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Dietary Patterns

Exploring Multidimensional and Within-Food Group Diversity for Diet Quality and Long-Term Health in High-Income Countries

Anaëlle Bolo, Eric Verger, H  l  ne Fouillet, Fran  ois Mariotti. *Adv. Nutr.* Vol. 15, Issue 9100278, Sept. 2024. Doi: 10.1016/j.advnut.2024.100278. [Article link](#)

Dietary diversity is a crucial component of healthy eating patterns because it ensures nutritional adequacy. Yet, concerns have been raised about the potential risks of its increase, which may reflect excessive consumption of unhealthy foods and higher obesity or cardiometabolic risk, particularly in high-income countries. However, the links between dietary diversity and different health outcomes remain inconclusive because of methodological differences in assessing dietary diversity. Numerous studies, mostly cross-sectional, have assessed dietary diversity using different indicators usually based only on the number of foods or food groups consumed. In this perspective, we emphasize that dietary diversity is a multidimensional concept encompassing the number of foods in the diet (food coverage) but also their relative proportions (food evenness) and the nutritional dissimilarity of foods consumed over time (food complementarity). Consequently, a comprehensive assessment of dietary diversity reflecting all its dimensions, both between and within-food groups, is needed to determine the optimal level of complementarity between and within-food groups required to improve health and diet quality. Moreover, given the prevailing context of abundant highly processed and energy-dense foods in high-income countries, promoting dietary diversity should prioritize nutrient-dense food groups. Until recently, within-food group diversity has received limited attention in research and public health recommendations. Still, it may play a role in improving diet quality and long-term health. This perspective aims to clarify the concept of dietary diversity and suggest research avenues that should be explored to better understand its associations with nutritional adequacy and health among adults in high-income countries.

Carbohydrates

Energy Expenditure in Humans: Principles, Methods, and Changes Throughout the Life Course

Rodrigo Fern  ndez-Verdejo, Guillermo Sanchez-Delgado, Eric Ravussin. *Ann. Rev. of Nutr.*, Vol. 44, 8/24. doi.org/10.1146/annurev-nutr-062122-031443. [Article link](#)

Humans require energy to sustain their daily activities throughout their lives. This narrative review aims to (a) summarize principles and methods for studying human energy expenditure, (b) discuss the main determinants of energy expenditure, and (c) discuss the changes in energy expenditure throughout the human life course. Total daily energy expenditure is mainly composed of resting energy expenditure, physical activity energy expenditure, and the thermic effect of food. Total daily energy expenditure and its components are estimated using variations of the indirect calorimetry method. The relative contributions of organs and tissues determine the energy expenditure under different physiological conditions. Evidence

shows that energy expenditure varies along the human life course, at least in part due to changes in body composition, the mass and specific metabolic rates of organs and tissues, and levels of physical activity. This information is crucial to estimate human energy requirements for maintaining health throughout the life course.

Protein

Solid-State Fermented Plant Foods as New Protein Sources

Tessa S. Canoy, Emma Schack Wiedenbein, Wender L.P. Bredie, Anne S. Meyer, Han A.B. Wösten, Dennis Sandris Nielsen. *Ann. Rev. FSFT*. Vol. 15:189-210, 6 2024. doi.org/10.1146/annurev-food-060721-013526. [Article link](#)

The current animal-based production of protein-rich foods is unsustainable, especially in light of continued population growth. New alternative proteinaceous foods are therefore required. Solid-state fermented plant foods from Africa and Asia include several mold- and Bacillus-fermented foods such as tempeh, sufu, and natto. These fermentations improve the protein digestibility of the plant food materials while also creating unique textures, flavors, and taste sensations. Understanding the nature of these transformations is of crucial interest to inspire the development of new plant-protein foods. In this review, we describe the conversions taking place in the plant food matrix as a result of these solid-state fermentations. We also summarize how these (nonlactic) plant food fermentations can lead to desirable flavor properties, such as kokumi and umami sensations, and improve the protein quality by removing antinutritional factors and producing additional essential amino acids in these foods..

Low- and No-Calorie Sweeteners

Effects of Nonnutritive Sweeteners on the BMI of Children and Adolescents: A Systematic Review and Meta-Analysis of Randomized Controlled Trials and Prospective Cohort Studies

Alan Espinosa, Kenny Mendoza, Hugo Laviada-Molina, Deirdre K. Tobias, Walter C. Willett, Josiemer Mattei, et. al. *Adv in Nutrit*. Sept. 18. Doi: 10.1016/j.advnut.2024.100292. [Article link](#)

The effect of nonnutritive sweeteners (NNSs) on the body mass index [BMI (in kg/m²)] of children and adolescents remains unclear despite rising consumption. Detailed systematic evaluations are warranted. We aimed to summarize evidence on NNS consumption and BMI sex- and age-specific absolute changes (kg/m²) in pediatric populations, by NNS type, study design, duration, analysis type, conflicts of interest (COI), geographical region, age, sex, and baseline BMI. We searched randomized controlled trials (RCTs) and prospective cohort studies in children (2–9 y), adolescents (10–24 y), and young adults (20–24 y). Pooled estimates derived from random-effects meta-analysis for BMI changes, and the evidence quality was evaluated overall and by subgroup. From 2789 results, we included 4 RCTs [n = 1372; mean follow-up = 42.6 wk (standard deviation = 18.4); 2 (50%) with COI], and 8 prospective cohort studies [n = 35,340; median follow-up 2.5 y (interquartile range = 1.7–6.3), 2 (25%) with COI]. No identified studies evaluated NNS in food, NNS beverages compared with water, or participants aged 20–24 y. Random allocation to NNS beverages (25–2400 mg/d, from beverages) showed less BMI gain [mean difference = -0.114 kg/m² (95% confidence interval [CI]: -0.207, -0.021); I² = 87.02%] compared with sugar-sweetened beverages (SSBs). Stratified estimates resulted in less BMI gain in adolescents, participants with baseline obesity, consumers of mixed NNS, longer trials, and trials without COI. Pooled estimates from prospective cohorts showed a nonsignificant association between NNS beverages and BMI gain [0.05 kg/m² (95% CI: -0.03, 0.13); I² = 75.06%; per daily 355 mL serving]. Stratified estimates remained consistent. Removing studies with COI attenuated estimates. Evidence had low to moderate quality. In summary, pooled results from RCTs comparing NNS beverages compared with SSBs showed less BMI gain in adolescents with obesity. Meta-analyses of long-term cohort studies did not display a significant association between NNS beverages and BMI changes.

Cognitive Health

Flavonoid-Rich Foods, Dementia Risk and Interactions with Genetic Risk, Hypertension and Depression

Amy Jennings, Alysha S. Thompson, Anna Tresserra-Rimbau. *JAMA Netw Open*, Sept. 18, 2024; 7(9):e2434136. Doi: 10.1001/jamanetworkopen.2024.34136. [Article link](#)

Objective: To examine associations of flavodiet score and intakes of flavonoid subclasses with dementia risk according to

genetic risk and presence of depression and hypertension. **Design, Setting and Participants:** This prospective, population-based cohort study included dietary data from adults aged 40 to 70 years in the UK Biobank, recruited between 2006 and 2010, with a mean (SD) follow-up of 9.2 (1.5) years. The data analyses were conducted from September 1 to 30, 2023. **Exposure:** Flavodiet score adherence and intake of flavonoid subclasses derived from 24-hour computerized dietary assessments. **Main Outcome and Measures:** The main outcome was incident all-cause dementia and interactions with genetic risk, hypertension, and depressive symptoms using multivariable Cox proportional hazards regression models. **Results:** The sample included 121 986 participants (mean [SD] age, 56.1 [7.8] years; 55.6% female; 882 with incident dementia). Comparing the highest with lowest quintile of flavodiet score, consuming 6 additional servings per day of flavonoid-rich foods was associated with a lower risk of dementia among all participants (adjusted hazard ratio [AHR], 0.72; 95% CI, 0.57-0.89), those at high genetic risk (AHR, 0.57; 95% CI, 0.42-0.78), and those with depressive symptoms (AHR, 0.52; 95% CI, 0.33-0.81) after multivariable adjustment. The greatest risk reduction was observed in participants consuming at least 2 of the following per day: 5 servings of tea, 1 serving of red wine, and 0.5 servings of berries, compared with those who did not achieve any of these intakes (AHR, 0.62; 95% CI, 0.46-0.84). Higher intakes of flavonoid subclasses, including anthocyanins, flavan-3-ols, flavonols, and flavones, of which tea, red wine, and berries are the main contributors, supported these findings, showing inverse associations with dementia risk. **Conclusions and Relevance:** In this cohort study, high adherence to a flavonoid-rich diet score was associated with a lower risk of dementia, with reductions more pronounced in individuals with a high genetic risk, hypertension, and depressive symptoms. These findings suggest that simple dietary changes of increasing intakes of commonly consumed flavonoid-rich foods and drinks may lower dementia risk.

The Effect of Whole-Diet Interventions on Memory and Cognitive Function in Healthy Older Adults – A Systematic Review

Lina Tingö, Cecilia Bergh, Julia Rode, Linnea Brengesjö Johnson, Lotte H Smit, Ashley N Hutchinson. *Adv in Nutrit.* Vol. 15, Issue 9100291, Sept. 2024. Doi: 10.1016/j.advnut.2024.10029. [Article link](#)

An increasing number of cross-sectional studies suggests that diet may impact memory and cognition in healthy older adults. However, randomized controlled trials investigating the effects of whole-diet interventions on memory and cognition in healthy older adults are rather rare, and conflicting results are often reported. Therefore, a systematic review was conducted to compile the current evidence regarding the potential effects of whole-diet interventions on 1) memory and 2) other cognitive outcomes in older adults. Studies that reported on randomized controlled trials with dietary interventions in healthy older adults (≥ 60 y) were included. Studies utilizing supplements, single food items, or trials in specific patient groups (i.e., neurodegenerative diagnoses) were excluded. For the 23 included articles, the main outcomes examined fell into 1 or more of the following categories: cognitive task-based outcomes related to memory, other cognitive task-based outcomes, and additional outcomes related to cognitive function or disease risk. Three of the studies that investigated dietary interventions alone and 2 multidomain studies showed positive effects on memory function, whereas 5 multidomain interventions and 1 intervention that focused on diet alone showed positive effects on other cognitive outcomes. The effect of randomized, controlled whole-diet interventions on memory and cognitive function in healthy older adults is modest and inconclusive, highlighting the need for more well-designed, sufficiently powered studies. Furthermore, the potential mechanisms by which diet impacts cognition in healthy aging need to be elucidated.

Neuroprotective Dietary Patterns and Longitudinal Changes in Cognitive Function in Older Adults

Elayna R. Seago, Brenda M. Davy, Kevin P. Davy, Ben Katz. *J. Academy of Nutrition and Dietetics.* September 25, 2024. Doi: 10.1016/j.jand.2024.09.012. [Article link](#)

Objective: The aim of this study was to examine the association of the Mediterranean, the Dietary Approach to Stop Hypertension (DASH), and Mediterranean-DASH Intervention for Neurodegeneration Delay (MIND) dietary patterns with global cognition over four waves of data from the Health and Retirement Study (HRS), a longitudinal panel study conducted at the University of Michigan. **Design:** This is a longitudinal secondary data analysis using HRS data drawn from the Food Frequency Questionnaire (FFQ) completed as part of the Health Care and Nutrition Survey administered in 2013 - 2014, neuropsychological assessment data obtained from the Core questionnaire in 2014, 2016, 2018, and 2020, and demographic data from the Core questionnaire in 2014. **Participants/Setting:** Participants with total daily energy intake below 600 or 800 kcal and above 6,000 and 8,000 kcal for women and men, respectively, were excluded based on criteria from a similar study using the same dataset. Additionally, participants with a diagnosis of dementia, Alzheimer's Disease, or stroke as of 2014 were excluded. There were 6,154 participants in the Mediterranean diet and DASH diet analyses and 5,143 participants in the

MIND diet analyses. **Main Outcome Measure:** A global cognitive measure incorporating immediate and delayed recall, serial 7s, and backwards counting scores was calculated for each participant at each wave. **Statistical Analysis:** The primary analyses examined the association between each diet type and cognition over four waves using separate multilevel models that controlled for age, gender, self-rated health, years of education, total energy intake, weekly exercise, and body mass index. **Results:** Mediterranean and DASH diet adherence were positively and significantly associated with baseline cognition and were associated with slower cognitive decline over a six-year period. MIND diet adherence was positively and significantly correlated with baseline cognition but was not significantly associated with slower cognitive decline over a six-year period. Cross level interactions for adherence to each dietary pattern and cognitive change over time, computed with standardized diet scores, were as follows: Mediterranean diet ($\beta = 0.03$, $p=0.002$), DASH diet ($\beta = 0.04$, $p=0.004$), and MIND diet ($\beta = 0.02$, $p=0.094$). **Conclusions:** The Mediterranean, DASH, and MIND dietary patterns are associated with better cognitive performance at baseline and the Mediterranean and DASH diets were associated with slower cognitive decline over time. Adherence to the DASH diet had the greatest magnitude of association with baseline cognition and rate of cognitive change.

Lipids

Biosynthesis and Metabolism of ApoB-Containing Lipoproteins

Jan Borén, Marja-Riitta Taskinen, Chris J. Packard. *Ann. Review of Nutr.* Vol. 44, 8, 2024. Doi: 10.1146/annurev-nutr-062222-020716. [Article link](#)

Recent advances in human genetics, together with a substantial body of epidemiological, preclinical and clinical trial evidence, strongly support a causal relationship between triglyceride-rich lipoproteins (TRLs) and atherosclerotic cardiovascular disease. Consequently, the secretion and metabolism of TRLs have a significant impact on cardiovascular health. This knowledge underscores the importance of understanding the molecular mechanisms and regulation of very-low-density lipoprotein (VLDL) and chylomicron biogenesis. Fortunately, there has been a resurgence of interest in the intracellular assembly, trafficking, degradation, and secretion of VLDL, leading to many ground-breaking molecular insights. Furthermore, the identification of molecular control mechanisms related to triglyceride metabolism has greatly advanced our understanding of the complex metabolism of TRLs. In this review, we explore recent advances in the assembly, secretion, and metabolism of TRLs. We also discuss available treatment strategies for hypertriglyceridemia.

Sodium

North American Considerations, Strategies and Practices in Reducing the Sodium Content in Processed Foods

Paula R. Trumbo, Kathleen A. Glass, Soo-Yeun Lee, Alanna Moshfegh, Paul A. Welling, Patricia Zecca. *Jrnl of Food Sci.* 17 Sept. 2024 doi.org/10.1111/1750-3841.17361. [Article link](#)



This research was supported by IAFNS [Sodium in Foods & Health Implications Committee](#)

Most Americans exceed the recommended limit for sodium in their diet, a risk factor for hypertension and cardiovascular disease. Efforts have been made by the food industry and government agencies to reduce the sodium content in foods and encourage the consumption of lower sodium diets. Such efforts, however, are not successful in improving public health when consumers do not accept and consume lower sodium foods. This review article provides an overview of the strategies that have been used by the US food industry to reduce and replace sodium in consumer-packaged goods, as well as future sodium reduction strategies and approaches for replacing sodium with potassium salts. Challenges in consumer acceptance regarding the reduction of sodium in foods are also discussed. Because of the widespread consumption of numerous sodium-containing consumer packaged goods, implementing future strategies in various aspects of salt reduction and potassium replacement in foods should have a profound impact on the health of Americans.

Sodium Content and Sodium Intake Contributions of Store-Bought and Restaurant-Prepared Foods in Their As-Eaten Form: NHANES, 2009-2018

Debra R. Keast, Patricia M. Guenther. *Curr. Dev. Nutr.* Vol. 8, Issue 10104455, Oct. 2024. Doi: 10.1016/j.cdnut.2024.104455. [Article link](#)



This research was supported by IAFNS [Sodium in Foods & Health Implications Committee](#)

Background: Guidance from the Food and Drug Administration (FDA) includes targets for the food industry to voluntarily reduce the sodium content (mg/100g) of packaged, processed, and prepared foods sold by stores and restaurants. Assessments of sodium intake by the U.S. population are needed to inform sodium-reduction efforts. **Objectives:** The objectives of this study were to assess the sodium content and sodium intake contributions of categories and subgroups of foods obtained from stores and restaurants and determine sodium intake reductions that would be achieved by meeting FDA targets. **Methods:** Analyses used dietary data from the National Health and Nutrition Examination Survey, What We Eat in America (WWEIA), 2009-2018, to assess sodium in foods consumed by the U.S. population aged $\geq 2y$. Data describing where foods were obtained were used to identify store-bought and restaurant-prepared foods. Combination codes were used to group foods, such as separate salad ingredients, that were eaten together. Foods in their as-eaten form were then classified into WWEIA food categories and subgroups corresponding to FDA targets. Sample-weighted estimates generated by SUDAAN analyses were used to calculate projected sodium intake reductions. **Results:** Store-bought, restaurant-prepared, and other foods contributed 62, 26, and 12%, respectively, of sodium in U.S. diets. Top-ranked food-category contributors of sodium included Sandwiches, Tortilla products, Pizza, Poultry, Soups, and Breads. Subgroups of these categories contributing the most sodium included store-bought lunchmeat sandwiches and hotdogs, restaurant-prepared burgers, store-bought and restaurant-prepared tacos/burritos, restaurant-prepared pizza with meat, and store-bought white/wheat bread. Meeting the FDA targets for these subgroups achieved the highest projected sodium intake reductions. **Conclusions:** Reductions of sodium in widely consumed foods, such as luncheon-meat sandwiches and restaurant-prepared pizza, were found to have the greatest impact on reducing sodium intake by the U.S. population. These findings could be used by restaurateurs, food manufacturers, policy makers and regulators, and clinical practitioners to inform sodium-reduction efforts.

Gut Health

Dietary and Lifestyle Insulinemic Potentials, Plasma Metabolome and Risk of Diverticulitis: A Prospective Cohort Study

Jane Ha, Yilun Wu, Dong Hoon Lee, Lisa L. Strate, Wenjie Ma, Andrew T. Chan, et. al. *AJCN*, Sept. 19, 2024. Doi: 10.1016/j.ajcnut.2024.09.017 [Article link](#)

Background: Diet and lifestyle factors have been linked to developing diverticulitis. However, it remains largely unknown whether the associations are mediated by metabolic disturbance, such as hyperinsulinemia and corresponding metabolomic perturbations. **Objective:** We investigated associations of the insulinemic potential of diet, lifestyle (diet, physical activity, body weight), and metabolomic patterns with the risk of incident diverticulitis. **Design:** We conducted a prospective cohort study including participants in three nationwide cohorts of US health professionals. The risk of incident diverticulitis was estimated according to quintiles of the empirical dietary index for hyperinsulinemia (EDIH) and empirical lifestyle index for hyperinsulinemia (ELIH). In a subset of participants with metabolomic measurements, we developed metabolomic dietary index for hyperinsulinemia (MDIH) and metabolomic lifestyle index for hyperinsulinemia (MLIH), metabolite profile scores correlating with EDIH and ELIH, respectively, and tested their associations with subsequent risk of diverticulitis. We also examined whether the associations of EDIH and ELIH with diverticulitis were mediated by the metabolite profile scores. **Results:** Among 184,508 participants (median age, 51 [IQR, 46-56] years), we documented 9,123 incident diverticulitis cases over 3,419,945 person-years. Compared with those in the lowest quintile, participants with the most hyperinsulinemic diets and lifestyles (highest quintiles of EDIH and ELIH) had a hazard ratio for the risk of diverticulitis of 1.22 (95% CI, 1.13-1.31) and 1.69 (95% CI, 1.57-1.81), respectively. Similarly, the metabolite profile scores were significantly associated with the diverticulitis risk with odds ratio of 1.96 for MDIH (95% CI, 1.47-2.60) and 1.93 for MLIH (95% CI, 1.48-2.51) when comparing extreme quintiles. The explainable proportions of EDIH- and ELIH-related diverticulitis risk by MDIH and MLIH were 70%

(95% CI, 6%-99%) and 57% (95% CI, 23%-86%), respectively ($P < .0001$ for both). **Conclusions:** Participants with dietary and lifestyle patterns corresponding to higher insulinemic potential had an increased risk of diverticulitis, which might be mediated by metabolomic profiles.

Emerging Science Areas

Emerging Area: 3D Printing for Medical Foods

Potential of 3D Printing in Development of Foods for Special Medical Purpose: A Review

Hao Shi, Min Zhang, Arun S. Mujumdar, Chunli Li. *CRFSFS*, 17 Sept. 2024 doi.org/10.1111/1541-4337.70005. [Article link](#)

Nutritional management has emerged as an effective strategy to mitigate the risks of malnutrition and disease-related mortality among patients. The emergence of novel food types, particularly foods for special medical purposes (FSMPs), has garnered increasing attention from researchers and businesses. 3D printing (3DP) technology, alternatively known as food additive manufacturing, has gained popularity among novel food developers due to its distinct capabilities in tailoring nutrition, appearance, texture, and enhancing overall edible quality. This review examines current market trends, product forms, and unique characteristics of FSMPs, highlighting the progress made in applying 3DP to the development of functional foods and drugs. Despite its potential medical benefits, there are limited instances of direct utilization of 3DP in the production of such specialized food type. Currently, the FSMP market faces several challenges, including limited product diversity, inadequate formula design, and a lack of product appeal. 3DP offers significant advantages in catering to the unique needs of special patients, encompassing both physiological medical benefits and enhanced sensory as well as psychological eating experiences. It holds great promise in promoting precision medicine and personalized home-based FSMPs preparations. This review will delve into the development strategies and feasibility of 3DP in creating specialized medical food for patients with unique conditions and across different age groups. Additionally, it explores the potential challenges of applying 3DP to the FSMP sector, such as regulatory frameworks, patient acceptance, cost of 3D-printed FSMPs, and the improvement of 3DP.

Emerging Science Area: Research Quality: AI vs. Human Judgement

Must Peer Reviewers be Human to Assess Quality?

Jackson Ryan. *Nature*, Vol. 633, S18-20, 19 September 2024. [Article link](#)

Large Language Models (LLMs) can churn out a plausible report, but when it comes to sound research judgement, people power is still seen as a safer option.

Engage with IAFNS

Low- and No-Calorie Sweeteners Stakeholder Exchange

October 15, 2024, Washington, DC

IAFNS will be hosting its annual invitation-only Low- and No-Calorie Sweeteners Stakeholder Exchange to elicit input.

[Register here](#)

Designing a Web-Based Tool for Cognitive Test Selection in Nutrition Research

October 18, 2024, Virtual Event

This dialogue will provide an opportunity for stakeholders to discuss identifying appropriate cognitive tests for nutrition research.

[Register here](#)

Report: IUFOST Task Force on Processing for Nutrition, Diet and Health

November 4, 2024, Virtual Event

The International Union of Food Science and Technology established a Task Force to address the role of food processing and terms in food classifications. Join us to learn more about this initiative.

[Register here](#)

Live Microbes in the Food Supply: Why They Matter and How to Share Data with USDA

November 6, 2024, Virtual Event

IAFNS hosts speakers that will address how to add products with live microbes to the USDA Global Branded Food Products Database.

[Register here](#)

Host-Microbiome Interactions in Health and Disease

November 19, 2024, Virtual Event

Join IAFNS as we learn about the latest research in this area underway at the Weizmann Institute, under the direction of Dr. Eran Elinav.

[Register here](#)

Retrospective Harmonization: A Novel Approach to Examining Dietary Patterns Associated with Cognitive Decline

December 5, 2024, Virtual Event

The IAFNS Cognitive Health committee will hear a final report from the Retrospective Harmonization Expert Group during this meeting.

[Register here](#)

IAFNS Science Innovation Showcase

December 10-12, 2024, Virtual Event

This science-first and science-focused event will bring together scientists from multiple sectors, at all stages of their careers from graduate students to professors to CEOs. Attendees will engage in dialogue on the data, the technology and science being applied across the food and beverage ecosystem. Submit your abstracts by Oct. 31 and join us to learn about next generation possibilities!

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