The babcock test for the estimation of butterfat in milk and cream

A H. Hobbs
Department of Agriculture

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FROM time to time inquiries are received from dairy farmers, and others, for details of the technique of the Babcock Test. An endeavour is made in the following article to describe in simple form the various steps in the manipulation of the test while, at the same time, drawing the attention of the beginner to the difficulties which may be encountered, and the necessary precautions to be observed, in order to obtain accurate and satisfactory results.

The Babcock Test was invented by Dr. Babcock, an American scientist, in 1890. It was originally designed for the estimation of the butterfat content of milk, but has since been modified and can be used for milk, cream, skim milk, buttermilk, etc. For practical factory and farm fat determinations, it is now used almost exclusively in the United States of America and Australasia.

It is the test generally used as a basis for payment for milk and cream and, in addition, enables producers to detect unprofitable cows, thus furnishing a valuable guide to herd improvement. It has also aided in the detection of fraud caused by the watering or skimming of milk.

Dr. Babcock based his test on the fact that strong sulphuric acid will break down the "solids not fat" of milk and thus enable the fat to separate out. To effect a speedy and complete separation of the fat the flasks holding the mixture of milk and acid are placed in a centrifugal machine, or so-called "tester," and whirled at high speed. Hot water is then added to bring the liquid fat into the graduated neck of the test flasks and, after repeated whirling, the length of fat column is measured, showing the percentage of fat contained in the sample tested.

DIRECTIONS FOR TESTING MILK

Apparatus required:—
Sample bottles.
17.6 c.c. pipette for measuring milk.
17.5 c.c. acid measure.
Sulphuric acid (specific gravity 1.82-1.83).
Milk test flasks (graduated 0-10).
Centrifuge (or tester).
Dividers.
Dairy thermometer.
Water bath.

Sampling.

The milk to be tested is first mixed by pouring from one vessel to another two or three times so that the butterfat will be evenly distributed throughout the bulk. The sample is then dipped out immediately and placed in a sample bottle.

Before measuring out the quantity to be tested, the milk in the sample bottle is further mixed by shaking the bottle vigorously. The shaking should not be so violent as to cause undue foaming. The reason for sampling immediately after mixing is that the butterfat is the lightest constituent of the milk and it will commence to rise to the surface within a few minutes if the milk is allowed to stand. Hence the sample taken would not be representative of the bulk.

The measuring pipette, which has a capacity of 17.6 cubic centimetres, is filled with milk by sucking the milk into it until this rises a little above the 17.6 c.c. mark; the forefinger is then quickly placed over the top end of the pipette before the milk runs down. By slightly releasing the pressure of the finger, the milk is now allowed to run down until it reaches the mark. The finger should be moist but not wet, so that the milk may be readily checked by gentle
pressure. The point of the pipette is now placed in the neck of the Babcock test flask, and the milk is allowed to flow slowly down the inside of the neck, care being taken that none is lost in the transfer. The last of the milk in the pipette is gently blown into the test flask.

Actually the amount of milk delivered by the pipette is 17.5 cubic centimetres, the difference, .1 c.c., being an allowance made for the small quantity which adheres to the walls.

The temperature of the milk at the time of sampling should be 65-70°F.

The accuracy of the test depends on the fact that the sample taken weighs 18 grams, and 17.5 c.c. of milk at its average specific gravity of 1.032 will be found to weigh this amount.

Adding the Acid.

17.5 c.c. of sulphuric acid, the temperature of which should be 65-70°F., is measured by means of the acid measure. This amount of acid is carefully poured into the test bottle containing the milk. In performing this operation, the test bottle is conveniently held at an angle, so that the acid will run down the wall of the bottle, and not run in a small stream into the centre of the milk. The bottle is slowly rotated during the adding of the acid, thus clearing the neck of adhering milk.

If the acid is poured into the middle of the milk, charring of the fat may occur, and there is also the danger of completely filling the neck with acid, in which case the expansion of air in the bottle may force the acid out on to the operator's hands.

The milk and acid in the test flask should be in two distinct layers. A black band of partially mixed liquid may appear between the layers, but this should be only slight. Such a dark layer often results in an indistinct fat column in the final reading. The appearance of black flocculant matter in or below the fat column renders a correct measurement difficult, if not impossible.

After adding, the acid is carefully mixed with the milk by holding the test bottle by the neck at an angle and giving it a rotary motion. In doing this, care should be taken that the liquid is not shaken into the neck, and when once the mixing has begun, it should be continued until completed. The mixture becomes hot by the action of the acid on the water in the milk and turns a dark chocolate colour. Its temperature will now be about 180°F. Violent mixing may cause charring of the fat, whilst insufficient mixing may produce curd in the fat column.

Note.—Sulphuric acid has a great affinity for water and will weaken, through the absorption of moisture from the atmosphere, if not kept in air-tight containers. It is very corrosive, hence stoppers for bottles should be of glass, earthenware, or rubber. It should be handled with care and, if spilt on the skin, should be washed off immediately with plenty of cold water. If spilt on the clothes, they should be washed as above and then treated with dilute ammonia solution.

Whirling the Tests.

The test flasks containing the mixture of acid and milk are placed in the centrifuge immediately mixing is completed, care being taken that they are placed in such a position that the machine is balanced correctly so that it will run without vibration.

Oil the machine before starting and increase the speed gradually. The correct speed is usually indicated on the crank of hand operated machines but, if not, it may be calculated from the diameter of the disc which carries the cups. The diameter is measured from the bottom of one cup, through the centre of the disc to the bottom of the opposite cup with both cups held in a horizontal position. The following speeds for discs of various size create the correct centrifugal force of 30 lb. per square inch inside the test flasks:—

<table>
<thead>
<tr>
<th>Diameter of Disc</th>
<th>Revs. per minute</th>
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<tbody>
<tr>
<td>10 in.</td>
<td>1074</td>
</tr>
<tr>
<td>12 in.</td>
<td>980</td>
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<tr>
<td>14 in.</td>
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<td>16 in.</td>
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<td>18 in.</td>
<td>800</td>
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<td>20 in.</td>
<td>759</td>
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<tr>
<td>22 in.</td>
<td>724</td>
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<td>24 in.</td>
<td>693</td>
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To find the speed of the handle, give the handle one full turn slowly, and note the number of revolutions of the disc. This figure is then divided into the revolutions
desired, according to the size of the disc, and the answer will represent the number of turns per minute of the handle.

Correct speed is important, as low speeds give low readings. Slightly excessive speed is not harmful, but increases the pressure in the bottles and may cause breakages.

It is not absolutely necessary to whirl the test bottles in the centrifuge as soon as the milk and acid are mixed, but this method is much to be preferred. They may, however, be left for any reasonable time up to 24 hours without the test being spoiled; but if left until the mixture becomes cold, the bottles must be placed in hot water (about 160°F.) for fifteen minutes before whirling.

The first whirling of the test bottles is carried out for five minutes. This will bring all the fat to the surface of the liquid.

Adding the Water.

Hot water (temperature 160-180°F.) is now added by means of a pipette, or some special device, to fill the bottle to the base of the neck. The bottles are whirled again at full speed for two minutes and hot water as above is added a second time until the lower part of the fat column comes within the scale on the neck of the bottle, preferably about the 1 or 2% mark, so as to allow for the sinking of the fat column due to the gradual cooling of the contents of the bottle. This second filling of water should be allowed to fall directly on to the fat, to assist in the removal of any undissolved matter.

The bottles are now whirled a third time for one minute. This completes the test.

The above whirling times should be taken from the time the machine reaches the correct speed.

Measuring the Fat.

The correct temperature for reading the fat column is 140°F. This is important for the reason that temperatures 10-15° lower than this give low readings owing to contraction of the fat, and vice versa; also this temperature ensures that the fat column will have a sharply defined upper and lower meniscus. If several tests have been done in a hand operated machine, they should be placed in the water bath at 140°F. with the water depth equal to the height of the fat column and allowed to remain there for three minutes before commencing to read.

The water between the fat column and the mixture in the test bottle should be clear. If milky, this indicates that too little, too weak, or too cold acid has been used, and the solids not fat are not thoroughly dissolved. If black flocculant substances are present, the indication is that too much, too strong, or too hot acid has been used, or that mixing has been too violent.

The fat column is measured from the bottom of the column to the extreme top of the meniscus as illustrated in Fig. 1. This operation is simplified by the use of the dividers, by placing one point on the bottom of the column and the other on the top of the meniscus; then the dividers are moved, without altering the distance between the points, so that the bottom point rests on the 0 mark on the scale, and the upper point gives the reading in per cent. of fat. The space between each two large divisions on the scale equals 1%, and that between each two of the smaller divisions equals two-tenths or .2%. If the fat column illustrated in Fig. 1 is examined, it will be found that the bottom of the column is on the second small graduation above the 1, and the top of the meniscus is mid-way between the third and fourth small graduations above the 5. Therefore, the per cent. of fat in this instance is 5.7 minus 1.4 = 4.3%.

Fig. 1.—Correct method of reading the milk test. Read from a to b.

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The reason for reading to the top of the meniscus is that it has been found by making a comparison between a large number of tests and the gravimetric analysis of the same samples, that an allowance has to be made for a small number of minute fat globules which, owing to their size, are not extracted from the mixture during whirling.

The relation between the amount of milk taken and the capacity of the graduated portion of the neck of the milk flask is as under:

The amount of milk taken is 18 grams (17.5 c.c.). The neck of the flask is graduated 0 to 10, and the capacity of this graduated portion is 2 c.c. Since the specific gravity of butterfat at 140°F. is .9, the weight of 2 c.c. of butterfat is 2 x .9 = 1.8 grams, and 1.8 grams is one-tenth or 10% of 18 grams. Therefore, the graduated portion of the neck, when full of butterfat, at 140°F., would represent 10% of the sample taken, and the small divisions 1% and .2%, respectively.

The quantity of butterfat contained in a definite amount of milk is calculated by means of the following formula:

\[
\text{Weight of milk in lb.} \times \text{Test} \times \frac{1}{100} = \text{lb. of fat.}
\]

Hence, if a cow produces in 24 hours, 36 lb. of milk with an average test of 4.3%, the butterfat contained in this milk will be—

\[
\frac{36 \times 4.3}{100} = 1.548 \text{ lb. fat.}
\]

COMPOSITE SAMPLING OF MILK

Where large numbers of different lots of milk are recorded daily, e.g., the milk supply to cheese factories, or in testing herds for production, a great saving in time, labour and material is obtained by the use of composite samples.

A composite sample is a mixture of samples of various deliveries of milk from the same source, taken over a period of time, usually not more than seven days.

To ensure that a composite sample is a true representation of the milk to which it refers, it is essential that each small sample should bear a definite relation to the quantity of milk from which it was obtained.

Example.

A cow gives 20 lb. of milk in the evening and 30 lb. in the morning. To obtain an accurate mixed sample from this cow it would be necessary to take from the morning's milk one and one half times the amount taken from the evening's milk. If using a two ounce sample bottle, it is convenient in calculating the amount of the sample to be taken from the night's milk to use a definite number of c.c. per pound of milk produced, to bring the night sample as close as possible to 20 c.c. Then it will be found that the quantity of milk produced by the cow the following morning will give a sample which will be contained comfortably in the two ounce bottle. Hence, in the above example, it would be necessary to take 1 c.c. per lb. of milk produced and the quantity of the evening and morning samples would be 20 c.c. and 30 c.c., respectively. If the cow gives 7 lb. in the evening, it will be necessary to take 3 c.c. per lb. of milk and the sample will be 7 x 3 = 21 c.c.; if the following morning she gives 9 lb., the quantity of the morning sample will be 9 x 3 = 27 c.c., making the total of the composite sample 21 plus 27 = 48 c.c.

In taking composite samples of daily supplies to factories of mixed herd milk, it may be found that the quantity delivered daily by each supplier will vary by only a few pounds, and, if this is so, the same quantity sample may be taken each day. If, however, any great variation occurs, it is necessary that the quantity of the sample should vary accordingly.

Composite samples are prevented from curdling by the addition to the first small sample taken of a few drops of Formalin (40% solution of formaldehyde in water). This, however, has the effect of decreasing the solubility of the solids not fat, which may result in a curdy fat column in the finished test. Consequently, as little formalin as possible should be used, depending on the size of the sample and the length of time it has to be kept. One drop of formalin, placed in the samples of evening milk for the purpose of herd recording, is sufficient to keep the milk sweet over night in hot weather.

Formalin is a poison, and should always be labelled as such.
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**THE BABCOCK TEST FOR CREAM**

Cream may be tested by the Babcock method in a somewhat similar manner as for milk. The results are accurate when the necessary care has been taken in sampling the cream and measuring the fat.

The specific gravity of cream is lower than that of milk, and varies according to its butterfat content; e.g., the more fat the cream contains, the less a certain quantity of it will weigh.

Cream is more viscous than milk, and more of it will adhere to the sides of the pipette, especially in the case of very thick cream; also, in the case of freshly separated cream, air will be present incorporated during the separating process. With ripened cream fermentation gases developed are held in the cream. Hence, in either of the latter two cases, the weight of a certain measure is diminished. Fig. 2 shows the height to which creams of varying fat content must be raised in the pipette to get the same weight of each.

The composition of cream varies greatly according to the operation of separators, temperature and composition of milk, etc.; the fat content of supplies delivered to butter factories in this country usually ranges from 30 to 50 per cent. Because of this wide variation, and for other reasons mentioned below, the measuring of cream for the Babcock test is inaccurate, and correct results can therefore only be obtained by weighing the sample to be tested.

Apparatus.

The apparatus used in the cream test is as for milk, substituting cream flasks graduated 0-30 in place of the milk flasks, and using a special cream balance for weighing the samples.

Sampling.

The cream to be sampled should be well stirred to ensure an even distribution of the butter fat. This is facilitated by the use of a metal stirrer having a mushroom end which will ensure thorough mixing. In taking the sample, it is the practice in butter factories in this State to use a "thief" sampler. This is constructed on the principle of a syringe and cuts a core of cream right through the contents of the can. This core is then readily transferred to the sample bottle by pressure on the plunger.
Weighing the Samples for Testing.

The special cream balance should be set up on a firm bench, and levelled by means of the adjusting screws. This balance is a delicate mechanism, and should be kept clean and bright, with the knife edges working freely to ensure accuracy. The cream test flasks are then placed in the balance trays and the scale is balanced by adjusting the small weight provided on the beam.

The samples should be heated to a temperature of 100-120°F. by placing them in warm water; this is done to ensure ease of weighing.

When the cream is thoroughly liquified, the first sample is shaken vigorously, and having first placed a 9 gram weight on one of the balance trays, the sample is immediately transferred by means of a pipette from the sample bottle to one of the cream flasks on the opposite side of the scale. The beam of the balance is now brought to rest on the supports, the 9 gram weight is removed from the tray and the second sample is balanced against the first. Each tray on the balance holds six flasks and the above procedure is repeated until all 12 samples have been weighed. In this manner, the sample numbers will be arranged with the odd numbers on one tray and the even numbers on the other and, as most factories are equipped with steam turbine centrifuges holding 36 flasks, it is customary to weigh and test the samples in batches of this number. After weighing, the samples are arranged in trays holding 36 flasks and approximately 9 c.c. of warm water is added to each flask and mixed with the cream. The mixing may be done by shaking all flasks together in the tray.

Adding the Acid.

Fifteen to 17.5 c.c. of acid is used. The amount depends on the quantity of fat in the cream, and can only be determined by observation. The colour of the mixture is the best guide, coffee brown being correct, light brown not sufficient, and black indicating too much acid used. Samples appearing too light in colour after mixing can be corrected by the addition of a little more acid and further mixing.

Owing to the “solids not fat” content of cream being lower than that of milk, the colour of the mixture will appear light at first, and it is advisable not to whirl at once after mixing but to allow the bottles to stand for five to 10 minutes until the colour change is complete.

The flasks may now be placed in the centrifuge and the procedure from this point is similar to the milk test until the stage of reading the fat column is reached.

Alternative Method.

A modification of the preceding method is given below and is preferred by some operators for the reason that where large numbers of tests are carried out daily, a considerable saving in quantity of acid and time is achieved.

Some experience is necessary, however, with this method to enable clear fat columns to be obtained regularly.

1. Weigh 9 grams cream.
2. Add 9 c.c. sulphuric acid. Mix and allow to act.
3. Add 7-9 c.c. of hot water.
4. Whirl five minutes.
5. Add hot water to top of neck.
6. Whirl one minute.
7. Place in water bath.
8. Read.

Where steam turbine centrifuges are used, errors due to expansion of the fat may occur if the centrifuge is allowed to get too hot. Very hot tests should be cooled to 140°F. for at least three minutes before reading to obtain correct results. Conversely, using hand operated centrifuges in cold weather, tests should be placed in hot water (temperature 180°F.) for a few minutes in between whirlings, and then placed in the water bath (temperature 140°F.) for three minutes prior to reading.

Reading the Cream Tests.

Fig. 3 shows the correct method of reading the fat column in cream tests, the reading being taken from the bottom of the fat column to the bottom of the meniscus. This reading is doubled to give the percentage of fat.

Other precautions to be observed for the correct measurement of the fat column are the same as in the milk test.
If the cream test illustrated in Fig. 3 is examined, it will be found that the bottom of the fat column is on the 2.5 mark and the bottom of the meniscus is on the 22.5 mark.

\[
22.5 - 2.5 = 20
\]

\[
20 \times 2 = 40\% \text{ of butterfat in the sample tested.}
\]

Relation between the quantity of cream taken and the graduated portion of the neck of the 18 gram 30% cream flask.

- Capacity of the graduated portion = 6 c.c.
- 30 graduations, each one = .2 c.c.
- Specific gravity of butterfat at 140°F = .9

Therefore, weight of fat in each division = .2 \times .9 = .18 grams; .18 grams = 1% of 18 grams.

As the weight of the sample used is 9 grams, the reading must be doubled.

The quantity of butterfat contained in a definite amount of cream is calculated as follows:

\[
\frac{\text{Weight of cream in lb.} \times \text{test}}{100} = \text{lb. of fat.}
\]

Hence a can containing 48 lb. of cream testing 43% would contain

\[
\frac{48 \times 43}{100} = 20.64 \text{ lb. of fat.}
\]

THE BABCOCK TEST FOR SKIM MILK AND BUTTERMILK

As mentioned previously, the Babcock test was designed originally for the estimation of fat in milk and such milk products as cream. For this purpose it is reliable. When used for testing the industry's by-products (skim milk and buttermilk) the results have been found to be considerably below those obtained by gravimetric analysis, i.e., extraction with ether and weighing the fat. Early attempts at testing skim milk and buttermilk were made by using the ordinary 10% 18 gram milk test flask, but these were found to be of no value for the reason that the fat appeared merely as a few dots in the neck of the flask, and could not be measured accurately.

Later the double-bore skim milk flask (illustrated in Fig. 4) was designed, and proved very convenient for the purpose. Its use has been adopted in all countries where the Babcock test is favoured. These flasks are graduated 0-25, the space between each two marks representing .01%, and the total graduated portion .25%.

The construction of these flasks for use in Britain, as laid down by the British Standards Institution, provides for the graduated portion of the neck to contain 50 divisions, each one representing .01% and the total .5%.

Eliminating the Meniscus in Cream Tests.

The meniscus in cream tests may be eliminated by the use of coloured glymol. Glymol is a white oil, lighter than butterfat, usually coloured red with Alkanet root. When added to the cream flask it levels off the top of the fat column giving a straight line at the top as well as the bottom, thus removing any doubt as to the point at which the reading should be taken.

Glymol should be added carefully by means of a pipette and allowed to run gently down the inside of the neck of the flask. If it falls directly into the fat column, it will sink into the liquid fat and, on rising, will carry some of the fat on its surface, thus decreasing somewhat the length of the fat column and giving low readings. Reading should be done immediately the glymol is added. If left, the colouring matter will combine with the surface fat, making accurate reading difficult.

The quantity of butterfat contained in a definite amount of cream is calculated as follows:

\[
\text{Weight of cream in lb.} \times \text{test} \quad \frac{\text{lb. of fat.}}{100}
\]

Hence a can containing 48 lb. of cream testing 43% would contain

\[
\frac{48 \times 43}{100} = 20.64 \text{ lb. of fat.}
\]
2 c.c. pipette for n-butyl alcohol.
Other apparatus is as for testing whole milk.

Place 2 c.c. n-butyl alcohol in the test flask and to this add 9 c.c. of the well-mixed buttermilk or skim milk to be tested. The temperature at sampling should be 65-70°F. Add 7-9 c.c. sulphuric acid, varying the amount to obtain a resultant fat column golden yellow in colour.

The contents of the flask are then mixed thoroughly, the flask is placed in the centrifuge and whirled at full speed for six minutes. Hot water is then added to fill the flask almost to the base of the neck, and a further whirling of two minutes is given. More hot water is added to float the fat into the graduated neck, and the flask again whirled for two minutes.

The reading is done at a temperature of 130-140°F., and the result is doubled to give the percentage of fat.

When the double-bore flask is used, it should be placed in the centrifuge with the large filling tube to the centre, so that all the fat will gather freely in the calibrated neck.

In performing the Babcock test on any milk product it is important that the water used for floating the fat into the neck of the flasks should be of a soft nature. Foam appearing on the surface of the fat column makes accurate reading difficult and is caused by the action of the acid on impurities (usually carbonates) in hard water.

If soft water cannot be obtained, the boiling of hard water will often correct the trouble, due to the fact that most of the carbonates which cause foaming will be precipitated.