Milk Secretion

Introduction
- Milk - nature's perfect food
- Mammary gland has a unique function - transfers food from parent to offspring
- Roles of lactation
  - Warmth - Hypothermia
  - Nutrition - Starvation
  - Antibodies - Disease
  - Physical Protection - Predators
  - Learned Skills - Various Hazards

Mammary Gland Anatomy
- Composed of 4 glands
- Separated into two halves
  - Medial suspensory ligament
- Fore and rear quarters of each half have separate ducts
  - Rear quarters 60% of milk
- Seven tissues support the udder
  - Medial suspensory ligament
  - Lateral suspensory ligament

Mammary Gland Anatomy
- Teat
  - Pronunciation
    - correct: 'tEt - ᵻ as ea in easy
    - incorrect: 'tit - ᵻ as i in hit
  - Sphincter muscle
  - Streak canal (keratin) – 0.25 – 0.5"
- Gland cistern
- Ducts - plumbing

Secretory Tissue
- Secretory (alveolar) cells
  - produce milk
- Alveolus - single layer of alveolar cells
- Several alveoli in a group from a lobule
- Myoepithelial cells - cover alveolus
  - oxytocin causes myoepithelial cells to contract, ejecting milk from the lumen

Milk Flow
- Alveolar cells secrete milk into lumen of the alveolus
- Lumen empties into terminal ducts
- Terminal ducts empty to secondary ducts
- Secondary ducts empty to primary ducts
- Primary ducts empty to gland cistern
- Gland cistern empties into teat cistern
Mammary Gland Development

- Development in embryonic bovine starts at 32 d
- Birth to puberty
  - isometric growth – 0 to 3 mo
  - allometric growth – 3 to 9 mo
- Puberty
  - Estrogen – duct growth
  - Progesterone – alveolar growth

Mammary Gland Development

- Pregnancy - exponential growth
  - estrogen, progesterone, placental lactogen
- Early Lactation
  - 10 d after parturition – 65% more DNA
  - Prolactin, growth hormone, cortisol
- Declining Lactation - cell # decrease
- Dry Period - gland involutes

Endocrine Control

- Mammary Growth
  - estrogen, progesterone, prolactin, growth hormone, and placental lactogen
- Lactogenesis - alveolar cells acquire ability to secrete milk
  - prolactin, glucocorticoids, estrogen, and progesterone (inhibits)

Endocrine Control

- Lactation
  - prolactin, GH, glucocorticoids, insulin, and thyroid and parathyroid hormones
  - Homeorhesis - a shift in nutrient partitioning
    - Change from tissue deposition to tissue mobilization
  - Blood - carries nutrients to udder
    - blood:milk = 400:1 - 500:1

Factors Affecting Secretion

- Milking frequency
  - 3x vs 2x milking – +15%
  - Interval > 14 h decreases >2%
  - 1x last 3 mo of lactation – -38% last 3 mo
  - 1x entire lactation – -40 to 50%
  - 13x/week – -5 to 11%
  - Cessation of milk 36 h after last milking

Factors Affecting Secretion

- Age
  - 30% increase in production from 1st to 5th lactation
  - 1st lactation peak 15% of 3rd lactation
  - 2nd lactation peak 6% of 3rd lactation
- Climate
  - Optimal temp = 40 to 70°F
  - Humidity = 60 to 80% if temp < 70°F
Milking Routine

Effect of Cow Prep on Milk Flow and Parlor Throughput

- Milk Letdown
- Oxytocin
- Prep Time
  - 10 – 20 sec
- Prep-Lag Time
  - 60 sec

Steady-state throughput for a Double-20 (cows/hour)

<table>
<thead>
<tr>
<th>Prep-Lag, sec</th>
<th>Milk Yield (lb/cow/milking)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>0</td>
<td>109</td>
</tr>
<tr>
<td>10</td>
<td>114</td>
</tr>
<tr>
<td>20</td>
<td>117</td>
</tr>
<tr>
<td>30</td>
<td>119</td>
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<tr>
<td>40</td>
<td>120</td>
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<tr>
<td>60</td>
<td>121</td>
</tr>
<tr>
<td>90</td>
<td>118</td>
</tr>
</tbody>
</table>

Ideal Prep Routine

- Minimize water use
- Use a sanitizer (i.e. prep-dip)
- Assure complete pre-dip coverage of teat surfaces
- Allow pre-dip 30 seconds contact time
- Remove all dirt from teat surfaces

Ideal Prep Routine

- Provide a minimum let down stimulus (teat massage, fore-stripping, teat drying) of 10 to 20 sec
- Provide a prep-lag time of 60 seconds
- Minimize machine-on time
- Minimize variation between milkers
- Not slow down milking
Milk Composition

Milk Composition
- Remember that dairies are paid for the amount of fat, protein, and other solids
- Breeds have similar milk lactose %, milk protein varies by 0.5% and milk fat by 1%
  - Fat is always higher than protein in a healthy cow
  - Milk fat depression is most common problem

Breed Statistics

<table>
<thead>
<tr>
<th>Breed</th>
<th>lb milk/yr</th>
<th>% fat</th>
<th>% protein</th>
<th>% of US cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein</td>
<td>24,755</td>
<td>3.67</td>
<td>3.18</td>
<td>93</td>
</tr>
<tr>
<td>Jersey</td>
<td>17,680</td>
<td>4.56</td>
<td>3.70</td>
<td>5.6</td>
</tr>
<tr>
<td>Brown Swiss</td>
<td>20,972</td>
<td>3.98</td>
<td>3.42</td>
<td>0.8</td>
</tr>
<tr>
<td>Guernsey</td>
<td>15,143</td>
<td>4.48</td>
<td>3.46</td>
<td>0.3</td>
</tr>
<tr>
<td>Arishire</td>
<td>16,864</td>
<td>3.87</td>
<td>3.31</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Milk Fat Depression (MFD)

Milk Fat Depression (MFD)
- Results in significant economic loss
- Causes
  - High grain diets
  - Short particle length of fiber
  - High fat diets
  - High grain diets (high NFC)
    - Lower milk fat and slightly higher protein
    - Lack of acetate for fat synthesis
    - Acetate:Propionate ratio ↓
  - Small particle size of fiber
    - Decreases rumination
    - Decreases forage digestion
    - Acetate:Propionate ratio ↓
- High fat diets
  - Polyunsaturated fatty acids (PUFA) and partially hydrogenated vegetable oils (PHVO)
  - Trans -18:1 inhibits fat production in the mammary gland

Milk Fat Depression (MFD)
- High grain diets (high NFC)
  - Lower milk fat and slightly lower protein
  - Small particle size ration
  - RUP – variable results
  - Fat – too much can decrease fat and protein
Milk Fat Depression (MFD)

- High fat diets (cont)
  - PUFA & high forage ↑ trans-11 in milk and no MFD
  - PUFA & high concentrate ↑ trans-10 in milk and caused MFD
  - trans-10, 18:1 and/or trans-10,cis-12,18:2 cause MFD
  - exacerbated by high concentrate:low forage

Definitions

- Mastitis – inflammation of mammary gland
  - Microorganisms (bacteria) invade udder, multiply, and produce toxins
- Clinical mastitis – visible signs of disease
  - Mild signs - flakes or clots
  - Severe signs – abnormal secretion, hot, swollen; fever, inappetance, death

Annual Loss Due to Mastitis

<table>
<thead>
<tr>
<th>Source</th>
<th>Loss/cow</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Reduced yield</td>
<td>121.00</td>
<td>66.0</td>
</tr>
<tr>
<td>Discarded milk</td>
<td>10.45</td>
<td>5.7</td>
</tr>
<tr>
<td>Replacement cost</td>
<td>41.73</td>
<td>22.6</td>
</tr>
<tr>
<td>Extra labor</td>
<td>1.14</td>
<td>0.1</td>
</tr>
<tr>
<td>Treatment</td>
<td>7.36</td>
<td>0.1</td>
</tr>
<tr>
<td>Vet</td>
<td>2.72</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>184.40</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Estimated Annual Losses

- $184 per cow
- $18,400 per 100 cow herd
- $1.7 billion is US
Somatic Cell Count (SCC)

- SCC is the # of leukocytes or white blood cells per ml of milk
- Normal milk <200,000 cells/ml
- Leukocytes enter gland in response to injury (infection)
- Elevated SCC indicative of mammary gland infection

Contagious (Subclinical) Mastitis

- Greatest financial loss (70% of losses)
- Caused by:
  - Strep. agalactiae
  - Staph. aureus
  - Mycoplasmaspp.
- Primary source
  - udders of infected cows
  - Mycoplasmaspp. – udders and respiratory

Contagious Mastitis

- Method of spread
  - primarily at milking (cloths, hands, units)
- Indicators
  - no clinical signs of disease (i.e. abnormal milk), except Mycoplasmaspp.
  - elevated somatic cell count (SCC)
    - >500,000 cells/ml
    - bacterial culturing

Contagious Mastitis

- Control
  - prevent spread at milking
    - segregate and milked last or with a separate milking unit
    - eliminate infectious cows
- Goals
  - eradicate Strep. agalactiae
  - reduce Staph. aureus to less than 5% of cows in the herd

Controlling Contagious Mastitis

- Staph - cure rate low
- Strep - responds well to antibiotic therapy
- Mycoplasma - cure rate low
- Prevention
  - clean, dry teats
  - minimize liner slips
  - use effective teat dip
  - maintain milking system

Controlling Contagious Mastitis

- Eliminate infections
  - treat all quarters at dry off
  - cull chronically infected cows
- Steps to follow
  - teat dip – predips and postdips effective
  - dry cow treat
  - proper milking procedure and functional equipment
  - cull chronic cows
Environmental (Clinical) Mastitis
- Caused by coliforms
  - *E. coli*
  - *Klebsiella spp.*
- Caused by environmental streptococci
  - *Strep. spp.* (uberis, bovis, dysgalactiae)
  - *Enterococcus Spp.*
- Primary source
  - environment of the cow

Environmental Mastitis
- Indicator of problem
  - high rate of clinical mastitis, usually in early lactation
  - SCC may be low, <300,000 cells/ml
- Risk
  - Higher during dry period – 1st 2 weeks and last 2 weeks
  - During lactation – early highest risk

Environmental Mastitis
- Control
  - reduce # of bacteria to which teat end is exposed
  - improve cleanliness of surroundings especially in late dry period and at calving
  - improve milking prep
- Goal
  - reduce clinical mastitis to less than 3% of the milking cows per month

Environmental Mastitis
- Duration of infections
  - Coliforms
    - More than 50% <10 days
    - Nearly 70% < 30 days
    - Can become chronic – 1.5% > 100 days
  - Strep
    - Longer than coliforms
    - 60% < 30 days
    - 18% chronic - >100 days
    - 40% eliminated spontaneously

Controlling Environmental Mastitis
- Prevention is the key
  - reduce # of bacteria to which teat end is exposed
  - highest infection rates: first 2 wks and last two wks of dry period
- Environment
  - clean and dry
- Bedding
  - inorganic - low nutrients and moisture

Controlling Environmental Mastitis
- Teat dipping (1% iodine, 0.5% chlorhexidine)
  - pre milking teat dip
    - reduces environmental mastitis by 50%
  - post milking teat dip
    - exerts some control over environmental streps
    - barrier dips effective against coliforms
- Dry cow therapy
  - treat all quarters at drying off
  - effective against strep, not coliform
- Proper milking procedure
# Infection Prevalence

<table>
<thead>
<tr>
<th>Bulk tank SCC/ml</th>
<th>% infected quarters</th>
<th>% production loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>200,000</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>500,000</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>1,000,000</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>1,500,000</td>
<td>48</td>
<td>29</td>
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# Production Losses

<table>
<thead>
<tr>
<th>SCC score</th>
<th>SCC/ml</th>
<th>Production Loss (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12,500</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>25,000</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>50,000</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>100,000</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td>200,000</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>400,000</td>
<td>600</td>
</tr>
<tr>
<td>6</td>
<td>800,000</td>
<td>800</td>
</tr>
<tr>
<td>7</td>
<td>1,600,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>

# Bulk Tank SCC and SCC Score Comparison

<table>
<thead>
<tr>
<th>Cow</th>
<th>Tank SCC</th>
<th>SCC Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4,000,000</td>
<td>8.3</td>
</tr>
<tr>
<td>2</td>
<td>3,000,000</td>
<td>7.9</td>
</tr>
<tr>
<td>3</td>
<td>1,500,000</td>
<td>6.9</td>
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<tr>
<td>4</td>
<td>400,000</td>
<td>5.0</td>
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<tr>
<td>5</td>
<td>250,000</td>
<td>4.3</td>
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<tr>
<td>6</td>
<td>200,000</td>
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<tr>
<td>7</td>
<td>150,000</td>
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<tr>
<td>8</td>
<td>100,000</td>
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<tr>
<td>9</td>
<td>75,000</td>
<td>2.6</td>
</tr>
<tr>
<td>10</td>
<td>50,000</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Avg 973,000 4.8

# Impact of Culling Cows on SCC

<table>
<thead>
<tr>
<th>Cow</th>
<th>Cow SCC</th>
<th>SCC Reduction</th>
<th>Tank SCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4,000,000</td>
<td>337,000</td>
<td>636,000</td>
</tr>
<tr>
<td>2</td>
<td>3,000,000</td>
<td>296,000</td>
<td>340,000</td>
</tr>
<tr>
<td>3</td>
<td>1,500,000</td>
<td>165,000</td>
<td>175,000</td>
</tr>
<tr>
<td>4</td>
<td>400,000</td>
<td>38,000</td>
<td>138,000</td>
</tr>
</tbody>
</table>

Cow 1 produces 41% of cells in tank
Cows 1 and 2 produce 72% of cells
Cows 1, 2, and 3 produce 87% of cells