Minnesota Dairy Days

Educating the dairy industry on today's and tomorrow's dairy technologies.

Pasteurizing Milk and Colostrum for Calves: An Option or Necessity?

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Outline

- Pasteurizing waste milk:
  - Considerations
  - Potential benefits
  - Potential problems
  - Review research
- Pasteurizing colostrum:
  - Unique issues
  - Review research

Feeding Waste Milk vs Milk Replacer?

- Advantages of feeding waste milk:
  - Economics
  - Improved nutrient intake
  - Disposal of a waste product
- Potential disadvantages
  - Pathogen exposure (if raw milk)
  - Consistent supply
  - System to transport & store raw and pasteurized milk
  - Concerns about antimicrobial residues

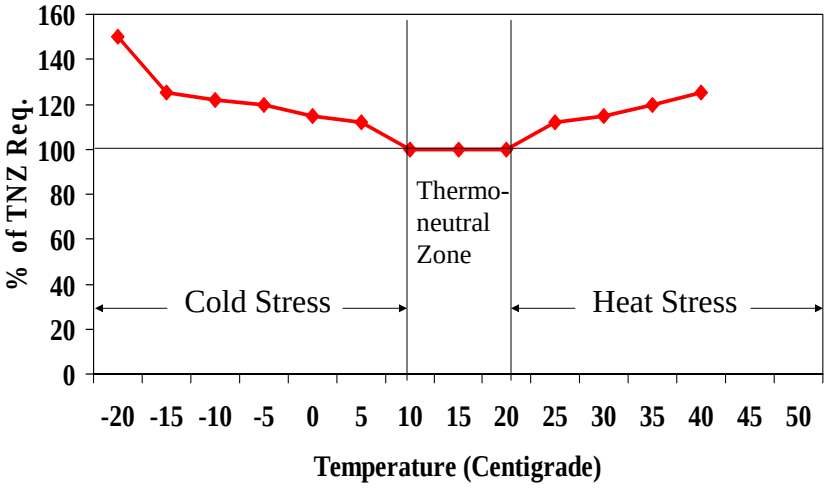
Nutrient Value & Performance Goals

- Drackley, 1998 : 45 kg (99 lb) calf

	20:20 M.R.	Whole Milk
Feeding Rate - 1 gall.	1 lb DM/d	10% B.Wt.
Energy Intake	2.47 Mcal/d	2.97 Mcal/d
Energy-allowable growth	**0.64 lb/d** (289 g/d)	**0.98 lb/d** (446 g/d)

- 20:20 M.R. has 82% of energy compared to whole milk
- Assuming protein is not limiting, calves fed whole milk should perform better due to increased energy intake alone.

Effect of Ambient Temperature on Calf Maintenance Requirements



Risks with feeding raw waste milk – Disease Transmission

- Pathogens transmitted in colostrum or milk:
  - *M. paratuberculosis* (Johne's)
  - *Mycoplasma* spp.
  - Salmonella spp.
  - *Listeria monocytogenes*
  - *Escherichia coli*
  - *Campylobacter* spp.
  - *Streptococcus* spp.

- Caution against feeding raw waste milk due to high number of bacteria pathogenic to cattle and human beings.

(Selim and Cullor, 1997)

Pasteurizing Waste Milk

- Heat milk to a target temperature for a target period of time for a given microbe.
- Goal: Reduce or eliminate pathogen exposure to calves.
- The rate of heat inactivation of bacteria increases exponentially with time at a given temperature

Goodnature Products, Inc.

Batch Pasteurizers

- LTLT: Low temp/long time
  - 145 ^{o}F (63 ^{o}C) x 30 minutes
- Milk heated in large vat
- Thermometer & temperature display
- Agitation for even heating
- Automated heat & cool cycle
- Manual wash

DairyTech batch pasteurizer
Windsor, CO
37 to 150 gallons

Other Examples of Batch Pasteurizers

DT Silver Pasteurizer
DairyTech, Inc.
20 gallons

Calf Guardian
Goodnature Products, Inc.
20 gallons

Continuous Flow Pasteurizers

- HTST: High temp/short time
  - 161 °F (72 °C) x 15 seconds
- Milk circulated quickly through heated coils
- Thermometer & temperature display or recording chart
- Automated heat & cool cycle
- +/- Automated CIP wash system
- More efficient if very large volumes

BetterMilk HTST pasteurizer
Winona, MN

Other Examples of Continuous Flow Pasteurizers

CalfStar, Inc.

Goodnature Products, Inc.

Does Pasteurization Effectively Kill Pathogens in Milk and Colostrum?

Pathogen	Batch (145°F, 30 min)	HTST (161°F, 15 sec)	Study
Salmonella spp.	Yes	Yes	UMN, 2002*
L. monocytogenes	Yes	Yes	UMN, 2002*
E. coli 0157:H7	Yes	Yes	UMN, 2002*
Staph. aureus	Yes	Yes	UMN, 2002*
M. bovis, M. californicum	Yes	Yes	JDS 2000, JDS 2004
Crypto. parvum	Nav	Yes	App Env Micro '96
Bovine Leukemia Virus	Yes	Yes	JAVMA '76

* Evaluated using commercial pasteurizers for milk and colostrum

What about Johne's Disease?

(*M. paratuberculosis or Map*)

- 5 - 30% of subclinically infected cows shed in milk or colostrum (increased risk of shedding with advanced stages of disease)
- Most studies report a complete kill with Batch or HTST designs:
  - Keswani and Frank, 1998
  - Grant et al., 1999
  - Stabel, 1996, 2001 * (batch on farm)
  - Stabel, 2003 * (HTST on farm)
- Some studies report some regrowth if milk inoculated at high concentrations of bacteria (> 100 CFU/ml):
  - Chiodini and Hermon-Taylor, 1993
  - Grant et al., 1996
  - Gao et al., 2002
- How much is shed by cows? What is the infective dose?
- Avoid fecal contamination of waste milk & colostrum

Considerations for Purchase and Use of On-Farm Pasteurizers

- Installation Requirements:
  - Purchase & installation costs
  - Installation support
  - Hot water heater
    - Self contained?
    - Buy a new one?
    - Enough hot water?
  - Water supply
  - Drainage requirements
  - Electrical requirements
  - Space / location

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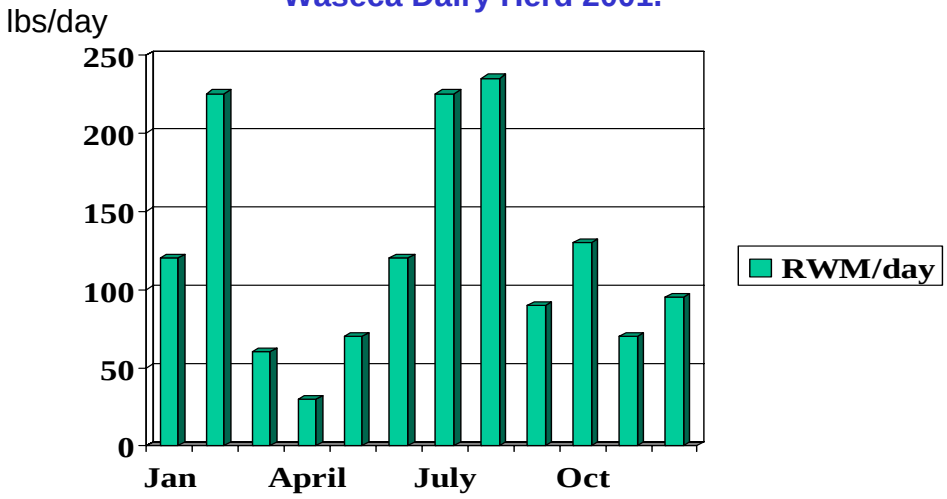
  - Space / location
- Day-to-day use:
  - Variable costs (water, electrical, labor, etc.)
  - Training staff
  - Pasteurization protocols
  - Cleaning protocols
  - Service / support
  - Transporting and storing raw and pasteurized milk
  - Availability of raw milk
  - Monitoring performance and cleaning

Potential Problems with using Pasteurizers

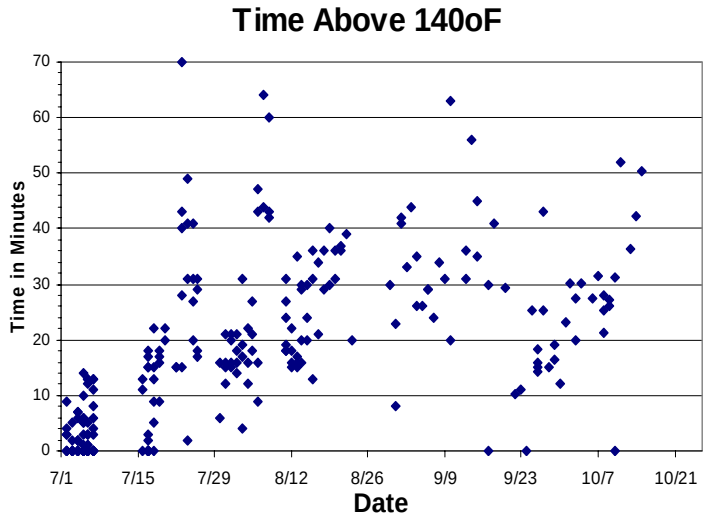
- Incomplete Pasteurization
  - Improper use – the human factor
  - Malfunction
  - Excessive bacteria counts in raw milk
- Curdling of fermented milk
- Recontamination of pasteurized milk
- Effective cleaning of equipment:
  - Effective cleaning protocols
  - Monitor cleaning function

Availability of Waste Milk

Example profile of an average daily discard raw waste milk (RWM) by month available, lbs Waseca Dairy Herd 2001.



Problem: Incomplete Pasteurization



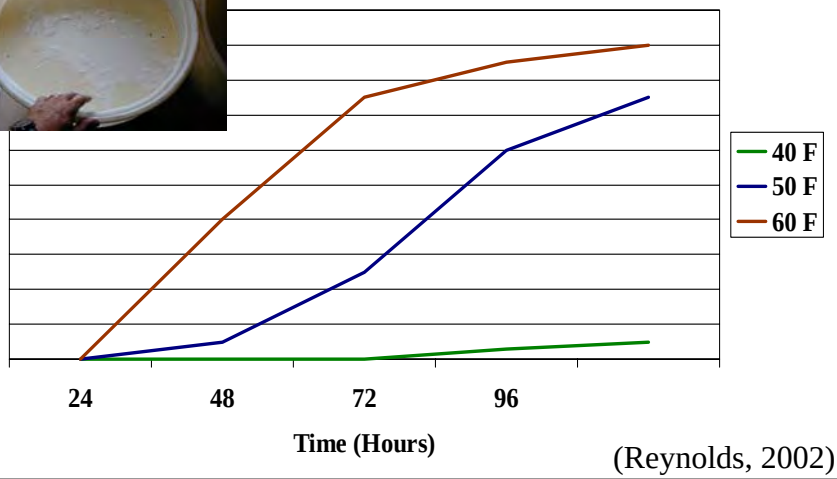
Dairy Food Safety Lab Data – Rossito, Reynolds, Cullor
Calf Ranch Pasteurization Trial

Another Cause of Incomplete Pasteurization:

- Problem:
  - Start with too many bacteria
  - high quality saleable milk: < 50,000 CFU/ml
  - Unchilled waste milk: > 1 billion CFU/ml in summer

Handling Pre-Pasteurized Milk: Storage Temperature and Bacterial Growth

Pasteurization does NOT equal sterilization (120oCx30min)



(Reynolds, 2002)

Avoiding Incomplete Pasteurization

- Solutions:
  - Collect and store in clean containers
  - Pasteurize and feed within a few hours of collection or chill until ready to pasteurize and feed
  - Monitor:
    - Times and temperatures
    - Periodic culture of milk samples (Cullor, 2003):
      - pre-pasteurized: < 1,000,000 CFU/ml total plate count
      - post-pasteurized: < 20,000 CFU/ml total plate count
    - Periodic Alkaline Phosphatase test
- WI study of 31 on-farm systems: 12% did not inactivate Alkaline Phosphatase enzyme

Problems: Coagulation when Pasteurizing Fermented Milk

- Problem:
  - Milk stored at warm ambient temp.
  - Acid production lowers milk pH towards 4.5
  - Heating decreases solubility: milk protein will coagulate at pH 4.6
  - Curd formation when pasteurize
- Solution:
  - Collect, pasteurize & feed within a few hours
    or
  - Chill raw milk until can pasteurize and feed

Field Research Feeding Pasteurized Waste Milk or Colostrum

California Field Study: Pasteurized Waste Milk vs Raw Waste Milk

- 300 calves fed either:
  a) Pasteurized colostrum and waste milk (n=150)
  b) Raw colostrum and waste milk (n=150)
- Benefits include higher weight gain, lower mortality, fewer days affected with diarrhea and pneumonia
- Calves fed pasteurized milk were worth an extra $8.13 in gross margin/calf (vs calves fed raw milk)
- Estimated economically feasible at 315 calves per day

Jamaluddin et al. 1996. JAVMA. 209(4):751-756

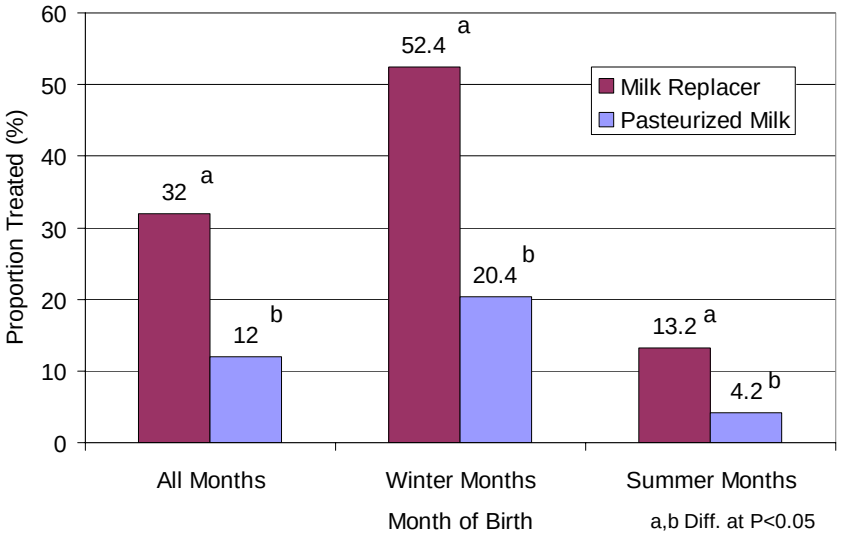
Minnesota Field Study: Pasteurized Waste Milk vs Milk Replacer

- 439 calves enrolled:
  - Dec., 2001 to Aug., 2002
- Treatment Groups:
  - Batch pasteurized waste milk (DairyTech, Inc. Windsor, CO)
  - 20:20 milk replacer
- Facilities: two greenhouse barns

Results: Preweaning Growth Rates

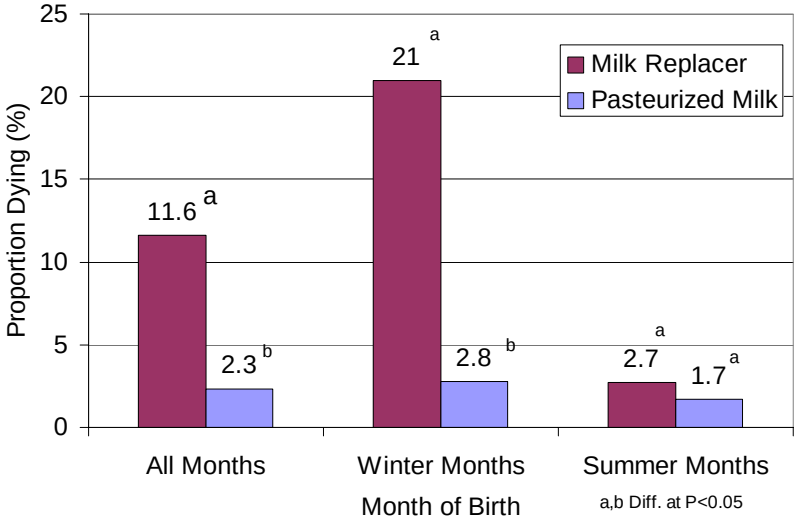
Parameter	Milk Replacer	Pasteurized Milk	P value < 0.05
Calves enrolled (n)	217	222	
Serum Total Protein (mg/dl)	5.7	5.8	
Arrival Weight (lb)	88.3	87.5	
Age at Weaning (d)	47	46	
Weaning Weight (lb)	133.9	146.3	*
Preweaning Gain (lb)	45.0	58.9	*
Avg. Daily Gain (lb/d)	0.76	1.04	*

Preweaning Treatment Rate (%)



Significant reduction in scours and pneumonia for all months

Preweaning Death Loss (%)



Significant reduction in death losses in winter months

Economic Analysis for Minnesota Study

- Excel spreadsheet: partial budget model and breakeven analysis
- Assumptions: used real data from our field study
  - Feeding 50 calves per treatment group
  - Used actual fixed costs (prorated for 3 years):
    - Purchase and installation, plumbing & wiring
    - Purchase holding tanks to chill milk at source dairy and heifer operation
    - Build trailer system to haul milk
  - Used actual operating expenses from study:
    - Utilities
    - Wash-up
    - Any additional labor
- Calculations considered:
  - Actual feeding costs per calf weaned (includes capital expenditures, fixed & operating costs for both feeding systems)
  - Differences in treatment and mortality rates
  - Differences in weight gain

Economic Analysis for Minnesota Study

- Results:
  - Relative cost advantage of pasteurized non-saleable milk system:
    - $0.69 per calf per day
    - $34 per calf weaned
  - Breakeven analysis:
    - 41 calves fed: if only consider feeding costs (capital, fixed & operating expenses)
    - 23 calves fed: if also consider reduced treatment and mortality, plus increased weight gain
- Do you own calculations:
  - Web site for College of Veterinary Medicine Center for Dairy Health, Management, and Food Quality:

    http://www.ahc.umn.edu/ahc_content/colleges/vetmed/Depts_and_Centers/CVM_Dairy_Center/index.cfm

Summary of Minnesota Study Results

(JAVMA – accepted for publication)

- Calves fed pasteurized waste milk had…
  - Better ADG: + 0.25 lb/day – all months
  - Fewer treatments for pneumonia and scours – all months
  - Fewer death losses - in winter months
  - Significant economic advantage:
    - $34 per calf weaned (or breakeven at 23 calves)
- Still to do:
  - Follow to maturity - Johne's testing

Can We Pasteurize Colostrum?

- Effectively destroys pathogens in colostrum (results similar to milk) (Green et al., 2002)
- Unique issues:
  - Viscosity changes
  - Damage immunoglobulins (e.g. IgG)

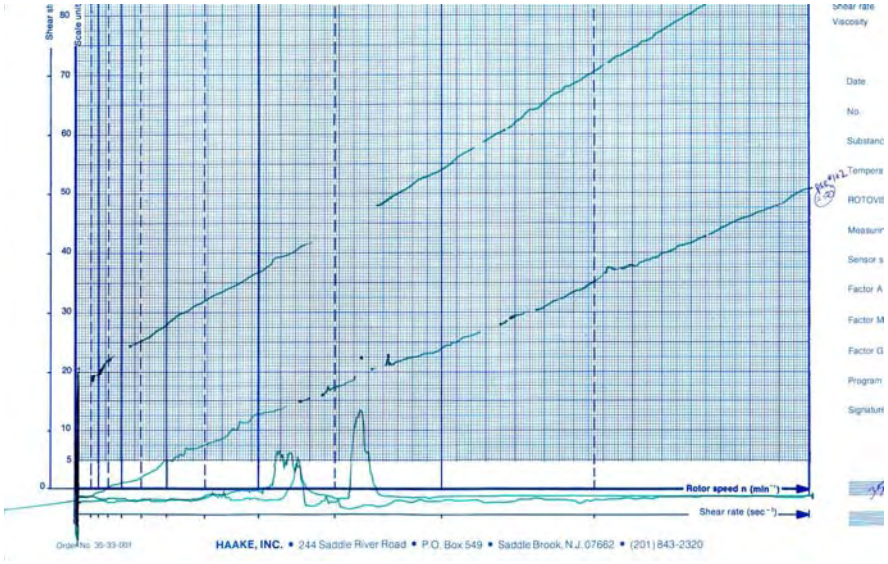
Colostrum Research in the Lab

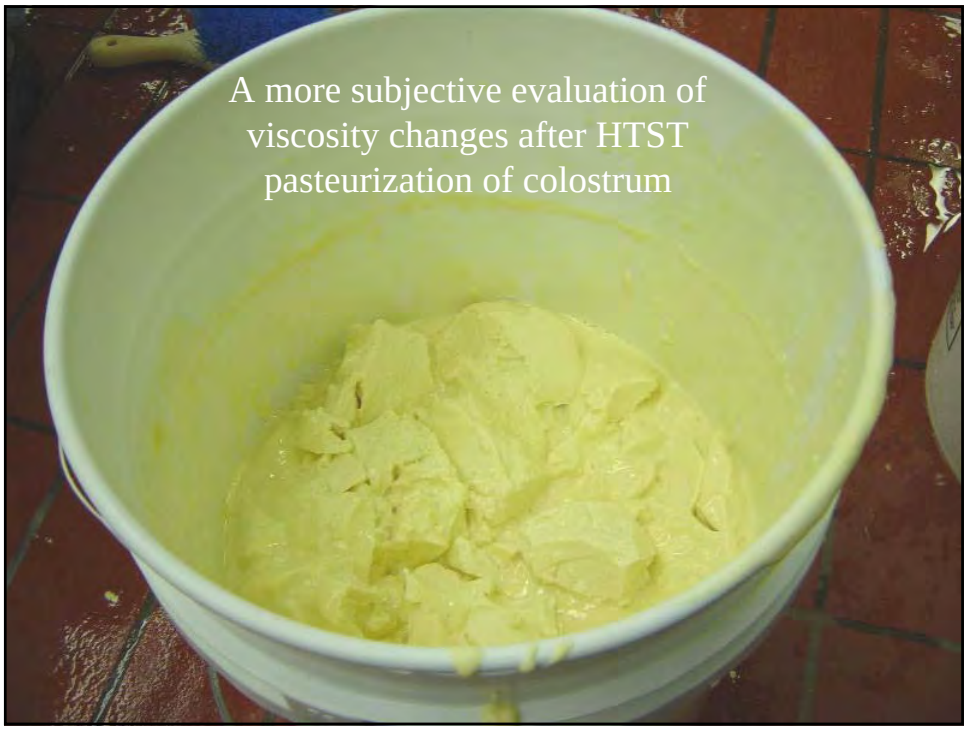
- Two batch designs:
  - 38 x 1 gal. batches (Weck)
  - 10 x 8 gal. batches (DairyTech)
- HTST
  - 5 x 1 gal. batches (BetterMilk)

Results: Effect of Pasteurization at Recommended Times/Temps. on Colostrum Viscosity

- Batch pasteurization:
  - 145 °F x 30 minutes
  - 1 gal. to 15 gal. batches
  - Usually only slight thickening
  - Still easy to feed & clean
- HTST pasteurization:
  - 161 °F x 15 seconds
  - 5 x 1 gal. batches
  - . . . don't do this at home

Effects of Pasteurization on Colostrum Viscosity (mPas)





Results:
Effect of Colostrum Pasteurization at Recommended Times/Temps. on IgG

- Batch or HTST pasteurization in lab or field studies
- **Avg. 25 – 30 % IgG loss** (1 gal. to 15 gal. batches)
- More likely to end up with good quality (> 50 mg/ml IgG) if start with high quality colostrum (> 60 mg/ml IgG)

Minnesota – Colorado
Field Study Pasteurizing Colostrum
(J Dairy Sci, 2003: 86:1503)

- 2000 cow dairy in CO: Mar. 2002
- 123 Calves fed (2 feedings):
  - fresh colostrum
    or
  - pasteurized colostrum
- Batch pasteurize 15 gal. batches
  - 145 ^{o}F x 30 min (DairyTech, Inc)

Results:
Effect on Calf Serum IgG Levels
(Goal > 10 mg/ml)

- Calves fed two feedings of colostrum at 1-2 hrs and 8-12 hrs

	Fresh	Pasteurized	
Fed 2 qt, 2 qt	19.1 (n = 40)	9.7 (n = 55)	SD
Fed 4 qt, 2 qt	16.1 (n = 8)	13.5 (n = 20)	NSD

- Producer still feeding pasteurized colostrum to all calves:
  - Aug ’02 – Mar’03: Mean serum IgG 20.4 mg/ml
    FPT rate = 11%

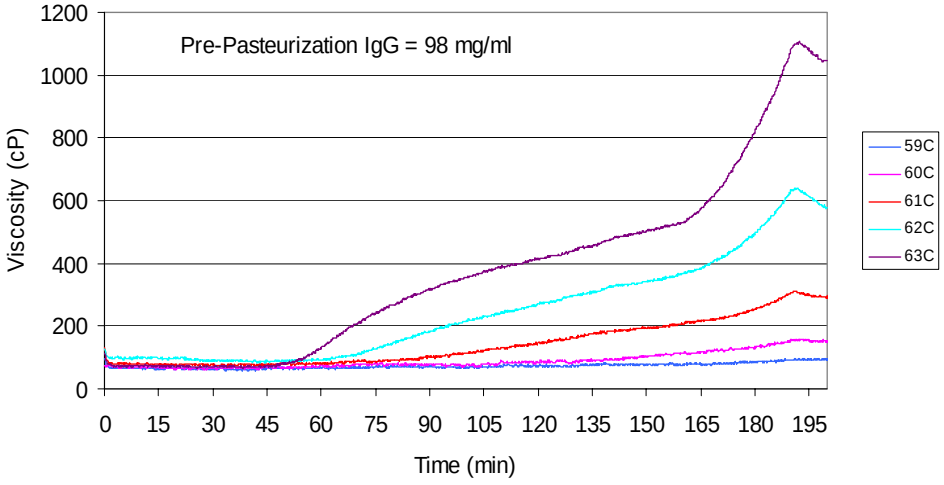
Ongoing Colostrum Pasteurization Work
Summer, 2004

- Hypothesis:
  - If we reduce the temperature, but increase the duration of heating, we can preserve antibodies while still killing pathogens (e.g. Salmonella in eggs)

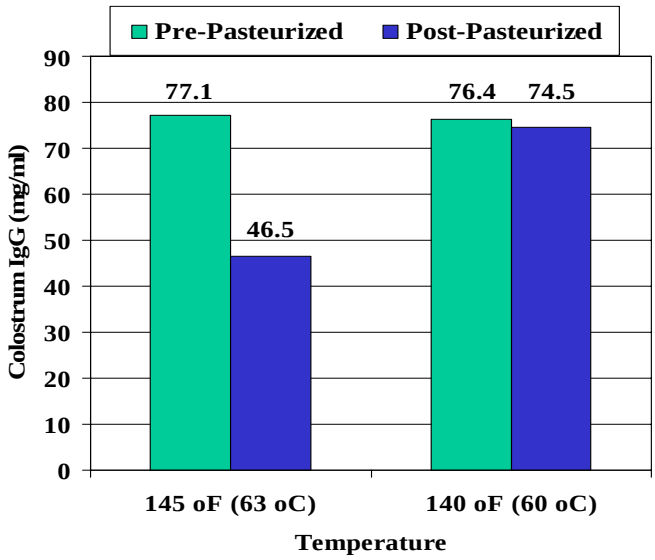
- Step 1.
  - Find the critical temperature at which colostral antibodies and viscosity are unaffected.
- Step 2.
  - Describe the pathogen lethality curve for pathogens if colostrum is heat treated at this critical temperature.

  “If we go to a lower temperature, how much longer do we have to heat colostrum to get the same pathogen kill?”

Viscosity Changes in High Quality Colostrum During Pasteurization at Five Different Temperatures



Effect of Temperature on Colostrum IgG Concentrations (mg/ml) (30 unique batches)



% IgG Loss:
145 °F: 39.7%
140 °F: 2.5%

The Next Step

- 140 ^{o}F was adequate to kill:
  - Listeria spp.
  - *E. coli*
  - Salmonella spp.
  - *Mycoplasma bovis*
- Please stay tuned for results (next 4 months)
  - *Mycobacterium avium* subsp. *paratuberculosis*

So, pasteurized colostrum can be successfully fed. However….

- I wouldn't recommend it to a producer unless you have all of your other 'colostrum management' ducks in a row:
  - Batch pasteurize (with agitator) small batches (< 15 gal.)
  - Use only high quality colostrum (colostrometer > 60 mg/ml)
  - Collect, store, and chill colostrum under clean conditions
  - Feed 4 qts ASAP after birth
  - Offer a second feeding of 2 qts at 6-12 hrs.
  - Monitor pasteurizer function and cleaning
  - Monitor serum Total Protein concentrations and disease in calves
  - Minimize infectious disease challenge to calves
- More research on time/temp., and colostrum substitutes

Summary

- Raw waste milk can be a big risk factor for calf diseases
- Pasteurization can allow feeding of waste milk
- There are significant nutritional, health, and economic advantages feeding pasteurized waste milk vs raw waste milk or traditional milk replacer programs.
- Requirements if pasteurizing waste milk:
  - Need to monitor time/temp (control chart)
  - Must clean well after each use
  - Chill milk before & after pasteurization (if delays)
- Pasteurizing colostrum: Not yet ready for prime time, but making progress

Acknowledgements

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Thank you!

Web site for College of Veterinary Medicine Center for Dairy Health, Management, and Food Quality:

http://www.ahc.umn.edu/ahc_content/colleges/vetmed/Depts_and_Centers/CVM_Dairy_Center/index.cfm