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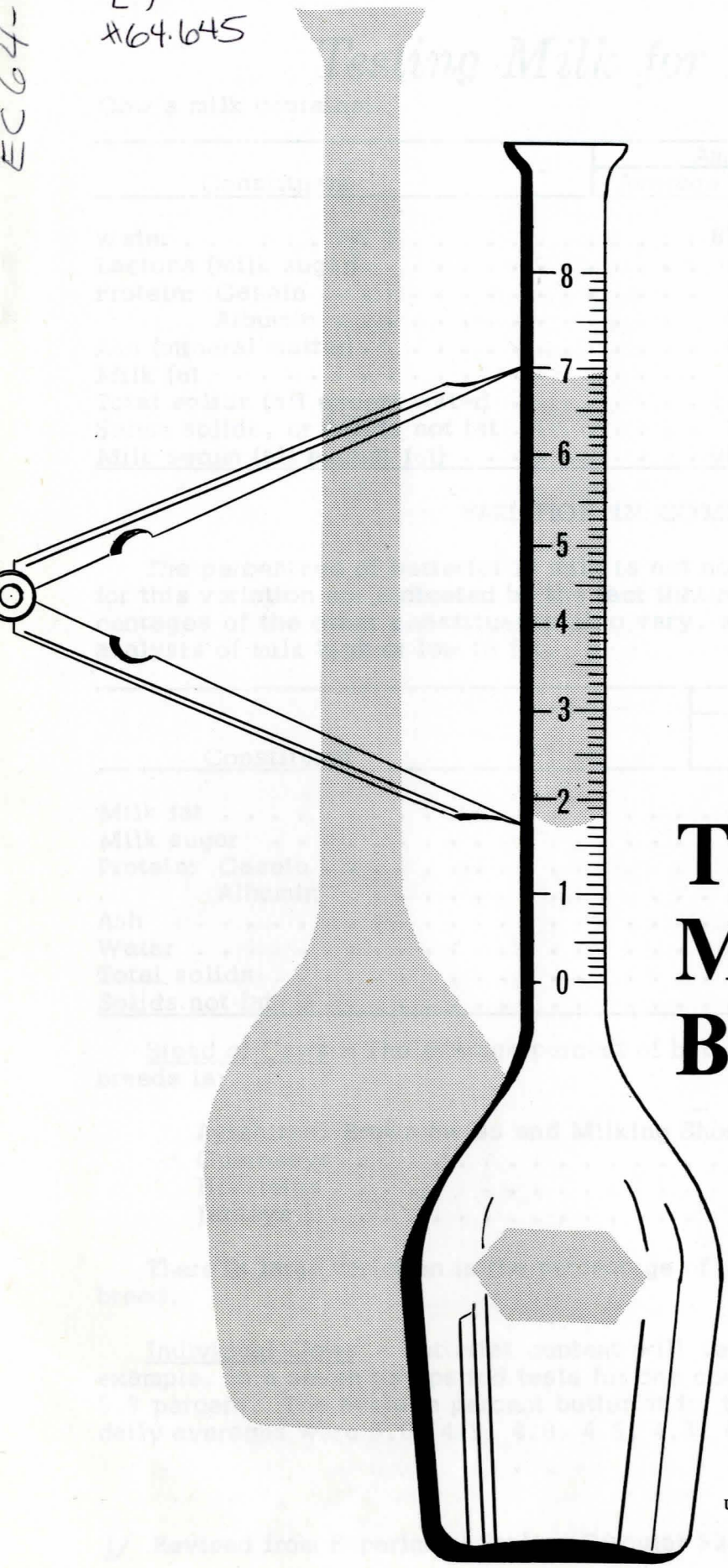

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TESTING MILK FOR BUTTERFAT

Extension Service
University of Nebraska College of Agriculture and Home Economics
and U. S. Department of Agriculture Cooperating
E. F. Frolik, Dean E. W. Janike, Director

Testing Milk for Butterfat[1/]

Cow's milk contains:

Constituent	Amount in normal milk: Average percent	Variation
Water	87.3	84.0-89.5
Lactose (milk sugar)	4.8	4.5- 5.2
Protein: Casein	2.7	2.0- 4.0
Albumin	0.7	0.5- 0.9
Ash (mineral matter)	0.7	0.6- 0.8
Milk fat	3.8	2.6- 6.0
Total solids (all except water)	12.7	10.5-16.0
Serum solids, or solids not fat	8.9	7.6-10.9
Milk serum (all except fat)	96.2	94.0-97.4

VARIATION IN COMPOSITION

The percentage of butterfat in milk is not normally constant. Factors responsible for this variation are indicated by the fact that as the percentage of fat varies the percentages of the other constituents also vary, as shown by the following comparative analysis of milk high or low in fat.

Constituent	Average amount in: High-fat milk percent	Low-fat milk percent
Milk fat	5.0	3.0
Milk sugar	5.0	4.7
Protein: Casein	3.1	2.5
Albumin	0.70	0.67
Ash	0.73	0.7
Water	85.47	88.43
Total solids	14.53	11.57
Solids not fat	9.53	8.57

Breed of Cows - The average percent of butterfat in milk from cows of the different breeds is:

	Percent
Ayrshires, Brown Swiss and Milking Shorthorns	4.0
Guernseys	4.9
Holsteins	3.5
Jerseys	5.3

There is large variation in the percentage of butterfat in milk from cows of the same breed.

Individual Cows - Butterfat content will vary from one milking to another. For example, in a seven day period tests for one cow varied from a low of 3.7 to a high of 5.9 percent. The average percent butterfat for the seven day period was 4.66 and the daily averages were 5.0, 4.9, 4.8, 4.5, 4.3, 4.4 and 4.7 percent.

1/ Revised from Experiment Station Circular 53 by L. K. Crowe

State of Lactation - If a cow is in good condition when she calves, her butterfat test will be moderately high. After about 30 days the tests will decline, reaching a minimum about 60 days after calving. After this the percentage of butterfat in the milk starts to increase again, reaching the maximum at the end of the lactation.

Age of Cow - A slight but consistent decline in percentage of butterfat as the cow advances in age is to be expected. It is very rarely more than a slight decline.

Heat Period (Estrus) - The effect of the heat period is not definite but in general the percentage of butterfat is slightly increased, while the amount of milk is slightly decreased.

Season - The butterfat percentage on the average is highest in December, January, and February and lowest in July and August.

Time of Day of Milking - When cows are milked twice daily at regular intervals, the morning's milk will generally contain the higher percentage of butterfat, but the quantity of milk will be less.

Weather Conditions - In cool or cold weather cows tend to produce milk containing a higher percentage of butterfat. Hot weather, especially when the humidity is high, tends to lower the percentage of butterfat.

Feed Conditions - Feeding practices that increase or decrease milk production affect the butterfat content of milk. Cows kept in good condition by liberal feeding will produce milk of a higher test than thin cows. A ration including all ground roughage and grain usually depresses the butterfat test. Grain pellets treated in certain ways with heat may also depress the butterfat test.

Other Factors - Completeness and regularity of milking, sickness, changing of milkers or milking methods, excitement or other disturbances of routine may affect both quantity of milk and percentage of butterfat in the milk.

Variation in composition may show incorrectly if the Babcock test is not carefully conducted. Temperature is important. Fat columns must be clear with distinct upper and lower surfaces. The fat column must be carefully measured.

BABCOCK TEST PRINCIPLES

This method of finding the percentage of butterfat in certain dairy products consists in transferring a definite weight of the product to be tested into a specially constructed and graduated test bottle. Sulfuric acid is then mixed with the material in the test bottle. The bottles are then centrifuged or whirled three times in succession, at a definite speed and for a definite time. Hot water is added to the contents of the bottle after the first two whirlings. After the last whirling the percentage of fat is measured directly with a pair of dividers.

The Babcock test is based on the following principles: that a strong acid will curdle and then dissolve or digest the curd in milk, thus freeing the butterfat; that heat developed from the action of the acid upon the water and milk solids melts the butterfat; that difference in the weight or specific gravity tends to separate the liquids; and that the application of centrifugal force (whirling) hastens the separation of the fat from the other milk constituents.

Milk fat or butterfat has a specific gravity (compared with water, which equals 1.00) of 0.93, while whole milk has a specific gravity of about 1.032. This means that one cubic centimeter (1 cc.) of butterfat would weigh 0.93 gram and 1 cc. of milk would weigh 1.032 grams.

The globules of butterfat in milk, being lighter than the surrounding fluid, tend to rise but are retarded by the interference of the other milk solids. Commercial sulfuric acid (H_2SO_4) first curdles and then digests the proteins in the milk. This frees the fat, and since heat is generated by the action of sulfuric acid on the water and solids of the milk, the fat is melted and tends to rise to the top. The sulfuric acid, being heavier than the milk serum, increases the specific gravity of the mixture, thus making it easier for the fat to rise.

In whirling, the test bottle is in a horizontal position with the bottom to the outside. Whirling produces centrifugal force which causes the heavier material to go to the bottom of the test bottle and forces the lighter fat to the top. With the addition of water, the fat is raised into the graduated neck of the test bottle where it can be measured.

The Babcock test is based upon the use of a definite weight of milk in the test bottle, which is graduated to be read directly in percentage of fat. In testing milk the 17.6-cc. pipette is used for measuring the milk into the test bottle. This pipette delivers 17.5 cc. of milk (0.1 cc. of milk sticks to the inside of the pipette). With milk of an average specific gravity of 1.032 the 17.5 cc. will weigh 18.06 grams (ordinarily regarded as 18 grams). The milk test bottle is so graduated that it can be read directly in percentage of fat when 18 grams of milk are used.

EQUIPMENT FOR BABCOCK TESTING

Centrifuge or Babcock tester - hand, steam, or electric. The 24-bottle electric centrifuge is most commonly used in D.H.I.A. testing.

Sample jars with tight covers - four-ounce size are very convenient.

Milk test bottles[2/] - either 8 or 10 percent total graduation, in 0.1 percent intervals.

Milk pipette[3/] - 17.6-cc. capacity for measuring milk.

Acid measure or dipper - 17.5-cc. capacity.

Thermometer - floating dairy type, with Fahrenheit graduation to 220°.

Dividers - for measuring the fat column.

Sulfuric acid (commercial grade), specific gravity 1.82 to 1.83 at 60° - 70° F.

Water bath - a vessel that will hold hot water in which all completed tests are placed before measuring the fat column.

2/ See Nebraska Standard Dairy Law, Bul. No. 3, State of Nebraska, Department of Agriculture, State Capitol, Lincoln.

3/ See Nebraska Standard Dairy Law, Bul. No. 3, State of Nebraska, Department of Agriculture, State Capitol, Lincoln.

Washing powder - any commercial powder, for cleaning glassware.

Test bottle brush - a small, wire-handled brush for cleaning bottles.

Pipette brush - especially designed for cleaning pipettes.

Sample jar brush - especially designed for cleaning sample jars.

SAMPLING MILK

Accuracy of testing depends to a great extent upon the care used in sampling. The sample must be uniform in composition and representative of the entire quantity of milk from which it has been taken. Careful testing will not correct inaccuracies in sampling.

Milk

To sample the milk of a cow, pour the complete milking from one vessel to another at least three times. Then dip out a sample of one to two ounces for testing, cover tightly to prevent evaporation, and set in a cool place.

Milk should not be tested until at least one hour after milking because of the air incorporated during milking, which would affect the weight of milk delivered by the pipette. If the milk has stood long enough for the cream to rise, it should be poured back and forth at least six times instead of three times. In pouring do not agitate unduly so as to cause churning. Milk can be sampled satisfactorily only when sweet.

Composite Sampling

In D.H.I.A. work practically all milk is tested as fresh milk. Equal amounts of milk are secured from the evening and morning milkings. If samples are not tested soon after they are secured, a preservative should be added to keep the milk from souring. Directions for the use of preservatives are on the containers.

Milk plants and creameries generally collect composite samples of milk for testing. A sample containing proportionate quantities of different lots of milk is called a composite. Either a dipper or sampling tube may be used. Composite samples should not represent milk delivered over a period of more than 15 days. Composite samples of milk must be kept in tightly covered sample jars in a cool, dark place. A good preservative should be used. The samples should not be allowed to freeze.

When the daily sample of milk is added to the composite sample, mix the contents of the jar by giving the jar a gentle, rotary motion. Unless this is done regularly each day, the cream that rises becomes tough, especially where it is in contact with the jar, and this makes it difficult to get a proper sample. Daily mixing also insures the complete solution and distribution of the preservative, essential in preventing souring and mold growth.

BABCOCK TEST FOR MILK

Preparing the Sample

Milk samples for testing should be between 60° and 70° F. as determined by a thermometer. They may be warmed or cooled by a water bath. To prevent melting the fat keep the temperature of the water bath below 85° F.

After having reached the proper temperature the sample should be poured slowly from one container to another at least 6 times to insure thorough mixing. Rapid pouring will incorporate air bubbles, making the succeeding measurement inaccurate. Care should be taken that no cream is left upon the lid or sides of the sample jar.

Measuring the Sample

Immediately after mixing insert the tip of a 17.6-cc. pipette into the prepared sample of milk, holding it with the thumb and second finger of the right hand and then draw in the milk by suction with the lips placed at the upper end until the pipette is filled well above the graduation mark on the stem.

Quickly place the dry, fleshy pad of the first finger of the right hand tightly over the upper end of the pipette. Holding the pipette perpendicular and with the graduation on the level with the eye, release the pressure slightly on the finger and allow the milk to run back into the sample until the surface of the milk is level with the graduation, disregarding the upper edges of the meniscus (the curved surface at the top of the milk column). Insert the tip of the pipette into the milk test bottle and allow the milk to run out. Blow the last drop of milk from the pipette.

Adding Acid

Measure 17.5 cc. of commercial sulfuric acid (specific gravity 1.82 - 1.83) into an acid measure or dipper. The acid should be at a temperature between 60° and 70° F. Hold the test bottle at an angle of 45 degrees, rotate it between the fingers, and pour in the acid very slowly. This will wash all the milk out of the neck of the bottle and prevent charring of the curd.

Variations in the temperature or strength of the acid will require use of a slightly greater or smaller quantity. It is advisable to add the last third of the acid in three portions, mixing the contents of the bottle after each addition with an even rotary motion. Acid should be added until the mixture, after mixing and upon standing for a minute, has a dark chocolate-brown color.

In mixing milk and acid, rotate the test bottle slowly until all the curd has been dissolved, always keeping the mouth of the bottle pointed away from yourself and others to prevent any possibility of injury from spurting acid. Sulfuric acid will burn the flesh and destroy cloth, wood, etc. Plenty of cold water followed by water in which alkali washing powder has been dissolved will stop its action.

Centrifuging (Whirling)

First time - After the correct color has been obtained in the acid-milk mixture, place the bottle in the centrifuge. Always place the bottles opposite each other so that the revolving disk carrying the buckets or pockets for the bottle will be balanced. Use a bottle filled with water as a balance if you have an uneven number of bottles. In centrifuges with double pockets, use the outside pockets if both are not filled.

Revolve the bottles at the proper speed, as indicated on the machine, for five minutes after that speed has been attained. Stop the centrifuge gradually to prevent breaking the bottles. Always be sure that the centrifuge is level, securely fastened to a firm foundation to prevent vibration, and is well oiled, clean, and free from foreign material.

The proper speed of a centrifuge is:

Diameter of wheel (inches)	R.P.M.
18	775-825
20	735-785
22	700-750
24	665-715

Diameter of wheel is the distance between the inside bottom of the opposite cups, measured through the center of rotation when the cups are extended horizontally. Check the speed with a tachometer with the door of the centrifuge closed.

After stopping the centrifuge add water at a temperature of not less than 160° F. until the bottle is filled to within one-fourth to one-half inch of the base of the neck. It is impossible to have this water too hot.

Soft or distilled water is preferable because sulfuric acid often forms gas bubbles in its action on lime salts in hard water. These bubbles collect at the surface of the fat column and make it difficult to measure accurately. If hard water must be used, it may be desirable to add a small amount of sulfuric acid to the water before it is added to the test bottles. About a teaspoonful of acid to a gallon of water will be sufficient. A pipette or a small glass nozzle attached to a container by a rubber hose may be used to add hot water.

Second time - Centrifuge the test bottles for three minutes at the proper speed, then add water at a temperature of not less than 160° F. until the lower extremity of the fat column is well above the zero mark of the graduation or scale on the neck of the test bottle. Add water carefully to prevent overflowing, and if using a pipette do not let the tip reach the fat column.

Third time - Centrifuge the test bottles at the proper speed for one minute, then place the test bottles in a water bath at a temperature of from 135° to 140° F. for five minutes, after which time the fat column may be measured.

Any vessel deep enough to hold enough water to immerse all but the upper one-half inch of the top of the neck of the test bottle can be used as a water bath. A frame of metal with compartments for individual bottles is convenient.

Fat columns can be measured directly from a heated centrifuge, provided the temperature of the air within the centrifuge can be maintained between 135° and 140° F. during the time required to measure the fat column.

Reading the Tests

Remove only one bottle from the water bath at a time. Hold the bottle in the hand with the fat column perpendicular and on a level with the eye. With the other hand place one point of a pair of dividers on the lowest point of the curve or meniscus at the bottom of the fat column, and the other point at the highest point of the fat column, or where the extreme upper edge of the fat comes in contact with the neck of the bottle.

Hold the dividers without changing the distance between the points and place one point on the zero mark of the scale of the test bottle and take the reading on the scale as indicated by the other point. Always read to the nearest mark or graduation on the

scale. The scale on the milk test bottle is marked in percentage of butterfat, being graduated to 8 or 10 percent in tenths of one percent.

If the test bottle is held toward the light, the extremities of the fat column may be seen distinctly. Readings should be made rapidly as the temperature of the fat column will change, causing an incorrect reading. The dividers should be tight enough at the joint to hold any position but they should move freely. Duplicate tests should check within 0.1 percent.

Emptying the Test Bottles

Empty the bottles into a stone or glass jar or on ashes. The acid in the test bottles should be carefully handled as it will attack wood, fabric, and all metals except brass and lead. Test bottles are easier to clean if vigorously shaken during emptying to dislodge the white sediment (calcium sulfate) in the bottom of the bottle and then washed at once.

Cleaning Glassware

Test bottles and sample bottles should be rinsed in warm water. They should then be filled with a solution of hot water in which an alkali washing powder is dissolved. Soap and soap powders are undesirable. Shake the test bottles vigorously, and clean the inside of the necks with a small brush. Then empty and rinse thoroughly with clean, hot water. If this method is ineffective, add a little sulfuric acid, shake thoroughly, and if necessary heat the contents of the bottle by holding it in a vessel of hot water, shake again thoroughly, and then empty and rinse with clean water. A pipette should be rinsed with water immediately after measuring the milk and then cleaned with the other glassware.

DEFECTS OF FAT COLUMNS - CAUSES AND REMEDIES

The perfect finished test should show a clear fat column varying in color from straw to golden yellow with upper and lower surfaces clear and distinct. A dark fat column or one that has dark specks within or directly below it may be caused by:

Cause	Remedy
1. Acid too strong.	1. Use less acid or the same quantity of weaker acid.
2. Too much acid.	2. Use less acid.
3. Pouring acid directly into milk.	3. Pour acid down side of bottle held at an angle.
4. Uneven mixing of acid and milk.	4. Mix milk with acid with an even rotary motion.
5. Acid too warm.	5. Temper to between 60° and 70° F.
6. Milk too warm.	6. Temper to between 60° and 70° F.
7. Failure to mix milk with acid promptly after addition of acid.	7. Mix acid and milk soon after the addition of the acid.

A light-colored fat column or one that has light specks within or directly below it may be caused by:

Cause	Remedy
1. Acid too weak.	1. Use more acid or the same quantity of stronger acid.
2. Too little acid.	2. Use more acid.
3. Milk too cold.	3. Temper to between 60° and 70° F.
4. Acid too cold.	4. Temper to between 60° and 70° F.
5. Curd not dissolved before centrifuging.	5. Mix milk and acid thoroughly before centrifuging.

Sulfuric acid spilled on hands, clothing, or elsewhere should be washed off immediately with plenty of cold water.

Empty the finished test on ashes or in a hole in the ground where the acid mixture may be covered.