Milking Machines
Machine Milking

- On larger farms,
- cows are milked by
- a machine
- Vacuum pump
- Vacuum vessel
- Teat cups
- Pulsator
Machine Milking

- Massage phase
- Suction is applied alternately to the left and right teats

Fig. 1.5 Machine milking equipment.
Vacuum line runs whole system

1. Vacuum Pump
2. Vacuum Pipeline
3. Milk Cooling Tank
4. Milk Pipeline

Dairy Processing Handbook p. 6
Problems with teat cup slippage & Vacuum irregularity

- Tissue damage
- Milk reflux to teat end
- Cross contamination

Fig. 6.5. Diagram showing the relationship between the position of the teat end and the liner (inflation) of the teat cup, during the milking process. Observe the depth of teat penetration, thickening of teat wall stroma, and open and closed position of liner as milking process proceeds. (Redrawn from radiograph tracings by Mein, Thiel, and Akan 1973, appearing in Thiel 1974)

Fig. 6.6. Diagram of air flow during a vacuum slip in a milking machine, often resulting in bacterial contamination of the teat end.
Breast pumps

What breast pump companies want

"Accept it, without the advances of medical technology it would be impossible for you to breastfeed your baby!"
Importance of Vacuum for Breastmilk Expression

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ABSTRACT

Objective: To determine the effect of the strength of applied vacuum on the flow rate and yield of breastmilk using an electric breast pump.

Study Design: Twenty-one breastfeeding mothers and two expressing mothers expressed their breastmilk for 15 minutes using an electric breast pump set at their own maximum comfortable vacuum, and at one to three softer vacuums. Milk yield and flow rate were measured.

Results: At the maximum comfortable vacuum (−190.7 ± 8.8 mm Hg) 4.3 ± 0.4 milk ejections occurred during 15 minutes of expression and yielded 118.5 ± 11.4 mL of milk (65.5 ± 4.1% of the available milk). Softer vacuums yielded less milk volume (p < 0.05) and less of the available milk (p < 0.01). Milk flow rate was greater during the first milk ejection than the third or subsequent milk ejections (p < 0.001). Cream content of the milk was highest after expressing for 15 minutes using the mother’s maximum comfortable vacuum.

Conclusions: Use of the mother’s maximum comfortable vacuum enhances milk flow rate and milk yield. The cream content of the milk at the end of the expression period was an indicator of how effectively the breast had been drained.
Pump vacuum impacts rate of milk released

**Vacuum and Breastmilk Expression**

**Table 1. Expression of Milk from the Left Breast**

<table>
<thead>
<tr>
<th></th>
<th>Vacuum (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A (190.7 ± 8.0)</td>
</tr>
<tr>
<td>n</td>
<td>23</td>
</tr>
<tr>
<td>Initial cream content (%)</td>
<td>1.98 ± 0.27</td>
</tr>
<tr>
<td>Initial degree of fullness</td>
<td>0.78 ± 0.04</td>
</tr>
<tr>
<td>Potential storage capacity (mL)</td>
<td>249 ± 21</td>
</tr>
<tr>
<td>Stimulation vacuum (mm Hg)</td>
<td>-80.9 ± 4.8</td>
</tr>
<tr>
<td>Time to first milk ejection (seconds)</td>
<td>91.6 ± 12.9</td>
</tr>
<tr>
<td>Number of milk ejections</td>
<td>4.3 ± 0.4</td>
</tr>
<tr>
<td>Total milk volume (mL)</td>
<td>118.5 ± 11.4</td>
</tr>
<tr>
<td>Time to 50% total (minutes)</td>
<td>3.6 ± 0.4</td>
</tr>
<tr>
<td>Time to 80% total (minutes)</td>
<td>6.7 ± 0.6</td>
</tr>
<tr>
<td>% available milk expressed</td>
<td>65.5 ± 4.1</td>
</tr>
</tbody>
</table>

Data are mean ± SEM values.
Significantly different from vacuum A: *p < 0.05, **p < 0.01.
Comparison of Manual and Electric Breast Pumps Among WIC Women Returning to Work or School in Hawaii

DONALD K. HAYES,1,2 CHERYL B. PRINCE,1,2 VALERIE ESPINUEVA,1,2 LORETTA J. FUDDY,1 RUOWEI LI,2 and LAURENCE M. GRUMMER-STRAWN2

ABSTRACT

Introduction: The Women, Infants, and Children (WIC) branch of the Hawaii Department of Health encourages and assists mothers in breastfeeding. A study was done to determine whether an electric breast pump (vs. a manual pump) would increase breastfeeding duration in those returning to work or school full-time.

Materials and Methods: During 2002–2003, a randomized trial was conducted among 280 women, with the duration of breastfeeding analyzed in 229 of these women. Descriptive analyses and a multivariate logistic regression analysis assessed factors associated with breastfeeding at 6 months. Unadjusted and adjusted survival analyses were performed to estimate the duration of breastfeeding.

Results: In all, 76.8% of women using the manual breast pump and 72.3% of those using the electric breast pump breastfed for at least 6 months. This difference did not reach statistical significance. In the survival analysis adjusted for pump assignment, maternal age, race/ethnicity, marital status, and parity, women with at least some college education breastfed for a 38% shorter time than women with a high school or lower education.

Conclusions: Our findings suggest that the manual breast pump may work as well as the electric breast pump when breastfeeding is encouraged and supported among women returning to work or school full-time. Particular attention should be given to examining reasons why women with greater education breastfed for a shorter duration. Further research is needed to validate these results to better inform breastfeeding women returning to work or school.
Importance of Proper Pump Flange Fitting

Fig. 239 Pre-pumping nipple size 20.64 mm
Fig. 240 Post-pumping size swells to 23.81 mm
Fig. 241 Glass flange -- 40 mm diameter

Fig. 234 Medela flange sizes 30 mm 24 mm
Fig. 235 Ameda (Hollister) flanges 25 mm 30.5 mm
Fig. 236 Tight fit in 25 mm flange
Fig. 237 Tight fit caused cracks at base of nipple
Fig. 238 Tight flange causes cracking and abrasion
ADVANTAGES to manual expression over mechanical methods

- Some mechanical pumps cause discomfort and are ineffective.
- It is more natural.
- Skin to skin contact is more stimulating; easier milk ejection reflex.
- It's convenient.
- It's ecologically superior.
- It's portable. How can a mother forget her hands?
- Best of all it's free!

http://newborns.stanford.edu/Breastfeeding/HandExpression.html
Expressed human milk storage Guidelines from the Centers for Disease Control and Prevention

<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature</th>
<th>Duration</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countertop, table</td>
<td>Room temperature (up to 77°F or 25°C)</td>
<td>6–8 hours</td>
<td>Containers should be covered and kept as cool as possible; covering the container with a cool towel may keep milk cooler.</td>
</tr>
<tr>
<td>Insulated cooler bag</td>
<td>5-39°F or -15-4°C</td>
<td>24 hours</td>
<td>Keep ice packs in contact with milk containers at all times, limit opening cooler bag.</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>39°F or 4°C</td>
<td>5 days</td>
<td>Store milk in the back of the main body of the refrigerator.</td>
</tr>
<tr>
<td>Freezer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezer compartment of a refrigerator</td>
<td>5°F or -15°C</td>
<td>2 weeks</td>
<td>Store milk toward the back of the freezer, where temperature is most constant. Milk stored for longer durations in the ranges listed is safe, but some of the lipids in the milk undergo degradation resulting in lower quality.</td>
</tr>
<tr>
<td>Freezer compartment of refrigerator with separate doors</td>
<td>0°F or -18°C</td>
<td>3–6 months</td>
<td></td>
</tr>
<tr>
<td>Chest or upright deep freezer</td>
<td>-4°F or -20°C</td>
<td>6–12 months</td>
<td></td>
</tr>
</tbody>
</table>

Machines for Milk Processing
Clarification / Separation / Standardization
Clarifier/Separator Purpose?

- Removes extraneous material
- Cream removal
- Fix fat composition
Separation and Clarification Equipment

- Same equipment
- Equipment construction
- Less dense particles move inwards
- More dense particles move outwards
Separation

- Old fashioned gravity creaming
- Revolutionized the dairy industry
- Purpose
- Separator
Clarification

- Extraneous material in raw milk
- Remove extraneous material
- Self desludging equipment
Standardization

- Recombination of skim and fat to provide the desired fat content
- Throttling valve
- Direct standardization
Homogenization
Background on Homogenization

- 1902 – Auguste Gaulin
- Reduces creaming of the fat globules in milk
- Mechanical treatment of the fat globules in milk while hot

Raw milk straight from the cow
Positive Effects of Homogenization

- No cream line in final product
- Milk’s susceptibility to oxidative rancidity is reduced
- Whiter, more attractive color
- Enhanced mouth feel
- Full bodied flavor
- Greater stability in cultured products
The Homogenizer

- Three-cylinder positive displacement piston pump and the homogenization valve
- It can process 20,000L/hour
- The high pressure pump

Fig. 6.3.4 The homogenizer is a large high-pressure pump with a back pressure device.

1. Main drive motor
2. V-belt transmission
3. Pressure indication
4. Crankcase
5. Piston
6. Piston seal cartridge
7. Solid stainless steel pump block
8. Valves
9. Homogenizing device
10. Hydraulic pressure setting system

Dairy Processing Handbook, Tetra Pak Processing
The Homogenizer

- Oil tanks
- Single stage – one oil tank
- Two stage – two oil tanks
- Milk is homogenized in first stage
- Second-stage provides a constantly controlled back-pressure to the first stage
- Second-stage also breaks up clusters that are formed directly after homogenization.

Dairy Processing Handbook, Tetra Pak
The Homogenizer

- Milk is supplied to the space between the seat and the forcer at high pressure.
- Milk moves through the gap at a velocity of 100 – 400 m/s and homogenization takes place in 10 – 15 microseconds.

Dairy Processing Handbook, Tetra Pak
Pasteurization

Why?
How?
Batch Method

- Uses a vat pasteurizer, which consists of a jacketed vat surrounded by circulating water, steam, or heating coils of water and steam.
- Milk is heated in the vat and held for the specified amount of time while being agitated.
- Milk can either be cooled in the vat or it can be removed hot.
- This method is not used often for plain fluid milk beverages, but it is used mostly for pasteurizing special batches of milk products such as ice cream, creams, started cultures for yogurt, cheese, and buttermilk as well as for flavored milk to help the ingredients disperse throughout the product.
Continuous Method

- Many advantages over batch pasteurization:
  - Efficiency: saves 90% of heating and cooling costs
  - Saves time: it is continuous and the holding time is seconds rather than 30 minutes as with the batch method
  - Saves floor space
- HTST plate pasteurizer – high temperature short time plate pasteurizer
- The HTST continuous plate pasteurizer consists of a cooling section, a regenerator, and a heating section.
Continuous Method - Plate Heat Exchanger

- The plate heat exchanger consists of a stack of corrugated stainless steel plates clamped together in a frame.
- Corrugated means “shaped into alternating parallel grooves and ridges”.
- This characteristic of the plate heat exchanger improves strength, fluid flow, and increases the surface area for the milk to come in contact with the plates.
- Gaskets are also attached to the plates to prevent the milk from leaking during pasteurization.

Plates from the regenerator.
Flow of the Continuous Method

- Raw milk is held in a tank at 4°C (39°F). From this tank, it is drawn into the regenerator section of the pasteurizer and warmed to 57°C - 68°C (134°F - 154°F) by heat from hot pasteurized milk flowing in a counter-current direction on the opposite side of the steel plates.

Fill tanks at the NCSU Dairy Plant
Flow of the Continuous Method

- The raw milk then passes through the timing pump, which delivers it to the rest of the HTST system and directs the rate that the milk flows through the holding tubes.
Flow of the Continuous Method

- Next, the milk passes through the heater section where hot water on opposite sides of the plates heats the milk to 72°C (161°F).
- The milk is now at the pasteurization temperature and it flows, under pressure, through the holding tubes and is held for a minimum of 16 seconds.
Flow of the Continuous Method

- The maximum velocity at which the milk is transported through the holding tubes is determined by the speed of the timing pump, surface friction, and the length and diameter of the holding tube.
Flow of the Continuous Method

- **Flow diversion device (FDD)** – is a three way valve.
- When the temperature is greater than the pasteurization temperature, 72°C (161°F), the valve opens to forward flow and the milk is transported through the rest of the HTST system.
- If the temperature is less than pasteurization temperature, the valve closes and the milk is diverted to the balance tank.
Roles of Dairy Packaging

Definition

1. To retard deterioration of the product by preventing microbial recontamination and excessive chemical deterioration.

2. Provide containment, facilitate use, identify products, and communicate and appeal to consumers.