Supplement Article

Looking beyond traditional nutrients: the role of bioactives and the food matrix on health

Christopher J. Cifelli

The unique physical-chemical properties of foods directly impact their digestion and absorption. Dairy foods are key components of healthy eating patterns because they provide protein and essential vitamins and minerals to the diet. Additionally, scientific evidence has shown that the benefits of milk and dairy foods on health are due to the overall composition of the whole food rather than its individual nutrients. Indeed, the unique bioactive components of milk and dairy products are integral to the health benefits attributed to dairy foods. A better understanding of the dairy matrix and the protein- and fat-derived bioactive components of milk and dairy products will help inform evidence-based dietary guidance.

Foods are complex. They are comprised of macro- and micronutrients that are packaged into a complex physiochemical structure. The unique structure and physical–chemical properties of each food impact how it is digested and the absorption of the nutrients contained within the food. Accordingly, there has been a shift in nutrition science from considering foods as nutrient delivery vehicles and focusing solely on meeting nutrient requirements to a whole-food approach that recognizes that the health value of foods is more than the sum of their nutrient parts. This concept – referred to as the food matrix – considers all the attributes of food, including its microstructure, texture, and form (eg, solid, gel, liquid), and how the nutrients and bioactive compounds are packaged and compartmentalized. Collectively, these attributes interact in ways that influence the digestion of food, the absorption of nutrients and bioactive compounds, and the physiological functions that impact health.[1,2] Additionally, scientific advances are enabling a deeper understanding of all the components present in foods and their potential impacts on health. Indeed, efforts like the Periodic Table of Food Initiative are working to create a public database of the biochemical composition and function of the food to help address nutrition-related challenges.[3]

Milk and dairy products form a complex food group. Nutritionally, milk is a nutrient-dense beverage that provides high-quality protein and essential vitamins and minerals. Indeed, dairy foods make significant contributions to the nutrient intakes of children and adults in the United States. For all Americans 2 years and older, milk is the number 1 food source of 3 of the 4 under-consumed nutrients of public health concern identified by the 2020–2025 Dietary Guidelines for Americans (DGA): calcium, vitamin D, and potassium.[4,5] Milk and dairy products are well recognized for their nutritional contributions to the diet and, as such, their consumption is recommended by government and health professional organizations, including the 2020–2025 DGA, the American College of Cardiology/American Heart Association, the American Academy of Pediatrics, and the National Osteoporosis Foundation.[6–10]

Affiliation: *Christopher J. Cifelli* is with National Dairy Council, Rosemont, Illinois, USA

Correspondence: *Christopher J. Cifelli*, National Dairy Council, 10255 West Higgins Road, Suite 900, Rosemont, IL 60018-5616, USA. E-mail: chris.cifelli@dairy.org.

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While dairy foods are well recognized for their nutrient contributions to healthy diets, the nutrients are only one component in the overall structure of dairy foods. Indeed, milk is a source of functional, bioactive compounds that may contribute to overall health. A growing body of research indicates that the consumption of dairy foods is linked with a lower risk of high blood pressure, cardiovascular disease, stroke, and type 2 diabetes.[11–16] The neutral or beneficial effects of consuming dairy foods on chronic disease risk may be explained in part by the combinations of components in the food matrix of the various milk and dairy products. Examples of potentially bioactive components that have been studied for their additive or synergistic effects include milk-derived bioactive peptides, the unique structure and functional components of the milkfat globule and the milkfat globule membrane, and bovine oligosaccharides. A growing recognition of the benefits of consuming dairy foods from the food matrix perspective has been described in many recent reviews.[17–20] Emerging evidence has shown that there are biologically active components embedded in the major milk proteins and fats that have potential health-promoting activities. The characteristics of the proteins in milk (eg, casein, whey) and the milkfat within the dairy food matrix influence the bioavailability of amino acids, bioactive peptides, fatty acids, and other lipid components. In the case of milkfat, the food form (eg, milk, cheese, or yogurt), the viscosity, the type of lipid emulsion, and the size of the particles can influence the digestion and absorption of the fatty acids from milk. For example, the long-chain saturated fatty acids (eg, palmitic acid, stearic acid) may be precipitated as calcium soaps or form crystals within the intestine during digestion, and this in turn will reduce the absorption and increase fecal excretion of both saturated fatty acids and calcium.[17] Additionally, milkfat is the most complex of all naturally occurring fats. Compositionally, milkfat contains many lipid species and more than 400 fatty acids. Structurally, the fatty acids and lipids in milkfat are organized in architecturally unique milkfat globules. The milkfat globules are highly diverse and consist of a triglyceride rich core and a milkfat globule membrane that contains numerous bioactive components. Taken together, the dairy matrix may help explain why saturated fatty acids from whole-fat dairy (e.g. whole-fat cheese, milk, and yogurt) does not seem to be physiologically equivalent to non-dairy sources of saturated fat on cardiovascular disease risk.[17,21]

There is increasing interest in the lesser known and less often discussed components that make up the immense diversity of compounds naturally present in milk. The dairy matrix offers a holistic way of understanding the benefits of dairy foods through its complex structure. The dairy group includes many highly diverse milks and dairy foods. Commercially available milks include forms with different fat levels (eg, whole, reduced-fat, low-fat, non-fat), flavors (eg, chocolate), and levels of lactose (eg, lactose-reduced, lactose-free). Fermented milk products include a wide variety of yogurts (eg, made with whole milk, low-fat milk, or non-fat milk; flavored and/or with fruit) and other fermented forms (eg, kefir), and hundreds of different cheese varieties. Additionally, the food matrices of milk and dairy products vary considerably. The structural and physicochemical characteristics of dairy products differ in their compactness, hardness, elasticity, protein-to-lipid ratio, calcium-to-phosphorus ratio, fermentation effects, and size of fat globules. For example, yogurt, a semi-solid, is produced by fermentation of milk. Although its nutrient content is similar to that of milk, fermentation leads to differences in its bioactive components when compared with those of milk.

It is apparent that the benefits of milk and dairy foods on health extend beyond those from individual nutrients to the overall make-up of the whole dairy food. The unique bioactive components that become available during the digestion of milk or other dairy products appear necessary for providing particular physiological benefits to the host. A better understanding of the relationship between the dairy matrix and health is needed to inform evidence-based dietary guidelines. Therefore, the reviews included in this supplement provide a state-of-the-science discussion of the dairy food matrix and of the evolving research on the protein- and fat-derived bioactive components in milk, cheese, and yogurt and other fermented dairy foods. Gaps and opportunities to improve understanding of these bioactive components will be explored. In addition, 1 article will discuss common and novel food-processing techniques and their impact on the isolation and functionality of the various bioactive components of milk.

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