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FACTORS AFFECTING TITRATABLE ACIDITY IN RAW MILK [1]

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Summary

The value of titratable acidity (TA) as an indicator of raw milk quality has been challenged recently, because milk is refrigerated within minutes after it leaves the cow until it reaches the consumer. Also, high milk protein may interfere with the test or confer falsely high TA values. Samples of milk containing <2.8% protein to >3.8% protein were used to examine the impact of protein on TA. The effects of milk age and bacterial counts also were investigated. Titratable acidity increased as milk protein content increased but the influence of bacterial populations and age were much more dramatic. As bacterial counts increased, TA values surpassed an acceptable level (upper maximum at .17%) for the KSU Dairy Processing Plant. At the same time, as raw milk increased in age, TA increased to the upper level of acceptability (.17%). Thus, TA appears to be a valid method of evaluating raw milk quality even though it can be influenced by the protein content.

(Key Words: Titratable Acidity, Raw Milk Quality.)

Introduction

Raw milk quality is an important issue to both dairy farmers and processors, because it affects the end product use and, hence, economic value. Currently, raw milk quality is determined by fat, protein, total solids content, bacterial counts, and somatic cell count (U.S. Department of Health and Human Services, 1993). Titratable acidity is not one of the pay factors listed on the milk check but has a strong economic impact, because it is one of the criteria used to determine whether or not raw milk enters the food chain as a premium-priced fluid product.

Titratable acidity (TA) is a rapid test (90 seconds to perform) indicating raw milk quality and provides an indirect measure of the acid content in milk. Generally, as milk acid content increases, TA values increase. All milk has a base acid content attributed to proteins, minerals and dissolved gasses.

Milk acid content is increased by the bacteria that convert lactose to lactic acid. When this occurs, a dramatic increase in TA value is observed. At the same time, milk has a strong buffering capacity (resisting a change in the acid or alkali content) because of its protein content. Because these proteins resist a change in the acid or alkali content, they, too, contribute to the "acidity" of milk.

Titratable acidity has been used for many years to indicate whether milk has undergone bacterial degradation (acid production) or temperature abuse or is aged. Because raw milk refrigeration is mandated by law, bacterial degradation and temperature abuse are no longer as prevalent as they once were. Thus, TA values are fairly predictable, and high quality raw milk has a relatively steady TA value ranging between .14 to .17% (expressed as lactic acid).

Today, two major factors impact the TA of raw milk: age and protein content. Raw milk

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can be several days old before it is processed, because manufacturing centers are larger and fewer in number. Thus, as milk ages, bacteria grow and subsequently decrease raw milk quality. Dairy cows are selected for increased milk protein content that tends to increase the TA value such that the TA range of acceptable raw milk may change. Thus, it is appropriate to study factors that have the greatest effects on the TA of raw milk.

Procedures

Raw milk was obtained from the KSU dairy herd and kept cold (<45 degrees F) until testing. Milk samples were divided in half with one half used to determine somatic cell count (SCC) (Bently Model #500; Bently Instruments, Inc., Chaska, MN) and protein and fat contents (Bently Model #2000-M Infrared Analyzer) by the Heart of America Dairy Herd Improvement Laboratory, Manhattan, KS. The other half was used to determine pH, TA, and bacterial counts by total aerobic plate counts (TPC) using approved methods at the KSU Dairy Processing Plant. All tests were done in duplicate, and at least three replications were conducted for all trials.

Trial 1. Effect of Protein Content. KSU Holstein cows were selected and grouped based on their milk protein content. Cows were grouped into four categories: high >3.8%, med-high (3.2-3.4%), med-low (3.0-3.2%), and low (<2.8%). At least 10 cows were placed into each group. Milk samples were obtained and analyzed within 24 hr.

Trial 2. Effect of Raw Milk Age. Raw milk from KSU Holstein cows was obtained, mixed, and then held at 43 degrees F. Starting at 6 hr and every 24 hr later, milk was tested for up to 5 days (96 hr).

Trial 3. Effect of Microbial Content. Raw milk from KSU Holstein cows was obtained and analyzed for total aerobic counts. Milk was evaluated for quality after creating three categories; low (~1,000 cfu/ml), medium (~1,000,000 cfu/ml), and high (~10,000,000 cfu/ml) microbial numbers.

Results and Discussion

Table 1 shows the effect of protein content on the TA values of raw milk. These values clearly indicated that as protein content increased, so did the TA value. It is important to note that, although the protein content varied over 1%, whereas the TA values differed by only .03%.

Overall, the quality of these raw milk samples was relatively similar. The pH values varied somewhat but are consistent with the protein and solids contents of these milk samples. Because protein and fat contents increased simultaneously, the increased TA value was expected. Total plate count (TPC) values were similar, indicating good control over temperature and a sound sanitation program at KSU.

Table 2 shows the results of milk age on the TA of raw milk. As can be seen from this table, TA value increased as the raw milk aged. Within 5 days, the TA value increased from .15 to .17%. At the same time, bacterial counts (TPC) increased dramatically (560 to >120,000 cfu/ml). This trial demonstrated that, even at refrigerated temperatures (43 degrees F), TA increased over time, most probably because of microbial growth. The other factors (protein content, fat content, and pH) remained constant during this 5-day period.

Table 3 shows the effect of bacterial counts (TPC) on the TA of raw milk. As the microbial populations increased, the TA value increased dramatically. This dramatic increase illustrates the historic implication of using TA as an indication of undesirable bacterial growth in milk. The first two samples shown in Table 3 may be considered acceptable as Grade A milk, if TA and pH values are disregarded as quality factors. However, the third sample contained too many bacteria to be considered for Grade A milk processing. The pH of this third sample also indicated that the milk proteins were destabilized, making it unsuitable for any manufactured milk product.

From the point of view if a processing quality program, these data indicate the importance of considering several factors when assessing raw milk quality. As bacterial counts and TA values increase and pH decreases, raw milk becomes more unsuitable for production of milk or a milk product that has desirable flavor, odor, appearance, and shelf life. Quality of the finished product can be only as good as the quality of the incoming raw materials. Therefore, processors often set acceptable limits or ranges on fat content, protein content, TPC, pH, and TA to determine what raw milk will be accepted into the processing plant.

Conclusions

This work shows that the factor having the greatest effect on the TA value of raw milk is bacterial content. As bacterial numbers increase, the quality of raw milk decreases and the TA value increases. Protein content can influence the TA value significantly, but not to the extent of bacterial numbers. Therefore, to control the bacterial numbers in raw milk, it is important to emphasize thorough cleaning and sanitizing procedures around all milk contact surfaces and to maintain milk at a low temperature (<43 degrees F) at all times.

Table 1. Effect of Protein Content on the Titratable Acid (TA), pH, Total Plate Counts (TPC), Fat Content, and Somatic Cell Counts (SCC) of Raw Milk

Category	Protein, %	TA[1]	pH	TPC[2]	Fat, %	SCC[3]
High	3.86 ± .34	.18 ± .01	6.83	2.3	4.28 ± .32	139 ± 97
Med-high	3.25 ± .19	.16 ± .02	6.90	3.7	3.90 ± .35	95 ± 104
Med-low	3.12 ± .16	.15 ± .02	6.90	1.7	3.25 ± .29	143 ± 111
Low	2.58 ± .09	.15 ± .01	6.87	1.5	3.25 ± .17	16 ± 6

n = 12.
[1]Expressed as % lactic acid.
[2]Multiplied by 1,000.
[3]Multiplied by 1,000.

Table 2. Effect of Raw Milk Age on the Titratable Acid (TA), pH, Total Plact Counts (TPC), Fat Content, Protein Content, and Somatic Cell Counts (SCC)

Age, hr	TA[1]	Protein, %	pH	TPC[2]	Fat, %	SCC[3]
0	.15 ± .01	3.00 + .24	6.58	.56	3.93 ± .25	153 ± 156
24	.15 ± .02	2.97 ± .25	6.59	.57	3.78 ± .34	123 ±105
48	.16 ± .01	2.98 ± .24	6.60	6.2	3.78 ± .39	117 ±102
72	.16 ± .02	2.96 ± .20	6.63	99	3.77 ± .37	122 ±104
96	.17 ± .02	2.98 ± .24	6.59	120	3.79 ± .36	129 ±109

n = 3.
[1]Expressed as % lactic acid.
[2]Multiplied by 1,000.
[3]Multiplied by 1,000.

Table 3. Effect of Microbial Counts on the Titratable Acid (TA), pH, Total Plate Counts (TPC), Fat Content, Protein Content, and Somatic Cell Counts (SCC) of Raw Milk

TPC[1]	TA[2]	pH	Protein %	Fat %	SCC[3]
1.3	.17 ± .01	6.66	3.76 ± .02	3.70 ± .21	96 ± 14
310	.24 ± .02	6.25	3.73 ± .38	4.20 ± .68	177 ± 77
1800	.60 ± .20	4.90	3.30 ± .03	3.50 ± .01	209 ± 13

n = 3.
[1]Multiplied by 1,000.
[2]Expressed as % lactic acid.
[3]Multiplied by 1,000.