THE EFFECT OF FEEDS ON THE CHEMICAL AND PHYSICAL COMPOSITION OF BUTTER.

MAJOR THESIS IN DAIRYING SUBMITTED BY

F. C. WILLIAMS.

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PURPOSE.

The purpose of this experiment is to determine the effects of (1) season of year, (2) period of lactation, and (3) different foods on the physical and chemical composition of butter fat.

PLAN OF EXPERIMENT.

In mapping out the experiment discussed in this paper, special attention was paid to the selection of cows of same breed, age, size, and period of lactation.

The milk and butter from each cow was handled and analysed separately through the entire process. In every instance, the milkings for seven days were handled alike.

The De Laval separator was used, and was regulated to deliver 20 per cent cream. Before separating, the milk was heated to 85 degrees, and the cream at once cooled down and put in its respective cans.

Cream was ripened and churned under standard conditions in every case and one pound prints made.

EFFECT OF SEASON OF YEAR.

(1).Moisture Content.

As every observant butter maker knows, the season of the year has a very marked effect on the moisture content of butter. However, there are a few other factors that may and do cause this to vary, such as locality, crops, and weather conditions, but every thing being equal, it has time and time again been demonstrated that an early spring and summer butter takes on an excess of moisture. This is, of course, due to pasture and dif ferences in feeds, bbecause the per cent of moisture decreases during the late fall and winter months.

(2). Chemical Composition.

As was demonstrated above that the season of the year has a marked effect on the moisture content, so it necessarily has a corresponding effect upon the chemical composition.

In this experiment time was not allowed to go into this phase of the subject very deeply, but the following table plainly shows this point.

This experiment extended over twelve months, beginning in January and ending December, 1915.

TABLE NO. I.

(1). EFFECT OF SEASON OF YEAR ON CHEMICAL COMPOSITION OF BUTTER FAT.

	R.M.No.	Iodine No.	Melting Point.
Jan.	30.08	31.20	33.40
Feb.	30.50	31.97	33.5
Mar.	31.30	31.94	33.5
Apr.	29.35	35.83	33.3
May	29.55	36.48	32.5
June	29.56	38.23	32.45
July	28.90	37.10	31.9
Aug.	27.13	38.99	32.1
Sept.	27.13	35.36	33.0
Oct.	26.45	34.27	33.2
Nov.	28.36	30.65	33.4
Dec.	29.63	30.30	33.6

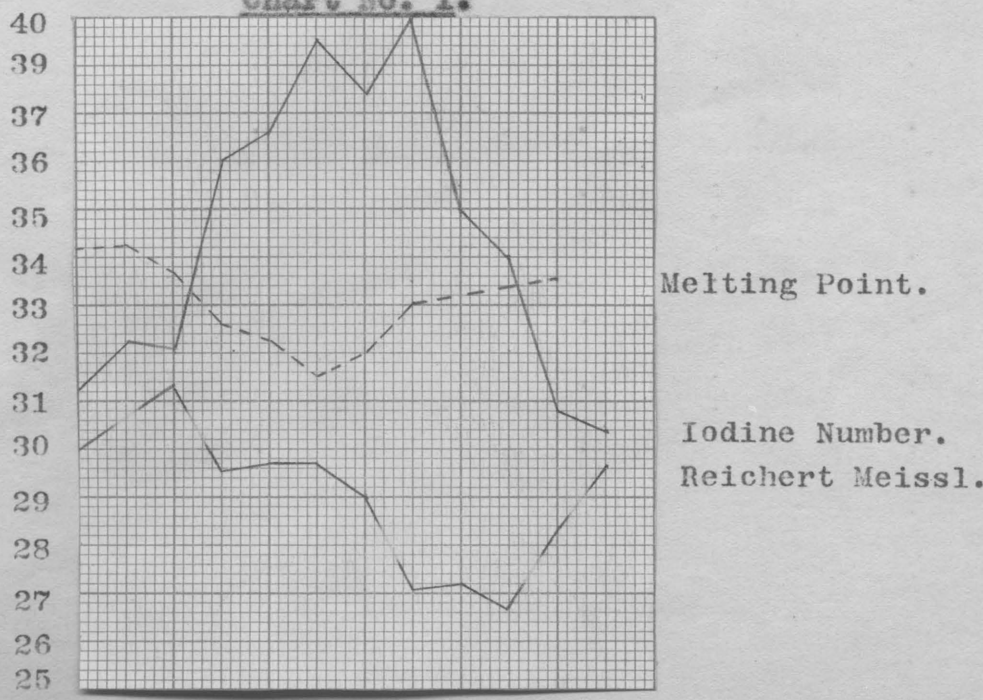
A study of Table No. 1 plainly illustrates the fact the per percent of valatile fatty acids was at its maximum during March and decreased steadily but slowly until October, after which time it made a marked increase during the following four months:

It will also be noticed that the Iodine absorption number was greatest during the summer months, decreasing rather rapidly during the fall and early winter. Then during January, February and March this value increased slowly but made an abrupt rise in April.

It is also interesting to note that the melting point was inversely as the iodine value. That is, in winter it was at its highest, and lowest during summer.

It will also be recalled that the moisture per cent is considerably higher in summer and bears a certain relation to the melting point; the higher the per cent of moisture the lower is the melting point. It is also plainly demonstrated that the melting point is more dependent on the percentage of olein than on that of butyrin, caprolin and allied glycerides.

Chart No. 1.



EFFECT OF PERIOD OF LACTATION ON CHEMICAL COMPOSITION.

It is a well known fact to every one that there is a vast and wide difference in milk during different parts of the period of lactation. The period has not only to do with the quantity of ingredients but likewise to the quality of same. Especially is this true in case of butter fat.

Colostrum milk is said by Grimmer to test very high in per cent volatile fatty acids, and correspondingly low in per cent olein. But as the period of lactation advances, the reverse is true, that is, the volatile acids decrease, while the olein increases.

The following table will give a clear idea and understanding of this question:

Table No. 2.

I(b) Effect of Period of Lactation on Chemical Composition.

Period	R.M. No.	Iodine Value.	Melting Point.
1st Mo.	34.55	32.08	35.2 C
2nd	32.62	32.15	35.2
3rd	31.57	31.67	35.4
4th	31.89	32.0	35.2
5th	31.59	32.30	34.7
6th	31.39	32.78	34.1
7th	30.39	34.74	34.5
8th	24.48	35.90	34.7
9th	28.72	35.23	34.7
10th	29.72	33.72	34.0

The above table represents the results of three cows, fed on a uniform ration, evading such feeds as are known to materially effect the butter fat constant.

Table No. 2 plainly illustrates that the volatile acids were highest during the early part of the period of lactation, decreasing slowly up to the last month, while the olein was lowest during the early part of the period of lactation and increased steadily as the period advanced. It is also very interesting to note that the volatile acids and olein vary inversely.

The Melting point varies but little, which is of remarkable interest.

Chart No. 2.

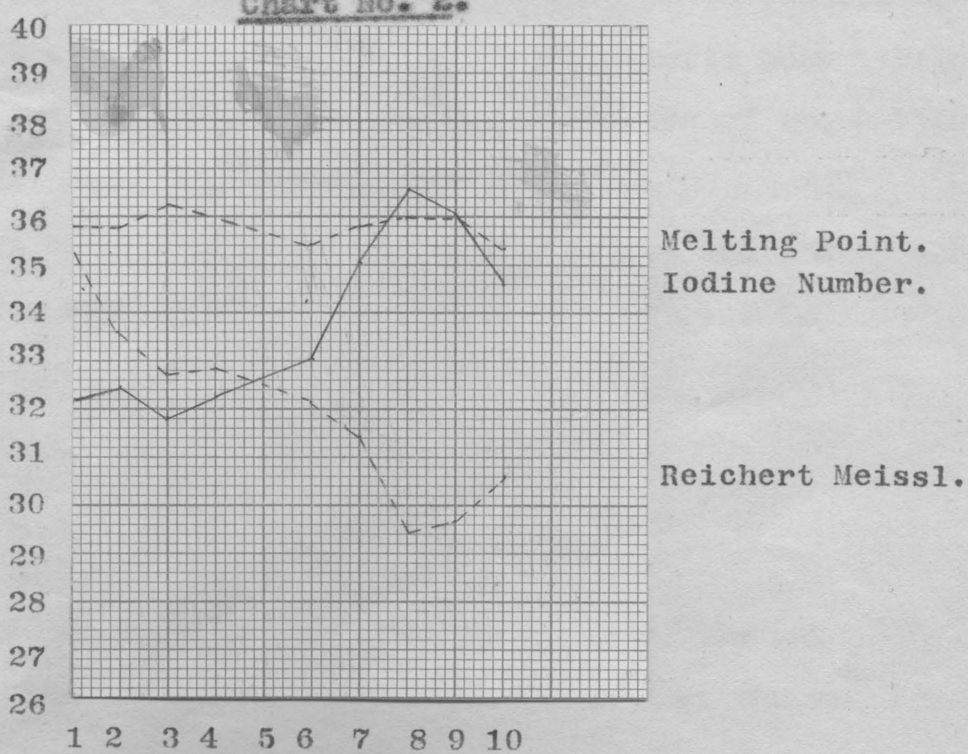


Chart No. 2 shows that the percentage of volatile acids is depentent upon the period of lactation and falls in general with the length of that period.

EFFECT OF FEEDS ON CHEMICAL and PHYSICAL COMPOSITION OF FAT.

Studies upon the composition of various feeding stuffs, especially upon the oils, have led to the supposition that in some instances the peculiar properties of feeds affect the composition of fat and various other dairy products.

In this experiment the writer had the following feeds under test: viz., cottonseed meal, linseed meal, corn silage and clover hay.

The chemical composition of butter fat, as influenced by the character of foods received by the animal, has hitherto been little studied from a chemical point of view, and to this phase of the subject special study was given.

Two cows of the College herd were selected and fed by the writer with a basal ration composed of all the feeds to be tested.

Basal Ration

4 lbs. Cottonseed meal,
4 lbs. Linseed meal,
10 lbs. Clover hay,
30 lbs. Corn silage.

When testing any of the above named feeds, the one in question was withdrawn and the ration properly adjusted to meet the requirement of the animal.

The feeding periods were conducted as follows:

Basal ----------January 20 - 27

C.S.M. ----January 27 - February 3.

Basal ----- ----- February 3 - 10

Linseed Meal ---- February 10- 17

Basal ---------- February 17- 24

Silage --- February 24 - March 2.

Basal ----------- March 2 - 9.

Clover hay ------- March 9 - 16.

Basal ---------- March 16 - 23

It will be noted that the cows were brought back to the basal ration every other week. This was done to give more accurate and reliable results.

Each week began on Thursday morning and ended the following Wednesday night. Milk was saved on Monday, Tuesday, and Wednesday of each week, and butter was made from the same and tested.

EFFECT OF OIL FEEDS ON COMPOSITION.

The following table illustrates the marked effect which oil feeds have on the chemical and physical composition of butter fat.

Table No. 3.

Feeds.	R. M. #	Iodine#	Melt. Pt.	Per cent Moisture	Hardness
Basal.	28.5	27.04	33.0	13.5	23.mm
C.S.M.	25.3	33.21	33.9	15.25	31.mm
Basal	27.7	27.17	32.3	13.9	29.mm
Linseed Meal	24.3	41.26	31.8	21.5	47.mm
Basal	28.6	26.73	33.0	13.2	25.mm

Table No. 3 shows the following facts:

First, that the oil feeds have a marked effect upon the Reichert-Meissl and Iodine Absorption values. There was an increase in the Iodine absorption value in both cases, but especially so in the case of linseed meal. This is due, no doubt, to the large per cent of olein in linseed meal.

It is also very interesting to notice that the volatile fatty acids and Iodine absorption values are just opposite.

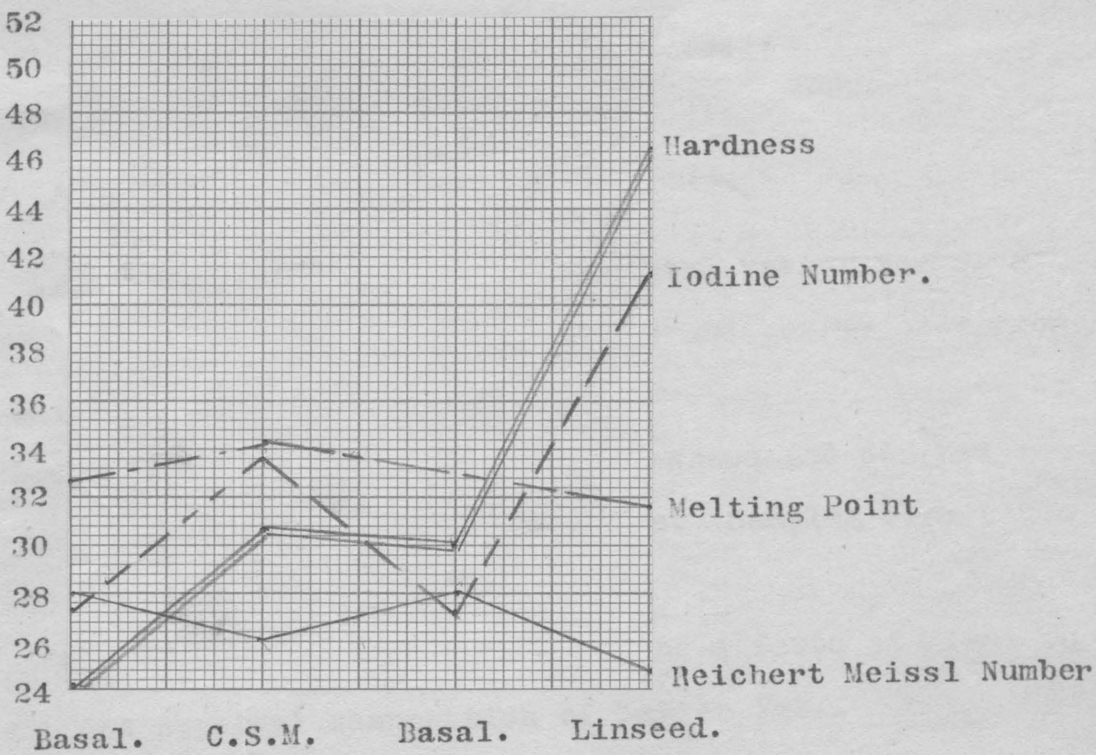
Here also we see that the melting point is affected by very little, if any.

The moisture content of linseed meal was very much increased, but did not vary very much in case of cottonseed meal.

Also, the depth which the needles penetrated, expressed in m.m., was considerably greater in case of the oil feeds. Especially so in case of linseed meal.

The butter appeared from general appearance and handlêng to be much harder and firmer in case of cottonseed meal than any other, but the test does not uphold this.

Chart No. 3.



EFFECT OF SILAGE AND CLOVER HAY ON COMPOSITION.

of Butter Fat.

Two cows were selected from the College herd and fed alternate rations of corn silage and clover hay, the rations being adjusted to meet the requirements of the animals.

EFFECT OF BLUE GRASS PASTURE ON CHEMICAL COMPOSITION OF BUTTER FAT.

Two cows of the college herd were used in this experiment. On May 30th the cows were put on basal ration, which is as follows:

4 lbs. cottonseed meal.

4 lbs. linseed meal.

30 lbs. corn silage.

*10 lbs. crimson clover.

After the cows had been on the basal ration for five days, milk was taken for six milking periods and butter made from same and analysed.

The cows were now turned out on grass and did not receive any grain in connection with the grass. Samples were taken as above and the butter analysed.

The following table will give the effects of grass on the chemical and physical composition of butter fat.

Table #5.

	Iod.	R.M.	Melt. Pt.	% H_2O.	Hardness.
Basal	29.3	26.75	33.	16.50	28.66 mm.
Grass	36.75	24.50	31.5	20.5	48. mm.

The above table will plainly show that the volatile fatty acids decreased, while the olein increased and the melting point dropped.

* Crimson clover was substituted for clover hay.

Effect of Corn Silage and Clover Hay On

Chemical Composition of Butter Fat.-

	R.M	Iodine #	Melt.	$\%H_2O$	Hardness
Basal	28.6	26.73	33.	13.2	25. mm
Silage	35.1	24.72	32.5	15.3	29. "
Basal	29.3	28.50	32.9	14.7	23. "
Hay	30.2	26.37	33.4	11.7	21. "
Basal	30.1	27.15	33.	16	27.

The above table indicates that the silage had a marked effect upon the volatile acid and caused the per cent olein to drop. This is directly opposite to that caused by the oil feeds, but again the melting point was affected but slightly.

When the cows were put back on basal ration the per cent of olein was increased and correspongingly the per cent volatile fatty acid dropped

It is also of interest to note that the addition of silage and also hay caused the moisture content of the butter fat to drop four or five points.

But the hardness seemed to follow directly the per cent moisture. As the moisture dropped, so likewise the penetration expressed in terms of m m. was correspondingly less, showing that the hardness was greater.

The above table also demonstrates that the butter made from hay ration was somewhat lower in per cent olein and considerably higher in volatile Eatty acids. The moisture content was also less but the melting point again did not vary much.

Olein had the greatest change and the drop of the melting point is very probably largely due to the great increase in the percent olein. Also butter made from grass was very soft as characteristic of summer butter.

Comparing table #5 with tables #3 and #4 you will find that (1) the volatile fatty acids decreased slowly, (2) Iodine absorption number increased, and (3) melting point dropped as the season of the year advanced.

You will also find that as to the effect of period of lactation that the following is true:

(1) Volatile acids decrease.

(2) Olein increases.

(3) Melting point is not affected to any extent.

CHEMICAL COMPOSITION OF PURE BUTTER FAT.(Lewkowitsch).

Pure butter fat consists almost exclusively of triglycerides of the fatty acids. Besides triglycerides it contains cholesterol and some natural colouring matters (lactochromes). The total amount of unsaponifiable matter is less than half a per cent. Certain compounds of phosphorus have also been stated to have been found in butter fat.

The following acids have been found in butter fat: acetic, butric, caproic, caprylic, capric, lauric, myristic, palmitic, stearic, arachidic, and oleic.

The extraordinary high precentage of glycerides of the soluble fatty acids in butter fat is characteristic and differentiates it from all other fats.

AVERAGE COMPOSITION OF BUTTER.

	Per cent.
Fat ----------------	82.97
Water --------------	13.78
Proteids -----------	0.84
Milk Sugar ---------	0.39
Ash ----------------	0.16
Salt ---------------	1.86

II. DESCRIPTION OF ANALYTICAL METHODS EMPLOYED IN THE EXAMINATION OF BUTTER FAT.

Reichert-Meissl Number.

This number indicates the number of cubic centimeters of N/10 $Ba(OH)_2$ required to neutralise that quantity of the solution of soluble volatile acids, which is obtained from 2.5 (or 5) grams of butter fat, by the Reichert-Meissl distillation process.

This method is by far the best and most valuable in the examination of butter fats. It is of paramount importance, for the reason that it is not possible to prepare a mixture of any fats likely to be used as butter adulterants without adding very considerable quantities of butter fat, so that the mixture may have a Reichert-Meissl value approaching that of normal butter, whereas all othervalues can be adjusted by a mixture of fats other than butter fat.

However, the Reichert-Meissl number is not constant and varies according to several things, such as country, feeds, breed, period of lactation and idiosyncrasy of cow.

Reichert Meissl apparatus.

The methods of examination used in this experiment are those used by the United States Department of Agriculture, Bureau of Chemistry, AOAC, and are as follows:

REAGENTS.

$^N/_{10}$ Sulphuric acid, standard $Ba(OH)_2$, phenolphthalein, pumice stone and glycerol-soda solution.

Determination.

Melt the butter fat and keep it at 60° C. for two or three hours, or until the water and curd has entirely separated. Pour the clear supernatant fat through a dry filter, using a hot water funnel.

Now measure accurately 5.75 c c of the solution and place same in the saponification flask. Add 20 c c glycerol-soda solution and heat over an asbestos plate until complete saponification has taken place, as is shown by the mixture becoming clear and no fumes being given off.

Now add 135 c c of recently boiled distilled water, drop by drop, to prevent foaming, and then add 5 c c dilute sulphuric acid and distill.

Catch 110 c c of the distilate and titrate against $Ba(OH)_2$, this number gives the Reichert-Meissl number.

NOTES.

1. The volatile acids are those which pass over with steam, irrespective of the boiling point of the acid.

2. There are several errors in this process and Wollny has shown them to be as follows:

(a) The absorption of carbon dioxide during saponification.

(b) The formation of volatile ethers during saponification.

(c) The formation of ethers during distillation.

(d) Variation of the fractional part of volatile acids distilled owing to the size and shape of the distilling vessel, and to the length of time distilled.

(e) The following table, compiled by Blyth, shows the Reichert-Meissl number of butter fat compared with other fats:

III(a)

Kind of Fat	R.M.#
Butter fat	24-32
" " plus 10% oil	26.8
" " " 50% "	18.0
" " 50% Cocoanut oil 22.5% Oleomargarine 27.5%	17.4
Oleomargarine	0.8-3.0
Lard	0.4-0.6
Olive oil	0.6

IODINE ABSORPTION NUMBER.

This examination indicates the percentage of iodine absorbed by the fat, expressed in terms of iodine.

It measures the proportion of unabsorbed fatty acids, which, both in their free state and in combination with glycerol, have the property of assimilating halogens with formation of additive compounds. Olein acts, for example, as follows:

$$(C_{17}H_{33}COO)_3C_3H_5 \text{ plus } 3I_2 = (C_{17}H_{33}I_2COO)_3C_3H_5.$$

Hubl's method was used and is as follows:

Reagents.

Hubl's iodine solution, decinormal sodium thiosulphate solution, starch paste which is made up fresh each day, Potassium iodide.

Determination.

Weigh on an accurate balance 1-2 gms. butter fat on a watch glass and place same in a wide mouth, glass-stoppered bottle. Dissolve the fat in 10 c c chloroform and after complete solution has taken place add 30 c c Hubl's iodine solution and allow to stand for three hours, in a dark place.

After standing for the above stated time, add 20 c c Hubl's potassium iodid solution and shake thoroughly, then add 100 c c distilled water to the contents of the bottle, washing down any free iodine that may be on the sides of the bottle.

Titrate the solution against sodium thiosulphate, using starch paste as an indicator.

It is necessary to run a check sample on the strength of the iodine solution every day, since it loses its strength on standing. It is also equally as important to run two or more samples of butter, because one sample may not be representative.

Calculation.

Wt. fat taken ---------------------- gms.

Quantity of iodine sol. used -------- cc

Thiosulphate equivalent to iodin used-------- cc

" " " " remaining -- cc

" " " " absorbed -- cc.

Per cent iodin absorbed (difference between amount used and amount remaining x 0.12697 x 100) ÷ wt. fat taken.

The following table shows the iodine absorption numbers of some of the more important fats. This table was determined by Tolman and Munson.

III(b)

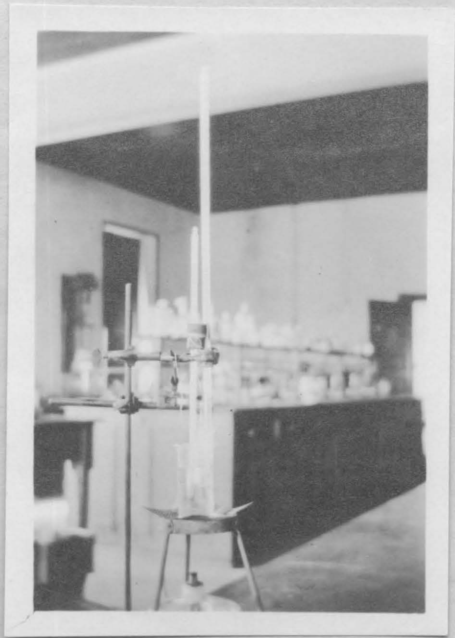
Kind of fat	Iodine #.
Butter fat	26-38
Olemargarine	52-65
Oleo oil	43.3
Olive oil	84.6
Linseed oil	171-178

MELTING POINT.

This examination indicates the degree at which different fats melt, and is very helpful in placing a fat in its respective class.

Apparatus.

Accurate thermometer reading easily tenths of a degree, an ordinary thermometer, a beaker 35 cm. high and 10 cm. wide, stand for supporting apparatus, alcohol 95 per cent and recently boiled distilled water.



Apparatus used to determine the Melting Point.

Determination.

Melt the butter fat and filter through a hot water funnel and allow the melted fat to drop on ice floating in recently boiled distilled water. Little disks are formed and can be collected by pressing the ice down under the water.

Place recently boiled alcohol and distilled water in the tube and cool contents down to below 30 degrees.

With the spatula place one of these disks in the tube and warm the solution up very slowly and note just the degree at which the disk rolls up. This is the melting point.

Notes.

(a) If the alcohol is added after the water has cooled, the mixture will contain air bubbles which will interfere with the experiment.

(b) The edge of the disk should not be allowed to touch the sides of the tube. If this happens, new determinations should be made.

(c) The melting point of butter is a little higher than that of oleomargarine, although artificial butters can be made with the same melting point.

The following table gives the melting point of some of the more important fats:

III (c)

Kind Fat.	Melting Point.
Butter	28-33
Oleomargarine	26.
Oleo	33-39
Beef tallow	42-49
Mutton tallow	44-50
Lard	36-46

PER CENT MOISTURE.

This examination indicates the amount water that the butter carries and consists of heating a sample of butter 1.5 - 2 gms. in hot water oven at the temperature of boiling water, until constant weight is obtained.

The sample should be cooled and weighed every hour, for if allowed to heat too long it has a tendency to oxidize, and hence increase in weight.

Butter should contain about 13 to 14 percent moisture, and the law states that butter sold on the market testing above 16 per cent shall be declared as adulterated and is subject to fine.

However, the percentage of moisture is controlled by the butter maker rather than the dairyman. For as everyone knows, if butter is churned at a high temperature that it will incorporate more moisture than if churned at a lower degree.

It might be well to state here, that all the churnings were made under the same conditions as near as possible.

The following table shows the range which moisture percentage may fall under:

III(d)

Maximum	35.15
Minimum	4.15
Mean	13.59

TEST FOR HARDNESS.

There is no official test for the hardness of butter, but the one which the writer describes here is the one used by him, and has been used by several others in working with butter and ice cream.

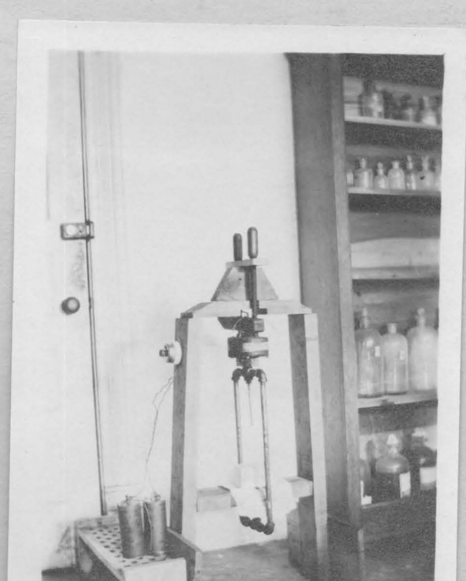
The principle on which this test works is based on the resistance of different materials to the penitration of different size needles falling through a definite space and with a constant and definate weight.

Needles of the following sizes were used: 5/16 inch, or whose diameter is 7.93 mm., 4/16, or 6.35, and 3/16, or 4.76mm.

All three needles were used, and each needle used three times at different places of the butter in order to get more representative results.

Before each test the sample of butter was placed in a bucket of water, whose temperature was 50 degrees C., and held at this temperature for two hours before testing, in order to avoid error, as might have been caused otherwise.

The accompaning picture will explain the apparatus.



The penetration of the needles in butter made from this dry ration clearly shows that the resulting butter was very much harder and firmer than any made during the entire experiment. This illustrates the fact that feeds which increase the per cent of olein has a tendency to produce soft butter and vice versa. The oil feeds increase, while the feeds rich in carbohydrates decrease.

SUMMARY.

1. The chemical composition of butter fat is almost entirely controlled by the (1), Season of the year, (2), period of lactation and different feed stuffs.

2. Feeds rich in vegetable oils are low in per cent volatile acids and high in olein and produce a soft butter.

3. Feeds rich in carbohydrates and poor in vegetable oils have a high per cent volatile acid and low per cent olein, and hence produce good, firm butter.

4. That during the season of the year when the cows are on pasture that the per cent moisture is at its highest, and at its lowest during the winter months.

5. The period of lactation has a very marked influence on the chemical composition of butter fat. The volatile acids are highest, and olein lowest during the early part of the period, and as the period advances, especially near the end, the olein becomes highest and the volatile acids drop. The melting point is very near the same.

6. The melting point of butter fat does not vary much, but is dependent on the percentage of olein; more so than that of butyrin, capronin, and allied glycerids

I. a. "Moisture Content of Butter." Bul. 159, Vol. XVI.
Purdue University. p.p. 287.

b. loc. cit. - p.p. 303.

II. United States Dept Agri. Bureau of Chemistry, A. O. A. C.
Bul. 107. Dr. Wiley, 1908.

III. a. "Elementary Quantitative Chemical Analysis."
Lincoln & Walton. p.p. 112.

b. loc. cit. p.p. 118.

c. " " " 108.

d. " " " 101.