottonseed meal added to a liberal ration of silage produced no noticeable change in any of the fat constants except the melting point. Since cottonseed meal produces marked changes in the constants when fed with dry roughage, these results are taken to indicate that silage counteracts the effect of cottonseed meal on the composition of butter.

Lot II. shows a marked contrast to Lot I.

There was a sharp rise in the iodin value and melting point and fall in the saponification value and Reichert-Meissl number when the experimental ration was substituted for the basal. All the constants returned towards normal in the last period. As in Lot I., the effect of five pounds of meal appeared to be less than that of three pounds, except in the case of the saponification value. The sudden and marked changes throughout the experiment, in Lot II., are similar to those reported in Table VI., which were attributed to the effect of cottonseed meal. It may be stated that the chief difference between the behavior of the constants in Lots I. and II. is the degree of fluctuation on the experimental rations. In Lot II., when cottonseed meal was fed with hay, the changes were much greater than in Lot I. which received silage with the meal.

If Lot II. had been given hay and no silage throughout the experiment, the marked fluctuations in the constants in comparison with Lot I. would have shown very clearly that cottonseed meal produced more change in the composition of the butter with dry roughage than with silage. It would then have been clearly indicated that silage counteracts the effect of cottonseed meal. However, another factor entered to influence the results. In the basal periods, Lot II. received silage; while during the experimental periods, hay was fed alone. The effect of roughage was clearly shown in the experiment by Eckles and

Palmer,[9] and substantiated by the work of Hunziker.[13] Their results indicate that the composition of butter fat is influenced to a marked degree by the removal of silage from the ration. The withdrawal of this feed brings about the same changes in the constants as the addition of cottonseed meal. It must be recognized, then, that the fluctuations observed in Lot II. were caused in part by the character of the roughage fed during the different periods.

It is difficult, therefore, to determine the exact amount of change in the fat constants of Lot II. which can be attributed respectively to the change in roughage and the addition of cottonseed meal. It is possible, however, to use the results presented in Figures I. to IV. as an approximate standard by which to measure the effects of roughage. In the experiment which these figures represent the removal of silage from the ration caused as much change in the Reichert-Meissl number and iodin value as was produced in the experiment represented by Figures V. and VI. The melting point and saponification value, on the other hand, were affected slightly less than in the present experiment. Such a comparison is open to criticism, yet it serves to show that the roughage is an important factor, and was partly responsible for the changes in all the constants. During the period of cottonseed meal feeding the saponification value was depressed to a marked degree, more in fact than in any other of the tabulated experiments. The total drop was 9.4 as compared with 6.1, the next largest figure reported. In this connection it may be noticed, (1) that the number was abnormally high at the start; (2) that this large drop accompanied a change in both the roughage and grain ration. The results which appear in Table VI., on the other hand, can be attributed to cottonseed meal alone; since the roughage was kept constant. The large fluctuation in the saponification value is then undoubtedly caused by the combined influence of the roughage and the cottonseed meal. Both of these factors are similarly combined to influence the other constants. It is not possible, however, to estimate the amount of change which is to be attributed to each.

In general, this experiment shows that very slight effects on the composition of butter result from feeding cottonseed meal with a liberal ration of silage; and that larger changes in the fat constants are to be expected when the meal is fed with a dry roughage, like alfalfa and timothy hay. It is believed that silage has the power to reduce the influence of cottonseed meal on the composition of butter, but the experiment fails to show the extent of this counteracting effect.

Conclusions.

From the results of this investigation the following conclusions may be drawn:

(1) The slight oily flavor and increased hardness of butter caused by feeding five pounds of cottonseed meal with dry roughage is fully as pronounced when silage constitutes a part of the ration.

(2) Silage tends to counteract the increased heat resistance of butter due to the use of cottonseed meal.

(3) The influence of cottonseed meal to retard deterioration in butter is not decreased but actually strengthened by the action of silage.

(4) When five pounds of cottonseed meal is added to a ration containing a liberal amount of silage, the changes obtained in the fat constants are very slight; but the experiment failed to show the extent to which the roughage inhibits the action of the meal.

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