

FY 2016 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 Strategic Goal 5 of the [ARS Strategic Plan for FY 2012-2017: Improve the Nation's nutrition and health](#). Specifically, this program contributes to Objective 1.1: Enable Americans to make health-promoting, science-based dietary choices. The mission of NP 107 is to define the role of food and its components in maintaining health throughout the life cycle. 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 food/nutrient intake of the U.S.

There are five research components in the [Human Nutrition Action Plan](#) for 2014-2019:

- 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 2016 and expected to have high impact in the field are listed below. Links to publicly available documentation are provided after each result.

A database for branded food products. The National Nutrient Database, maintained by ARS in Beltsville, Maryland, contains information on the chemical composition of commonly consumed foods. However, although as many as 400,000 to 500,000 foods may be available in the U.S. food supply and the typical grocery store makes more than 30,000 items available to consumers, until recently the database contained information on fewer than 9,000 individual items. A public-private partnership among ARS, the North American branch of the International Life Sciences Institute, 1World Sync, and Label Insight brought nutritional label information of almost 90,000 additional foods to the database. This addition will strengthen the ability of USDA and other Federal health agencies to more accurately monitor the food supply and to estimate nutrient consumption by consumers.

Website: <https://ndb.nal.usda.gov/ndb/>

The glycemic index is not reproducible enough for diet advice nor does it affect metabolism.

The use of the glycemic index (GI) remains controversial. Although some health organizations and a few countries promote use of the GI for dietary recommendations, the USDA/HHS Dietary Guidelines for Americans do not. There is very limited data on variability between and within individuals and sources of that variability. ARS-supported researchers examined these factors in 63 healthy adult volunteers. Using white bread as the standard GI food, between and within person coefficients of variability were 20% and 25%, respectively. Blood measures of insulin and glucose status together explained almost one-third of that variability. Another study of 91 obese adults fed reduced calorie diets either high or moderate in total carbohydrates and high or

low GI for 17 weeks. There was no effect of any diet on weight loss, fat loss, resting metabolic rate or metabolic adaptation. These results demonstrate that GI is unlikely to be useful for guiding food choices in people.

Publications: Matthan NR, Ausman LM, Meng H, Tighiouart H, Lichtenstein AH. [Estimating the reliability of glycemic index values and potential sources of methodological and biological variability](#). Am J Clin Nutr. 2016; 104:1004-1013.

Karl JP, Roberts SB, Schaefer EJ, Gleason JA, Fuss P, Rasmussen H, Saltzman E, Das SK. [Effects of carbohydrate quantity and glycemic index on resting metabolic rate and body composition during weight loss](#). Obesity. 2015; 23:2190-2198.

Long-term caloric restriction reduces inflammation without impairing immunity. Calorie restriction (CR) slows aging and cancer growth in many animal species but the relevance to humans is unknown. ARS-supported scientists collaborated with several other institutions to directly study this question by assigning 143 healthy, non-obese adults to CR and 75 to continue their usual intake for 2 years. CR led to a 10% weight loss and a reduction in circulating inflammatory markers, total white blood cell, and lymphocyte counts. CR had no effect on delayed-type hypersensitivity skin response or antibody response to vaccines. Reductions in C-reactive protein (CRP) and tumor necrosis factor-alpha (TNF) were 40% and 50%; both of these markers are associated with increased heart disease, cancer, and other chronic health problems. Long-term CR appears to improve the health of young to middle aged adults and may decrease risk of major chronic diseases.

Publication: Meydani SN, Das SK, Pieper CF, Lewis MR, Klein S, Dixit VD, Gupta AK, Villareal DT, Bhapkar M, Huang M, Fuss PJ, Roberts SB, Holloszy JO, Fontana L. [Long-term moderate caloric restriction inhibits inflammation without impairing cell-mediated immunity: a randomized controlled trial in non-obese humans](#). Aging (Albany NY). 2016; 8:1416-1431.

Naturally occurring trans fatty acids have adverse effects on serum lipids. It is generally accepted that industrially produced trans fatty acids (TFA) found in partially hydrogenated oils lower beneficial HDL-cholesterol and raise harmful LDL-cholesterol, but no studies had ever directly examined the effects of consuming naturally occurring TFA from ruminant animals. ARS scientists conducted a feeding trial in 106 healthy adult volunteers fed 3% industrial TFA, 3% ruminant TFA, or 1% conjugated linoleic acid (CLA, another naturally occurring TFA but with a different chemical structure) for 24 days each. Both types of TFA raised LDL-cholesterol, ruminant TFA also raised HDL-cholesterol, while CLA lowered triglycerides and had no effect on other lipids. These results support the current labeling guidelines from the Food Safety Inspection Service and Food and Drug administration.

Publication: Gebauer SK, Destailats F, Dionisi F, Krauss RM, Baer DJ. [Vaccenic acid and trans fatty acid isomers from partially hydrogenated oil both adversely affect LDL cholesterol: a double-blind, randomized controlled trial](#). Am J Clin Nutr. 2015; 102:1339-1346.

Aging results in a decline of skeletal muscle quantity and function; these factors are major determinants of independent physical functioning in later life. ARS-funded researchers and Tufts University collaborators examined 3-year changes in muscle mass, strength, power, and physical performance among older adults and mobility-limited older subjects. They found that declining muscle function (strength and power) is an independent contributing factor, not just to falling, but to increased fear of falling and to deteriorations in quality of life. These findings

reinforce the importance of preserving muscle health with advancing age to reduce fall risk and improve quality of life.

Publication: Trombetti A, Reid KF, Hars M, Herrmann FR, Pasha E, Phillips EM, Fielding RA. [Age-associated declines in muscle mass, strength, power, and physical performance: impact on fear of falling and quality of life.](#) Osteoporos Int. 2016; 27:463-471.

Excess weight gain in pregnant women is driven primarily by increased calories. Excess weight gain during pregnancy leads to adverse outcomes for both mothers and infants. There has been ongoing debate whether excess gestational weight gain is the result of increased consumption or adaptive changes in energy expenditure during pregnancy. An analysis by ARS supported scientists of 45 pregnant women obtained measurements of these factors before conception and at 3 time points during pregnancy. The one-quarter of women who gained excess weight ate 750 calories more per day than those who gained ideal amounts of weight. The women decreased energy expenditure in physical activity during pregnancy but there was no difference by weight gain. Future interventions for weight gain during pregnancy may be more effective if focused only on limiting energy intake while increasing nutrient density of the diet.

Publication: Gilmore LA, Butte NF, Ravussin E, Han H, Burton JH, Redman LM. [Energy Intake and Energy Expenditure for Determining Excess Weight Gain in Pregnant Women.](#) Obstet Gynecol. 2016; 127:884-892.

Baseline data for the 2020 Dietary Guidelines for Americans. One of the gaps in dietary recommendations is the lack of science for dietary advice aimed at children from birth to 24 months of age. The U.S. Government is committed to adding this age group so researchers from the ARS Children's Nutrition Research Center collaborated with investigators at Deakin University in Australia to analyze dietary intake reported by mothers for 2740 infants and toddlers in the NHANES study from 2005 to 2012. In children under 1 year of age, infant formulas and baby foods were the leading source of calories and nutrients. In the children from 12-24 months, milk, 100% juice and grain-based mixed dishes were important sources but a number of foods of low nutritional quality contributed to energy intake including sweet bakery products, sugar-sweetened beverages, and savory snacks. Non-flavored milk and ready-to-eat cereals were the most important contributors to micronutrient intakes. These data will help formulate future recommendations for this age group.

Publication: Grimes CA, Szymlek-Gay EA, Campbell KJ, Nicklas TA. [Food sources of total energy and nutrients among U.S. infants and toddlers: National Health and Nutrition Examination Survey 2005-2012.](#) Nutrients. 2015; 7:6797-836.

A component of milk helps reduce the negative effects of higher saturated fat intake. The U.S. Dietary Guidelines urge limited intake of saturated fat because epidemiological data suggest it is associated with cardiovascular disease. However, results from previous human studies indicate this may not always be true. Consequently, ARS researchers at the Western Regional Research Center examined the effect of a high-saturated-fat meal on inflammatory markers in obese men and women for 6 hours following the meal. Two different forms of saturated fat (palm oil and whipping cream) were ingested with and without the addition of milk fat globule membrane (MFGM). MFGM surrounds the fat globules in milk and has been shown to reduce inflammation associated with some foods. ARS researchers found that consumption of MFGM with either palm oil or whipping cream resulted in lower total cholesterol, LDL cholesterol,

insulin, and small molecules associated with inflammation. This suggests that the addition of MFGM ameliorates the negative effect of a high-saturated-fat meal in overweight and obese men and women.

Publication: Demmer E, Van Loan MD, Rivera N, Rogers TS, Gertz ER, German JB, Smilowitz JT, Zivkovic AM. [Addition of a dairy fraction rich in milk fat globule membrane to a high-saturated fat meal reduces the postprandial insulinaemic and inflammatory response in overweight and obese adults](#). J Nutr Sci. 2016; 5:e14.

What We Eat in America. What We Eat in America (WWEIA) is the nutrition portion of the National Health and Nutrition Examination Survey (NHANES) conducted in partnership with the Centers for Disease Control & Prevention. In 2016, ARS scientists released food and nutrient consumption data for 2013-2014 in 56 publicly available tables. They also released the WWEIA Food Categories which classifies more than 8,000 foods and beverages in the USDA food composition database into 152 categories that can be used by researchers. Thousands of scientific papers have been published over the years linking food consumption to nutrient status and health. NHANES is the only nationally representative survey of its kind and provides snapshots over time of the status of the American people.

Website: <http://www.ars.usda.gov/nea/bhnrc/fsrg>

Identification of structural components of dry beans that limit iron bioavailability. Dry beans are an important dietary source of many minerals, especially in areas where food is insecure. It may be possible to supply dietary iron through dry beans, but iron bioavailability is low in many varieties, and the reasons for low bioavailability are unclear. Approximately 80 percent of the iron in beans is found in a portion of the bean called the cotyledon, where cells are rich in protein and phytic acid. ARS researchers in Ithaca, New York, with their collaborators from Cornell University, found that cotyledon cell walls are not softened or rendered nutritionally useful by cooking and are highly resistant to digestion in the upper intestine, which is the major site of iron absorption. This makes a major portion of bean iron unavailable for absorption until it reaches an area of the intestine where microbes can digest the cotyledon cell walls. However, the latter portions of the intestine do not have much capacity for iron absorption. Moreover, release of the iron is affected by distribution of iron in the seed or coat, and the presence of inhibitors of absorption, including dietary fiber and pigments, in the beans. These findings will help with development of bean breeding and processing strategies that can improve beans as a source of iron.

Publication: Glahn RP, Tako E, Cichy K, Wiesinger J. [The cotyledon cell wall and intracellular matrix are factors that limit iron bioavailability of the common bean \(*Phaseolus vulgaris*\)](#). Food Funct. 2016; 7:3193-200.

Farmed salmon consumption reduces indicators of cardiovascular disease risk. It is known that salmon contains omega-3 fats that are considered to be heart healthy. ARS scientists in Grand Forks, North Dakota, studied the benefits of eating farmed salmon on lowering the risk of cardiovascular disease in healthy adults. Subjects ate increasing amounts of farmed salmon for 4 weeks, and indicators of cardiovascular disease risk were measured, including serum lipoprotein concentration, size, and density. The study results indicate that eating as little as 3 ounces of salmon twice a week modified serum lipoprotein particle size (a relatively newly developed risk

factor for heart disease) and concentration in a manner associated with reduced cardiovascular disease risk.

Publication: Raatz SK, Johnson LK, Rosenberger TA, Picklo MJ. [Twice weekly intake of farmed Atlantic salmon \(*Salmo salar*\) positively influences lipoprotein concentration and particle size in overweight men and women.](#) Nutr Res. 2016; 36:899-906.

Intermittent feeding of the amino acid leucine enhances growth in newborns. About 9 percent of infants born in the United States are of low birth weight (LBW) or very low birth weight, and optimum nutrition is crucial for their immediate and long-term health. LBW infants are usually fed through a stomach tube either continuously or intermittently. ARS-funded scientists in Houston, Texas, with collaborators from Baylor College of Medicine, studied feeding regimens in young pigs as a model for human infants. The piglets were fed an optimal formula diet continuously, or one supplemented with intermittent pulses of the amino acid leucine for 21 days. Addition of leucine to the diet enhanced lean growth by stimulating skeletal muscle synthesis. These results suggest that leucine may be useful in nutritional therapy to enhance growth in LBW infants and prevent later problems resulting from delayed development.

Publication: Boutry C, El-Kadi SW, Suryawan A, Steinhoff-Wagner J, Stoll B, Orellana RA, Nguyen HV, Kimball SR, Fiorotto ML, Davis TA. [Pulsatile delivery of a leucine supplement during long-term continuous enteral feeding enhances lean growth in term neonatal pigs.](#) Am J Physiol Endocrinol Metab. 2016; 310:E699-E713.

Swine are a better model for human immunity than mice. Although the mouse is the most widely used laboratory animal model for humans, many discoveries from them do not always translate to the human condition. ARS researchers compared part of the innate immune system collectively termed the inflammasome in humans, mice, and pigs. Among 11 gene families that control the inflammasome, 9 were similar in humans and pigs but only 3 were similar in humans and mice. Confirming this observation, inflammatory cell responses in pigs were closer to those of humans than were cells from mice. This work supports using swine to model both human immunological and inflammatory responses to infection, as long as the noted differences are kept in mind.

Publication: Dawson HD, Smith AD, Chen C, Urban JF Jr. [An in-depth comparison of the porcine, murine and human inflammasomes; lessons from the porcine genome and transcriptome.](#) Vet Microbiol. 2016 pii: S0378-1135(16)30137-7.

Validation of sampling the intestinal microbiome for metabolic activity. The bacteria of the large intestine have recently been discovered to considerably influence metabolic activity in the body, primarily through absorption of bacterially produced metabolites. To determine if the molecules are important, ARS researchers detected a total of 270 low molecular weight metabolites in contents of the colon-cecum and feces from mice. Of that total, 93% were present in both specimens, establishing for the first time that fecal samples can be used as a valid, non-invasive proxy for most metabolic activity higher up in the intestinal tract.

Publication: Zeng H, Grapov D, Jackson MI, Fahrman J, Fiehn O, Combs GF. [Integrating Multiple Analytical Datasets to Compare Metabolite Profiles of Mouse Colonic-Cecal Contents and Feces.](#) Metabolites. 2015; 5:489-501.