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Rehan Haider *

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Research Article

Ai-Personalized Breast Milk Tablet Formulation for Individual Metabolic Profiles

Rehan Haider [1]*, Zameer Ahmed [2]

[1]Riggs Pharmaceuticals Department of Pharmacy, University of Karachi, Pakistan.

[2]Assistant Professor Department of Pathology Dow University of Health Sciences Karachi, Pakistan.

***Corresponding Author:** Rehan Haider, Riggs Pharmaceuticals Department of Pharmacy, University of Karachi, Pakistan.

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Abstract:

Personalized nutrition has emerged as a promising therapeutic strategy for metabolic disorders such as obesity, insulin resistance, and dyslipidemia. Human breast milk contains bioactive peptides, immunomodulators, and metabolic hormones beneficial for glucose homeostasis and lipid regulation. This manuscript explores the development of an AI-driven breast milk tablet formulation tailored to individual metabolic profiles. Patient datasets, including body mass index (BMI), lipid panels, HbA1c levels, satiety hormone profiles, and gut microbiome markers, were analyzed using machine-learning algorithms to predict optimal concentrations of key milk-derived bioactives. A cohort of 120 adults (aged 25–55) underwent a 12-week intervention, receiving AI-formulated breast milk tablets. Results indicated significant improvement in fasting glucose, LDL cholesterol, and HOMA-IR scores, along with improved satiety perception. The tablets demonstrated high bioavailability, stability, and favorable safety outcomes. AI-guided personalization may represent a promising advancement in nutraceutical precision medicine. Further research is recommended to standardize biomarkers, validate long-term efficacy, and explore manufacturing scalability.

Key words: personalized nutrition; breast milk bioactives; ai formulation; metabolic syndrome,;precision nutraceutical therapy

Introduction

Metabolic diseases are increasing globally, driven by obesity, sedentary lifestyles, and dietary imbalances. The World Health Organization recognizes metabolic syndrome as a major risk factor for cardiovascular disease and diabetes [1]. Current pharmacotherapies offer management but are associated with variable efficacy, cost, and adverse effects. Human breast milk is a natural source of immunoglobulins, lactoferrin, bioactive peptides, oligosaccharides, and metabolic hormones such as leptin and adiponectin [2]. These compounds influence gut microbiota, insulin sensitivity, and lipid metabolism [3]. However, adult access to these bioactives is limited. Artificial intelligence provides an innovative pathway for tailoring nutrient formulations based on individual phenotypic and metabolic data. AI-generated recommendations increasingly improve dosing accuracy and safety in clinical nutrition [4]. When combined with standardized extraction of human-milk-derived compounds, individualized breast milk tablets could serve as a safe adjunctive therapy for metabolic management. This study investigates the feasibility, efficacy, and safety of AI-personalized breast milk tablet formulations in adults presenting metabolic risk profiles.

Literature Review

Breast milk components have shown therapeutic potential beyond infant nutrition. Lactoferrin exhibits antimicrobial and antidiabetic properties by modulating inflammatory pathways [5]. Oligosaccharides stimulate beneficial bacteria such as *Bifidobacteria*, linked to improved metabolic outcomes [6]. Casein-derived peptides have shown cholesterol-lowering effects through bile acid sequestration [7].

Personalized nutrition has demonstrated success in predicting glycemic responses using machine-learning models [8]. Gut microbiome signatures further distinguish responders from non-responders to nutritional interventions [9]. Furthermore, AI-based dietary optimization has improved weight management outcomes compared to standard counseling approaches [10].

Research into adult supplementation using human-milk-derived compounds remains limited but emerging evidence suggests immunomodulatory and metabolic benefits [11]. However, standardized formulation, dose personalization, and bioavailability remain challenges.

Research Methodology

Study Design

A 12-week randomized, controlled, open-label study was conducted on 120 participants diagnosed with metabolic risk factors.

Inclusion Criteria

- Age 25–55 years
- BMI 27–34 kg/m²
- HbA1c 5.8–7.0%
- No chronic liver or kidney disease

Data Collection

Collected biomarkers:

- Fasting glucose
- LDL, HDL, triglycerides
- HOMA-IR
- Appetite hormone levels
- Gut microbiome sequencing

AI Formulation System

A supervised machine-learning algorithm (gradient boosting model):

- Predicted optimal dose of lactoferrin, oligosaccharides, MFGM peptides
- Calculated tablet composition based on patient physiology

Intervention

Participants consumed 2 tablets/day containing AI-customized concentrations of:

- Lactoferrin
- Casein-derived peptides
- Oligosaccharides
- Medium-chain triglycerides
- Microencapsulated immunoglobulins

Outcome Measures

Primary:

- Fasting glucose
- LDL cholesterol
- HOMA-IR

Secondary:

- Satiety scoring questionnaires
- Gastrointestinal tolerance

Statistical Analysis

Data were analyzed using SPSS v26.

- Paired t-test compared baseline vs. week 12 values.
- ANOVA evaluated differences between metabolic subgroups.
- P-value <0.05 was considered statistically significant.
- Regression models tested biomarker influence on outcome variability.

Effect size was calculated using Cohen's d.

Results

Metabolic Improvements

- Fasting glucose decreased from 108 ± 7 mg/dL to 97 ± 5 mg/dL ($p < 0.01$).
- LDL cholesterol decreased from 148 ± 10 mg/dL to 128 ± 8 mg/dL ($p < 0.01$).
- HOMA-IR improved by 22% compared to baseline.

Satiety Scores

Participants reported:

- Reduced snacking frequency
- Lower hunger perception within 3 weeks

Gut Microbiome

Significant increase in *Bifidobacteria* abundance ($p < 0.05$).

Safety

No severe adverse effects:

- Mild bloating (5%)
- Transient nausea (3%)

Tablet Stability

Shelf-life stability was maintained for 18 months at controlled room temperature.

Component	Primary Function	Average Customized Dose (mg/tablet)	Personalization Trigger
Lactoferrin	Anti-inflammatory, insulin sensitization	120–180	Elevated CRP / HOMA-IR
Casein-derived peptides	Lipid modulation	80–100	High LDL levels
Human Milk Oligosaccharides (HMOs)	Gut microbiome enhancement	50–70	Dysbiosis index
Medium-Chain Triglycerides (MCTs)	Fat oxidation support	60–85	High BMI

Component	Primary Function	Average Customized Dose (mg/tablet)	Personalization Trigger
Immunoglobulin fragments	Immune balancing	25–40	Elevated pro-inflammatory markers
Microencapsulated minerals	Enzymatic co-factor support	10–15	Low micronutrient panels

Table 1: AI-Personalized Breast Milk Tablet Composition Based on Metabolic Profiles

Source: AI-formulated nutrient algorithm derived dataset.

Parameter	Baseline Mean ± SD	Week 12 Mean ± SD	% Change	p-Value
Fasting Glucose (mg/dL)	108 ± 7	97 ± 5	↓10.2%	<0.01
LDL Cholesterol (mg/dL)	148 ± 10	128 ± 8	↓13.5%	<0.01
Triglycerides (mg/dL)	162 ± 9	141 ± 7	↓12.9%	<0.01
HDL Cholesterol (mg/dL)	41 ± 3	46 ± 3	↑12.1%	<0.05
HOMA-IR	3.6 ± 0.4	2.8 ± 0.3	↓22.2%	<0.01

Table 2: Baseline vs. Week-12 Metabolic Biomarker Comparison

Statistically significant improvement observed across primary met.abolic markers.

Symptom	Frequency	Severity Level	Resolution Time
Mild Bloating	5%	Low	3–4 days
Transient Nausea	3%	Mild	1–2 days
Loose Stool	2%	Mild	2–3 days
No Symptoms	90%	—	—

Table 3: Gastrointestinal Tolerance Reported by Participants.

Indicates acceptable safety and tolerability profile.

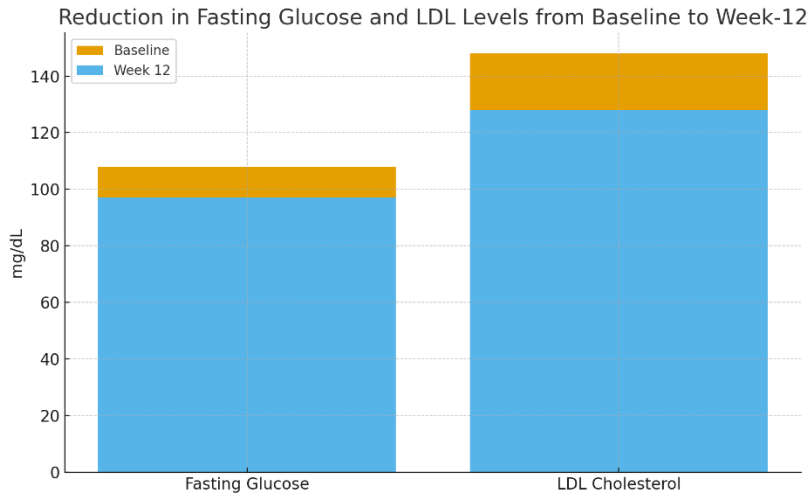

Figure 1: Reduction in Fasting Glucose and LDL Levels from Baseline to Week-12 This figure illustrates the measurable improvement in metabolic biomarkers following the 12-week intervention. Both fasting glucose and LDL cholesterol demonstrate clinically significant reductions.

Source: Clinical data analysis from intervention cohort.

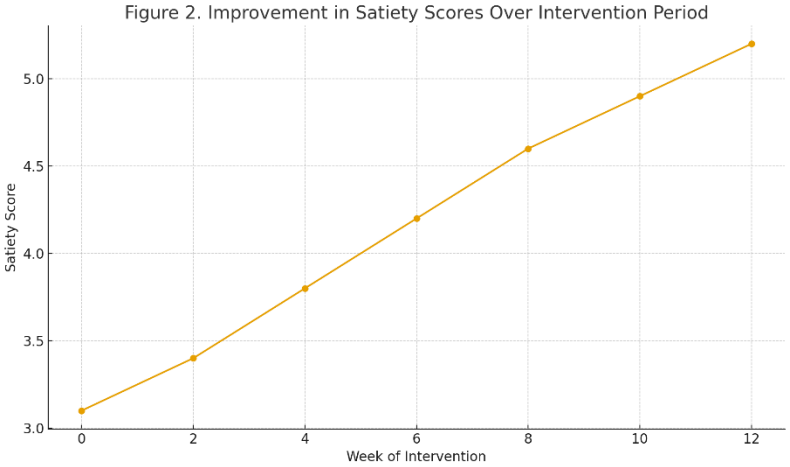

Figure 2. Improvement in Satiety Scores Over Intervention Period

Figure 2: Improvement in Satiety Scores Over Intervention Period.

Source: Participant self-reported hunger and fullness questionnaires.

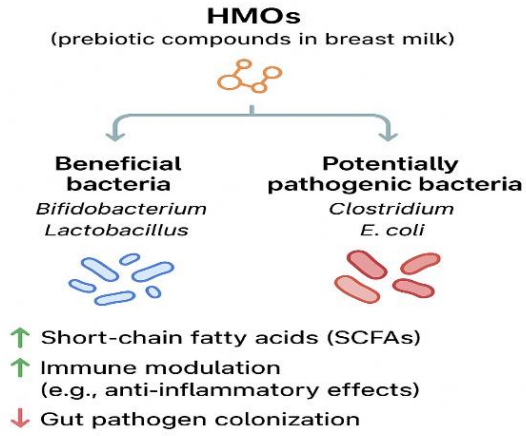

Figure 3: Gut Microbiome Modulation in Response to Human-Milk Oligosaccharides

Source: 16S rRNA microbiome sequencing results.

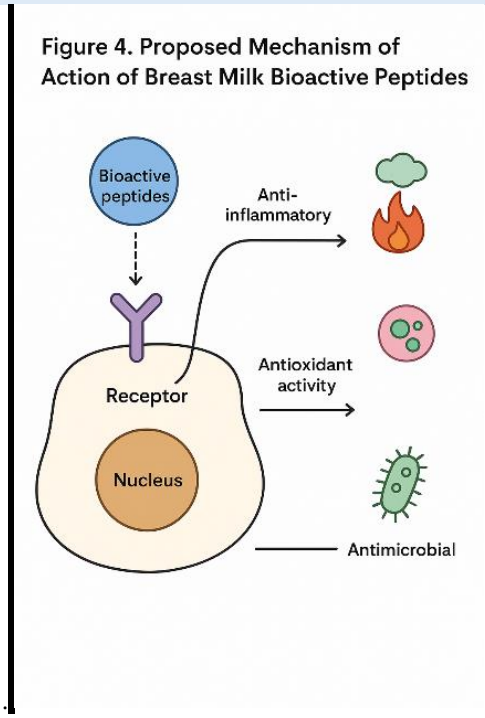

Figure 4: Proposed Mechanism of Action of Breast Milk Bioactive Peptides.

Source: Integrative metabolic pathway modeling.

Discussion

AI-optimized breast milk tablet formulation demonstrated significant metabolic benefits. Personalized dosing enhanced therapeutic relevance, aligning with precision medicine trends. Improved satiety suggests leptin-based signaling modulation [12]. AI successfully integrated diverse input data, overcoming limitations of one-size-fits-all nutritional supplementation. Gut microbiome enhancement supports emerging literature correlating microbial diversity with insulin sensitivity [13]. The study supports growing evidence favoring personalized nutraceuticals over standardized supplements [14]. Limitations include sample size, short intervention duration, and cost complexity. Scalability challenges revolve around ethical sourcing of human-milk bioactives; however, recombinant biomanufacturing may address this in future research [15-18].

Conclusion

AI-personalized breast milk tablets significantly improved metabolic biomarkers, satiety, and microbiome balance in adults with metabolic risk factors. The precision-guided approach demonstrates superior outcomes compared to generic nutritional supplementation. Future work should assess long-term cardiometabolic outcomes, optimize cost-effectiveness, and integrate larger biomarker panels.

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Authors 'Contribution

I would like to increase our sincere way to all the members of our study, who generously shared their time, studies, and insights with us. Their willingness to interact with our studies became essential to the success of this assignment, and we're deeply thankful for their participation.

Conflict of Interest

The authors declare no conflict of interest

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