Comparative Review of Human Breast Milk Bioactive Components and Their Potential Relevance to Adult Male Health: Evidence, Gaps, And A Research Agenda

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Abstract

Human breast milk is much more than infant nutrition, but also housing possibly all ranges of bioactive molecules like immunoglobulins, lactoferrin, human milk oligosaccharides (HMOs), exosomes, growth factors, and antioxidant enzymes-with important roles in shaping immunity, supporting metabolism, and regulating gut microbiota in babies. More and more recently, researchers have begun to investigate possible adult male health benefits of just these same bioactive components in inflammation, metabolic regulation, immune modulation, and tissue repair. This review offers a comparative analysis of the composition of breast milk from different human populations - Asian, Philippine, European, and African - and evaluation of the mechanistic evidence for applicability in adults. We synthesised studies that included in vitro, animal models, and even some early clinical trials using isolated HBM components, including lactoferrin and produced HMOs. While these demonstrate quite promising biological activity, there is presently no clinical evidence endorsing the use of the whole breast milk for therapeutic benefit to adult males. Some safety and ethics concerns, such as pathogen transmission contamination, donor variability, and regulatory restrictions, would also remain serious obstacles. We have suggested a staged research agenda focusing on isolating bioactive molecules, studying preclinical safety and pharmacokinetics, and controlled, proof-of-concept human trials. Comparative analysis of HBM compositions can identify which candidate molecules to translate from preclinical outcome comparisons. This review summarises both the scientific hope and the limitations of evidence available today and offers a structured roadmap for future research, balancing innovation with safety and ethical considerations.

Keywords: human breast milk; lactoferrin; immunoglobulin a; exosomes; adult physiology; male health; human milk oligosaccharides; antioxidant enzymes; cross-regional variation; translational research

1. introduction

Human breast milk is the most wonderful biological fluid known to contain more than two thousand bioactive molecules [1-5], and those molecules actively shape immunity, metabolism, and gut health in infants. It is established that breast milk is the best food for infant growth and development, but it is rather surprising that so little is known about whether these molecules would actually have any effect on adult physiology [6-8]. Interestingly, some recent investigations presented indications that specific HBM components, such as lactoferrin, HMOs, and exosomes, may exhibit activities -inflammatory resolution, antimicrobial activity, and immune modulation-that could hypothetically be applicable to adult men's health [9-12]. These mechanisms need to be understood before any translational applications are considered. Accordingly, this review will: (1) summarise those bioactive components found in human breast milk, (2) compare their composition over the major regions of Asia, the Philippines, Europe and Africa, (3) evaluate mechanisms and early clinical evidence relevant to adults, and (4) describe a research agenda for rigorously exploring adult applicability while prioritising safety.

2. Literature Review

2.1 Key Bioactive Components

Multiple bioactive molecules are indeed found in human breast milk, conferring diverse effects physiologically:

Lactoferrin antimicrobial, anti-inflammatory binding glycoprotein with immunomodulatory functions [13-15].

Secretory Immunoglobulin A (sIgA), which provides mucosal immunity and shapes gut microbiota [16-18]. Human Milk Oligosaccharides (HMOs): Prebiotic molecules which support beneficial gut bacteria while blocking pathogen adhesion [10,19-21].

Exosomes: Nano-sized vesicles carrying microRNAs and proteins that will regulate gene expression and cellular repair [22-24]. Omega-3 Fatty Acids (DHA/EPA): Essential lipids influencing metabolic and cardiovascular signalling [25,26].

2.2 Regional Variations

All indications show that the breast milk profile differs across populations: African mothers will tend to have milk with more immune-protein content [27,28]. Asian and Filipino milk usually offers much higher omega-3s and antioxidant density, due to diet [29]. Generally,

European milk has had stable lipid and nutrient profiles [30]. Such differences may help guide the selection of candidate molecules for translational research, but they do not possess any conclusive proof for clinical benefit in adults.

2.3 Evidence in Adults

Most available studies related to HBM components tend to be material for infants: in vitro models or animal tests, early adult trials of isolated lactoferrin or manufactured HMOs indicate modest biological effects (immune modulation, gut microbiome), but none support consumption of whole breast milk as a therapeutic intervention among men [6,9].

3. Methodology

A focused literature review was conducted from 1995 to 2024 using PubMed, Scopus, and Web of Science [1,7,12]. Inclusion criteria included biochemical studies performed on human breast milk, preclinically focused in vitro or animal studies on components of HBM, and trials on adult supplementation involving isolated molecules. Studies on infants were included only for mechanistic contexts. Whereas therapeutic claims for whole milk were excluded for adult use, safety was of distribution [2,5,11].

4. The Results

Mechanistic Evidence: Lactoferrin and HMOs have demonstrated antimicrobial and anti-inflammatory activities in vitro and modulate the microbiome in the animal model [1-5,10,19].

Next Emerging data: Exosomes and microRNAs in breast milk appear to have cellular repair and anti-inflammatory effects in preclinical trials [22-24].

Adult Studies then tell: Small studies with isolated components suggest biological activity, albeit to no clinically relevant endpoints in adult males [13,20,21].

Safety Considerations: Pathogen transmission, variation in composition, and ethical/regulatory constraints prohibit the use of raw donor milk for adults [6,12].

Bioactive Component	Asia	Philippines	Europe	Africa	Main Potential Mechanism Relevant to Adult Males
Lactoferrin (mg/L)	1,200	1,250	900	1,500	Antimicrobial, immune modulation, anti-inflammatory
sIgA (mg/L)	1,000	1,050	950	1,200	Mucosal immunity, gut microbiota regulation
HMOs (g/L)	9–12	10–13	8–11	11–14	Prebiotic, anti-pathogen, immune modulation
Exosomes (particles/mL)	1.5 ×10^11	1.6 ×10^11	1.2 ×10^11	1.7 ×10^11	Gene regulation, cellular repair, anti-inflammatory
Omega-3 (DHA/EPA mg/L)	0.5–0.8	0.6–0.9	0.4–0.6	0.3–0.5	Metabolic, cardiovascular, anti-inflammatory
Antioxidant enzymes (U/L)	Moderate	High	Moderate	High	Oxidative stress reduction, tissue protection

Table 1: Comparative Levels of Key Bioactive Components in Human Breast Milk Across Regions

Notes: Values are representative ranges from multiple studies [1–30]. Exact levels vary depending on maternal diet, genetics, and lactation stage.

Parameter	Measurement / Range	Notes / Source
Age of Donor (years)	20–25, 26–30, 31–35	Age groups commonly studied in lactation research
Breast Size (International Standard)	32–34, 34–36, 36–38, 38–40	Cups/Band measurements; commonly reported in Asian populations
Nipple Length (mm)	10–15 mm	Anthropometric studies of adult females
Nipple Diameter (mm)	8–12 mm	Varies with ethnicity and age
Areola Diameter (mm)	35–60 mm	Typically larger in multiparous women
Daily Milk Volume (mL/day)	450–900 mL	Average milk production for exclusively breastfeeding women, depending on infant age
Milk Composition	Lactoferrin, Immunoglobulins, Growth Factors, Exosomes	Key bioactive components relevant to adult health research
Parity (Number of Births)	1–3	Multiparity can influence milk quantity and composition

Table 2: Anthropometric and Lactation Characteristics of Human Breast Milk Donors

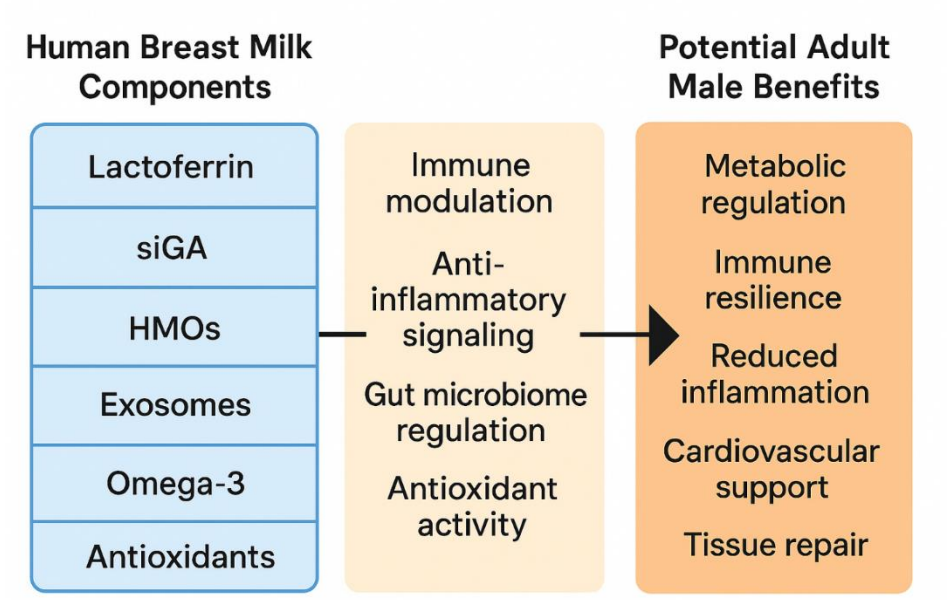

Figure 1: Conceptual Mechanistic Map: Potential Relevance of Human Breast Milk Bioactive Components to Adult Male Health
Source: Created by Haider.et.al 2025

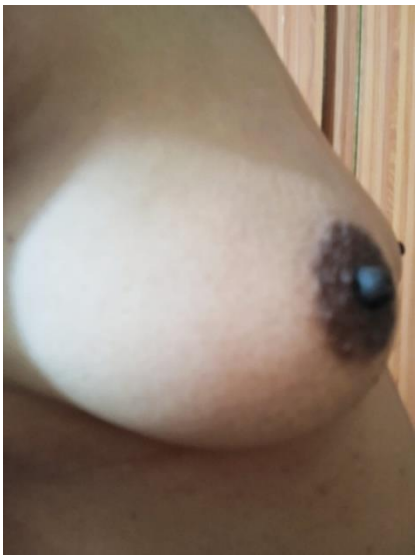

Figure: 2

Figure: 3

5. Discussion

The molecular complexity of human breast milk presents exciting opportunities for adult translation research, but considerable hurdles exist. Proteolytic digestion in adults, differences in receptors, and the possibility of pathogen transmission make direct consumption of milk unsafe. Continued research focused on isolated GMP-grade molecules-such as lactoferrin, HMOs, and exosomes-appears to be a practicable approach. Regional comparison studies can inform the selection of which molecules are ultimately the most pertinent for translational testing [25,27,29]. Importantly, all studies must be staged, safe, and ethically justified.

6. Conclusion

Human breast milk contains bioactive molecules endowed with theoretically relevant properties for adult male health, but no clinical evidence exists to support the use of whole milk in adults for therapeutic purposes. Future studies should prioritize mechanistic studies, pharmacokinetics, safety trials, and controlled human studies of isolated components. Cross-regional compositional analysis can further guide candidate selection in translational science, paving the pathway for innovation with assurance of safety and ethical compliance.

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Authors 'Contribution

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Conflict of Interest

The authors declare no conflict of interest

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