The Babcock test for butterfat, named for its inventor, Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station, is a rapid, accurate, inexpensive and simple method of testing milk and milk products for the percentage of butterfat. It is based upon the action of sulphuric acid and the use of centrifugal force.

The sulphuric acid dissolves all the milk solids except the fat and as a result allows the fat to rise more rapidly. The chemical action resulting from the addition of the acid generates heat which melts the fat globules and causes the fat to rise more rapidly. The separation of the fat is
further aided by the increase in specific gravity of the serum caused by
the heavy sulphuric acid.

The centrifugal force throws the heavy parts violently outward
and the fat is gradually forced to the center (the top of the mixture).

TESTING WHOLE MILK

The steps to be followed in the operation of the Babcock test are:

1. Secure a representative sample of milk.
2. Measure out 17.6 c.c. of this milk with a pipette.
3. Transfer the milk from the pipette to the test bottle.
4. Add 17.5 c.c. of sulphuric acid to the milk in the test bottle.
5. Thoroughly mix the milk and acid by shaking with a rotary motion.
6. Place the bottles in the centrifuge, (Babcock tester), cover, and whirl at the proper speed for 5 minutes.
7. Add hot water until the contents rise to the neck of the bottle and whirl again for 2 minutes. Next add enough more hot water to bring the fat column entirely within the graduated portion of the neck of the bottle and whirl again for 1 minute.
8. Read the test at a temperature of about 135° Fahrenheit.

Securing a Representative Sample.—In the testing of milk and cream for butterfat by the Babcock method the most serious errors ordinarily result from failure to secure a representative sample rather than in the operation of the test itself. Since a single test may involve several hundred dollars worth of produce the importance of obtaining an accurate and representative sample can not be over emphasized. Butterfat in milk exists in minute globules in suspension. These, being lighter than the rest of the milk, tend to rise, carrying
with them small amounts of the other solids resulting in the familiar creaming of milk. Before the test is made, care must be taken that the sample represents a fair average of the milk to be tested. The milk should be thoroughly mixed by pouring back and forth from one vessel to another several times, or by thoroughly stirring. Milk should be sampled when at a temperature between 60 and 70°F. If the cream layer does not completely disappear upon agitation, the milk should be warmed to about 95°F., thoroughly mixed, and cooled to about 70°F. before procuring the sample. (The reader is also referred to page 15 where sampling is further discussed).

**Measuring the Milk.**—The milk is measured with a 17.6-c.c. pipette. After the milk is thoroughly mixed, the tip of the pipette is immediately inserted and the milk sucked up with the mouth until it rises well above the graduation mark on the stem. The dry forefinger is then quickly placed over the mouth of the pipette. Holding the pipette vertically

![Figure 4](image4.png)  
**Fig. 4.—Correct way to transfer the milk from the pipette to the test bottle.**

![Figure 5](image5.png)  
**Fig. 5.—The wrong way of transferring the milk to the test bottle.**

with the mark on a level with the eye, gently relax the pressure of the finger and allow the milk to flow slowly out until the top of the column
of milk is level with the mark on the pipette. The pipette then holds just enough milk to deliver the correct amount for the test.

Filling the Test Bottle.—Place the tip of the pipette in the neck of the test bottle. Hold both the test bottle and the pipette in a slightly oblique position and let the milk run slowly into the bottle. The object of inclining the test bottle and pipette is to allow the milk to run down the side of the neck of the test bottle thus allowing an exit for the air in the bottle. If this precaution is not observed the neck of the bottle may clog up and some of the milk run over the top. When nearly all of the milk has run out of the pipette, the last drop may be forced out by blowing into the upper end of the pipette. In this manner 17.5 cubic centimeters of milk (18 grams) are delivered into the bottle, the extra one-tenth of a cubic centimeter held by the pipette is the amount which ordinarily remains clinging to its wall.

![Image of pipette](image.png)

Fig. 6.—Putting the milk into the test bottle (alternate plan). The lower end of the pipette must be small enough to fit loosely inside the neck of the test bottle.

Skilled testers, who desire greater speed in the testing procedure often use two pipettes. In this case a pipette with the lower part small enough to be inserted into the neck of the test bottle and yet allow the escape of air, is used. There is no objection to this procedure, provided
the outside of the pipette has been wiped dry, otherwise, too much milk may be delivered to the test bottle. Furthermore, milk adhering to the pipette point interferes with the outgoing air which is being displaced by the milk, and the consequent loss of milk in the bubbles that escape will necessitate starting the test over again.

Adding the Acid.—After the milk has been measured into the test bottle, the acid, also at a temperature of about 70°F., should be added.

The acid is added by means of a measuring cylinder. To get the correct amount fill the measure up to the mark (17.5 c.c.). Hold the test bottle in an inclined position and slowly pour in the acid. The bottle should be rotated slowly at the same time so that all milk adhering to the neck will be washed down. The milk and acid should now be in two distinct layers in the bottle. Never drop the acid directly through the body of the milk for charred, black particles may be produced which will obstruct the reading later.

The acid may also be added by means of a glass dipper made with a lip so as to facilitate pouring. Where a large number of samples are tested daily the acid burette holding one dozen charges and equipped with a siphon system saves much time.
The acid used is commercial sulphuric, specific gravity 1.82 to 1.83. It is very destructive to skin, clothing, wood, and most metals. If any is accidentally spilled, it should be washed off quickly and washing soda, ammonia water, or some other alkali applied to neutralize it.

Fig. 9.—Adding the acid by means of a dipper.

Mixing the Milk and Acid.—The acid and milk should be thoroughly mixed immediately by shaking the bottle carefully with a gentle rotary motion. Point the neck of the bottle away from the face because if, in shaking, any of the mixture gets into the neck, it may be thrown out violently. When once begun the mixing must not be interrupted until the solution is complete. The effect of the acid on the milk is first to curdle it, and then to dissolve the curd. As the mixing progresses, the contents are gradually changed to a dark brown color. A common error with beginners is to fail to continue the shaking until all particles or clots of curd are entirely dissolved.

Whirling the Bottles.—The test bottles with the milk and acid properly mixed are now placed in the sockets of the tester or centrifugal machine. They should be arranged in pairs on opposite sides of the center so that they will balance when rotating. If an odd number of tests is to be made, a test bottle filled with water may be used to balance the machine. It is better to put the bottles in the tester directly after mixing
Fig. 10.—The acid burette, holding one dozen 17.5 c. c. charges, and fitted with a siphon for quick filling.

Fig. 11.—Mixing the milk and the acid. A gentle motion gives most complete and safest mixing.

the milk and acid while the bottles are hot. When the bottles are in place, the tester is covered to keep them from getting cold and to protect the operator from flying glass, if any of them break while whirling. Whirl
for 5 minutes at proper speed. This will be sufficient to bring practically all of the fat to the surface.

Proper Speed of the Tester.—The tester, or centrifuge, should travel at a speed to develop sufficient centrifugal force to completely separate the fat from the rest of the mixture. The smaller the diameter of the centrifuge wheel the faster it must travel in order to develop the necessary force. The following table shows the speed required for different diameter machines:

<table>
<thead>
<tr>
<th>Diameter-Inches</th>
<th>R.P.M. of Wheel</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>980</td>
</tr>
<tr>
<td>14</td>
<td>907</td>
</tr>
<tr>
<td>16</td>
<td>849</td>
</tr>
<tr>
<td>18</td>
<td>800</td>
</tr>
<tr>
<td>20</td>
<td>759</td>
</tr>
<tr>
<td>22</td>
<td>724</td>
</tr>
</tbody>
</table>

Adding the Water.—With a pipette, hot soft water is added to the bottles until the contents come nearly to the lower part of the neck. The cover is then replaced and the whirling repeated for 2 minutes. Hot water is again added until the entire fat column is brought within the graduated portion of the neck. It must never reach beyond the top mark or some of the fat may be lost. Whirling is then repeated for another minute.

Reading the Test.—If the test is successfully conducted the fat will be in a clear, golden-yellow column sharply separated from the clear and nearly colorless acid solution immediately below it and there will be no foam at the top. The bottles must be kept warm either in the tester or preferably in a water bath until read. The test bottles should be placed in a water bath, temperature 130-140°F., for 5 minutes prior to
reading. The water in the bath should be sufficient to cover the neck of the bottle to the highest extremity of the fat column. The reading should always be made at a temperature of between 130° and 140°F. The fat at this temperature will have a well-defined meniscus or curved surface at both the top and the bottom. The reading can be made best with an ordinary pair of dividers, measuring from the extreme bottom of the lower meniscus to the extreme top of the upper meniscus. The points are placed at the upper and lower limits of the fat column and the dividers are then lowered without changing the “spread” until one point is at the zero mark. The other point will indicate the percentage butterfat in the sample tested. The test bottle used for whole milk is graduated by tenths to either 8 or 10 per cent.

**Imperfect Tests.**—If the foregoing directions are followed strictly, a perfect test should result. It is not to be expected, however, that the beginner will always meet with success. An imperfect test may result from one or more of the following causes:

1. *Foam or gas bubbles on the fat column obscuring the upper meniscus*. This defect is caused by using hard water. The carbonates of the water are decomposed by the acid and liberate carbon dioxide which
forms the foam and gas bubbles. The water used should, preferably, be soft water, but hard water may be used if a few drops of sulphuric acid are added.

2. A dark-colored fat column containing black particles and with black particles obscuring the lower meniscus. This trouble results from any one or a combination of the following causes: (a) acid too strong; (b) too much acid; (c) acid at too high temperature when added to milk; (d) milk too warm when acid was added; (e) allowing the acid to drop directly into the milk; (f) an interruption in the mixing of the acid and milk before the solution is complete; (g) allowing the acid and milk to stand too long in the test bottle before being mixed.

3. A light-colored fat column containing white curdy material obscuring the lower meniscus. This results from one or more of the following causes: (a) acid too weak; (b) too little acid; (c) acid too cold when added to milk; (d) milk too cold when acid was added; (e) mixing was not continued long enough to dissolve all of the milk solids.

TESTING CREAM

In general, the operation of the cream test is the same as the milk test, but there are some modifications. The most important of these is that the cream sample must be weighed into the bottle instead of being measured.

The Babcock test is based upon the use of 18 grams of milk or cream. When testing milk it is possible to measure out this amount with a pipette accurately enough for all practical purposes, but with cream, conditions are different. Depending upon its fat content and thickness, cream may adhere to a pipette or measure, so that all of it will not run into the test bottle. Furthermore, the specific gravity will vary with the richness and also with the amount of air which the cream may contain. It is, therefore, impossible to obtain a measure which will deliver the correct weight of cream under all conditions, and consequently the cream must be weighed.

Cream test bottles are made for both 18-gram and 9-gram samples. The smaller 9-gram bottle is more widely used because it is more convenient to handle and more accurate to read. Small torsion balances prove very satisfactory for weighing the cream, and may be purchased specially made for cream testing.

Preparing Cream for Test.—A point never to be lost sight of in the testing of cream and milk is that the small quantities taken for the test must be truly representative. The preparation of cream for testing does not differ materially from that of milk. The fat must be evenly distributed and if there are no lumps in the cream this can usually be accomplished by pouring from one bottle to another. If lumps are present it is advisable to first pass the cream through a very fine sieve rubbing...
the lumps through with the finger and then to mix in the usual manner. If the cream has stood some time in the sample jar, the top may have become hard, leathery, and difficult to mix. In this case the jar should be set in warm water until its contents are warmed to a temperature of about 110°F. when the cream will be softened sufficiently to be easily mixed. Care should be exercised to prevent overheating of the cream which may result in the fat becoming oily and running together in large droplets thereby introducing errors in sampling.

**Weighing the Sample.**—The weight of the sample depends upon the size of the bottle used. A 9-gram bottle is recommended. The ordinary pipette is most convenient for putting cream into the test bottle because the flow can be easily checked when the correct quantity has been run in. The weight must be exact. While beginners often experience some difficulty, practice will bring about proficiency in this operation.

**Completing the Test**—Acid is added in the same manner as when testing whole milk except that the quantity of acid required is somewhat less. Usually the best plan is to add the acid until the mixture becomes the color of coffee to which cream has been added.
After the cream has been weighed into the test bottle the addition of acid and computation of the test may be by any one of the three methods described below.

**Method I.**—Add 8-12 c.c. of the sulphuric acid, when the 9 gram bottle is used, or 14-17 c.c. if the 18-gram bottle is used; or add acid until the mixture of cream and acid, after shaking assumes a chocolate brown color. Shake until all lumps have completely disappeared; then add 5-10 c.c. soft water (obtained by adding a few drops of acid to water before adding to sample) at 140°F. or above. Transfer the bottle to the centrifuge, counterbalance it, and, after the proper speed has been attained whirl for 5 minutes. Add hot water until the liquid column approaches the top graduation of the scale; then whirl 1 minute longer at a temperature of 130-140°F. Place the samples in a water bath at 130-140°F. for 5 minutes. Add glymol and with the aid of dividers or calipers measure the fat column in terms of percentage, from its lower surface to the bottom of the upper meniscus.

**Method II.**—(For a 9-gram bottle only) After the cream has been weighed into the test bottle, add 9 c.c., soft water and thoroughly mix; add 17.5 c.c. sulphuric acid and shake until all lumps have completely disappeared. Transfer the bottle to the centrifuge, balance it properly, and, after the proper speed has been attained, whirl 5 minutes. Fill the bottle to the neck with hot water and whirl 2 minutes. Add hot water until the liquid column approaches the top graduation of the scale, then whirl 1 minute longer. Adjust the temperature of the samples to 130-140°F., add glymol, and measure the fat column with the dividers.

**Method III.**—After the cream has been weighed into the test bottle, particularly if a 25 c.c. 9-gram bottle has been used, 8 to 9 c.c. of sulphuric acid are added directly to the cream and the acid and cream are thoroughly mixed as directed in methods 1 and 2. The bottles are then placed in the centrifuge and whirled for five minutes. Hot water (140°F. or higher) is added to float the fat to the base of the neck of the bottles. A few drops of sulphuric acid should be added to hard water before it is used. The bottles are next centrifuged for 2 minutes. Hot water is added to float the fat well up into the graduated portion of the neck of the bottle, and the bottles are again centrifuged for 1 minute. The bottles are next removed from the centrifuge and placed in a water bath at a temperature of 130-140°F. with the level of the water above that of the fat. After 5 minutes in the water bath, glymol is added and the fat column is measured with the dividers as described above.

This method, while used often in commercial practice, usually results in a number of charred or "burnt" samples in the hands of the beginner. Considerable experience is necessary in order to gauge temperature conditions, etc., which govern the quantity of acid to be added.
Reading the Cream Test.—The important difference between reading the cream test and the milk test is that in the cream test the fat column included is from the bottom of the lower meniscus to the bottom—not the top—of the upper meniscus. A more accurate reading can be made by adding a few drops of a colored oil (glymol) to the top of the fat column. The glymol levels the top meniscus and the reading is then taken from the bottom of the lower meniscus to the union of the fat and glymol. The test bottle ordinarily used for cream is graduated by five tenths to fifty per cent.

TESTING SKIMMILK AND BUTTERMILK

Skimmilk and buttermilk are tested in the same manner as whole-milk, but since the amount of fat is very small, it is necessary to use a special bottle. A double-necked bottle is used, the larger of the two necks being used for the introduction of the milk and acid, and the smaller neck for the reading of the test. A little more care in mixing the milk and acid should be used to prevent the fluid rising in the smaller neck, also, the bottle should be run in the centrifuge a little longer than for whole milk testing. About 5 to 7 minutes is sufficient for the first whirling,
the usual 2 minutes for the second, and 1 minute for the third. The test bottle for skimmilk and buttermilk is graduated by hundredths to one-half of one per cent.

Fig. 17. — A standard skimmilk test bottle.

Fig. 18. — A completed test; reading .06 per cent.

CLEANING THE GLASSWARE

As soon as all samples are read the bottles should be emptied immediately. An earthen jar with a perforated cover is a safe, convenient receptacle for the waste. The bottles should be given an occasional shake while emptying to loosen the sediment in the bottom. The bottles and other glassware can be easily cleaned with hot water and a good washing powder. A brush should be used as an aid in cleaning. Rinse with clear hot water. Bottles which are extremely dirty or have solidified material in them may be cleaned by using fine sand or shot to loosen the hardened matter and then washed with water and washing powder as described above.

MATERIALS AND APPARATUS

It is very important that the glassware be calibrated accurately. Test bottles and pipettes may be obtained which conform to the requirements of the United States Bureau of Standards, and it is advisable to use them.

Any of the makes of centrifugal machines should prove satisfactory so long as they are run at the speed recommended by the maker.
All glassware, scales, and the commercial sulphuric acid used in the Babcock test are regularly sold and may be secured from practically all dairy supply companies.

The sulphuric acid used should have specific gravity of 1.82-1.83. This should be specified when ordering. The strength of the acid may be checked by means of a special type of hydrometer.

Difficult Sampling

As a rule the sampling of milk and cream for testing purposes presents no problem except that of proper mixing. Occasionally it is necessary, however, to obtain samples of sour, partially churned and frozen milk.

**Sampling Sour Milk or Cream.**—Sour milk or cream in which the casein is coagulated, frequently must be sampled. If not too sour the milk may be thoroughly agitated, and a sample removed as in sampling sweet milk. If the milk or cream has stood for a long while and a tough leathery layer has formed over the top, the material should be warmed slightly, agitated thoroughly and sampled at once while the butterfat is still melted.

In sour cream lumps may be broken up by passing them through a strainer or sieve during the warming process. In the creamery receiving
sour cream, the practice usually followed is to agitate the sample thoroughly and use the "McKay sampling tube" for securing the sample.

**Partially Churned Milk or Cream.**—It is very difficult to secure a representative sample of milk or cream if the fat has been partially churned. Often commercial plants refuse to accept a test made on such milk or cream. A reasonably accurate test may be secured, however, if the product is heated to a temperature of 100-110°F. or a point sufficiently high to melt the churned fat globules, and then agitated vigorously and a sample removed immediately.

**Frozen Milk or Cream.**—The unfrozen portion of a partially frozen sample of milk or cream is usually highest in fat and will give erroneous values if used for testing purposes. The entire sample or lot of milk or cream to be sampled should be warmed to 90°F. and the sample for analysis secured in the usual way.

**Composite Samples**

The purpose of the composite sample is to reduce the number of analyses. A composite milk sample is one which, when properly prepared represents two or more lots of milk or cream. For accurate results the amount of milk constituting each sample going into the composite must be in proportion to the amount of milk involved.

Wide use of the composite sample is made in connection with the purchase of milk at creameries, cheese factories, condenseries and milk receiving stations. To make sure of the quality of milk delivered by each patron, the operator must either test each patron's milk daily, or prepare a sample, in which each delivery will be represented, and test this at intervals. As a rule, the period covered, when milk is purchased by the test, is either 1 or 2 weeks. In many instances the composite sample is also used for obtaining records of production on individual cows in the dairy herd.

**Equipment Required.**—The equipment required for preparing composite samples consist of air tight sample jars, a sampling tube or dipper, and a suitable preservative.

The sample jar should be constructed so as to prevent evaporation of the sample. This requires a tight-fitting stopper. A wide mouth bottle fitted with a rubber stopper has been found to be the most reliable and practical container for holding the composite milk or cream sample (See Fig. 6). The container should be labeled permanently. This may be accomplished by using a metal tag on which is stamped a number and which can be attached to the container by means of a wire. A gummed label may be used by coating the label with white shellac, after it is
pasted on the bottle, so as to prevent its soaking off when the bottles are immersed in water.

The dipper or the sampling tube may be used in sampling milk where a composite sample is desired. The sampling tube has the advantage of regulating the quantity of milk taken in proportion to the amount of milk to be sampled. Where several lots of milk, varying in quantity and test, are to be sampled the sampling tube is essential unless the operator goes to the trouble of weighing the milk and taking a proportionate sample of each by weight. This procedure is time consuming and often impractical hence the advantage of the sampling tube which makes it possible to accomplish the sampling with a minimum of labor. The dipper may be used very satisfactorily where the milk does not vary widely in percentage of fat. Since the dipper takes equal parts from each sample it follows that considerable error may result if this method is used for sampling milk from lots of various quantity and test. Practical experience as well as experimental evidence teaches that for all practical purposes the sampling dipper may be used with a feeling of accuracy where mixed herd milk is sampled from day to day. While there is some little variation in the percentage of fat from individual cows, there is very little variation in the percentage of fat in the mixed herd milk from day to day. It is assumed of course that the milk is thoroughly mixed and equivalent amounts of milk are involved each day.

Preservatives for Sample.—Samples of milk may be kept sweet for testing purposes by means of preservatives. Several preservatives are used.

Corrosive Sublimate or Mercuric Bichloride

This compound is one of the strongest and most effective preservatives used. This preservative is sold in tablet form and may be obtained from any dairy equipment company or a drug store. One small tablet will keep a pint of milk sweet a week or more. This chemical is highly poisonous and usually a red dye is added to warn against the use of preserved milk as a food. The presence of this compound does not interfere with the Babcock test.

Formalin.—A 40% solution of formaldehyde, known as formalin, is a very effective preservative. Formalin is in liquid form and 1 cubic centimeter or 28 drops will serve as a preservative for 1 quart of milk for a week or more. One objection to formalin as a preservative is its hardening effect on the curd or casein of the milk making it difficult to test. This trouble may be corrected by giving a little more time for the action of the sulphuric acid on the casein. Corrosive sublimate in large quantities will also cause hardening of the curd.
Care of Composite Samples.—The most important precaution to observe in the care of composite samples are briefly as follows:

1. Keep bottle tightly stoppered using a non-absorbable type of topper.
2. Keep samples in a cool place away from direct sunlight.
3. Agitate samples thoroughly each time a new sample is added so as to mix the preservative and newly added milk and to prevent the drying of milk on the sides of the container.

Testing Composite Samples.—Composite samples should be tested as a rule every 7 to 10 days. Care must be exercised to make sure that the fat is evenly distributed throughout the sample. The formation of masses of cream which have to be melted should be avoided. As a rule the sample jars should be placed in a water bath at 90 to 100°F. for a few minutes, in order to make possible a thorough distribution of the fat on agitation.