A STUDY OF THE INCORPORATION OF CASEIN IN CREAMERY BUTTER

THESIS FOR DEGREE OF M. S.

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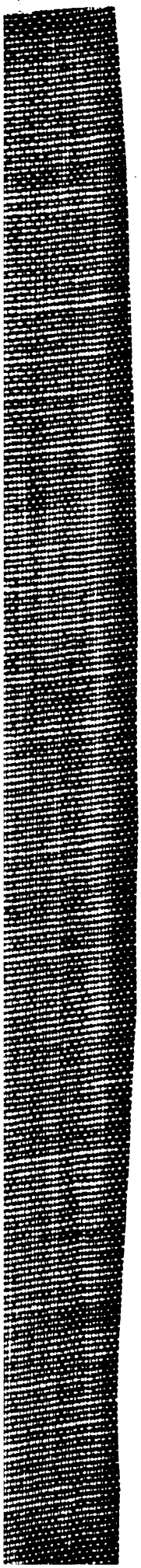

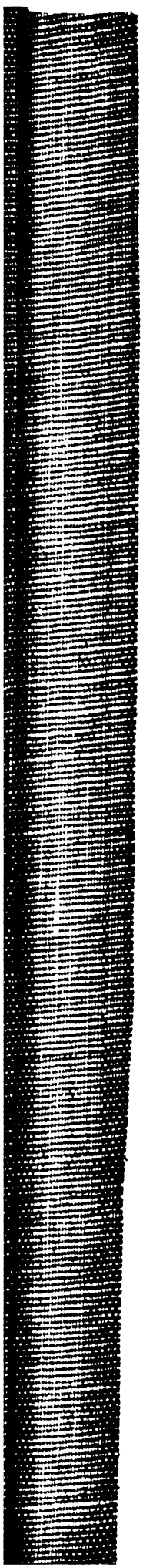

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THESIS

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Submitted to the faculty of the Michigan Agricultural College in partial fulfillment of the requirements for the degree of Master of Science.

by

Royce W. Wyant.

1920

Thesis

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A STUDY OF THE INCORPORATION OF CASEIN IN CREAMERY BUTTER.

For many years creamery buttermakers have been operating upon a single standard for determining the composition of butter. This standard as established by the Internal Revenue Department fixed the maximum moisture content of butter below 16 per cent. (1) The moisture content was taken as a standard for two reasons: first, because moisture is the least valuable of the butter constituents, and second, the composition of butter, so far as moisture is concerned, is largely under control of the buttermaker. Therefore, a standard which limited the amount of moisture in butter was deemed adequate for the protection of the consumer.

A recent ruling by Dr. C. L. Alsberg, Chief of the Bureau of Chemistry, has made the double standard effective. (2). This standard requires that the maximum moisture content of butter be limited to 16 per cent and the minimum fat content be at least 80 per cent. These two standards are apparently substantially equivalent and it would seem that so long

as adulterants were not used in the manufacturing process, the single or moisture standard would be a sufficient guarantee to the consumer.

In a letter to the members, G. L. McKay, secretary of the American Association of Creamery Butter Manufacturers, reports a conversation with Dr. Alsberg, Chief of the Bureau of Chemistry, in which he states "I personally called his attention to the fact that there is at least 25 per cent of the butter now in storage that would be lower than 80 per cent fat, and it would be a serious problem for the dairy business to have his department go out and seize this butter".

Without question this storage butter referred to by Mr. McKay was legal butter as defined under the moisture standard regulation, that is, this butter contained less than 16 per cent moisture. Moreover, this butter represented normal creamery butter manufactured according to modern methods. These facts suggest that the percentage of the other constituents of butter not included under the double standard regulation is of considerable importance.

The supporters of the double standard regulation maintain that the consumer of butter is paying for the fat which it contains and, therefore, the per

cent of fat in butter is equally as important as is the per cent of moisture. The logic of the foregoing statement is apparent and without doubt the moisture standard and the fat standard will finally be adopted in all countries where the dairy industry is prominent.

The cost of butterfat has doubled in the past three years. (3) Added to the increased cost of raw material is the enormous increase in the overhead expense of operating a creamery. It is obvious that the creamery manager must use all of the legitimate means at his disposal to make the greatest profit from the butterfat which is delivered at the factory. Moreover, competitive conditions compel the operator of a creamery to manufacture butter the composition of which is as near the legal limits as prudence will allow.

The present known methods for determining each of the several constituents of butter are inadequate for general creamery practice. The moisture and salt content may be rapidly and accurately computed in any creamery by the buttermaker. These tests will in the future, as they have in the past, be the ones commonly used for creamery testing. For technical reasons the direct determination of the fat and casein content of butter must be left to the chemical laboratory.

Butter contains the following commercial constituents: fat, moisture, salt, and curd. The fat content and the moisture content are fixed at 80 and 16 per cent respectively. The other constituents of butter must come within the remaining 4 per cent provided the law is not violated or good factory practice abused. A moderately salted butter contains about 2.5 per cent salt. Some markets prefer a heavier salt while others demand a light salt or none at all. The average salt content of 695 samples of American creamery butter as reported in Bureau of Animal Industry bulletin 149 was 2.15 per cent. This would still leave 1.85 per cent for the curd content. Keeping the other factors constant, 3 per cent salt would leave 1 per cent for curd. This is in agreement with the analyses of the 695 samples mentioned above as the average curd content of this butter was 0.88 per cent. The fact that of the 695 samples of creamery butter analyzed the curd content of individual samples varied from 0.12 per cent to 3.41 per cent makes this problem worthy of study. All authorities agree that a high curd content should be avoided so as to insure better keeping quality of the butter. For these two reasons this study was undertaken. It was hoped that the extent of incorporation and the factors that are re-

sponsible for incorporation might be determined under factory conditions.

REVIEW OF LITERATURE.

There is an abundance of published data relating to the composition of creamery butter. The most comprehensive study was completed in 1912 by Thompson, Shaw, and Norton (4) of the Dairy Division and published as bulletin 149 of the Bureau of Animal Industry. A summary of this bulletin is given on the preceding page. Lee and Barnhart (5) of the Illinois Experiment Station made an extended study of the composition of creamery butter collected from the markets at Chicago, Elgin, and Aurora. These investigators found the average casein and ash content of the 231 samples analyzed to be 0.37 per cent.

Nothing would be gained by reviewing the entire published data upon the composition of creamery butter. Most of the analyses were made to determine the moisture content as the moisture standard was effective at that time. The curd content of butter has been for the most part ignored. It has been variously reported by investigators as casein, protein, nitrogen, and curd. The per cent of this constituent in butter was usually arrived at by subtracting the sum of the

percentage of fat, moisture, and salt from one hundred.

Attention might be called to the results of the analyses of 200 samples of Minnesota creamery butter as reported by James Sorensen, State Dairy and Food Commissioner (6) and tabulated by McKay (7). The curd content of this butter varied from nothing to 10.42 per cent.

Guthrie (8) states, "The amount of washing that butter receives and the quality of the wash water is important. From the physical standpoint butter must be washed because the brine should be clear and not milky. From the bacteriological viewpoint the buttermilk should be washed out so that the bacteria will be deprived of it as a food."

According to Jensen (9) "lactic acid bacteria were found to multiply much more rapidly in unwashed than in washed butter".

Thom and Shaw (10) add that "excess curd in butter favors mold growth and if the butter is properly washed it is less subject to the mold."

McKay and Larsen (11) after extended study and observation conclude that "butter should not be over churned in the buttermilk as too much curd and milk sugar are incorporated. This cannot readily be removed and in many instances it injures the flavor

and keeping quality of the butter."

McKay and Larsen (12) further discuss the effect of curd upon the keeping quality of butter. "The chief object of washing butter is to remove as much buttermilk as possible. The more impure the cream is, the greater is the importance of getting the butter properly washed. The removal of the buttermilk constituents should be as complete as conditions will permit." The same authors bring forth a note of warning by stating "unless the butter is of very poor quality excessive washing should be avoided. If the quality of the butter is poor, many of the undesirable flavors and odors are removed by excessive washing; while if the butter has a fine rich flavor it should be retained and not extracted by washing the butter more than is needed".

Michels (13) believes "one washing in which as much water is used as there was cream is usually sufficient. When butter churns very soft two washings may be advantageous."

Wing (14) advances a reason for the variation in casein content by stating the "higher the temperature at which the cream is churned, the more casein will be incorporated with the butter." Wing concludes

without giving any reason that the percentage of casein should not exceed 4 per cent.

Mortensen (15) believes "the pasteurization of sour cream affects the percentage of protein in the butter, as the casein in the presence of the acid is hardened and thrown into clumps known as curd particles that are quite readily removed in the draining and washing of butter".

Stocking (16) concludes "the purpose of washing butter is to remove the buttermilk" without giving any reason either for or against a small amount of casein in the finished butter.

McKay and Larsen (17) state "according to the present methods of manufacture, water, salt and fat are the components most likely to vary. Casein varies very little. Occasionally the curd content may go as high as 4 per cent. It rarely exceeds 2 per cent and seldom falls below 0.5 of 1 per cent. A high curd content will show itself in the butter in the form of a milky brine or in the form of white specks. If there is less than 2 per cent curd present in the butter, the brine shows no noticeable milkiness. More than that much curd can, as a rule, be detected from the color of the brine. If the casein or the curd has been incorporated in the form of small lumps

or specks, then abnormal amounts of curd appear. When the sample of butter is taken for analysis such a speck of curd present in the sample raises the final curd content to a comparatively high figure. As has been mentioned before, the curd and milk sugar are incorporated from the buttermilk into the butter during the churning. In manufacturing butter for storage these substances should be excluded from the butter as thoroughly as possible. The milk sugar and albuminoids constitute the chief food for bacterial growth".

The foregoing review of literature is not by any means exhaustive. The results of the principle investigations up to the present time are given together with comments by several of the leading authorities.

THEORETICAL DISCUSSION.

Casein is a nitrogenous compound of milk representing about 2.5 per cent of milk by weight. It exists in milk in combination with certain calcium salts in the form of extremely minute gelatinous particles in suspension. Casein is insoluble in water and is precipitated by heat in the presence of dilute acids or acid salts. (18) In the

process of cream separation most of the casein is thrown out as skimmilk. The remaining portion is thrown out with the fat and these two constituents with the lactose make up the principal solid material in cream. A cream low in fat must, therefore, be high in casein.

The preliminary treatment cream receives before churning in the pasteurization and ripening process tends to precipitate the casein. The degree of precipitation depends upon the duration and intensity of the heat used and the acidity of the cream. (19) Thus when the cream is placed in the churn the casein is in a fine granular condition and with the fat globules forms an emulsion. (20)

As the cream is agitated during the churning process the individual fat globules coalesce forming a globule of larger size. A continuation of the agitation forms butter granules and when the granules are about 50 mm. in diameter the churning is complete. While the granule is forming small particles of casein are mechanically incorporated which cannot be removed by subsequent washing. The casein that adheres to the outside of the granule or is held mechanically in pockets between the granules may be removed by careful washing and draining.

Casein particles may be present in butter in two forms. The small minute particles, as referred to above, are invisible and can only be seen when large numbers are suspended in water, forming a milky brine. Under certain conditions of manufacture where the cream is allowed to sour and become lumpy and is then pasteurized, the lumps of curd are hardened due to the action of heat in the presence of acid. These lumps may remain intact during churning and be finally incorporated producing the characteristic "speckled" butter sometimes found on the market. This butter shows defective workmanship and would hardly be termed normal because modern buttermakers know how to avoid this condition. Without question some of the analyses showing a high percentage of casein were made from this inferior product. In this study butter made according to present day knowledge will be considered normal.

On page 5 the fact that some confusion exists as to the definition of the word curd is mentioned. Curd is usually defined as the remaining constituents of butter which are not included under the terms fat, moisture, and salt. It consists mainly of casein, lactose, and ash. McKay and Larsen (21) state "in the analysis of butter the milk sugar is usually

included with the proteids (curd) and the ash is reckoned with the salt".

Guthrie (22) says, "The curd of modern butter contains very little if any albumin, for it is taken out in the washing. The curd, therefore, if largely casein".

Lee and Barnhart (23) express this constituent of butter in bulletin 139 as casein and ash. Mortensen and Gaessler (24) in Iowa bulletin 156 report this constituent as protein. Thom and Shaw (25) state "the curd is equal to the nitrogen times the factor 6.38." Thompson, Shaw and Norton (26) in bulletin 149 state, "The term curd includes the lactose and ash."

It will be seen from the foregoing statements that an accepted or recognized definition of curd has not been established. For this reason the term casein is used throughout this paper.

EXPERIMENTAL WORK.

In order to determine the extent casein may be incorporated in butter under factory conditions a number of churnings were made. By varying the methods of churning, washing, and draining an attempt was made to find how much casein might be added to the butter and the conditions which influence in-

corporation. One vat of cream was used for each experiment. After the preliminary vat treatment as outlined in vat record, the cream was divided into two churnings. One churning was handled according to good factory methods as outlined in churn record and served as a check, being normal creamery butter. The remaining portion of the cream was handled so as to make a possible variation in the casein content of the finished butter. The following variations from the normal were used:

1. Unwashed butter.
2. Working butter in buttermilk.
3. Over churning in the presence of buttermilk.
4. Churning at high and low temperatures.
5. Adding starter after churning.
6. Adding cream after churning.

A vat and churn record was completed for each experiment. The duplicate lots of butter were sent to market to find if any variation in score or selling price of the butter would be made.

METHOD OF SAMPLING.

As the butter was completely finished and ready to put into tubs small samples were taken from at least 12 parts of the churn. These were placed in

a glass jar and covered. The covers were made air tight by dipping in melted paraffin. The samples were then held at 10° F. until analyzed. When ready for analysis the jars were placed in a water bath at 75 - 80° F. until the butter was soft enough so that it could be thoroughly stirred and mixed until of salvy consistency.

METHOD OF ANALYSIS.

A number of preliminary samples were analyzed to determine the casein content according to the official and optional methods. The method recommended by Leach (27) was finally adopted for this work. This method is as follows: About 10 grams of the properly mixed sample are weighed on an analytical balance into a tared, flat aluminum moisture dish. The moisture is evaporated from the sample by heating over a hot plate at 100° C. until bubbling ceases. The contents of the dish are then cooled and 50 cc of petroleum ether are added. The contents of the dish are next washed on to a filter paper and the residue washed approximately free from fat with petroleum ether. The residue is then allowed to dry on the filter paper which is then transferred to a Kjeldahl digestion flask

and the nitrogen determined according to the Gunning (28) method. The casein is calculated as follows:

$$\frac{\text{Nitrogen} \times 6.38}{\text{Amount of sample}} \times 100 \text{ equals per cent of casein}$$

In all cases triplicate determinations of each sample were made.

METHOD OF CHURNING.

The normal churnings in the following experiments were made according to a standard method and represent butter manufactured under modern factory conditions. As these churnings were made during the spring and winter months a variation in churning temperature was necessary, due to the seasonal change in the composition of butterfat. The chief variation between the normal and special churnings was in the washing, working, and draining of the butter. The standard method used in all normal churnings is as follows: When the butter granules are about 50 mm in diameter the buttermilk is drawn off and water from a hose is sprayed over the butter and allowed to drain out through the open churn gate. Enough wash water is used in this manner to free the churn and butter granules from excessive buttermilk. When the wash water is but slightly turbid the churn gate

is closed and enough water is added to the churn to float the butter. The workers are then engaged and the butter worked several revolutions of the churn in the wash water. The water is drawn off first through the churn gate and finally carefully drained through the partly opened churn cover. The butter is then tested for moisture, salted, and finished.

METHOD OF RECORDING EXPERIMENTS.

The following ten experiments consist of two churnings each. Churning No. 1 in each instance represents normal creamery butter manufactured according to standard method as outlined on page 15. An additional supplementary record for each churning is given on the page immediately following the experiment.

EXPERIMENT NO. I.

To determine the effect upon the casein content of the finished butter by working the butter in the buttermilk.

The second churning in this experiment was handled the same as the first to the end of the churning process. Then one-half of the buttermilk was drawn off and the butter worked ten revolutions in the buttermilk. The remaining buttermilk was drawn off as thoroughly as possible through the churn gate and then carefully drained by revolving the churn several revolutions and allowing the buttermilk to drain out through the partly opened churn cover. When most of the unincorporated buttermilk had been removed in this manner the butter was salted and finished without washing. The body and flavor of the butter in this churning was identical with that of the first churning which was made from the same vat of cream.

Churn No.	% of Casein
1	0.4189
2	0.5562

CHURN RECORD NO. I.

Jan. 22, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 20

Weight - 1568 lbs. Test 30 lbs. Butterfat 470

	Date	Hour A.M. or P.M.	Temp.	%Acid
When filled	1-22-20	8:30	A. M.	34	.36
When cooled	" " "	11:30	A. M.	45	.35
When churned	" " "	1:30	P. M.	49	.35

Amt. Color - 7 oz. Color per 100 lbs. butterfat - 1.5 oz.

CHURNINGS

	Temperature				Time			Rev's worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	49	57	56	56	1:30	1:55	25	5	19
2nd:	49	58	-	-	1:46	2:36	50	10	36

	Weight	Lbs B.F.	Calculated: Butter	Salt Amt.	Salt Rate	Net Wt.	Lot No.
1st:	1568	470	573	18	4%	565	12
2nd:	-	-	-	-	-	-	13

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.08	13.4	15.6	2.9	95	20.2
2nd:	.10	13.9	15.2	3.2	-	-

EXPERIMENT NO. II.

To determine the effect upon the casein content of the finished butter by working the butter in the buttermilk.

The second churning in this experiment was handled in the same manner as the first until the churning process was complete. About half of the buttermilk was then drawn off and the butter worked for ten revolutions in the buttermilk. The remaining buttermilk was drawn off as thoroughly as possible through the churn gate. To free the butter from any unincorporated buttermilk the churn was revolved several times with the workers engaged and carefully drained after each revolution through the partly opened churn cover. The butter was then salted and finished without washing. The butter in this churning was somewhat soft. A very small amount of unincorporated buttermilk remained in the churn.

Churn No.	% of Casein
1	0.3476
2	0.5064

CHURN RECORD NO. II.

Mar. 1, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time - 30

Weight - 1668 lbs. Test 37 lbs. Butterfat 617

	Date	Hour	A.M. or P.M.	Temp.	%Acid
When filled	3-1-20	1:30	P. M.	40	.36
When cooled	" " "	3:30	P. M.	45	Neut.
When churned	3-2-20	8:15	A. M.	56	.31

Amt. Color - 6 oz. Color per 100 lbs. butterfat - 1 oz.

CHURNINGS

	Temperature				Time			Rev's Worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	56	58	58	58	8:15	8:35	20	5:	20
2nd:	56	58	-	-	8:55	9:20	25	10:	30

	Weight	Lbs B.F.	Calculated: Butter	Salt: Amt.	Salt: Rate	Net Wt.	Lot No.
1st:	1668	617	752	24	4%	738	31
2nd:	-	-	-	-	-	-	32

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.08	14.2	15.0	3.1	121	19.6
2nd:	.11	15.0	15.2	3.2	-	-

EXPERIMENT NO. III.

To determine the effect upon the casein content of the finished butter by working the butter in the buttermilk.

Churning No. 2 in this experiment was handled in the same manner as churning No. 1 until the butter granules were of the desired size. About one-half of the buttermilk was then drawn off and the butter worked twenty revolutions of the churn in the buttermilk. The remaining buttermilk was drawn off through the churn gate as completely as possible. The unincorporated buttermilk was squeezed out of the butter by working several revolutions and allowing the buttermilk to drain out of the churn cover after each revolution. The butter was then salted and finished without washing. The excessive working of the butter in the buttermilk in this churning incorporated 16 per cent moisture.

Churning No.	% of Casein
1	0.3676
2	0.5166

CHURN RECORD NO. III.

Mar. 5, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1388 lbs. Test 42 lbs. Butterfat 582

	Date	Hour	A.M. or P.M.	Temp.	% Acid
When filled	3-5-20	10:30	A. M.	40	.32
When cooled	" " "	12:30	P. M.	45	.31
When churned	3-6-20	8:20	A. M.	56	.33

Amt. Color - 7 oz. Color per 100 lbs. butterfat 1.2 oz.

CHURNINGS

	Temperature				Time			Rev's Worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	56	58	58	58	8:20	8:45	15	6:	13
2nd:	56	59	-	-	9:10	9:35	25	20:	15

	Weight	Lbs B.F.	Calculated Butter	Salt Amt.	Salt Rate	Net. Wt.	Lot No.
1st:	1388	582	710	24	4%	707	-
2nd:	-	-	-	-	-	-	-

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.13	15.4	15.4	3.2	125	21.4
2nd:	.10	16.0	16.0	2.9	-	-

EXPERIMENT NO. IV.

To determine the effect of washing upon the casein content of butter.

The second churning in this experiment was handled in the same manner as the first until the churning process was complete. The buttermilk was then drawn off through the churn gate as completely as possible and the butter carefully drained from the unincorporated buttermilk by revolving the churn several times and allowing the buttermilk to drain out of the partly opened churn cover after each revolution. The butter was then salted and finished without washing. The body of the butter is this churning was firm and the brine clear. The butter in churning No. 2 compared favorably as to flavor,, body, and color with the butter in churning No. 1 which was made from the same vat of cream.

Churn No.	% of Casein
1	0.4012
2	0.5406

CHURN RECORD NO. IV.

Jan. 23, '20.

Vat

Condition of Cream - good Past. Temp. 145 Past Time 30

Weight - 1608 lbs. Test 40 lbs. butterfat 643

	Date	Hour	A.M. or P.M.	Temp.	%Acid
When filled	1-23-20	8:30	A. M.	36	.42
When cooled	" " "	10:30	A. M.	45	Neut.
When churned	" " "	1:40	P. M.	50	.28

Amt. Color - 9.5 oz. Color per 100 lbs. butterfat 1.5 oz.

CHURNINGS

	Temperature				Time			Rev's Worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	50	58	58	58	1:40	2:08	28	12:	35
2nd:	50	57	-	-	2:20	2:40	20	-:	35

	Weight	Lbs B.F.	Calculated: Butter	Salt Amt.	Salt Rate	Net Wt.	Lot No.
1st:	1608	643	784	25	4%	770	14
2nd:	-	-	-	-	-	-	15

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.09	13.2	14.2	3.1	127	19.7
2nd:	.07	14.6	15.8	3.2	-	-

Experiment No. V.

To determine the effect of washing upon the casein content of butter.

The second churning in this experiment was handled similar to the first until the butter granules were of the desired size. The buttermilk was then drawn off and the butter drained free from excessive buttermilk by revolving the churn, with the workers engaged, several revolutions and allowing the buttermilk to drain out through the churn cover after each revolution. The butter was then salted and finished without washing. The butter in this churning was a trifle soft and somewhat over-worked. The brine is clear but the body is somewhat weak due to excessive working.

Churn No.	% of Casein
1	0.3155
2	0.4542

CHURN RECORD NO. V.

Feb. 24, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1595 lbs. Test 40 lbs. butterfat 638

	Date	Hour	A.M. or P.M.	Temp.	% Acid
When filled	2-24-20	8:30	A.M.	38	.33
When cooled	" " "	11:30	A.M.	44	.32
When churned	" " "	1:50	P.M.	48	.33

Amt. Color - 6.5 oz. Color per 100 lbs. butterfat 1.5 oz.

CHURNINGS

	Temperature				Time			Rev's Worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	48	56	56	56	1:50	2:20	30	7:	18
2nd:	48	56	-	-	3:50	4:20	30	-:	15

	Weight	Lbs B.F.	Calculated: Butter	Salt Amt.	Salt Rate	Salt net Wt.	Lot No.
1st:	1595	638	778	25	4%	787	28
2nd:	-	-	-	-	-	-	29

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.08	14.0	15.4	2.7	149	23.3
2nd:	.06	14.3	15.8	2.9	-	-

EXPERIMENT NO. VI.

To determine the effect of washing upon the casein content of butter.

Churning No. 2 in this experiment was handled in the same manner as churning No. 1 until the butter granules were of the desired size. The buttermilk was then drawn off through the churn gate and the unincorporated buttermilk was removed by revolving the churn several revolutions with the workers engaged and allowing the buttermilk to drain out through the partly opened churn cover after each revolution of the churn. The butter was then salted and finished without washing. The butter in this churning is of good quality and the brine is clear. No special variation in body or flavor of this butter was noted when compared with churning No. 1 which was made from the same vat of cream.

Churn No.	% of Casein
1	0.3782
2	0.5505

CHURN RECORD NO. VI.

Mar. 14, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1479 lbs. Test 34 lbs. butterfat 502

	Date	Hour	A.M. or P.M.	Temp.	% Acid
When filled	3-14-20	8:30	A.M.	40	.48
When cooled	" " "	10:00	A.M.	45	Neut.
When churned	3-15-20	8:45	A.M.	53	.25

Amt. Color - 6 oz. Color per 100 lbs. butterfat 1.5 oz.

CHURNINGS

	Temperature				Time			Rev's worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	53	56	54	54	8:45	9:03	18	9:	26
2nd:	53	56	-	-	9:10	9:35	25	5:	20

	Weight	Lbs. B.F.	Calculated: Butter	Salt: Amt.	Salt: Rate	Net Wt.	Lot No.
1st:	1479	502	612	20	4%	610	-
2nd:	-	-	-	-	-	-	-

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.06	14.2	15.8	3.2	108	21.5
2nd:	.11	15.0	16.0	3.1	-	-

EXPERIMENT NO. VII.

To determine the effect of washing upon the casein content of butter.

The second churning in this experiment was handled in the same manner as the first until the churning process was complete. The buttermilk was then drawn off as completely as possible through the churn gate and then carefully drained by revolving the churn several revolutions with the workers engaged and allowing the unincorporated buttermilk to run out of the partly opened churn cover after each revolution of the churn. The butter was then salted and finished without washing. Very little difference between the flavor, body, and brine of these two churnings could be noticed.

Churn No.	% of Casein
1	0.4372
2	0.5252

CHURN RECORD NO. VII.

Feb. 2, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1683 lbs. Test 35 lbs. butterfat 589

	Date	Hour	A.M. or P.M.	Temp.	% Acid
When filled	2-2-20	8:30	A.M.	40	.47
When cooled	" " "	10:40	A.M.	45	Neut.
When churned	" " "	1:30	P.M.	49	.34

Amt. Color - 8 oz. Color per 100 lbs. butterfat 1.5 oz.

CHURNINGS

	Temperature				Time			Rev's worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	49	56	56	56	2:15	3:00	45	13:	31
2nd:	49	55	-	-	1:45	2:35	50	10:	16

	Weight	Lbs B.F.	Calculated Butter	Salt Amt.	Salt Rate	Net Wt.	Lot No.
1st:	1683	589	718	23	4%	711	20
2nd:	-	-	-	-	-	-	19

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.08	12.0	15.1	2.4	122	20.7
2nd:	.08	14.0	15.4	3.6	-	-

EXPERIMENT NO. VIII.

To determine the effect of adding cream to the butter upon the casein content of the finished butter.

The second churning in this experiment was handled the same as the first until the butter was ready to be salted. The moisture was then determined and seven pounds of sweet cream containing 27 per cent of butterfat was added to the butter with the salt. The butter was then finished without further washing. Practically all of the added cream was incorporated with the butter. The butter in this churning did not differ materially from that in the first churning. The theoretical amount of casein added would be approximately 0.127 pounds. The amount actually added as shown by the chemical analysis was 0.880 pounds.

Churn No.	% of Casein
1	0.3301
2	0.3543

CHURN RECORD NO. VIII.

Feb. 6, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1630 lbs. Test 35 lbs. butterfat 570

	Date	Hour	A.M.orP.M.	Temp.	%Acid
When filled	2-6-20	9:30	A.M.	40	.45
When cooled	" " "	11:30	A.M.	45	Neut.
When churned	" " "	2:00	P.M.	48	.27

Amt. Color - 8 oz. Color per 100 lbs. butterfat 1.5 oz.

CHURNINGS.

	Temperature				Time			Rev's Worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	49	55	57	57	2:00	2:27	27	6:	17
2nd:	49	58	57	57	2:25	2:50	25	13:	35

	Weight	Lbs B.F.	Calculated: Butter	Salt Amt.	Salt Rate	Net Wt.	Lot No.
1st:	1630	570	695	22	4%	700	-
2nd:	-	-	-	-	-	-	-

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.09	15.0	14.6	3.1	130	22.8
2nd:	.08	14.0	15.6	3.0	-	-

EXPERIMENT NO. IX.

To determine the effect of adding starter to the butter upon the casein content of the finished butter.

The second churning in this experiment was handled in the same manner as the first churning until the butter granules were of the desired size. After carefully washing the butter granules with a spray of water from hose, four gallons of ordinary starter was added to the churn. The butter was then worked ten revolutions of the churn. The excess starter was then drained off and the butter salted and finished without washing. It is apparent that all of the starter which was added could not be incorporated without over working the butter.

Churn No.	% of Casein
1	0.3155
2	0.4718

CHURN RECORD NO. IX.

Mar. 29, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1175 lbs. Test 38 lbs. butterfat 446

	Date	Hour	A.M.orP.M.	Temp.	%Acid
When filled	3-29-20	4:30	P. M.	38	.40
When cooled	" " "	5:25	P. M.	45	Neut.
When churned	3-30-20	8:10	A. M.	54	.30

Amt. Color - 8 oz. Color per 100 lbs. butterfat 2 oz.

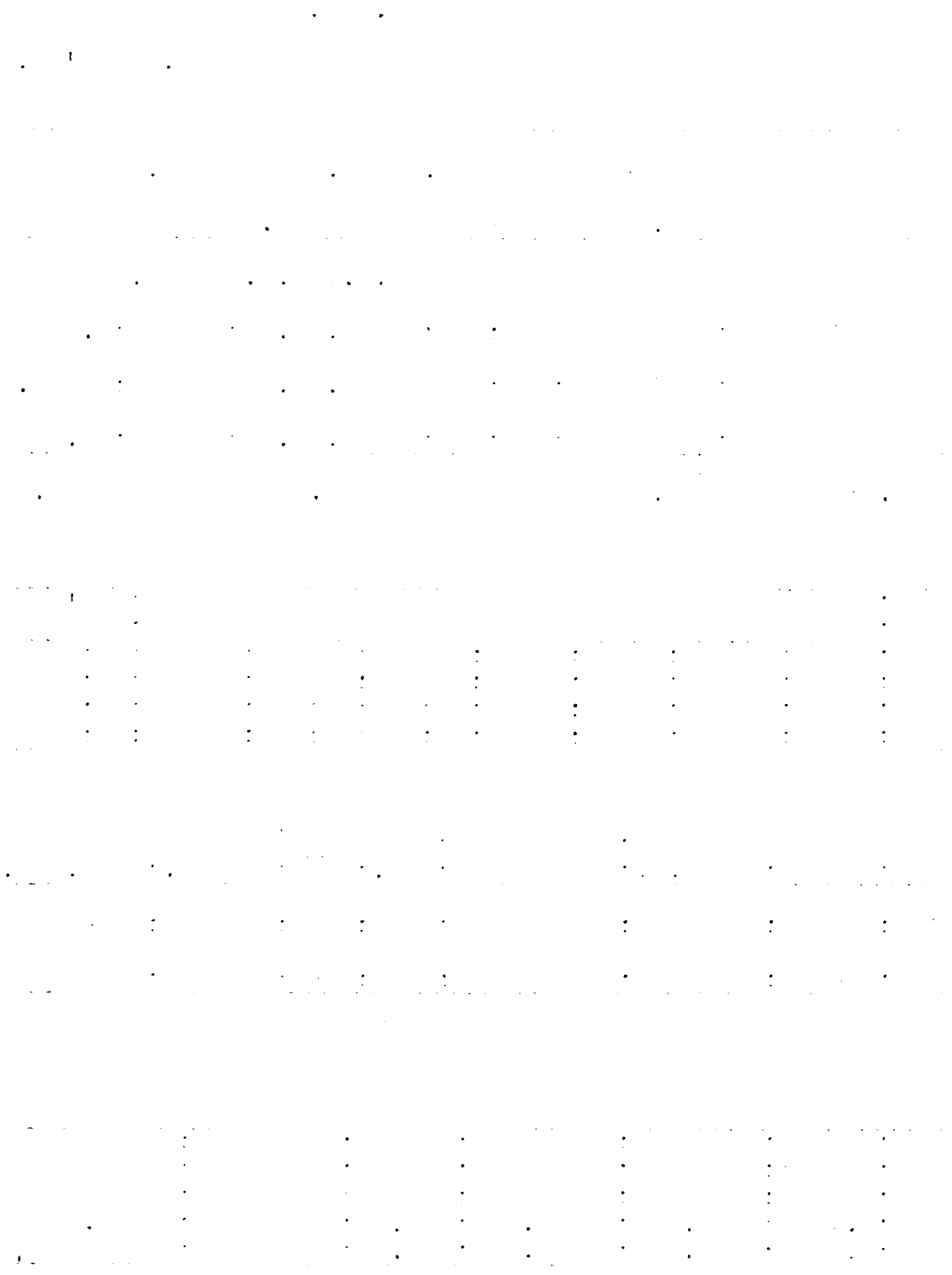
CHURNINGS

	Temperature							Rev's Worked
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn	
1st:	54	56	56	56	8:05	8:25	20	6: 30
2nd:	54	56	-	-	8;35	8:50	15	7: 16

	Weight	Lbs B.F.	Calculated: Butter	Salt Amt.	Salt Rate	Net Wt.	Lot. No.
1st:	1175	446	544	18	4%	538	-
2nd:	-	-	-	-	-	-	-

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	% Overrun
1st:	.10	13.4	14.5	3.0	92	20.6
2nd:	.11	12.0	14.5	3.3	-	-



EXPERIMENT NO. X.

To determine the effect upon the casein content of butter by working starter into the butter and then washing.

Churning No. 2 in this experiment was handled in the same manner as churning No. 1 until the end of the churning process. The butter granules were then washed with a spray of water from hose and carefully drained. Five gallons of starter was added to the churn and the butter worked 20 revolutions of the churn to incorporate the starter. The excess starter was drained off and the butter carefully washed, salted, and finished. The flavor, body, and brine of the butter in this churning was identical with that of the butter in churning No. 1 which was made from the same vat of cream.

Churn No.	% of Casein
1	0.3347
2	0.3808

CHURN RECORD NO. X.

Jan. 28, '20.

Vat

Condition of cream - good Past. Temp. 145 Past. Time 30

Weight - 1272 lbs. Test 34 lbs. butterfat 432

	Date	Hour	A.M. or P.M.	Temp.	%Acid
When filled	1-28-20	8:30	A. M.	35	.43
When cooled	" " "	11:30	A. M.	45	Neut.
When churned	" " "	1:30	P. M.	48	.29

Amt. Color - 6.5 oz. Color per 100 lbs. butterfat 1.5 oz.

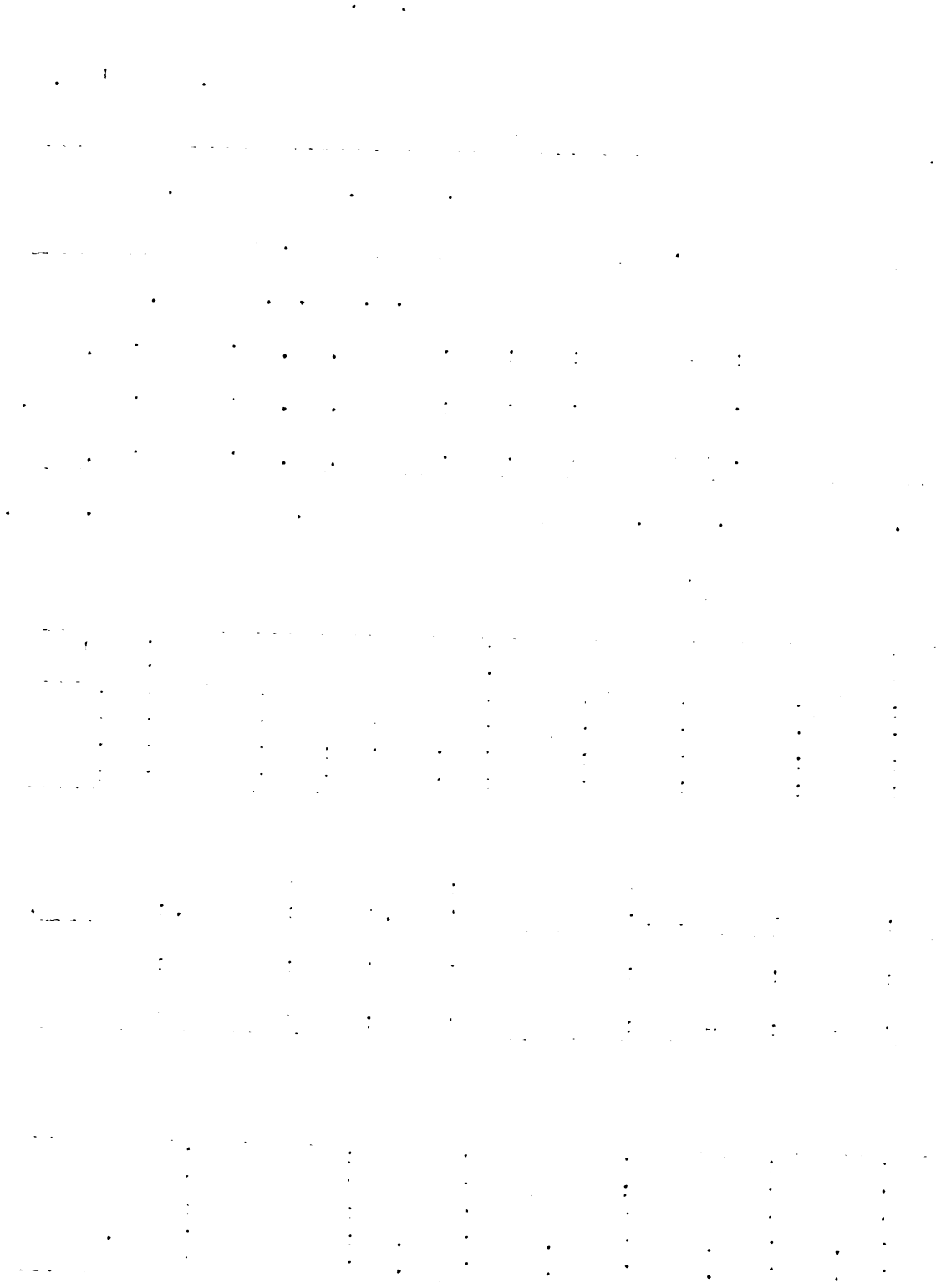
CHURNINGS

	Temperature				Time			Revs worked	
	Cream	Butter milk	1st wash	2nd wash	Start	End	Churn		
1st:	48	55	55	55	2:20	2:45	25	18:	25
2nd:	48	56	55	-	1:36	2:06	30	20:	50

	Weight	Lbs B.F.	Calculated: Butter	Salt Amt.	Salt Rate	Net Wt.	Lot No.
1st:	1272	432	527	18	4%	523	-
2nd:	-	-	-	-	-	-	-

TESTS AND OVERRUN

	Butter milk	Moisture before salting	Moisture after salting	Salt Test	Overrun	%Overrun
1st:	.09	14.2	15.6	3.1	91	21.0
2nd:	.06	12.8	15.1	2.7	-	-



EXPERIMENT WITH HAND CHURNS.

In order to determine the effect of high churning temperature upon the casein content of the finished butter two churnings were made in a ten gallon barrel churn.

In churning No. 1 the cream was pasteurized, ripened and churned at 60° F. This butter was carefully worked and drained but was not washed. The body of this butter is somewhat weak but represents a good quality of farm dairy butter.

The cream for the second churning was placed at 70° F. for four days and allowed to ripen spontaneously. The cream was then pasteurized and churned at 65° F. When the churning was complete the buttermilk was nearly all removed and the butter was worked to incorporate as much buttermilk as possible. This butter was not washed. The butter in this churning is an unsatisfactory grade of farm dairy butter.

Churn No.	% Butter Fat	Acidity	Churning Time	Moisture	%Casein
1	34	.35	25	17	0.4900
2	18	.80	20	20	0.5915

Summary:

The average casein content of the normal samples of butter in these experiments is 0.3646 per cent.

The average casein content of the butter which was worked in the buttermilk is 0.5264 per cent.

The average casein content of the unwashed butter is 0.5176 per cent.

The average loss of casein due to washing the butter is 0.1530 per cent.

The casein content of unwashed butter, churned at abnormally high temperature, is 0.5407 per cent.

The casein content of the butter to which starter had been added, is 0.4718 per cent.

Casein cannot be incorporated in butter to any appreciable extent by using modern factory methods of manufacture.

One per cent is sufficient allowance for all the constituents of butter which may be classified under the term curd.

By incorporating 15.5 per cent moisture and allowing 1 per cent for curd as much as 3.5 per cent of salt may be incorporated without reducing the fat content of the butter below the legal standard.

No difference in score or selling price of the duplicate lots of butter was made upon the Chicago market.

Speckled butter was not found in any of the samples.

Milky brine was not found in any of the samples of butter.

With the exception of sample No. 1 the keeping quality of the washed butter was slightly better than that of the unwashed butter.

Excessive overrun is probably due to the incorporation of moisture and not to curd under modern factory conditions.

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