USDA United States Department of Agriculture
Agricultural Research Service

Agricultural Research Service
National Program 107
Human Nutrition
2024 National Program Annual Report

This report synthesizes research and accomplishments from scientists and their support staff working in USDA Agricultural Research Service (ARS) National Program 107 (NP107), Human Nutrition from October 1, 2023, through September 30, 2024.

Mission

The mission of USDA ARS NP 107, Human Nutrition, is to define the role of food and its components in optimizing health throughout the life cycle for all Americans by conducting high national priority research.

Vision

The vision for the program is that well-nourished Americans make health-promoting diet choices based on scientific evidence.

Relationship to USDA and ARS Strategic Plans and Goals

NP 107 addresses high-priority problems of national importance as outlined in ARS Program Area 1, Strategic Goal 4: Make Safe, Nutritious Food Available to All Americans; Objective 4.2: Encourage healthy dietary choices through data-driven, flexible, customer-focused approaches of the **ARS Strategic Plan 2023-2026**.

It also addresses the **USDA Strategic Plan for Fiscal Years 2022-2026**, Goal 4: Providing All Americans Safe, Nutritious Food; Objective 4.2- Encourage Healthy Dietary Choices Through Data-Driven, Flexible, Customer-Focused Approaches.

This research also addresses the **USDA Science and Research Strategy 2023-2026**, Priority 3: Bolstering Nutrition Security and Health, and the **USDA Science Blueprint A Roadmap for USDA Science from 2020 to 2025**, Theme 3: Food and Nutrition Translation.

Introduction

As nutrient requirements to prevent deficiency diseases have been mostly defined, nutrition research now needs to address optimization of health and prevention of chronic diseases. NP 107 is well-positioned to work on this as three of the six Human Nutrition Research Centers have Congressionally mandated missions of studying nutrition and its health effects during different phases of the lifecycle. New functions of nutrients continue to be discovered as do new metabolic pathways, including microRNAs and the role of intestinal bacteria in regulating metabolism and preventing disease.

Human nutrition research studies nutrient composition of foods, what people consume, methods to improve precision and accuracy of those activities, nutrient requirements for all age groups including pregnant and lactating women, how nutrition can maintain health throughout the lifespan from conception to old age and preventing the development of chronic diseases including obesity. Unique aspects of the ARS Human Nutrition Program are its work with crop and animal production researchers to discern how changes in farming conditions and practices affect the nutrient content of the American

diet; compilation of food composition analysis and its dissemination in databases; and conduct of a nationally representative diet survey of how much and what foods Americans eat. This information is needed by regulatory agencies, health agencies, and health professionals to understand the nutritional status of the American population and its multiple subgroups.

Defining features of NP 107 research include an emphasis on food-based approaches to improving health, the capacity of six, internationally recognized Human Nutrition Research Centers with the core capability for long-term, multi-disciplinary, translational research in high priority areas to improve the Nation's health along with the availability of premier scientists, state-of-the-science equipment and facilities for human research across the lifecycle. Unique national resources that are part of NP 107 include the National Nutrient Data Laboratory, the Food Surveys Research Group that conducts the "What We Eat in America" portion of National Health and Nutrition Examination Survey (NHANES), and a laboratory that develops and improves methods for food analysis. Partnerships with other federal, non-profit, and industry groups allow ARS to leverage funds and build upon common research goals.

There are five research components in the Human Nutrition Action Plan for 2019-2024:

- Linking Agricultural Practices and Beneficial Health Outcomes
- Monitoring Food Composition and Nutrient Intake of the Nation
- Scientific Basis for Dietary Guidance
- Prevention of Obesity and Obesity-Related Diseases
- Life Stage Nutrition and Metabolism

Component 1: Linking Agricultural Practices and Beneficial Health Outcomes

Agriculture is the source of food in our diets; to this end agriculture is the basis for our nutritional and nutritionally related health status. Agricultural policies, decisions, and procedures determine the type and amount of foods available to the public; agricultural practices also may impact the nutritional content and appeal of those foods. There is an urgent need to understand how agricultural practices align with dietary patterns that promote optimal health and to identify the extent to which agricultural practices and decisions impact the nutrition and quality of food relevant to human nutrition and health. Within the ARS, cooperation between national programs in human nutrition and those oriented towards agricultural production provides the synergy to develop sustainable methods of producing foods that will contribute to optimal public health.

Problem Statement 1A: Determine Agricultural Practices that Influence the Nutritional Status of Americans

Agricultural decisions may function as either facilitators or barriers to the consumption of healthy diets. Healthy diets depend on the selection of foods dense in nutrients and other health-promoting compounds. Agricultural practices interact with the physical environment as well as with the genetic potential and post-harvest handling of food crops to influence the chemical composition of foods. Chemical composition in turn is a primary determinant of the nutritional quality as well as the taste and appeal of those foods. Human nutritionists need to work in conjunction with agricultural scientists to determine agricultural decisions that lead to meaningful impacts on human health. Information generated by these studies is needed to develop public, private and scientific direction that will continue to optimize the healthfulness of our food supply.

Accomplishments:

- **How genetics and environment affect cranberry fruit metabolites**. Climate change is dramatically influencing crop yields and nutritional composition, and a systematic method is

needed to evaluate how cultivars and growing locations affect the composition of fruits and vegetables. ARS scientists at the Beltsville Human Nutrition Research Center in Beltsville, Maryland, collected 15 cultivars of cranberries from 16 growing locations in 4 states and a Canadian province. They used mass spectrometry and sophisticated chemometric analyses to identify and quantify the chemical components (sugars, acids, flavonoids) for each cultivar and location and found the greatest variation in composition was related to growing locations. This method can serve as a model for evaluating how genetics and environment affect the composition of foods. (NP107, C1, PSA, C2, PSA, 8040-52000-066-000D)

Geng, P., Harnly, J.M., Sun, J., Chen, P. 2024. Variability and determinants of secondary metabolite profiles in cranberries (Vaccinium macrocarpon) from key cultivation states. Journal of Agriculture and Food Research. 15:100983. https://doi.org/10.1016/j.jafr.2024.100983

Component 2: Monitoring Food Composition and Nutrient Intake of the Nation

Monitoring food composition and nutrient intake of Americans is foundational for promulgating public policy, developing dietary guidance, conducting nutrition research and making decisions regarding food production. The food choices Americans make are dynamic and reflect an everchanging U.S. food supply and population, and vigilance, adaptability, and sophistication are needed to stay at the forefront of this endeavor.

Problem Statement 2A: Provide U.S. Food Composition Data

Foundational to characterizing the nutritional intake of Americans is knowledge of the composition of the foods they eat; this has been a function of the USDA since the nineteenth century. The U.S. food supply is fluid and the task of providing timely and accurate food composition data is made complex by constant change in food regulations and policy, food choices and consumer preferences, food production and processing methods that induce compositional variability, and demographic changes in the American population. It is increasingly important to link compositional data to data from other domains most notably agricultural production, environmental quality and impact with human health outcomes. It is important to understand the magnitude of variability in food composition and whether such variability impacts human health. There is a need to characterize foods consumed by ethnic and at-risk populations. Data must also reflect increased research and consumer interest in the components of foods that have the greatest positive or negative effects on health. Continued development of state-of-the-art analytical techniques is essential to providing accurate and reliable data.

Accomplishments:

- **How genetics and environment affect cranberry fruit metabolites**. Climate change is dramatically influencing crop yields and nutritional composition, and a systematic method is needed to evaluate how cultivars and growing locations affect the composition of fruits and vegetables. ARS scientists at the Beltsville Human Nutrition Research Center in Beltsville, Maryland, collected 15 cultivars of cranberries from 16 growing locations in 4 states and a Canadian province. They used mass spectrometry and sophisticated chemometric analyses to identify and quantify the chemical components (sugars, acids, flavonoids) for each cultivar and location and found the greatest variation in composition was related to growing locations. This method can serve as a model for evaluating how genetics and environment affect the composition of foods. (NP107, C1, PSA, C2, PSA, 8040-52000-066-000D)

  Geng, P., Harnly, J.M., Sun, J., Chen, P. 2024. Variability and determinants of secondary metabolite profiles in cranberries (Vaccinium macrocarpon) from key cultivation states. Journal of Agriculture and Food Research. 15:100983. https://doi.org/10.1016/j.jafr.2024.100983

Problem Statement 2B: Determine Food Consumption and Dietary Patterns of Americans

"What We Eat in America (WWEIA), NHANES," conducted in partnership with the Department of Health and Human Service's National Center for Health Statistics, is the only nationally representative American dietary survey. The resulting data are used by a broad array of national and international government agencies, food industries and researchers for development of public policy and dietary guidance, guiding food product development and assessment, and for scientific research. ARS will continue to collect, disseminate, and evaluate the nutritional data. However, changing demographics and consumer choices, as well as new uses of, and demands for, data make it essential that ARS adapt new and improved methodologies and technologies for data collection, processing, quality control and dissemination.

Accomplishments:

- **Improving nutrition security to combat diabetes.** Not having enough nutritious food and having a poor diet increases the risk of diabetes. Researchers at the Children's Nutrition Research Center in Houston, Texas, conducted a study to investigate how the Supplemental Nutrition Assistance Program (SNAP) affects food security (having enough food), nutrition security (having adequate nutrients), and factors associated with diabetes. Results for adults across five U.S. states indicate that people with a higher nutrition security score were less likely to have diabetes, even after considering other factors such as age and income. This study highlights the importance of not just feeding people but feeding them healthy, nutrient-rich foods to prevent chronic diseases such as diabetes. Improving nutrition security to reduce diabetes risk, which can drive healthier consumer choices, influences agricultural practices and guides public health policies for broader societal and environmental benefits. (NP107, C2, PSB, C4, PSA, 3092-10700-068-020S)

  Almohamad M, Dave JM, Calloway EE, Li R, Sharma S. Relationship between food security, nutrition security and diabetes: the role of supplemental nutrition assistance program participation. Current Developments in Nutrition 2023 Mar 30;8(5):102153 https://doi.org/10.1016/j.cdnut.2024.102153

- **Benchmark dataset for evaluating image-based dietary assessment.** Photo-based dietary assessment methods are becoming more feasible as artificial intelligence methods improve. However, a dataset for benchmarking algorithm performance has been needed to advance using these methods in nutrition studies. ARS researchers in Davis, California, conducted the Surveying Nutrient Assessment with Photographs of Meals (SNAPMe) Study to develop a benchmark dataset of food photographs paired with traditional food records. The SNAPMe database contains 3,311 unique food photos linked with 275 food records from 95 participants who photographed all foods consumed and recorded food records in parallel for up to 3 study days. Publicly available algorithms for ingredient prediction from food photos performed poorly on the SNAPMe benchmark, especially for single-ingredient foods and beverages. The SNAPMe database will provide nutrition and computer science researchers with a benchmark to test future algorithms for improving photo-based dietary assessments. (NP107, C2, PSB, 2032-51530-026-000D)

  Larke, J.A., Chin, E.L., Bouzid, Y.Y., Nguyen, T.T., Vainberg, Y., Lee, D., Pirsiavash, H., Smilowitz, J.T., Lemay, D.G. 2023. Surveying nutrient assessment with photographs of meals (SNAPMe): A benchmark dataset of food photos for dietary assessment. Nutrients. 15(23). Article 4972. https://doi.org/10.3390/nu15234972.

- **Differences in household diets confounded by nutrition security and high barriers.** Nutrition security, or the ability to acquire food that promotes health, is a relatively new concept that is distinct from food security and requires careful evaluation to determine its usefulness for nutrition

research. ARS researchers in Stoneville, Mississippi, and University of Central Arkansas collaborators determined that both food and nutrition security affect food choice. However, when faced with high environmental and household utilization barriers to healthful food purchasing and preparation, dietary decisions did not differ between households with nutrition security and those without nutrition security. Strategies and policies that remove household utilization barriers may help lessen the burdens of both food and nutrition insecurity. (NP107, C2, PSB, C5, PSA 6001-51000-004-000D**)**

Thomson JL, Landry AS, Walls TI. Direct and indirect effects of food and nutrition security on dietary choice and healthfulness of food choice: causal mediation analysis. Current Developments in Nutrition 2024 Jan 13;8(2):102081. https://doi.org/10.1016/j.cdnut.2024.102081

Thomson J, Landry A, Walls T. Differences in socioeconomic, dietary choice, and nutrition environment explanatory variables for food and nutrition security among households with and without children. Nutrients 2024 Mar 19;16(6):883. https://www.mdpi.com/2072-6643/16/6/883

- **Differences in diets across older adulthood.** Dietary guidance is set based on age and life stage and defines older adults as 60 years or older, but little is known about if or how diet quality differs beyond age 60. ARS-funded researchers in Boston, Massachusetts, used data from the National Health and Nutrition Examination Survey to compare diet quality and dietary intakes in each decade of life for older adults. Men and women in their 80s had markedly lower energy intakes than adults aged 60-69 years, and this lower energy intake was accompanied by a lower intake of nutrient dense food and a higher intake of snacks and sweets. This analysis provides justification for considering defining older adults by different decades of life when setting dietary guidance, rather than considering only one group of adults 60 years and older. (NP107, C2, PSB, C3, PSB, 8050-51000-099-000D**)**

  Shea, K., Barger, K., Rogers, G., Talegawkar, S., Eicher-Miller, H., Booth, S.L. 2024. Dietary intakes of community-dwelling adults in the United States across older adulthood: NHANES 2015-March 2020. Journal of Nutrition. https://doi.org/10.1016/j.tjnut.2023.12.014.

Component 3: Scientific Basis for Dietary Guidance

Dietary Reference Intake values for individual nutrients and the Dietary Guidelines for Americans form the basis for federal, state, and local food and nutrition policies. These are used by researchers, health professionals, the food industry, and individual Americans. Strong scientific evidence is needed to provide accurate dietary guidance. Generating this evidence is challenging due to changes in the demographics of the U.S. population, changes in the food supply, changes in how and where food is prepared and consumed, inter-individual variability in responses to dietary differences, and environmental influences. This work is also challenged by publication of sometimes contradictory data regarding specific foods, micro/macronutrients, and disease prevention. There is accumulating evidence that components beyond recognized nutrients contribute to optimal health and recommendations need to be considered for these substances. ARS scientists will utilize population-based and clinical studies to provide evidence for dietary guidance and will utilize animal and cellular studies to examine specific mechanisms.

Problem Statement 3A: Improve the Scientific Basis for Updating National Dietary Standards and Guidelines

Our understanding of the physiologic processes underlying healthy development and aging and the prevention of disease is constantly expanding. We are faced with the need to accumulate new information relating how diets, foods, and bioactive food components, and physical activity influence these processes. There is increasing appreciation of individual genetic and epigenetic differences that influence how dietary intake and physical activity affect health. Additionally, there is increasing evidence that some substances may exert their effects on health indirectly through alterations of the microbiome.

Accomplishments:

- **Objective biomarkers to assess food intake.** People often provide inaccurate information about their diets, so establishing links between diet and health will require discovering, developing, and using new biomarkers for food intake. ARS researchers at the Beltsville Human Nutrition Research Center in Beltsville, Maryland, and University of Illinois collaborators used artificial intelligence approaches to identify fecal genes and genomes that accurately predict food intake. The researchers found there is high predictive accuracy to using these approaches for foods in the study (vegetables and nuts). These findings indicate metagenomics hold promise for establishing fecal bacterial genes as biomarkers of food intake as an objective complement to self-reported food measures. (NP 107 C3, PSA, C3, PSB, 8040-51000-059-000D)

  Shinn LM, Mansharamani A, Baer DJ, Novotny JA, Charron CS, Khan NA, Zhu R, Holscher HD. Fecal Metagenomics to Identify Biomarkers of Food Intake in Healthy Adults: Findings from Randomized, Controlled, Nutrition Trials. Journal of Nutrition. 2024 Jan;154(1):271-283. https://doi.org/10.1016/j.tjnut.2023.11.001.

- **Skin carotenoid biomarker of food intake is reliable.** Carotenoids are colorful bioactive compounds in fruit and vegetables that are absorbed and deposited in human skin and can be measured optically to provide an estimate of carotenoid and fruit and vegetable intake. However, the device that measures compounds in adults needs to generate comparable results for individuals with different skin tones, weights, ages, race and ethnicity, biological sex, sun exposure levels, and starting skin carotenoid status. Researchers at the Children's Nutrition Research Center in Houston, Texas, found that the starting (baseline) skin carotenoid concentration was the main variable affecting individual differences in skin carotenoids in response to diet. Individuals with higher baseline skin carotenoid concentrations have smaller responses than those with lower baseline concentrations. This research indicates that an individual's baseline skin carotenoid concentration may need to be considered when using changes in skin carotenoid concentration as a biomarker of dietary change. (NP107, C3, PSA, C5, PSA, 3092-10700-066-020S)

  Jilcott Pitts S, Moran NE, Laska MN, Wu Q, Harnack L, Moe S, CarrpManthe P, Gates E, Chang J, Zaidi Y, Gelineau A, Berg L, Caraft NE. Reflection Spectroscopy-Assessed Skin Carotenoids Are Sensitive to Change in Carotenoid Intake in a 6-Week Randomized Controlled Feeding Trial in a Racially/Ethnically Diverse Sample. Journal of Nutrition. 2023 Apr;153(4):1133-1142 https://doi.org/10.1016/j.tjnut.2023.02.017

- **A reliable measurement for cowpea consumption.** Legumes, particularly cowpeas (also known as black-eyed peas), are indigenous crops in sub-Saharan Africa and contain higher protein percentages than cereals, so they can play an important role in combating childhood malnutrition and stunted growth. However, there is currently no reliable and convenient way to determine cowpea consumption levels, so researchers have been limited in assessing the effectiveness of activities promoting legume consumption and compliance with nutritional education efforts. Researchers associated with the Children's Nutrition Research Center in Houston, Texas, aimed to identify a suite of metabolic consumption biomarkers by collecting and analyzing urine and dried blood spots from children and pregnant women in Northern Ghana who consumed four cowpea varieties. Ten candidate biomarkers were identified for cowpea consumption, including phytochemicals unique to plants and other biomarkers that indicate how cowpeas affect human metabolism and provide insight into how cowpeas enhance human nutrition. These results support a suite of key metabolites for dietary legume and cowpea-specific food exposure of global health importance and will permit a reliable measure of cowpea consumption in the future. (NP107, C3, PSA, C5, PSB, 3092-10700-067-010S)

Tipton M, Baxter BA, Pfluger BA, Sayre-Chavez B, Munoz-Amatriain M, Broeckling CD, Shani I, Steiner-Asiedu M, Manary M, Ryan EP. Urine and Dried Blood Spots from Children and Pregnant Women Reveal Phytochemicals, Amino Acids, and Carnitine Metabolites as Cowpea Consumption Biomarkers. Molecular Nutrition Food Research. 2024 Feb;68(4). https://doi.org/10.1002/mnfr.202300222

Problem Statement 3B: Identify Roles of Food, Food Components and Physical Activity in Promoting Health and Preventing Disease

Diet-related chronic diseases such as type 2 diabetes, cardiovascular disease, osteoporosis, and cancer are major public health concerns in the United States. In addition, age-related declines in visual function, cognition, immunity, and the musculoskeletal system may all be amenable to nutritional modulation. Population-based research links dietary patterns, the intakes of specific nutrients or other food components and physical activity with health maintenance and decreased risk of disease. However, rigorously designed evaluations of the relationships and analysis of the physiologic processes underlying these effects are often lacking or are equivocal. Advances in technology have created new tools and opportunities that afford scientists a hitherto unprecedented ability to discern the mechanisms by which these factors promote health and prevent disease. Advanced techniques in genomics, proteomics and metabolomics, as well as recently discovered physiologic relationships such as host-gut microbiome interactions or inter-organ microRNA-based signaling provide ARS scientists with potentially fruitful, high-impact lines of research.

Accomplishments:

- **Ultra-processed foods as part of a healthy diet.** ARS scientists in Grand Forks, North Dakota, demonstrated that foods meeting the broadest classification of an ultra-processed food (UPF) currently include many nutrient-dense foods recommended in dietary guidance. They developed a sample menu for a nutrient-dense diet that is aligned with Dietary Guidelines for Americans (DGA) recommendations, obtains 91 percent of its energy from UPFs, and scored 86 out of 100 points for diet quality. This research is valuable for the nutrition science research community, as it demonstrates that the definition of UPFs needs further refinement before becoming a usable framework for impacting public health. Questions about the nutritional value of UPFs have been a popular media topic, so this research is also valuable for policymakers, consumers, and the food industry; the researchers also received invitations to present this work at plenary sessions in national and international scientific meetings and conferences, and the research publication resulted in several letters to the editor. The Dietary Guidelines Scientific Advisory Committee will investigate the relationship between UPF intake and cardiometabolic health outcomes for the first time for the 2025-2030 DGA. (NP107, C3, PSB, 3062-51000-057-000D)

  Hess, J.M., Comeau, M.E., Casperson, S.L., Slavin, J., Johnson, G.H., Messina, M., Raatz, S., Scheet, A.J., Bodensteiner, A., Palmer, D. 2023. Dietary guidelines meet NOVA: developing a menu for a healthy dietary pattern using ultra-processed foods. Journal of Nutrition. 153(8):2472-2481. https://doi.org/10.1016/j.tjnut.2023.06.028.

- **Objective biomarkers to assess food intake.** People often provide inaccurate information about their diets, so establishing links between diet and health will require discovering, developing, and using new biomarkers for food intake. ARS researchers at the Beltsville Human Nutrition Research Center in Beltsville, Maryland, and University of Illinois collaborators used artificial intelligence approaches to identify fecal genes and genomes that accurately predict food intake. The researchers found there is high predictive accuracy to using these approaches for foods in the study (vegetables and nuts). These findings indicate metagenomics hold promise for establishing fecal bacterial genes as biomarkers of food intake as an objective complement to self-reported food measures. (NP 107 C3, PSA, C3, PSB, 8040-51000-059-000D)

Shinn LM, Mansharamani A, Baer DJ, Novotny JA, Charron CS, Khan NA, Zhu R, Holscher HD. Fecal Metagenomics to Identify Biomarkers of Food Intake in Healthy Adults: Findings from Randomized, Controlled, Nutrition Trials. Journal of Nutrition. 2024 Jan;154(1):271-283 .https://doi.org/10.1016/j.tjnut.2023.11.001

- **New software enables health predictions from diet or microbiome data.** Microbiome data are organized in a taxonomic tree that encodes the parent-child relationships of different microbes. Diet data can similarly be organized into a tree of relationships between types of food. Prior to this work, analyses of diet or microbiome data had to be conducted at a fixed level without leveraging the relationships between foods or between microbes. ARS researchers in Davis, California, developed a method of hierarchical feature engineering called TaxaHFE, which dynamically collapses tree-based data based on taxonomic information together with information gain, maximizing the information contained at various taxonomic levels while reducing redundancy. The TaxaHFE software improves predictions of health outcomes from diet and/or microbiome data while simultaneously increasing the ability to interpret the results. This new technology enables nutrition scientists to discover diet and/or microbiome relationships with health. (NP107, C3, PSB, Project No. 2032-51530-026-000D)

  Oliver, A., Kay, M., Lemay, D.G. 2023. TaxaHFE: A machine learning approach to collapse microbiome datasets using taxonomic structure. Bioinformatics. 3(1). Article vbad165. https://doi.org/10.1093/bioadv/vbad165.

- **Differences in diets across older adulthood.** Dietary guidance is set based on age and life stage and defines older adults as 60 years or older, but little is known about if or how diet quality differs beyond age 60. ARS-funded researchers in Boston, Massachusetts, used data from the National Health and Nutrition Examination Survey to compare diet quality and dietary intakes in each decade of life for older adults. Men and women in their 80s had markedly lower energy intakes than adults aged 60-69 years, and this lower energy intake was accompanied by a lower intake of nutrient dense food and a higher intake of snacks and sweets. This analysis provides justification for considering defining older adults by different decades of life when setting dietary guidance, rather than considering only one group of adults 60 years and older. (NP107, C2, PSB, C3, PSB, 8050-51000-099-000D**)**

  Shea, K., Barger, K., Rogers, G., Talegawkar, S., Eicher-Miller, H., Booth, S.L. 2024. Dietary intakes of community-dwelling adults in the United States across older adulthood: NHANES 2015-March 2020. Journal of Nutrition. https://doi.org/10.1016/j.tjnut.2023.12.014.

- **Chokeberry reduces inflammation in human preadipocytes.** Chokeberry is a North American fruit used by Indigenous peoples as food and to prevent chronic disease. Preadipocytes (precursors to fat cells) and mature adipocytes secrete inflammation markers, while chokeberries contain anti-inflammatory anthocyanins, so this may be one way that chokeberries prevent chronic disease. ARS researchers in Grand Forks, North Dakota, and University of North Dakota collaborators conducted a cell culture study to determine if anti-inflammatory effects of chokeberry extract occurred through an epigenetic mechanism in human primary preadipocytes. The chokeberry extract was found to epigenetically reduce inflammation in the human preadipocyte cells, so chokeberry may have prevented chronic illness in Indigenous peoples because of anti-inflammatory effects. This suggests increased consumption of chokeberry juice may be a feasible dietary solution to reducing inflammation that can cause chronic disease. (NP107, C3, PSB, 3062-51000-057-000D)

  Brunelle, D.C., Larson, K.J., Bundy, A.N., Roemmich, J.N., Warne, D., Redvers, N. 2023. Chokeberry reduces inflammation in human preadipocytes. Journal of Functional Foods. 112:1-12. https://doi.org/10.1016/j.jff.2023.105947

Component 4. Prevention of Obesity and Obesity-Related Diseases

The high prevalence of obesity in the American population has major economic, social, and public health consequences. Because obesity is an underlying contributor to many disorders, including cardiovascular disease, type 2 diabetes, nonalcoholic fatty liver disease, and several cancers, its increase fuels escalation of health care costs. Diabetes alone costs > $170 billion dollars annually in the U.S. A prevalence of obesity above the national average is found in higher risk groups including African Americans, Hispanic Americans, and nightshift workers. Because reduction of excess body weight is difficult to achieve and even harder to sustain, experts are increasingly aware of the critical need for effective, proven methods for the primary prevention of weight gain, particularly in children.

Problem Statement 4A: Understand the Causes and Effects of Obesity and Obesity-Related Disorders

The rise in obesity is the result of multiple factors, all with different degrees of impact. These factors include dietary, biological, behavioral, economic, and environmental. There is a need to further investigate the causal factors for obesity and sequelae such as heart disease and diabetes so that effective diet-, activity-, and science-based policy solutions to these problems may be developed.

Accomplishments:

- **Improving nutrition security to combat diabetes.** Not having enough nutritious food and having a poor diet increases the risk of diabetes. Researchers at the Children's Nutrition Research Center in Houston, Texas, conducted a study to investigate how the Supplemental Nutrition Assistance Program (SNAP) affects food security (having enough food), nutrition security (having adequate nutrients), and factors associated with diabetes. Results for adults across five U.S. states indicate that people with a higher nutrition security score were less likely to have diabetes, even after considering other factors such as age and income. This study highlights the importance of not just feeding people but feeding them healthy, nutrient-rich foods to prevent chronic diseases such as diabetes. Improving nutrition security to reduce diabetes risk, which can drive healthier consumer choices, influences agricultural practices and guides public health policies for broader societal and environmental benefits. (NP107, C2, PSB, C4, PSA, 3092-10700-068-020S)

  Almohamad M, Dave JM, Calloway EE, Li R, Sharma S. Relationship between food security, nutrition security and diabetes: the role of supplemental nutrition assistance program participation. Current Developments in Nutrition. 2023 Mar 30;8(5):102153. https://doi.org/10.1016/j.cdnut.2024.102153

- **Effects of eating tree nuts on metabolism and associated metabolic markers.** Eating tree nuts is associated with health benefits, but more information is needed about how these benefits are generated. ARS researchers in Davis, California, collaborated with researchers at the University of California-Davis and Merced and found unique bioactive lipids in walnuts that might help explain how nut consumption influences human health. In another human intervention trial, people who consumed almonds for 8 weeks exhibited enriched plasma lipids in unsaturated fatty acids, accelerated lipid clearance, altered bioactive lipid profiles, improved vitamin E status, and changes in energy metabolism in their gut microflora by modulating their responses to dietary sugar intake. Together, these data demonstrate that tree nuts contain factors beyond their classically recognized antioxidant and quality fat profiles, and these additional factors might influence the physiological control of energy metabolism and glucose regulation in healthy humans. (NP107, C4. PSA, 2032-51530-025-000D)

Abbattista R, Feinberg NG, Snodgrass IF, Newman JW, Dandekar AM Unveiling the “hidden quality” of the walnut pellicle: a precious source of bioactive lipids. Frontiers in Plant Science. 2024 Jun 18:15:1395543. https://doi.org/10.3389/fpls.2024.1395543

Component 5: Life Stage Nutrition and Metabolism

Three of the six ARS Human Nutrition Research Centers have Congressionally mandated missions to focus their work on specific portions of life, namely pregnant and lactating women, children, and the elderly. In addition to determining nutrient and physical activity requirements for these groups, enhanced understanding of metabolic processes in early and late life that differ from usually studied young adults is essential to develop more relevant recommendations, government policies and programs, and to contain health care costs. One aspect of this is the concept of “nutritional programming” that occurs during periods of development and can result in long term alterations of gene expression and future changes such as the slow loss of muscle mass among the elderly that leads to reduced calorie needs, frailty, and higher medical costs.

Problem Statement 5A: Identify Dietary and Related Lifestyle Impacts for Healthy Development and Function from Conception to Old Age

Food and its components are essential to the fundamental processes of healthy development and aging. There are multiple gaps in our knowledge of those relationships in humans. These gaps limit the ability to make authoritative recommendations for nutrient requirements, dietary composition and patterns, and lifestyles that lead to health. With expansion of the aged population in the U.S., more people suffer from declines in vision, immune function, cognition, and musculoskeletal capability. Subsequently, there is greater demand for characterizing diet and lifestyle requirements that help maintain health and quality of life. Other data are essential to define the mechanisms by which foods and food components regulate metabolism, development, growth, and senescence. In many cases, identifying specific mechanisms requires use of animal and cell culture models and it is important that appropriate models are utilized.

Accomplishments:

- **Foods that may prevent dementia.** While there is no conclusive evidence that eating or avoiding a specific food can prevent dementia, including Alzheimer’s disease, ARS-funded researchers in Boston, Massachusetts, found increasing evidence that suggests diets emphasizing fruits and vegetables, such as a Mediterranean diet, have the potential to reduce the risk of developing dementia. Flavonoids (naturally occurring bioactive pigments found widely in plant-based foods) have shown potential neurocognitive benefits. To further understand the benefits of flavonoid-rich fruits, the researchers examined the associations between midlife and late-life intake of flavonoid-rich fruits and risk of dementia. They observed that greater overall consumption of flavonoid-rich fruits in midlife was associated with reduced risk of developing dementia, and intake of specific fruits later in life, including citrus fruits and blueberries, may also have a protective role against developing dementia. (NP107, C5, PSA, 8050-51530-014-000D)

  Lyu C, Jacques PF, Doraiswamy PM, Young B, Gurnani AS, Au R, Hwang PH. Flavonoid-Rich Fruit Intake in Midlife and Late-Life and Associations with Risk of Dementia: The Framingham Heart Study. Journal Preventative Alzheimers Disease 2024;11(5):1270-1279.

  http://doi.org/10.14283/jpad.2024.116

- **Differences in household diets confounded by nutrition security and high barriers.** Nutrition security, or the ability to acquire food that promotes health, is a relatively new concept that is distinct from food security and requires careful evaluation to determine its usefulness for nutrition research. ARS researchers in Stoneville, Mississippi, and University of Central Arkansas collaborators determined that both food and nutrition security affect food choice. However, when

faced with high environmental and household utilization barriers to healthful food purchasing and preparation, dietary decisions did not differ between households with nutrition security and those without nutrition security. Strategies and policies that remove household utilization barriers may help lessen the burdens of both food and nutrition insecurity. (NP107, C2, PSB, C5, PSA 6001-51000-004-000D)

Thomson JL, Landry AS, Walls TI. Direct and indirect effects of food and nutrition security on dietary choice and healthfulness of food choice: causal mediation analysis. Current Developments in Nutrition 2024 Jan 13;8(2):102081 https://doi.org/10.1016/j.cdnut.2024.102081

Thomson J, Landry A, Walls T. Differences in socioeconomic, dietary choice, and nutrition environment explanatory variables for food and nutrition security among households with and without children. Nutrients 2024 Mar 19;16(6):883. https://www.mdpi.com/2072-6643/16/6/883

- **Maternal health and sex of fetus affect exercise benefits during pregnancy.** Exercise during pregnancy is beneficial to both mother and child health, but more information is needed about how maternal exercise during pregnancy mediates these benefits. ARS scientists and collaborators at the University of Colorado and Oklahoma found the effects of exercise prior to and during pregnancy affect the placenta in different ways, depending on sex of the fetus. In male placentas, maternal exercise led to inhibition of signaling pathways, biological functions, and down-regulation of transcripts related to lipid and steroid metabolism. However, in female placentas, maternal exercise led to activation of pathways, biological functions, and gene expression related to muscle growth, brain, vascular development, and growth factors. Overall, these findings suggest that effects of maternal exercise/physical activity on the placenta and presumably on the offspring are influenced by maternal health status and sex of the baby. (NP107, C5, PSA, 6026-10700-001-000D)

  Ruebel ML, Borengasser SJ, Zhong Y, Kang P, Faske J, Shankar K. Maternal exercise prior to and during gestation induces sex-specific alterations in the mouse placenta. International Journal of Molecular Science 2023 Nov 17;24(22):16441 https://doi.org/10.3390/ijms242216441

- **Human milk miRNAs associations with maternal dietary nutrients, milk microbiota, infant gut microbiota, and growth.** Human milk contains several nutritive and non-nutritive bioactive compounds, including microRNAs (miRNA), whose composition is likely impacted by several factors such as age, body mass index, stress, and diet. An ARS researcher in Little Rock, Arkansas, demonstrated that the maternal source of dietary protein (animal or plant protein) has an impact on human milk miRNA composition and that miRNA expression was associated with maternal dietary polyphenols and maternal microbiota. In addition, milk miRNAs were associated with infant gut microbiota and growth parameters, further emphasizing the role of bioactive milk components on maternal and child health outcomes. (NP 107, C5, PSA, 6026-51000-012-000D)

  Yeruva L, Mulakala BK, Rajasundaram D, Gonzalez S, Cabrera-Rubio R, Martinex-Costa C, Collado MC. Human milk miRNAs associate to maternal dietary nutreints, milk microbiota, infant gut microbiota growth. Clin Nutr 2023 Dec;42(12):2528-2539.

  Human milk miRNAs associate to maternal dietary nutrients, milk microbiota, infant gut microbiota and growth - Clinical Nutrition

Problem Statement 5B: Identify Determinants and Consequences of Nutritional Status, Diet and Body Composition on Metabolic Programming

Mammalian development proceeds via a specific series of irreversible steps from conception to adulthood that affects body structures, functions, and gene expression patterns. The irreversible nature of biological development involves diverse “critical windows,” developmental periods during which specific milestones must be achieved to lay the groundwork for subsequent steps. While it is clear that diet has a

fundamental role in these developmental processes, there are relatively few data on the nutritional requirements and/or the mechanisms through which foods and food components function during these critical windows. Research on nutritional programming will lead to dietary recommendations during periods of development in order to optimize short- and long-term health.

Accomplishments:

- **Boys' and girls' reactions to dietary fiber.** To confirm the previous ARS finding that increasing dietary fiber intake reduced the amount of belly pain in boys but not girls, researchers at the Children's Nutrition Research Center in Houston, Texas, evaluated the dietary fiber intake in healthy children and those who often had belly pain. They found that in healthy boys and those with frequent belly pain, the more dietary fiber consumed, the less pain the boys had while there was no relationship between the amount of dietary fiber intake and belly pain in healthy girls and those with frequent belly pain. When they examined only children with frequent belly pain, boys who ate more than the recommended amount of dietary fiber had less belly pain than those who did not eat at least the recommended amount. In contrast, girls with belly pain who ate more than the recommended amount of dietary fiber had more belly pain than the girls who ate less than the recommended amount. (NP 107, C5, PSB, 3092-10700-067-010S)

  So, Y.S., Badu, S., Wu, Q., Yalcinkaya, N., Mirabile Y., Castaneda R., Musaad, S., Heitkemper, M., Savidge, T.C., Shulman R. J. Sex-Dependent Efficacy of Dietary Fiber in Pediatric Functional Abdominal Pain Gastroenterology, Volume 166, Issue 4, 645 - 657. e14

  https://www.gastrojournal.org/article/S0016-5085(23)05607-X/fulltext?referrer=https%3A%2F%2Fpubmed.ncbi.nlm.nih.gov%2

- **A reliable measurement for cowpea consumption.** Legumes, particularly cowpeas (also known as black-eyed peas), are indigenous crops in sub-Saharan Africa and contain higher protein percentages than cereals, so they can play an important role in combating childhood malnutrition and stunted growth. However, there is currently no reliable and convenient way to determine cowpea consumption levels, so researchers have been limited in assessing the effectiveness of activities promoting legume consumption and compliance with nutritional education efforts. Researchers associated with the Children's Nutrition Research Center in Houston, Texas, aimed to identify a suite of metabolic consumption biomarkers by collecting and analyzing urine and dried blood spots from children and pregnant women in Northern Ghana who consumed four cowpea varieties. Ten candidate biomarkers were identified for cowpea consumption, including phytochemicals unique to plants and other biomarkers that indicate how cowpeas affect human metabolism and provide insight into how cowpeas enhance human nutrition. These results support a suite of key metabolites for dietary legume and cowpea-specific food exposure of global health importance and will permit a reliable measure of cowpea consumption in the future. (NP107, C3, PSA, C5, PSB, 3092-10700-067-010S)

  Tipton M, Baxter BA, Pfluger BA, Sayre-Chavez B, Munoz-Amatriain M, Broeckling CD, Shani I, Steiner-Asiedu M, Manary M, Ryan EP. Urine and Dried Blood Spots From Children and Pregnant Women Reveal Phytochemicals, Amino Acids, and Carnitine Metabolites as Cowpea Consumption Biomarkers Mol Nutr Food Res. 2024 Feb;68(4):e2300222. https://doi.org/10.1002/mnfr.202300222