The Effects of Raw Milk Storage Conditions on Freezing Point, pH, and Impedance

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ABSTRACT

In the dairy industry, raw milk samples collected for quality testing should be tested or refrigerated immediately to control bacterial growth. A thermistor cryoscope is used to accurately determine the freezing point depression (FPD) of raw milk. Milk containing extraneous amounts of water will have a grossly elevated FPD. Milk that has been spoiled or adulterated with other sources, such as sugar, salt, or milk powder, will depress the freezing point, potentially masking the addition of added water. The pH of milk is a general measure of acidity in the sample. Lower pH values indicate an acidification process such as bacterial spoilage. Impedance methods monitor changes in the metabolic processes and will measure lactic acid as a by-product of lactose, for example.

The purpose of this study was to show the effects that storage conditions have on FPD, pH, and impedance of raw milk. In two identical experiments, 20 raw milk samples were stored at 20-25°C, and 20 at 2-8°C, for 168 hours. All samples were tested at numerous intervals throughout this time period. Spoiled and unspoiled milk samples generated similar results using all 3 methods up to 24 hours of storage. Between 24 and 48 hours, the FPD of the spoiled milk was erroneously depressed by an average of 102.4 m°C, the pH was lowered by an average of 1.19 units, and the impedance measurement dropped by an average of 19.1 ohms. The FPD, pH, and impedance data collected generally indicate that raw milk samples with or without refrigeration can be tested up to 24 hours without showing an appreciable shift in response due to bacterial spoilage.

INTRODUCTION

There are sampling handling standards and guidelines that must be followed in the dairy industry in order to generate accurate results, indicating that milk has not been adulterated and is safe for consumption. According to the Grade "A" Pasteurization Milk Ordinance (Department of Health and Human Services) and the Standard Methods for the Examination of Dairy Products (APHA), when a milk sample is collected for testing it must be cooled and stored immediately between 0ºC-4.4ºC. If the milk sample is delivered to an off-site laboratory for testing, it must be packaged appropriately for shipping, making sure that the sample remains at 0ºC-4.4ºC until testing begins. If this sample is not held at the recommended temperature, the test results will be affected. From the time a milk sample is collected to the time it is tested, there is a very small window in which to test samples. Improper storage conditions will result in compromised analyses.

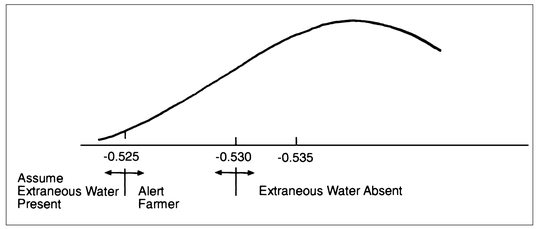

Fig. 1. Action to be taken on freezing point results

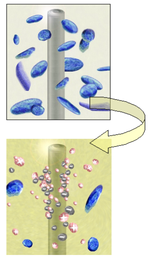

Fig. 2. Impedance principle

A thermistor cryoscope is used in estimating the proportion of water in milk by the freezing point depression method. The basis of this test is related to the salt balance, or osmotic pressure, of a cow's milk and its blood. Osmotic pressure of a cow's milk can only vary by narrow limits, and it follows that the salt balance of her milk (freezing point) can only vary by narrow limits. The average freezing point of normal milk is about 0.5ºC. Additional solutes will depress the freezing point, whereas abnormal water intake or bad feeding will elevate the freezing point (Fig. 1).

Many factors can mask the addition of water to milk. The addition of sugar, salt, and milk powder will depress the freezing point, masking any water that could have possibly been added. Another possible item that can mask the addition of water is not properly storing the milk prior to testing. Bacterial spoilage will cause a depression in the freezing point, therefore masking the addition of water.

Titratable acidity and sometimes pH are tested at the same time as the freezing point test to ensure that any acidity developed from spoilage (for example, where lactose is converted to lactic acid) is not influencing the measurement and masking the possibility of adulteration. pH is the measure of the amount of dissociated hydrogen ions and, therefore, a rough estimate of acidity of the milk.

Impedance measurements or electrical conductivity of milk samples stored at varying temperatures can also be used to indicate extent of spoilage. As bacteria multiply, they convert large molecules into smaller, more mobile metabolites (Fig. 2), which change the electrical properties of the medium. These metabolites increase the conductance and reduce the impedance of the medium.

This study was conducted to evaluate the effects that improper storage conditions have on the FPD, pH, and impedance of milk samples.

MATERIALS AND METHODS

Sample Preparation. For the two identical experiments, raw milk was purchased and immediately dispensed into forty 50 mL vials and stored at 2-8ºC overnight. On the following day, 20 of the vials were removed from 2-8ºC and stored at room temperature (20-25°C) for the remainder of each of the experiments. The 20 raw milk samples stored at 2-8°C are considered the "unspoiled" samples, and the 20 raw milk samples stored 20-25°C are considered "spoiled" samples.

Testing Procedures. Both the unspoiled and spoiled samples were tested over sixteen different intervals for 168 hours. Three tests were completed at each testing interval, including FPD (Cryoscope Model 4250, Advanced Instruments, Inc.), pH (Orion 43), and impedance (BacTrac 4300, Advanced Instruments, Inc.). FPD was conducted on two cryoscopes, testing five samples of each milk type, at each time interval. Impedance and pH were evaluated concurrently at each time interval using the same milk samples. Microsoft® Excel 2000 was used for statistical analyses.

RESULTS

Spoiled and unspoiled milk samples generated similar results using all three methods up to 24 hours of storage. Between 24 and 48 hours, the FPD of the spoiled milk was erroneously depressed by an average of 102.4 m°C (Figs. 3, 4), the pH was lowered by an average of 1.19 units (Fig. 5), and the impedance measurement dropped by an average of 19.1 ohms (Fig. 6).

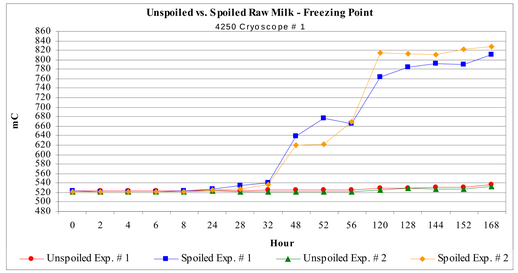

Fig. 3. Unspoiled vs. spoiled raw milk - freezing point method 1

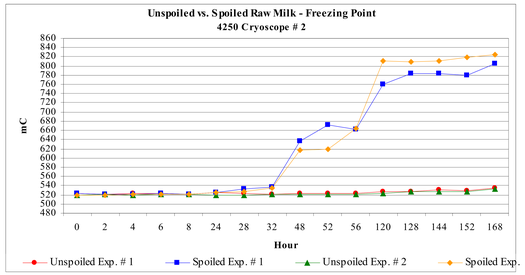

Fig. 4. Unspoiled vs. spoiled raw milk - freezing point method 2

CONCLUSION

This study indicates that raw milk samples stored at ambient or refrigerated temperatures for up to 24 hours can reliably be tested for FPD, pH, and impedance without showing an appreciable shift in response. Spoiled milk samples will depress the freezing point and mask the presence of added water. It is recommended that raw milk sample collection and storage condition guidelines be strictly followed prior to quality testing to ensure the most accurate results.

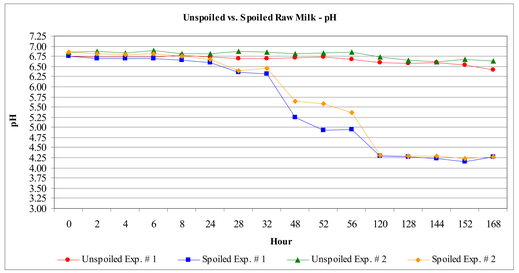

Fig. 5. Unspoiled vs. spoiled raw milk - pH method

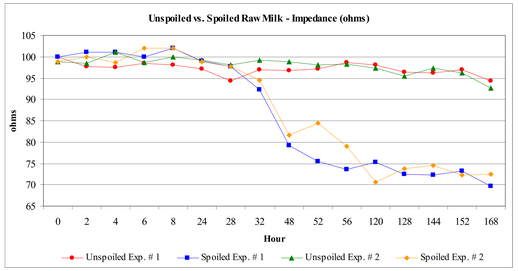

Fig. 6. Unspoiled vs. spoiled raw milk - impedance method

ACKNOWLEDGEMENT

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