Advances in Nutrition 14 (2023) 363–365

Advances in Nutrition
AN INTERNATIONAL REVIEW JOURNAL
journal homepage: https://advances.nutrition.org/

Perspective

Perspective: Seeing the Forest Through the Trees: The Importance of Food Matrix in Diet Quality and Human Health

Gregory D. Miller [1,*], Jean Ragalie-Carr [1], Moises Torres-Gonzalez [2]

[1] *National Dairy Council, 10255 W Higgins Rd, Rosemont, IL 60018, USA;* [2] *Nutrition Research, National Dairy Council, 10255 W Higgins Rd, Rosemont, IL 60018, USA*

A B S T R A C T

Poor nutrition is linked to morbidity and mortality globally. The nutrition transition toward diets composed of high amounts of ultra-processed foods that are more refined, calorie-dense, and poor in nutrients is considered a factor in the rise of diet-related metabolic diseases in low- and middle-income countries. Historically, nutrition strategies aimed at mitigating metabolic diseases linked to suboptimal diets have targeted isolated nutrients such as fats; however, they overlook the complexity and importance of whole foods and food matrices, which can lead to unintended consequences such as avoidance of nutrient-dense foods. Dairy foods, such as milk, cheese, and yogurt, are underconsumed nutrient-dense foods that often fall in the cross-hairs of reductionist nutrition strategies because of their contribution of calories, saturated fat, and sodium to the diet. This article highlights dairy foods as an example for exploring the complex matrices of food, nutrients, and other bioactive components that are associated with improved nutrient status and reduced risk of metabolic diseases while considering a holistic approach to improving diet quality and human health.

Keywords: food matrix, diet quality, dairy, cheese, yogurt, milk

Statements of Significance

Historically, nutrition strategies aimed at mitigating metabolic diseases linked to suboptimal diets have targeted isolated nutrients such as fats; however, they overlook the complexity and importance of whole foods and food matrices and can lead to unintended consequences. This article explores the complex matrices of nutrients and other bioactive components that are associated with improved nutrient status and reduced risk of metabolic diseases and considers a holistic approach to improving diet quality and human health.

Perspective

Low-quality diet is linked to leading causes of death worldwide

Good nutrition is fundamental to human health, with an estimated 1 in 5 adult deaths globally attributed to suboptimal diets [1]. Rapid increases in rates of obesity and metabolic diseases, such as heart disease, cancer, and diabetes, are in part attributable to a global nutrition transition toward diets with high amounts of ultraprocessed foods that are more refined, calorie-dense, and poor in nutrients, many of which have been reformulated to create alternatives to staple foods [2] such as flavored rice and mixed dishes, for example, frozen pizza and burritos. Additionally, noncommunicable diseases (NCDs) are the leading cause of death worldwide, disproportionally affecting people in low- and middle-income countries (LMICs) [3]. Of note, the metabolic diseases affecting higher-income countries, such as heart disease and type-2 diabetes, are emerging in lower-income countries [4], with 82% of premature NCD deaths occurring in LMICs [5], which are currently faced with the triple burdens of malnutrition, micronutrient deficiencies, and overweight or obesity [4]. Current data, the

Abbreviations: FOP, front-of-pack; LMIC, low- and middle-income countries; NCD, noncommunicable disease.

* Corresponding author: *E-mail address:* gregory.miller@dairy.org (G.D. Miller).

https://doi.org/10.1016/j.advnut.2023.03.005
Received 28 September 2022; Received in revised form 13 January 2023; Accepted 9 March 2023; Available online 17 March 2023

majority of which is from higher-income countries, indicate that marginalized groups have a higher burden of NCDs [5]. Data from higher-income countries also indicate that higher overall diet quality is associated with reduced risk of NCDs [6,7], with dietary guidance in these countries now focusing on recommendations for an overall dietary pattern approach to improve public health [8]. For example, even guidance from the American Heart Association now emphasizes a dietary pattern approach to improve cardiovascular health [9].

Reductionist nutrition strategies aimed at mitigating disease ignore the food matrix and may lead to unintended consequences

Attempts to improve diet quality globally have traditionally relied on reductionist nutrition recommendations that focused on the presence or absence of individual nutrients. For example, front-of-pack (FOP) nutrition labeling schemes have been proposed as a mechanism to help consumers make healthier food choices by labeling foods according to their nutrient content, but they have limitations. Although the assumption is that FOP labeling may encourage healthier food purchases [10], the data are mixed [11]. Unlike food-based dietary guidelines that provide an overarching framework for healthy dietary patterns, FOP labeling provides guidance to select specific foods, which raises questions on the criteria used to define terms, the implications of assigning healthiness values to individual foods in the context of complex diets [12], and how those messages are received by consumers [13].

The need for nuance in nutrition strategies aimed at improving public health is apparent when considering nutrient profiling schemes [14], and FOP labeling fails to capture food-matrix effects on human health. The food matrix refers to not only the chemical and physical components of food but also their molecular relationships that affect how food is digested and metabolized [15]. Whole-milk dairy foods, for example, are complex matrices of macronutrients, micronutrients, and other bioactive components that are differentially packaged and compartmentalized, which affect how they are digested, absorbed, and utilized within the body [16,17]. The effects of individual dairy foods such as milk, cheese, or yogurt on human health cannot be predicted solely by their saturated fat and/or sodium content. For example, a dietary intake assessment of prepackaged Graviera cheese and a nutrition characterization study using the standard European Nutri-Score FOP labeling scheme in Greece observed that although Graviera cheese was a valuable source of nutrients in the Greek diet, it was classified by the Nutri-Score as "less healthy" because it contained "negative" nutrients such as saturated fat and sodium [18]. The "less healthy" designation was inconsistent, however, with Greece's food-based dietary guidelines that encourage daily consumption of dairy as a basic food [18]. Diet soda, on the other hand, received a higher Nutri-Score healthfulness rating than cheese because it did not contain calories, saturated fats, or sugars [19].

A similar scenario is playing out right now in the United States where the FDA's proposed rule for "healthy" as a nutrient content claim on food labels would exclude whole-milk dairy foods as well as low-fat cottage cheese and part-skim mozzarella cheese sticks, which can be components of healthy dietary patterns [20] and part of the dairy food group that is recommended by the Dietary Guidelines for Americans [8]. Finding an appropriate algorithm for FOP labeling to best guide consumer food choices will be difficult and requires additional research.

Ignoring the food matrix to focus on individual nutrients of concern also does not necessarily help improve diet quality and can lead to consumer confusion. In a meso level framework analysis conducted in the United States, researchers found that common FOP claims that relied on the classification of positive and negative nutrients were not actually correlated to overall nutrition quality [21]. Results were based on the evaluation of 37 different FOP claims by ~75–80 participants each and showed claims influenced inferences consumers made about healthfulness despite the fact that they were not correlated to nutrition quality [21]. The results of this study demonstrated an unintended consequence of FOP labeling, which was to give the impression of a "health halo" to foods with little nutritional value.

An analysis of Nutri-Score labeling from 43 Belgian supermarkets that aimed to evaluate its impact on consumer purchases over 1 mo reported mixed results, leading researchers to conclude that FOP labeling was unlikely to significantly influence consumer behavior [11]. A study conducted in the United States came to a similar conclusion, indicating that although FOP labeling was used to support shopping goals, it did not significantly affect decision-making [13]. Further, researchers concluded that consumers' perception and actual understanding of nutritional information differed [13]. The results of these studies indicated that FOP labeling discouraged consumers from eating foods that would otherwise fall into an overall healthy dietary pattern, did not result in nutritional literacy, and attracted attention but did not alter purchasing.

Research indicates that a focus on avoiding nutrients may lead to unintended consequences related to nutrient adequacy, diet quality, and metabolic health [18,20]. Modeling exercises in Europe and the United States indicated that, in addition to contributing calories and saturated fat to the diet, dairy foods also contribute calcium, vitamin D, potassium, and high-quality protein [18,20]. The nutrients in dairy foods are difficult to replace with other foods. Furthermore, fermented dairy foods, such as yogurt and cheese, are associated with reduced risk of CVDs and type 2 diabetes, regardless of their fat content [16]. In fact, a recent Mendelian randomization analysis based on publicly available genome-wide association studies determined that cheese consumption causally reduced risks of type 2 diabetes, coronary heart disease, hypertension, and ischemic stroke, leading researchers to conclude, "…it may be inappropriate to assess the effect of cheese on cardiovascular disease just based on saturated fatty acids" [22].

Holistic and inclusive strategies are necessary for ensuring improved global diet quality

Current evidence indicates that a food system approach—a holistic consideration of all elements, relationships, and effects of foods on human health—is what may lead to improved diet quality, reduce metabolic dysregulation, and help mitigate the rise in NCDs globally. A scoping review that aimed to assess the effectiveness of policy actions to improve healthy food consumption and prevent NCDs found that upstream interventions such as price interventions to subsidize whole foods that are currently underconsumed, for example fruits and vegetables, were consistently effective in improving healthy eating habits and the consumption of nutrient-dense foods [23]. This

contrasted with labeling, which generally demonstrated smaller effects [23]. Additionally, multicomponent interventions that combined provision and promotional activities were effective [23].

The shift to promotion of overall healthy dietary patterns is a welcome change from targeting individual foods and nutrients. By communicating a dietary pattern approach to healthy eating, all foods can fit and be inclusive of cultural and personal differences. This type of approach considers the importance of the total diet, allows the food matrix to remain intact, and avoids assigning good foods and bad foods on the basis of reductionist nutrition science, which can be counterproductive and lead to unintended consequences such as consumer confusion, food avoidance, and malnutrition [24].

Acknowledgments

The authors' responsibilities were as follows—GDM, JRC, and MT-G: contributed equally to the design, writing, and final content of this manuscript; and all authors: read and approved the final manuscript.

Funding

The authors reported no funding received for this study.

Author disclosures

All authors are employed by the National Dairy Council.

References

[1] F. Branca, A. Demaio, E. Udomkesmalee, P. Baker, V.M. Aguayo, S. Barquera, et al., A new nutrition manifesto for a new nutrition reality, Lancet 395 (10217) (2020) 8–10, https://doi.org/10.1016/S0140-6736(19)32690-X.

[2] B.M. Popkin, L.S. Adair, S.W. Ng, Global nutrition transition and the pandemic of obesity in developing countries, Nutr. Rev. 70 (1) (2012) 3–21, https://doi.org/10.1111/j.1753-4887.2011.00456.x.

[3] GBD 2015 Risk Factor Collaborators, Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2015: a systematic analysis for the global burden of disease study 2015, Lancet 388 (10053) (2016) 1659–1724, https://doi.org/10.1016/S0140-6736(16)31679-8.

[4] N.D. Ford, S.A. Patel, K.M. Narayan, Obesity in low- and middle-income countries: burden, drivers, and emerging challenges, Annu. Rev. Public Health 38 (2017) 145–164, https://doi.org/10.1146/annurev-publhealth-031816-044604.

[5] J. Williams, L. Allen, K. Wickramasinghe, B. Mikkelsen, N. Roberts, N. Townsend, A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries, J. Glob. Health. 8 (2) (2018), https://doi.org/10.7189/jogh.08.020409, 020409.

[6] V. Miller, P. Webb, R. Micha, D. Mozaffarian, Global Dietary Database, Defining diet quality: a synthesis of dietary quality metrics and their validity for the double burden of malnutrition, Lancet Planet. Health. 4 (8) (2020) e352–e370, https://doi.org/10.1016/S2542-5196(20)30162-5.

[7] K.S. Petersen, P.M. Kris-Etherton, Diet quality assessment and the relationship between diet quality and cardiovascular disease risk, Nutrients 13 (12) (2021), https://doi.org/10.3390/nu13124305.

[8] [Internet], Dietary Guidelines for Americans, 2020-2025, 9th Edition, U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020 [date updated, date cited]. Available from: DietaryGuidelines.gov.

[9] A.H. Lichtenstein, L.J. Appel, M. Vadiveloo, F.B. Hu, P.M. Kris-Etherton, C.M. Rebholz, et al., Dietary guidance to improve cardiovascular health: a scientific statement from the American heart association, Circulation 144 (23) (2021) e472–e487, https://doi.org/10.1161/CIR.0000000000001031.

[10] H. Croker, J. Packer, S.J. Russell, C. Stansfield, R.M. Viner, Front of pack nutritional labelling schemes: a systematic review and meta-analysis of recent evidence relating to objectively measured consumption and purchasing, J. Hum. Nutr. Diet. 33 (4) (2020) 518–537, https://doi.org/10.1111/jhn.12758.

[11] S. Vandevijvere, N. Berger, The impact of shelf tags with nutri-score on consumer purchases: a difference-in-difference analysis of a natural experiment in supermarkets of a major retailer in Belgium, Int. J. Behav. Nutr. Phys. Act. 18 (1) (2021) 150, https://doi.org/10.1186/s12966-021-01207-7.

[12] C. Julia, M. Fialon, P. Galan, M. Deschasaux-Tanguy, V.A. Andreeva, E. Kesse-Guyot, et al., Are foods 'healthy' or 'healthier'? Front-of-pack labelling and the concept of healthiness applied to foods, Br. J. Nutr. 127 (6) (2022) 948–952, https://doi.org/10.1017/S0007114521001458.

[13] C. Oswald, K. Adhikari, A. Mohan, Effect of front-of-package labels on consumer product evaluation and preferences, Curr. Res. Food Sci. 5 (2022) 131–140, https://doi.org/10.1016/j.crfs.2021.12.016.

[14] A. Drewnowski, T.D. Gonzalez, C.D. Rehm, Balanced hybrid nutrient density score compared to nutri-score and health star rating using receiver operating characteristic curve analyses, Front. Nutr. 9 (2022) 867096, https://doi.org/10.3389/fnut.2022.867096.

[15] E. Capuano, T. Oliviero, M.A.J.S. van Boekel, Modeling food matrix effects on chemical reactivity: challenges and perspectives, Crit. Rev. Food Sci. Nutr. 58 (16) (2018) 2814–2828, https://doi.org/10.1080/10408398.2017.1342595.

[16] D. Mozaffarian, Dairy foods, obesity, and metabolic health: the role of the food matrix compared with single nutrients, Adv. Nutr. 10 (5) (2019) 917S–923S, https://doi.org/10.1093/advances/nmz053.

[17] C.M. Weaver, Dairy matrix: is the whole greater than the sum of the parts? Nutr. Rev. 79 (Suppl 2) (2021) 4–15, https://doi.org/10.1093/nutrit/nuab081.

[18] E. Katsouri, E. Magriplis, A. Zampelas, E.H. Drosinos, G.J. Nychas, Dietary intake assessment of pre-packed graviera cheese in Greece and nutritional characterization using the nutri-score front of pack label scheme, Nutrients 13 (2) (2021), https://doi.org/10.3390/nu13020295.

[19] IARC Evidence Summary Brief No 2 [Internet], The Nutri-Score: a science-based front-of-pack nutrition label, WHO, International Agency for Research on Cancer, 2021 [cited 7 September, 2022]. Available from: https://www.iarc.who.int/wp-content/uploads/2021/09/IARC_Evidence_Summary_Brief_2.pdf.

[20] V.L. Fulgoni, D.R. Keast, N. Auestad, E.E. Quann, Nutrients from dairy foods are difficult to replace in diets of Americans: food pattern modeling and an analyses of the National health and nutrition examination survey 2003-2006, Nutr. Res. 31 (10) (2011) 759–765, https://doi.org/10.1016/j.nutres.2011.09.017.

[21] Q. André, P. Chandon, K. Haws, Healthy through presence or absence, nature or science?: a framework for understanding front-of-package food claims, J. Public Policy Mark. 38 (2) (2019) 172–191, https://doi.org/10.1177/0743915618824332.

[22] M.J. Hu, J.S. Tan, X.J. Gao, J.G. Yang, Y.J. Yang, Effect of cheese intake on cardiovascular diseases and cardiovascular biomarkers, Nutrients 14 (14) (2022), https://doi.org/10.3390/nu14142936.

[23] L. Hyseni, M. Atkinson, H. Bromley, L. Orton, F. Lloyd-Williams, R. McGill, et al., The effects of policy actions to improve population dietary patterns and prevent diet-related non-communicable diseases: scoping review, Eur. J. Clin. Nutr. 71 (6) (2017) 694–711, https://doi.org/10.1038/ejcn.2016.234.

[24] A. Fardet, C. Richonnet, Nutrient density and bioaccessibility, and the antioxidant, satiety, glycemic, and alkalinizing potentials of fruit-based foods according to the degree of processing: a narrative review, Crit. Rev. Food Sci. Nutr. 60 (19) (2020) 3233–3258, https://doi.org/10.1080/10408398.2019.1682512.