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BULLETIN No. 153

COMPARISON OF METHODS OF SAMPLING CREAM FOR TESTING

By CARL E. LEE and NELSON W. HEPBURN

URBANA, ILLINOIS, FEBRUARY, 1912

Summary of Bulletin No. 153

1. In testing cream, duplicates obtained by the same or different testers are accompanied by a reasonable variation. In samples reported 87.7 percent were exact duplicates or checked within one-half percent, 9.8 percent varied one percent from the individual, while 2½ percent showed a variation of more than one percent. The above figures are significant to anyone expecting exact duplicate results each time a sample is retested. Pages 550-551.

2. There is a greater latitude of variation between composites and individual samples than there is between two sets of composites, but this variation is approximately evenly divided. Pages 552-553, 554-555.

3. Of Hepburn's composites 36.40 percent tested above, while 41.99 percent fell below the individual. Pages 552-553.

4. Two series of composites taken in the same manner showed the following tendency for variation: 63.73 percent were exact duplicates, or varied but one-half percent; 17.60 percent varied 1 percent; 6.33 percent varied 1.5 percent; 7.52 varied 2 percent; 2.1 percent varied 2.5 percent; while 2.8 percent varied more than 2.5 percent. Page 565.

5. During the winter months 41.87 percent of the composites tested *lower* than the individual against 35.38 percent testing *higher*. During the summer months 33.91 percent tested *lower* against 43.16 testing *higher*. Page 570.

6. The results of long time averages are seen in the figures showing that during Lee's period of six months only 15.7 percent of the samples varied more than one-half percent, that during Hepburn's period 15.9 percent of the samples varied more than one-half percent, and that under the proportionate system, for a period of six months, 24.75 percent of the samples varied more than one-half percent. Page 572.

7. Based on the year period only 5.95 percent of Lee samples varied more than one-half percent, while during the same length of time 7.78 percent of Hepburn's varied more than one-half percent. Page 572.

8. Results from the yearly average butter fat show 14.52 percent of composites below the individual and 7.7 above, by Lee, and by Hepburn, 15.34 percent below and 7.78 above. These results are closer than the results obtained by duplicate testing. Page 572.

9. Results are corroborated by total pounds of butter fat in Table 16, showing a variation between individual and composite samples of 27 hundredths and 16 hundredths percent for Lee and Hepburn respectively. Page 574.

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COMPARISON OF METHODS OF SAMPLING CREAM FOR TESTING

By CARL E. LEE, Assistant Chief in Dairy Manufactures,* and NELSON W. HEPBURN, First Assistant in Dairy Manufactures

INTRODUCTION

For several years past butter fat, as determined by the Babcock test, has been used as a paying basis for the dairy product delivered to creameries; yet, after years of experience, those who have watched the development of the various systems of testing and sampling are realizing that many of those systems approved or disapproved by common consent, may or may not be giving results which are mutually satisfactory to both manufacturer and patron.

Since butter fat is the basis of all creamery calculation and, in turn, the basis of payment for the product from the farm, it is imperative that the method, or methods, followed in taking samples and determining the percentage of fat be consistent to a degree which will work hardship neither to the manufacturing concern nor to the patron of the creamery.

It is conceded that the Babcock test, properly manipulated, is the easiest and the most accurate and economical means in the hands of the creamerymen for testing milk and cream for fat, and that the points of dispute and subjects for popular and scientific discussion are more intimately associated with systems of sampling.

It is not the purpose of this investigation to advocate any one method of sampling as being accurate above all others; for it is perfectly clear that if it should appear that any or all the systems give equally good results, they would not all be applicable to every condition. For example: our larger, and many of our smaller, centralizers pay for each delivery or shipment of cream. This, in itself, presupposes the testing of every can of cream as it arrives, and the system of sampling automatically regulates itself. It will further appear that the experience of the operator, the number of patrons, and the business principles followed, all modify the testing system.

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IMPORTANCE OF TESTING

There is a common opinion among creamery inspectors that testing does not occupy the prominent place it should in creamery practice, indicating that few are familiar with the disastrous results of careless testing and practices of sampling which may lead to an inaccurate determination of butter fat. If the test applied to creamery weights is to be used as a basis for payment, then it bears the same relation to that industry that a system of weights and measures does to any commercial business. Few realize that the creamery overrun will, on a 40 percent cream basis, be increased or decreased 3 percent by introducing an error of 1 per cent in testing. This means, in a plant averaging 700 pounds of butter daily, a loss or gain of 21 pounds of butter, worth about $6.00—the salary of two good men. Thus it becomes evident that any practice resulting in a test uniformly high is a source of constant drain to the plant. Should the error fall in the opposite direction, the plant must sooner or later suffer from a list of dissatisfied patrons.

As already referred to, the method of sampling cream for the determination of butter fat has been a subject of dispute and doubt, particularly since the change in manufacturing conditions has led to the delivery of a large amount of butter fat in the form of cream. The object, therefore, of this investigation is primarily to compare the efficiency of systems of sampling now in use, to test their reliability, and to form some opinion of their application and relation to creamery practice.

METHODS OF COLLECTING DATA

The data presented in this bulletin cover the work of one year in the creamery operated by the Department of Dairy Husbandry, University of Illinois. As a result of this method of gathering material several topics of secondary interest have presented themselves, some of which seem to bear a direct relation to the subject in hand. Wherever possible such influences have actually been taken into account, but many of the facts that appear can be assigned no numerical value and at best one may only call attention to their possible influence.

If the sole object of the investigation had been to make mere comparisons on the various systems of sampling cream, this probably could have been more successfully and more scientifically carried out entirely distinct from the commercial activity; but with the secondary object in view it seemed best not only to compare the systems on a large scale, but also to correlate them as closely as possible with modern creamery practice. This end was accomplished, as each sample represented not only a comparison but also a can of cream which contributed to the creamery's daily supply.

During the year the creamery had on its list some 103 patrons but the results published are on only 77, as the other 26 began delivering toward the end of the season and would not make fair comparisons with patrons delivering cream the whole year. The output was, on an average, about 2500 pounds of butter per week.

KINDS OF SAMPLES TAKEN

The comparisons drawn in the following data are between "individual" samples, that is, samples taken from each delivery and tested at once; "ordinary composite" samples; and "proportionate" samples, that is, samples taken in proportion to the amount of cream received. The composite system of sampling here referred to consists merely in obtaining a sample composed of representative amounts of cream from each delivery of a single patron for a period of fifteen days—the method employed in whole milk creameries. The samples were kept in one-half pint lightning jars with tin covers, and preserved with corrosive sublimate, in tablet form, two small tablets being used during the hot months and one during the cooler season. In making the composite no effort was made to obtain a sample in proportion to the amount delivered; the object being merely to have a sample composed of cream from each delivery at the end of fifteen days, as well as a sample large enough for convenient manipulation in testing. It may be added, however, that this practice, when averaged, usually results in securing amounts of cream from each delivery which are approximately equal in volume.

Since the primary object was to compare individual and composite sampling, the first step was to obtain a representative sample of cream from each patron's delivery. This was usually a half pint taken from a can of cream after it had been vigorously stirred to insure thoro mixing. These samples were then tested for fat, and composites made by adding approximately equal amounts of cream for each delivery to the respective composite bottles; that is, if patron Number One delivered a can of cream a half pint bottle was taken for a sample, tested, and about one-fourth of it added to composite bottle Number One.

The method of handling the proportionate sample varied from this only in that an effort was made to secure samples in proportion to the amount of cream delivered.

DETAILS OF TESTING

For the whole experiment 40 percent 18-gram bottles, graduated to one-half percent were used. Scales for weighing samples were of the creamery torsion type. The duplicates represent the results of two men working independently, rather than the close-

ness of duplication by one man. This offers the additional advantage of making it possible to form some opinion of variations occasioned by two persons doing the same testing.

In preparing the composites for testing they were handled in lots of 24 each, the capacity of the centrifuge. The samples were removed from the shelf and placed in rotation in a pan of sufficient height to permit the addition of hot water to the cream line. After warming to fluid condition the cream and fat were removed from the sides of the bottles by means of a spatula, after which a uniform sample was obtained by pouring several times from one vessel to another. An 18-gram sample was then weighed into the test bottle, after which the composite was passed to the second tester, who obtained a duplicate.

Subsequent to the sampling the testing, with few exceptions, was carried on in the usual manner. Highly satisfactory results were gained, however, by a slight change in manipulation previous to the whirling. This consisted of filling the test bottles with water to the base of the neck, previous to the first whirling. Experience in testing cream indicated that the use of such a method resulted in a larger proportion of clear tests, and the absence of those common faults described as curdy samples and burned fat. It may be noted in this connection that the testing of cream, and especially of composites, during the summer months is frequently attended by undesirable results in the form of burned samples or otherwise cloudy tests.

It will be noted that each system of sampling is practically a problem of its own and will necessarily be treated as such preliminary to comparing it with any other system. In the general comparison the individual sample is used as the basis for comparison.

Since all the data are taken from the creamery records, the comparisons appear first in terms of pounds of butter fat. Such comparisons are interesting from the standpoint of the problem of financial loss or gain accruing to each patron, but they are not on a comparable basis, as the pounds of cream for each patron might be widely different. It thus becomes evident that a system of sampling occasioning a large number of pounds variation, in special instances might, or might not, be the cause for a high percentage variation. In view of these facts it seemed best to make a preliminary study of each system, and then compare it with the individual system on the percentage basis. Since each composite represented the test of a patron's cream for a half month, the individual samples would be reduced to similar terms by dividing total pounds of butter fat for those fifteen days by the total pounds of cream,—in other words, determining the "average test." The average test, representing the individual samples, is then fittingly compared with any composite taken for the same length of time.

In each comparison the "individual" sample is represented in the distribution table by the average test and the comparisons may be said to be drawn in three forms: First, in the form of distribution tables representing all the tests; second, in the form of distribution tables showing the effect of averages on the distribution; while the third is a comparison of averages expressed in terms of pounds of butter fat obtained by adding all the butter fat for the year under each system.

DIFFERENCES IN DUPLICATES

During the month previous to the beginning of this experiment preliminary data had been collected which emphasized the suggestion that there is a uniform variation in testing duplicate cream samples, together with a similar variation in the results of two persons attempting to do duplicate work.

The following distribution table is a comparison of the results of Lee's and Hepburn's tests on composites and the summary is no doubt a tangible expression of the usual variation that may be expected from two experienced testers with like standards. Observations from field conditions, however, would lead one to believe that the variation of results obtained by two creamerymen would considerably exceed this. This factor of variation between duplicate samples or between two testers should be borne in mind in drawing other comparisons, as it must be evident that any subsequent variation must be in excess of this if it is to be attributed to method of sampling.

Reading to the right of the zero point gives the number of Lee's composite samples with their respective percents *above* Hepburn's. Reading to the left gives a similar comparison *below* Hepburn's, while the zero column represents the number of samples in which there was no variation. The comparison is based on samples of individual patrons for a period of one year.

From the summary of Table 1, indicated by "total" and "average percentage variation," it is clear that there is a slight tendency on the part of Hepburn to test higher than Lee. This difference may be due to the use of different types of scales during the first five months of the comparison, rather than to any tendency to read differently; for it appeared from the beginning that, with respect to reading, there was a remarkable agreement in the judgment of the two testers. This became more evident as the season advanced, due no doubt to a longer experience in reading and the further establishment of a like standard.

TABLE 1.—VARIATION BETWEEN TWO TESTERS

Patron number	Percent below Hepburn											Percent above Hepburn									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
1										6	9	6	1	1							
2									2	6	10	5									
3									1	3	6	2									
4										8	9	4									
6								1	2	9	4	5	2								
7									1	3		3	1								
8						2			1	2	10	4	3								
9									1	6	9	6	1								
10										8	5	9									
11									1	3	6	2	1								
12										4	8	9									
13									1	7	9	6									
14										3	8	11									
15									2	7	7	4									
18										6	10	3	2	1							
19								1	1	5	7	7	1								
20									2	4	9	4	1								
21									1	1	12	7	2								
22										5	6	3	1								
23										8	8	6	1								
24									2	9	6	6									
25									2	7	8	5	1								
26									2	5	7	1	1								
27									3	1		5	1								
28								1	2	6	7	7									
29										7	3	6									
30									1	3	12	4	1								
31										7	7	2	2								
32											7	4	1								
33									1	4	7	3	1								
34										4	10	5	4								

| | | |

TABLE 2.—COMPARING COMPOSITE WITH INDIVIDUAL SAMPLING ACCORDING TO HEPBURN'S TEST

Patron number	Percent below individual										Percent above individual								
	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½
1							1	4	2	13	1			1	1				
2						1	2		4	4	4	5		1	1				
3							2	2	5	2		1	2						
4				2			2	2	2	7	2	1	2						1
6					1	1	4	1	5	2	3		3						
7				1					1	2	1			1	1				
8						1	2		5	3	4	1	3	1					
9					1	1	1	1	5	2	4	4		1	1	1			
10								2	3	4	8	2	1			1			
11						1		1	2	4	4	1	1	1					
12					1	1	1	3	2	3	3	3		1				1	
13							1		3	7	4	2			3				
14				1		1	1	3	2	7	1	2	1			2			
15		1							1	4	10	3	1						
18					1		2	7	6	4	1								
19							1	4	3	2	3	3	1	2	1				
20					1			3	3	5	2	1	2		1				
21							1	1	4	3	4	2	2	2		1	1		
22					1		2	1	2	2	2	4							
23				1				1	6	5	4	1	1		1			1	
24								2	8	5	2	2	1	1					
25				1			1	6	5	5	1		1						
26			1					3	1	7	2	2	1						
27						1		1	5	3	1	2							
28							1	2	6	6	2		1	1					
29								2	4	6	2		2						
30							2		2	5	2	1	2	2		2			
31						1	1	5	3		1	2	1						
32							1	1	3	3	2		1						
33					1	1	1	3	4				2	1					
34					1	1	1	4	1	9	1		1				1		

35						2		2	3	2	2	1	2						
36							1	1	4	4	2	1		2	2	1			
37							1	1	4	1	3	2	2	3		2			
38						1			6	5	2	3	2	1		1			
39				1	1		1	1	1	3		2	1						
40								1	3	4	4		4	1	1				
41				1				1	4	9	2	4							
42								4	2	8	3	3		1					
43					1	1	1	3	5	3	3	1							
44					3		1	3	3	3	5	1	1		1				
45									2	1	1								
46							3	1	3	7	2	3		2					
48						2	1	2	5	3	1	4			1				
49							2		3	1	2	1		1					
50				1					1	1	2	1	1		1				
51									2	1		2							
52							2	1	2	1	2		1						
53							1		1	1	1								
54						1		2	4	3	4	3			1				
55							1	1	4	4	8		2						
56							1		5	5	1	4						1	
57						1	·1	2	1	4	3	1	1	1					
58				1				5	6	3	1	2			1				
59							1	4	5	3		2				1	1	1	
60					1	1	3	1	2	3	2		3	2		1			
61							1	1	2	3	2	2		2					
63			1			3		1	4	4	2	1				1			
64						1		1		5	4								
66					1	2	1		1	2	5	2			1				
69								2	2	5	2		1						
70						2	2		4	2	4	1			1			1	
71					1		2		2	6	2	2			1				
75								2	3	4	3	3							
Total		1	2	10	16	28	58	108	207	248	161	97	54	32	21	14	3	5	1
Average percent		.093	.187	.93	1.50	2.62	5.44	10.13	19.41	23.26	15.10	9.09	5.06	3.0	1.97	1.4	.28	.469	.093

Total number of samples 1066

TABLE 3.—COMPARING COMPOSITE WITH INDIVIDUAL SAMPLING ACCORDING TO LEE'S TEST

Patron number	Percent below individual											Percent above individual									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
1								3	1	4	11	3				1	1				
2					1			2	1	1	6	5	4	1	1						
3								3	5		1	1	2	1							
4											6										
6						1	5	3	1	4	4	1	3	1	1						
7						1			1	1	1	1				1	1	1	1		
8							1	1	4	4	4	5	1	2		1	1				
9							1	2	3	4	2	4		3	2	1		1			
10									3	1	8	7	2	2					1		
11						1			2	3	7			1	2						
12							1	1	5	5	2	2	2	3				1			
13								1	3	7	5	3	2		2		1				
14							1	1	2	6	6	4	1			2		1			
15				1					1	4	8	4	1	3							
16							2	1	9	7	2		3								
19				1				1	4	5	2	2	2	5			1	1	1		
20						1	1		2	6	8	3	1		1						
21								1	1	1	4	6	6		2	1	1	1			
22						1	1	2	1	2	4	3	2								
23										8	6	2	1	3					2		
24								3	2	4	9	1	2	2		1					
25							1	1	7	6	4	2	1								
26			1					1	4	3	3	4		1							
27					1			2	3	2	7	2	3								
28							1	1	2	8	7	3	1								
29							1		3	4	6	1	1	1							
30									3	2	6	3		4	2	1	1				
31	1			1			1	1	5	1	3		2	1	1						
32							1		2	2	4	1		2					1		
33							1	1	3	4	1	2	1	1	1		1				
34						1		1	5	2	5	3	1	1	1		2				

35							1	2	2	2	2	2	4	1							
36								1	2	3	4	5	2	2		2					
37								1	3	4	2	4	3	3	3						
38								1	1	6	2	2	4			1					
39							1	1	4	1	2		1	1							
40									2	3	4	3	4	1		1					
41							1	1	1	9	4	3	2	2							
42							1	1	5	3	4	5	1	1	2						
43							3	3	2	4	2	5	1		2						
44						1	1	1	5	3	4	5	1	1			1				
45										1	3	2									
46							1	4	1	2	9	4		1	1						
48					1			2	1	3	6	1	4	1					1		
49								2		2	5	1		1							
50						1			1	1	3	3		1		1					
51								1	1	1	3	1									
52							3	1		2	2	1		2							
53				1				2			2	1									
54							1	1		3	6	5	3	1			1				
55								2	4	4	7	2	3								
56						1		1		1	7	3	1	2		1					
57						1		1	2	6	5	2		1							
58					1			1	5	5	5		3		1						
59							1		4	4	4	2	1	1				1	1		
60					1		2	1	2	3	4	2		2	2	1	1				
62									2	2	5	3		1	1						
63					1	1	1	1	2	6	3	2		1		2					
64								1	2		4	3	1								
66						1	2		1	3	2	4	3			1	1				
69								2		2	2	4	1	1							
70							2	1	1	5	3	2	2				1		1		
71				1				1	3	2	5	4			1	1					
75					1			1	2	1	5	1	2	2	2						
Total	1		1	5	7	12	40	71	149	208	282	165	92	68	31	20	15	7	9		
Average percent	.084		.084	.42	.58	1.01	3.4	6.	12.6	17.9	23.8	14.	7.7	5.7	2.6	1.69	1.27	.58	.76		

Total number of samples 1182

Referring to the summary of Table 1 it is seen that 87.7 percent of the 1165 samples reported tested the same or fell within the limit of one-half percent variation, while there is only one instance where the difference was as much as 3 percent. It is further a fact worthy of comment that the differences are approximately evenly distributed on either side of the zero line, which means that in any series of such tests these irregularities tend to correct or at least to equalize each other.

Table 2 is a distribution table used as a basis for comparing Hepburn's composite tests with average individual tests on each patron, for periods of fifteen days each during one year. The data are arranged similar to those in Table 1. The zero column shows the number of composites testing the same as the average individual tests. Reading to the right of the zero column gives the number of samples with their respective percentages of fat above the individual, while those below the zero column give the number of samples with their respective percentages of fat below the individual.

In studying the comparison of composite with individual samples it is at once obvious that a much wider distribution is displayed than in the comparison of duplicate testing, but again, there is a remarkable equilibrium of total results derived from the tendency for the same number of samples to vary an equal amount in either direction.

Out of a total of 1066 samples used for comparison 36.46 percent tested higher than the individual, while 40.30 percent fell below the individual, and 57.77 percent either tested the same or came within the limit of one-half percent variation. Of the composites 19.22 percent varied one percent from the individual; 10.5 percent varied 1.5 percent; 5.62 percent varied two percent; while in 6.92 percent there was a variation of more than two percent. The highest variation recorded in this comparison is in two samples differing 4.5 percent from the individual.

Special attention should be directed toward the figures showing that 40.30 percent of the composites tested lower than the individuals and only 36.46 percent tested above the individual. While in this investigation we cannot hope to assign a cause to such a tendency, its presence is noted in every comparison.

Table 3 is a complement of Table 2 and needs no explanation. Since this is a comparison of Lee's composite with the individual samples, it should be noted that there is the same degree of correlation between Table 2 and Table 3 as between the comparison of testers in Table 1.

The variation of Lee's composite from the individual is practically the same as in the comparison of Hepburn's composite with the individual. 55.7 percent of the samples tested the same or fell within the limit of one-half percent variation; 20.3 percent varied one percent from the individual; 11.7 percent, 1.5 percent; 6 percent, 2 percent; while 6.39 percent varied more than 2 percent. The highest variation was 5 percent in one sample.

PROPORTIONATE SAMPLING

The comparison of the individual samples with the proportionate composite is on a slightly different basis from those comparisons involving individual and ordinary composites, since the data covers a period of only six months and consequently represents about half the number of samples used in former comparisons.

The proportionate sample was taken by means of a graduated pipette, the size of the samples varying in different instances from 1 cc. per pound of cream to 10 or 20 cc. The amount of cream usually delivered by the patron was the standard determining the ratio to be used, and the effort was made in this case, as with the regular composite, to have a sample at the end of fifteen days large enough to be convenient for manipulation in testing. In this we were successful only in so far as we were able to estimate the amount of cream to be delivered by a patron for fifteen days, and so it often happened that the sample for the testing period was represented by a smaller amount of cream than is suitable for the best results.

Theoretically, composites taken in proportion to the amount of cream should give results corresponding most closely to the individual testing, and such would probably be the case in sampling milk or thin cream, but the mechanical difficulties attending the use of such a system with heavy cream tend to destroy its proportionate value, and with thick, sour, and viscous cream, such a sample often becomes proportionate only in name. This perhaps will serve to explain the cause for some of the irregularities of the proportionate sample taken in this manner.

Table 4 illustrates by distribution the difference between proportionate composites and individual samples. In this, as in former cases, the individual is used as a standard for comparison.

TABLE 4.—COMPARISON OF PROPORTIONATE COMPOSITE SAMPLES WITH INDIVIDUAL SAMPLE

Patron number	Percent below individual											Percent above individual									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
1								2	2	2	5	1		1							
2						1			1	5	2	4									
3													1	2							
4																					
6						2		1	3		3	2		1		1					
7																					
8							2	1	1		2	1					2				
9		1							3	1	1	2	1	1		1	1				
10									1	1	3	1	4		2				1		
11										1	1	1		2	1						
12							2				1	3	3			2			1		
13							1	1	1	1	2	1	6								
14								1		4	1	3	3		1						
15		1									3	3	2								
18					1		2	2	5		2	1		1							
19							2		2	2	1			1	2	1	2				
20										2	3	3	1	1	1	1					
21							1	1		1	3	1		1	4				1		
22	1							1			3		1								
23								1	2	2	3		4								
24									3	3	2	1	2	1	1						
25							1		1	2	4	1									
26			1				1			1	2	1			2						
27							1	1			1	1	1			1	1				
28					1		1	1	2	2	3	1	1	1							
29								1		3	2		1								
30										2	2			2			1				
31			1				1		1	1	1	1	1			1					
32								1		1	1										
33								2		1			1			1					
34					1		1	2		3			1	2							

35							1				1	1		3							
36					1		1	1						2	1		1				
37									3	2	3	2	1								
38								1		1	3	2		2		1	1				
39											1						1				
40								1	1	1	3		2								
41								2	1	1	2		3		1		1				
42							1		2	1	2	2	1	1	1						
43			1	1	1	1		1	1	1	1		1					1			
44						1	2	1	2	1		3				1					
45										2	1	1									
46							1	2		1	3	2	1		1						
48								1	4	1	2	2	1								
50									1	2	1										
51								1		1	1	1					1				
52						2	3	2		1											
53								1	1	2											
54						1	1				2	2	2	2					1		
55						2		1	1	3	3										
56								1	1	2	2	1		1				1			
57		1					1	1		2		1	1								
58						1		2	2	1	2	1		1							
59							2	1	1	1		1	1								
60					1	1			2	1	2	2		1							
61										1	1	1				1	1				
63								1	1	1	2	1	2		1						
64						1	1	1			1	1	2		1						
66								3		1	1	1	1								
69										2	2	1					1				
70					1	1		1	2	2	2			1							
71								1	2	2	2			1							
75						1				1	1	2	2								
Total	1	3	3	1	7	15	30	46	56	79	104	64	55	32	20	12	14	2	4		
Average percent	.2	.5	.5	.2	1.3	2.7	5.5	8.4	10.	14.5	19.1	11.2	10.2	5.9	3.6	2.2	2.6	.4	.7		

Total number of samples 546

TABLE 5.—COMPARISON OF PROPORTIONATE COMPOSITE WITH HEPBURN'S COMPOSITE: COMPARISON BASED ON A FIVE-MONTHS PERIOD

Patron number	Percent below Hepburn's											Percent above Hepburn's									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
1				1				1	2	2	2	1	3								
2					1			1	3	1	2		1	1							
4								1	1	2	2		2		3						
6							1	2	1	4			3						1		
8				1			1		3		3		1								
9						1	1			2	2	1	1	1	2						
10										3	2	4		1	1						
11								1		1	1	2	1								
12							1				3	2	1	3							
13								2		2		2	1	1		2		1			
14							1	1		2	2	1	4								
15								1	2	3	3	1									
18						1			1	4	2	2	1								
19								1	2	2		2	1		2	1					
20											2	1	5			1					
21								2	2	3	3	1									
22									1			1		1		1					
23					1	2				3	3	1		1							
24								1	2	4	4										
25							1	1	1	4	1		2		1						
26								1	1	1	1		1	1							
27						1			1			1	1	1						1	
28					1		1			2	5	1		1							
29									1	3		2		1							
30								1		1	1	2		2							
31						2		1			1	3	1								
32									1		1	1									
33									1	2		2									
34							1	1	1	2		3	1			1					
35										1	3			1							

36							1		1	2		1	2					1			
37					1	2			2	3	2		1								
38									2	2	5				2						
39													1	1							
40								1	2	2	1	2									
41									4	1		2	1			1	2				
42								1	1	3	2	1	1	2							
43									2			2				1					
44								2		2	1	1	3		2						
45									1	1	1	2									
46					1	1	1		1		3	2		1	1						
48							1	2	2		3	1	2								
50								2		2											
51									1	2	2	1									
53									3		1										
54								1	1	1	1	2		1	1						
55					1			1	1	3	2	2									
56									2	3	1	1			1	1					
57	1			1			1		1	1	1	1		1							
58									1	2	5	1		1							
59						1		1	1	2	1	1			1						
60				1					1	1	2	5									
61										1	1	2	1								
63				1	1		2	2	1		1		1	1							
64							1			2		1	3	1							
66			1					1	1	1	2	1									
67																					
69									1	1	2		1				1				
70						1		1		3	2	3									
71									4	1	1			1							
75					1		1			3	2	2	1								
Total	1		1	5	8	12	16	34	64	99	94	74	49	26	17	9	3	2	1	1	
Average percent	.19		.19	.97	1.55	2.32	3.1	6.59	12.4	19.2	18.21	14.34	9.49	5.04	3.29	1.74	.581	.387	.19	.19	

Total number of samples 516

TABLE 6.—PERCENTAGE SUMMARY OF DISTRIBUTION TABLES COMPARING THE DISTRIBUTION BY EACH SYSTEM OF SAMPLING

	Percent below											Percent above									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
Lee's with Hepburn's composite					.086	.17	.2	.94	5.48	25.8	39.1	22.8	4.3	.9							
Hepburn's composite with individual			.09	.187	.93	1.50	2.62	5.44	10.13	19.41	23.26	15.1	9.09	5.06	3.0	1 97	1.4	.28	.47	.09	
Lee's composite with individual				.42	.58	1.01	3.4	6.0	12.6	17.9	23.8	14.0	7.7	5.7	2.6	1.69	1.2	.58	.76		
Individual with proportionate	.18	.54	.54	.18	1.29	2.74	5.5	8.44	10.2	14.5	19.08	11.19	10.09	5.87	3.7	2.2	2.6	.36	.72		
Proportionate with Hepburn's composite	.19		.19	.97	1.55	2.32	3.1	6.39	12.4	19.18	18.21	14.34	9.49	5.04	3.3	1.74	.58	.39	.19	.19	

Table 4 shows a still greater latitude of distribution: viz., 44.77 percent, against 55.7 percent in the previous comparison, tested the same or varied only one-half percent; 20.29 percent varied 1 percent; 14.31 percent, 1.5 percent; 9.16 percent, 2 percent; and 11.31 percent, more than 2 percent. The widest variation was 5 percent. Here again, with 44.12 percent of the samples testing *below* and 36.65 percent testing *above,* is a tendency for the composite to fall below the individual. No doubt the wider latitude of variation, as well as a greater tendency to collect on the low side in this system of sampling, is largely accounted for by the fact that in an effort to secure a proportionate sample where small amounts of cream were delivered, it often happened that small samples were collected for testing. This practice sometimes resulted in samples which were too small for convenient manipulation.

The foregoing distribution table (Table 5) is prepared merely to show how the proportionate composite varied from Hepburn's regular composite. Whether this comparison would be any criterion for the comparative results of proportionate and ordinary composite samples in general, would depend largely on how the proportionate samples were taken. The notable feature of this table is the tendency of the proportionate composite to fall below the regular composite.

Table 6 is the percentage summary of distribution tables numbers 1, 2, 3, 4 and 5, compiled here merely to show their comparative values. Figures in the table show percentage of samples varying in either direction from the zero line by each system.

Table 7 is a comparative expression, in terms of percent, of the variation occasioned by the methods, with the individual used as a basis for comparison. Column 1 gives the percent of samples testing the same as, or varying one-half percent from the individual; column 2, the percent varying one percent; column 3, the percent varying 1.5 percent; column 4, the percent varying 2 per cent; column 5, the percent varying more than 2 percent. Columns 6 and 7 are quite significant in that they show the total percent of samples testing above and below the individual and are consequently the one quantitative expression of the difference between the various composites and their relation to the individual.

TABLE 7.—SUMMARY TABLE COMPARING THE DIFFERENT SYSTEMS OF SAMPLING WITH THE INDIVIDUAL SYSTEM

	1	2	3	4	5	6	7
	Percent same or varying ½%	Percent varying 1%	Percent varying 1-½%	Percent varying 2%	Percent varying more than 2%	Percent above individual	Percent below individual
Hepburn with individual	57.77	19.22	10.50	5.62	6.92	36.46	40.30
Lee with individual	55.70	20.30	11.70	6.00	6.39	34.30	41.99
Proport'n-ate with individual	44.77	20.29	14.31	9.16	11.31	36.65	44.12

DIFFERENCE IN SAMPLES TAKEN IN THE SAME MANNER

From the foregoing data it is evident that there is considerable difference in tests resulting from the various commercial methods of collecting samples, which naturally leads up to the question of how much variation there might be between samples purported to be taken in the same manner. Such data would be especially interesting on the ordinary composite, since this is the usual creamery sample. It would be further suggested that any variation obtained under different systems of sampling should be in excess of this if it is to be attributed to the difference in method. As a means of obtaining some idea of the variation in samples taken in a like manner two ordinary composites were collected during the last month of the experiment. These were taken after the manner described for collecting the regular composite, so that either might have been used as a paying basis for the month. The results here showed 34.6 percent of the samples to be exact duplicates; 19.08 percent, one-half percent high; 9.86 percent, one percent high; 2.11 percent, one and one-half percent high; 4.22 percent, two percent high; 1.4 percent, two and one-half percent high; and 1.4 percent, four percent high. 10.5 percent were one-half below the individual; 7.74 percent, one percent below; 4.22 percent, one and one-half percent below; 2.83 percent, two percent below; 0.7 percent, two and one-half percent below; and 1.4 percent, three and one-half percent below.

By subtracting the variation resulting from duplicate testing, we then have some indication of the variation accruing to samples taken in the same manner. This, however, is perhaps only a suggestion of results, since the number of comparisons are too small to warrant any conclusions.

SEASONAL INFLUENCE

The condition of composites, together with some knowledge of the causes for such conditions, is probably responsible for the inference that seasons of the year, accompanied by various intensities of heat, cold and light, have their effect upon the results obtained from the composite samples. As a means of comparing the effect of seasons two distribution tables, numbers 8 and 9, are here presented, comparing composite with individual samples, for the winter months of December, January, February and March, and the summer months of June, July, August and September.

TABLE 8.—COMPARISON OF COMPOSITES WITH INDIVIDUAL SAMPLES FOR THE MONTHS OF DECEMBER, JANUARY, FEBRUARY AND MARCH

Patron number	Percent below individual											Percent above individual									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
1									1	2	5										
2						1		1	2	1		2									
4					1				1	3	2			1							
6						1			3		2			1							
8										2	2	2	1				1				
9						1	1	1		3		2									
10									2	1	1	3						1			
12									3	2	1	2									
13										1	4	1			1	1					
14								2	1	1	4										
15			1								1	2	1	1							
18							1	2	2	2				1							
19							1			3		3				1					
20							1		1	1	2	2		1							
21								1	1	1	2	1	1					1			
22						1	1	2					2								
23										2	1	2	2				1				
24									1	2	1	1		1	2						
25									2	2	1	2				1					
26			1						1		2		1								
27											2				1						
28							1			1	6										
29										2											
30								1			3	2	2	1			1				
31								1						1	2						
32										4	1	1									
33													3	2				1			
34									4		3		1		1						
35							1		2			2		3							
36								1	1	2	2		1								
37								1		2		3	1		1						

38											2	2		1	2			1				
40											1	4	1	2	1							
41					1					2	1	1	1	2								
42								2		2	1	2					1					
43								2		1	2	1	3	1			1					
44				1						1	2	1	3									
45											3	1	1	1								
46								1		1		5	1									
47											2	2	2	1			1					
51										1	2	2		2								
52								2		1	2	1	2	1	1	1						
53					1					1	2	1	1									
54							1				3	2	2									
55											2	1	3	2								
56											1	1		2								
57										1		3										
58								2		2		2	1	1								
59								1		2	3	2										
60						1		4		2		3	3									
61										1		1		1								
63						1		1				3	1	1				1				
64							1			1		3	3									
66								1			1	1	3	1			1					
70					1		1				1	1	3							1		
75								1		3		1	1	1	1							
Total			2	1	4	6	10	30	50	71	95	68	36	18	9	7	5	3	1			
Average percent			.48	.24	.95	1.44	2.4	7.22	12.04	17.1	22.55	16.38	8.67	4.33	2.16	1.68	1.2	.72	.24			

Total number of samples 416

TABLE 9—COMPARISON OF COMPOSITES WITH INDIVIDUAL SAMPLES FOR THE MONTHS OF JUNE, JULY, AUGUST AND SEPTEMBER

Patron number	Percent below individual											Percent above individual									
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
1										1	3	1				1	1		1		
2								2		2	1	1	1								
3								2	1	1	1			2							
4								1	1		2		1	1						1	
6							1	1		2	2	1		1							
8							1	1		1	1			1	1						
9												2	2		2	1					
10										1	2	3	1								
11							1			1	2	2	1								
12								1	1	2	1		1		1						
13										2	2	1	2								
14										1	2	3	1								
15											2	4	1								
18									2	1	4										
19									2	1			2		1			1			
20						1			1		4			1							
21											1	2	1	1	1						
22									2	2		2	1								
23	1										2	2		1		1					
24									1	2	2	1	1								
25					1					3	2		1								
26									1		2	1	2	1							
27									3		1	1	1	1							
28										5	1			1							
29									1		3		2								
30											1			3	2		1				
31						1	1		2	1		1									
32											1		1					1			
33						1	1	1		1		1			1						
35										1	1	1	1								
36											1	3			1	2					

37									1	1		3		1	1						
38										2	2		1	1	1						
39							2	1	1		1		1	1							
40											4		3								
41											4		3								
42										1	3	2	1								
43							1	1	1	1	1	2									
44							2	1	1	1	1		2	1		1					
45																					
46									1	1	1		1	2		1					
48								1			2	1	1	1	1						
49									1		2	1	2	1							
50										1	3	1		1		1					
51																					
54											3	1	1	1							
55									1			2	3		1						
56									1		2	2	1						1		
57									1		1	1	2	1		1					
58											2	2	1	1			1				
59									1		1	2		1				1	1		
60											1		2		2	1		1			
61									1		2	1	1	1		1					
63						1					3	1	1								
66							1				1	1	2	1							
69										1		5			1						
70									1	1	2			1			1			1	
71										1		4		1							
75											1	2	1	1							
Total	1					2	7	10	20	27	64	91	56	48	24	16	9	4	3	3	1
Average percent	.25					.52	1.8	2.59	5.18	7.	16.57	23.57	14.49	12.43	6.92	4.14	2.33	1.04	.78	.78	.25

Total number samples 386

TABLE 10.—PERCENTAGE SUMMARY OF DISTRIBUTION TABLES 8 AND 9

	Percent below individual											Percent above individual								
	5	4½	4	3½	3	2½	2	1½	1	½	0	½	1	1½	2	2½	3	3½	4	4½	5
Winter months			.48	.24	.95	1.44	2.40	7.22	12.04	17.10	22.55	16.38	8.67	4.33	2.16	1.68	1.20	.72	.24		
Summer months					.52	1.80	2.59	5.18	7.00	16.57	23.57	14.49	12.43	6.92	4.14	2.33	1.04	.78	.78		.25

Table 10 is compiled from Tables 8 and 9, as a summary showing the comparative percentages and their distribution resulting from seasonal selection.

TABLE 11.—SEASONAL INFLUENCE

	Same or ½ percent variation	1 percent variation	1½ percent variation	2 percent variation	More than 2 percent variation	Percent of samples below individual	Percent of samples above individual
Winter months	56.03%	20.71%	11.55%	4.56%	6.95%	41.87%	35.38%
Summer months	54.63%	19.43%	12.10%	6.73%	7.75%	33.91%	43.16%

Table 11 is also derived from Tables 8 and 9, illustrating still further the comparative relation between composite and individual samples collected during the two extreme seasons of the year.

The study of seasonal influence is, in this connection, of peculiar interest, since the question of difference caused by season is intimately related to influences of evaporation and other factors potent in causing disagreement between composites and individuals. Referring to Table 11, we note a tendency for the composite to fall below the individual in winter, with more than a corresponding tendency for a higher test in summer.

RESULTS OF AVERAGES

Tables 12 and 13 are summary tables derived from data recorded under Table 16, which gives total butter fat, cream, and average tests by patrons under each system of sampling for six months and for one year. It might be added that the object of inserting the six-months comparison is to show data comparable with the proportionate samples, since they were collected only for that length of time.

TABLE 12.—COMPARISON OF COMPOSITE WITH INDIVIDUAL TESTING FOR SIX MONTHS

	2½	2	1½	1	½	0	½	1	1½	2	2½
Number of variations according to Lee		2	2	7	22	60	13	6	1		
Percentage variation according to Lee		1.7	1.7	6.2	19.5	53.7	11.5	5.30	.8		
Number of variations according to Hepburn		2	2	7	11	70	16	5	1		
Percentage variation according to Hepburn		1.75	1.75	6.13	9.64	61.4	14.	4.4	.87		
Number of variations according to "proportionate"	1	2	2	19	20	52	12	4			
Percentage variation according to "proportionate"	.9	1.77	1.77	16.81	17.61	46.01	10.62	3.6			

Tables 12 and 13 show the distribution of the average tests, with a marked tendency for agreement of the various systems. It is apparent that, disregarding the proportionate sample, average results for comparatively long periods show no more difference between the various systems than exists between duplicate samples.

Table 15 is still further summarized in Table 14 (A and B), showing the percent of samples testing the same or varying only

one-half percent, one percent, one and one-half percent, and two percent. Attention should again be directed to the two columns showing the percent of composites above and below the individual, since this is a quantitative record of the percentage difference based on pounds of butter fat delivered by patrons for the six-months period and for the yearly period.

TABLE 13.—COMPARISON OF COMPOSITE WITH INDIVIDUAL TESTING FOR ONE YEAR

	2½	2	1½	1	½	0	½	1	1½	2	2½
Number of variations according to Lee		1	1	5	10	91	9				
Percentage variation according to Lee		.85	.85	4.27	8.55	77.8	7.7				
Number of variations according to Hepburn		1	4	3	10	90	8	1			
Percentage variation according to Hepburn		.85	3.39	2.56	8.54	76.92	6.83	.85			

TABLE 14.—SUMMARY TABLE SHOWING PERCENTAGE DIFFERENCE OF VARIOUS COMPOSITES COMPARED WITH THE INDIVIDUAL. RESULTS DERIVED FROM POUNDS BUTTER FAT DELIVERED

(A) Based on a Period of Six Months

	Same or ½ per cent variati'n	1 per cent variati'n	1½ per cent variati'n	2 per cent variati'n	Below individual	Above individual
Lee	84.70%	11.6%	2.50%	1.70%	29.10%	17.60%
Hepburn	85.04%	10.53%	2.62%	1.75%	19.27%	19.27%
Proportionate	84.24%	20.41%	1.77%	1.77%	38.86%	14.22%

(B) Based on a Period of One Year

Lee	94.05%	4.27%	0.85%	0.85%	14.52%	7.70%
Hepburn	92.29%	3.41%	3.39%	0.85%	15.34%	7.69%

The above table still further emphasizes the tendency for variation of results to equalize each other, especially at the end of long periods of time, indicating clearly that there is very little difference in the various methods of sampling when results are compared for a season.

The following tabulated data on three patrons, representing the pounds of butter fat for the year and half-year, for each fifteen days, are presented in corroboration of former data and as an example of the derivation of results in former tables based on the 77 patrons. These are typical results, selected at random, and are quite representative of what was found in the other 74, as is shown in the various distributions.

TABLE 15.—SHOWING COMPARISON IN TERMS OF POUNDS OF BUTTER FAT

Patron number		Total ½ mo. deliveries for 6 mo. period				Total ½ mo. deliveries for yr. period		
	Method of sampling	Pounds cream	Pounds fat	Average test		Pounds cream	Pounds fat	Average test
2	First half of month							
	Individual	1019.5	275.89	27.06		2808.5	746.79	26.59
	Lee's composite		276.68	27.13			748.54	26.65
	Hepburn's "		277.19	27.19			748.99	26.67
	Proportionate		269.45	26.43				
	Second half of month							
	Individual	897	163.31	18.21		2605	661.58	25.39
	Lee's composite		162.00	18.06			660.29	25.34
	Hepburn's "		163.20	18.19			662.35	25.42
	Proportionate		161.05	17.95				
31	First half of month							
	Individual	375.5	126.97	33.80		629	228.66	36.40
	Lee's composite		130.78	34.80			228.71	36.40
	Hepburn's "		131.23	35.00			229.22	36.5
	Proportionate		128.39	34.20				
	Second half of month							
	Individual	178	63.41	35.60		465	178.77	38.40
	Lee's composite		60.90	34.20			174.25	37.50
	Hepburn's "		61.10	34.30			173.82	37.40
	Proportionate		61.76	34.70				
56	First half of month							
	Individual	603.5	131.63	21.80		1335.5	236.50	17.70
	Lee's composite		132.37	21.95			234.09	17.55
	Hepburn's "		132.79	22.00			235.43	17.60
	Proportionate		129.09	21.4				
	Second half of month							
	Individual	471	92.98	19.70		1124.15	307.90	24.80
	Lee's composite		93.49	19.85			311.90	25.10
	Hepburn's "		93.33	19.80			312.22	25.20
	Proportionate		98.63	20.9				

Table 16 is a summary showing the total number of pounds of butter fat for each system of sampling and testing for six months and for one year.

TABLE 16.—SUMMARY IN TERMS OF TOTAL FAT

Total for six months				Total for one year		
Individual	Lee's composite	Hepburn's composite	Proportionate	Individual	Lee's composite	Hepburn's composite
18508 lbs	18455 lbs	18487 lbs	18344 lbs	48233 lbs	47105 lbs	47156 lbs
Pounds difference	53.05	20.45	164.02		128.34	76.95
Perc'tage difference	.28	.11	.88		.27	.16

Table 16 is a striking illustration of the tendency for variation to equalize under the various systems of sampling. It should be noted here also that pounds of butter fat, by any system of composites, fall slightly below the individual, but that from the commercial point of view the yearly percentage difference is not worthy of comment.

On 600 pounds of butter fat, a high yearly estimate for the patrons referred to, the difference for the year would amount to 1.62 pounds of butter fat by Lee and one pound by Hepburn.

CONCLUSIONS

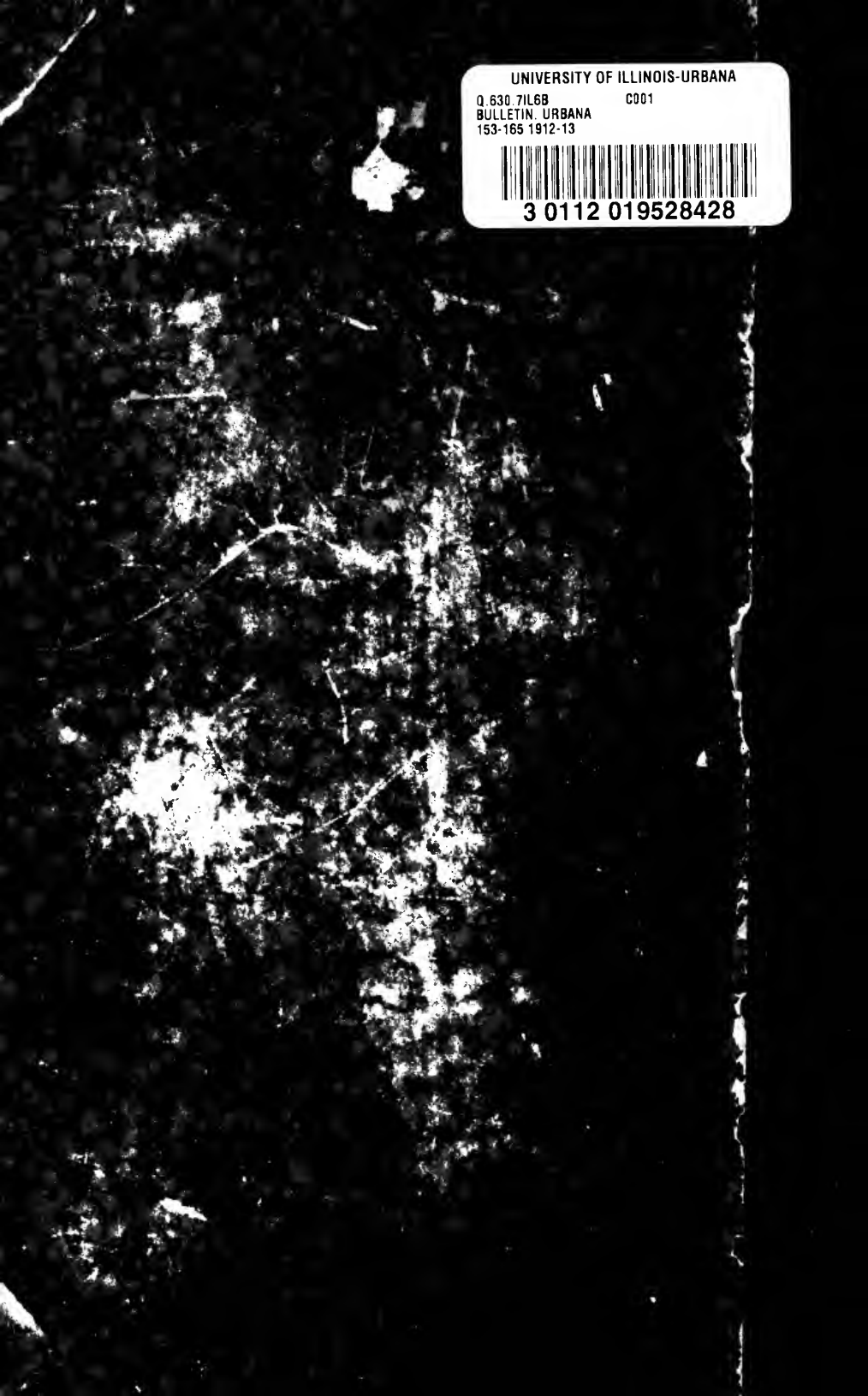
1. Reasonable allowance should be made for difference in duplicate samples tested by the same or different testers.

2. In testing cream there is a marked tendency for variation between composite and individual testing for short periods of time, but the distribution of this variation is such as to occasion very small amounts of difference when figured on seasonal periods.

3. Composite samples tend to test slightly higher than individual samples in summer, and lower in winter.

4. Based on yearly averages there is practically no difference between composite and individual samples.

5. Testing in creamery practice should be accorded a place of prominence commensurate with the importance of the results to be derived from it.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