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Pasteurization of Human Donor Milk

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Introduction

- Appropriate and adequate nutrition is critical to reduce the risk of mortality in the preterm infant and to promote growth (Parker, 2019).
- Human milk best source of nutrition and reduces the risk of common neonatal complications, including necrotizing enterocolitis, late-onset sepsis and retinopathy of prematurity (Li et al., 2017).
- When Mother's Own Milk (MOM) is unavailable, The World Health Organization and the American Academy of Pediatrics both recommend that human donor milk is the next best option (Peila et al., 2016).
- Human milk can be obtained from a donor source and is considered safe for consumption following a screening process and pasteurization to eliminate the risk of infectious microbial agents being passed to the infant (Baumgartel & Dean, 2019).
- Human Milk Banks collect, pool, and pasteurize donor milk (Peila et al., 2016).
- Two methods of pasteurization are commonly utilized: thermal and nonthermal.
- Each method has been shown to reduce chemical components of the milk and cause loss of immunological benefits and bactericidal action (Pitino et al., 2019).
- Pasteurized Human Donor Milk (HDM) has the potential to adversely affect neonatal growth and increase the risk for complications of prematurity (Baumgartel & Dean, 2019).

Relevance

Previously, pasteurization of HDM focused entirely on elimination of harmful contaminants and transmissible viruses. Recent research has examined the importance of the microbiome and the relation to infant gut health, disease resistance, and immunity (Lyons et al., 2020). Focus is shifting to methods that can provide HDM safely while maintaining the beneficial components that support optimal health.

Pathophysiology

Lactation is regulated by hormonal controls during pregnancy and in the postpartum period. Following delivery of the placenta, progesterone decreases and estrogen increases. With levels of prolactin, insulin, and cortisol also rising, milk production is induced. Human milk is synthesized when prolactin stimulates milk protein and lactose synthesis. Secretion of milk from the mammary glands is dependent on oxytocin being released from the posterior pituitary. The suckling of an infant creates a feedback loop that ensures an effective supply and demand system (Lyons et al., 2020).

Human milk is a complex and highly individualized mix of macronutrients, micronutrients, and bioactive compounds, including:

Antibodies
Immunoglobulins
Lactoferrin
Lysozyme
Growth factors
MicroRNAs
Oligosaccharides
Antimicrobial peptides
See Table 1

Heat has been shown to damage immune cells and bioactive proteins and reduce the oxidative benefits of human milk (Li et al., 2017). See Table 2. HDM is often fortified following pasteurization in an attempt to replace the lost nutrients (Parker, 2019). Human milk fortifiers are derived from bovine-based products and can increase risk for complications in the neonate (Parker, 2019).

Table 1 ***Composition of raw human donor milk***

Table 1

Concentration of immunoglobulins, growth factors, and hormones in raw DHM batches.

	n	Median	IQR	Range (Minimum–Maximum)	CV (%)
IMMUNOGLOBULINS					
IgA (mg/L)	18	473.32	381.51–694.43	109.83–905.02	43.21
IgG (mg/L)	17	17.99	13.59–46.84	7.80–75.95	69.98
IgM (mg/L)	20	18.79	9.22–47.48	5.08–87.28	85.33
GROWTH FACTORS					
EGF (μg/L)	6	3.51	3.24–3.99	3.14–4.01	10.27
TGF-β2 (μg/L)	21	1.84	1.20–2.45	446.36–4592.45	50.76
HORMONES					
Adiponectin (μg/L)	24	7.74	6.41–9.27	3.74–17.6	36.68
Ghrelin (ng/L)	15	28.21	16.25–43.93	10.55–57.84	49.97
Leptin (ng/L)	20	116.97	79.05–184.50	68.4–348.19	53.14

n, number of DHM batches analyzed; IQR, interquartile range (Q25–Q75); CV, coefficient of variation; EGF, epidermal growth factor; Ig, immunoglobulin; TGF-β2, transforming growth factor-beta 2.

(Escuder-Vieco et al., 2018)

Signs and Symptoms

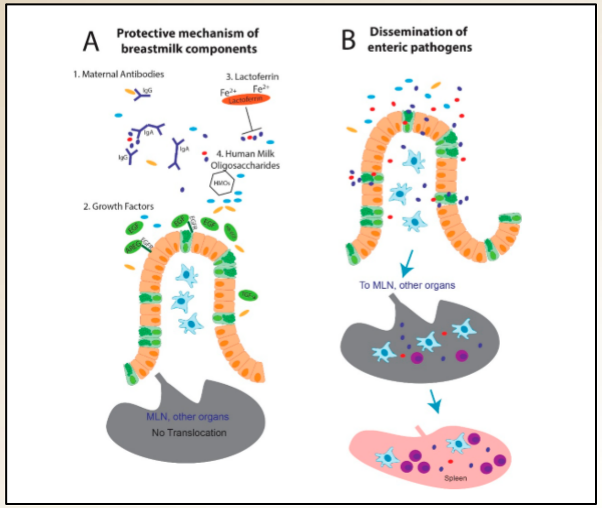
- Signs and symptoms of suboptimal neonatal nutrition from bovine-based fortifiers include:
  - Feeding intolerance
  - Elevated inflammation markers
  - Late-onset sepsis
  - Growth retardation (Li et al., 2017)

Pasteurization

Thermal Methods
- Holder
  - Eliminates microbiological contaminants
  - Pooled milk is heated in a water bath at 62.5 C for 30 minutes (Li et al., 2017)
- High Temperature Short Time (Flash heating)
  - Milk is heated to 72 C for 10 minutes
  - Often used in low resource areas to prevent transmission of HIV (Pitino et at., 2019)
  - Recommended as minimum pasteurization for informal milk sharing groups (Pitino et al., 2019)

Nonthermal Methods
- High Pressure Processing
- UV-C Irradiation
  - Newer method that irradiates HDM and damages microorganisms through DNA destruction
  - Spares bioactive elements

Figure 1 Maternal protection from pathogens



(Kleist et al., 2020)

Underlying Pathophysiology

- Bioactive compounds such as human milk oligosaccharides have a bifidogenic effect (Lyons et al.,2020)
- Lactoferrin plays a role in gastrointestinal and brain development (Pitino et al., 2018)
- Choline is important for infant brain development (Lyons et al., 2020)
- Secretory IgA prevents respiratory and GI infections and regulates immune response to dietary antigens (Lyons et al.,2020)
- Folate and vitamin C are important in synthesis and repair of DNA and RNA (Pitino et al., 2018)

Table 2 ***Concentrations of macronutrients and micronutrients per liter of raw and pasteurized human donor milk***

Dolores hendrerit duo etPitini et al.

Analyte	Raw	Post-Holder	Post–flash heat	Post–UV-C	Post-HHP
Carbohydrate, g/L	69 ± 3[a]	69 ± 4[a]	69 ± 3[a]	69 ± 3[a]	67 ± 4[b]
Fat, g/L	31 ± 8	31 ± 8	31 ± 8	31 ± 8	29 ± 8
Crude protein, g/L	10 ± 2	11 ± 2	10 ± 2	11 ± 2	11 ± 2
Energy, kcal/L	616 ± 72	613 ± 74	611 ± 75	610 ± 75	591 ± 74
Folate, nmol/L	191 ± 83[a]	139 ± 39[b]	145 ± 55[b]	143 ± 56[b]	177 ± 62[a,b]
Total vitamin C, mg/L	15 ± 12[a]	5.4 ± 6.7[b]	5.9 ± 8.5[b]	4.2 ± 4.1[b]	3.7 ± 2.8[b]
Ascorbic acid, mg/L	14 ± 11.2[a]	5.4 ± 6.5[b]	5.5 ± 6.8[b]	2.9 ± 3.3[b]	3.3 ± 3.4[b]

[1]Values are means ± SDs, $n = 17$ for each group. Data were analyzed using linear regression models (PROC MIXED) followed by pairwise comparisons as appropriate (LS-MEANS). Labelled means in a row without a common letter differ, $P < 0.05$. HHP, high hydrostatic pressure processing.

(Pitino et al., 2019)

Implications for Nursing Care

Family Education
- Provide evidence supporting administration of HDM.
  - Emphasize screening and pasteurization processes (Baumgartel & Dean, 2019).
- Challenge parent preference of refusal of HDM (Baumgartel & Dean, 2019).
- Provision of HDM is an ethical obligation for optimal care.
  - Engage family in a benefit vs risk analysis (Baumgartel & Dean, 2019).
- Recognize cultural norms that may impact viewpoint on HDM.

Access issues
- Cost prohibitive for some hospital systems (Fengler et al., 2020).
  - Pasteurized HDM costs significantly more per day of care than MOM or formula (Fengler et al., 2020).
- Lack of availability in underserved communities.
- Triaging the most critically ill neonates.

Advocacy
- Support further research into best practices for pasteurization (Matthews et al., 2020).
- Follow applicable legislation and demand Medicaid reimbursement for HDM (Fengler et al., 2020).

Special Considerations

Coronaviruses are known to cause severe respiratory syndromes such as SARS, MERS, and COVID-19 (Spatz, 2020). Research on the transmission of COVID-19 through human milk has been limited. Samples of HDM from positive, symptomatic patients have been tested and the virus has not been detected (Spatz, 2020). Evidence indicating that COVID-19 is transmitted primarily through respiratory droplets have led organizations to recommend that symptomatic women mask when directly breastfeeding their infant (Spatz, 2020). The vital role HDM plays in infant health indicates that it should continue to be utilized to provide better outcomes. Spatz specifically states (2020) "During this current pandemic, there have been reports of formula shortages and cost gouging the cost of infant formula. We should use this pandemic as a way to increase the visibility of the critical role of human milk and breastfeeding for all families at all times".

Conclusions

Infant growth rates are stated to be a direct result of the quality of the lipidome provided through human milk. Carotenoids, valuable for their anti-oxidative properties, and bile salt simulated lipases (BSSL), which allow easy digestion of lipids in an infant's gastrointestinal tract, are among the most affected components during thermal pasteurization. High pressure processing is a non-thermal way to reduce the impact of the process on human donor milk, allowing the nutritive and protective properties to transfer to the infant upon ingestion (Wesolowska et al., 2020).

Without the application of heat, UVC avoids damaging protein content by aggregation and denaturation. DNA of microorganisms present in the milk is damaged by the irradiation and important bioactive factors are spared, as

Conclusions Cont.

evidenced through analysis of milk proteins and lipases (Li et al., 2017). The increased preservation of bioactive components was achieved with UVC while also managing to reduce the bacterial load effectively. UVC is a superior method of pasteurization and can be applied to donated human milk to increase benefits to the neonatal population. A randomized controlled trial would best determine treatment methods to achieve optimum growth and intestinal health in neonates (Li et al., 2017).

Lipids and proteins were the most affected by the application of heat. Macronutrient concentrations were significantly decreased following pasteurization by the Holder method (Piemontese, 2019).

Overall, additional research is needed to determine best practices for human milk pasteurization and evaluate the reduction in nutrients and active biochemical components (Matthews et al., 2020).

References

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