The Dairy Food Matrix May Help Explain the Unique Health Benefits of Milk, Cheese and Yogurt

Overview

Dairy foods, including milk, cheese and yogurt, are nutrient-dense and provide a unique package of essential nutrients that are foundational components of nutritionally adequate, healthy eating patterns recommended by leading health and wellness authoritative organizations. Regular consumption of dairy foods is associated with a lower risk of cardiovascular disease, hypertension, type 2 diabetes and obesity and can promote immune, digestive, bone and muscle health. These favorable effects of dairy foods may stem from its unique food matrix – the interactions between dairy's nutrients, bioactive components and physical structure that may influence their health effects in ways that cannot be predicted by examining its individual nutrients alone. This means that dairy foods like milk, cheese and yogurt are more than the sum of their nutrients – they are wholesome, versatile foods that can play an important role in supporting whole body health.

Defining the dairy food matrix

The dairy food matrix refers to the diverse nutrients and bioactive components found in milk, cheese and yogurt, and the ways in which these components interact within their unique physical structures.[1,2] Every dairy food begins with milk, and its transformation into different types of yogurt and cheese yields distinct food matrices, reflecting the assortment and versatility of the many nutrient-dense options that make up the dairy food group.[1,3] Food matrix science is an emerging area of research, and growing evidence suggests a food's matrix may impact digestion, metabolism and health outcomes in different and complementary ways.[3]

Dairy foods provide a package of essential nutrients that benefit health and wellness across the lifespan

Nutrient-dense dairy foods (i.e., milk, cheese and yogurt) provide a unique package of up to 13 essential nutrients

that help support health and well-being across the lifespan and there's room to improve consumption because they are often underconsumed.[4] Milk, cheese and yogurt contribute substantially to dietary intakes of key nutrients such as calcium, vitamin D and potassium, which play important roles in bone health, muscle function and other physiological processes.[4] Dairy foods also provide an important array of nutrients that are important for growth and development as well as promotion of cardiometabolic, immune and bone health, including high-quality protein (whey and casein), vitamin B12, vitamin A, phosphorus, magnesium, zinc, selenium and iodine.[5-7] Iodine, in particular, plays a critical role during pregnancy and lactation by supporting healthy fetal and infant development.[8] The concentrated package of essential nutrients found in dairy foods is difficult to replace with non-dairy foods without increased costs and added calories in the diet. Modeling studies indicate that consuming the recommended daily amounts of dairy foods consistent with the Dietary Guidelines for Americans (DGA) can help close many nutrient gaps experienced by Americans at an affordable cost.[4,9,10]

Since its first publication in 1980, dairy foods (i.e., milk, cheese and yogurt) have been considered a distinct food group in the DGA due to their unique and wide-ranging nutrient contributions to healthy eating patterns. The health benefits of dairy milk and other dairy foods are backed by decades of peer-reviewed literature that supports the role of dairy foods, both as a food group alone and as part of healthy eating patterns, in reduced risk of diet-related diseases, including obesity, hypertension, cardiovascular disease and type 2 diabetes.[11] Because dairy foods provide readily bioavailable nutrition that is affordable and accessible, they can be an important part of a practical, whole food approach to help Americans achieve nutritionally adequate, healthy diets.

Beyond nutrients, dairy foods contain a rich array of bioactive compounds

In addition to essential nutrients, dairy foods can contain a broad variety of bioactive components, such as bioactive peptides, polar lipids, oligosaccharides and other compounds that may influence metabolism, immune function and gut health.[1,12,13] Milk, the starting food for all other dairy foods and products, contains hundreds of bioactive compounds, with others formed during fermentation.

Bioactive peptides

Bioactive peptides, made up of short chains of amino acids, are among the most well-known bioactive compounds in dairy foods. Mechanistic research has linked certain bioactive peptides found in dairy foods with potential antioxidant, anti-inflammatory and antihypertensive effects, such as inhibition of angiotensin-converting enzyme (ACE), a key regulator of blood pressure.[13-16] *In vitro* studies also suggest a potential role of casein-derived peptides in enhancing mineral absorption by binding calcium and phosphorus and consequently increasing their solubility and bioavailability.[16,17]

Bioactive lipids

Dairy fat is the most complex fat found in nature, containing >400 distinct fatty acids organized into two main structural components: the milk fat globule membrane (MFGM), a naturally occurring tri-layer membrane that surrounds each fat droplet, and the triglyceride core inside the droplet.[18] Components of the MFGM, such as polar lipids including phospholipids and sphingomyelin, have been linked via experimental research with potential bioactivity that may promote intestinal barrier integrity, regulate lipid absorption and reduce inflammatory signaling.[19,20] The triglyceride core contains a wide range of fatty acids, including short-, medium-, odd- and branched-chain fatty acids as well as naturally occurring *trans* fatty acids, and results of emerging research have linked these with potential improvements for lipid metabolism, inflammation and gut health.[21,22]

Fermentation-derived bioactives

Fermentation further diversifies the bioactive profile of dairy foods. During fermentation, live and active cultures transform milk into yogurt, kefir and certain cheeses, changing both the food's physical structure and its profile of

nutrients and bioactive compounds. As part of this process, these beneficial microbes modify milk components and generate new bioactives which may function to influence gut barrier function, immune response and metabolic signaling as part of fermented dairy foods.[13,23-25] For example, fermentation can convert vitamin K_1 found in dairy milk to vitamin K_2, a nutrient that has been linked with benefits for bone and cardiometabolic health.[25,26] Additionally, live and active cultures found in some fermented dairy foods may survive digestion, potentially contributing to favorable shifts in the gut microbiome.[23,25,27]

Nutrients and bioactives may work together within a dairy food to impact health outcomes

An emerging body of research suggests that each food's unique matrix – the combination of its nutrition, bioactive compounds and physical structure – may influence the timing of digestion, absorption and bioavailability of its components, ultimately, affecting health outcomes. This concept is known as the food matrix effect and may help explain the health benefits of dairy foods that have been consistently observed in decades of nutrition research.[28-30]

Mechanistic research suggests the unique dairy food matrix may play a role in the well-documented benefits of dairy foods for bone health. Dairy foods provide more bone-supporting nutrients than any other food or food group. These nutrients include high-quality protein, calcium, vitamin D, potassium, magnesium, phosphorus, iodine and zinc. In dairy milk, about two-thirds of calcium is bound within protein clusters called casein micelles, and these casein micelles may help carry calcium through the gastrointestinal tract and support its gradual release during digestion and efficient absorption by the body.[2,12,17,31]

The health benefits linked to consuming fermented dairy foods, such as yogurt, kefir and certain cheeses, may also be due in part to their food matrix. For example, *in vitro* research suggests yogurt's food matrix may help enhance the viability of its live and active cultures when eaten, enhancing the likelihood that the microbes will survive digestion and make it to the colon to promote gut health.[32,33] Researchers have also examined why cheese, a food that can be higher in saturated fat and sodium, is associated with beneficial to neutral impacts on blood pressure and overall cardiovascular health.[34-37] While more research is needed, one contributing mechanism may be the way in which the overall food matrix of cheese affects fat and mineral absorption.[38,39] During digestion, calcium in cheese binds to fatty acids to form insoluble calcium soaps, inhibiting their absorption.[40,41] Overall, the food matrix is an emerging area of science, and continued research will deepen understanding of the complex interplay between single nutrients, a whole food, diet and health.

The intersection of food matrix science and public health application: Yogurt qualified health claim

Milk, cheese and yogurt are associated with a reduced risk of type 2 diabetes.[51,52] In fact, a new qualified health claim for yogurt was announced on March 1, 2024 by the U.S. Food and Drug Administration (FDA).[53] The claim identifies a potential link between regular yogurt consumption and a reduced risk of type 2 diabetes, stating, "Eating yogurt regularly, at least 2 cups (3 servings per week), may reduce the risk of type 2 diabetes according to limited scientific evidence."

The evidence supports the health effects of yogurt as a food, rather than related to any single nutrient or compound and thus is independent of fat or sugar content. This qualified health claim provides an example of how food matrix science can be applied in the future to benefit public health.

Opportunities for food matrix science in public health

Food matrix science offers a valuable framework for advancing a whole-food approach to nutrition guidance. Beyond the importance of individual nutrients, a food matrix perspective also considers how whole foods and overall eating patterns influence health and well-being across the lifespan.

Study Spotlight: Examining the role of whole milk dairy foods in cardiometabolic health through a food matrix lens

The complexity of dairy fat, which is part of the total food matrix of milk, cheese and yogurt, may help explain the link between dairy food consumption across a range of fat levels and beneficial to neutral cardiometabolic health outcomes.[29] In an analysis of three separate prospective cohort studies involving 120,877 participants conducted in the U.S. (with follow-up period up to 24 years), researchers examined the relationship between eating habits and weight gain every four years.[42] They found that long-term weight change was associated with specific foods rather than being predictable based on the total and saturated fat content. Weight gain after four years was most associated with consumption of potato chips, potatoes, sugar-sweetened beverages and unprocessed/processed meats. Weight loss after four years was most associated with consumption of vegetables, whole grains, fruits, nuts and yogurt. No significant differences in weight were associated with the consumption of composite whole-fat dairy foods, including whole milk and cheese, as well as low-fat dairy foods and low-fat or skim milk.

These findings are consistent with decades of observational and clinical evidence that indicates consuming dairy foods, including whole- and reduced-fat milk, cheese and yogurt, is associated with beneficial to neutral effects on cardiometabolic health.[43-47] This study and the current body of science suggests that a food-based approach – one that considers a food's matrix rather than individual nutrients alone – may be most meaningful when examining diet and health.[54]

Recommendations from major medical and health authorities and the DGA increasingly emphasize whole foods and eating patterns rather than isolated nutrient targets.[4,48-50] This evolution reflects a growing recognition that people eat foods, not individual nutrients, and that the health effects of a diet are impacted by the interplay of foods consumed together. Food-based nutrition guidance provides an opportunity to translate evolving scientific evidence, such as insights from food matrix research, into practical, whole-food messages that support balanced, nutrient-rich eating patterns. For health and wellness professionals, applying this approach may also help better communicate the important role of foods in shaping overall nutrition, diet quality and health.

Conclusion

Together, food matrix research suggests that the health effects of dairy foods are explained by more than their individual nutrients alone. Interactions among nutrients, bioactive compounds and the physical structure of a dairy food's matrix may influence digestion, absorption and metabolism in ways that help explain the consistent evidence supporting the health benefits of milk, cheese and yogurt across a range of fat levels. As the science continues to evolve, a food matrix perspective may strengthen understanding of dairy foods within a whole-food approach to nutrition and health.

Key Takeaways for Health & Wellness Professionals

- **Dairy foods are whole foods that offer more than individual nutrients.** The dairy food matrix reflects how nutrients, bioactive compounds and physical structure interact to influence digestion, absorption and overall health effects.[1-3,28-30]
- **Each dairy food provides a unique package of essential nutrients and bioactives.** Milk, cheese and yogurt contain a unique combination of nutrients and bioactives – potentially including bioactive peptides, polar lipids and other fermentation-derived compounds – that may work together to support health in ways that may be difficult to replicate with non-dairy foods.[1-3,12,13-27]
- **Fermented dairy foods may offer distinct benefits through their unique matrix.** Foods like yogurt and certain cheeses contain live cultures and bioactives that may support gut, immune and metabolic health. Research also suggests yogurt's unique food matrix may help explain its health benefits across a range of fat and sugar levels.[13,23-28]
- **The complex matrix of whole-milk dairy foods may help explain their effects on cardiometabolic health.** Decades of research suggest that consuming dairy foods across a range of fat levels is associated with beneficial or neutral cardiometabolic outcomes, suggesting their health effects depend on the whole food, not just saturated fat content.[29,42-47,54]
- **A whole-food approach to nutrition and health may be more meaningful than focusing only on single nutrients.** For health and wellness professionals, a food matrix perspective can help support practical guidance that helps people build balanced, nutrient-rich eating patterns.[29,54]

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