**Human Nutrition (NP 107)**
**2021 Annual Report**

The Human Nutrition National Program (NP 107) addresses high-priority problems of national importance as outlined in ARS Research Goal 1.1 of the ARS Strategic Plan for FY 2018-2020: Define the Role of Food and its Components in Optimizing Health throughout the Life Cycle for all Americans. Our research also addresses USDA Strategic Goal 7, Provide all Americans access to a safe, nutritious and secure food supply and USDA Science Blueprint Program Theme 3, Food and Nutrition Translation.

The vision of the program is that well-nourished Americans make health-promoting diet choices based on scientific evidence. To accomplish these goals, the Human Nutrition Program of ARS conducts basic and applied research resulting in discoveries at the molecular, cellular, individual, and population levels on nutrient requirements, metabolism and health, and intake of foods and nutrients in the United States.

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

Two new programs have been added during the past fiscal year. A new ARS program has been established at the Arkansas Children's Hospital in Little Rock Arkansas. The program will focus on the microbiome and a Research Leader and support scientists have been hired. A new program has been established at College Station, Texas, in collaboration with AgriLife-Texas A&M University. Recruitment has begun for a Research Leader and the program will focus on precision nutrition and responsive agriculture.

Selected accomplishments completed during fiscal year 2021 and expected to have high impact in the field are listed below. Links to publicly available documentation are provided after each result.

Lean beef in a Mediterranean diet pattern reduces heart disease risk. Eating red meat has a reputation for being bad for the heart. However, when consumed in a healthy dietary pattern, lean beef may reduce heart disease risk factors such as bad cholesterol. ARS researchers at Beltsville, Maryland, and colleagues at The Pennsylvania State University, conducted a dietary intervention study in humans to determine how much lean beef, as part of a Mediterranean diet pattern, can be consumed to promote heart health. Daily, volunteers consumed 0.5, 2.5, or 5.5 oz of lean beef as part of a healthy Mediterranean diet pattern and 2.5 oz as part of a typical American diet. At all intake levels, lean beef as part of the Mediterranean diet pattern reduced bad cholesterol and other risk factors for heart disease. While the traditional Mediterranean diet is low in lean beef, this study demonstrates how people can incorporate lean beef into a healthy diet and benefit further from beef's other key nutrients. (NP107, C1 and 3, PS1A, 3A and 3B, Project No. 8040-51530-011-000D)

Publication: Fleming JA, Kris-Etherton PK, Petersen KS, Baer DJ. Effect of varying quantities of lean beef as part of a Mediterranean-style dietary pattern on lipids and lipoproteins: a randomized crossover controlled feeding trial. American Journal of Clinical Nutrition 2020; 113(5):1126-1136.

Adolescents with prediabetes or type-2 diabetes have impaired metabolic flexibility. Metabolic flexibility (MF) refers to the ability to utilize different nutrients (fats and sugars) and to transition between them while fasting and after a meal. Impairment in metabolic flexibility can lead to metabolic disease. However, it is not clear whether metabolic flexibility is impaired in obese youth. ARS-funded researchers in Houston, Texas, found that adolescents with prediabetes and type 2 diabetes have a defect in metabolic flexibility. Individuals with prediabetes and type 2 diabetes can't change the use of fuels as easily as normal weight individuals or individuals with obesity but with normal sugar levels. This is related to their severe insulin resistance which impairs the use of available fuels appropriately. These results highlight the need for additional studies to investigate which changes in diet or physical activity could improve how the body utilizes these nutrients and help mitigate the risk of type-2 diabetes. (NP107, C5, PS5A, Project No. 3092-51000-065-000D)

Publication: Bacha F, Bartz SK, Puyau M, Adolph A, Sharma S. Metabolic flexibility across the spectrum of glycemic regulation in youth. Journal of Clinical Investigation. 2021:6(4):e146000.

Intake of carbohydrates and fats influences the risk of metabolic diseases. The role of a cellular process, known as methylation, controls genes associated with the risk of metabolic diseases such as obesity, type 2 diabetes, high blood pressure, hypertension, and abnormal lipids remains unknown. ARS-funded researchers in Boston, Massachusetts, examined whether carbohydrate and fat intakes influenced methylation and the risk of metabolic diseases in 3,954 people representing Hispanic, Black, and White populations. The analyses demonstrated strong associations of a specific methylation marker with metabolic characteristics such as body mass index, triglyceride, glucose, and hypertension in each population and all three populations combined. The results demonstrated that carbohydrate intake induces a specific methylation site that reduces the risk of all metabolic diseases examined. In contrast, fat intake inhibits a specific methylation site and increases the risk of such metabolic diseases. These findings identify how balancing carbohydrate and fat intake can have an effect on the risk of metabolic diseases that currently affects millions of Americans. (NP107, C4 and 5, PS4A and 5A, Project No. 8050-51000-107-000D)

Publication: Lai C, Parnell LD, Smith CE, Guo T, Sayols-Baixeras S, Aslibekyan S, Tiwari HK, Irvin MR, Bender C, Fei D, Hidalgo B, Hopkins P, Absher DM, Province M, Elosua R, Arnett DK, Ordovas JM. Carbohydrate and fat intake associated with risk of metabolic diseases through epigenetics of CPT1A. American Journal of Clinical Nutrition. 2020;112(5):1200–1211.

Vitamin A (VA) supplementation improves immune function in Bangladeshi infants. Vitamin A (VA) protects against respiratory and intestinal infections, but the mechanism is not fully known. In animals, VA increases a protein that allows immune cells to migrate to the intestinal mucosal immune sites where they protect against pathogenic microorganisms. However, this has not been shown in humans. ARS researchers in Davis, California, working with colleagues at the International Centre for Diarrhoeal Disease Research in Bangladesh, conducted a randomized, controlled trial of VA supplementation in 306 Bangladeshi newborns and found that VA increased expression of this protein by T regulatory (Treg) cells in early infancy. Since Treg cells play a central role in regulating immunity at mucosal surfaces, these results suggest that increased expression of this specific protein may be a mechanism by which VA supplementation during infancy decreases the risk of death from common childhood infections in populations at risk of deficiency. (NP107, C3, PS3A, Project No. 2032-51530-026-000D)

Publication: Ahmad SM, Huda NM, Raqib R, Qadri F, Peerson J, Tanumihardjo S, Stephensen CB. High-dose vitamin A supplementation at birth increases the percentage of CCR9+ treg cells in infants with lower birthweight in early infancy and decreases plasma sCD14 and prevalence of vitamin A deficiency at two years. Journal of Nutrition. 2020;150(11):3005-3012.

Mothers weight status influences the composition of breast milk. Excess maternal weight has been negatively correlated to breastfeeding. To better understand how excessive maternal weight changes human milk composition, ARS-funded scientists in Little Rock, Arkansas, investigated the difference in specific sugars (oligosaccharides) content of human milk from normal weight mothers compared to overweight or obese mothers. Not only was the human milk from overweight or obese mothers different in oligosaccharides content, but also, infant intakes of these specific sugars was associated with greater growth and higher body fat content. These results imply that maternal weight status may impact infant nutrition through the composition of breast milk. (NP107, C4, PS4A, Project No. 6026-51000-012-000D)

Publication: Saben JL, Sims CR, Abraham A, Bode L, Andres A. Human milk oligosaccharide concentrations and infant intakes are associated with maternal overweight and obesity and predict infant growth. Nutrients. 2021;13(2):446.