

FY 2019 Annual Report for National Program 107 Human Nutrition

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](#). 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 U.S.

Twenty-nineteen marked the renewal of the projects in our 5-year research cycle. All projects underwent rigorous anonymous external peer review by the ARS Office of Scientific Quality Review in the last 12 months and have new objectives. 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

Selected accomplishments completed during fiscal year 2019 and expected to have high impact in the field are listed below. Links to publicly available documentation are provided after each result.

A healthy microbiome in infants predicts better vaccine response. Vaccination is the best approach to prevent infectious diseases, but response to vaccines can be highly variable for unknown reasons, especially when given in early infancy. ARS scientists in Davis, California, conducted a study of 306 infants aged birth to 3 years to determine whether an infant that had a microbiome colonized with greater numbers of a beneficial bacteria (*Bifidobacterium infantis*) had better responses to four vaccines (tuberculosis, polio, hepatitis B, and tetanus) also given in early infancy. The abundance of *Bifidobacterium* was positively associated with better responses to the tuberculosis, tetanus, and hepatitis B vaccines when the responses were measured in early infancy and was also associated with better responses to the tuberculosis, tetanus, and polio vaccines measured at 2 to 3 years of age. This study is the first to demonstrate that bifidobacteria, which are abundant in the infant gut as a result of breastfeeding, may lead to long-term enhancement of the immune system. This observation demonstrates that early life nutrition can improve health by enhancing vaccine memory responses.

Publication: Huda MN, Ahmad SM, Alam MJ, Khanam A, Kalanetra KM, Taft DH, Raqib R, Underwood MA, Mills DA, Stephensen CB. [Bifidobacterium Abundance in Early Infancy and Vaccine Response at 2 Years of Age](#). Pediatrics. 2019; 143: e20181489.

Newly created atlas of epigenetic variation in humans. More than 15 years after scientists first mapped the human genome, most diseases still cannot be predicted based on genes, leading researchers to explore epigenetics as causes of disease. The most stable form of epigenetic regulation is DNA methylation, which changes gene conformation and gene expression, but progress on this topic has been limited by lack of information on cell type specificity. ARS-supported scientists in Houston, Texas, performed deep sequencing of genomic DNA in tissues representing the three germ layers during development followed by producing a computer algorithm to identify individual regions that vary in DNA methylation. The nearly 10,000 regions the researchers mapped out, called correlated regions of systemic interindividual variation (CoRSIVs), comprise a previously unrecognized level of molecular individuality in humans. Because epigenetic marking of genes has the power to either stably silence or activate them, any disease that has a genetic basis may also have an epigenetic component. This map forms the basis of understanding about disease processes from an epigenetic perspective.

Publication: Gunasekara CJ, Scott CA, Laritsky E, Baker MS, MacKay H, Duryea JD, Kessler NJ, Hellenthal G, Wood AC, Hodges KR, Gandhi M, Hair AB, Silver MJ, Moore SE, Prentice AM, Li Y, Chen R, Coarfa C, Waterland RA. [A genomic atlas of systemic interindividual epigenetic variation in humans.](#) Genome Biol. 2019; 20:105

Improving USDA food composition databases. USDA food composition databases are used by a diverse community to make policy decisions, investigate the impact of diet on health, develop new foods, advise patients on improving their diets, and address the general need for more information on what is in the food we eat. The USDA has been compiling data on food composition for more than 100 years, but in recent years the amount, type, and format of the data have become outdated. To rectify this problem ARS scientists in Beltsville, Maryland, created and publicly released FoodData Central. FoodData Central provides access to all USDA food composition information—such as expanded nutrient information, links to Special Interest Databases, and links to related agricultural and experimental research data—in a single location. The USDA databases includes legacy databases, a database used for the What We Eat in America survey, data on branded food products, and Foundation Foods (the primary source of analytical food composition data from this point forward). This new database will allow the USDA to continue to be the world’s foremost authority for nutritional data well into this century.

Website: [FoodData Central](#)

Intermittent feeding promotes growth more than continuous feeding in a neonatal pig model. Every year, more than 50,000 infants born prematurely in the United States cannot eat normally and may be fed by a tube inserted into the stomach. Premies may be fed continuously or intermittently as if one were consuming meals. So far, it is unknown whether there is a benefit of one pattern of feeding. A comparison cannot be performed in infants for ethical reasons, so to study this question under controlled conditions, ARS-supported scientists in Houston, Texas, studied neonatal pigs with implanted stomach tubes for 21 days. Even though both groups were fed the same amount of nutrients, body weight, lean mass, spine

length, and muscle mass were all greater in the piglets fed intermittently. Additional results from this study suggest the pulsatile changes in amino acids and insulin contributed to the benefits. Widespread adoption of pulsatile feeding of premature infants has the potential to improve growth, reduce the length of hospital stays, and lower health care costs.

Publication: El-Kadi SW, Boutry C, Suryawan A, Gazzaneo MC, Orellana RA, Srivastava N, Nguyen HV, Kimball SR, Fiorotto ML, Davis TA. [Intermittent bolus feeding promotes greater lean growth than continuous feeding in a neonatal piglet model.](#) Am J Clin Nutr. 2018; 108:830-841.

Brain activation in children with obesity differs from that in normal-weight children. Obesity in U.S. children has tripled over the past few decades. Understanding how normal-weight and obese young children process high-calorie food stimuli may provide ways to alter unhealthy eating behaviors. ARS-supported scientists from Little Rock, Arkansas, used functional magnetic resonance imaging (fMRI) to map activation of brain regions in 8- to 10-year-old children viewing images of high-calorie food (e.g., an ice cream sundae) or non-food (e.g., a telephone) items. Normal-weight children had significantly higher activation of two brain regions associated with cognitive control and memory than obese children; the area involved was larger and the strength of activation was higher. These results suggest that normal-weight and obese children process high-calorie food stimuli differently. The findings point to the importance of early and sustained education in children about healthy food choices.

Publication: Samara A, Li X, Pivik RT, Badger TM, Ou X. [Brain activation to high-calorie food images in healthy normal weight and obese children: a fMRI study.](#) BMC Obes. 2018; 5:31.

Progressive resistance training improves muscle fatigue and strength in older adults. Progressive resistance/strength training has been consistently shown to improve muscle strength in older adults, but its effect on muscle fatigue in older adults with limited mobility remains unclear. ARS-funded researchers in Boston, Massachusetts, recruited 70 mobility-limited older adults (aged 70–92 years) and randomly assigned them to participate in either progressive resistance training or home-based flexibility training 3 times per week for 12 weeks. After 12 weeks, the progressive resistance training group showed a significant improvement in muscle fatigue and strength compared with the home-based flexibility group. These results show that progressive resistance/strength training improves muscle fatigue and strength in mobility-limited older adults. Because older adults are often affected by muscle and strength loss, the discovery of effective strength training interventions could prolong independence and quality of life in older adults.

Publication: Englund DA, Price LL, Grosicki GJ, Iwai M, Kashiwa M, Liu C, Reid KF, Fielding RA. [Progressive Resistance Training Improves Torque Capacity and Strength in Mobility-Limited Older Adults.](#) J Gerontol A Biol Sci Med Sci. 2019; 74:1316-1321.

Diet, gut bacteria, and chronic diarrhea. More than 1.2 million people in the United States suffer from inflammatory bowel disease; this disease also spontaneously occurs in monkeys. Gut bacteria aid nutrient absorption, whereas nutrients influence which gut bacteria live and

die. To study this interaction, ARS researchers in Davis, California, in collaboration with University of California-Davis scientists, discovered that even though both healthy and diseased animals consumed the same foods, the “diet” of their gut microbes was not the same. Gut microbes in diseased animals consumed more of the protective mucin layer produced by intestinal cells. The microbes also participated in cross-feeding relationships in which one microbe degraded part of the protective layer, leaving another part for another microbe. These discoveries will enable new strategies to prevent chronic gastrointestinal diseases, such as ulcerative colitis, in humans. (NP107, C3, PS3b, Project No. 2032-51530-026-00D)

Publication: Westreich ST, Ardeshir A, Alkan Z, Kable ME, Korf I, Lemay DG. [Fecal metatranscriptomics of macaques with idiopathic chronic diarrhea reveals altered mucin degradation and fucose utilization.](#) *Microbiome*. 2019; 7:41.

Cashews provide fewer calories than listed on the food label but do not reduce heart disease risk factors. The U.S. Food and Drug Administration (FDA) allows a qualified health claim for nuts stating that their consumption may reduce risk of heart disease but specifically excludes cashew nuts. ARS researchers in Beltsville, Maryland, conducted a controlled-diet study for 4 weeks during which volunteers followed a diet with or without 1.5 servings of cashews daily and found no changes in blood cholesterol or a half dozen other markers associated with heart disease. However, the nuts provided 17 percent fewer metabolizable calories than was predicted from the food label value. These studies support the FDA exclusion of cashews from its authorized health claim on nuts and heart disease but suggest cashew consumption will contribute less to weight gain than predicted from food labels. (NP107, C3 and 4, PS3a and b and 4b, Project No. 8040-51530-011-00D)

Publications: Baer DJ, Novotny JA. [Metabolizable Energy from Cashew Nuts is Less than that Predicted by Atwater Factors.](#) *Nutrients*. 2018; 11: E33.

Baer DJ, Novotny JA. [Consumption of cashew nuts does not influence blood lipids or other markers of cardiovascular disease in humans: a randomized controlled trial.](#) *Am J Clin Nutr*. 2019; 109:269-275.

Evening snacking generally involves less healthy choices. On any given day, almost two-thirds of Americans eat or drink something after 8:00 P.M. This is of concern to researchers and policymakers because most people generally have consumed enough calories for the day by the end of their evening meals. ARS researchers in Beltsville, Maryland, analyzed data from more than 10,000 volunteers in the What We Eat in America, National Health and Nutrition Examination Survey and found that one in five adults obtained 30 percent or more of their total daily calories from late-evening consumption of foods and beverages. Those who ate late at night took in about 15 percent more calories than nonsnackers did. Snacking was most prevalent among non-Hispanic black subjects. The most commonly eaten late evening food category was “snacks and sweets” and the most commonly consumed beverage was water. Behavioral interventions for weight control or healthier diets could focus on this vulnerable time during which fewer calories and healthier choices could be selected.

Publication: Sebastian RS, Wilkinson Enns C, Goldman JD, Moshfegh AJ. [Late evening food and beverage consumption by adolescents in the U.S.: What We Eat in America, NHANES 2013-2016](#). Food Surveys Research Group Dietary Data Brief No. 25. December 2019.

Medium-chain saturated fats reduce obesity severity in mice. Dietary fats comprise 30 percent of average daily energy intake. Dietary fats occur in many forms, and dietary saturated fat is associated with elevated obesity, fatty liver, inflammation, and insulin resistance. Medium-chain saturated fats such as those found in coconut and palm kernel oil are metabolized differently than other fats. ARS scientists in Grand Forks, North Dakota, studied whether substituting medium-chain saturated fats for long-chain saturated fats would reduce obesity outcomes in mice. Using carefully formulated diets, the research showed that obese mice that ate the medium-chain saturated fats had reduced insulin resistance, fatty liver, and inflammation compared with mice that ate the long-chain saturated fats found in more commonly eaten foods. These data suggest that medium-chain saturated fats may provide benefit for reducing obesity outcomes and warrant subsequent clinical study.

Publication: Žáček P, Bukowski M, Mehus A, Johnson L, Zeng H, Ratz S, Idso JP, Picklo M. [Dietary saturated fatty acid type impacts obesity-induced metabolic dysfunction and plasma lipidomic signatures in mice](#). J Nutr Biochem. 2019; 64:32-44.

Comparing the effects of different fatty acids on heart health. Saturated and unsaturated fatty acids are known to affect one's risk for heart disease differently, but it remains unclear whether specific saturated fatty acids have different effects. ARS-supported scientists in Boston, Massachusetts, fed older women who had elevated serum cholesterol three diets for 5 weeks. The diets were enriched with a monounsaturated fat called oleic acid and one of two saturated fatty acids with slightly different structures, either a palmitic saturated fatty acid or a stearic saturated fatty acid. Half the fat in each diet was from the fatty acid. Blood levels of LDL-cholesterol, a risk factor for heart disease, were similar in the women who consumed the stearic and oleic acid diets and significantly lower in the women who consumed the palmitic acid diet. This information will allow healthier choices in dietary recommendations.

Publication: Meng H, Matthan NR, Wu D, Li L, Rodríguez-Morató J, Cohen R, Galluccio JM, Dolnikowski GG, Lichtenstein AH. [Comparison of diets enriched in stearic, oleic, and palmitic acids on inflammation, immune response, cardiometabolic risk factors, and fecal bile acid concentrations in mildly hypercholesterolemic postmenopausal women-randomized crossover trial](#). Am J Clin Nutr. 2019; 110:305-315.

Vitamin D supplements do not improve muscle performance. Vitamin D deficiency has been associated with decreased muscle strength in some studies but has no effect on strength in others. Reduced muscle performance in older adults is an important problem because it leads to falls, fractures, other injuries, and loss of independence in older adults. Based on the hypothesis that individuals with low levels of vitamin D may benefit most from taking vitamin D supplements, ARS-funded researchers in Boston, Massachusetts, conducted a study in older

men and women who had low-to-normal blood levels of vitamin D. Over 12 months, participants were given either a dose of vitamin D (800–1,600 IU per day) or a placebo. The researchers found that supplementation had no effect on muscle strength, muscle power, or balance in this study population, and concluded that added vitamin D had no effect on muscle performance in adults with vitamin D levels in the lower part of the normal range. Although vitamin D is not important for muscle strength, maintaining normal levels of vitamin D in the body is important for other reasons, including bone health.

Publication: Shea MK, Fielding RA, Dawson-Hughes B. [The effect of vitamin D supplementation on lower-extremity power and function in older adults: a randomized controlled trial.](#) Am J Clin Nutr. 2019 Feb 1;109(2):369-379.