

COMPONENT (Fat, Protein, Other Solids) TEST VARIATIONS IN RAW MILK

INTRODUCTION

In 1890, the Babcock test for determining fat content of milk was first introduced by Dr. Stephen M. Babcock of the University of Wisconsin. Because of its simplicity and relative low cost of operation, the Babcock test was readily accepted by the dairy industry in this country.

As the testing of producer milk samples moved from milk plant boiler rooms and workshops into laboratories, improvements and innovations in equipment and technique resulted. Modifications were developed for testing products such as cream, skim milk, buttermilk, homogenized milk, chocolate milk, and other dairy products.

Electronic instruments now test milk for fat, protein, and other solids (components). These instruments are capable of automatically delivering accurate component information of milk samples only if they have been calibrated to a chemical reference.

The accuracy of any testing method or instrument is highly dependent on the condition of the sample being tested. If the sample is improperly obtained or is of questionable condition, even the very best test procedure will not produce accurate results.

For more information on sample care and preparation see DPC 51, [Controlling the Accuracy of Electronic Testing Instruments for Milk Components](#).

The first section of this guideline is designed to aid all concerned dairymen and other quality-minded people in assuring proper sampling and operation of farm bulk tanks pertaining to factors that may affect the accuracy of component tests of the milk. The following section on sampling is not intended to provide a comprehensive coverage of the subject, but to identify those factors that may affect the results of the component tests of the milk. For more detailed information on sampling see DPC 7, [Sampling Fluid Milk](#) and DPC 50, [Farm Bulk Milk Collection Procedures](#).

GUIDELINES FOR SAMPLING AND SAMPLE CARE

Haulers and sample handlers can cause inaccuracies in component tests, as well as other test results, by improper sampling techniques and sample handling. It is important that all milk samples be taken from properly agitated tanks and held in approved sample containers under refrigeration until tested. Special sampling considerations should also be given to irregular or partial pickups.

Sampling Procedures and Care of Samples

For the purposes of this guideline, a milk sampler is any person who collects samples from farm milk tanks for the official purposes of laboratory analysis. Milk samplers typically include milk haulers, field representatives and regulatory personnel. All milk samplers should be properly trained and licensed/permitted prior to sampling milk for official purposes.

The “Universal Sample” and Milk Agitation

The milk sampler has the responsibility of collecting a representative “universal sample” from the producer's farm bulk tank(s). The concept of the “universal sample” is that each official milk sample collected can be used for a wide variety of testing purposes. Because of this, it is extremely important that each and every sample be a representative sample from a homogenous tank of milk. To ensure a representative sample is collected each tank of milk must be agitated for the appropriate length of time prior to sampling. 3-A® Sanitary Standards for Farm Bulk Milk Tanks, Number 13-10 requires that a means for mechanical and/or air agitation shall be provided that will result in a variation in milk fat content of the product in the tank of not more than ± 0.1 % as determined by an Official AOAC Milk Fat Test when the tank is (1) filled to 100% of its capacity with product and the agitator has been observed in operation for a minimum of 5 minutes if the capacity of the tank is less than 1,500 gallons (5,700 L) or (2) filled to

100% of its capacity with product and the agitator has been in operation for 10 minutes if the capacity of the tank is 1,500 or more gallons (5,700 L) or as designated by manufacturer.

It is extremely important that a representative sample be taken from each farm bulk tank. Insufficiently agitated tanks can result in poor samples which will not be accurate for component testing or other tests of milk quality, e.g., somatic cell or bacteria counts.

Sampling Equipment

It is essential that milk samplers possess the appropriate equipment and supplies when obtaining an official “universal milk sample”. Sampling equipment should meet the requirements specified in *Standard Methods for the Examination of Dairy Products*, (*SMEDP*). Listed below are the essential equipment and supplies necessary for obtaining an official milk sample:

- Sample containers and waterproof, indelible pen. Sample containers must be sterile, leak-proof and large enough to hold an appropriate sample volume for tests to be conducted on the sample. A waterproof, indelible pen should be used to record the appropriate information on each sample container. In addition to meeting the requirements specified in *SMEDP*, sample containers should also meet the requirements specified in Appendix J of the *Grade A Pasteurized Milk Ordinance*.
- Sample transfer instrument. Several types of sampling instruments are approved for sampling milk. Sampling dippers are most commonly used and must be transported in a suitable container that contains an approved sanitizing solution. Other approved sample transfer instruments are identified in *SMEDP*.
- Sanitizing solution and appropriate sanitizer test kit or test strips. An approved sanitizing solution of appropriate strength should be used in the dipper container. The solution should be discarded and replaced at appropriate intervals. For milk haulers, this usually means each time the milk truck tanker is washed and sanitized. The sanitizer test kit or strips should be used to ensure the sanitizer solution is maintained at the appropriate strength as identified in *SMEDP*. Milk haulers will also need a sanitizer spray bottle to use for other hauling activities.
- Thermometer. An approved thermometer should be used to obtain the milk temperature prior to sampling. Digital or dial bimetallic thermometers should be accurately calibrated and cleaned and sanitized prior to use. Glass, mercury-type thermometers should never be used when sampling milk.
- Sample case and appropriate supplies. An insulated sample case of suitable construction must provide ample space to store all samples as well as an ice and water mixture to cool and maintain the sample storage temperature at 32° to 40° F (0° to 4.4° C). A rack or vial float should be used to keep samples in an upright position and to allow the ice and water mixture to be maintained at the level of the milk in the sample containers.
- Other supplies. Additional supplies needed while sampling milk include a watch to time milk agitation, a pen, and appropriate paper supplies to record pertinent sampling information.

Sample Identification

All milk samples, including any “special” samples, should be adequately identified with an indelible, waterproof pen. Producer’s bulk tank samples must be identified, at minimum, with the following information:

- Producer identification
- Date and time of sample collection (including AM/PM or military time)
- Milk temperature
- Sampler’s initials and
- Any other pertinent information required by the local regulatory agency or the milk buyer.

Samples obtained from irregular lots of milk such as milk sampled when haulers make irregular or partial pick-ups should be further identified. Additionally, some milk buyers use bar code “stickers” to identify the producer. When “stickers” are used, care should be taken to not distort the bar code with any hand written information. Proper sample identification is extremely important because this information is used to determine whether the sample is “fresh” enough to use for milk component testing and other tests for milk quality. All information recorded on sample containers must be legible.

Temperature Control Sample

Any single sample or sample set must be accompanied with a temperature control sample. The temperature control sample is used to determine if the sample(s) are being maintained at the appropriate temperature. Milk haulers

should obtain the temperature control sample at the first milk pick-up of the day. The temperature control sample should be identified with the previously mentioned sample identification information along with the initials "TC".

Sampling Procedures

Milk from a farm bulk tank should always be sampled prior to opening the tank outlet valve. After the appropriate agitation time and after hand washing and drying, drain the sanitizer from the sample dipper and rinse the dipper in milk at least twice. Sample well below the milk surface (6 – 8 inches) with the agitator running and avoid sampling foamy areas of milk. Without touching the inside of the sample container, fill the container approximately $\frac{3}{4}$ full (or to the container's fill-line) while holding it away from the bulk tank lid opening. Immediately close the container and place the sample in an appropriate manner in the insulated sample storage case. Milk should never be sampled from the bulk tank outlet valve, site gauge tube, with an unapproved sampling device or while the producer is still milking.

Milk of Questionable Condition

Milk that is sour, frozen, partially churned, contaminated or has an otherwise abnormal appearance or odor can result in inaccurate milk component tests as well as other inaccurate milk quality results. When milk of questionable condition is sampled, the sample container and accompanying paperwork should be clearly identified to alert the laboratory of this matter.

Sample Storage and Care of Samples in Transit

All official samples used for milk component testing and other official milk quality tests must be physically handled in a manner that preserves sample integrity from the time the sample is obtained until the sample is analyzed in the laboratory. A key point to remember in this regard is "sample chain of custody". This concept specifies that all individuals who sample milk, physically handle official milk samples or test milk in the laboratory are appropriately licensed, permitted or certified to perform these activities by the local regulatory agency. Each individual must properly document the receipt of all samples as they are transferred from one responsible party to the next. Maintaining the "sample chain of custody" ensures that milk samples will be stored within the appropriate temperature range of 32° to 40° F (0° to 4.4° C) and handled in a manner to preserve their integrity.

Samples are routinely transferred from the milk sampler's insulated sample case into sample storage refrigerators. Refrigerators used to store milk samples must be of sufficient size to prevent overcrowding. Overfilled refrigerators generally have problems with air circulation, which in turn results in poor cooling. Samples should be stored in as orderly a manner as practical to allow optimal air circulation. Ideally, units should be equipped with self-closing doors to ensure better control of cooling.

Detailed records are required for all milk sample storage refrigerators. *SMEDP* indicates, at minimum, an approved thermometer on both the top and bottom shelves be used to monitor each unit. These thermometers must be examined twice daily and documented with written records. When checking the refrigerator, assure samples remain stored in an orderly manner. When necessary, clean and sanitize the refrigerator to maintain a sanitary condition.

Refrigerators in milk plant receiving areas must be maintained in optimal working condition, especially refrigerators exposed to outdoor humidity and heat generated from trucks and other equipment. Routine maintenance should be a priority to ensure proper refrigerator operation. Minimal routine maintenance items include examining the refrigerator unit's compressor, Freon level and door gaskets.

Individuals who access any refrigerator containing samples should not keep doors open for extended periods. Attention to details such as these will go a long way towards ensuring proper sample storage temperatures.

Other Sample Handling Issues

Sample couriers and those who ship official samples have a significant responsibility in regards to sample transportation. Couriers should carefully check each refrigerator to ensure the appropriate temperature range of 32° to 40° F (0° to 4.4° C) is maintained as they collect samples at each receiving station. If the proper temperature range is not observed, promptly notify a responsible person. Samples found to be stored at improper temperatures should be conspicuously identified and not used for routine testing purposes. Couriers as well as other individuals who ship samples are required to properly pack samples in insulated coolers. Samples should be packed in a manner to minimize "leakers" and ensure an adequate amount of ice to keep the samples at an appropriate temperature until they arrive at the laboratory.

Routine monitoring of sample storage and transportation conditions reveals that failure to maintain sample temperatures within the permissible temperature range is a common problem. Sample stress due to freezing and excessively warm temperatures can result in inaccurate test results for milk components and other official milk tests. Each individual involved in the “sample chain of custody” process must follow proper procedures to ensure the integrity of official milk samples from the time of sampling through laboratory analysis.

Irregular Milk Pickup

When milk is picked up on a regular basis, either every day or every other day, the morning's and evening's milk are blended and the test results from samples taken are representative of the farm's entire production for that period. But when milk is picked up on a variable basis or partial milkings are picked up, the tests can vary significantly from other milk pickups at the same farm.

The problem of variable pickups has become more pronounced in recent years as farms have increased in size. Haulers are forced to make pickups on some of these larger farms at varying intervals to prevent over filling of bulk farm tanks and tankers in the case of direct load farms.

When variable pickups are made on an infrequent occasion, it is recommended that the milk hauler properly identify the samples from these pickups as usual with proper tank number and time. However, if variable pickups are made at a given farm on a regular and ongoing basis, it becomes very difficult to establish an adequate procedure to ensure accurate payment tests. To assure proper identification of samples taken, a separate number/letter and time should be assigned with the producer number for each pickup of milk.

Depending on the interval between milkings there can be considerable difference between morning and evening components tests. Differences of several points, ranging from 0.20% to 0.30%, and in some cases as high as 1% - can occur between morning and evening fat tests.

Example : A producer on every other day pickup (4 milkings) started increasing production to a point where the bulk tank would not hold the four complete milkings. To accommodate the producer, the hauler began picking up the milk prior to the second morning (3 milkings) and again after the morning milking was completed (1 milking). In this example, the hauler did not take a sample from the first pickup (3 milkings), but he did sample the second pickup (1 milking). This type of sampling caused the producer's average fat test to drop from 3.925% to 3.25% fat due to the following:

The milking interval between night and morning milkings is not normally a perfect 12-hour interval. Evening milkings normally test higher than morning milkings due to a shorter interval between the completion of the morning milking and the start of the evening milking. In this example, assume that if a sample had been taken from the three (3) milkings, two nights and one morning, it would have tested at 4.15% fat. The sample from the one morning milking tested at only 3.25% fat. Since the morning sample was the only sample collected the producer's fat average dropped to the 3.25%.

The effect of variable milk pickup on tests can be further illustrated by considering the following example. Using the test results from the above example, assume that the hauler took a sample from the three (3) milkings and a sample from the one (1) milking. The following results would occur:

Simple Average Test:

Sample from 3 milkings	=	4.15% (represents 3000 lbs.)
Sample from 1 milking (am)	=	3.25% (represents only 1000 lbs.)
Simple Average	=	3.70%

The problem with a simple average test as shown in this example is that three (3) milkings at the 4.15% test represents three times more pounds of milk than the one (1) milking at the 3.25% test.

The problem can be solved by calculating a weighted average test for the milk.

Weighted Average Test:

$$\begin{array}{rcl}
 & \underline{\%BF} & \underline{\text{Lbs. Milk}} & \underline{\text{Lbs. BF}} \\
 3 \text{ milkings} & = & 4.15\% \times 3000 \text{ lbs.} & = 124.5 \\
 1 \text{ milking} & = & 3.25\% \times 1000 \text{ lbs.} & = \underline{32.5} \\
 & & & 157.0
 \end{array}$$

157 lbs. BF ÷ 4000 lbs. milk = 3.925% weighted average fat test

As illustrated by the two examples above, the weighted average test yielded a 3.925% fat test compared to the 3.700% fat test obtained from the simple average for a difference of 0.225% fat.

A weighted average can also be used for the other milk components such as protein and other solids.

Another common problem is multiple tanks on the farm. A sample from each tank must be obtained and properly identified. Often one tank is smaller than the other. Depending on the amount of evening's or morning's milk added to each tank, the tests can vary considerably. In these situations, the producers should follow the same filling procedures for each tank each day, so that the milk and components in each tank is consistent from day to day.

Fortunately, with the rapid automatic milk testing instrumentation employed today, component testing can be performed on every load of milk very economically. Therefore, the goal should be to obtain a sample on every load of milk and use weighted averages for calculation purposes.

Partial Pickup

Some dairy farms allow their haulers to make partial pickups, leaving milk in the bulk tank. In item 10r.3 in the *Grade A Pasteurized Milk Ordinance*, specific guidelines for partial pickups are outlined. Partial pickups should be avoided when possible due to complications caused by this practice. Components test problems similar to those associated with irregular pickups can occur with partial pickups. Additionally, the chance of having high bacteria tests due to not washing the bulk tank between milk pickup is a very strong possibility.

LABORATORY ANALYSIS

Incorrect laboratory analysis is usually the implication when milk component tests vary erratically. Although no laboratory is 100% perfect, laboratories are rarely the cause of milk component test variations as each official milk-testing laboratory must adhere to strict quality control guidelines to maintain compliance with applicable state and federal agencies.

Testing milk components as a basis for milk payment and for standardizing dairy products has occurred for many years. This task has been greatly simplified by the development of electronic testing instruments for estimating the percentages of various components in milk. These instruments have dramatically improved laboratory efficiency by increasing the number of samples that can be analyzed and allowing the determination of percentages of several components simultaneously.

There are several different makes and models of electronic testing instruments currently available or in use for testing milk or other dairy products. Instruments using the turbid metric (light scattering) method for fat tests only are used in some plants for milk standardization and routine "in-house" testing. Instruments using the infrared or near-infrared energy at specific wavelengths are capable of analyzing milk for other components in addition to fat and are regularly used in laboratories for payment purposes.

Infrared testing procedures for determining the components of milk samples approved by the Official Methods of Analysis of AOAC International (AOAC) and *SMEDP* are accepted by regulatory agencies for a basis of milk payment.

As with all electronic instruments, control of the accuracy of the instrument's output is imperative. Since these instruments provide indirect measurements (i.e., light scattering or absorption), they must be routinely calibrated and adjusted to agree with the results of chemical reference methods in order to produce accurate, reproducible readings. The preferred chemical reference method utilized for milk fat is the Modified Mojonnier, or ether extract analysis, for protein is the Kjeldahl method and for total solids is the forced air oven method. Instruments that are accurately

calibrated using these chemical reference methods should provide highly accurate milk component tests. Laboratories using these types of electronic testing instruments and chemical reference methods must maintain rigid quality control programs to ensure consistent and accurate test results for milk fat as well as other components.

GUIDELINES FOR PRODUCERS

Reasons for Component Test Variations

Day-To-Day Variation

The day to day variation of component tests is more prevalent than most people realize. Usually an increase in milk production results in a decrease in component tests and vice versa. However, a consistent relationship does not always exist between the test results and the weight of milk delivered from pickup to pickup. Many herds have seasonal trends in production, changes in herd size, batches of new heifers, or other major changes affecting production and testing.

Individual cows within any one particular breed will show variations in their ability to produce components. Cows producing milk of higher component content are most likely to show greater variations.

The effect of environmental temperature in regard to the component content of milk has been found to be quite definite. Hot, humid, uncomfortable weather affects both volume and component tests. Sudden storms or changes in temperature may noticeably affect the tests.

Lactation

Generally, the amount of milk produced decreases and the component tests increase as the lactation period progresses. A noticeable decline in component tests usually occur from time of freshening until the second or third month of lactation, which is normally followed by a gradual increase in the component tests to the end of the lactation period.

Another factor influencing component tests is the body condition of the cow at the time of calving. On average, cows calving with good body condition will have higher component tests than cows with poor body condition. On the other hand, cows with inadequate energy intake or that are losing body weight rapidly in early lactation may have extremely high milk fat levels as a result of metabolic changes accompanying subclinical or clinical ketosis. Also, a common method of detecting herd levels of subclinical rumen acidosis is to check the proportion of cows with a lower fat than protein percentage.

Seasonal

Component tests tend to drop in the spring and summer then increase in the fall season. These variations are largely due to the fact that cows will eat more roughage type feeds in cooler weather compared to the decrease of dry matter intake in hot, humid weather. During the summer months, fat test may decline 0.1% for each 10° F (5° C) increment increase over 70° F (27° C).

Health Problems

Diseases of cows may have varying effects on component tests. Production may decline and milk component tests rise. However, when cows have mastitis, ketosis, or milk fever, both production and component tests usually decline.

Age

The age of the cow will not have a great effect on the overall herd test. However, the component tests of individual cows may tend to decline from the first to the fifth lactation.

Exercise

Slight exercise may increase the component tests somewhat without reducing the quantity of milk secreted.

In Heat Estrus

Cows in heat usually produce less milk and can have considerably higher or lower component tests.

Nutrition

Nutritional problems can cause severe milk component depressions (that may or may not affect production), so daily herd samples may vary because of improper nutritional practices. Some of the more common nutritional causes of depressed component tests are:

1. Feeding rations high in concentrate and low in forage, by far is the most common nutritional cause.
2. Feeding forages that are too finely chopped (less than a ¼ inch in length).
3. Feeding hay that is too high in Relative Feed Value (too digestible) and that does not provide adequate levels of effective fiber.
4. Feeding hay equivalent of less than 2 percent of body weight.
5. Feeding low fiber, pelleted, or cooked feeds.
6. Overfeeding or underfeeding prior to freshening.
7. Feeding high-fat rations.
8. Feeding certain by-product feeds, such as distillers grains that are high in vegetable oil.
9. Feeding certain feed additives that may change rumen microbial populations.

When the fiber intake of dairy cows is inadequate, the result is low fat tests. To avoid milk component test depression, dairymen should make certain that all cows eat at least two pounds of hay equivalent per hundred pounds of body weight daily. Since cows need long fiber to allow the rumen to function properly, to help counteract a lack of fiber in the diet, dairymen may include a buffer in their concentrate such as sodium bicarbonate or magnesium oxide. A dairy nutritionist should be consulted in this regard. Water also serves as a ruminal buffer, and encouraging cows to drink adequate amounts of clean water can help to prevent component test depression. Frequent feeding of a complete blended ration, or total mixed ration (TMR), will help to maintain a constant supply of feed in the rumen which will help promote normal rumen condition.

Feeding Facilities

Comfortable cows may spend more time chewing their cud. This in turn causes cows to provide copious volumes of saliva that help to buffer the rumen and prevent reductions in component percentages. Furthermore, location of the feeding surface no more than a few inches above the floor surface also encourages saliva production while eating, compared to eating from an elevated surface.

Milking Practices

Milking practices that affect tests include changing milking intervals or time of milking, insufficient vacuum, poorly operating equipment, or poor milking methods. Many dairy farms have a longer milking interval between the evening and morning milking, resulting in more milk production of lower component percentages during the morning milking. Incomplete milk let-down also affects component tests. The first milk from the udder has a lower fat percent (1% to 2%) than the last milk obtained during milk out (7% to 9%), so milk of highest fat percentage will remain in the udder if not completely milked out. Another factor related to daily variations is that cows milked in a parlor might change their milking order, and, therefore, the interval between their milking times.

Sample Handling and Testing

Sample handling and care is critical at all times, and special attention should be given during periods of extreme weather. Samples should be stored and transported in an ice water immersion at temperatures of 32- 40° F (0-4.4° C) at all times.

It is a good management practice to occasionally check the milk hauler's procedures at the farm. Observe the procedures the milk hauler follows in obtaining the sample and measuring the volume of milk. A dairy farmer has

the unique opportunity to personally observe the measuring of milk at the farm as well as the care given by the milk hauler in obtaining a true representative sample.

COMPARING DHIA AND PAYMENT TESTS

Comparing Tests for the Same Period

DHIA and bulk tank samples are not measuring the same milk. When reviewing the DHIA herd summary, understand that the herd average for each component is the result of many calculations. The DHIA milk fat and protein percentages reported start by calculating the amount of fat (or protein) produced for each cow. The amount of fat (or protein) produced by each cow is summed for all the cows in the herd and divided by the total milk produced on test day to provide the average component percentages. The DHIA test day average for each component is a true average for every cow in the herd that was tested which includes cows with saleable milk and cows with milk used on the farm or discarded. Fresh cows are not included in the DHIA test until seven days after freshening. DHIA records are meant for comparing cows and making management decisions based on preserved samples, not as a basis for determining payments. In contrast, milk processors' component tests are for payment of milk based on fresh, refrigerated samples.

The milk samples collected for analysis by the milk processor includes only saleable milk that is part of a specific pickup. The bulk tank may not represent the entire 24-hour milk production for the herd. Each herd is different with respect to milk marketing. Milk from some herds is picked up multiple times per day, whereas other herds' milk may be picked up every other day.

The composition of milk for each pickup will vary because of several factors. In herds with multiple pickups per day, different groups of cows will be represented in each load of milk. The cows tend to be grouped according to stage of lactation, reproductive status, and/or production records, thus causing the average component composition to vary for each group.

A smaller herd's milk composition is more sensitive to individual cow events, such as a freshening cow, cows being dried-off and milk withholding times. Herd management factors, such as feeding and milking times also contribute to variations in milk composition.

Both the DHIA and processor payment laboratories provide consistent and accurate results for dairy producers. However, these results will not be identical every month. DHIA results provide essential management information for each individual cow's milk composition, production, and somatic cell counts. This information helps the producer to manage feed rations, milking procedures and determine when and which cows to cull.

PERFORMANCE OF BULK MILK TANKS

Few producers realize that the condition of the milk at the time of the pickup may be the cause of inaccurate component tests. Improper operation of the farm bulk tank is one of the major causes of churning, freezing or foaming. If freezing, churning or foaming of milk occurs in the farm bulk tank, the milk loses its normal physical characteristics, making it impossible to get an accurate component test. A producer should periodically check his farm bulk tank to see that it is operating properly. This can be done by a quick visual check of the milk within the tank.

1. Tanks with chart recorders should be reviewed for consistent cooling performance. The holding temperature of the farm bulk tank should be uniform and not vary from milking to milking or day to day.
2. The compressor should not start and stop more often than normally.
3. The compressor should cool the milk to 40°F (4.4 ° C) in less than one hour after the completion of milking.
4. The cooling radiator (condenser) on the compressor should be free of dirt and hay chaff to allowing for free air movement.
5. There should not be any sign of freezing, churning or foam in the tank.

For additional information see DPC 48, [Cooling Milk on the Farm](#).

Freezing

Milk can freeze during the first milking and thaw as additional milk is added. The compressor of a direct expansion tank should not be started at the first milking until milk touches the agitator unless specifically recommended by the

manufacturer. If there is insufficient milk in the tank when the compressor is turned on, a thin layer of milk may freeze, and, although it is not visible, can affect component tests. Clumps clinging to the walls of the bulk tanks upon emptying the bulk tank indicate freezing has occurred.

A severe problem exists if freezing is noted by the presence of ice particles floating on the surface of the milk. One characteristic of the ice-like particles of protein and fat observed in the tank is that they seem to disappear when a sample of the milk is collected with a dipper and the ice crystals are touched. The milk sample should be discarded after being observed and touched.

Churning

The presence of butter particles, either large pea-shaped or small flake-shaped, normally indicates churning of milk due to inadequate cooling. When insufficient cooling occurs, churning of milk is common because of continual agitation during the second, third, and fourth milkings. Churning can also be caused by excessive agitation at temperatures above 50°F (10° C). Bulk tanks should maintain temperatures below 45°F (7.2° C). The ideal temperature for the bulk tank is 36° F (2.2° C).

However, sometimes churning is the result of problems in the milking system. A poorly operating milk pipeline system or dumping station may cause churning. Milking systems should be thoroughly checked. Pipeline must be of adequate size to ensure proper handling of the milk. Fittings on pipeline milkers must be tightened regularly and properly gasketed to prevent air incorporation and agitation. Likewise air leaks should be eliminated so as not to cause churning of the fat at warm temperatures.

Foaming

Foaming of milk is a common observation. In the case of a café's cappuccinos, the production of stable foam is desirable, but it is not desirable when storing and sampling milk. Proteins are the chief cause of stable foam. They adsorb to the thin film surrounding air bubbles, giving stability to the entrapped air. Since low temperatures make milk more receptive to the taking in of air, the ideal temperature for bulk tanks (2° to 4°C) favors the formation of foam. Excessive agitation in the bulk tank will cause excessive foaming, which will in turn cause differences in the component tests of the milk.

LARGE DAIRY FARMS

The trend in dairy farming over the past few years has been toward larger farms with more cows. Many farms have more than 500 cows, with a few having more than 20,000 cows. Sampling and testing of these types of operations must be given special consideration due to operational constraints within the facility. One constraint includes milk storage on the farm. The milk tank/silo may not hold one day's production, thus the transportation system must be able to pick up milk multiple times in a single day. Therefore, permanent storage facilities may be forgone in lieu of using the milk tanker as a storage device.

Dairy farm herd managers may group cows based on lactation, age, milk production volume or any number of other variables. These groups might represent a single load of milk for only one milking cycle, or possibly a partial cycle. It is imperative that variations in component tests outside normal parameters not be discounted. With the possibility of significant variations in components for loads of milk from a single farm, it is necessary that each load is tested and a weighted average used for payment purposes. This insures that the value of the milk is properly represented for both the buyer and seller. Any outlier programs used to determine bad samples/tests should determine the normal individual farm variability for each farm before applying a one-size-fits-all acceptable variance. Each farm will have its own normal variation based on its individual management practices.

Sample Collection on Large Farms

Farm bulk tank sample collection on large farms will differ from smaller farms due to tank size and tank style. Large farm bulk tanks vary greatly in size from 6,000 gallons to more than 12,000 gallons. Large farms may use multiple bulk tanks. These bulk tanks may be horizontal or upright silos. Both types of tanks must be agitated prior to sample collection. If the tank capacity is over 1,500 gallons (5,700L), the milk must be agitated at least ten (10) minutes, or as long as required by the tank manufacturer. For additional information see DPC 7, Sampling Fluid Milk.

Large horizontal tanks can be sampled from the top portal after agitation similar to sampling a small bulk tank. Dippers should be purged three times with milk prior to sampling from the top of a horizontal bulk tank. The large silos will have a sampling spigot or sampling port on the lower portion of the silo for sample collection. It is critical that this spigot or port be cleaned with a sterilizing solution prior to sampling. After cleaning, sample spigots should be purged, allowing milk to flow through to remove residual cleaning solution. Purging should last approximately one second to adequately remove the cleaning solution from the sampling spigot.

Sampling Ports

Component samples can be collected from sampling ports of a properly agitated silo or tanker with no reduction in sample quality. Sampling ports should be wiped with a sterile solution prior to inserting the sampling device.

Multiple Bulk Tank Farms

When collecting milk at multiple load farms, it is critical that the driver obtain his load of milk from silos in chronological order. First filled, first emptied is a good rule of thumb. If farm bulk tanks are smaller than a load of milk, weights (stick readings) must be recorded for all bulk tanks collected. Samples should be obtained from each silo or bulk tank pumped onto the milk truck. These samples will allow for a weighted average test of the producer's tanks to be compared to a load sample and weight.

Milking Directly Onto a Tanker

Due to size, some producers find it advantageous to forgo bulk tanks and milk directly onto a tank trailer. When this system is used in-line, initial lowering of milk temperature to 7°C (45°F) or less with plate coolers is critical due to no additional cooling being available on bulk tankers. Tankers filled by this method should be sampled after an acceptable agitation has occurred. Currently acceptable methods for sampling are out of the top of the tanker (dome lid) after milk is air or mechanically agitated or from a properly functioning drip sampler. If a drip sampler is used, it is imperative that the collection container be refrigerated as the milk is pumped directly onto a tanker and also after collection of the representative sample. One notable advantage of direct tanker loading is that it reduces the number of times milk goes through a pump, which may lower bacteria counts and reduce sheering of fat globules caused by multiple pumping methods.

Farms that milk directly onto tankers should be routinely audited by outside agencies. These agencies include USDA, Federal Milk Market Administrators offices, state agricultural offices, and, if a member of a cooperative, the cooperative's field person. In addition to regulatory and cooperative verification at these farms, a raw milk purchasing plant may also wish to validate sampling procedures.

Farms with Scales

In certain parts of the country, the milk is scaled for weight at the farm. Scales used for payment purposes must be checked and/or calibrated by a weights and measures certified company every six months. This ensures that both producer and purchaser are treated equitably. It is acceptable in most states for producers in close proximity to each other to share a single set of scales. This practice diffuses cost to several individuals.

Plant Load Samples on Single Load Producers

Even if a tanker contains milk from only one producer, agitation prior to collecting a plant load sample is critical. These loads should be agitated for at least fifteen minutes to obtain a representative load sample. If they have been loaded for less than one hour, exceptions may prove viable, dependent upon local and state regulations. Loads with short hauls to handlers may be accurately sampled without additional agitation if sampled immediately upon arrival.

If any loads of milk are allowed to sit more than 30 minutes, agitation prior to sampling or a sample from a properly operating drip sampler is a must for payment verification.

Testing Large Farms

It is imperative that component tests not be discarded when testing large farms. Exceptions to this rule are recognized factors such as a leaking vial, a known faulty agitator, or other known abnormalities in sample collection. Large farms regularly see one percent differences in component tests for a selected group of cows. If one group of cows consists of early lactation heifers in one load of milk and a second group of late lactation cows are contained in another load of milk, large variations in components are expected. In some dairies a managed group of cows may include several hundred head. These cows are given rations that differ from one another depending on group makeup. Component test results for managed groups change throughout the cows' lactations

and life cycles, depending on their production, age, reproductive status, and stage of lactation. Therefore, each producer's milk should be tested as accurately as possible, and laboratory personnel should resist the temptation to omit a test as an outlier. A 0.50 percent change in fat tolerance used for smaller farms is not viable when dealing with large multiple group herds. Laboratories should develop self-adjusting statistics for making tolerance determinations. This will vary from farm to farm. Statistical data analysis can be used to avoid improper test elimination when analyzing component tests.

Large Dairy Farms Future

Large farms are expected to grow in number and size for the foreseeable future. Decisions to adjust the present system to facilitate these farms are vital for maintaining quality sampling and testing as well as collection and assimilation of data. Large dairies are the backbone of our modern dairy industry. Sampling and testing procedures must continue to improve to provide the most accurate and precise component tests possible.

REFERENCES

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Food & Drug Administration, CFSAN, Milk Safety Branch
2. DPC Guideline #65 "Installing and Operating Milk Precoolers Properly on Dairy Farms"
3. DPC Guideline #7 "Sampling Fluid Milk"
4. Wehr, H.M., Frank, J.F., ed. Standard Methods for the Examination of Dairy Products. 17th ed. Washington, DC: American Public Health Association, 2004.