

February 2023

# Nutrition Briefs



## Dietary Patterns

### Reproducibility and Validity of the Toronto-Modified Harvard Food Frequency Questionnaire in a Multi-Ethnic Sample of Young Adults.

Daiva E Nielsen, Beatrice A Boucher, Laura A Da Costa, David J A Jenkins, Ahmed El-Soheby. *Eur J Clin Nutr.* 2023 Feb;77(2):246-254. doi: 10.1038/s41430-022-01209-z. [Article link](#)

**Significance:** The Toronto-modified Harvard FFQ, when compared to three-day-food record method, is a reproducible and valid tool to estimate dietary intake among a multi-ethnic sample of young adults. No significant difference in mean intake was found for 27/38 nutrients for a one-year comparison of the two methods.

**Background/Objectives:** To assess the reproducibility and validity of a Toronto-modified Harvard food frequency questionnaire (FFQ) among a multi-ethnic sample of young adults. **Subjects/methods:** A total of 150 participants recruited from the Toronto Nutrigenomics and Health Study cohort who had existing dietary intakes assessed by FFQ (FFQ1) and reassessment one year later (FFQ2). Of these, 100 participants also completed a three-day food record to evaluate the validity of the FFQ for 38 nutrients (energy, 14 macronutrients, 22 micronutrients, and 1 bioactive). Analyses were also stratified between the two major ethnic groups (Caucasian and East Asian). **Results:** Among the full sample, mean intakes of most nutrients (27/38) did not differ significantly between estimates derived from FFQ2 compared to the three-day food record. Energy, sex, and ethnicity adjusted deattenuated Pearson correlation coefficients ranged from 0.20 to 0.92 (mean  $r = 0.52 \pm 0.15$ ), and 34/38 validity coefficients were  $r \geq 0.32$ . Gross misclassification of intakes between FFQ2 and the three-day food record was low (<6%), but energy, polyunsaturated fatty acids (PUFA), and sodium were underestimated by FFQ2. Mean intakes between FFQ1 and FFQ2 did not differ significantly for any nutrient. Between the two major ethnic groups, mean validity coefficients were similar, but varied for individual nutrients with saturated fat, PUFA, and omega 3 being among the most discrepant. **Conclusions:** Compared to a three-day food record, the Toronto-modified Harvard FFQ is a reproducible and valid tool to estimate dietary intake among a multi-ethnic sample of young adults. However, incorporation of protocols to improve the assessment of culturally diverse diets should be considered.

## Carbohydrates

### Carbohydrate Intakes Below Recommendations with a High Intake of Fat are Associated with Higher Prevalence of Metabolic Syndrome

Dakota Dustin, Corina Kowalski, Meredith Salesses, Acree McDowell, Penny M Kris-Etherton, Martha Belury, LuAnn K Johnson, Zach Conrad. *J Acad Nutr Diet.* 2023 Feb 23;S2212-2672(23)00098-9. doi: 10.1016/j.jand.2023.02.011. [Article link](#)



This work was supported by [IAFNS Dietary Lipids](#) and [Carbohydrates Committees](#).

**Significance:** A cross-sectional analysis of a nationally represented sample of US adults from 1999-2018 NHANES, found prevalence of metabolic syndrome was higher in individuals with below recommended intake for carbohydrates, compared to those who met recommended intakes.

**Background:** Over one-third of adults in the United States have metabolic syndrome, and dietary carbohydrate intake may modify the likelihood of developing this condition. Currently, there is a lack of consistent evidence



demonstrating the relationship between carbohydrate intake that falls below recommendations and metabolic syndrome. Not accounting for the differences in fatty acid classes of these dietary patterns may be a reason for inconsistent findings. **Objective:** This study evaluated the association between a carbohydrate intake below recommendations and metabolic syndrome stratified by fat quantity and fatty acid classes in a nationally representative sample of U.S adults. **Design:** This cross-sectional study acquired data on food and nutrient intake and markers of metabolic syndrome from respondents in the National Health and Nutrition Examination Survey (NHANES) 1999-2018. **Participants/setting:** This study included 19,078 respondents who were  $\geq 20$  y, had reliable and complete data on food and nutrient intake and markers of metabolic syndrome; and were not pregnant or breastfeeding. Main outcome measures: The main outcome was prevalence of metabolic syndrome. Statistical analyses performed: Usual dietary intake was estimated using the National Cancer Institute's usual intake methodology. Multivariable logistic regression models assessed the relative odds of prevalent metabolic syndrome between those who had a carbohydrate intake below recommendations and those who met carbohydrate recommendations. **Results:** Those who had a carbohydrate intake below recommendations had 1.067 (95%CI: 1.063-1.071) times greater odds of having metabolic syndrome compared to those who met carbohydrate recommendations ( $P < 0.001$ ). High intake of fat of any class was associated with higher odds of metabolic syndrome [total fat: 1.271 (95%CI: 1.256-1.286); SFA: 1.072 (1.060-1.085); MUFA: 1.317 (1.300-1.333); PUFA: 1.056 (1.047-1.066)];  $P < 0.001$  for all comparisons] in those who had a carbohydrate intake below recommendations. **Conclusions:** The odds of prevalent metabolic syndrome were higher among individuals who had a carbohydrate intake below recommendations compared to individuals who met carbohydrate recommendations.

## Protein

### Effects of pH-shifting Treatments on the Emulsifying Properties of Rice Protein Isolates: Quantitative Analysis of Interfacial Protein Layer

Qian Shen, Hongmin Dai, Luming Wen, Wei Zheng, Beixi Li, Jun Dai, Bin Li, Yijie Chen. *Food Res Int.* 2023 Feb;164:112306. doi: 10.1016/j.foodres.2022.112306. [Article link](#)

**Significance:** Compared to acid treatment, particle size of emulsion of rice protein isolated and subjected to alkaline treatment was smaller. These findings will help future studies develop applications for stabilizing grain protein emulsions.

**Background:** For the limitation of poor solubility and interfacial adsorption capacity of rice protein isolates (RPI), in this work the effects of pH-shifting treatments on the emulsifying properties of RPI were investigated. The results showed that the particle size of the emulsion stabilized by alkaline pH-shifting treated RPI was smaller than that stabilized by acid pH-shifting treated RPI. In addition, the RPI-10 stabilized emulsion showed a more uniform particle size distribution, which was explained by its high emulsifying activity and stability (EAI: 49.5 m<sup>2</sup>/g, ESI: 59.5 min). The interface rheology results showed that the alkaline pH-shifting treatment could promote the protein rearrangement and subsequently formed interface film with higher rate of protein penetration and rearrangement. The quantitative analysis of adsorbed proteins in the RPI-10 stabilized emulsion showed that glutelin-type isoforms as major proteins in RPI were increased at the oil-water interface for their balanced distribution of the hydrophilic and hydrophobic amino acid group. These quantitative and interfacial rheology analysis could improve deep understanding of the interfacial properties of pH-shifting treated RPI, and promote the development of application in grain protein stabilized emulsion.

## Low and No-Calorie Sweeteners

### The Effect of Non-Nutritive Sweetened Beverages on Postprandial Glycemic and Endocrine Responses: A Systematic Review and Network Meta-Analysis

Roselyn Zhang, Jarvis C Noronha, Tauseef A Khan, Néma McGlynn, Songhee Back, Shannan M Grant, Cyril W C Kendall, John L Sievenpiper. *Nutrients.* 2023 Feb 20;15(4):1050. doi: 10.3390/nu15041050. [Article link](#)



This work was supported by [IAFNS Low- and No-Calorie Sweeteners Committee](#).

**Significance:** Result from a systematic review and network meta-analysis of human acute trials comparing the effects of non-nutritive sweetened (NNS) beverages with water and sugar-sweetened beverages suggest those sweetened with single or blends of NNS exhibited no acute metabolic and endocrine effects, like water. This

finding suggests potential uses of NNS beverages as an alternative replacement for sugar sweetened beverages in an acute postprandial setting.

**Background:** There has been an emerging concern that non-nutritive sweeteners (NNS) can increase the risk of cardiometabolic disease. Much of the attention has focused on acute metabolic and endocrine responses to NNS. To examine whether these mechanisms are operational under real-world scenarios, we conducted a systematic review and network meta-analysis of acute trials comparing the effects of non-nutritive sweetened beverages (NNS beverages) with water and sugar-sweetened beverages (SSBs) in humans. **Methods:** MEDLINE, EMBASE, and The Cochrane Library were searched through to January 15, 2022. We included acute, single-exposure, randomized, and non-randomized, clinical trials in humans, regardless of health status. Three patterns of intake were examined: (1) uncoupling interventions, where NNS beverages were consumed alone without added energy or nutrients; (2) coupling interventions, where NNS beverages were consumed together with added energy and nutrients as carbohydrates; and (3) delayed coupling interventions, where NNS beverages were consumed as a preload prior to added energy and nutrients as carbohydrates. The primary outcome was a 2 h incremental area under the curve (iAUC) for blood glucose concentration. Secondary outcomes included 2 h iAUC for insulin, glucagon-like peptide 1 (GLP-1), gastric inhibitory polypeptide (GIP), peptide YY (PYY), ghrelin, leptin, and glucagon concentrations. Network meta-analysis and confidence in the network meta-analysis (CINeMA) were conducted in R-studio and CINeMA, respectively. **Results:** Thirty-six trials involving 472 predominantly healthy participants were included. Trials examined a variety of single NNS (acesulfame potassium, aspartame, cyclamate, saccharin, stevia, and sucralose) and NNS blends (acesulfame potassium + aspartame, acesulfame potassium + sucralose, acesulfame potassium + aspartame + cyclamate, and acesulfame potassium + aspartame + sucralose), along with matched water/unsweetened controls and SSBs sweetened with various caloric sugars (glucose, sucrose, and fructose). In uncoupling interventions, NNS beverages (single or blends) had no effect on postprandial glucose, insulin, GLP-1, GIP, PYY, ghrelin, and glucagon responses similar to water controls (generally, low to moderate confidence), whereas SSBs sweetened with caloric sugars (glucose and sucrose) increased postprandial glucose, insulin, GLP-1, and GIP responses with no differences in postprandial ghrelin and glucagon responses (generally, low to moderate confidence). In coupling and delayed coupling interventions, NNS beverages had no postprandial glucose and endocrine effects similar to controls (generally, low to moderate confidence). **Conclusions:** The available evidence suggests that NNS beverages sweetened with single or blends of NNS have no acute metabolic and endocrine effects, similar to water. These findings provide support for NNS beverages as an alternative replacement strategy for SSBs in the acute postprandial setting.

### The Artificial Sweetener Erythritol and Cardiovascular Event Risk

Witkowski, M., Nemet, I., Alamri, H. et al. The artificial sweetener erythritol and cardiovascular event risk. *Nat Med* (2023). doi.org/10.1038/s41591-023-02223-9. [Article link](#)

**Significance:** An analysis of multiple studies examining the use of sugar substitute erythritol and atherothrombotic disease risk reveals that erythritol is both associated with incident MACE risk and fosters enhanced thrombosis. Further studies to assess the long-term safety of erythritol are needed.

Artificial sweeteners are widely used sugar substitutes, but little is known about their long-term effects on cardiometabolic disease risks. Here we examined the commonly used sugar substitute erythritol and atherothrombotic disease risk. In initial untargeted metabolomics studies in patients undergoing cardiac risk assessment (n = 1,157; discovery cohort, NCT00590200), circulating levels of multiple polyol sweeteners, especially erythritol, were associated with incident (3 year) risk for major adverse cardiovascular events (MACE; includes death or nonfatal myocardial infarction or stroke). Subsequent targeted metabolomics analyses in independent US (n = 2,149, NCT00590200) and European (n = 833, DRKS00020915) validation cohorts of stable patients undergoing elective cardiac evaluation confirmed this association (fourth versus first quartile adjusted hazard ratio (95% confidence interval), 1.80 (1.18–2.77) and 2.21 (1.20–4.07), respectively). At physiological levels, erythritol enhanced platelet reactivity in vitro and thrombosis formation in vivo. Finally, in a prospective pilot intervention study (NCT04731363), erythritol ingestion in healthy volunteers (n = 8) induced marked and sustained (>2 d) increases in plasma erythritol levels well above thresholds associated with heightened platelet reactivity and thrombosis potential in in vitro and in vivo studies. Our findings reveal that erythritol is both associated with incident MACE risk and fosters enhanced thrombosis. Studies assessing the long-term safety of erythritol are warranted.

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## Cognitive Health

### Association Between Dietary Folate Intake and Cognitive Impairment in Older US Adults: National Health and Nutrition Examination Survey

Kai Zhang, Bingjin Li, Zhaoxuan Gu, Zhengyan Hou, Tianzhou Liu, Jiayu Zhao, Mengyu Ruan, et. al. *Arch Gerontol Geriatr.* 2023 Feb 3;109:104946. doi: 10.1016/j.archger.2023.104946. [Article link](#)

**Significance:** An analysis of a representation sample of older adults (60+ years) from the NHANES study suggests an inverse correlation between dietary folic acid intake and cognitive impairment. The study found an L-shaped association between dietary folate intake and cognitive decline with an inflection point close to 510.383 milligrams per day.

**Objective:** To determine the association between dietary folate intake and low cognitive performance in older adults. **Methods:** In this cross-sectional observational study, 2011-2014 data from the 2010 National Health and Nutrition Examination Survey, including 2,524 adults aged 60 years and older, included 24-hour dietary intakes. Total folic acid intake was calculated as the sum of folic acid supplements and dietary folic acid. Cognitive function was assessed using three tests. The association between folate intake and cognitive function was assessed using a multivariate conditional logistic regression model. **Results:** 2524 participants from two survey cycles (2011-2014) in the NHANES aged 60 years and over. In the multivariate logistic regression, the OR of developing folate was 0.96 (95% CI: 0.94-0.98) in participants with Z test. Folate intake was negatively associated with cognitive function. Compared with Q1, Q4 ( $\geq 616.3$  mg/day) in the AFT and DSST tests reduced the risk of cognitive impairment by 31% (OR = 0.69, 95% CI: 0.52-0.93) and 44% (OR = 0.56, 95% confidence interval: 0.44-0.7). In the comprehensive evaluation of IR and AFT scores, the association between dietary folate intake and low cognitive performance in US adults is linear. We also found a significant interaction between gender and cognitive ability (P value for the interaction was 0.021). **Conclusions:** Dietary intake of folic acid may be inversely associated with cognitive impairment. The DSST study found an L-shaped association between dietary folate intake and cognitive decline in US adults, with an inflection point of approximately 510.383 mg/day.

## Lipids

### Soluble Fiber Supplementation and Serum Lipid Profile: A Systematic Review and Dose-Response Meta-Analysis of Randomized Controlled Trials

Abed Ghavami, Rahele Ziaei, Sepide Talebi, Hanieh Barghchi, Elyas Nattagh-Eshtivani, Sajjad Moradi, Pegah Rahbarinejad et. al. *Adv Nutr.* 2023 Feb 2;S2161-8313(23)00005-4. doi: 10.1016/j.advnut.2023.01.005. [Article link](#)

**Significance:** A large meta-analysis of RCTs found that each 5 gram per day increase in soluble fiber supplementation resulted in a significant reduction in total cholesterol and LDL cholesterol, suggesting soluble fiber supplementation could help in management of dyslipidemia and cardiovascular disease risk.

To present a comprehensive synthesis of the effect of soluble fiber supplementation on blood lipid parameters in adults, a systematic search was undertaken in PubMed, Scopus, and ISI Web of Science of relevant articles published before November 2021. Randomized controlled trials (RCTs) evaluating the effects of soluble fibers on blood lipids in adults were included. We estimated the change in blood lipids for each 5 g/d increment in soluble fiber supplementation in each trial and then calculated the mean difference (MD) and 95% CI using a random-effects model. We estimated dose-dependent effects using a dose-response meta-analysis of differences in means. The risk of bias and certainty of the evidence was evaluated using the Cochrane risk of bias tool and the Grading Recommendations Assessment, Development, and Evaluation methodology, respectively. A total of 181 RCTs with 220 treatment arms (14,505 participants: 7348 cases and 7157 controls) were included. There was a significant reduction in LDL cholesterol (MD: -8.28 mg/dL, 95% CI: -11.38, -5.18), total cholesterol (TC) (MD: -10.82 mg/dL, 95% CI: -12.98, -8.67), TGs (MD: -5.55 mg/dL, 95% CI: -10.31, -0.79), and apolipoprotein B (Apo-B) (MD: -44.99 mg/L, 95% CI: -62.87, -27.12) after soluble fiber supplementation in the overall analysis. Each 5 g/d increase in soluble fiber supplementation had a significant reduction in TC (MD: -6.11 mg/dL, 95% CI: -7.61, -4.61) and LDL cholesterol (MD: -5.57 mg/dl, 95% CI: -7.44, -3.69). In a large meta-analysis of RCTs, results suggest that soluble fiber supplementation could contribute to the management of dyslipidemia and the reduction of cardiovascular disease risk.



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## Sodium

### Top Sodium Food Sources in the American Diet-Using National Health and Nutrition Examination Survey

Mavra Ahmed, Alena Ng, Anthea Christoforou, Christine Mulligan, Mary R. L'Abbé. *Nutrients* 2023, Feb. 15(4), 831; doi.org/10.3390/nu15040831. [Article link](#)



This work was supported by [IAFNS Sodium Foods and Health Implications Committee](#).

**Significance:** An analysis of the 2017-2018 NHANES study found more than 50 percent of dietary sodium intake in the US came from familiar food groups including pizza, rolls, breads, processed meats, mixed dishes and meals, cakes and cookies. These findings provide beneficial insights for targeted programs and policy.

Reducing population-level sodium intake can reduce hypertension, an important preventative strategy to lower the risk of cardiovascular diseases, the leading cause of death in the United States. Considering that most dietary sodium is derived from prepackaged foods, this study quantitatively estimates the proportion contribution and mean sodium intake from key food category contributors to total sodium intake in the US population. Data from the 2017-2018 National Health and Nutrition Examination Survey, which collected interviewer-administered 24 h dietary recalls from Americans (n = 7081), were analyzed. Based on the average proportion contributed, the top 15 sources of sodium were identified overall and by age/sex, poverty-income and race/ethnicity. More than 50% of US population-level dietary sodium intake was contributed by: pizza (5.3%); breads, rolls and buns (4.7%); cold cuts and cured meats (4.6%); soups (4.4%); burritos and tacos (4.3%); savoury snacks (4.1%); poultry (4.0%); cheese (3.1%); pasta mixed dishes (2.9%); burgers (2.5%); meat mixed dishes (2.5%); cookies, brownies and cakes (2.4%); bacon, frankfurters and sausages (2.4%); vegetables (2.2%); and chicken nuggets (1.5%), with the results remaining consistent among population subgroups. The results identified the top sources of sodium in the American population overall, as well as in key population subgroups, which can inform policies and programs aimed at reducing sodium intake.

## Gut Microbiome

### Positive Health Outcomes Associated with Live Microbe Intake from Foods, Including Fermented Foods, Assessed Using NHANES Database

Colin Hill, Daniel J Tancredi, Christopher J Cifelli, Joanne L Slavin, Jaime Gahche, Maria L Marco, Robert Hutkins, Victor L Fulgoni 3rd, Daniel Merenstein, Mary Ellen Sanders. *J Nutr.* 2023 Feb 21;S0022-3166(23)12622-8. doi: 10.1016/j.tjn.2023.02.019. [Article link](#)

**Significance:** This novel study reported for the first time the potential association of foods with higher microbial concentrations with modest health improvements. An additional 100 gram intake of microbe-containing foods correlated with lower systolic blood pressure, C-reactive protein, plasma glucose, insulin, triglycerides, waist circumference and higher HDL cholesterol.

**Background:** Live dietary microbes have been hypothesized to contribute to human health but direct evidence is lacking. **Objectives:** To determine if dietary consumption of live microbes is linked to improved health outcomes. **Methods:** Data from the National Health and Nutrition Examination Survey (NHANES) 2001-2018 were used to assess microbial intake and their adjusted associations with selected physiological parameters (e.g., blood pressure, anthropometric measures and biomarkers) among adults aged 19+ years. Regression models were constructed to assess microbial intake with each physiological parameter, adjusted for demographics and other covariates. Microbial intake was assessed as both a continuous variable and as a three-level categorical variable. Fermented foods were assessed in a separate model. **Results:** In continuous models, an additional 100g intake of microbe-containing foods was associated with lower systolic blood pressure -0.331 (-0.447, -0.215) mm Hg, C-reactive protein -0.013 (-0.019, -0.008) mg/dL, plasma glucose -0.347 (-0.570, -0.124) mg/dL, plasma insulin -0.201 (-0.304, -0.099) uU/mL, triglycerides -1.389 (-2.672, -0.106) mg/dL, waist circumference -0.554 (-0.679, -0.428) cm, and BMI -0.217 (-0.273, -0.160) kg/m<sup>2</sup> and higher HDL cholesterol 0.432 (0.289, 0.574) mg/dL. Patterns were broadly similar when microbial intake was assessed categorically and when fermented foods were assessed separately. **Conclusions:** This study is the first to quantify, in a nationally representative data set of American adults and using stable sets of covariates in the regression models, the adjusted associations of dietary intakes of live microbes with a variety of outcomes, including anthropometric measures, biomarkers and blood pressure. Our findings suggest that foods with higher microbial concentrations are associated with modest health

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## Emerging Science Areas

*Emerging Areas: Nutrition*

Emerging Area: Sweat as Diagnostic Biofluid for Health Assessment

### **Skin-Interfaced Microfluidic Systems Help Assess Health Status and Chemical Exposure**

Da Som Yang , Roozbeh Ghaffari, John A. Rogers. *Science*. 23 Feb 2023. Vol 379, Issue 6634. pp. 760-761. [Article link](#)

**Significance:** Recent advances in microfluidic technology have enabled the use of sweat as biofluid to assess health status and chemical balance, screen for disease conditions, monitor loss of essential chemical species, and detect trace toxins or exogenous agents without the need for external sample collection and analysis.

Eccrine sweat glands in the skin are key components of an ingenious system for evaporative cooling. Their action is controlled by the sympathetic nervous system in an adaptive, closed-loop manner to help maintain thermal homeostasis during physical or mental exertion or exposure to high temperatures. Sweat not only removes heat but also helps excrete other chemicals and metabolites from the body. Recent advances in engineering have enabled eccrine sweat to be used for diagnostic purposes, in the form of soft microfluidic analysis systems (1, 2) that gently adhere to the skin for in situ capture, storage, and biochemical evaluation of directly sourced microliter samples. These noninvasive technologies create a broad spectrum of possibilities for using sweat to assess health status and chemical balance, screen for disease conditions, monitor loss of essential chemical species, and detect trace toxins or exogenous agents without the need for external sample collection and analysis. Eccrine glands appear across all regions of the body; in most circumstances, they are responsible for the largest total volume of sweat loss. The other two main types of sweat glands present in the dermis layer, the apocrine and apoeccrine glands, produce sweat with comparatively complex and variable chemical content. They also do so from specific anatomical regions that are not readily accessible given their location and hair coverage. These considerations motivate the choice of eccrine glands as a central focus for sweat analysis.

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