REVIEW ARTICLE

Dairy Products and Metabolic Disorders: A Narrative Review of Current Evidence

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ABSTRACT

Dairy products present a complex relationship with human metabolic diseases. Evidence suggests that fermented dairy products are consistently associated with a reduced risk of metabolic disorders, likely mediated by bioactive proteins, minerals, vitamins, probiotics, and fatty acids. Effects are highly context-dependent, influenced by product type, processing, individual physiology, and overall diet. Current evidence supports prioritizing unsweetened, fermented dairy within balanced dietary patterns for overall metabolic health. This review examines the association between dairy consumption and the risk of metabolic disorders, the role of bioactive dairy components, and their implications for metabolic health outcomes.

Keywords: *Bioactive peptides, Dairy products, Gut microbiota, Metabolic disorder, Saturated fat*

INTRODUCTION

Milk and dairy products are nutritionally valuable components of a balanced diet throughout life (Visioli & Strata, 2014). For adults, consuming dairy daily – such as 2 glasses of milk or fermented alternatives like yogurt, kefir, or moderate amounts of cheese – helps meet essential nutrient requirements (Janiszewska *et al*., 2020). The relationship between dairy consumption and metabolic disorders—including type 2 diabetes (T2D), cardiovascular disease (CVD), obesity, and metabolic syndrome (MetS)—is complex and highly dependent on factors such as the specific dairy product, processing methods, individual genetics, gut microbiota, and overall dietary pattern.

Dairy Composition and Bioactive Components

Dairy products provide a unique matrix of essential macronutrients (bioavailable proteins like casein and whey, predominantly saturated fats alongside mono- and polyunsaturated fats and conjugated linoleic acid (CLA), and lactose) and micronutrients (calcium, potassium, magnesium, phosphorus, vitamins A, D, B12, and riboflavin). They also contain bioactive compounds, probiotics, and trace hormones (Muro *et al*., 2011; Pereira, 2014; Ranvir *et al*., 2023). Bioactive peptides released during digestion or fermentation demonstrate multifunctional properties: ACE-inhibitory peptides (lactokinin) lower blood pressure; immunomodulatory peptides (immunoglobulins, cytokines) regulate immune responses; antimicrobial peptides (lactoferrin, glycolipids, Casocidin) inhibit pathogens; mineral-binding phosphopeptides (caseinophosphopeptides) enhance nutrient absorption; and growth-promoting peptides (growth

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DAIRY PRODUCTS (Milk, Yogurt, Cheese, Kefir, Fermented Options)

Compositional Matrix			
Proteins	Lipids	Minerals	Bio-actives
Whey Casein	Saturated fatty acid CLA Odd-chain SFA Polar lipids	Calcium Magnesium Potassium Phosphorus Vitamin D	Probiotics ACE-inhibitory peptides Immunoglobulins Lactoferrin Growth factors

Mechanisms of Action			
Metabolic regulation	Cardio- vascular	Inflammatory modulation	Gut-related effect
↑ Insulin secretion (GLP-1/GIP) ↑ Insulin sensitivity ↑ Glucose uptake ↑ Satiety	↓ Blood pressure (ACE inhibition) ↓ LDL ↑ HDL	↓ Cytokines ↓ CRP Immune regulation	↑ Beneficial bacteria ↑ Barrier integrity ↓ Endotoxemia ↓ Gut permeability

Practical Recommendations	
Prioritize	Limit
Plain yogurt Kefir Aged cheeses (cheddar, parmesan) Unsweetened products	Sugar-sweetened yogurts Ice cream Flavored milk drinks Butter, cream (excess) High-fat non-fermented products
For lactose intolerance: Fermented dairy (reduced lactose), lactose-free products, enzyme supplements	

Fig. 1: Comprehensive overview of the relationship between dairy products and metabolic health (CLA, conjugated linoleic acid; SFA, saturated fatty acids; LDL, low-density lipoprotein; HDL, high-density lipoprotein; CRP, C-reactive protein; GLP, glucagon-like peptide; GIP, glucose-dependent insulinotropic polypeptide; ↑, increase; ↓, decrease).

factors) support organ development (Park & Nam, 2015). Figure 1 presents a conceptual framework organizing the complex relationships between dairy products and metabolic health.

Dairy and Metabolic Disease

Concerning T2D, a major global health burden characterized by insulin resistance and hyperglycemia, observational studies consistently associate higher total dairy intake, particularly yogurt and low-fat dairy, with a reduced risk of development (Sébédio and Malpuech-Brugère, 2016). Fermented dairy shows the strongest inverse association with T2D. Proposed mechanisms include whey protein's enhancement of insulin secretion (via GLP-1 and GIP) and satiety, synergistic roles of calcium and vitamin D in β-cell function and insulin sensitivity, probiotics modulating gut microbiota and inflammation, and the metabolic functions of magnesium and potassium (Gillespie *et al*., 2015; Asbaghi *et al*., 2019; Hadjimbei *et al*., 2022; Chu *et al*., 2023). However, added sugars in dairy products negate these benefits.

The impact of dairy fat, primarily saturated fatty acids (SFAs), on CVD risk is nuanced. While traditional views linked SFAs to increased LDL-C, fermented dairy (cheese, yogurt) often shows neutral or beneficial associations with CVD risk despite SFA content. Potential mechanisms include the "dairy matrix effect," calcium-binding fats, bioactive peptides (e.g., ACE-inhibitory effects that lower blood pressure), and probiotic modulation of gut health and inflammation. Low-fat fermented options may be prudent for high-risk individuals (Tapsell, 2015).

For MetS, a cluster of abnormalities often accompanying obesity, higher intake of low-fat and fermented dairy is generally associated with lower prevalence. Benefits likely stem from combined effects on insulin sensitivity, blood pressure (potassium, magnesium, bioactive peptides), HDL-C, and inflammation. Calcium and vitamin D may also influence adiposity through effects on thermogenesis, lipid oxidation, and fecal fat excretion (Kaess *et al*., 2012; Pannu *et al*., 2016; Teegarden *et al*., 2008).

Potential protective effects of dairy components (calcium, vitamin D, proteins, CLA) against certain cancers, notably colorectal cancer, are suggested by some studies (Lopez-Caleya *et al*., 2022; Boot *et al*., 2023), although evidence for prostate cancer risk remains inconclusive, warranting further research and potential individualized guidance (Downer *et al*., 2017; Sargsyan & Dubasi, 2020).

Finally, lactose intolerance affects a significant portion of the global population. Management strategies include lactose-free products or fermented options such as yogurt and aged cheeses, where bacterial fermentation substantially reduces lactose content, thereby improving digestibility (Facioni *et al*., 2020).

Future Directions

Despite substantial progress in understanding the metabolic effects of dairy products, important knowledge gaps remain. Future research should prioritize long-term randomized controlled trials comparing full-fat versus low-fat fermented dairy in diverse populations. Mechanistic studies are needed to clarify the roles of odd-chain saturated fatty acids and other bioactive lipids identified through metabolomic analyses. Personalized nutrition approaches that investigate interactions among dairy consumption, genetic variants (particularly lactase persistence), gut microbiota composition, and metabolic phenotypes will enable more precise dietary recommendations. Additionally, dose-response relationships for specific dairy types and their effects on hard clinical endpoints require further investigation.

CONCLUSION

Milk and dairy products are associated with reduced risks of obesity, type 2 diabetes, cardiovascular disease, and metabolic syndrome. These effects are attributed to their unique nutrient matrix, which contains high-quality proteins, bioactive peptides, minerals (calcium, magnesium), and fatty acids with metabolic activity. Current evidence suggests that dairy can be a beneficial component of metabolic health-promoting diets, although its effects vary depending on the product type and individual metabolic status.

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