EFFICACY OF ON-FARM PASTEURIZED WASTE MILK SYSTEMS ON UPPER MIDWEST DAIRY AND CUSTOM CALF REARING OPERATIONS

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Introduction

The practice of feeding raw waste milk to neonatal calves has long been discouraged because of the potential for disease transmission. Pasteurization of waste milk on commercial dairy and custom calf rearing operations is currently being considered as an option to feed neonatal calves to reduce disease transmission potential and capture economic efficiencies. Interest has primarily been fueled by the recent availability of reasonably priced on-farm milk pasteurization equipment. Despite new interest and use of pasteurized waste milk systems on commercial dairy and custom calf rearing operations, few monitoring systems are in place for producers and their consultants to evaluate the efficacy of waste milk pasteurization on a routine basis. To date, an economical commercial assay for testing pasteurization efficacy of waste milk fed to calves has not been available. The object of this project was to establish an economical evaluation system for on-farm milk pasteurizers and evaluate their efficacy in a commercial environment.

Objectives

1. Develop a viable commercial assay to evaluate efficacy of on-farm milk pasteurizers.
2. Determine typical protein and energy contents of pasteurized waste milk fed to calves on commercial dairies and custom calf rearing operations.

3. Determine if quality of raw waste milk influences the quality of pasteurized waste milk or the pasteurization process.

Methods

Initial meetings were held with project investigators and Ag Source/CRI (Stratford, WI) personnel. Commercial testing procedures to evaluate pasteurizer efficacy in food processing (milk plants) were adapted to fit the needs of commercial dairy producers and calf growers. Basic tests adapted included: measurement of fat and protein by infrared spectroscopy (Combi 30, Foss Electric AS, Denmark), alkaline phosphatase (**AP**) activity, bacterial plate count (**BPC**), somatic cell count (**SCC**). Samples were plated for *Salmonella* species, *Escherichia coli*, total *Coliform* species, *Streptococcus*

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agalactiae, *Strep.* species, *Staphylococcus aureus*, *Staph.* species, and *Enterococcus* species. Milk samples were also evaluated for β-lactam and non β-lactam antibiotics by Charm procedures (Charm Sciences, Inc., Lawrence, MA). Energy contents for both raw and pasteurized waste milk were calculated via standard equations (NRC, 2001).

Field sampling procedures (test kits) were developed by the project investigators and Ag Source/CRI personnel. Test kits included two sterile milk vials, freezer packs, and an insulted mailer box. Test kits were distributed to University of Wisconsin-Extension agents and representatives of Vita Plus Corporation (Madison, WI) with a general call for sample submission and sampling guidelines. Producers were asked to provide samples from a single day's supply of waste milk prior to pasteurization (raw) and after pasteurization (pasteurized). Samples were refrigerated, placed in an insulated mailer with an ice pack, and mailed to Ag Source/CRI, Stratford, WI, for analysis as described above.

Statistical Analysis

Data was evaluated as a completely randomized design. Protein, fat and energy contents of raw and pasteurized waste milk were compared using ANOVA procedures of SAS (2001). Relationships between BPC, SCC, and bacterial species present in raw and pasteurized waste milk were evaluated using correlation (CORR) procedures of SAS (2001). Differences in binomial data (AP, β-lactam and non β-lactam antibiotic residues) in raw and pasteurized waste milk were evaluated using categorical modeling (CATMOD) procedures of SAS (2001).

Results and Discussion

Sixty-two milk samples were evaluated (raw waste milk = 31 and pasteurized waste milk = 31) in the field study. The nutrient compositions of raw waste milk are presented in Table 1; pasteurized waste milk nutrient compositions are presented in Table 2. Fat contents of raw and pasteurized waste milk (% of DM) averaged 35.4 and 31.2 percent, respectively, which is 15.0 and 1.3% higher than fat content of whole milk defined in the Nutrient Requirements of Dairy Cattle (2001). Fat contents of raw and pasteurized waste milk were higher, as compared to whole milk. These results were not unexpected, as waste milk often contains colostrum and transitional milk, which has high solids and fat content, as compared to whole milk (Raising Dairy Replacements, 2003). Likewise, protein contents of raw and pasteurized waste milk were approximately 28.2 (% DM), which is 11.0 percent higher than whole milk (NRC, 2001). Similar to fat, colostrum and transitional milk in waste milk would elevate the protein content of waste milk, as compared to whole milk (Raising Dairy Replacements, 2003). Lactose contents of raw and pasteurized waste milk were similar to whole milk at 4.25 - 4.42 % (as is). Lactose content in milk is not highly variable (Welper and Freeman, 1992); therefore, little variance would be expected. Higher fat and protein, and normal lactose contents of waste milk yielded higher metabolizable energy (5.79 and 5.45 vs. 5.37 Mcals/kg) than typically defined for whole milk (NRC, 2001). Mean profile of waste milk suggests neonatal calves fed an equal amount of DM from waste milk would consume more calories and protein, as compared to a similar amount of DM ingested from whole milk or milk replacer (20 % fat, 20 % protein), (NRC, 2001).

We observed a wide range of fat and protein contents in waste milk. For pasteurized waste milk, fat contents ranged from 22.3 to 37.6 % of DM and protein contents ranged from 23.1 to 40.8 % of DM. These data suggest that there can be wide variations in nutrient content of pasteurized waste milk between farms. Because of singular evaluation of waste milk from a given operation in this study, we do not know if similar within-operation variation of fat and protein content of waste milk exists. These data do; however, suggest that sampling waste milk for nutrient content would lend important inference to neonatal nutrition programs.

Microbial population means and ranges for raw and pasteurized waste milk are presented in Tables 3 and 4. Somatic cell count data are also described in Tables 3 and 4. We observed a large variation in bacterial populations in raw waste milk (Table 3), which was expected, and has been observed in other investigations (Selim et al., 1997).

The AP activity of raw and pasteurized milk for the commercial dairy and custom calf operations is presented in Figure 1. Alkaline phosphatase is an enzyme active in raw milk, but is inactivated when milk is heated to pasteurization temperature (Ludikhuyze, et. al, 2000). Alkaline phosphatase was active in all raw waste milk samples (Figure 2). The pasteurization process denatured AP on 27 of 31 operations, indicating adequate temperature was employed for pasteurization. Pasteurizers on four of 31 operations (12.9%) did not denature AP, indicating pasteurizing temperature may have been to low; thus, not meeting the AP standard to be considered pasteurized milk (Pasteurized Milk Ordinance, Appendix G, Section II, 2001).

Antibiotic residues (β-lactam and non β-lactam) in raw and pasteurized waste milk are presented in Figure 2. Approximately 65.0 % of waste milk samples evaluated were positive for antibiotic residues. Twenty samples tested positive for β-lactam drug residues in both raw and pasteurized waste milk samples. In all cases, milk from the same operation tested positive β-lactam residues in raw and pasteurized waste milk, indicating pasteurization had little influence on antibiotic activity. Similarly, 21 waste milk samples tested positive for non β-lactam drug residues in the corresponding raw and pasteurized milk sample. Because we were unable to quantify the absolute level of antibiotic residues in the waste milk samples specific inferences cannot be made. Issues of feeding pasteurized waste milk containing antibiotic residues were beyond the scope of this study, but warrants further investigation.

Conclusions

Because nutrient content of waste milk is highly variable, routine testing of waste milk for nutrient content should be considered for all operations using an on-farm milk pasteurizer. In general, we observed a high efficacy of on-farm milk pasteurizers, indicated by proper denaturing of AP, a reduction of BPC to Food and Drug Administration grade “A” milk standards, and a reduction of all major specific bacterial pathogens. Simply pasteurizing waste milk; however, does not guarantee proper pasteurization performance. We observed questionable efficacy of waste milk pasteurization on 4 of 31 (12.9%) operations. These observations support producers adopting a routine sample procedure to evaluate pasteurizer performance. We made no attempt to correlate the type of pasteurizer to pasteurization efficacy. We observed successful pasteurization processes in a number of pasteurizer equipment configurations and, likewise, observed questionable pasteurizer performance in operations with totally different pasteurization equipment. Maintenance of pasteurizer equipment, management and evaluation of the pasteurizers appears critical to the success of waste milk pasteurization. Finally we observed a 50.0% incidence of antibiotic residues in pasteurized waste milk. Further research is needed to determine what effect antibiotic residues have on calf health and livestock production systems.

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Table 1. Nutrient composition of raw waste milk before pasteurization from 31 commercial dairy or custom calf rearing operations.

Nutrient	Mean	Range	SD	SE
Fat, % of DM	35.4	27.3 - 49.5	5.82	1.05
Fat, %	4.42	3.41 - 6.19	.73	.13
Protein, % of DM	28.3	23.6 - 41.8	3.47	.62
Protein, %	3.54	2.95 - 5.23	.43	.08
Lactose, % of DM	34.0	27.3 - 38.2	2.69	.48
Lactose, %	4.25	3.41 - 4.78	.34	.06
Energy[1]				
GE[2], Mcal/kg	6.22	5.27 - 7.69	.65	.12
ME[3], Mcal/kg	5.79	4.90 - 7.15	.60	.11
NEm[4], Mcal/kg	4.97	4.22 - 6.15	.52	.09
NEg[5], Mcal/kg	3.99	3.38 - 4.93	.42	.07

[1] Calculated (NRC, 2001)
[2] Gross Energy
[3] Metabolizable Energy
[4] Net Energy for Maintenance
[5] Net Energy for Gain

Table 2. Nutrient composition of pasteurized waste milk from 31 commercial dairy or custom calf rearing operations.

Nutrient	Mean	Range	SD	SE
Fat, % of DM	31.2	22.3 - 37.6	4.26	.77
Fat, %	3.90	2.79 - 4.70	.53	.10
Protein, % of DM	28.1	23.1 - 40.8	3.49	.63
Protein, %	3.51	2.89 - 5.10	.44	.08
Lactose, % of DM	35.3	30.2 - 38.4	1.63	.29
Lactose, %	4.42	3.78 - 4.80	.20	.04
Energy[1]				
GE[2], Mcal/kg	5.86	5.10 - 7.11	.48	.09
ME[3], Mcal/kg	5.45	4.75 - 6.61	.44	.08
NEm[4], Mcal/kg	4.69	4.08 - 5.69	.38	.07
NEg[5], Mcal/kg	3.76	3.27 - 4.56	.31	.05

[1] Calculated (NRC, 2001)
[2] Gross Energy
[3] Metabolizable Energy
[4] Net Energy for Maintenance
[5] Net Energy for Gain

Table 3. Microbiological composition of raw waste milk from 31 commercial dairy or custom calf rearing operations.

Component	Mean	Range	SD	SE
BPC[1] (1,000 cfu/mL)	8822	6 - 72000	14655	2632
SCC[2] (1,000 ESCC/mL)	1772	110 - 3800	994	179
	- - - - - - - - - - - - -	-cfu/mL - - - -	- - - - -	- - - - -
Escherichia Coli	10000	< 10 - 80000	17589	3159
Total *Coliforms*	82052	600 - 800000	148489	26669
***Salmonella* species**	243	< 10 - 2000	611	110
Streptococcus agalactiae	1281	< 10 - 34000	6089	1094
***Strep.* species**	47281	200 - 170000	41762	7501
Staphylococcus aureus	549	< 10 - 11000	2021	363
***Staph.* species**	8426	< 10 - 88000	21992	3950
***Enterococcus* species**	17274	< 10 - 180000	36082	6481

[1] Bacterial Plate Count
[2] Somatic Cell Count

Table 4. Microbiological composition of pasteurized waste milk from 31 commercial dairy or custom calf rearing operations.

Nutrient	Mean	Range	SD	SE
BPC[1] (1,000 cfu/mL)	35	0 - 420	89	16
SCC[2] (1,000 ESCC/mL)	1518	240 - 3800	738	132
	---------------cfu/mL---------------			
Escherichia Coli	134	< 10 - 3400	611	110
Total *Coliform* spp.	1805	< 10 - 40000	7231	1299
***Salmonella* spp.**	< 10	< 10 - < 10	0	0
Streptococcus agalactiae	14	< 10 - 200	47	8
***Streptococcus* spp.**	5117	< 10 - 68000	13656	2453
Staphylococcus aureus	< 10	< 10 - < 10	0	0
***Staphylococcus* spp.**	54	< 10 - 700	149	27
***Enterococcus* spp.**	723	< 10 - 9000	2228	400

[1] Bacterial Plate Count
[2] Somatic Cell Count

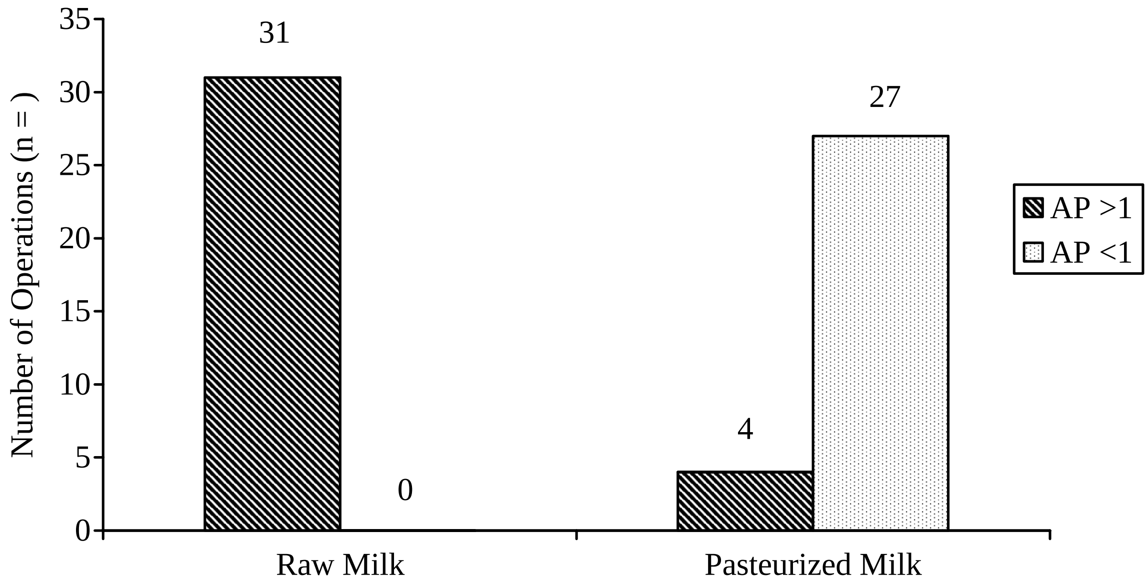

Figure 1. Alkaline phosphatase (AP) activity in raw and pasteurized waste milk from 31 Wisconsin dairy and custom calf rearing operations. The AP activity in raw and pasteurized milk differed at $P < 0.05$.

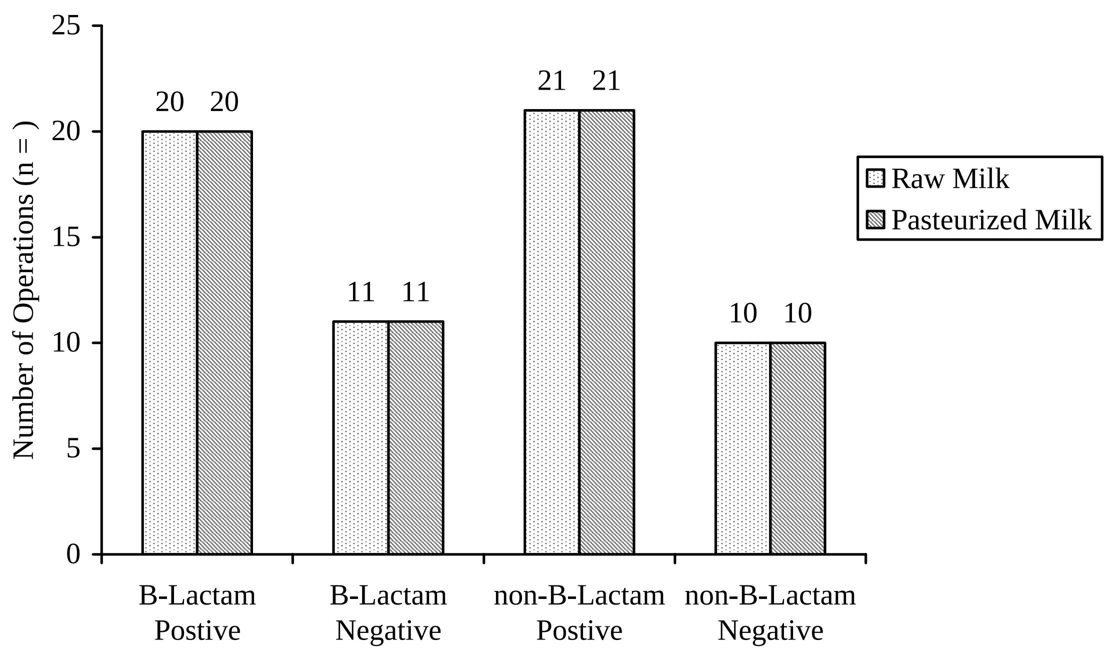

Figure 2. Incidence of antibiotic residues found in raw and pasteurized waste milk from 31 Wisconsin commercial dairy or custom calf rearing operations. Antibiotic residues between raw and pasteurized milk did not differ ($P = 1$).