Reflection on the history, coordination, and funding trends for U.S. public meat research: Information to enhance resource allocation

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ABSTRACT: A study was conducted to analyze resource allocation for public meat research in the United States and characterize the portfolio of meat research investments. Trends in the amount of public resources provided for meat research (beef, pork, lamb, and poultry) were analyzed for fiscal years 1980, 1985, 1990, 1995, and 1997. An in-depth analysis was conducted for data from fiscal year 1998 to characterize the profile of the research portfolio. Funding levels and scientist-year equivalents were aggregated to represent the measures of resource allocation for three mutually exclusive research categories: 1) meat quality, 2) food safety, and 3) product development and processing. Data for the 1998 profile analysis were derived from a computer search based on the combination of key words and research classification codes to avoid duplication and cluster research projects. Individual research projects were individually reviewed and a percentage was assigned to four mutually exclusive research categories: 1) meat quality, 2) food safety, 3) product development and processing, and 4) marketing. As meat research evolved over the past century, considerable efforts were expended by researchers and administrators to ensure the coordination of research and program relevance. This is demonstrated by the establishment of numerous multistate research committees. Total funding for meat science increased only modestly when adjusted for inflation during the two decades of this study; however, notable changes occurred in the distribution of resources in the portfolio. Funding for meat quality and product development and processing remained virtually unchanged when adjusted for inflation, whereas funding for food safety increased considerably. The total number of scientists conducting meat research remained virtually unchanged during the period, but the proportion allocated to food safety research increased substantially. The federal portion of total funding decreased from 61.3% to 51.6% between 1980 and 1997, whereas the percentage from both state appropriations and private sources increased. Modifications in research emphasis were influenced by industry problems such as meat quality, public perceptions about food safety, the availability of research funding, scientific advances occurring in molecular biology and genetic manipulation, and the changing meat industry. The information in this paper provides administrators and researchers the opportunity to make better informed decisions about resource allocation for meat research.

Key Words: Funding, History, Meat Animals, Research, Resource Allocation

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Introduction

Research related to meat science has dramatically changed over the past several decades, as has the meat industry. It is recorded by the American Meat Science Association (AMSA, 1972) that the first college "meats" course was taught at the University of Minnesota in 1894 (Allen, 1983) with emphasis on instruction in killing, dressing, cutting, and curing meat. The National Live Stock and Meat Board was established in 1922 and the Committee on Cooperative Research was formed in 1924, consisting of scientists from the meat industry, the United States Department of Agriculture (USDA), and several agricultural experiment stations. The Purnell Act, passed by the U.S. Congress in 1925, provided public funds for some of the first research projects focused to address meat quality and palatability issues.

The above events initiated research activities centered on meat. However, there is limited information that links the history, coordination, and funding trends. This paper includes an overview of the history of meat science; coordination endeavors among university, federal, and private researchers and educators; and funding trends for public meat research.

History

A meat laboratory was established at the University of Minnesota in 1900. During the subsequent two de-

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cades, courses were added to the curriculum at several state universities, including Illinois, Michigan, Pennsylvania, Ohio, New York, Kentucky, Iowa, Colorado, and North Dakota. Ten additional states began instruction on "meats" in the 1920s, as described by AMSA (1972). One of the earliest graduate degrees in the area of meat research, perhaps the first, was awarded to D. E. Brady in 1937 (Brady, 1937) by the University of Minnesota.

Research efforts in the 1920s were directed toward studies of animal husbandry factors that influence meat quality and palatability characteristics, such as soft pork due to feeds high in saturated fats and meat manufacturing and preparation (Calkins, 1997). Meat research in the 1930s stressed applied research and more interactions with home economists concerning cooking characteristics. The Warner-Bratzler meat shear (Bratzler, 1949) was developed as a reliable measure of meat tenderness. A separate section in the American Society of Animal Production's *Journal of Animal Science* was established in 1946 and the Reciprocal Meat Conference (RMC) was created in 1947 by university and USDA representatives consisting of teachers, researchers, and extension specialists for the purpose of exchanging ideas and experiences.

Concurrently, regional (multistate) research was authorized in USDA in 1946 to fund cooperative research on problems important to multiple state agricultural experiment stations and to avoid duplication of research efforts. Funding for multistate research (a component of the Hatch formula funding) is allocated to Land Grant institutions through the Cooperative State Research, Education, and Extension Service, the agency responsible for dispersing the federal funds and providing programmatic oversight. In addition to providing funding and the valuable infrastructure for coordinating research, multistate research leverages additional funding (often at least four to five times the amount of federal funding, depending on the area of research) from other sources, such as state appropriations, private industry, and other federal agencies. Examples of the first multistate research projects include NC-1, *Improvement of beef cattle through breeding methods;* W-1, *the improvement of beef cattle through the application of breeding methods;* and NE-1, *Causes and prevention of reproductive failure in dairy cattle.*

In the decade of the 1950s, meat science emerged as a distinct discipline, and research focused on carcass composition, tenderness, meat curing, and phenotype-carcass yield relationships (Berg and Walters, 1983), (Breidenstein and Carpenter, 1983). During this time, scientists in Europe formed the European Meat Research Workers organization in 1955 to encourage interaction among meat researchers. Research in the 1960s continued to emphasize physical composition and yield of carcasses, chemical analyses, histological characteristics of muscle, and biochemical properties of meat. Rapid changes in carcass composition were achieved because most carcass traits of interest are highly heritable. Objective measurements of lean-to-fat ratios were developed, as were objective measurements of meat quality. Research also focused on the effects of stress on meat quality and the comparisons of muscle characteristics in red meat to other animal species (e.g., mouse, rat, chick, monkey). Meat scientists increased their interactions with others conducting animal breeding and nutrition studies to determine the genetic and environmental factors that influence meat quality. Beef research accentuated the evaluation of technologies to measure and improve tenderness, whereas the pork industry focused on the pale, soft, and exudative (**PSE**) meat problem. The American Meat Science Association was formed in 1964 by members of RMC to facilitate exchange of information among researchers and educators.

Significant change occurred in the 1970s when emphasis was placed on increases in basic research and responses to nutritional concerns by the public. Funding support for research increased during this period, and the number of graduate students associated with meat research grew rapidly. Studies in the 1970s highlighted the effects of stress on meat quality (e.g., PSE), rapid growth, heavily muscled animals, confinement rearing, hormonal effects, and the linkage of endocrinology to growth. United States scientists became more aware of the stress-related problems in swine being experienced in other parts of the world, particularly Europe and Scandinavia. Exotic beef cattle breeds were introduced into the United States and evaluated for meat characteristics. Growth biology evolved out of traditional meat science, emphasizing studies on muscle cell structure and composition, muscle fiber development, protein synthesis, lipid metabolism, satellite cells, and muscle enzymes. It is important to accentuate that, during this decade, meat science research increasingly drew upon numerous other fields of science—including biochemistry, physiology, endocrinology, microbiology, neurology, biophysics, and histology—resulting in research results being published in a variety of scientific journals, many of which are not among the traditional animal science journals. These included but were not limited to journals affiliated with developmental biology, anatomy, biochemistry, growth, pathology, neurology, zoology, cell molecular biology, nutrition, and food chemistry. Also, a new section in the *Journal of Animal Science,* "meat science and muscle biology," was formed during this time.

During the 1970s, considerable effort was made to expand coordination and communication among meat researchers. Several regional (multistate) research committees were formed. The multistate research committee NC-91, *Effect of composition, distribution, and quantity of lipids on meat and poultry,* established in 1968, was subsequently broadened in 1975 to encompass studies of lipids in all meat animals through the research project NCR-97, *Regulation of adipose accretion in meat animals.* The NC-131 project, *Molecular mechanisms regulating skeletal muscle growth and dif-*

ferentiation was also formed in 1975 by university and USDA scientists to investigate factors regulating net accumulation of protein in skeletal muscles with emphasis on protein synthesis, protein degradation, and skeletal muscle cell characteristics. Another research project established in 1975, the NC-136 project, *Improvement of thermal processes for food,* emphasizes basic research to increase efficiencies (particularly to reduce energy costs) during food processing, includes meat and meat products. The current objectives for NC-136 focus on measuring and modeling biochemical properties of foods and product development. Project W-122, *Improve food safety through discovery and control of natural and induced toxicants and antitoxicants,* initiated in 1972, includes research related to studies of contamination of meat cuts during cutting, packaging, and other handling steps.

Project S-123, *Marketability and acceptability of beef produced under forage and forage-grain management systems,* was formed in 1977 to evaluate the quality and acceptability of meat produced by various management systems. It was followed by W-177, *Enhancing the global competitiveness of U.S. red meat,* in 1986, involving meat scientists and agricultural economists to investigate approaches to improve marketing of beef domestically and internationally. The objectives for W-177 were recently modified to reflect changing priority areas of research and currently are 1) improve global red meat customer satisfaction by focusing on red meat food safety issues, 2) enhance the ability of the red meat and livestock industries to capture value, and 3) evaluate the transmission of economic signals throughout the market. The first objective reflects the recent emphasis on food safety. Research project S-295, *Enhancing food safety through control of food-borne disease agents,* established in 2000 (and its predecessor, S-263), also includes research to reduce pathogens in meat. The current objectives for S-295 encompass preharvest reduction of food-borne pathogens in animals and the environment and chemical and physical decontamination in food-processing plant environments.

It should be noted that even though coordination and sharing of ideas and experiences are enhanced through these multistate research committees, other significant mechanisms complement these activities. They include educational programs coordinated by professional organizations, such as the Reciprocal Meat Conference, the Institute for Food Technologists, the Federation of American Societies of Experimental Biology, and the American Society of Animal Science among others. Participation in the European Meat Research Workers conferences was broadened and U.S. scientists became increasingly more active in the organization as it evolved into the International Congress of Meat Science and Technology in 1987.

The foregoing paragraphs gave numerous examples of coordination and changes in research focus. It is important to track this rich history of meat research and the research portfolio beyond the 1970s to obtain an overview of the history of meat research in the United States, summarize research coordination efforts, analyze the sources of public funding and trends for meat research, and characterize a recent portfolio of U.S. meat research investments.

Methods

Trends in the amount of public resources provided for meat research (beef, pork, lamb, and poultry) were analyzed. Funding levels and scientist-year (SY) equivalents were summarized for research conducted at public institutions for fiscal years 1980, 1985, 1990, 1995, and 1997. A separate and in-depth analysis was conducted for data from fiscal year 1998 to characterize the profile of the research portfolio. The source of the data for both analyses was the USDA Current Research Information System (CRIS, 2000), a national database that contains information on public agricultural research conducted by USDA agencies (primarily at Agricultural Research Service [ARS] laboratories) and universities (predominantly Land Grant institutions). United States Department of Agriculture agencies receive funding via appropriations from the U.S. Congress, whereas Land Grant institutions derive funding from multiple sources that are often categorized as 1) appropriations from state legislatures; 2) grants and formula funding from the USDA Cooperative State Research, Education, and Extension Service (CSREES); 3) grants and contracts from other federal agencies (e.g., the National Institutes of Health, the Department of Energy, the Environmental Protection Agency, and the Department of Defense); and 4) private sources, including commodity organizations, direct industry support, and research endowments. Often these multiple sources of funding are combined to support an individual research project at a Land Grant institution, providing valuable flexibility for research management.

To compare changes in research investments over the two decades, expenditures were adjusted for changes in prices using the 1982 to 1984 Consumer Price Index (CPI), Bureau of Labor Statistics base (CPI, 2000), a frequently cited measure of inflation pegged to a standardized base period.

Research projects documented in CRIS (2000) are classified by 1) research problem area (RPA), 2) commodity or subject of investigation (e.g., animal species), and 3) field of science. For the purpose of these analyses, each unique combination of codes identified in any project constituted a data point for the input. Funding levels ($ millions) and the number of scientist-year equivalents associated with each data point were aggregated to represent the measures of research investment.

A computer search strategy was developed to apportion resources associated with research projects 1980 to 1997 to the following three mutually exclusive research categories: 1) meat quality, 2) food safety, and 3) product development and processing. The category meat quality was defined as production of animal products

Table 1. U.S. public meat research funding ($ millions) by research category from 1980 to 1997[a]

Year	Meat Quality	Food Safety	Product Devel./Proc.	Total
1980	16.3 (13.4)	9.0 (7.4)	7.6 (6.3)	32.9 (27.1)
1985	17.5 (18.8)	9.0 (9.7)	7.4 (8.0)	33.9 (36.5)
1990	16.1 (21.0)	10.5 (13.7)	7.0 (9.1)	33.6 (43.8)
1995	14.3 (21.8)	15.6 (23.7)	8.4 (12.8)	38.3 (58.3)
1997	14.3 (23.0)	19.8 (31.7)	8.8 (14.1)	42.9 (68.8)

[a]Data were adjusted according to the Consumer Price Index (CPI, 2000; Base Period 1982 – 1984 = 100). Unadjusted data are shown in parenthesis.

with improved acceptability with emphasis on the physiology and biochemistry of fats, proteins, and flavor components (RPA 409); quality maintenance in marketing animal products (RPA 412); and the nutrient composition a component of RPA 708 (human nutrition). Food safety research was defined as the protection of food and feed supplies from harmful microorganisms and naturally occurring toxins (RPA 702). Information for the category product development and processing drew upon RPA 410, new and improved meat, milk, eggs, and other animal food products, but was limited to meat through a defined search that excluded milk, eggs, and other animal products.

Data for the 1998 profile analysis were derived from a computer search based on the combination of key words and classifications codes (CRIS, 2000) to avoid duplication and cluster research projects. Each of the 388 research projects selected by the computer from the 1998 data were subsequently manually reviewed, and a percentage was assigned to the following four mutually exclusive research categories: 1) meat quality, 2) food safety, 3) product development and processing, and 4) marketing. This more in-depth analysis capitalized on the modified classification system (CRIS, 2000) that was implemented for 1998 data and subsequent years.

Direct comparisons of the two analyses should be limited to broad conclusions due to the different search strategies and because the recently modified classification system is only applicable to the 1998 data. The analysis of the 1980-to-1997 data yields general trends in resource allocation, whereas the in-depth analysis for the 1998 data characterizes a recent profile of the research investment portfolio.

Results and Discussion

Tables 1 and 2 summarize resource allocations defined as research funding ($ millions) and scientist-year (SY) equivalents for the three research categories meat quality, food safety, and product development and processing for the period 1980 to 1997.

The total public investments in meat research shown in Table 1 increased modestly (30%) when adjusted for inflation, although actual funding increased 154% over the 1980-to-1997 time period ($27.1M compared to $68.8M). Funding for the research category meat quality decreased slightly (13%) when adjusted for inflation.

The most dramatic increase in funding (120%) occurred for food safety research. Much of the increase took place subsequent to 1990, increasing to the point at which food safety research represented 46.2% of all meat research in 1997, thus demonstrating the response to public concern about emerging pathogens associated with the safety of animal products. Federal sources provided a larger proportion of the funding for food safety research in recent years partly because food safety is viewed as a national issue by the U.S. Congress, not a location-specific problem. Because food safety is a priority with Congress, additional increases in funding are anticipated.

Only slight increases in funding (16%) occurred for product development and processing research between 1980 and 1997. This is partially explained by the fact that less emphasis on product development and processing in the public sector occurred during this time, and the majority of research for this program category is conducted by private industry rather than public institutions. Research conducted by private industry was not part of this study.

Table 2 displays the number of scientist-year equivalents for the three corresponding research categories in Table 1. The overall number of SY equivalents allocated to meat research decreased from 221 in 1980 to 209 in 1997. However, the SY equivalents committed to meat quality decreased from 97 to 69 and the number for product development and processing research decreased from 59 to 47. This is in contrast to the 65 to 93 increase in the number of SY equivalents for food safety research, reflecting shifts in resource allocation within the meat research domain. The average expendi-

Table 2. Scientist-Year equivalents by research category from 1980 to 1997[a]

Year	Meat Quality	Food Safety	Product Devel./Proc.	Total
1980	97	65	59	221
1985	82	64	54	200
1990	88	62	40	190
1995	76	77	47	200
1997	69	93	47	209

[a]Rounded to the nearest whole scientist-year equivalent.

Table 3. Funding ($ millions) by source of funding from 1980 to 1997[a]

	Federal	State	Private	Total
Year	$(M) %	$(M) %	$(M) %	$(M) %
1980	20.2 (16.7) 61.3	9.5 (7.8) 28.9	3.2 (2.6) 9.8	32.9 (27.1) 100
1985	20.7 (22.3) 61.3	9.6 (10.3) 28.4	3.4 (3.7) 10.3	33.7 (36.3) 100
1990	15.1 (19.7) 45.0	12.5 (16.3) 37.1	6.0 (7.9) 17.9	33.6 (43.9) 100
1995	19.8 (30.1) 51.7	12.7 (19.3) 33.1	5.8 (8.9) 15.2	38.3 (58.3) 100
1997	22.1 (35.5) 51.6	13.7 (22.0) 32.0	7.0 (11.3) 16.4	42.8 (68.8) 100

[a]Data were adjusted according to the Consumer Price Index (CPI, 2000; Base Period 1982 – 1984 = 100). Unadjusted data are shown in parenthesis.

ture per SY equivalent (funding divided by the number of SY equivalents) increased from $148,869 to $205,263 between 1980 and 1997 when adjusted for inflation (CPI, 2000) or $122,624 to $329,187 if unadjusted. This suggests that the cost of conducting research (e.g., instrumentation and laboratory supplies for basic and[or] in-depth research) has increased at a rate greater than overall inflation as measured by the CPI.

During the 1980-to-1997 period, there was progressively less emphasis on live animal and carcass composition and histological characteristics of muscle and more emphasis on studies of the cellular and molecular mechanisms that influence net protein and adipose accretion. Also, research efforts were increasingly being focused on diet and health issues and public concerns about emerging pathogens. Members of the NCR-97 research committee, formed in 1975 to investigate factors affecting adipose accretion in meat animals, shifted their emphasis to the study of mechanisms at the molecular, cellular, and tissue level to regulate adipose accretion in meat-bearing animals. The original NC-131 objectives evolved to the current objectives: 1) characterize the signal transduction pathways that regulate skeletal muscle growth and differentiation, 2) determine the nuclear mechanisms that control gene expression in skeletal muscle, and 3) characterize muscle proteins and their functional domains involved in myofibrillar assembly and disassembly.

In the 1980s, basic research was conducted on cellular and molecular biology, diet and health issues, and food safety especially microbiological contamination. Two new sections were added to the *Journal of Animal Science* in this decade, "Growth and Developmental Biology" and "Meat Science," to capture the breadth of research related to meats and reflecting changes in the type of research being conducted. Research emphases included studies of cellular and molecular mechanisms, growth hormone, β-agonists, insulin effects, and satellite cells. The inventory of journals for publication of meat-related research continued to expand to include those associated with biological chemistry, cell biology, food biochemistry, molecular biology, and cell physiology among others.

Table 3 shows the proportion of total public funding for meat research from federal sources (combines ARS, CSREES, and other federal agencies), state appropriations, and private sources. Funding from all three sources increased for the period; however, the proportionality of the contributions from the three sources changed appreciably. The federal portion of total funding decreased from 61.3% to 51.6% between 1980 and 1997, whereas the percentage from both state appropriations and private sources increased during that period. The greatest percentage increase was from private sources (9.8% to 16.4%).

Four attributes of the 1998 data were analyzed: 1) percentage investment by research category, 2) distribution of research effort by geographic region, 3) sources of public funding, and 4) the diversity of scientific disciplines employed by meat researchers.

The percentage of the total meat research funding for the four research categories, meat quality, food safety, product development and processing, and marketing was 30.6, 47.2, 18.3 and 4.0 respectively. The research on food safety continued to be the major component of the total meat research portfolio. The marketing research category, added to the 1998 analysis, although small, integrates numerous research disciplines including meat science, food science and economics. The members in the multistate research committee, W-177, *Enhancing the global competitiveness of U.S. red meat,* represent an example of cooperation to improve marketing of beef domestically and internationally.

The distribution of funding for meat research in 1998 by geographic region was summarized (Table 4). The southern region includes 39.8% of the total, followed by the north-central region, 28.8%; the northeast region, 20.0%; and western region, 11.3%. Although meat research is conducted in virtually every state, it is concentrated in the southern and north-central regions of the

Table 4. Resource Allocation by Geographic Region, 1998[a]

Region	$ (Millions)	Scientist-Years
Southern	15.9 (25.9)	88
North Central	11.5 (18.8)	55
Northeast	8.0 (13.0)	32
Western	4.5 (7.3)	23
Total	39.9 (65.0)	198

[a]Data were adjusted according to the Consumer Price Index (Base Period 1982 – 1984 = 100). Unadjusted data are shown in parenthesis.

Table 5. Resource allocation by source of funding, 1998[a]

Funding Source	$ (Millions)	Percentage
USDA-CSREES	4.0 (6.5)	10.0
USDA-ARS	15.4 (25.1)	38.7
Other federal agencies	1.8 (3.0)	4.5
State appropriations	13.1 (21.4)	32.9
Private sources	5.5 (9.0)	13.8
Total	39.9 (65.0)	100.0

[a]Data were adjusted according to the Consumer Price Index (Base Period 1982 – 1984 = 100). Unadjusted data are shown in parenthesis.

nation, where the majority of meat animals are produced and where large Land Grant institutions and(or) USDA laboratories are located.

The proportion of public research by source of funding is shown in Table 5 for 1998. Federal sources (i.e., ARS, CSREES, and other federal agencies) represented 53.2%, whereas state appropriations were 32.9% and private sources were 13.8%. The federal contribution for meat research is higher than that for many other fields of agricultural research partly due to the national emphasis on food safety and concentrations of research efforts at several large ARS research locations.

The $6.5M (unadjusted) funding provided to universities by CSREES in 1998 was nearly equally divided between research grants and formula funding to states (noncompetitive distribution based primarily on the size of the state and the amount of agricultural production in the state): $3.1M and $3.4M, respectively.

Meat research bridges the farm gate, spanning animal production, processing, and product development and merchandising; traverses university departmental boundaries to include animal science, food science, nutrition, biochemistry, and others; and employs numerous scientific disciplines. The magnitude of the diversity of scientific disciplines contributing to meat research was studied in more detail by analyzing the percentage assignment to the CRIS fields of science for each 1998 research project. There were 30 fields of science represented in the classification of the 388 projects. The most common fields of science were biochemistry and biophysics, bacteriology, and chemistry, followed by nutrition and metabolism, microbiology (other than bacteriology), molecular biology, economics, and general biology. Of the 388 projects, 132 (34%) included more than one field of science, illustrating the contributions made by multiple disciplines to meat research projects in order to solve problems facing the meat industry.

Implications

The analyses illustrate the evolution of meat research at public institutions, the emergence of the field of meat science as a distinct discipline, and the dramatic changes that occurred in the type of research conducted at public institutions in response to meat industry needs and public concerns. Meat research interfaces with many disciplines and makes contributions to all segments of the meat industry. Considerable efforts have been expended by researchers and administrators to ensure the coordination and relevance of research over the past several decades. The data in this article provide administrators and researchers at universities and USDA information for making better decisions related to resource allocations for meat research.

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