PENNSTATE

Pasteurization of Waste Milk for Dairy Calves

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All dairy operations

- Have a supply of milk not for sale.
  - Excess colostrum
  - Transition milk
  - Mastitic milk
  - Milk containing antibiotics

- 48 to 137 lbs/cow/year (Blosser, 1979).

What to do with it?

There are two options:

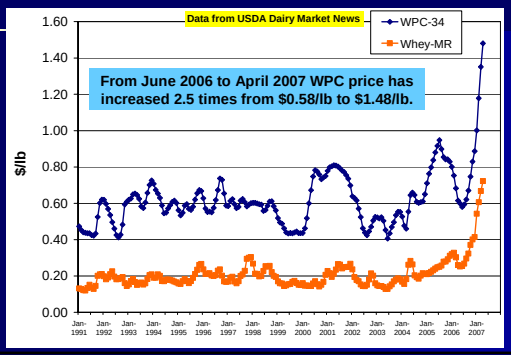
- Throw it away and feed milk replacer?
  - Huge cost associated with that.
- Feed it to the calves?
  - With great precaution.

Feeding waste milk vs. milk replacer

There are some advantages and disadvantages:

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

Economics: WPC-34 and Whey Prices



Nutrient value

	20:20 MR	Milk
Feeding rate	1 lb DM/d	10% BW (1 gal)
Energy content	4.40 Mcal/kg DM	5.29 Mcal/Kg DM
Energy intake	2.47 Mcal/d	2.97 Mcal/d
Growth (energy)	0.64 lb/d	0.98 lb/d

Drackley, 1998

MR has 83% of energy compared to milk.

If protein is not limiting, calves fed whole milk should perform better due to increased energy intake.

Pasteurized milk versus 20:20 milk replacer

	Pasteurized waste milk	20:20 milk replacer
Weight gain to weaning (lb)	58.8	44.3
Weight at weaning (lb)	147.3	134.0
ADG (lb/d)	1.04	0.76
Preweaning death loss (%)	2.3	11.6

Godden et al., 2005

Real advantages!!!

- Improved health.
- Improved growth.
  - Residual IgG effect
- No production differences.
- No documented antibiotic resistance.

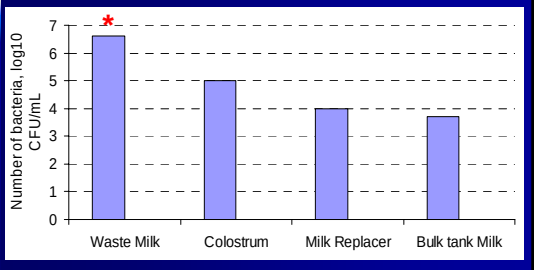
What is the problem?

- Disease transmission.
- Therefore, people should be cautious when feeding raw waste milk due to high number of pathogens present.

Some pathogens that can be transmitted through milk

- *Mycobacterium avium* subspecies *paratuberculosis*
- *Salmonella* species
- *Mycoplasma* species
- *Listeria moncytogenes*
- *Camphylobacter* species
- *Mycobacterium bovis*
- *Enterobacter* species
- *Staphylococcus* species
- *E. coli*
- *Pasteurella* species
- BVD virus
- Bovine leukosis virus

Bacterial counts in some common liquid calf feeds



Selim and Cullor, 1997

Bacterial composition of raw waste milk samples from 31 commercial farms

Bacteria	Mean	Min	Max	SD
E. coli	10,000	<10	80,000	17,589
Salmonellla spp.	243	<10	2,000	611
Streptococcus spp.	47,281	200	170,000	41,762
Staphylococcus spp.	8,426	<10	88,000	21,992

Jorgensen et al., 2006

PATHOGENS IN WASTE MILK OR COLOSTRUM

- Pathogens can be transmitted in waste milk or colostrum.
  - Direct shedding from the mammary gland.
  - Post-harvest contamination.
  - Bacterial proliferation in improperly stored milk or colostrum (Stewart et al., 2005).

BACTERIAL CONTAMINATION

- There is a need to prevent contamination during harvest, storage, and feeding.



MANAGEMENT PRACTICES

- To prevent bacterial proliferation:
  - Refrigeration
  - Freezing
  - Pasteurization


PASTEURIZATION

- Process of heating liquids for the purpose of destroying harmful organisms.
- Pasteurization is not sterilization.
- Reduce the number so that they are unlikely to cause disease.

METHODS

- Batch pasteurization
  - Heated at 145°F for 30 min.

METHODS

- High temperature-Short time (HTST)
  - Heated at 161°F for 15 sec.

PASTEURIZATION OF WASTE MILK

- On-farm pasteurizer unit (150°F for 30 min) was demonstrated to destroy M. paratuberculosis (Stabel, 2001).
- Pasteurization held at 149°F for 10 min destroyed common mastitic mycoplasma such as M. bovis, M. californicum, and M. canadense (Butler et al., 2000).

On-farm HTST Pasteurization kills *M. paratuberculosis*

	High inoculum		Low inoculum	
Strain	Before	After	Before	After
19698 (lab)	8.2×10^4	ND[1]	6.0×10^1	ND
	7.8×10^4	ND	1.3×10^2	ND
	2.3×10^3	ND	2.3×10^2	ND
167 (wild)	1.9×10^5	ND	6.3×10^2	ND
	2.1×10^5	ND	4.2×10^2	ND
	2.2×10^4	ND	8.2×10^2	ND
6112 (wild)	1.9×10^6	ND	5.4×10^1	ND
	5.9×10^5	ND	4.3×10^2	ND
	6.8×10^5	ND	2.1×10^2	ND

[1]ND = Not detected

Stabel et al., 2004

On-farm HTST Pasteurization kills *Salmonella* species

		High inoculum		Low inoculum	
Species	Strain	Before	After	Before	After
S. derby	NVSL	2.0×10^6	ND[1]	2.5×10^3	ND
	2681b	2.0×10^6	ND	1.5×10^3	ND
		2.0×10^6	ND	9.0×10^2	ND
S. dublin	NVSL	6.0×10^6	ND	NP[2]	NP
	3129	9.0×10^6	ND	NP	NP
		3.3×10^7	ND	NP	NP
S. typhimurium	NVSL	2.1×10^7	ND	NP	NP
	5372	2.1×10^7	ND	NP	NP
		2.0×10^7	ND	NP	NP

[1]ND = Not detected [2]NP = Not performed

Stabel et al., 2004

On-farm HTST Pasteurization kills *Mycoplasma* species

		High inoculum		Low inoculum	
Species	Strain	Before	After	Before	After
M. bovis	1135-6	1.0×10^6	ND[1]	1.0×10^2	ND
	UCD9	1.0×10^6	ND	1.0×10^2	ND
	Jasper	1.0×10^6	ND	1.0×10^2	ND
M. californicum	Cs657	1.0×10^6	ND	1.0×10^2	ND
	ST6	1.0×10^6	ND	1.0×10^2	ND
M. canadense	275C	1.0×10^6	ND	1.0×10^2	ND
M. serogroup 7	CS826	1.0×10^6	ND	1.0×10^2	ND
	PG50	2.0×10^4	ND	1.0×10^2	ND

[1]ND = Not detected

Stabel et al., 2004

Caution!!!

- Failure to follow procedures
  - Not heating to correct temperature.
  - Not holding at temperature long enough.
- Some data shows
  - 13% of farms had incomplete pasteurization in a survey of 31 farms (Jorgensen et al., 2006).
  - Two dairies in North Carolina experienced failure of pasteurization in 18% and 15% of samples collected (Scott et al., 2006).

Installation requirements

- Hot water heater
- Water supply
- Special electrical requirements
- Space/location
- Drainage requirements
- Waste water removal
- Purchase and installation costs

Considerations for day-to-day use

- Train employees to properly use and clean the equipment.
- Time/labor to use and clean equipment.
- Cleaning requirements.
- Service
  - How quickly can service be provided?

Considerations for day-to-day use

- Moving and storing waste milk before and after pasteurization.
- Monitoring pasteurizer performance.
- Initial load of pathogens determines final load.
- Plan for feeding when waste milk isn't available.

Post-pasteurization contamination

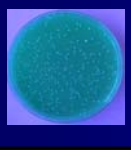
- Cleaning and sanitizing feeding equipment
  - Store milk in clean, closed containers.
  - Feed to calves in clean buckets or bottles.
- Storage temperature
  - Milk must be fed or cooled immediately.
  - Sitting at room temperature can allow bacteria to grow rapidly.
- Feeding methods & timing
  - Length of time milk is exposed to ambient temperatures can affect bacterial growth.
  - Summer may be more challenging.

Tips for success

- Train employees in pasteurizer operation and concepts of pasteurization.
- Monitor pasteurization temperature and holding time for every batch of milk.
- Clean pasteurizer after every use following procedure recommended by the manufacturer.

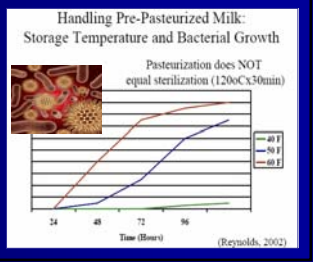
More tips for success

- Periodically check bacteria numbers in milk before and after pasteurization to ensure equipment is working
  - Pre-past.: <1,000,000 CFU/ml SPC.
  - Post-past.: < 20,000 CFU/ml SPC.



More tips for success

- After pasteurizing milk, feed it or cool it to reduce bacterial growth; do not store at room temperature.



More tips for success

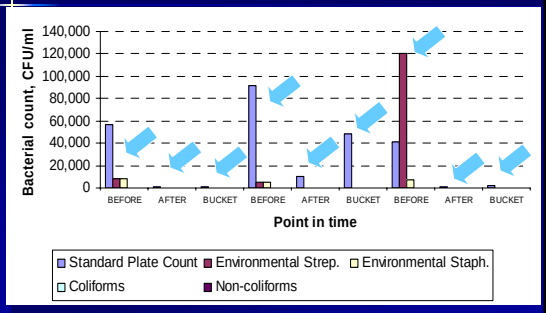
- If milk is not fed within 24 hours of pasteurization, pasteurize it again before feeding.
- Do not pasteurize extremely abnormal milk
  - Nutritional characteristics may be altered.

Real life data

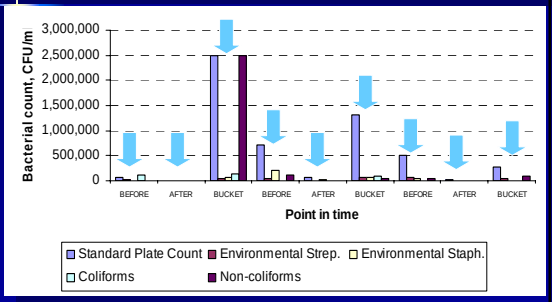
- We went to different farms.
- Took samples before pasteurization.
- Took samples after pasteurization.
- Took samples in front of the calf.



One farm



Another farm



Can we pasteurize colostrum?

- Pasteurization effectively destroys pathogens in colostrum (Green et al., 2002).
- Adoption of commercial on-farm pasteurization systems resulted in significant health and economic benefits (Godden et al., 2005).
- Studies have been limited.

MEAN BACTERIAL COUNT IN COLOSTRUM (145°F for 30 min)

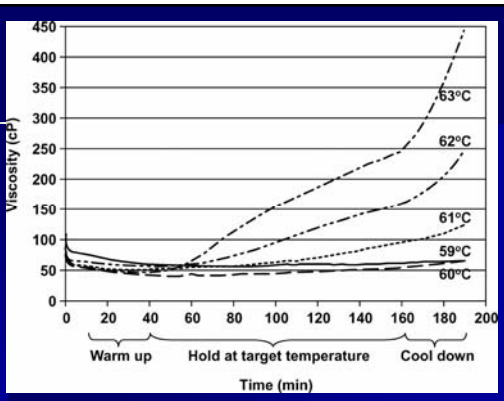
	Bacterial count (cfu/ml)			
Bacteriology	Preheating	Postheating	SEM	P
SPC	16,161.4	21.4	4,084.0	0.001
PIC	11,317.9	12.9	2,985.9	0.001
CC	10,293.6	3.6	3,749.6	0.001
NC	2,162.1	0.0	629.9	0.001
ES	3,784.3	0.0	2,520.9	0.001
CNS	43,113.6	2.9	22,724.4	0.001
SA	3,627.1	0.0	2,524.7	0.022

Elizondo et al., 2007

OTHER FINDINGS

- Godden et al. (2006) inoculated batches of first-milking colostrum with Mycoplasma bovis, L. monocytogens, E. coli, and Salmonella sp.
- No detection after colostrum was heat-treated at 140°F for 30 min.

HEAT TREATMENT REALLY REDUCES THE BACTERIAL LOAD BUT WHAT HAPPENS TO OTHER ATRIBUTES?



Viscosity changes during heat treatment of bovine colostrum at 5 temperatures for 120 minutes (McMartin et al., 2006).

MEAN VISCOSITY OF COLOSTRUM AFTER HEAT TREATMENT

	Viscosity (cP)	
Temp (°F)	Preheating	Postheating
138	1.93[a]	1.80[a]
140	1.88[a]	1.85[a]
142	1.91[a]	2.14[b]
144	1.91[a]	2.38[b]
145	1.86[a]	2.65[b]

P < 0.05

(McMartin et al., 2006).

WHAT ABOUT IgG LEVELS?

PASTEURIZATION OF COLOSTRUM

5 ml volumes of 18 colostrum samples at 145°F for 30 min.

- Fresh colostrum IgG 44.4 g/l
- Pasteurized colostrum IgG 37.2 g/l
- IgG loss 12.3%

Meylan et al., 1995

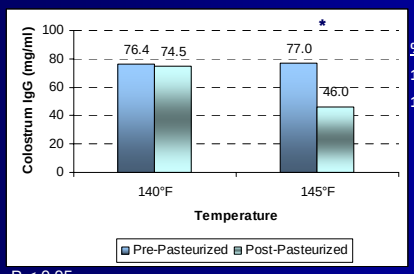
MEAN IgG CONCENTRATION OF COLOSTRUM AFTER HEAT TREATMENT

	IgG (mg/mL)	
Temp (°F)	Preheating	Postheating
138	73.6[a]	77.1[a]
140	71.6[a]	70.4[a]
142	73.0[a]	66.1[a]
144	73.3[a]	58.5[b]
145	76.1[a]	43.7[b]

P < 0.05

(McMartin et al., 2006).

MEAN IgG CONCENTRATION OF COLOSTRUM AFTER HEAT TREATMENT



% IgG loss:
140°F: 2.5
145°F: 40.2

P < 0.05

(McMartin et al., 2006).

MEAN IgG CONCENTRATION IN COLOSTRUM (145°F for 30 min).

	IgG level (mg/ml)			
IgG	Preheating	Postheating	SEM	P
IgG_1	84.8	73.8	2.7	0.009
IgG_2	4.3	2.9	0.4	0.014
Total IgG	89.1	76.7	2.8	0.005

Elizondo et al., 2007

14% reduction in total IgG