Monitoring Composition of Waste Milk Fed to Dairy Calves

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ABSTRACT:

With the increasing size of dairy farms and the aim to reduce costs of raising heifers, many farms are opting to pasteurize waste milk for feeding to calves. However, when using this feeding practice, the producer needs to know the composition of the milk being fed. A 700-cow Holstein farm in Ohio was used for collecting daily samples of waste milk. The milk was sampled prior to pasteurization and was analyzed for milk components at the farm using a LactiCheck. Samples of the milk also were sent to DHI Cooperative, Inc. for analysis of milk components. The pH and ethanol coagulation were taken as indicators of whether or not the waste milk was spoiled. Readings with a Brix refractometer were taken on each of the milk samples. Among the 55 samples collected, the average pH of the milk was 6.61 + 0.29 and the Brix reading was 10.1 + 0.4. Only three (5.5%) of the samples tested positive with the ethanol coagulation test, realizing that at least one of the samples tested positive due to lack of refrigeration. The Brix readings were highly correlated ($P < 0.01$) with the concentrations of fat and solids in milk (both with on-farm and DHI measurements). Given that the Brix readings were not very variable (8.9 to 10.4) in our study, an equation ($Y=2.077 + 0.9984x$, where Y = milk solids and x = Brix reading) from a previously published study (J. Dairy Sci. 92:3503-3509, 2009) was applied to our data, with an average error of 0.48% milk solids for the 55 samples. Using the methods described to measure total solids allows the dairy producer to fortify waste milk with the appropriate amount of milk replacer to increase total solids to the desired level, which will improve calf performance and will increase farm profitability.

INTRODUCTION:

Profitability of dairy farms is influenced by several characteristics, one of which is calf management. The growth and health of replacement animals influences their future milk yield. Since the first two years of life for heifers on a dairy farm do not result in any income, and the average Holstein heifer costs the farmer approximately $1225 (Heinrichs and Swartz, 1990), it is important to make sure the producer is keeping costs as low as possible. Over the past few decades, many different feeding strategies have been implemented on dairy operations to try and reduce costs. It has been established in the industry that whole milk is the best feed source for calves, but the cost of this feeding practice outweighs the benefits. This then leads to the use of using milk replacers, but recent studies have shown that this may not be the best feed source for dairy calves. Therefore, the newest feeding practice for calves in the dairy industry is feeding pasteurized waste milk.

This feeding practice has emerged partly because of the increasing size of dairy farms and the aim to reduce costs of raising heifers. Producers are investing in these pasteurizers since calves fed pasteurized waste milk and colostrum are worth $8.13 more per calf than those fed non-pasteurized waste milk and colostrum (Jamalauddin et al., 1996). A study completed by Elizondo-Salazar et al. (2010) also showed that pasteurizers are effective in lowering the levels of bacteria in the milk to acceptable levels. Even with the expense of purchasing a pasteurizer, calves fed the pasteurized waste milk cost $0.69/day less than those fed commercial milk replacer (Godden et al., 2005). In addition to the pasteurization of waste milk for lowering costs on dairy farms, feeding this whole milk also has been shown to cause increased growth rates, and lower morbidity and mortality in calves (Godden et al., 2005).

Since this feeding practice is continuing to grow, the demand for pasteurizers has increased, and consequently the cost of these pasteurizers has decreased. Due to this increased demand and decreased cost, it has been estimated that an operation only needs to be feeding at least 23 calves per day to justify the overhead cost of purchasing a pasteurization system (Godden et al., 2005). Since the recent trend in the dairy industry is for operations to expand their herd size, more and more producers are able to afford a pasteurization system. However, a major downfall of this feeding practice is that the producer does not know the composition of the milk being fed. The proportion of milk from fresh cows and cows treated for mastitis (often lower in solids than from healthy cows) will affect the composition of the waste milk. It is important to know the composition of the waste milk because adequate concentrations of fat and protein (or total solids) in the milk is vital for sound health and expected growth rates for the calves.

Simple tests, such as pH and ethanol coagulation, can be easily used, but they only indicate whether or not the waste milk has spoiled. Other on-farm measurements are needed that are more reflective of milk composition. Total solids in milk can be determined using a Brix refractometer, with the Brix readings being converted to total solids using reported equations. In addition, these refractometers are inexpensive and the readings are very rapid. On-farm analytical instruments are available today for measuring the fat, protein, and other solids in milk (e.g., LactiCheck®; Page & Pedersen, International, Ltd., Hopkinton, MA). These instruments require routine calibration, but standards for the calibration are readily available and the calibration steps are simple. Although these instruments are much more expensive than refractometers, they provide more information than just total solids, and they can be used to monitor the composition of milk from individual cows and the bulk tank. Continued improvement in on-farm measurement of the composition of waste milk fed to calves will improve calf performance and increase farm profitability.

OBJECTIVES:

This study aimed to determine an adequate way to measure the solids content in waste milk fed to dairy calves. Since waste milk composition varies by the number of fresh cows and cows treated for mastitis on the farm, it was hypothesized that the milk solids content of the milk would vary significantly from day to day. Therefore, by having an affordable milk component analyzer on farm, such as LactiCheck (LIC) or a brix refractometer, producers would likely have an adequate manner to fortify waste milk to the desired level of milk solids.

MATERIALS AND METHODS:

Milk Collection:

Beginning in September 2011, waste milk was collected daily from a 700-cow Holstein farm in South Solon, Ohio. Samples were collected before pasteurization from the pasteurizer (Westward Pasteurizer, Dairy Tech, Inc., Lynden, WA). Once collected, the samples were cooled to room temperature and then split into three vials. One vial was used to analyze the sample with the LIC, another used to take pH and brix readings (VEE GEE Scientific, Inc., Kirkland, WA), and the third contained preservative (bronopol) and was sent to the DHI laboratory (Columbus, OH) for component analysis. Normal pH reading for milk ranges between 6.5 to 6.7 (Okigbo et al., 1985) and total solids readings should be around 13% (Moore et al., 2009).

Milk Analysis:

The farm herdsman and other farm crew members were trained on how to collect samples, run the LIC, and take Brix and pH readings, and they were responsible for these duties each day. The research group then came to the farm every Sunday to collect the vials used for pH and Brix readings, and the DHI vials to be brought back to Columbus. The DHI laboratory (DHI Cooperative, Inc., Columbus, OH) analyzed for fat, protein, lactose, and other solids using infrared spectroscopy (B2000 Infrared Analyzer, Bentley Instruments, Chaska, MN).The pH and Brix sample was used to complete the ethanol coagulation test (Moore et al., 2009) in a research lab, and every Monday the other samples were dropped off at DHI Cooperative. Weekly calibration was completed on the LIC using raw milk standard samples from Eastern Laboratory Services (Medina, OH) to ensure adequate results. Calibration for fat and protein levels was performed by the research group. In November 2011, data collection was ended (n = 55). A waste milk fortification chart was then developed based on a target of 13% solids in milk.

Data Analysis:

The Proc Corr procedure of SAS (Version 9.1, SAS Institute Inc., Cary, NC) was used for data analysis. Significant differences were declared at $P \leq 0.05$ and a trend at $P \leq 0.10$.

RESULTS:

Among the 55 samples collected, the average pH of the milk was 6.58 $\pm$ 0.13 and the Brix reading was 10.1 $\pm$ 0.4 (Table 1). Only three (5.5%) of the samples tested positive with the ethanol coagulation test, realizing that at least one of the samples tested positive due to lack of refrigeration. In comparison to the previous study conducted by Moore et al. (2009), this spoilage rate was very low compared to the farm they studied that had a spoilage rate of 66.7%.

The Brix readings were significantly correlated ($P < 0.01$) with the concentrations of fat and solids in milk (both with on-farm and DHI measurements; Table 2); however, the negative relationship between solids and Brix readings must have occurred due to lower than expected variability in concentration of solids in the waste milk.

Table 1: Mean, standard deviation, minimum values and maximum values for fat, solids, Brix readings, and pH.

	Mean	**Standard Deviation**	**Minimum**	**Maximum**
Fat (Lacticheck), %	**4.29**	**2.21**	**1.23**	**15.39**
Solids (Lacticheck), %	**12.78**	**1.66**	**9.06**	**21.19**
Protein (Lacticheck), %	**3.18**	**0.31**	**1.67**	**3.53**
Fat (DHI)[1], %	**4.29**	**2.3**	**1.48**	**16.01**
Solids (DHI), %	**13.1**	**2.16**	**11.01**	**23.5**
Protein (DHI), %	**3.32**	**0.24**	**2.65**	**4.23**
Brix %	**10.1**	**0.3**	**8.9**	**10.4**
pH	**6.58**	**0.13**	**4.66**	**6.89**

[1] DHI = Dairy Herd Improvement

Table 2: Correlation coefficients of milk fat, solids, protein, and Brix readings[1]

`	Fat (LIC)	Fat (DHI)	Solids (LIC)	Solids (DHI)	Protein (LIC)	Protein (DHI)	Brix %
Fat (LIC)	**1.00**	**--**	**--**	**--**	**--**	**--**	**--**
Fat (DHI)	**0.71** ***P*** **< 0.01**	**1.00**	**--**	**--**	**--**	**--**	**--**
Solids (LIC)	**0.92** ***P*** **< 0.01**	**0.64** ***P*** **< 0.01**	**1.00**	**--**	**--**	**--**	**--**
Solids (DHI)	**0.79** ***P*** **< 0.01**	**0.99** ***P*** **< 0.01**	**0.75** ***P*** **< 0.01**	**1.00**	**--**	**--**	**--**
Protein (LIC)	**-0.66** ***P*** **< 0.01**	**-0.41** ***P*** **= 0.08**	**-0.37** ***P*** **< 0.01**	**-0.42** ***P*** **= 0.01**	**1.00**	**--**	**--**
Protein (DHI)	**-0.50** ***P*** **< 0.01**	**-0.27** ***P*** **= 0.03**	**-0.32** ***P*** **= 0.01**	**-0.21** ***P*** **= 0.12**	**0.65** ***P*** **< 0.01**	**1.00**	**--**
Brix %	**-0.34** ***P*** **< 0.01**	**-0.34** ***P*** **= 0.01**	**-0.34** ***P*** **= 0.01**	**-0.38** ***P*** **= 0.01**	**0.17** ***P*** **= 0.18**	**0.30** ***P*** **= 0.02**	**1.00**

[1] LIC = LactiCheck and DHI = Dairy Herd Management

This data in Table 2 demonstrates the similarities between the LactiCheck and DHI results. The standard deviation of the Brix readings was low on a day by day basis (Table 1). The low pH reading of 4.66 was a sample that accidentally had not been refrigerated. Given that the brix readings were not very variable (8.9 to 10.4) in our study, an equation ($y = 2.077 + 0.9984x$, where y = milk solids and x = brix reading) from a previously published study (Moore et al., 2009) was applied to our data (Figure 1). By using this equation, we were able to determine that the average error, between actual and estimated values, for the 55 samples was 0.48% milk solids. In general, our total solids levels were below 13% almost every day of the project.

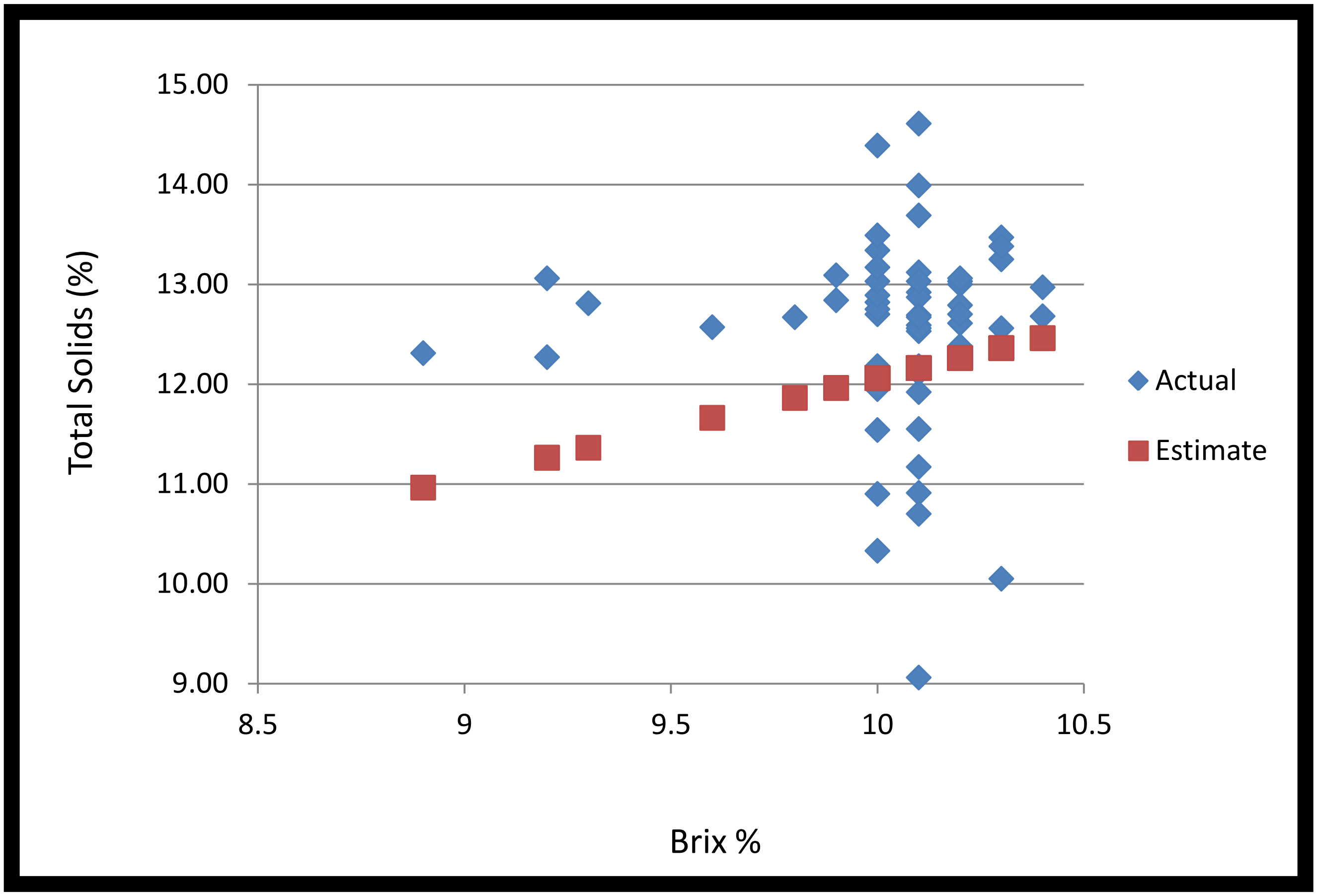

Figure 1: Brix readings versus total solids (DHI) in milk and estimated milk solids from Brix reading using equation by Moore et al. (2009).

The solids content of the waste milk varied on a day-to-day basis, but the level of variation was not as high as we hypothesized. The LactiCheck instrument is an accurate on-farm milk analyzer as long as it is calibrated weekly with raw milk standards. In addition to being able to use LactiCheck, producers can also use a Brix Refractometer to accurately determine the concentration of total solids in the milk. By using the data we collected, we were able to create a waste milk fortification chart which can aid producers when they are determining how to feed their calves (Table 3). This chart was created using Brix readings since this was the cheaper on-farm analysis tool.

Brix %	Waste Milk Total Solids (%)	Milk Replacer Needed (lb/gal Waste Milk)
8.0	**10.1**	**0.28**
8.5	**10.6**	**0.23**
9.0	**11.1**	**0.19**
9.5	**11.6**	**0.14**
10.0	**12.1**	**0.09**
10.5	**12.6**	**0.04**
11.0	**13.1**	**0.00**

Table 3: Waste milk fortification chart

This waste milk fortification chart was constructed based off the ideal calf replacer being 13% total solids. From this chart, a producer could take a Brix reading (ex. 9.0) and then know that they would need to add 0.19 lb of milk replacer to each gallon of waste milk they feed to their calves to reach a total solids level of 13%.

Milk spoilage issues on this farm were very minimal. Some farm have a spoilage rate as high as 66.7% (Moore et al., 2009), whereas this farm only had a rate of 5.5%. The waste milk was not sitting in the pasteurizer for an extended amount of time, and therefore, was still fresh when it was being fed to calves. This speaks to the management of the farm and shows that the pasteurizer was being run quickly and consistently every day. By insuring that the pasteurizer is running efficiently every day, this farm is guaranteeing that the bacteria counts in the milk being fed to the calves is being reduced to acceptable levels in comparison to what they were before pasteurization (Elizondo-Salazar et al., 2010).

IMPLICATIONS:

With these results, producers can feed a highly nutritious diet to their calves at a very affordable price. The brix refractometer is very affordable, and for large-scale dairy farms, they can easily afford an instrument such as the LactiCheck milk analyzer; therefore, with such instruments, they can get more detailed component analysis. The waste milk fortification chart allows producers to fortify their waste milk and would only cost them a few minutes to take the brix reading and then measure out the desired amount of milk replacer. These low cost and simple steps can be implemented on dairy farms across the nation and can result in healthier replacement animals and therefore long term increases in profitability.

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