

An Evolving Nutrition Focus

*Rediscovering Protein's Role
in the Optimal Human Diet*



BEEF

Funded by
the Beef Checkoff.



M·E·A·T

FOR INDISPENSABLE PROTEIN



IT is a fact that all protein foods are not of equal value. Meat is one of the best sources of this indispensable food factor. For this reason meat has an important place in the diet.

The wear and tear of everyday activity is constantly breaking down the body tissues. Protein foods are the ones which repair and build up the worn-out tissues.

One reason that meat protein is so valuable is that it is 98 per cent digestible. The body is able to utilize practically all of the protein in meat.

Another important characteristic of meat protein is that it makes other proteins more valuable by making up their deficiencies.

The pendulum of "the protein requirement" has swung back and forth between high and low, but scientists are generally agreed that a liberal amount of high quality protein is safest.

Meat is a rich source of high quality protein.

EAT MEAT FOR PROTEIN



*From Meat for Every Occasion recipe booklet (1933).
Compliments of National Live Stock and Meat Board*

An Evolving Nutrition Focus

Rediscovering Protein's Role in the Optimal Human Diet

“As it turns out, though, the third macronutrient, protein, may well be the most underappreciated – yet crucial – component in optimal diets.”

Background

Over the past 40 years, fat and carbohydrates have been the macronutrients filling the media headlines related to human nutrition. As it turns out, though, the third macronutrient, protein, may well be the most underappreciated – yet crucial – component in optimal diets. How did protein lose its place in this important nutrition discussion? And is a protein rebound happening now?

The dietary guidance from public health and government agencies has always been based on the dietary needs of Americans. Through the first half of the 20th century, disease prevention was the focus of nutrition guidance. Illnesses such as goiter, rickets, beriberi and pellagra were common and associated with the lack of certain vitamins and nutrients in the diet. In the 1920s, the fortification of foods with essential vitamins and minerals was identified as a safe, effective way to bolster the nutrient content of food and improve public health.

In 1921, Dr. David Marine and Dr. O.P. Kimball presented findings from their clinical study that demonstrated how sodium iodide treatments effectively prevented goiter in Akron schoolgirls. Soon after, the state of Michigan, one of the geographic areas within the so-called “goiter-belt” due to the prevalence of profound iodine deficiency in children, conducted a highly successful public

health campaign to make iodized salt available to consumers for the prevention of iodine deficiency. By 1924, iodized salt was commonplace, and most table salts today are fortified with iodine.

In 1938, the American Medical Association’s Council on Foods and Nutrition endorsed the addition of nutrients to foods if the impact could improve public health. For example, in the 1930s, fortification of milk with vitamin D became a key weapon in the near-complete eradication of rickets in the United States. Similarly, by the early 1940s, 75 percent of white bread was baked using flour enriched with thiamin, niacin, iron and riboflavin to help fight against micronutrient-deficiency diseases like pellagra and beriberi, thereby virtually eliminating them as public health threats.

With the advancement of food fortification, Americans were not only better nourished, they were successfully preventing nutritional deficiencies. Starting in the 1950s and over the next half century, the public health focus shifted from what was not in the diet that should be, to what was in the diet that should not be. With more choices in the food supply, it became important to avoid the overfed/undernourished paradox.

Fat: A Popular Villain

The 1977 Dietary Goals for the United States, published by the U.S. Senate’s Committee on Nutrition and Human Needs, asserted

PROTEIN RESEARCH OVER THE YEARS

1800s

Protein is determined to be an essential nutrient.

1920s

A diet of animal protein and vegetables is shown to be superior to a diet of vegetables alone.

1930s

Meat is shown to provide nutrients required for work performance and release of energy.

1940s

First RDA is published in 1943; protein RDA is set at 0.8 grams/kilogram of body weight/day.

Low levels of lean meat intake are shown to relate to decreases in hemoglobin and red cells in the blood.

1950s

After beef consumption, protein is shown to break down rapidly and become available for utilization by the body.

1960s

Protein studies show that requirement levels for essential amino acids, widely accepted for 20 years, are too low.

that “too much fat, too much sugar or salt can be and are linked directly to heart disease, obesity, cancer and stroke, among several killer diseases.” While sugar and salt were identified, Americans focused their attention on one villain – fat. Specifically, animal fat.

The Dietary Goals document encouraged Americans to increase their carbohydrate consumption and decrease their fat consumption. The Dietary Goals failed to emphasize recommendations for protein consumption.

Since the 1977 Dietary Goals document was released, Americans have been adjusting their diets to follow this dietary advice – and have been getting fatter.

The turn of this century saw a gradual shift in conventional thinking, with carbohydrates getting more publicity, and not always in a positive way. Low-carb diets started becoming popular; the Atkins diet and others demonstrated that fat isn’t necessarily the villain when it comes to weight gain.

In spite of this, protein was still very much an afterthought in many nutrition discussions. Some contended Americans were eating as much as they needed – or in some cases too much. A growing body of evidence over the last two decades demonstrates that more research focus on protein is needed, and increasing intake in many instances may be beneficial to health. Much of this evidence has

been made possible through nutrition research funded by the Beef Checkoff Program.

What Constitutes Good Nutrition

In 1816, Francois Magendie, a French physiologist, determined that protein was an essential nutrient. Eleven years later, William Prout, British physician and chemist, introduced the idea that proteins, carbohydrates, fats and water are necessary to sustain life in mammals. The term “protein” was coined in 1838 by Gerrit Jan Mulder, a Netherlands physician and chemist who was one of the first to promote the “optimum” human diet – emphasizing moderation, neither too little nor too much. “Considering the history of the diets of older and younger civilized nations, it appears that mankind and the human organism can endure much, but rules concerning the best kinds of foods are not given,” Mulder said. “I do not speak of such food which can preserve life and health. I mean such foods with which life and health are preserved in the best way.”

Since those early years, nutrition scientists have been working to determine the appropriate proportion of macronutrients in a diet that optimizes human health, a topic still actively debated by nutrition scientists today. The meat industry, of course, has weighed in with its case for the importance of protein. And with good reason. There is no question that protein is essential to a healthful diet.



Francois Magendie
1783 - 1855



Gerrit Jan Mulder
1802 - 1880

1970s

Studies are conducted on the effects of meat protein on young adults and the importance of meat protein in the diets of children.

Studies are conducted on protein deficiency and protein quality during pregnancy.

1980s

Optimal dietary protein intake for the elderly to produce maximum defenses against infections is studied.

1990s

Studies are conducted to explore the effects of meat’s protein on body composition, different life stages and life styles, and weight control.

2000s

Sufficiency of protein intake for various population groups is studied.

Macronutrient AMDRs are set for adults and children.

The relationship between animal protein intake and the likelihood of meeting the protein RDA is studied.

Studies are conducted on the health benefits of adequate, high-quality protein intake at each meal.

An Evolving Nutrition Focus

Rediscovering Protein's Role in the Optimal Human Diet



George H. Whipple
1878 - 1976



Paul R. Cannon
1892 - 1986

What is Protein?

The basic building blocks of protein are amino acids which play an important role in human metabolism. About 20 percent of the body is made up of amino acids. When dietary protein is digested, it is broken down into amino acids which the body uses to make proteins that support many bodily functions, including growth, transport and storage of nutrients, repair of body tissues (especially in the muscles, bones, skin and hair), as well as the removal of all kinds of waste deposits. Amino acids are also a source of energy for the body.

The essential, or indispensable, amino acids (EAA), threonine, tryptophan, methionine, leucine, isoleucine, lysine, phenylalanine, valine and histidine, cannot be synthesized in the body and thus must be supplied by the diet. Generally, plant proteins, when eaten alone, do not contain all of the EAA in sufficient quantities and, therefore, are incomplete. Animal proteins contain all nine EAA and are considered a complete, high-quality protein source. While protein can be found in both plant and animal foods, animal-based proteins have been shown to be more bioavailable and are more readily useable by the body. In addition, plant proteins are often less digestible, thus less useable. For example, high amounts of insoluble fiber, tannins, trypsin inhibitors, haemagglutinins and phytates are responsible for lower digestibility of nutrients, including protein from plant foods.²

Considering the challenge of meeting all nutrient needs within the calorie allowance allotted by age, gender, and activity level,

animal proteins are an efficient way to meet protein needs. For example, a 3-ounce serving of lean beef, on average, provides 25 grams of protein in just 154 calories. It would take 6 tablespoons of peanut butter (564 calories), 1 $\frac{3}{4}$ c of black beans (382 calories), or 3 cups of quinoa (666 calories) to provide the same amount of protein.³

Broadening the Effort

The meat industry became involved in the discussion of meat's role in good nutrition during the 1920s. That's when the National Live Stock and Meat Board, established in 1922, began a program funded by producers and packers to increase consumer understanding of the important nutritional role of meat in the diet.

Research supported by the Meat Board led to significant breakthroughs in the field of nutrition. In 1924, for instance, Dr. James R. Sloanaker, a physiologist from Stanford University, shared his 12 years of research demonstrating a diet of animal protein and vegetables is superior to a diet of vegetables alone. And in the early 1930s, Dr. George H. Whipple of the University of Rochester received the Nobel Prize for his Meat Board-funded discovery of the relation of meat and meat products to blood regeneration, and that liver could be fed to prevent and cure anemia – changing the public's attitude toward liver.

Meat as a protein food constituted a large part of Meat Board-funded research in the early years. Protein utilization from meat was researched as early as the 1930s at the University of Chicago. Paul R. Cannon, M.D., looked at protein utilization and energy intake and found that meat provided nutrients required for work performance and the release of energy.

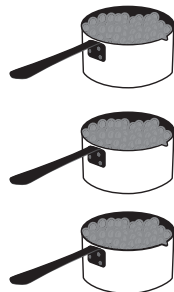
At Pennsylvania State College in 1943, Dr. Pauline B. Mack studied meat in the diets of older persons. She found that as the age of the subjects increased, the reduced levels of lean meat intake were related to decreases in hemoglobin and red cells in the blood. This resulted in fatigue, nervousness, progressively poorer reflexes and increasing heart dysfunctions.

As research became more sophisticated, it was possible to investigate the intricate aspects of protein, and protein in meat, in more detail. Over its first 60 years the Meat Board funded almost 60 studies focused on protein and/or amino acids out of a total of 293 studies.

What Does 25 Grams of Protein Look Like?



Peanut Butter
6 tablespoons
564 calories



Quinoa
3 cups
666 calories



Black Beans
1 $\frac{3}{4}$ cups
382 calories



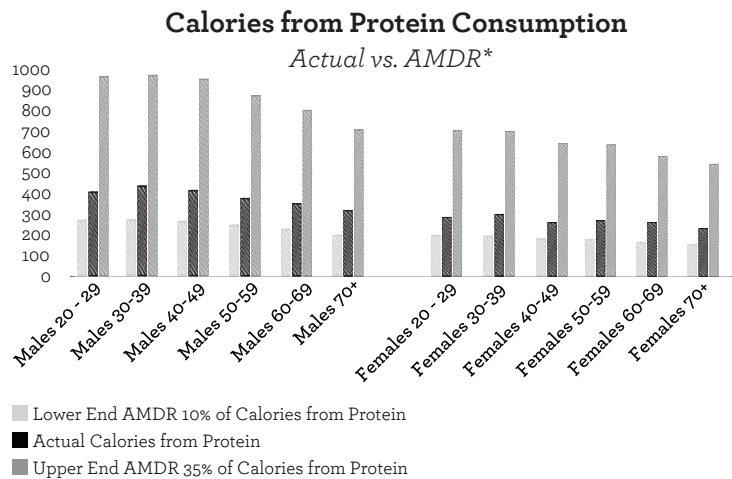
Lean Beef
3 ounces
154 calories

More recently, beef checkoff-funded research has shown that heart-healthy diets including high-quality lean protein help lower LDL cholesterol, reduce the risk of chronic disease and reduce high blood pressure.⁴⁵ Another study showed that exercise is more effective when paired with a higher-protein diet.⁶

Back to Basics

Nutrition Guidelines

The Food and Nutrition Board of the National Academy of Medicine establishes ranges of macronutrient intakes associated with reduced risk of chronic disease, while providing recommended intakes of other essential nutrients. These ranges, called Acceptable Macronutrient Distribution Ranges (AMDRs), were introduced in 2002 and are established as percentages of total energy intake. They offer flexibility for consumption of each macronutrient allowing for individual differences, including age and health status. The AMDR for protein is 10 to 35 percent of energy for adults (5 to 20 percent for children 1 to 3 years of age and 10 to 30 percent for children 4 to 18 years of age).



*Acceptable Macronutrient Distribution Range, Institute of Medicine Guidelines
Source: *What We Eat in America, NHANES 2011-2012*, www.ars.usda.gov/nea/bhnrc/fsrg

The Recommended Dietary Allowance (RDA) for protein for healthy individuals, 0.8 g/kg of body weight (0.36 g/pound of body weight) per day, is derived by estimating the amount of protein

needed to maintain nitrogen balance for the average adult. The RDA is aimed at preventing deficiency as opposed to promoting optimal health.⁷ The RDA has remained unchanged for 70 years.⁸

More recent research suggests that a higher-protein intake above the RDA, though well within the AMDR guidelines set by the National Academy of Medicine, may provide additional positive health outcomes, such as preventing muscle loss, maintaining physical function and supporting weight management and more healthful metabolic profiles.

Legacy of Vernon Young

Significant research in the area of protein requirements and appropriate intake across population segments was conducted by a visionary scientist at the Massachusetts Institute of Technology named Vernon R. Young. In the 1960s, Young became the leading expert on protein and amino acid requirements and metabolism. Through his research using stable isotopes, he was able to show the requirement levels for EAA, widely accepted for 20 years, were too low.

Young was both innovative and intuitive in his approach to protein research and, in the second half of the 20th century, published more than 600 studies in scientific journals. A substantial number addressed nitrogen losses and utilization, which laid the cornerstone for determining actual protein requirements. His study design for the United Nations University field trials in 15 countries provided the evidence to support a 33 percent increase in the international recommended allowance for dietary protein.

This work led to improved estimates of protein deficiencies in developing countries and ultimately affected agricultural and health policy. Over his career, Young studied protein absorption, protein quality, protein synthesis and breakdown as related to specific populations, synthesis of both indispensable and dispensable amino acids, along with many other related protein questions.⁹

More than any other, Young's research laid the groundwork for a renewed interest in protein, and many of the scientists he trained are now expanding the understanding of protein's role in health. Is it really reduced carbohydrates or fats that create improved diets? Or could an increase in protein be a critical factor in optimal diets?



Pauline Berry Mack
1891 - 1974



Vernon R. Young
1937-2004

An Evolving Nutrition Focus

Rediscovering Protein's Role in the Optimal Human Diet

“While previous research had uncovered some important evidence necessary for assessing protein's value, more research was needed to determine the dietary protein intake for optimal health.”

With heightened interest around obesity, and a growing criticism of the efficacy of low-fat diets for weight management and optimal health, protein food groups began collaborating at the turn of this century to increase their efforts to move the discussion forward about the importance of protein in the diet. A Protein Think Tank in May of 2006, including a group of seven internationally recognized experts in protein research, convened to identify research needs for understanding the role of beef protein in promoting good health. This led to the first Protein Summit in 2007.

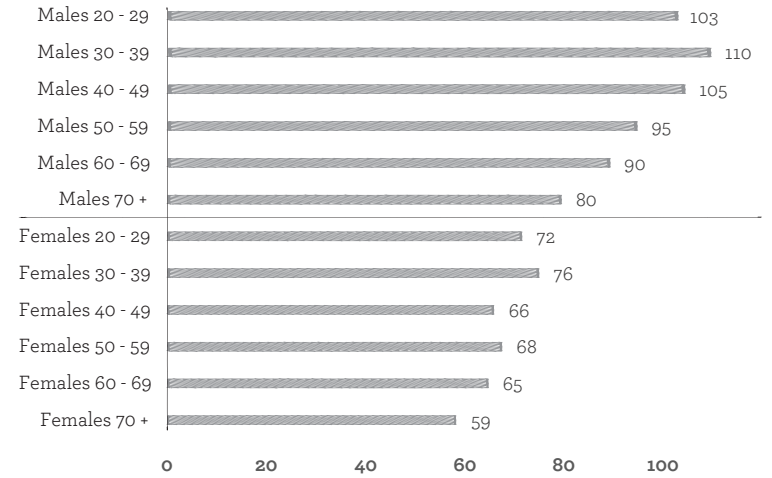
Protein Summit 2007: Exploring the Impact of High-Quality Protein on Optimal Health

The Summit was an international scientific effort with significant implications for protein research that took place May 23-24 in Charleston, SC. More than 50 protein researchers from the United States, Canada, England, Denmark, the Netherlands, France, Australia and New Zealand participated. Working groups addressed topics including the role of dietary protein intake in optimal health, muscle maintenance, and disease prevention; and protein quality assessment. They identified research gaps to develop investigative initiatives to determine protein's contribution to optimal health.

There was consensus that research continued to reinforce the importance of higher protein intakes to various health outcomes such as weight management, diabetes and cardiovascular disease. The proceedings from the Summit were published in a supplement consisting of eight papers in the May 2008 issue of the *American Journal of Clinical Nutrition*.

One area of focus among researchers at the Summit was the potential benefits increased protein intake presents to certain populations. One study, for instance, showed that while most age/sex groups appeared to consume more protein than the respective Estimated Average Requirements (EAR), a significant percentage of adolescent females and older women had inadequate protein intake.¹⁰ Furthermore, as Americans age they tend to decrease their protein intake. Given the rising concern about the loss of skeletal muscle mass and strength associated with aging, protein intake in older Americans deserved increased attention.

Protein Consumption in Grams by Gender and Age



Source: *What We Eat in America, NHANES 2011-2012*, www.ars.usda.gov/nea/bhnrc/fsrg

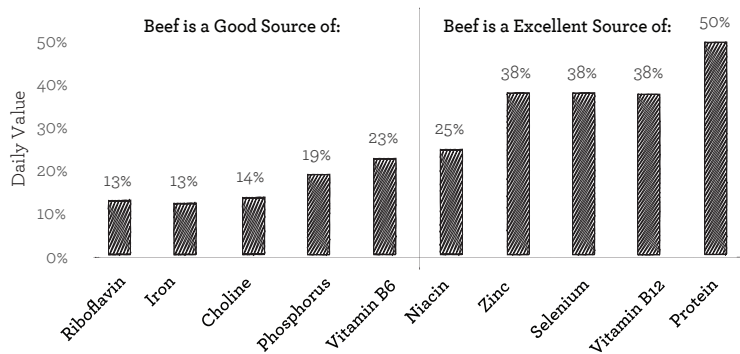
Based on the Summit's proceedings, it was apparent that while previous research had uncovered some important evidence necessary for assessing protein's value, more research was needed to determine the intake levels of protein for optimal health, including the role of EAA in lean body mass retention, cell signaling, bone health, glucose homeostasis, and satiety induction.¹¹ The research presented at the Summit further renewed industry interest in the positive protein aspects of its products. It also gave the industry direction for funding further research.

An International Concern

The impact of protein intake isn't just an issue in this country; it's an increasing concern globally. While red meat is sometimes viewed as a culprit for poor-health-related diseases, it can serve as a means to reduce malnutrition and increase food security in developing countries. Recognition of key micronutrients as well as the protein contributed by red meat to the global food supply has sometimes been overshadowed by recommendations from developed countries to reduce fat consumption. Relative to the energy it supplies, the impact of red meat on the nutritional quality of the human diet through its contribution of protein and key micronutrients is underappreciated.¹²

According to the Food and Drug Administration, a food that contains 10 – 20 percent of the Daily Value of a nutrient in a recommended serving size is technically defined as a “good” source of that nutrient. With 20 percent or more of the Daily Value of a nutrient, the food is considered an “excellent” source. Daily Value refers to the recommended amount of a nutrient needed each day.

An Average 3-oz Serving of Beef Enhances Diet Quality³



On September 16, 2013, in coordination with the Beef Checkoff, the International Meat Secretariat supported a Symposium on Protein Requirements during the International Union of Nutritional Sciences International Congress of Nutrition in Granada, Spain. Strong evidence supporting a beneficial effect in increasing high-quality protein intake for optimal health throughout all life stages was presented by internationally recognized protein scientists to a global audience of nutrition experts. (The proceedings of the Symposium are available on www.beefresearch.org.)

At the Symposium, four researchers provided evidence-based information about the nutritional qualities of protein and its role in a healthful, sustainable diet. Dr. Paul Moughan, professor at Massey University in New Zealand, reported that a large body of research shows that individual dietary EAA have different physiological and regulatory roles, so there may be a need to assess each as a nutrient in its own right.

Meanwhile, Dr. Rajavel Elango, professor at the University of British Columbia, said current protein recommendations for adult humans and children appear significantly underestimated, based on

methods of determining those requirements. He said a reassessment of recommendations for protein intake in children is an urgent need. Both researchers explained how the method for establishing the protein RDAs for all life stages is not taking into consideration all relevant factors, and offered new solutions for determining a more precise RDA.

In agreement, Dr. Nancy Rodriguez, professor at University of Connecticut, noted the RDA sets the minimal amount of dietary protein for most adults, and is based on nitrogen balance, not functional outcomes. This is particularly relevant to dietary directives for healthy aging. She said an increase in protein intake has shown benefits to bone health by increasing calcium absorption. Furthermore, high-quality proteins are a nutrient-dense source of many essential micronutrients that contribute to the nutritional status of older adults.

The final speaker, Dr. Caryl Nowson, professor at Deakin University, Australia, focused on the protein needs of older people, referencing a study that found older adults who consumed the U.S. RDA for 10 days were in negative nitrogen balance. Further, the study reported that food- and meal-based strategies rather than supplemental drinks are likely to be more sustainable and are recommended as the initial approach to optimizing protein intake in this population.¹³

Protein Summit 2.0: Evaluating the Role of Protein in Public Health

The International Symposium was followed immediately by Protein Summit 2.0 on October 2-3, 2013, co-sponsored by the Beef Checkoff Program, Dairy Research Institute, Egg Nutrition Center, Global Dairy Platform, Hillshire Brands and National Pork Board. The meeting was hosted by Purdue University’s Ingestive Behavior Research Center; the Reynolds Institute on Aging and University of Arkansas for Medical Sciences; and the University of Missouri’s Department of Nutrition and Exercise Physiology and the Nutritional Center for Health. Its purpose was to assess advances in protein research since the first Summit in 2007 and determine further research needs to better understand dietary protein’s impact on human health. More than 50 international nutrition scientists, health experts and nutrition educators joined the eight-member



Relative to the energy it supplies, the impact of red meat on the nutritional quality of the human diet through its contribution of protein and key micronutrients is underappreciated.

An Evolving Nutrition Focus

Rediscovering Protein's Role in the Optimal Human Diet

“Much of the progress made in understanding the unique role of dietary protein is directly attributable to the research funded by beef producers through their Beef Checkoff Program.”

steering committee in Washington D.C. to discuss dietary protein's role in weight management, including satiety and healthful diet adherence; metabolic activity, as well as its impact on renal function and bone health; healthy aging, including prevention of muscle loss; and establishing a foundation to build more healthful diets within energy (calorie) goals.

Tremendous advances in both protein research and interest in the subject had been made since the first Summit. It was noted in the 2013 Summit introduction that the proceedings from the first event, published as a supplement to the *American Journal of Clinical Nutrition* in 2008, had been downloaded more than 70,000 times. Furthermore, it was recognized that since the 2007 Summit, “the scientific literature has expanded with research indicating that higher-protein intakes contribute to better diet quality, healthy weight management, improved body composition, and maintenance of, or increase in, lean body mass for certain populations.”¹⁴

Weight loss research, for instance, suggests that higher-protein diets that contain between 1.2 and 1.6 g of protein per kg of body weight per day and include meal-specific protein quantities of at least 25-30 g provide improvements in appetite control, body weight management, and/or cardiometabolic risk factors, compared with lower-protein diets.¹⁵

The role of protein in healthy aging received further attention as a result of the Summit. Researchers demonstrated that consuming an adequate amount of high-quality protein at each meal, in combination with physical activity, represents a promising strategy to prevent or delay the loss of skeletal muscle mass and strength.¹⁶

The proceedings from this Summit were published in a supplement consisting of six papers in the June 2015 issue of the *American Journal of Clinical Nutrition*. Additional research is needed, including human clinical trials, as well as animal and cellular models, to continue to enhance our understanding of the role of protein in growth and maintenance of muscle mass and function during aging.

Building on What's Known


Each research project provided additional knowledge, but, like most research, left questions unanswered and avenues open for further exploration.

For example, a small checkoff-funded pilot study reported in 2014 suggests that consumption of a daily breakfast meal – particularly one high in protein – may be beneficial in reducing food cravings throughout the day.¹⁷

Another study looked at protein intake for infants. Because increased adiposity in formula-fed infants has been associated with high intakes of cow-milk protein, limited protein intake in later infancy has been recommended. A study published in 2014 showed that protein from meats may actually increase linear growth and weight gain in breastfed infants without excessive gain in adiposity. These results suggest the response to higher-protein intake may be different in breastfed and formula-fed infants.¹⁸

Conclusion

Scientific research can be a slow process, and by its very nature not all research will support beef marketing efforts. For more than 90 years, the industry has invested in critical research to increase knowledge about the nutritional properties of beef and the benefits it provides to the diet. Much of the progress made in understanding the unique role of dietary protein is directly attributable to the research funded by beef producers through their Beef Checkoff Program.

Nutrition research also provides a foundation for beef checkoff-funded education and information programs. In fact, scientific assessments of the value of beef products to human health have been a cornerstone of beef industry outreach success for nearly a century, but the future of the beef industry depends on continuing this commitment. With a topic as multifaceted as optimal human nutrition, the questions surrounding the role of protein continue to outnumber the answers, making the investment in nutrition research as critical as ever. 

Citations

1. Brouwer E, Gerrit Jan Mulder (1802-1880). *J Nutr* 1952;46:3-11.
2. Sarwar GG, et al. Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. *Br J Nutr* 2012;108:S315-32.
3. US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 27 (revised). Version Current: May 2015. Internet: <http://www.ars.usda.gov/ba/bhnrc/ndl>.
4. Roussell MA, et al. Beef in an Optimal Lean Diet study: effects on lipids, lipoproteins, and apolipoproteins. *Am J Clin Nutr* 2012;95:9-16.
5. Roussell MA, et al. Effects of a DASH-like diet containing lean beef on vascular health. *J Hum Hypertens* 2014;28:600-5.
6. Layman DK, et al. Dietary protein and exercise have additive effects on body composition during weight loss in adult women. *J Nutr* 2005;135:1903-10.
7. Rodriguez NR, Garlick PJ. Introduction to Protein Summit 2007: exploring the impact of high-quality protein on optimal health. *Am J Clin Nutr* 2008;87:1551S-3S.
8. Rodriguez NR. Protein-centric meals for optimal protein utilization: can it be that simple? *Nutr J* 2014;144:797-8.
9. Scrimshaw NS, et al. Vernon R Young: the man, the scientist, the visionary. *Am J Clin Nutr* 2006;83:496S-9.
10. Fulgoni VL 3rd. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003-2004. *Am J Clin Nutr* 2008;87:1554S-7S.
11. Millward DJ, et al. Protein quality assessment: impact of expanding understanding of protein and amino acid needs for optimal health. *Am J Clin Nutr* 2008;87:1576S-81S.
12. McNeill S, Van Elswyk ME. Red meat in global nutrition. *Meat Sci* 2012;92:166-73.
13. Proceedings of The International Meat Secretariat's Symposium on Protein Requirements for optimal health throughout all life stages, September 16, 2013, Granada, Spain.
14. Rodriguez NR. Introduction to Protein Summit 2.0: continued exploration of the impact of high-quality protein on optimal health. *Am J Clin Nutr* 2015;101:1317S-9S.
15. Leidy HJ, et al. The role of protein in weight loss and maintenance. *Am J Clin Nutr* 2015;101:1320S-9S.
16. Layman DK, et al. Defining meal requirements for protein to optimize metabolic roles of amino acids. *Am J Clin Nutr* 2015;101:1330S-8S.
17. Hoertel HA, et al. A randomized crossover, pilot study examining the effects of a normal protein vs. high protein breakfast on food cravings and reward signals in overweight/obese "breakfast skipping", late-adolescent girls. *Nutr J* 2014;13:80.
18. Tang M, Krebs NF. High protein intake from meat as complementary food increases growth but not adiposity in breastfed infants: a randomized trial. *Am J Clin Nutr* 2014;100:1322-8.



**For more information, contact
National Cattlemen's Beef Association**

A contractor to The Beef Checkoff Program

303.694.0305 • BeefResearch.org



Funded by the Beef Checkoff.