THE NORTH CAROLINA FOOD PROCESSING AND MANUFACTURING INITIATIVE:

AN ECONOMIC FEASIBILITY STUDY

Prepared for the State of North Carolina
by the partnership of

NC State University
College of Agriculture and Life Sciences
and the
North Carolina Department of
Agriculture & Consumer Services

December 2014

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January 1, 2015

Please find attached to this letter a report entitled *The North Carolina Food Processing and Manufacturing Initiative: An Economic Feasibility Study* in response to Section 13.1 of 2014 NC Legislation:

> *PLANT SCIENCES RESEARCH AND INNOVATION INITIATIVE – SECTION 13.1*
>
> *(a) The funds appropriated by this act to the Department of Agriculture and Consumer Services for the Plant Sciences Research initiative shall be used by the Commissioner to develop jointly with the College of Agriculture and Life Sciences at North Carolina State University and other stakeholders a formal proposal and economic needs assessment for establishment of a public/private partnership between the University, other academic institutions, private companies in the agribusiness and bioscience sectors, the Department, and other State regulatory agencies for the following amounts and purposes: (i) the sum of three hundred fifty thousand dollars ($350,000) for a partnership to be known as the "Plant Sciences Research and Innovation Initiative" and (ii) the sum of two hundred fifty thousand dollars ($250,000) for a partnership to be known as the "Food Processing Initiative."*
>
> *(b) The Department and North Carolina State University shall jointly submit a copy of the proposal and report on the results of the economic needs assessment to the Chairs of the House of Representatives Appropriations Subcommittee on Natural and Economic Resources, the Chairs of the Senate Appropriations Committee on Natural and Economic Resources, the Agriculture and Forestry Awareness Study Commission, and the Fiscal Research Division by January 1, 2015.*

This report specifically addresses the economic feasibility study for section 13.1, part (a) (ii) related to "Food Processing/Manufacturing" and was completed in partnership with the NC Department of Agriculture and Consumer Services and the College of Agriculture and Life Sciences at North Carolina State University. The economic analysis, evaluations and recommendations provided in this report have been provided after extensive external stakeholder input and food/agricultural data for North Carolina, and beyond.

It is our hope that this report provides meaningful information for North Carolina to grow its number one industry – Agriculture – to even higher levels. Questions and suggestions related to this report can be directed to either one of us or to the project lead: Dr. Christopher R. Daubert, Department Head of Food, Bioprocessing, and Nutrition Sciences, NC State University College of Agriculture and Life Sciences at cdaubert@ncsu.edu or 919-515-2951

Sincerely,

Steven W. Troxler, Commissioner
North Carolina Department of Agriculture
and Consumer Services

Richard H. Linton, Ph.D., Dean
NC State University
College of Agriculture and Life Sciences

Abstract

North Carolina has a rich history processing its biomass resources into value-added products. However, over the last two decades, three of North Carolina's traditional industrial strengths – textiles, furniture, and tobacco – have experienced significant economic decline, calling into question North Carolina's long-standing dominance in value-added biomass processing and manufacturing.

The decline in the textile, furniture, and tobacco manufacturing industries has led to underutilization of capacity throughout the State of North Carolina, particularly within the rural regions. This decline then begs the question as to whether or not it is feasible to transition this underutilized capacity to strengthen and grow another industrial sector – namely the value-added food manufacturing sector.

The answer to this question is, unequivocally, yes. By fully leveraging the existing value-added biomass processing and manufacturing capacity of the state along with North Carolina's key innovation drivers, the economic decline can be reversed. This result can be achieved by developing programs and initiatives that leverage North Carolina's unique opportunities and help it to overcome the market barriers and hurdles that are currently impeding the industry's development.

As will be illustrated through this report's analysis, it is clear that North Carolina has a unique opportunity to leverage its agricultural resources, industrial capacity, and research innovation assets to catalyze the economic growth of an important value-added industry. It is proposed that a Food Processing and Manufacturing Initiative be developed that will serve to catalyze industrial development throughout the state of North Carolina; It should focus on four primary objectives:

- Capture added value from North Carolina's agricultural commodities through the development of innovative food products and processing technologies
- Foster the growth of food manufacturing entrepreneurial endeavors
- Proactively target site selection attraction opportunities within the food manufacturing supply chain
- Provide regulatory training and outreach to the food processing/manufacturing sector.

Funding in the amount of $500K/year for a three-year period is recommended to plan and further develop the Food Processing and Manufacturing Initiative. Due to the strong food science partnership already in place between NCDA&CS and NC State, it is proposed that the two organizations collaborate to hire a project director and establish a guiding coalition to map a strategy that will achieve the recommendations proposed in this study. Key stakeholders to be part of the coalition should include food industry leaders, the North Carolina Department of Commerce, existing food-related entrepreneurial endeavors, research innovation assets located throughout NC at a variety of higher education and research institutions, and the workforce development and community college system. The project director would be charged with overseeing the coalition to 1) develop a strategic business plan to leverage and coordinate existing activities, 2) design new programmatic efforts and operations to implement the four primary recommendations, and 3) establish a statewide food manufacturing network. As part of the strategic business planning effort, additional sources of funding would need to be identified for eventual build-out

and programmatic implementation. This initial financial investment will unite the food processing entities of North Carolina and accelerate the economic benefit and job growth potential projected by this study.

By accomplishing the recommendations outlined in this study, North Carolina has the opportunity to catalyze food processing and manufacturing industrial development throughout the state. Battelle anticipates that by implementing the North Carolina Food Processing and Manufacturing Initiative, the total economic impact of the food value chain will be an increase of nearly 38,000 jobs and an increase in associated economic output of $10.3 billion by 2020. This economic growth will help to change the economic trajectory of North Carolina's communities, creating employment opportunities and enhancing economic sustainability.

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Executive Summary

While North Carolina has a rich history in agricultural production and forestry, its economy, unlike many other agricultural states across the nation, has been significantly concentrated in converting or transforming its biomass resources into value-added products. However, North Carolina's long-standing dominance in value-added biomass processing and manufacturing, which includes the textile, furniture, and tobacco industries, has been in a state of decline. The decline in these value-added biomass processing and manufacturing industries has led to underutilization of capacity throughout North Carolina, particularly within the rural regions of the state.

This state of decline begs the question as to whether or not it is feasible to transition this underutilized capacity to strengthen and grow another industrial sector – namely the value-added food manufacturing sector. This sector is depicted in Figure ES-1, and it represents strengths along the entire food-related "value chain" – the holistic set of value-adding industry activities from research and development of new products and ingredients and other inputs, on through food processing and manufacturing, into packaging, and through a high-functioning distribution network onto store shelves and home cupboards.

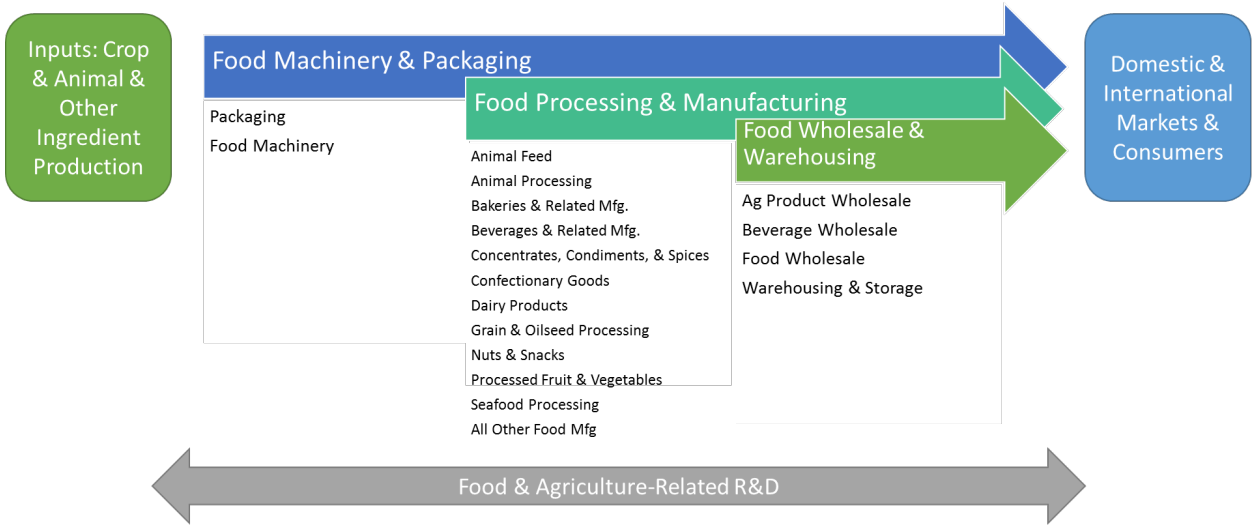

Figure ES-1. The Food Processing and Manufacturing Value Chain.

The objective of this study is to determine whether or not a food processing and manufacturing initiative intended to catalyze the development of value-added food processing and manufacturing businesses statewide is in fact feasible based on the agricultural resources, industrial capacity, and research innovation assets present in North Carolina today.

Industrial Analysis Findings

It is important to note that while the food manufacturing industrial sector is already present throughout the state, the level of industrial concentration is not as high as one might expect based on the state's agrarian history, long-standing capacity in other value-added biomass processing industries, and access to major population centers. Key findings from the industrial analysis include:

- North Carolina's food "value chain" is large with a few key strengths. The state sector, however, has shed jobs in recent years, particularly among its largest components.
- The sector is truly statewide, with distinct regional specializations that stand out, though the recent performance among North Carolina regions varies.
- North Carolina is competing nationally and globally as a leader in animal processing and packaging, two highly specialized state subsectors; Additionally, the state is emerging in a number of other high-value food-related sectors including beverages, nuts and snacks, and animal feed.
- North Carolina has visible gaps in its food value chain that could limit the growth potential for existing and emerging companies, or for companies interested in locating in the state, namely its significant under-concentration in key wholesale and distribution areas in agricultural products and food-related warehousing and storage.
- In discussions and interviews with North Carolina food processors and other stakeholders, there is a consistent concern raised regarding a gap in the presence and availability of "intermediate" food processors.
- North Carolina's food value chain is outperforming the U.S. sector atlarge in the productivity of its workforce as measured by value added per worker. This signals the competitive nature of state companies within the industry and when combined with generally lower labor costs/wages makes North Carolina attractive to companies interested in locating here.
- Industry innovation in North Carolina's food sector indicates limited innovation activity in the form of patents, with some patenting in packaging and meat processing technologies.

To advance the food manufacturing industrial sector in North Carolina, it is critical to further public-private partnerships that align innovation drivers with new product development opportunities within both large and small firms. In this way, North Carolina food processing and manufacturing firms will be better able to take advantage of growing and emerging global market opportunities.

Catalyzing the Growth of Value-Added Food Manufacturing in North Carolina

To understand factors that are hindering the value-added food manufacturing sector's development in North Carolina, it is important to analyze the specific barriers to development currently existing within the state's food-related business model/value supply chain, as well as the identification of opportunities that could catalyze growth. To this end, the Battelle TPP project team examined a series of data sources and conducted over 100 qualitative interviews in order to identify areas for development and growth.

As a result of the analysis, four drivers were identified as critical to the continued development of North Carolina's value-added food manufacturing sector and are discussed below.

Capturing added value from North Carolina's agricultural commodities through the development of innovative food products and processes.

Worldwide agricultural commodity markets are highly competitive and price-driven. As a result, even though national agricultural productivity continues to increase, the real value of that production at "the farm gate" continues to decline. The future of agricultural and rural sustainability in North Carolina will very much depend on the ability to construct "value-added" chains of production that vertically integrate the food-related business model/value supply chain. The basic value-added concept is shown in Figure ES-2 and illustrates the substantial difference in potential income between simply growing and selling any agricultural commodity (the farmer row) and the total income that may be realized in a state that provides a vertically integrated value-added chain. In this example, by growing the berry, performing the raw agricultural processing step, further processing the berry product to obtain chemicals and compounds of nutraceutical value, and then retailing them, additional economic value is realized. An integrated value chain captures a far higher percent of the final dollar figure spent on the product for the state.

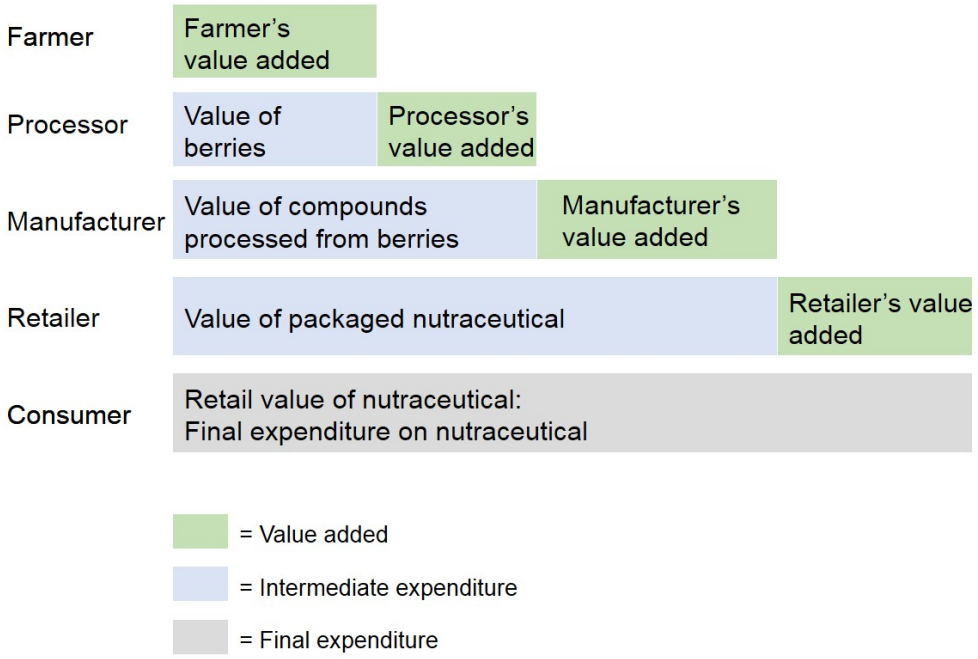

Figure ES-2. The Value-Added Concept—Berries to Nutraceuticals Illustrative Example.

Innovation in commodity processing and food manufacturing involves new product invention, development, product quality improvements, efficiency improvements, and food safety. Based on the innovation drivers found within North Carolina – food product innovation, packaging technologies, flavors, extraction and sensory technologies, food safety technologies, and functional foods – coupled with the commodities found within North Carolina and how they are currently being utilized as value-added products, North Carolina is uniquely positioned to add value to its agricultural commodities thereby driving economic growth.

Fostering the growth of food manufacturing entrepreneurial endeavors.

Entrepreneurial activity is closely tied to a state's or region's level of economic growth. However, catalyzing entrepreneurial activity is a challenge for many states. It is often stated that entrepreneurship is a "contact sport," and the barriers and obstacles to being able to scale a firm is significant, particularly for food processing and manufacturing firms. The three areas that entrepreneurs indicate are their greatest obstacles are talent, capital, and sales. Within North Carolina, a number of initiatives to support food-related entrepreneurial endeavors exist, including:

- NC State's Entrepreneurial Initiative for Food (ei4F) program, which works with small business owners and prospective entrepreneurs to manufacture and process quality food products safely.
- North Carolina's Department of Agriculture and Consumer Services (NCDA&CS), which provides North Carolina food-related entrepreneurial endeavors both agribusiness development services and initiatives such as "Goodness Grows in North Carolina," "Got to Be NC" campaign, the NC Specialty Foods Association, and the state's farmers markets.
- A number of regional shared-use commercial kitchens and/or food incubators, such as the Blue Ridge Food Ventures and the Piedmont Food and Agricultural Processing Center, in addition to several private sector co-packers who will conduct smaller batch runs for entrepreneurs.
- While not food processing/manufacturing specific, North Carolina also has developed more generalized entrepreneurial/small business development programs to aid in the growth of small businesses, including:
  - N.C. Community College System's small business centers;
  - NC State's Industrial Extension Service (IES) that focuses on assistance to manufacturers in production process, cost improvements, and diversification;
  - Small Business and Technology Development Centers (SBTDC) that focuses on the full range of business sectors with respect to strategy, budgeting, marketing, operational processes, and related issues; and,
  - Military Business Assistance Center (MBAC) that focuses on companies interested in military contracting.

However, even with these resources, interviews with entrepreneurs suggest that it can be difficult to access entrepreneurial support services tailored to the unique food processing and manufacturing industry sector. And even when the various programs are accessed, they are often disconnected from one another, making it difficult and confusing to the entrepreneur who is seeking assistance. The bottom line is that finding different and unique ways to support entrepreneurs and the growth of entrepreneurial food processing and manufacturing companies is an important component in North Carolina's efforts to develop the industrial base.

Proactively targeting site selection attraction opportunities within the food manufacturing supply chain.

The increased number of mergers and acquisitions that have occurred in the food processing and manufacturing industry in the recent past is creating a doubled-edged sword environment for economic development organizations. The first edge of the sword has been a trend for several years for food processors to regionalize production rather than have a centralized facility. This developed as a result of steadily increasing transportation costs and quality concerns. Therefore, food processors are moving closer to population centers and toward the points of consumption. This will only be accelerated by the consolidation of brands under a single corporate entity. The other edge of that sword is the

consolidations, and possible subsequent job losses, due to these acquisition and improvements in food processing technology.

The business environment makes efforts to attract industries complicated for some states. While the site selection determinants for the food processing/manufacturing industry are driven by concerns regarding food safety, cost control, and access to a qualified labor pool, there are additional factors that didn't exist in the food processing industry 20 years ago, such as skyrocketing fuel costs, concerns among consumers over dietary health and food safety, adequate water availability in many locations, ever-growing and restrictive environmental regulations, energy costs, and sustainability, which are now factoring in predominately in site selection determinations. The issue is that very few economic developers understand the complexity of the industry's business model.

North Carolina is in the unique position, due to both the environmental situation facing California as well as the consolidation of the food processing/manufacturing industry around the nation, to proactively leverage its unique biomass value-added production capabilities, including access to agricultural commodities, water, a trained workforce, and proximity to large population centers, to proactively pursue attraction opportunities. North Carolina's state government has proven through the years its ability to target key clusters in the pursuit of economic growth and diversification of its economy. This focus now needs to be applied to the attraction of key components of the food-related, value-added supply chain.

Providing regulatory training and outreach to the food processing/manufacturing sector.

In 2011, the Food Safety Modernization Act (FSMA) was signed into law and heralded as the most significant reform to U.S. food safety standards in over 70 years. In interviews with small- and medium-size food processors and manufacturers, significant concern was expressed regarding their ability to understand and then comply with the vast regulations of the industry. The implementation of FSMA is only continuing to put a strain on the time, resources, and knowledge required to ensure that a company remains compliant with both the federal and state regulations. In particular, due to the roll-out nature of FSMA, companies, as well as inspectors, are finding it difficult to stay abreast of changes that are being implemented.

North Carolina, led by the efforts of NC State, is already well-regarded for its regulatory training and outreach to both industry as well as state and federal inspectors, and therefore is in a unique position to create a competitive advantage for its industrial base by providing regulatory training and outreach to the food processing and manufacturing sector, thereby proactively helping to improve the business climate.

A Call to action

In answer to the question that was posed at the outset of this endeavor – is it feasible to foster the economic development of a value-added food manufacturing industrial sector in the state of North Carolina – the answer is, unequivocally, yes. By fully leveraging the existing agricultural resources and industrial capacity of the state, found particularly in the rural regions, along with North Carolina's key research innovation drivers, the recent economic decline experienced by the industry sector can be reversed by developing programs and initiatives that leverage North Carolina's unique opportunities and help it to overcome the market barriers and hurdles that are currently impeding the industry's development.

It is proposed that a Food Processing and Manufacturing Initiative be developed that will serve to catalyze industrial development throughout the state of North Carolina and be composed of four primary initiatives:

- **Capturing added value from North Carolina's agricultural commodities through the development of a Food Product & Process Innovation Center** that would serve as a statewide resource to increase the breadth, depth, and expertise in product and process development. It is envisioned that the Food Product & Process Innovation Center would be comprised of food labs, GMP pilot plant facilities, intermediary food processing facilities, and demonstration facilities built around the specialized knowledge and expertise in North Carolina's five innovation drivers: food product and process innovation, packaging, functional foods, flavors, extracts and sensory technologies, and food security. In addition to working with a range of companies encompassing every stage in the business life cycle, the Food Product & Process Innovation Center would also be charged with working with the various state commodity groups to ascertain which commodities would be best served by developing a value-added research and application program. It is envisioned that the Food Product & Process Innovation Center would be located on NC State's Centennial Campus, serving from a central location the needs of the food processing and manufacturing industry across the state.
- **Fostering the growth of food processing and manufacturing entrepreneurial endeavors through the development of a Value-Added Food Entrepreneurship Network**, a seamless entrepreneurial services delivery system that provides all of the services required by an entrepreneur to ideate, develop, create, and scale their food processing and/or food manufacturing business. To this end, it is envisioned that three nodes would be developed initially, one in each region of the state. All three nodes would provide a full range of business assistance and market development expertise. The three nodes would also develop intermediary processing capability that could be utilized by start-up companies from throughout their region and tailored to the specific agricultural commodities with the greatest demand for further processing/manufacturing. In addition, start-up companies would also be able to gain access to more technical expertise located at the Food Product & Process Innovation Center. Based on the existing analysis, it is recommended that Blue Ridge Ventures, located in Asheville, would be a strong partner as the Mountain Region's value-added food entrepreneurship node, and if selected, would also bring intermediary processing capacity to the network. It is further recommended that the Piedmont Region's value-added food entrepreneurship node be co-located at the Food Product & Process Innovation Center in order to leverage the research, innovation assets, pilot plants, and intermediary processing capacity that will be developed at that facility. Finally, it is recommended that a value-added food entrepreneurship node be located within the Coastal Plains region, possibly leveraging the efforts of Ayden to develop a food manufacturing entrepreneurship center.
- **A proactive industrial recruitment campaign,** leveraging North Carolina's unique biomass value-added production capabilities, including access to agricultural commodities, water, a trained workforce, and proximity to large population centers, to pursue food manufacturing attraction opportunities. The North Carolina Department of Commerce, in close partnership with the NCDA&CS, should either develop or recruit staff with food processing/manufacturing business model expertise and then proactively target potential candidates for relocation marketing efforts. In addition, the state's economic development toolkit will need to be examined to ensure that the current offerings are relevant to this industry sector and are on par with other states' incentive programs.
- **Providing regulatory training and outreach to the food processing and manufacturing sector.** North Carolina, led by the efforts of NC State, is already well regarded for its regulatory training and outreach to both industry as well as state and federal inspectors. North Carolina has the opportunity to further set itself apart from other states by proactively developing additional in-depth training, education, and outreach efforts relevant to the food processing and manufacturing sector and relevant inspectors, particularly as it relates to the ongoing roll-out of

FSMA. By helping to ensure that the small and medium size food processors and manufacturers in the state, as well as those that are tasked with undertaking the inspections, have access to the knowledge required in an educational format that is tailored to their specific situation, North Carolina has the opportunity to create a competitive advantage for its industrial base by proactively helping to improve the business climate.

Funding in the amount of $500K/year for a three-year period is recommended to plan and further develop the Food Processing and Manufacturing Initiative. Due to the strong food science partnership already in place with NCDA&CS and NC State, it is proposed that the two organizations collaborate to hire a project director and establish a guiding coalition to map a strategy that will achieve the recommendations proposed in this study. Key stakeholders to be part of the coalition should include food industry leaders, the North Carolina Department of Commerce, existing food-related entrepreneurial endeavors, research innovation assets located throughout North Carolina at a variety of higher education and research institutions, and the workforce development and community college system. The project director would be charged with overseeing the coalition to 1) develop a strategic business plan to leverage and coordinate existing activities, 2) design new programmatic efforts and operations to implement the four primary recommendations, and 3) establish a statewide food manufacturing network. As part of the strategic business planning effort, additional sources of funding would need to be identified for eventual build-out and programmatic implementation. This initial financial investment will unite the food processing entities of North Carolina and accelerate the economic benefit and job growth potential projected by this study.

The value of catalyzing the growth of the food processing and manufacturing industrial sector is that it will spur growth and competitive advantage within the state. Economic gains that are predicted if a robust, proactive action plan for fostering the food-related value chain is implemented include:

- Rising productivity of companies in the value chain, creating a competitive advantage for the state
- Accelerated pace of innovation resulting in new products and processes
- More frequent start-up of new, high-growth-potential businesses
- Stronger supplier networks, increasing the economic multiplier impact of the value-chain for the state
- Larger pools of specialized workers and education and training programs geared to the particular industrial needs, introducing significant cost savings for firms and increasing the breadth and depth of employment opportunities for workers in the supply chain.

By implementing the initiatives outlined in this study, North Carolina has the opportunity to catalyze food processing and manufacturing industrial development across the state. Battelle anticipates that if the recommendations prescribed in this report are implemented, by the year 2020 the annual economic impact of North Carolina's food manufacturing industry could be:

- **$80.2 billion in total North Carolina economic output (business volume)**, comprising $47.6 billion in direct economic output and $32.6 billion in indirect and induced output.
- **290,553 jobs in North Carolina**, comprising 103,768 direct jobs and an additional 186,785 jobs generated in the North Carolina economy via the employment multiplier effect.
- Direct and indirect employment generating **personal**

Projected Impact

Battelle anticipates that the total direct and indirect impact of the food value chain, with the prescribed steps of this study implemented, will be an increase of nearly 38,000 jobs and an increase in associated economic output of $10.3 billion by 2020.

income for North Carolina residents amounting to $15.4 billion annually. This is divided between direct income at $6.2 billion and indirect and induced income at $9.2 billion.

In summary, as illustrated in Table ES-1, the benefits of developing a robust food value chain within North Carolina are significant.

Table ES-1. Benefits of a Robust Food Value Chain in North Carolina

Expansion of Economic Output and Economic Growth	Employment and Personal Income
Substantial economic activity is generated throughout the food value chain. Companies supplying inputs to manufacturing generate significant revenues, as do the direct agricultural commodity and livestock sectors and all the business sectors that provide inputs to agricultural production. The direct expenditures of each value-chain element in turn generate indirect output as suppliers also receive revenues and make expenditures in North Carolina.	Each component of the food value chain provides jobs and income for North Carolina employees and business owners. The wages and benefits generated by this value chain provide support for families in every county in North Carolina. Via the multiplier effect, the spending of income in North Carolina via the food value chain employees generates income for a broad range of other businesses and individuals in the state.
Local and State Government Revenues	**Economic Diversification**
Business taxes paid up and down the food value chain, together with personal income and property taxes paid by those employed directly or indirectly via the value chain, provide significant sources of revenue for state and local governments in North Carolina. Again, the broad geographic spread of the food value chain across North Carolina assures that all North Carolina counties, and the vast majority of individual municipalities and school districts, receive revenues directly and indirectly generated by the food value chain.	The food value chain, with its varied inputs and outputs, creates a broad spread of economic activity across the state. The sector provides a secure economic base for the state – one unlikely to sustain a significant impact from one structural shift. Furthermore, modern agricultural science and the biosciences are generating new products and innovations that will create new business opportunities for North Carolina, expanding the base of business and further diversifying the state's economy.
Enhanced State and Community Sustainability	**Reduced Social Costs**
The long-term growth and sustainability of North Carolina is, in part, secured by the impacts described above. The food value chain forms part of an integrated economic system that supports business revenues, business growth, personal wages and benefits, government revenues, health, and social welfare. This activity is woven into the overall fabric of state, county, and community economies contributing support for overall economic and social sustainability.	Without the food value chain, North Carolina would experience substantial economic dislocation and associated social costs. The geographic diversity of the sector provides family economic support across the state, into North Carolina's major cities and its smallest rural communities. Without the economic activity generated by the sector, North Carolina would experience substantial costs in social support programs, unemployment compensation, and human-capital retraining expenses.

List of Acronyms and Abbreviations

ARS	USDA Agricultural Research Service
AUFSI	Auburn University Food Systems Institute
BLS	U.S. Bureau of Labor Statistics
C2ER	Council for Community and Economic Research
CAGR	cumulative annual growth rate
CALS	College of Agriculture & Life Sciences
CAPPS	Center for Advanced Processing and Packaging Studies
CAS	College of Agricultural Sciences
CASIC	Center for Advanced Science, Innovation and Commerce
CMAST	Center of Marine Sciences and Technology
CNR	Michigan State University College of Agriculture and Natural Resources
EDA	U.S. Economic Development Administration
Ei4F	Entrepreneurial Initiative for Food
FBNS	Food, Bioprocessing, & Nutrition Sciences
FDA	U.S. Food and Drug Administration
FPC	Food Processing Center
FSMA	Food Safety Modernization Act
GREEN	Generating Research and Extension to meet Economic and Environmental Needs
I/O	input/output
IANR	Institute of Agriculture and Natural Resources
IES	Industrial Extension Service
MBAC	Military Business Assistance Center
MEP	Manufacturing Extension Partnership
MSU	Michigan State University
MSUE	Michigan State University Extension
M-TAC	Manufacturing Technology Acceleration Center
NAICS	North American Industry Classification System
NC LEAD	North Carolina Department of Commerce's Labor and Economic Analysis Division
NC State	NC State University
NC	North Carolina
NCDA&CS	N.C. Department of Agriculture and Consumer Services
NIC	Nebraska Innovation Campus
NIST	National Institute of Standards and Technology
NSF	National Science Foundation

OSU	Oregon State University
QCEW	Quarterly Census of Employment & Wages
SBA	U.S. Small Business Administration
SBIR	Small Business Innovative Research
SBTDC	Small Business and Technology Development Center
SDFRC	Southeast Dairy Foods Research Center
SOP	standard operating procedure
PHHI	Plants for Human Health Institute
TPP	Technology Partnership Practice
UNDESA	United Nations Department of Economic and Social Affairs
USDA	U.S. Department of Agriculture
WHO	World Health Organization

Chapter 1: Introduction

Setting the Global Context

The past half-century has seen marked growth in food production, allowing for a dramatic decrease in the proportion of the world's population that is hungry. The innovations that spurred this growth were driven primarily by what is now referred to as the Green Revolution – a series of research, development, and technology transfer initiatives that occurred between the 1940s and the late 1960s that increased agricultural production worldwide. The initiatives, led by the work of Norman Borlaug – credited as being the "Father of the Green Revolution" – focused primarily on improvements in agricultural production and involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers.

Even with these significant technological advancements, more than one in seven people today still lack access to sufficient protein and energy from their diet, and even more suffer from some form of micronutrient malnourishment. The Division of the United Nations Department of Economic and Social Affairs (UNDESA) projects that global population, which was roughly 6.5 billion in 2006 and 7 billion in 2012, will grow to 9.6 billion by 2050. At least 3 billion more people are predicted to enter the global middle class by 2030, and as a result of their increase in personal income, will more than likely demand more resource intensive foods such as meats and vegetable oils.

While the demand for food continues to increase, tension is rising as food producers are experiencing greater competition for land, water, and energy, and the environmental impact of some of the Green Revolution's innovations are becoming increasingly clear. A threefold challenge now faces the world: Match the rapidly changing demand for food from a larger and more affluent population to its supply; do so in ways that are environmentally and socially sustainable; and ensure that the world's poorest people are no longer hungry. This challenge requires changes in the way food is produced, stored, processed, distributed, and accessed that are as radical as those that occurred during the 18th- and 19th-century Industrial and Agricultural Revolutions and the 20th-century Green Revolution.[1]

Interestingly, many of the solutions being posed to help ensure global food security continue to focus on inputs to production or production itself. While increases in production will undoubtedly have an important part to play, they will be constrained as never before by the finite resources provided by Earth's lands, oceans, and atmosphere. Yet, even in the face of this reality, very little discussion is occurring regarding the role of innovation in food processing/manufacturing and its potential impact on global food security. Technological innovations will need to occur in post-harvest processing, food manufacturing, and distribution processes aimed at meeting the needs highlighted in the following paragraphs.

Reducing Food Waste

Roughly 30 to 40 percent of food in both the developed and developing worlds is lost to waste, although the causes behind this are very different. In the developing world, losses are mainly attributable to the absence of food-chain infrastructure and the lack of knowledge or investment in storage technologies on

[1] Godfray, H. Charles. "Food Security: The Challenge of Feeding 9 billion People". Science, Vol. 327, no. 5967, pp 812–818. Published January 28, 2010.

the farm. For example, as much as one-third of the rice grain harvest in Southeast Asia can be lost after harvest to pests and spoilage. In contrast, in the developed world, pre-retail losses are much lower, but those arising at the retail, food service, and home stages of the food chain have grown dramatically in recent years, for a variety of reasons. At present, food is relatively cheap, at least for these consumers, which reduces the incentives to avoid waste. Consumers have become accustomed to purchasing foods of the highest cosmetic standards; hence, retailers discard many edible, yet only slightly blemished products. Commercial pressures can encourage waste: The food service industry frequently uses “super-sized” portions as a competitive lever, whereas “buy one get one free” offers have the same function for retailers. Litigation and lack of education on food safety have led to a reliance on “use by” dates, whose safety margins often mean that food fit for consumption is thrown away.[2]

Another component of reducing food waste will be to discover innovations in shelf-stability. Shelf stable food (sometimes called ambient food) is food of a type that would normally be stored refrigerated but that has been processed so that it can be safely stored in a sealed container at room or ambient temperature for a usefully long shelf life. Various food preservation and packaging techniques are used to extend the shelf life of a food. Decreasing the amount of available water in a product, increasing its acidity, or irradiating or otherwise sterilizing the food and then sealing it in an air-tight container, are all methods used to extend a food's shelf life without unacceptably changing its taste or texture.

Modifying Human Diets and Enhancing Functional Nutrition Content

Poor diets and unhealthy food choices by consumers lead to negative health outcomes: both in terms of malnutrition at one end of the spectrum and obesity at the other. Many in the developed world eat unbalanced diets, high in sugars and fats – diets that contain far more calories than are required to provide sustenance resulting in obesity and other health disorders (such as diabetes and cardiovascular disease). In the developing world it is estimated that over 800 million people suffer from malnutrition, whereby their readily available food supply provides an insufficient nutrient profile for health.

The primary role of diet has been historically viewed as providing sufficient nutrients to meet the nutritional requirements of an individual. There is now, however, increasing scientific evidence to support the hypothesis that some foods and food components have beneficial physiological and psychological effects over and above the provision of the basic nutrients. Today, nutrition science has moved on from the classical concepts of avoiding nutrient deficiencies and basic nutritional adequacy to the concept of "positive" or "optimal" nutrition. The research focus has shifted more to the identification of biologically active components in foods that have the potential to optimize physical and mental well-being and which may also reduce the risk of disease. Many traditional food products including fruits, vegetables, soya, whole grains and milk have been found to contain components with potential health benefits. In addition to these foods, new foods are being developed to enhance or incorporate these beneficial components for their health benefits or desirable physiological effects.

Consumer interest in the relationship between diet and health has increased substantially in industrialized nations. There is much greater recognition today that people can help themselves and their families to reduce the risk of illness and disease and to maintain their state of health and well-being through a healthy lifestyle, including the diet. Ongoing support for the important role of foods such as fruits and

[2] Godfray, H. Charles. “Food Security: The Challenge of Feeding 9 billion People”. Science, Vol. 327, no. 5967, pp 812–818. Published January 28, 2010.

vegetables and wholegrain cereals in disease prevention and the latest research on dietary antioxidants and combinations of protective substances in plants has helped to provide the impetus for further developments in the global functional food market.

The development of “foods for health” – foods with robust nutrition characteristics associated with a healthy diet are needed, and in some instances this may require the development of staple foodstuffs with enhanced nutrient and vitamin content. Similarly, technologies that improve the taste, smell and other sensory inputs during human consumption can also enhance utilization of more healthy foods. Finally, foods can also be modified to carry vaccines, functionally enhanced nutrients, probiotics and other health enhancement products.

Incorporating the Localvore Movement into Regional Food Value Chains to Take Advantage of Value-Added Processing and Manufacturing Opportunities

The strengthening local food movement (localvore movement) in towns across the nation is reshaping the food value chain model. The localvore movement describes a growing phenomenon in which consumers increasingly are seeking out the flavors of fresh, vine-ripened foods grown on local farms rather than those trucked to supermarkets from faraway lands. It is a movement that is gradually reshaping the business of growing and supplying food to Americans.

The local food movement has not been lost on the giants of food retailing. Large supermarket chains like Wal-Mart, Kroger, and even Whole Foods depend on their scale to compete. Their systems of buying, delivering, and stocking are not easily adapted to the challenges of providing local food, which by its nature involves many diverse groups of farmers. Nonetheless, all the giant food chains and a growing number or regional retailers are devoting a small but growing share of shelf space to locally bought produce and value-added products.

The local food movement has many of the same hallmarks of the organic foods movement, which sprang up in the 1970s to place a premium on foods grown without pesticides and synthetic fertilizers. Indeed, almost all of today's small farmers use organic techniques. But many consumers believe that organic foods, although seemingly healthy, may still damage the environment. For instance, organic fruits that are grown in Chile and Argentina and then shipped halfway around the world require fossil fuels and carbon emissions to power tankers and trucks thousands of miles. Instead of focusing just on pesticides and chemicals, consumers now take into account carbon footprints. The message seems to be: If you buy organic, you care about your own body; if you buy local, you care about your body and the environment.

As consumer purchasing behavior is altered by the localvore movement, regions will be provided with opportunities to spur economic development by focusing on value-added food products.

North Carolina’s Current Value-Added Agricultural Processing Situation

Although North Carolina has a rich history in agricultural production and forestry, its economy, unlike many other agricultural states across the nation, has been significantly concentrated in converting or transforming its biomass resources into value-added products. In general, adding value is the process of changing or transforming a product from its original state to a more valuable state.

As a result of this focus on biomass value-added production, agriculture and its related food manufacturing, forestry, and natural fiber industries are incredibly important to North Carolina’s economy.

NC State University (NC State) recently estimated the value of agriculture and agribusiness or "food, fiber, and forestry" at $78 billion, or nearly one-fifth of the state's GDP, and the level of employment at 640,000 of the state's 4 million employees in 2012.[3]

However, North Carolina's long-standing dominance in value-added biomass processing and manufacturing has been in a state of decline. Over the last two decades:

- The textile industry, which has historically been a key driver of North Carolina's economy, has faced significant employment decline in the state as a result of increased competition from foreign textile producers, which has resulted in either mill closings or the development of labor-saving machinery to drive down costs. As a result, between 1992 and 2012, employment across the textile and apparel value chain declined by 82 percent as the state shed approximately 238,000 jobs, from approximately 290,000 jobs in 1992 to 52,000 in 2012.[4]
- North Carolina's long dominance in the furniture industry has been challenged by the increasingly global nature of furniture manufacturing. Furniture imports to the nation are growing, especially from China and other developing and emerging markets, leading to North Carolina plant consolidations and shutdowns, and production being offshored. As a result, between 1992 and 2012, employment in the furniture industry sector in North Carolina declined by 56 percent, from approximately 80,000 to 35,000, a net loss of 45,000 jobs.[5]
- The tobacco industry has traditionally been one of the most important industries in North Carolina and a backbone of the state's agricultural heritage. However, over the last few decades, as the number of American smokers declined steadily and restrictions on public smoking increased, the large manufacturers began cutting costs and laying off large numbers of workers and relocating their factories to less expensive areas. In addition, as demand for domestically produced tobacco flagged, the federal quotas were also diminished, leading many farmers to cease growing tobacco. As a result, between 1992 and 2012, the number of individuals employed by the tobacco industry sector in North Carolina declined by 56 percent, from approximately 32,000 to under 10,000 jobs, a net loss of more than 22,000 jobs.[6]

The decline in these value-added biomass processing and manufacturing industries has led to underutilization of capacity throughout the state of North Carolina, particularly within the rural regions of the state. This then begs the question as to whether or not it is feasible to transition this underutilized capacity to strengthen and grow another industrial sector – namely the value-added food manufacturing sector. While this sector already is present throughout the state, the level of industrial concentration is not as high as one might expect based on the state's agrarian history, long-standing capacity in other value-added biomass processing industries, and access to major populations centers.

Background and Report Purpose

In the Fall of 2014, the North Carolina General Assembly authorized and appropriated funds for the development of a feasibility study and action plan for a Food Processing and Manufacturing Initiative to expand agribusiness and food processing and manufacturing industries in the state of North Carolina.

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[3] NC State University, College of Agriculture and Life Sciences, "Agriculture and Agribusiness: North Carolina's Number One Industry," Fact Sheet, 2014.

[4] Duke University's Center for Globalization, Governance & Competitiveness, "North Carolina in the Global Economy: Textiles & Apparel" Viewed at: http://www.ncglobaleconomy.com/textiles/overview.shtml.

[5] Duke University's Center for Globalization, Governance & Competitiveness, "North Carolina in the Global Economy: Furniture" Viewed at: http://www.ncglobaleconomy.com/furniture/overview.shtml.

[6] Duke University's Center for Globalization, Governance & Competitiveness, "North Carolina in the Global Economy: Tobacco" Viewed at: http://www.ncglobaleconomy.com/NC_GlobalEconomy/tobacco/overview.shtml.

To maximize the impact of North Carolina's food processing and manufacturing innovation assets, it is critical to determine how investments in the research infrastructure related to the state's food science and related fields can best be leveraged, strengthened, and ultimately linked to market opportunities and regionally-based industry specializations. To meet this need, NC State College of Agriculture & Life Sciences (CALS) undertook a study to advise on the creation of a food processing and manufacturing initiative intended to catalyze the development of value-added food manufacturing businesses statewide.

Battelle's Technology Partnership Practice (TPP) was engaged by NC State CALS to help in this strategic effort. Battelle TPP is the economic development consulting arm of the world's largest independent non-profit research and development organization. Battelle TPP brings to this project a position as the national leader in cluster-driven economic development practice with an established track record in developing and advising many of the most successful modern agbioscience development programs in the U.S.

The study was developed with input from a Steering Committee comprised of industrial, academic, and government thought leaders in food processing and manufacturing. In addition, the Battelle project team interviewed more than 100 business, academic, and civic leaders to gain an understanding of North Carolina's existing strengths and capabilities in food processing and manufacturing and to gather input on the barriers/hurdles to development as well as the types of activities needed to position the state to develop additional value-added manufacturing capacity in the future. The following study is the collective result of the input received.

This report is organized into four additional chapters:

- Chapter 2 provides an assessment of North Carolina's food value chain by examining industry employment, establishment, and wage data and recent trends in food manufacturing and related industries; the productivity and value-adding context of these sectors in North Carolina; and the capacity and value of the state's agricultural production complex.
- Chapter 3 provides an assessment of North Carolina's food-related innovation by examining research and innovation mechanisms that both drive and support the food value chain in the state. Understanding the areas in which food-related research and innovation are occurring provides information regarding the potential areas of economic growth in the future.
- Chapter 4 provides a discussion of the avenues in which to catalyze the growth of value-added food manufacturing in North Carolina. A detailed analysis examines North Carolina's food-related business model/value supply chain areas that provide the greatest opportunity for development and growth as well as North Carolina's food-related innovation areas for development and growth.
- Chapter 5 describes an action plan for next steps in the implementation of a food processing and manufacturing initiative and the potential economic impact that could be realized from catalyzing the growth of the value-added food processing and manufacturing industry in North Carolina.

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Chapter 2: North Carolina's Food Value Chain

Critical in assessing the ability of North Carolina to develop and grow a leading food manufacturing industry is to first understand the position of the industry within the state today. How is the sector currently positioned and what are the implications of this going forward? What have been the recent trends relative to the national industry? Is North Carolina well concentrated in the sector and does it have distinct niche strengths from which to build? Are there gaps in the continuum of sectors and infrastructure necessary to thrive as an industry "cluster"?

The answers to these key questions are addressed in this section of the report through an analysis of:

- North Carolina industry employment, establishment, and wage data and recent trends in food manufacturing and related industries
- The productivity and value-adding context of these sectors in North Carolina
- The capacity and value of the state's agricultural production complex.

North Carolina's Food Value Chain

A robust and thriving state food manufacturing industry cluster goes well beyond manufacturing activities alone. It will demonstrate competencies and niche strengths along the entire food-related "value chain" – the holistic set of value-adding industry activities from research and development of new products and ingredients and other inputs, on through food processing and manufacturing, into packaging, and through a high-functioning distribution network on to store shelves and home cupboards.

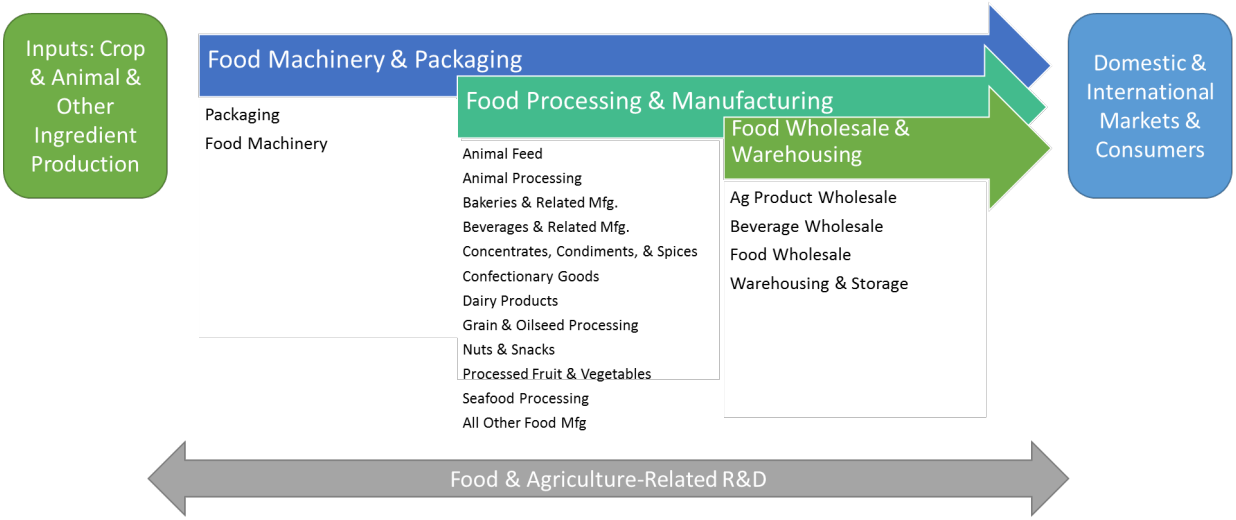


Figure 1. The Food Value Chain.

Figure 1 outlines this value chain and the detailed "subsectors" of the food industry developed and defined by Battelle (see Appendix A for a detailed definition). North Carolina is a major player in U.S. and global agriculture from both a production and research perspective. Its significant agricultural production

across both crops and animals is summarized in this section; however from an industry clustering perspective is not included in the detailed analysis of the food value chain. Likewise, the state is a global leader in university and industrial R&D activities specific to the agricultural biosciences, and has established a key role in food and nutrition-related research not only through its leading universities but also through the sizable and focused public-private research efforts. The state's research competencies are detailed in another section of the study.

Employment and Establishment Analysis

North Carolina's food value chain is large and well concentrated with a few key strengths. The state sector, however, has shed jobs in recent years, particularly among its largest components. In 2012, the sector employed more than 90,000 or 2.8 percent of all state private sector jobs (see Table 1). This represents a relatively high concentration for an economy the size of North Carolina's – employment in the food value chain is 8 percent greater relative to the state private sector compared with the national average. Put another way, the state has a "location quotient" of 1.08.

Location quotients measure the degree of job concentration within a state or region relative to the nation.[7] A regional LQ greater than 1.0 is said to have a greater concentration than the national average. When the LQ is significantly above average, 1.20 or 20 percent greater, the region is said to have a "*specialization*" in the industry.

Among the 18 subsectors along the food value chain, North Carolina has a specialized employment concentration in two: animal processing (LQ is 2.20) and in food-related packaging (LQ is 1.37). A third nearly specialized subsector, "all other food manufacturing" (LQ is 1.14) includes perishable prepared foods such as frozen meals. Animal processing is the largest and most specialized employer along the value chain and reflects current and historical strengths in raising and harvesting hogs and pigs and turkeys and developing related food products.

The food industry in North Carolina has ridden the ups and downs of recent business cycles, a somewhat different trajectory of employment changes compared with the more steady performance of the sector across the U.S. At the state level, North Carolina employers increased hiring at the peak of the economic expansion in 2006 and 2007 by 2.5 percent and 3.0 percent, respectively. The sector peaked with the broader economy in 2007 and subsequently shed those job gains – declining by 5,000 jobs or 5.3 percent (see Figure 2). While the sector in North Carolina has seen virtually no net change in jobs (−0.2 percent) since 2001, the national food value chain has *declined* by 1.5 percent in employment.

Job losses among North Carolina food value chain employers during the recession and early years of the economic recovery were driven by the state's largest subsectors, from 2007–12:

- *Animal Processing* declined by nearly 3,500 jobs
- *Food Wholesale* declined by almost 1,900 jobs
- *Packaging* declined by just over 1,500 jobs.

[7] Location quotients (LQs) are a standard measure of the concentration of a particular industry in a region relative to the nation. The LQ is the share of total state or regional employment in the particular industry divided by the share of total industry employment in the nation. An LQ greater than 1.0 for a particular industry indicates that the region has a greater relative concentration, whereas an LQ less than 1.0 signifies a relative underrepresentation. An LQ greater than 1.20 denotes employment concentration significantly above the national average. In this analysis, regional specializations are defined by LQs of 1.20 or greater.

Table 1. Summary Employment Metrics for the North Carolina Food Value Chain, 2012.

Food Value-Chain Sector & Key Subsectors	Establishments		Employment, 2012	Employment Change		NC LQ, 2012
	Count, 2012	Change, 2009–12		NC, 2009–12	US, 2009–12	
Total Private Sector	**250,607**	**3%**	**3,223,192**	**2.8%**	**3.3%**	**1.00**
Food Value-Chain, Total	**2,173**	**14%**	**90,584**	**−2.0%**	**1.4%**	**1.08**
Food Processing & Manufacturing						
Animal Processing	135	5%	30,975	−4.7%	−2.3%	**2.20**
Bakeries & Related Mfg	253	25%	7,216	−7.4%	3.4%	0.87
Beverages & Related Mfg	147	27%	4,823	15.6%	6.6%	0.85
Processed Fruit & Vegetables	39	11%	2,928	−6.2%	−2.2%	0.59
All Other Food Mfg	35	6%	2,080	2.5%	4.8%	1.14
Nuts & Snacks	28	22%	1,523	6.8%	9.0%	1.06
Grain & Oilseed Processing	25	0%	1,456	9.5%	1.2%	0.83
Animal Feed	62	9%	1,398	5.0%	2.0%	0.91
Dairy Products	39	39%	950	26.5%	1.2%	0.25
Confectionary Goods	34	31%	673	23.3%	2.0%	0.41
Seafood Processing	28	0%	671	11.3%	1.4%	0.61
Concentrates, Condiments, & Spices	16	23%	233	14.8%	6.0%	0.18
Food Wholesale & Warehousing						
Food Wholesale	931	14%	20,753	−1.9%	1.3%	0.99
Beverage Wholesale	144	21%	4,853	11.0%	6.2%	0.97
Agricultural Product Wholesale	105	3%	1,099	−2.5%	−0.4%	0.51
Warehousing & Storage	44	−2%	967	−5.7%	5.9%	0.55
Food Machinery & Packaging						
Packaging	102	−3%	7,803	−9.5%	−2.5%	**1.37**
Food Machinery	6	0%	183	−38.2%	4.8%	0.37

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN. Note: Location Quotients highlighted in Red indicate a specialized state subsector.

Bar charts below graphically depict the employment changes in the food value chain subsectors over the longer-term, 2001–12 (see Figure 3), and during the economic recovery, 2009–12 (see Figure 4). The mixed performance of the subsector is evident with job gains and losses during both period generally cancelling each other out across the broad food value chain sector.

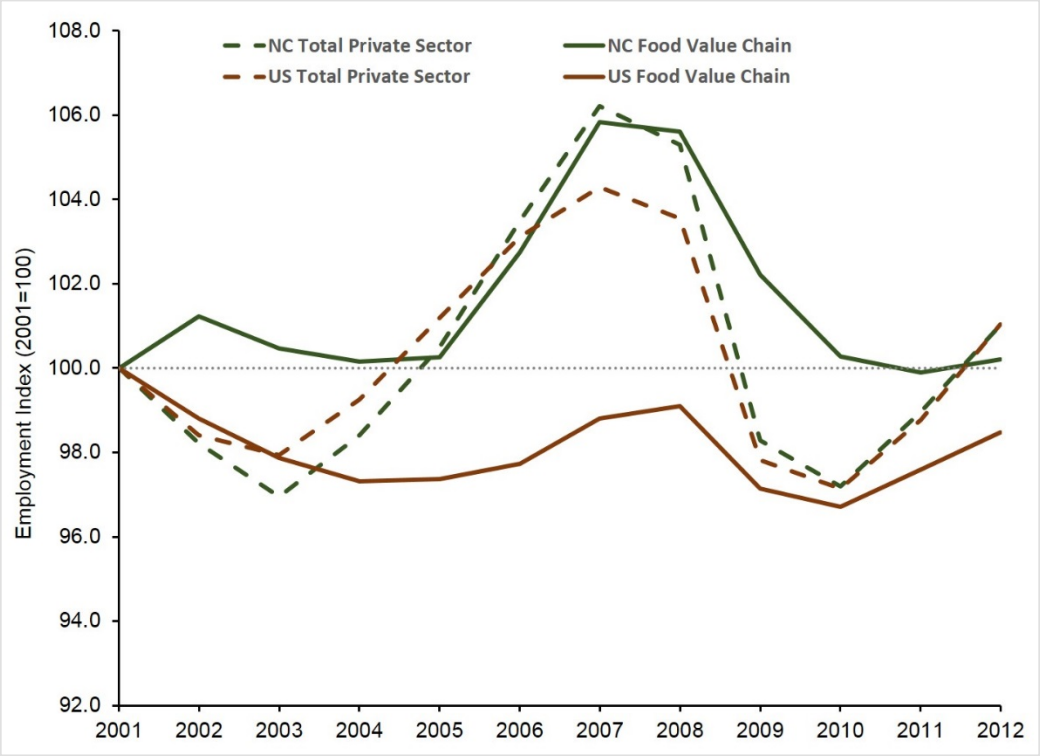


Figure 2. Employment Trends in the Food Value Chain and Total Private Sectors, NC vs. U.S., 2001–12 (Index, 2001=100).

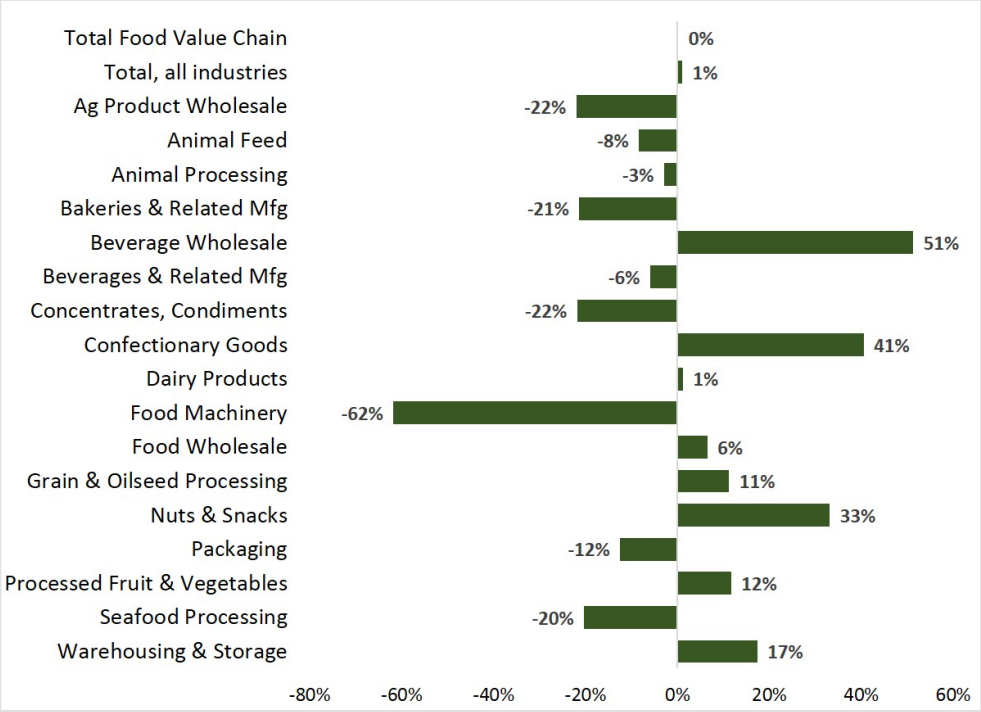


Figure 3. Longer-Term Employment Trends in the NC Food Value Chain Subsectors, 2001–12

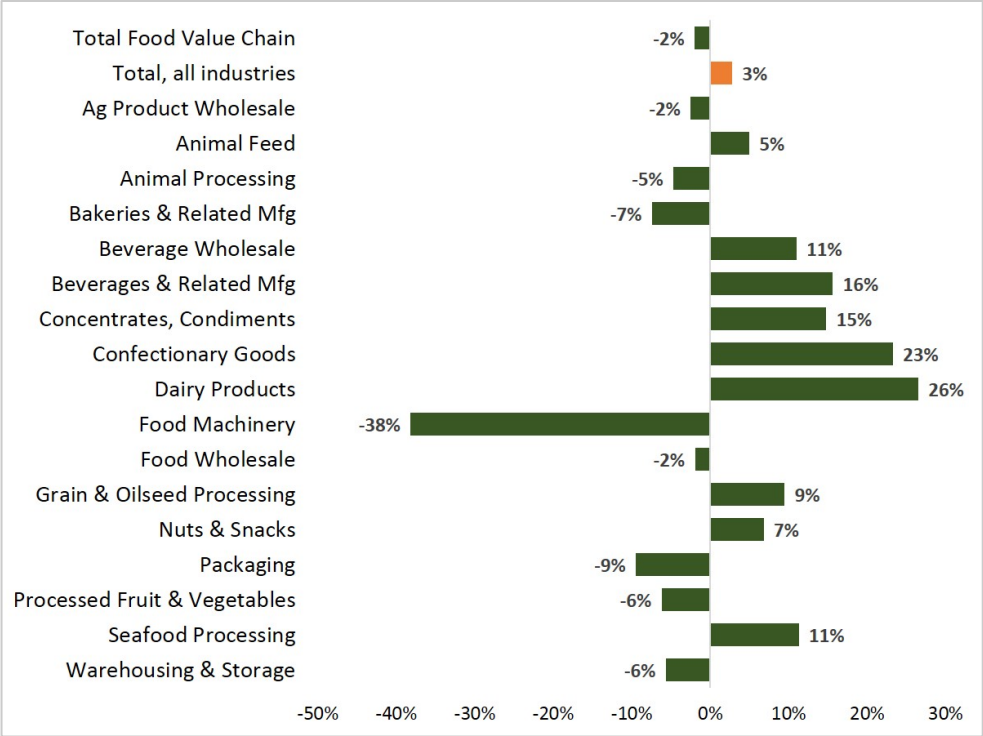


Figure 4. Economic Recovery Employment Trends in the NC Food Value Chain Subsectors, 2009–12.

North Carolina's specialized concentrations in animal processing and in packaging are evident in the pie charts shown in Figure 5. Just over 1 in 3 sector jobs in the state are in animal processing compared with half that share at the national level.

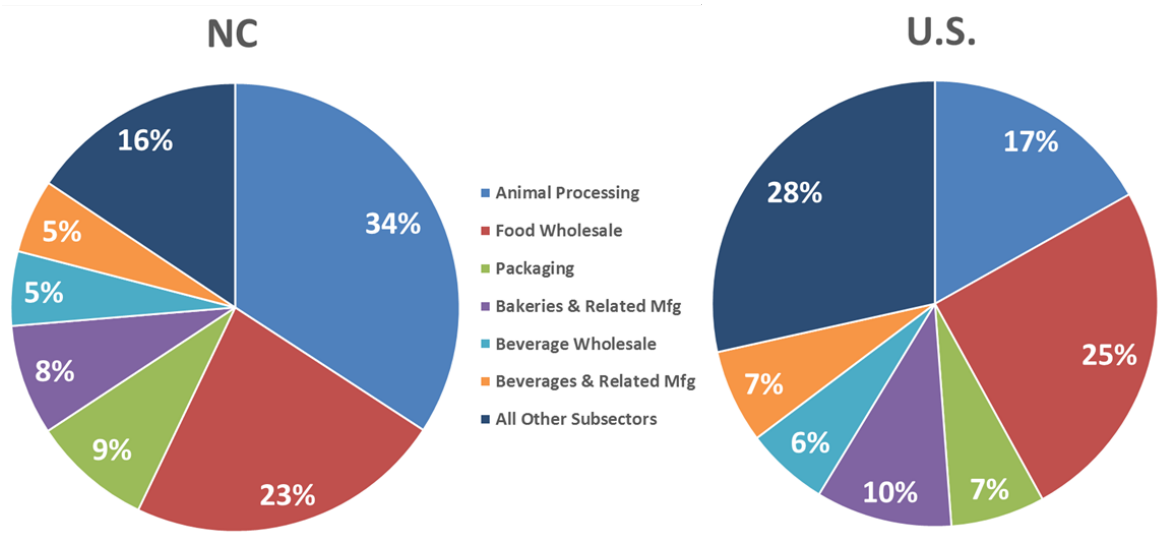


Figure 5. Employment Composition of the NC and U.S. Food Value Chain, 2012

Innovation-driven industries like modern food manufacturing are dynamic, and the composition of the state sector is shifting beneath the surface. From an employment perspective, North Carolina's larger industry subsectors are undergoing a transition with its four largest – animal processing, food wholesale, packaging, and bakeries, all experiencing employment declines during the current economic expansion since the economy reached its trough in 2009. At the same time, a wide array of subsectors more modest in size, are emerging and growing jobs as we move beyond the deep national recession.

These underlying subsector dynamics during the early economic expansion years are illustrated in the "bubble" chart shown in Figure 6. A bubble chart is useful in presenting three key variables on one graphic: the size of the subsector (size of each bubble); the relative employment concentration (location quotient on the vertical axis); and recent trends (employment change on the horizontal axis). Based on the placement of the bubbles, industries can be characterized by the quadrant in which they appear – those segments that are specialized or highly concentrated and growing are deemed "stars", those not yet specialized but growing are characterized as "emerging", etc.

Among the growth subsectors that appear on the right side of the vertical axis are several that can be further characterized as "*high growth*" – that is, they not only grew in North Carolina during the recovery years since 2009, but they also outpaced national job growth. These include:

- Dairy Products (26 percent increase)
- Confectionary Goods (23 percent increase)
- Beverages & Related (16 percent increase)
- Concentrates, Condiments, & Spices (15 percent increase)
- Seafood Processing (11 percent increase)
- Beverage Wholesale (11 percent increase)
- Grain & Oilseed Processing (9 percent increase)
- Animal Feed (5 percent increase).

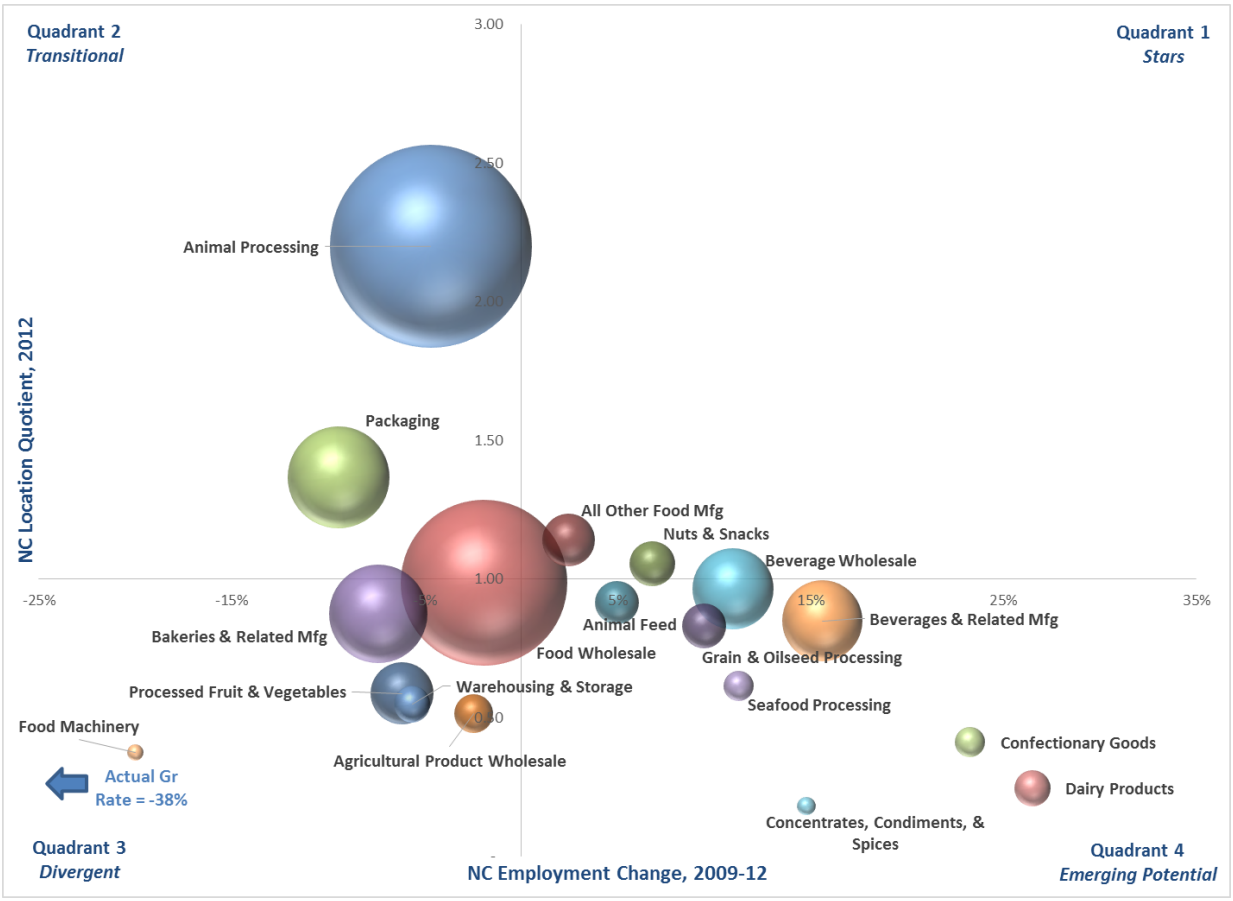


Figure 6. Employment Size, Concentration, and Recent Trends within the Food Value Chain in NC, 2012

Highlights from the analysis of the food value chain subsectors are detailed below and in Table 2, which shows the detailed industry specializations and growth sectors within each subsector.

- **Animal processing**, the state's largest and most specialized industry subsector, is in transition with job losses over both the longer-term and more recent recovery period. Given its size and importance to the overall food value chain, the employment trend in animal processing has largely mirrored that for the overall food sector with strong job gains from 2005–07 and since hitting a peak in 2007 has declined by nearly 3,500 jobs or 10 percent. Two-thirds of subsector jobs are in poultry processing (more than 21,000 jobs) which has shed 7 percent of its jobs since 2007. The only growth sector during the recovery has been in rendering and meat by-products, by far the smallest of the subsectors component industries.
- North Carolina has a large, specialized, and diverse base in food-related **packaging**. The subsector has a specialized employment concentration in six of its component industries and while the subsector has experienced a nearly double-digit employment decline since 2007 (−9.5 percent), several components are growing spanning plastics, paper, and glass packaging and containers. Examples of state packaging companies include:
  - A growing number of spin-out companies from NC State's Center for Advanced Processing and Packaging Studies (CAPPS) research, including Aseptia with manufacturing operations in Troy. Aseptia is a state-of-the-art aseptic food processing technology company that was

recently named as a 2014 Red Herring Top 100 North America award winner. Aseptia is working to transform the food industry by providing shelf-stable products that maintain the flavors and nutrients of fresh foods without preservatives through the utilization of advanced thermal processing with continuous flow monitoring in a completely aseptic environment.

- With a production facility in Everetts, Syfan produces a whole range of polyolefin shrink films, from ultra-thin to heavy duty films to films specially designed to wrap raw meat products. Syfan serves a number of food-related and other industries including the bakery, beverage, candy/confections, dairy, fruit and vegetable, grain meat and snack food sectors.
- Rexam, a multinational company headquartered in the UK, is one of the leading global beverage can makers and has a production facility in Winston-Salem. Rexam produces many different kinds of cans for different beverage products, from fruit juice to alcoholic beverages, and boasts the widest range of can sizes in the industry.
- Weener, another multinational headquartered in Germany, produces a wide array of plastics packaging products, including plastic caps and closures, bottles, dispensing and dosing systems and plastic valve products. Located in Wilson, NC, it introduced one of the first dispensing silicone valves used to package honey. Weener bottles receive a special coating that protects them from scratches and blocking through a proprietary process. In addition to food and beverage markets, Weener services the personal care, household goods and healthcare sectors.

- North Carolina's **food wholesale** subsector employed nearly 21,000 in 2012, an employment base that has increased by 6.5 percent since 2001 despite recent modest declines coming out of the recession (−1.9 percent since 2009). Food wholesale activity tends to be very population-driven, and North Carolina's wholesale segment reflects this with a 0.99 location quotient, or right at the national average concentration. Offsetting declines in other parts of the wholesale sector were recent job gains since 2009 in fruits and vegetables; poultry; meats; and general line grocery wholesale establishments. North Carolina is emerging with strong gains in **beverage manufacturing and beverage wholesale** operations. The beverage subsectors combine to employ nearly 10,000 across the state, which includes nearly 1,400 net new jobs since 2009. The state has an emerging presence and position in several beverage areas with firms adding jobs since 2009 in wineries, breweries, bottled water, and coffee and tea. While still somewhat modest in size, each of these component sectors experienced double-digit job growth during the early stages of the recovery. Breweries, once well behind employment in soft drinks, have emerged with 39 percent job growth since 2001 and in 2012 overtook soft drinks as the largest beverage sector in North Carolina. Breweries, along with bottled water and ice manufacturing, have a specialized employment concentration in the state.

> ***North Carolina's Craft Beer Boom***
>
> Craft beer in North Carolina has seen a dramatic increase in demand over the past eight years. NC had 26 breweries in 2006, but is now home to 110, including three big name craft breweries who expanded their business into NC: Sierra Nevada, New Belgium and Oskar Blues. Craft beer production in NC reached 263,488 barrels in 2013, a 66% increase over the previous year. The epicenter of the craft beer boom is Asheville, in Western NC, which is home to more breweries per capita than any other U.S. city (about one brewery per 8,000 people).
>
> A combination of factors led to the state's craft beer boom: a strong "locavore" movement (buying local), a healthy outdoor and music culture and a "Pop the Cap" law passed in 2005 which allowed brewers to produce beer with up to 15% alcohol by volume (ABV). Prior to the bill's passage brewers had only been able to produce beers with 6% ABV, which greatly reduced the varieties of beer that could be produced.

- While the **food machinery** sector is quite small in North Carolina, at just under 200 jobs in total, there is substantial innovation and intellectual property emanating from one of its companies – Tipper Tie. Tipper Tie, part of the Dover company, has a long history of providing food

processing equipment and systems to the dairy, seafood, meat, poultry, sausage, pet food and baked goods industries. Headquartered in Apex, the company also serves sealant, adhesive and industrial explosives manufacturers. Their products range from clips, food labels and sausage loops to industrial emulsifiers and automated bagging and clipping systems. In 1958, Tipper Tie produced the Tipper Clipper, a machine that clipped and tied both ends of a meat casing, revolutionizing the industry and eventually leading to the development of today's clipper and clip industries.

Table 2. Detailed Industry & Product Market Drivers of the NC Food Value Chain Subsectors

Food Value Chain Subsectors	Specialized Component Industries (State LQ>1.20)	Growing Component Industries (2009–12)
Food Processing & Manufacturing		
Animal Processing	• Poultry processing • Rendering & meat by-product processing • Animal, except poultry, slaughtering	• Rendering & meat by-product processing
Bakeries & Related Mfg.	• Cookies & crackers	• Tortilla mfg. • Commercial bakeries
Beverages & Related Mfg.	• Bottled water • Breweries • Ice	• Wineries • Breweries • Bottled water • Coffee & tea
Processed Fruit & Vegetables	• Specialty canning	• Specialty canning
All Other Food Mfg.	• Perishable prepared foods	• All other misc. food mfg.
Nuts & Snacks	• Roasted nuts and peanut butter	• Roasted nuts and peanut butter • Other snack foods mfg.
Grain & Oilseed Processing	• Flour milling • Soybean processing	• Soybean processing
Animal Feed	• Other animal food mfg.	• Dog & cat food • Other animal food mfg.
Dairy Products	n/a	• Ice cream & frozen desserts • Milk mfg.
Confectionary Goods	n/a	• Non-chocolate confectionery products
Seafood Processing	n/a	• Fresh & frozen seafood processing
Concentrates, Condiments, & Spices	n/a	n/a
Food Wholesale & Warehousing		
Food Wholesale	• General line grocery merchant wholesalers	• Fruit & vegetable wholesale • Poultry products wholesale • Meat wholesale • General line grocery merchant wholesalers
Beverage Wholesale	n/a	• Beer wholesale • Wine & spirits wholesale
Ag Product Wholesale	• Other farm product raw materials wholesale	• Grain & field bean wholesale
Warehousing & Storage	n/a	• Refrigerated warehousing & storage

Food Value Chain Subsectors	Specialized Component Industries (State LQ>1.20)	Growing Component Industries (2009–12)
Food Machinery & Packaging		
Packaging	• Plastics packaging film & sheets • Folding paperboard box mfg. • Coated paper bag & pouch mfg. • Glass containers • Nonfolding sanitary food containers • Coated & laminated packaging paper	• Plastics bag & pouch mfg. • Coated & laminated packaging paper • Coated paper bag & pouch mfg. • Glass containers
Food Machinery	n/a	n/a

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN.

Note: Detailed industries shown here limited to those with a 2012 base employment level of 200 or more.

North Carolina has visible gaps in its food value chain that could limit the growth potential for existing and emerging companies, or for companies interested in locating in the state, namely:

- The relatively under-concentrated distribution infrastructure specific to **agricultural wholesale and food-related warehousing and storage**. North Carolina's concentration of employment in these sectors stands at roughly half of that seen nationally – subsector location quotients are 0.51 and 0.55, respectively. As a major agricultural producer with significant food processing activity, these low concentrations raise concerns that are further compounded by the recent employment declines in the state, particularly while one of the sectors, food-related warehousing and storage, is boosting jobs nationally coming out of the recession.
- In discussions and interviews with North Carolina food processors and other stakeholders, there is a consistent concern raised regarding a gap in the presence and availability of "intermediate" food processors – those processors willing and able to receive and process seasonal or small- to mid-sized raw inputs to food related products. Unfortunately, the federal industry classification structure does not allow for isolation of this distinct type of intermediate processor in the employment data as these operations are aggregated in with broader food processing.

Industry Productivity Analysis

The nature of modern food manufacturing can vary substantially by state, by industry subsector, or even by company as the products, processes, and price points of food companies can be vastly different. Disruptive shifts in products and industries occur as consumer tastes and preferences change. Examples across developed countries might include a move toward locally grown or organic ingredients in restaurants or on store shelves or a shift in consumer beer preferences away from mass-marketed American lagers toward a range of craft or micro-brewery offerings. These moves can alter the value-adding profiles of companies and their workers based on ingredients sourced or more tech-based or even more labor-intensive manufacturing processes.

Some industries may lag in employment growth, but excel in efficiency and productivity which points not to weakness, but rather to underlying strength. More specifically, estimates of "value-added" attributed to an industry cluster allow one to gauge the contribution to Gross State Product made by the sector beyond the cost of inputs to production. In other words, value added represents the difference between an industry's total output and the cost of its intermediate inputs. The metric of value-added per employee is a useful measure of the overall contribution to GSP by each worker and is thus a proxy for industry productivity and the value of that state industry above and beyond input costs like goods and services

purchased from other industries or imported. Higher productivity makes companies and industries more competitive as they produce at a greater value given the same inputs, in this case, human capital.

North Carolina's food value chain is out-performing the U.S. sector at-large in the productivity of its workforce as measured by value-added per worker with 11 of 12 manufacturing industry subsectors exceeding their national counterparts in this key metric (see Table 3). The analysis leverages data from the IMPLAN Input/Output models specific to the U.S. and North Carolina and while we are able to develop productivity estimates for the food manufacturing component of the broader food value chain, as well as for packaging, we are unable to develop estimates for the wholesale and machinery segments due to insufficient industry detail in the models.

Table 3. Value-Added per Worker in Food Processing & Manufacturing and in Packaging, 2012.

Food Value Chain & Subsectors	Value-Added per Employee, 2012		NC as a Share of U.S.
	North Carolina	U.S.	
Total Private Sector	**$95,035**	**$93,779**	**101%**
Total Food Processing & Manufacturing	**$173,639**	**$116,196**	**149%**
Animal Feed	$349,797	$208,168	168%
Animal Processing	$6,943	$50,383	153%
Bakeries & Related Manufacturing	$151,950	$67,835	224%
Beverages & Related Manufacturing	$625,526	$211,816	295%
Concentrates, Condiments & Spices	$1,139,896	$509,587	224%
Confectionary Goods	$188,183	$114,165	165%
Dairy Products	$214,145	$134,199	160%
Grain & Oilseed Processing	$346,158	$235,920	147%
Nuts & Snacks	$415,129	$185,300	224%
Processed Fruits & Vegetables	$201,592	$90,830	222%
Seafood Processing	$43,983	$59,581	74%
All Other Food Manufacturing	$ 106,993	$75,630	141%
Packaging	**$107,598**	**$115,776**	**93%**

Source: Battelle analysis of IMPLAN Input/Output model data for NC and the U.S.

Note: Data not available for wholesale distribution and food machinery sectors due to insufficient industry sector detail within the IMPLAN models.

Across the food processing and manufacturing component of the broader food value chain, North Carolina companies and their workers are generating more than $173,000 per worker, a 49 percent greater level of output relative to the national sector. This higher productivity trend carries through nearly all of the food processing and manufacturing subsectors.

- The greatest per worker value-added context, both in North Carolina and the U.S. is the highly productive **concentrates, condiments and spices** subsector with an especially high degree of value added in flavoring syrup and concentrates. The subsector is unique in that it aligns better, in many respects, with an industry sector like chemicals manufacturing, with a laboratory setting producing high-value chemicals with relatively few workers. Mother Murphy's Laboratories, with its headquarters, manufacturing, distribution, and R&D facilities in Greensboro, develops new and existing flavors for a range of food, pharmaceutical, and tobacco industry clients.

- North Carolina's **beverage manufacturers** are demonstrating nearly three times the subsector average in value added activities. This reflects the industry focus in North Carolina in high-value beer, coffees and tea manufacturing relative to soft drinks, ice and other lower-value products.
- In snack foods, North Carolina manufacturers like **Snyder's-Lance**, headquartered in Charlotte, are producing a whole range of snack products with well-established brand-loyalty.
- Lower relative value added activity in the state **packaging** subsector is related to a greater concentration of employment and production in paper-related packaging which has a lower value added profile in North Carolina relative to the U.S. North Carolina is more competitive in its plastics, glass, and metal container and packaging sectors.

The productivity analysis shows North Carolina is clearly competing and competing well along the food value chain on the productivity of its workforce, its high-value product focus and offerings, and its deployment of advanced processing technologies. **In certain industries, employment declines can at least partially be explained by productivity strength, a logical progression as companies require fewer employees to produce the same or greater amounts of value-added goods and services**. This is likely the case for North Carolina's labor-intensive animal processing subsector as companies innovate and realize efficiencies from technology advances.

A recent Economist article[8] details the efficiencies and productivity gains realized in Denmark's animal processing cluster with innovation along every detail of pig slaughterhouse and distribution activity, including:

- Using photography integrated into cutting machines to adjust blades and optimize cuts to individual pig contours
- Detailed assessments on where to send various meat cuts and parts around the globe to take advantage of the highest and best prices
- Even having workers wear green instead of white to put pigs into a "better mood"
- Sprouting up of IT companies developing software tools for various aspects of herd management, food safety, distribution, and other applications.

The article notes that innovation and productivity are in-grained in the Danish food processing cluster much like the culture of innovation surround Silicon Valley, "In Central Denmark just as in California, innovation is in the air, improving productivity is a way of life, and the whole is much greater than the sum of its parts. Entrepreneurs see the future in meat and milk." Danish research institutions, much like those in North Carolina, are leading productivity-driving innovation like, for example, in bovine research developing robots that milk and wash cows, and even muck out stalls, and microchips that monitor behavior.

Industry Wages Analysis

Industry wages are affected by, and signal a whole range of factors including the value of goods and services produced by individual companies; the skill sets and education levels demanded of workers; the cost of living and doing business in a particular state, region, or nation; and the composition of an industry and whether it tends to be concentrated and focused in higher-value production. Given the insights of the value-adding productivity analysis, one might expect to see higher average wages along North Carolina's food value chain, but that is not the case.

[8] The Economist, "Bringing Home the Bacon: Tiny Denmark is an Agricultural Superpower," January 4, 2014.

North Carolina food value chain workers earned $39,485 annually, on average in 2012, or 20 percent less than their industry counterparts earned nationally (see Figure 7). The industry's composition in North Carolina can explain part of this differential – the state's largest and most concentrated component is animal processing, also its lowest paying subsector at just $29,528 on average per year. With more than twice the average concentration of jobs in North Carolina, this highly specialized subsector pulls down wages across the full sector. If the animal processing jobs are removed from the broader food value chain, for instance, the average state wage increases by about $5,000 to more than $44,000.

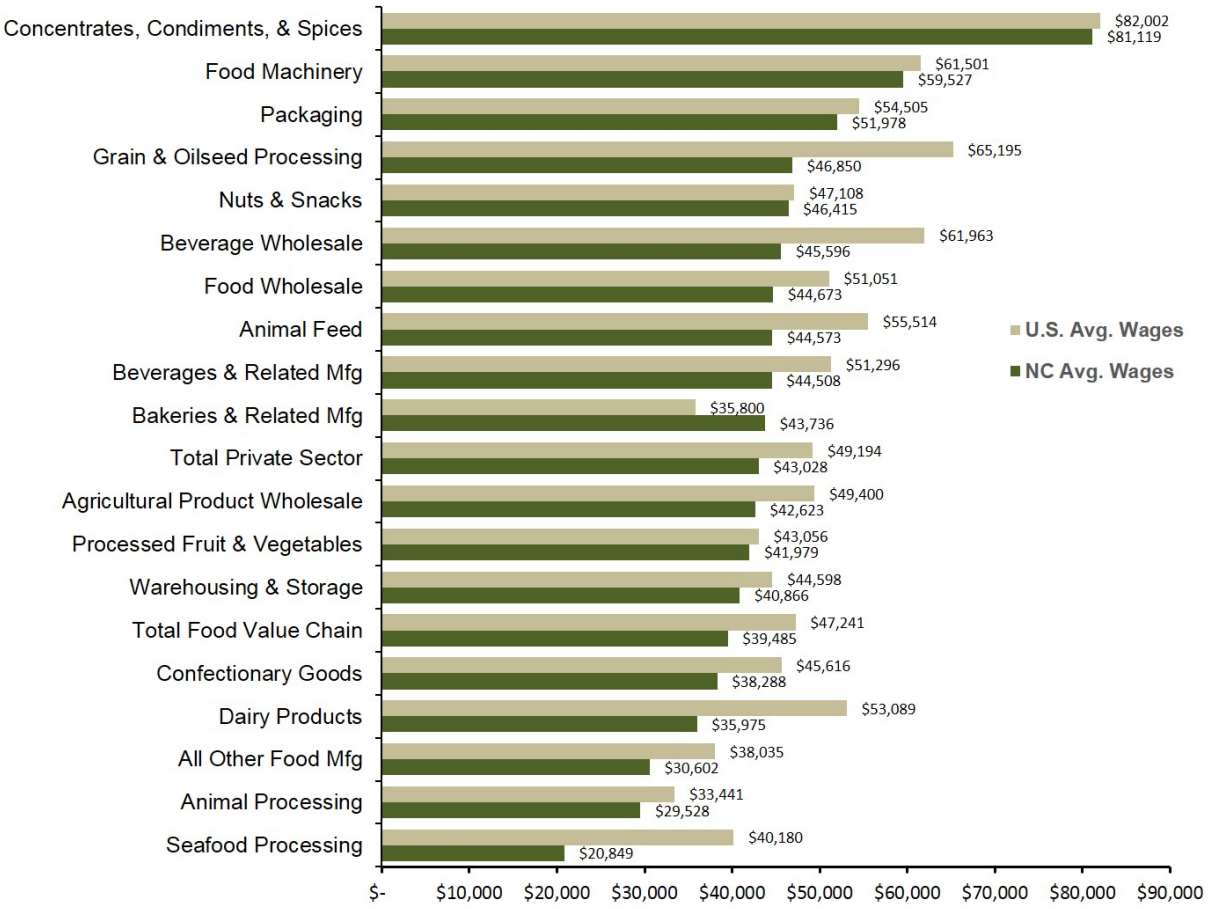


Figure 7. Average Annual Wages in the North Carolina and U.S. Food Value Chain, 2012.

Food value chain workers earn less than their counterparts, on average, across the entire state private sector. North Carolina's private sector average reached just over $43,000 in 2012 or about $3,500 per year more than that paid to food value chain workers. For perspective, the state's private sector average wage is 14 percent lower than that for the U.S. overall, reflecting a lower cost state to live and conduct business.

The cost of living in North Carolina, calculated for metro areas quarterly by the Council for Community and Economic Research (C2ER) and averaged for states by the Missouri Economic Research and Information Center, is calculated to be about 3.5 percent below the national average for an indexed value of 96.5 in 2014. The cost of living will tend to be lower in rural areas, more typically the location of major

animal processing and other food manufacturing establishments. This lower cost of living and often rural context is another factor in North Carolina's below-average wages across the food value chain.

Two cost components of the cost of living index – utilities and transportation – are well below the national average at 97 and 98, respectively. These represent critical costs of doing business for food producers who are heavy users of refrigerated warehousing and trucking, in addition to major shippers of agricultural and other inputs as well as final goods across the state and greater region. These cost savings are a competitive advantage to siting operations in North Carolina.

In combination with the value-added analysis, the lower costs to businesses from a wage perspective indicates North Carolina has a highly competitive landscape across its food value chain with significant value to offer companies locating in the state.

The Regional Industry Footprint of the NC Food Value Chain

To best understand the regional footprint and economic specializations of the food value chain across North Carolina, the following analysis breaks down the statewide industry assessment across the three major regions of North Carolina – Mountain (23 counties in Western NC), Piedmont (36 counties in Central NC), and Coastal Plains (41 counties in Eastern NC). The regions are designated on the map provided in Figure 8.

Figure 8. North Carolina's Major Regions.

Ninety percent of food value chain jobs are concentrated in the Piedmont and Coastal Plains regions of North Carolina, although the Mountain region demonstrates its own strengths and growth areas in the cluster (see Table 4 and Figure 9).[9]

[9] For more detailed summary employment tables for each region, by subsector, see the Appendix.

Table 4. Food Value Chain Summary Employment Metrics for NC Regions, 2012.

NC Region	Establishments		Employment		Location Quotient, 2012	Avg. Wages, 2012
	Count, 2012	Change, 2009–12	Jobs Counts, 2012	Change, 2009–12		
Piedmont	1,246	14.8%	44,941	−5.5%	0.79	$44,326
Coastal Plains	685	11.0%	36,575	0.4%	1.99	$34,712
Mountain	242	16%	9,068	7.8%	1.13	$34,749

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN.

The Piedmont region, at nearly 45,000 jobs, employs one of every two food value chain workers in the state, although given the size of the region's economy, the food sector is not considered to have a specialized employment concentration (LQ is 0.79). Regional employers operate 1,246 individual business establishments, a figure that has grown significantly just since the end of the recent recession, rising nearly 15 percent since 2009. Employers have cut the region's food value chain workforce by 5.5 percent since 2009, accounting for the overall decline in the sector at the statewide level. Average wages in the Piedmont food sector are highest among the three regions, and 12 percent or nearly $5,000 greater than the statewide average.

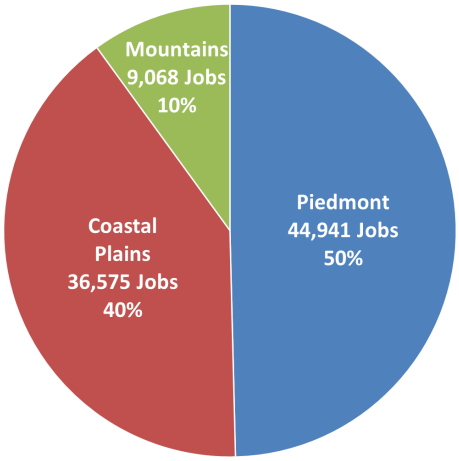


Figure 9. Employment Composition of the NC Food Value Chain by Region, 2012.

The Coastal Plains region has a large and highly specialized employment concentration across the food value chain. Regional companies employed more than 36,000 in 2012 across 685 establishments for a regional concentration that is twice that seen nationally (LQ is 1.99), and despite the net employment decline at the state level, the region has added a modest number of jobs since 2009 (up 0.4 percent).

In the Mountains region, food value chain employers are operating 242 individual establishments that employ more than 9,000. The food sector is highly concentrated and emerging in the industry with a 13 percent greater concentration of jobs compared with the national average and job growth of nearly 8 percent since the recession ended.

Longer-term trends shown in Figure 10 and Figure 11 highlight the growth in the Coastal Plains sector as driving statewide food value chain growth since 2001. The Mountain and Piedmont regions have trended more like the national sector over the decade plus. However, the Mountain region has led employment growth rates during the economic recovery, albeit from a much smaller base.

The detailed industries driving the region-wide employment trends are presented in Table 5 and segmented across three key performance categories defined below. The analysis finds unique

specializations and growth areas as well as commonalities and key overlaps. Packaging is primarily a specialization in the Piedmont region, beverages are a specialization in the Mountains, and the Coastal Plains has established specializations in several unique areas. Commonalities include animal processing as a key subsector for both the Mountains and Coastal Plains, and an emerging beverage wholesale segment growing in both the Piedmont and Mountain regions.

- *Current Strengths* – a specialized industry (LQ≥1.20) that is growing jobs.
- *Emerging Strengths* – a growing industry that is not yet specialized.
- *Specialized Opportunities* – a specialized industry (LQ≥1.20) that is losing jobs.

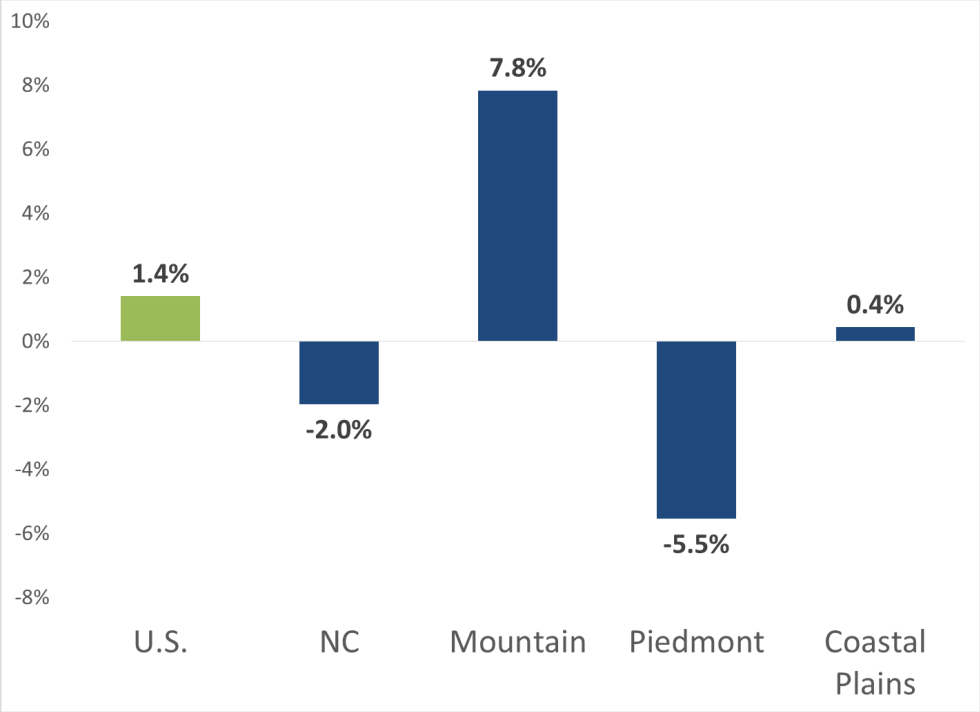


Figure 10. Employment Trends in the Food Value Chain During the Recovery, 2009–12.

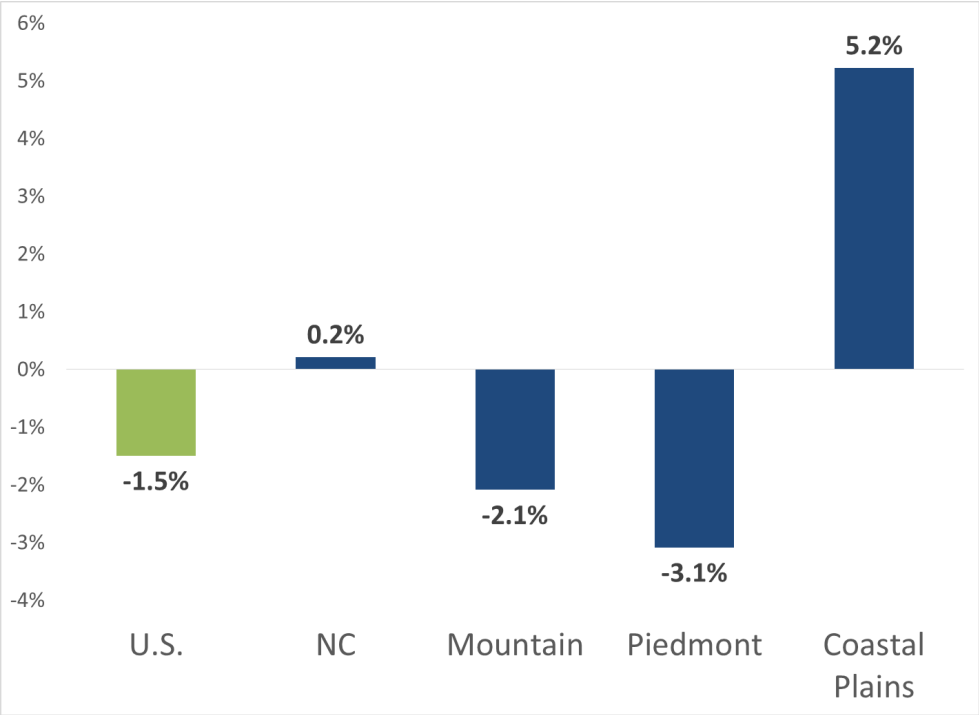


Figure 11. Employment Trends in the Food Value Chain Over the Longer-Term, 2001–12.

Table 5. Detailed Strengths and Opportunities across the Regional Food Value Chain

NC Region	Current Strengths	Emerging Strengths	Specialized Opportunities
Piedmont	• Packaging • All Other Food Mfg.	• Beverages • Grain & Oilseed Processing • Animal Feed • Dairy Products • Confectionery Goods • Concentrates, Condiments & Spices • Beverage Wholesale • Ag Product Wholesale • Warehousing & Storage	n/a
Coastal Plains	• Animal Processing • Seafood Processing • Nuts & Snacks • Animal Feed • Food Wholesale	• Bakeries & Related	• Ag Product Wholesale • Processed Fruit & Vegetables
Mountain	• Animal Processing • Beverages • All Other Food Mfg.	• Processed Fruit & Vegetables • Food Wholesale • Beverage Wholesale	n/a

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN.

The Piedmont region's niche in packaging is highly specialized and growing, with about 6,200 regional jobs it accounts for 80 percent of the state packaging subsector. During the economic recovery, regional packaging firms have increased employment by 3.2 percent while the national sector has shed jobs (−2.5 percent). Packaging is 59 percent more concentrated in the region relative to the nation. Given the large size of the Piedmont economy, just one other area has a specialized employment concentration and that is "all other food manufacturing" which primarily includes perishable prepared foods with products like salads, sandwiches, pizzas, peeled or cut vegetables. This segment is 21 percent more concentrated in the region and has grown its jobs base by 4 percent. Looking to emerging areas, 9 of the 18 regional subsectors are not considered to be specialized but have grown over the last 3 years. Some of the fastest regional growth areas include: grain and oilseed processing (up 24 percent), warehousing and storage (up 22 percent), beverages (up 17 percent), and though it has a more modest base, dairy products has increased employment by 63 percent.

The Coastal Plains region is highly specialized across the overall food value chain and this plays out across many of its subsectors. In fact, in 2012, 7 of 18 food subsectors have a specialized concentration of employment in the region. Among these 5 are considered "current strengths" with strong growth in the two largest subsectors – animal processing (up 3.3 percent) and food wholesale (up 6 percent), both outpaced the nation over the last 3 years of economic recovery. Nuts and snacks, seafood processing, and animal feed are also specialized and growing more rapidly (though off of a smaller jobs base). The bakery subsector is emerging across the region with 9 percent job growth over 3 years.

Food value chain strengths in the Mountain region are largely driven by the three largest regional subsectors – animal processing, food wholesale, and beverages. Animal processing is highly specialized with more than 3,500 regional jobs and a LQ of 2.62. Regional firms have increased jobs by 24 percent or nearly 700 jobs in just 3 years. Food wholesale, while just under the specialization threshold (LQ is 1.12), is a large and growing Mountain region subsector, with growth of 20 percent since 2009. With the rise in craft brewing, the region now employs more than 600 in beverage manufacturing for a regional LQ of 1.17. Jobs in the subsector are up 27 percent over 3 years and the beverage wholesale subsector is thriving as well.

North Carolina's Agricultural Production, an Overview

North Carolina has a rich history in agricultural production and forestry. Farm and broad economic prosperity during and just after World War II led to the largest number of farm operations in the state's history. Since that peak around 1950, that figure has steadily and sharply dropped (see Figure 12), along with acreage farmed. In 1950, there were 301,000 North Carolina farms, today that figure is 50,000. As has been the case nationally, increased productivity on farms has led to smaller amounts of land, and workers needed to produce similar yields.

In J. Paul Lilly's summary of the "Agricultural History of North Carolina," the NC State University Professor Emeritus cites two important, relatively recent, shifts in North Carolina agriculture[10]:

- Animal agriculture replaced crops as the leading source of farm income
- A shift in agricultural production within the state from West to East.

[10] Lilly, J. Paul, "Agricultural History of North Carolina," available online at: http://www.ncagr.gov/stats/general/history.htm.

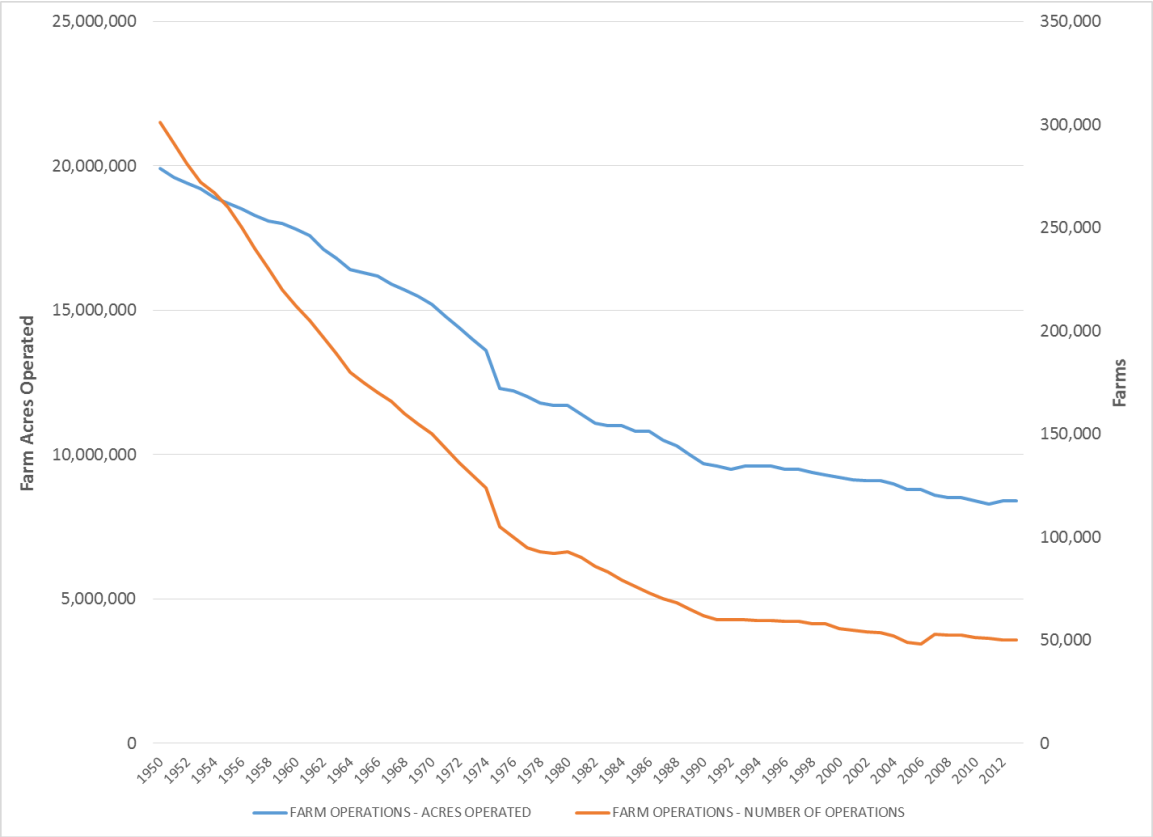


Figure 12. Farms and Farm Acreage Operating in North Carolina, 1950–2013.

In selling $12.6 billion in total agricultural goods in 2012, North Carolina ranks 8th among all states in its agricultural production market value. Two-thirds of this value is represented in livestock, poultry, and related animal products receipts, the remaining 34 percent is the market value of crops (see Figure 13 and Table 6). Animal production is led by the $4.8 billion in poultry and eggs sold in 2012, ranking North Carolina 1st among all states in value; and sales of $2.9 billion in hogs and pigs (2nd nationally). Crop production receipts were highest among grains, oilseeds, dry beans, and peas ($1.8 billion); tobacco ($732 million); nursery and greenhouse products ($580 million); vegetables, melons, potatoes and sweet potatoes ($435 million). North Carolina is among the national leaders in tobacco (1st), cut Christmas trees (2nd), and cotton (5th).

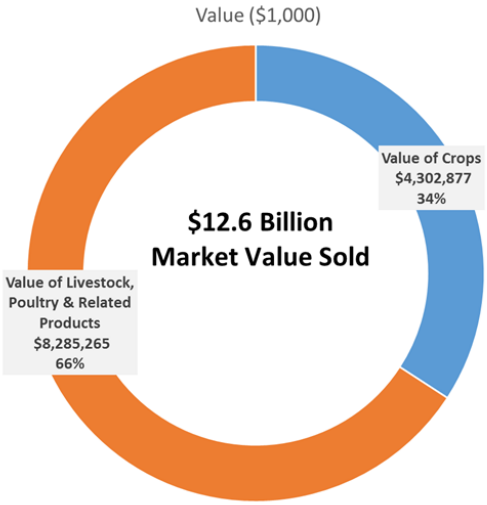


Figure 13. Market Value of North Carolina Agricultural Products Sold, 2012 (dollars in thousands).

Table 6. Value of North Carolina Sales by Commodity Group (dollars in thousands), 2012.

Commodity Group	Market Value Sold ($1,000)	U.S. Ranking
Poultry and eggs	$4,837,026	1
Hogs and pigs	$2,873,988	2
Grains, oilseeds, dry beans, and dry peas	$1,774,127	18
Tobacco	$732,772	1
Nursery, greenhouse, floriculture and sod	$580,230	7
Vegetables, melons, potatoes and sweet potatoes	$434,974	10
Cotton and cottonseed	$403,366	5
Cattle and calves	$332,733	34
Other crops and hay	$225,162	26
Milk from cows	$179,265	29
Fruit, tree nuts, and berries	$85,150	17
Cut Christmas trees and short rotation woody crops	$67,097	2
Horses, ponies, mules, burros, and donkeys	$23,548	17
Aquaculture	$23,365	16
Other animals and other animal products	$8,089	33
Sheep, goats, wool, mohair, and milk	$7,251	31

Source: USDA, Census of Agriculture.

Crop acreage in North Carolina is tilted toward grain and bean production, however, this does not reflect the importance to the state and nation of key food crops for which North Carolina is among the national leaders. Specifically, these include sweet potatoes, peanuts, and cucumbers (particularly for pickling) as well as a strong position in other fruits and vegetables (see Table 7).

- North Carolina is the nation's top producer of sweet potatoes with only California close in production. North Carolina's 2012 production was valued at $161 million, representing 37 percent of all U.S. production value.
- The value of North Carolina's peanut production in 2012 was $148 million or 7 percent of the national total.
- The state is a major producer of cucumbers, both processed (for pickles) as well as fresh market. In processed cucumbers, North Carolina's $12 million in production value was 3rd among states representing 8 percent of national production value (well behind Florida and Michigan). In fresh market cucumbers, the state produced nearly $14 million in value or 7 percent, with a ranking in market value of 7th. The Mt. Olive Pickle Company, in Mt. Olive, has a rich history and has grown over time to become the largest independent pickle company in the nation as well as the 2nd largest pickle brand (in sales) in the country. Annually, the company produces 110 million jars of pickles, pickle relishes, and peppers. Its production facilities are huge, operating on 110 acres of land and within 675,000 square feet of production, warehouse, and office space. Mt. Olive has leveraged research partnerships with NC State University in and around food sciences, horticulture, and engineering research.

Table 7. Production Value of North Carolina's Top Food Crops, 2012.

Food Crop	NC Production Value, 2012	NC Share of Nat'l Production Value	NC Ranking
Sweet Potatoes	$161,200,000	37%	1
Peanuts	$148,231,000	7%	5
Tomatoes, Fresh Market	$37,019,000	4%	5
Watermelon	$23,520,000	5%	7
Strawberries	$23,490,000	1%	3
Bell Peppers	$19,778,000	4%	6
Squash	$15,660,000	7%	6
Cucumbers, Fresh Market	$13,634,000	7%	7
Cucumbers, Processed for Pickles	$12,322,000	8%	3

Source: USDA, National Agricultural Statistics Service, Annual Survey.

North Carolina is a national leader in turkey, hog, and chicken (broilers) production and a major egg producing state (see Table 8). The state is the top producer of turkeys with more than 54 million sold in 2012 representing nearly 20 percent of all turkeys sold nationwide. The state's vertically integrated supply chain for turkeys includes Butterball, the largest producer of turkey products in the nation, located in Garner, just outside of Raleigh. The company's largest processing plant, at 675,000 square feet, is located in Mt. Olive, North Carolina. Additional processing takes place in three other states and combined, Butterball produces more than 1 billion pounds of turkey products each year.

Table 8. Production of North Carolina Livestock, Poultry, and Eggs, 2012.

Livestock, Poultry & Eggs	NC Production, 2012	NC Share of Nat'l Production	NC Ranking
Turkeys (Sales, Head)	54,109,724	19%	1
Hogs (Value of Production)	$2,553,214,000	13%	2
Chickens – Broilers (Sales, Head)	801,883,037	9%	4
Eggs (Count)	3,087,000,000	3%	9

Source: USDA, National Agricultural Statistics Service, Annual Survey and USDA Agricultural Census.

Hog and pig production is another area of national leadership from North Carolina's agricultural production sector – in 2012 state-based production was valued at more than $2.5 billion or 13 percent of the U.S. This places North Carolina 2nd among states, only behind Iowa in hogs. Smithfield Foods, headquartered in Smithfield, Virginia, is the nation's largest pork producer and processor; and while the company is headquartered out of state, it operates the world's largest slaughterhouse and processing plant in Tar Heel, North Carolina. Smithfield produces a large array of packaged meats under familiar brand names including: Smithfield, Eckrich, Farmland, Armour, Cook's, Gwaltney, John Morrell, Kretschmar, Curly's, Carando, Margherita and Healthy Ones. The company is vertically integrated to control its supply chain from conception through to packing with significant operations along this chain based in North Carolina.

North Carolina is 4th among all states in chicken broiler production. Case Farms Chicken is a vertically integrated farming and processing company with multiple state locations in Goldsboro, Morganton, and Troutman that include hatcheries, processing plants, a genetics office, and business and financial operations. The company produces 2.8 million chickens per week and produces more than 900 million pounds of product each year that span fresh, partially cooked, and frozen for export. Case Farms is adding value with a whole range of chicken-based products including breaded items (fillets, wings, tenders) as well as chicken nuggets and patties.

From a regional perspective, North Carolina's agricultural production is primarily concentrated in the Eastern part of the state, the Coastal Region. As indicated in Table 9, the region accounts for nearly two-thirds of total dollar receipts from farming – $7.8 billion in receipts in 2012. This regional share remains consistent at 64 percent across the two major components of livestock and crops. The Piedmont yields one-quarter of the state's farming receipts, accounting for a slightly higher share in livestock (27 percent). In Western North Carolina, the Mountains region brings in 6 percent of all receipts.

Table 9. Summary of Total Farm Cash Receipts by NC Region, 2012.

State & Regions	Total Farm Cash Receipts		Livestock Receipts		Crop Receipts	
	Total ($ thousands)	Share	Total ($ thousands)	Share	Total ($ thousands)	Share
North Carolina, Total	**$12,144,547**	**100%**	**$7,350,185**	**100%**	**$4,356,417**	**100%**
Coastal Plains	$7,795,213	64%	$4,690,077	64%	$2,789,702	64%
Piedmont	$3,016,840	25%	$1,981,839	27%	$922,966	21%
Mountains	$768,480	6%	$451,280	6%	$306,732	7%

Source: North Carolina Department of Agriculture & Consumer Services, Agricultural Statistics – 2013 Annual Statistics Book.

*Notes: Total farm cash receipts includes government payments. Regional shares will not sum to 100 percent due to rounding and inclusion of some unpublished county detail to avoid disclosure of individual farming operations.

North Carolina does have distinct regional specializations that stand out. For example, hog production is located primarily within the Coastal Plains region while dairy production is located in the Piedmont region. Poultry and egg production can be found within both the Coastal Plains and the Piedmont regions. The vast majority of the vegetables, including sweet potatoes, fruits, and nuts are produced in the Coastal Plains region. The Piedmont Region produces other field crops, while both the Piedmont and Mountains regions produce a significant share of greenhouse and nursery products, including Christmas trees. Agricultural production highlights across North Carolina's three regions are summarized in Table 10.

North Carolina plays a major agricultural role in the production of a diverse set of crops and livestock that contribute significantly to feeding the U.S. and increasingly global population. The state has long faced challenges in production agriculture in its quality of soil and topography, and the economics and opportunities of tobacco and cotton and other land development have come at the expense of producing more food-related commodities. That said, the state continues to play a major role within the U.S., particularly in its leading or top-tier position in turkeys, hogs, chickens, and sweet potatoes.

Table 10. Leading Food-Related Commodity Production by NC Region.

Food-Related Commodity Groups	Mountains	Piedmont	Coastal Plains
Livestock, Poultry, & Eggs	6 percent of State Receipts Key Production Areas: • n/a	27 percent of State Receipts Key Production Areas: • Broilers • Eggs • Dairy	64 percent of State Receipts Key Production Areas: • Hogs • Turkeys • Broilers • Eggs
Crops	7 percent of State Receipts Key Production Areas: • Other Field Crops • Greenhouse & Nursery**	21 percent of State Receipts Key Production Areas: • Other Field Crops • Greenhouse & Nursery**	64 percent of State Receipts Key Production Areas: • Vegetables, Fruit, Nuts & Berries • Other Field Crops – Soybeans – Corn – Peanuts – Wheat

Source: North Carolina Department of Agriculture & Consumer Services, Agricultural Statistics – 2013 Annual Statistics Book.

* Total farm cash receipts includes government payments. Regional shares will not sum to 100 percent due to rounding and inclusion of some unpublished county detail to avoid disclosure of individual farming operations.

** Includes Christmas trees.

Summary

Key Findings from this economic analysis include:

- North Carolina's food "value chain" is large with a few key strengths. The state sector, however, has shed jobs in recent years, particularly among its largest components.
- The sector is truly statewide, with distinct regional specializations that stand out, though the recent performance among North Carolina regions varies.
- North Carolina is competing nationally and globally as a leader in animal processing and packaging, two highly specialized state subsectors; additionally, the state is emerging in a number of other high-value food-related sectors including beverages, nuts and snacks, and animal feed.
- North Carolina has visible gaps in its food value chain that could limit the growth potential for existing and emerging companies, or for companies interested in locating in the state, namely its significant under-concentration in key wholesale and distribution areas in agricultural products and food-related warehousing and storage.
- In discussions and interviews with North Carolina food processors and other stakeholders, there is a consistent concern raised regarding a gap in the presence and availability of "intermediate" food processors.
- North Carolina's food value chain is out-performing the U.S. sector at-large in the productivity of its workforce as measured by value-added per worker. This signals the competitive nature of

state companies within the industry and when combined with generally lower labor costs/wages makes North Carolina attractive to companies interested in locating here.

- Industry innovation in North Carolina's food sector, to be further detailed in the next section of the report, indicates limited innovation activity in the form of patents, with some patenting in packaging and meat processing technologies.

North Carolina's large, well concentrated, and highly productive food value chain is well positioned to compete now and into the future. There are opportunities to take the sector to the next level and to compete both nationally and globally among and across a whole range of agricultural and value-added food products and increasingly, into beer, wine, and other beverages. Indications from the data presented here, as well as from the perspectives of North Carolina food manufacturers are that there are gaps to be addressed to help the industry reach a more significant scale. These gaps will require targeted investments, programs, and initiatives to catalyze activities and move the state forward.

Chapter 3: North Carolina's Food-Related Innovation

To provide a comprehensive examination of the importance of the food industry to North Carolina, it is worth noting the research and innovation mechanisms that both drive and support the industry in the state. Understanding the areas in which food-related research and innovation are occurring provides context to this overall study of the state's food industry.

Research activities within the university infrastructure can be captured to some extent by examining recent publication activities in peer reviewed journals as well as food-related research awards from the USDA. Innovation within the "food" industry is more difficult to ascertain but to some degree is apparent in both private sector and public university-based patent activity (both patents awarded and pending applications).

It is important to note that North Carolina's research institutions carry out significant, and often more "basic" research related to animal physiology and health, veterinary science, general plant biology or agriculture. However, this assessment was purposeful in its focus on the "food-related" research and innovation mechanisms within the state of North Carolina. To the extent possible, this analysis focused on innovations specifically related to "food" (versus agriculture, plant or animal sciences) such as food science, food processing, and food safety. Beyond these areas, the analysis also attempted to bring to light research leading to the enhancement of food properties (e.g., texture, flavor) or nutritional characteristics of a food item, plant, or animal. Therefore, if research and innovation in the state did not incorporate, to at least some degree, a "food" context, the publications or patents were not included in the analysis. For example, if a research publication presented findings regarding the nutrition properties of soybeans it was included; an article or patent discussing general plant characteristics of a new soybean variety would be excluded. Similarly, if research was reported on swine breeding without a direct link or discussion to "food" it would also be excluded from the analysis.

Research Publications

A key indicator of areas of research competency and strength is the publication of research articles within peer-reviewed journals – disciplines and research topics with larger numbers of research publications indicate areas where significant levels of research is occurring.

The involvement by North Carolina's research institutions in food-related research and innovation can be examined in part by assessing the journals in which the state's researchers publish their findings. Using both specific food-related disciplines as well as key words, at total of 898 recent (January 2009 through September 2014) publications (peer reviewed journal articles) were identified in the food and nutrition context.[11] Table 11 identifies these research articles by North Carolina institution. The overall size of NC State's efforts can be seen in that NC State accounts for more than half of the state's research publications. Yet, other institutions in the state also contribute to the overall food-related research activities.

[11] Outside of the key Food Science/Nutrition discipline articles were included that described research related to the food property enhancement, food processing, and nutritional characteristics of a food item, plant, or animal. General plant biology or agriculture articles were not included in this analysis. For example, if an article presented research findings regarding the nutrition properties of soybeans it was included. If the article discussed general plant characteristics of a soybean plant it was excluded.

Examining the food-related disciplines provides some initial perspectives on the state's food-related research capacity. Table 12 provides the core discipline context of the 898 research publications. Of these, more than 80 percent are found within the core Food Science/Nutrition discipline.

However, as shown in Table 13, the Food Science/Nutrition discipline accounts for under 1 percent of ***all*** North Carolina research publications.[12] Most importantly Table 13 also shows that North Carolina is a Top 10 performer of food science and nutrition research accounting for over 5 percent of the total U.S. publications in this discipline.

Table 11. North Carolina Research Publications by Institution.

Key North Carolina Institutions	Number of Key NC Food-Related Articles
NC State University	460
University of North Carolina	196
North Carolina A&T State University	60
Duke University	53
Wake Forest University	38
East Carolina University	32
Appalachian State University	10
Other North Carolina Public and Private Research Organizations (including companies)	67

Source: Thomson Reuters Current Contents Connect Database; Battelle analysis.

Note: Data will not sum to 898 as some articles have authors from two or more North Carolina institutions.

Table 12. North Carolina Research Publications by Discipline.

Research Discipline	Number of Key NC Food-Related Articles
Food Science/Nutrition	733
Agricultural Chemistry	31
Agriculture/Agronomy	4
Animal Sciences	66
Biochemistry	3
Biology	14
Biotechnology	3
Cell & Developmental Biology	1
Environment/Ecology	6
Medical Research, General Topics	1
Plant Sciences	3
Veterinary Medicine/Animal Health	33
Total, Food-Related Research Publications	**898**

Source: Thomson Reuters Current Contents Connect Database; Battelle analysis.

[12] Comparatively, the Psychology discipline accounts for more than 4 percent of North Carolina's research publications and Physics accounts for more than 2 percent.

Table 13. Comparative Performance in Recent Food Science/Nutrition (FS/N) Research Publications.

State	State Share of U.S. FS/N Discipline	FS/N Discipline Share of State Total Research Articles	State Share of Total U.S. Research Articles
California	10.1%	0.4%	18.1%
New York	7.8%	0.6%	11.2%
Massachusetts	7.5%	0.6%	10.3%
Texas	6.8%	0.6%	8.4%
Pennsylvania	6.7%	0.7%	7.6%
Illinois	5.7%	0.7%	6.2%
Georgia	5.6%	1.2%	3.9%
North Carolina	5.3%	0.8%	5.1%
Washington	5.2%	0.8%	5.1%
Ohio	4.7%	0.7%	5.2%
Minnesota	4.3%	1.1%	3.1%
Michigan	4.0%	0.7%	4.8%
Wisconsin	4.0%	1.2%	2.6%
Florida	3.8%	0.6%	4.8%
Iowa	2.9%	1.4%	1.6%

Source: Thomson Reuters Current Contents Connect Database; Battelle analysis.

Examining the food and nutrition-related journal titles provides further insights into the specific areas of strength within North Carolina's research capacity. Table 14 shows those journal titles in which North Carolina researchers have published eight or more articles in the 2009–2014 period. A strong focus in nutrition-related research is readily apparent in the wide variety of nutrition-oriented journals included and accounts for more than 30 percent of the total food and nutrition-related articles. Core "animals for food" science research (e.g., dairy, food, and poultry sciences) is also seen in more than 20 percent of the articles. Looking at some of the journals with smaller numbers of articles also shows some unique aspects of North Carolina's food-related research. At a smaller scale, food-related chemistry and toxicology and food safety and protection each account for at least 10 percent of the total articles, with other unique areas including medicinal food, sensory/texture research, and food-related engineering and technology.

Table 14. North Carolina Research Publications by Journal Title.

Key Journal Titles (with more than five publications)	Number of Key NC Food-Related Articles
Journal of Nutrition	86
Journal of Dairy Science	77
Journal of Food Science	54
Journal of Nutrition Education and Behavior	40
Journal of The American Dietetic Association	36
Journal of The Academy of Nutrition and Dietetics	33
Public Health Nutrition	32
Food and Chemical Toxicology	31
Journal of Agricultural and Food Chemistry	30
Journal of Food Protection	28
Poultry Science	26
Food Chemistry	25
Foodborne Pathogens and Disease	24
British Journal of Nutrition	23
Journal of Sensory Studies	18
Avian Diseases	17
Journal of Medicinal Food	15
Journal of Applied Poultry Research	15
Food Hydrocolloids	13
Applied and Environmental Microbiology	13
Journal of Nutritional Biochemistry	12
Journal of Animal Science	11
Molecular Nutrition & Food Research	11
International Dairy Journal	10
Journal of Food Engineering	9
Journal of Food Agriculture & Environment	9
Natural Product Communications	9
International Journal of Food Science and Technology	9
International Journal of Food Microbiology	8
Milchwissenschaft-Milk Science International	8

Source: Thomson Reuters Current Contents Connect Database; Battelle analysis.

Patents and Applications

A key mechanism to examine the link between research and innovation is to examine recently issued patents and recent patent applications (January 2009 through September 2014). During this period, the analysis identified 70 awarded patents and an additional 111 pending applications in food-related areas or 181 total food-related patents and applications.[13] Patent activities are unique in that the geography of the patent can be defined by either the location of the actual inventor(s) or by the location of the organization (e.g., company or university) that is assigned or "owns" the patent.

[13] Given the vagaries of patent classifications, it is likely a small number of patents or applications may have been missed through our classification and key word-based searches.

Table 15 provides information on key food-related patent assignees tied to North Carolina. Tipper Tie, Inc. with 66 recent patents and applications accounts for more than one third of the total (181) recent patent-related activity. However, beyond Tipper Tie and the other organizations shown in Table 15, the level of food-related innovation in North Carolina, as reflected by patent activity, is fairly limited with many companies and individuals with one or two patents. NC State's involvement in food-related innovation is shown through a total of nine recent patents and applications. Aseptia, Inc. (Wright Foods), an aseptic food processing/packaging company, is currently the second largest North Carolina company in terms of patent activity. In fact, two of the patents assigned to NC State were invented by the faculty member co-founder of Aseptia.

Table 15. North Carolina Connected Food-Related Patents and Applications.

Assignees (with three or more patents or applications)	Patents	Applications	Total
North Carolina-Located Assignees (with or without NC inventor)			
Tipper Tie Inc., Apex	56	10	66
NC State University, Raleigh	5	4	9
Aseptia Inc., Raleigh	2	3	5
Chiquita Brands, Charlotte		4	4
Carrier Commercial Refrigeration, Charlotte	2	1	3
Novozymes North America Inc., Franklinton	2	1	3
Non-North Carolina-Located Assignees (with NC inventor)			
Michael Foods Inc., Minnetonka, MN	6		6
Innovative Cereal System LLC, Wilsonville, OR	5		5

Source: Thomson Reuters Thomson Innovation Patent Analysis database; Battelle analysis.

Table 16 provides more perspective on the types of food-related innovation activities occurring in North Carolina. Nearly 60 percent of the patent-related activity is processing and packaging related – including packaging machinery, processing for meat and poultry, containers, or other processing-related equipment. Most of the Tipper Tie patents fall into these IPC classifications. Preservation innovations account for more than 20 percent and specific food products account for more than 10 percent of the food-related patent activity.

Table 16. North Carolina Connected Food-Related Patents and Applications.

IPC Symbol	IPC Description (IPC Classes with 2 or more patents/applications)	Patent Award	Patent Application	Grand Total
B65B	MACHINES, APPARATUS OR DEVICES FOR, OR METHODS OF, PACKAGING ARTICLES OR MATERIALS	29	14	43
A23L	FOODS, FOODSTUFFS, OR NON-ALCOHOLIC BEVERAGES, NOT COVERED ELSEWHERE; THEIR PREPARATION OR TREATMENT, e.g. COOKING, MODIFICATION OF NUTRITIVE QUALITIES, PHYSICAL TREATMENT, PRESERVATION	15	14	29
A22C	PROCESSING MEAT, POULTRY, OR FISH	20		20
B65D	CONTAINERS FOR STORAGE OR TRANSPORT OF ARTICLES OR MATERIALS; PACKAGING ELEMENTS; PACKAGES	5	4	9
A47J	KITCHEN EQUIPMENT; COFFEE MILLS; SPICE MILLS; APPARATUS FOR MAKING BEVERAGES	4	4	8

IPC Symbol	IPC Description (IPC Classes with 2 or more patents/applications)	Patent Award	Patent Application	Grand Total
A61K	PREPARATIONS FOR MEDICAL PURPOSES		6	6
A21D	TREATMENT, e.g. PRESERVATION, OF FLOUR OR DOUGH FOR BAKING, e.g. BY ADDITION OF MATERIALS; BAKING; BAKERY PRODUCTS; PRESERVATION THEREOF	5		5
A23G	COCOA; COCOA PRODUCTSSUBSTITUTES FOR COCOA; CONFECTIONERY; CHEWING GUM; ICE-CREAM; PREPARATION	1	4	5
A23B	PRESERVING, e.g. BY CANNING, MEAT, FISH, EGGS, FRUIT, VEGETABLES, EDIBLE SEEDS; CHEMICAL RIPENING OF FRUIT OR VEGETABLES; THE PRESERVED, RIPENED, OR CANNED PRODUCTS	1	3	4
G06F	ELECTRIC DIGITAL DATA PROCESSING	4		4
A22B	SLAUGHTERING	2	1	3
A23K	FEEDING-STUFFS SPECIALLY ADAPTED FOR ANIMALS;	2	1	3
B65G	TRANSPORT OR STORAGE DEVICES, e.g. CONVEYORS FOR LOADING OR TIPPING	3		3
H05B	ELECTRIC HEATING; ELECTRIC LIGHTING NOT OTHERWISE PROVIDED FOR	3		3
A23C	DAIRY PRODUCTS, e.g. MILK, BUTTER, CHEESE; MILK OR CHEESE SUBSTITUTES; MAKING THEREOF	2		2
A23F	COFFEE; TEA; THEIR SUBSTITUTES; MANUFACTURE, PREPARATION, OR INFUSION THEREOF	2		2

Source: Thomson Reuters Thomson Innovation Patent Analysis database; Battelle analysis.

USDA Food Related Research Grants

To further augment the examination of the food and nutrition-related research and innovation context in North Carolina, recent (January 2009 through September 2014) competitive awards from the USDA were also examined (Table 17).[14] The universities use these funds to develop and further augment the resources used for their on-going research efforts. Additionally, two companies – Farmhand Foods and Wiser Systems – received USDA Small Business Innovative Research (SBIR) grants. Farmhand Foods received both a Phase I and Phase II award for the development of a regional food hub that aggregates, markets, and distributes local meats. Wiser Systems also received Phase I and II awards to develop RFIDs for affordable, item-level tracking of critical foodstuffs that require specialized packing and handling techniques and environments (e.g., controlled temperature, humidity, air circulation).

[14] These awards are distinct from the on-going agriculture and food-related efforts from the NC State's ag extension and experiment station or USDA specific efforts through their Agricultural Research Service presence in North Carolina.

Table 17. Recent USDA Food Related Research Grants to North Carolina.

North Carolina Universities	Grants	Reported Funding
NC State University	23	$9,960,747
North Carolina A&T State University	10	$3,018,538
University of North Carolina	2	$648,539
North Carolina Central University	2	$647,723
Duke University	1	$500,000
Fayetteville State University	1	$366,519
Appalachian State University	1	$140,090
North Carolina Companies (SBIR Awards)	**Grants**	**Amount**
Wiser Systems	2	$550,000
Firsthand Foods	2	$476,860

Source: USDA CRIS database with costs as reported; Battelle analysis.

Research and Innovation Themes

To better "connect the dots" between North Carolina's research publications, patents, and research grants, Battelle employed the OmniViz™ textual pattern recognition and clustering software system to provide detailed quantitative analysis regarding research and innovation strength areas. OmniViz™, originally developed by Battelle, uses pattern recognition algorithms to cluster textual information from research and innovation records into grouped strength areas or "themes". This analysis is particularly valuable because it allows free association of words and phrases, rather than forcing clustering on preselected key words – thus, there is no a priori bias to the clusters identified.

Battelle performed the analysis using the publication, patent and USDA research grant records described above. A total of 1,123 data points were incorporated in the analysis. The performance of the clustering analysis involves the following steps:

- **Step 1 – Content Development**: Developing a data set with sufficient descriptive content (publication, patent/patent application, and research grant records including titles, abstracts, and additional textual material if available).
- **Step 2 – Pattern Recognition**: The analysis generates clusters where grant activities have apparent relationships and produces a series of words to describe and link these cluster areas.
- **Step 3 – Interpretation and Grouping by Battelle**: The identification of key themes and groupings that result from OmniViz™ require analytical expertise to interpret and explain the types of technologies and specific activities that are represented in the cluster items.

OmniViz™ output is provided in graphical form (Figure 14) with related data. This allows for visualization of key cluster areas and deeper investigation of the actual publications, patent or grant information contained within each apparent cluster.

As shown in Figure 14 and detailed in Table 18, the OmniViz™ analysis identified 40 distinct clusters of food and nutrition-related activity by North Carolina researchers, inventors, universities, and companies. These clusters range in size from a high of 142 records in "nutritional composition" to the smallest cluster

with just one unique record in "fortified cereals".[15] These 40 clusters are then further associated and interpreted by Battelle into eight ***metaclusters*** (or groupings of related clusters) which reflect important themes within the North Carolina data.

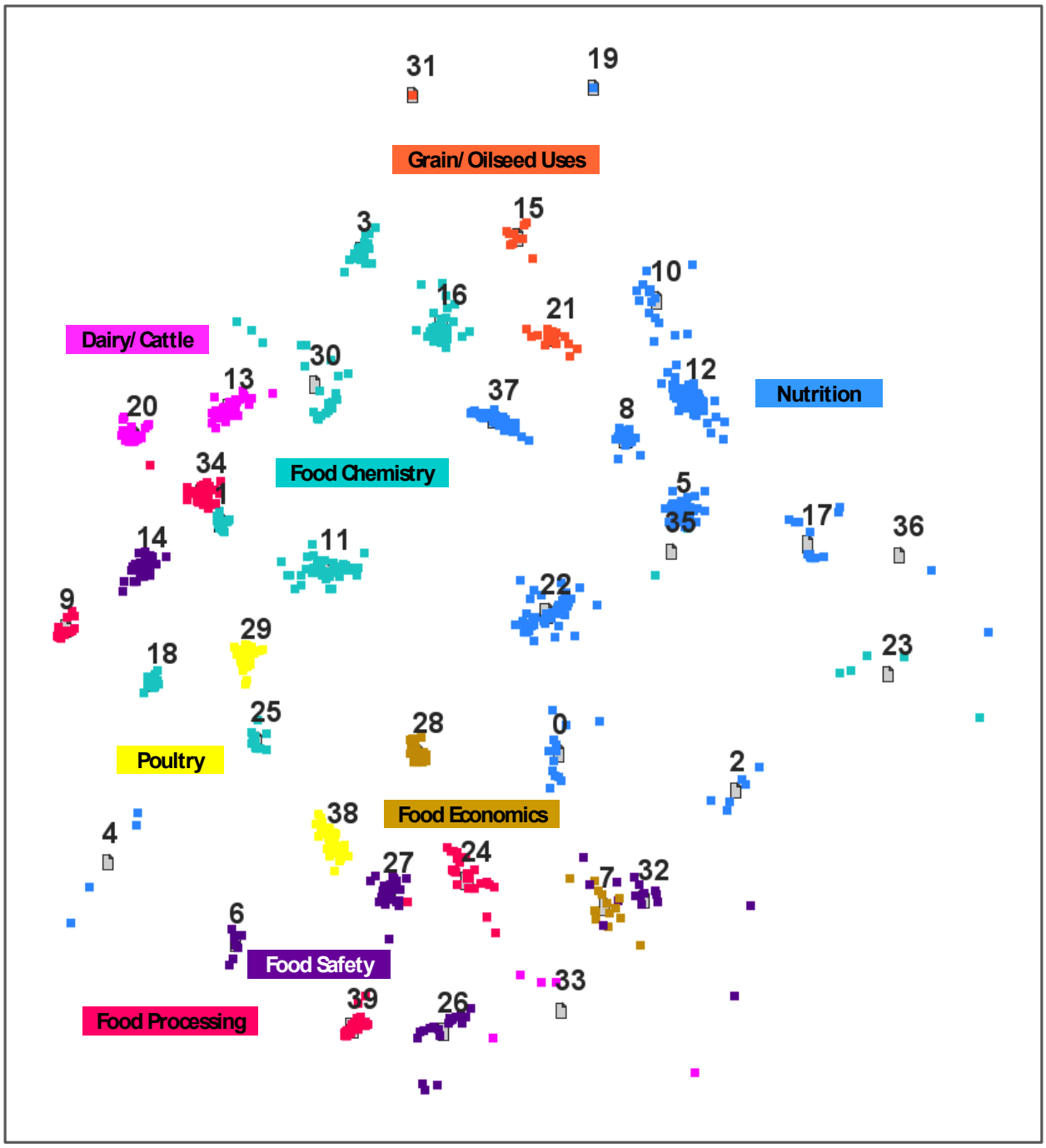


Figure 14. OmniViz Cluster of North Carolina Food-Related Research and Innovation.

[15] Appendix B provides additional information on these clusters consisting of the key words upon which each cluster is built.

Table 18. OmniViz Cluster of North Carolina Food-Related Research and Innovation.

Meta Cluster (Total Records)	Cluster Number	Cluster Name	Total Records	Publica-tions	Patent Awards	Patent Applica-tions	USDA CRIS-Food Related
Dairy/Cattle (82)	13	Milk Production	42	41	1		
	20	Dairy Cattle	35	35			
	33	Animal Health – Dairy	5	5			
Food Economics	7	Market/Consumer	14	11			3
	28	Sustainable Agriculture	23	10			13
Food Processing (160)	9	Fermentation/Pickling	15	15			
	24	Preparation	36	1	19	16	
	34	Meat/Poultry Processing	34	15	16	1	2
	39	Packaging	75	2	52	21	
Grain/Oilseed Uses (36)	15	Corn	10	10			
	21	Oil/Soybeans	25	22	1	2	
	31	Sorghum	1	1			
Food Chemistry (217)	1	Whey	42	39	3		
	3	Antioxidants	33	31		1	1
	11	Sensory – Flavor	43	41		2	
	16	Extracts	29	26		3	
	18	Whey Protein	26	22	3	1	
	23	Vitamins	5	4		1	
	25	Sensory – Texture	14	13			1
	30	Peanut Allergens	23	21	1		1
	35	Supplements	2	2			
Food Safety (124)	6	Foodborne Illness	9	9			
	14	Bacteriology	46	42		1	3
	26	Listeria	21	20			1
	27	Pathogen Strains	32	31			1
	32	Toxicology	16	16			
Nutrition (367)	0	Behavior	13	13			
	2	Inflammation	6	6			
	4	Dietetic Standards	4	4			
	5	Obesity	50	49			1
	8	Diabetes-Related	30	29			1
	10	Infant Nutrition	14	14			
	12	Nutritional Composition	142	123	4	5	10
	17	Metabolism	11	11			
	19	Fortified Cereals	1	1			
	22	Fruits & Vegetables	50	41		6	3
	36	Women's Nutrition	4	3	1		
	37	Beverage Consumption	42	25	8	9	
Poultry (100)	29	Farming/Production	59	53	2	1	3
	38	Animal Health – Poultry	41	41			
	Totals	**40 Clusters**	**1,123**	**898**	**111**	**70**	**44**

The eight metaclusters (or themes) can be generally described as:

- ***Dairy/Cattle*** – A research driven theme focused on milk production and the production and health characteristics of dairy cattle.
- ***Food Economics*** – A research driven theme focused on two principal dimensions: consumer preference and sustainable agriculture, both of which received USDA research support.
- ***Food Processing*** – An innovation driven theme (including the most patent-related activity of any metacluster). The third largest metacluster in the analysis is divided into four key processing areas primarily by technologies: packaging, preparation, meat/poultry processing, and fermentation/pickling.
- ***Grain/Oilseed Uses*** – A small research driven theme built around grain (corn) and oilseed (soybeans) processing and their uses.
- ***Food Chemistry*** – A research driven theme that is the second largest among the eight metaclusters. Primarily based upon the chemical and analytical analysis of food and food components.
- ***Food Safety*** – A research driven theme combining both broader outbreak and response research with specific food safety-related bacteriology and toxicology.
- ***Nutrition*** – The largest theme grouping together research linking food and nutrition to specific biomedical conditions, consumption and diet outcomes, and distinct subpopulations (e.g., infants, women). Supported in part through USDA research funding.
- ***Poultry*** – A research driven theme focused on poultry production and health characteristics.

Chapter 4: Catalyzing the Growth of Value-Added Food Manufacturing in North Carolina

For economic growth to occur within the value-added food manufacturing industrial sector of North Carolina, an entire interconnected sequence of positive factors, or what Battelle terms innovation ecosystem, has to be in place that connects and strengthens the drivers of innovation and industry development. If links in the innovation chain either inadequately address economic needs or are missing altogether, a sustainable value-added food manufacturing cluster able to generate quality jobs is unlikely to develop (see Figure 15). It is also important to note that needs vary greatly based on the stage a company has reached in its life cycle (start-up, small, medium, or large company).

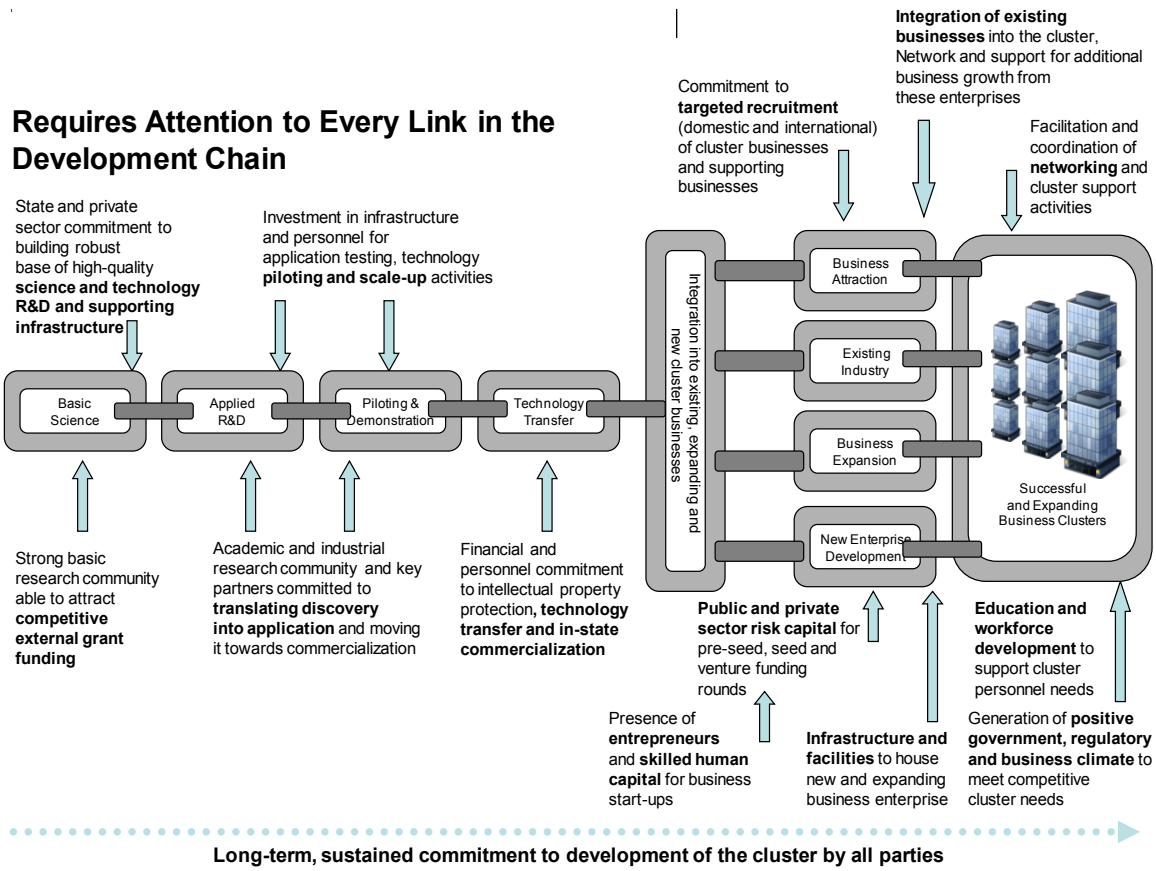


Figure 15. Value-Added Food Processing/Manufacturing Innovation Ecosystem.

Critical components of such an innovation ecosystem include developing programmatic initiatives that:

- Accelerate the commercialization of innovative technologies.
- Foster value-add private sector/academic collaborations that focus on interdisciplinary, applied research that solve key food value chain needs.
- Provide in-depth support at all stages of the enterprise creation and business launch cycle.

- Offer an integrated system for multi-use facilities and shared-use equipment targeted to scaling value-added food processing and manufacturing companies.
- Create global comparative advantage as a result of the mutual proximity, connections, and shared specialized infrastructure, labor markets and services.

The following narrative organizes the current situation facing North Carolina's value-added food manufacturing innovation ecosystem into two categories:

- Opportunities for growth related to the industry's business model
- Opportunities for growth related to the industry's areas of innovation.

It is important to note that these two areas are not independent of one another, but in fact the success of catalytic initiatives in one component of the innovation ecosystem is strongly correlated to the success of catalytic initiatives in the second component of the innovation ecosystem.

North Carolina's Food-Related Business Model/Value Supply Chain Areas for Development and Growth

Food-Related Business Model/Value Supply Chain Drivers

The value of having an industrial sector that is highly concentrated is that it spurs growth and competitive advantage within a state. Typical economic gains are substantial, including:

- Rising productivity of companies in the value chain, creating a competitive advantage for the state
- Accelerating pace of innovation resulting in new products and services
- More frequent start-up of new, high-growth-potential businesses
- Stronger supplier networks, increasing the economic multiplier impact of the value-chain for the state
- Larger pools of specialized workers and education and training programs geared to the particular industrial needs, introducing significant cost savings for firms and increasing the breadth and depth of employment opportunities for workers in the supply chain.

The economic analysis discussed in detail in Chapter 2 indicates that North Carolina enjoys a food processing and manufacturing industrial base that is both large and well concentrated with a few key strengths. Furthermore, the sector is truly statewide, with distinct regional specializations that stand out. The industry sector, however, has shed jobs in recent years, particularly among its largest components, and recent performance among North Carolina regions varies.

This quantitative overview of North Carolina's food-related industrial base needs to be further supplemented by a micro analysis of specific barriers within the food-related business model/value supply chain to better understand factors that are hindering the industry sector's further development, as well as the identification of opportunities that could catalyze growth. To this end, the Battelle TPP project team examined a series of data sources and conducted numerous qualitative interviews in order to identify areas for development and growth.

As a result of the analysis, four food-related business model/value supply chain drivers were identified as critical to the continued development of North Carolina's value-added food processing and manufacturing sector:

- Capturing added-value from North Carolina's agricultural commodities through the development of innovative food products and processing technologies
- Fostering the growth of food processing and manufacturing entrepreneurial endeavors
- Proactively targeting site selection attraction opportunities within the food processing and manufacturing supply chain
- Providing regulatory training and outreach to the food processing and manufacturing sector.

A description of each of these key food-related business model/value supply chain drivers can be found in the narrative that follows.

Capturing Added-Value from North Carolina's Agricultural Commodities

Worldwide agricultural commodity markets are highly competitive and price driven. As a result, even though national agricultural productivity continues to increase, the real value of that production at "the farm gate" continues to decline. The future of agricultural and rural sustainability in North Carolina will very much depend on the ability to construct "value-added" chains of production that vertically integrate the food-related business model/value supply chain. The basic value-added concept is shown in Figure 16 and illustrates the substantial difference in potential income between simply growing and selling any agricultural commodity (the farmer row) and the total income that may be realized in a state that provides a vertically integrated value-added chain. In this example, by growing the berry, performing the raw agricultural processing step, further processing the berry product to obtain chemicals and compounds of nutraceutical value, and then retailing them, additional economic value is realized. An integrated value chain captures a far higher percent of the final dollar figure spent on the product for the state.

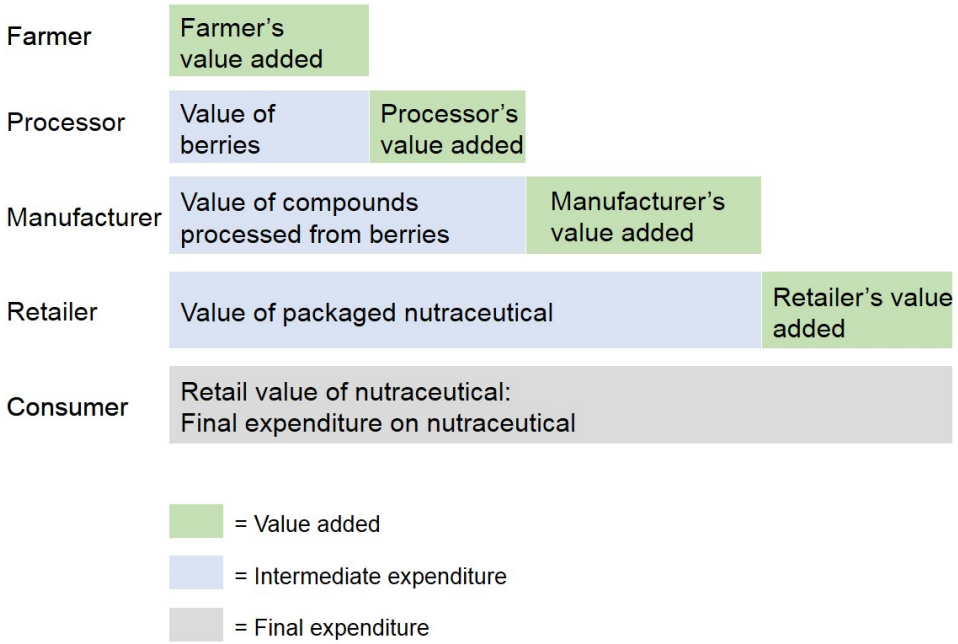


Figure 16. The Value-Added Concept – Berries to Nutraceuticals Illustrative Example.

Recognizing the enhanced value earned when a vertically integrated value-added chain is developed, the produce-and-then-sell mentality of the commodity business is being replaced by the strategy of first determining what attributes consumers want in their food products and then creating or manufacturing products with those attributes. With the continuous shifting to a global economy, the international market for value-added products is growing. Market forces have led to greater opportunities for product differentiation and added value to raw commodities because of:

- increased consumer demands regarding health, nutrition and convenience
- efforts by food processors to improve their productivity
- technological advances to produce what consumers and processors desire.

Producers involved with adding value will become more than commodity producers absorbing all the shocks brought about by global markets. They will think of themselves as producing products for end users, instead of producing only raw commodities. This, however, requires a different way of doing business and requires significant coordination throughout the value-added supply chain.

Coordination focuses on arrangements among those that produce and market farm products. Horizontal coordination involves pooling or consolidation among individuals or companies from the same level of the food chain. An example would be hog producers combining their market hogs to make a truckload. Vertical coordination includes contracting, strategic alliances, licensing agreements and single ownership of multiple market stages in different levels of the food chain. Vertical coordination, either through ownership integration or contractual arrangements, is necessary to link production processes and product characteristics to the preferences of consumers and processors.

Fundamental changes through coordination are altering traditional marketing relationships that link consumers, food retailers and wholesalers, food processors and producers. However, individual producers usually do not have sufficient levels of production to effectively produce, process and market their products. Few individuals possess all of the very different skills necessary for processing, marketing and business management, as well as staying efficient with their production enterprises. Therefore, a coordinated effort is needed to increase market efficiency or cost reduction. Many observers believe that both upstream and downstream linkages of processors will continue to increase in the 21st century.

Current Flow of Value within North Carolina's Food Processing/Manufacturing Industry

To provide further perspective on the North Carolina food processing and manufacturing industry, the Battelle team examined the data provided by the 2012 North Carolina IMPLAN model. Five values within the model provide a picture of production flow within the various product sectors (which roughly correspond to NAICS code industries).[16] These five data points include:

- Total Commodity Supply: Total value of the commodity (agricultural product or food product) produced in the state of North Carolina.
- Foreign Exports: Value of commodities shipped to foreign (non-U.S.) countries.
- Domestic Exports: Value of commodities shipped to other U.S. states.

[16] Input/Output analysis uses commodity (product) flows to measure the value of production and how this value flows throughout the economy. The use of commodities allows for industries to produce goods outside of their core industry definition. For example, companies classified as bakeries could also produce snack foods or cookies and crackers. These figures are developed and derived by IMPLAN, Inc., but are estimates.

- Locally Met Intermediate Demand: Value of commodities flowing to the same or other commodity groups as a downstream production input.
- Locally Met Institutional/Household Demand: Value of commodities sold to in state consumers for final consumption.

Together, these values, shown in Table 19, provide an understanding of the state food processing output and what happens to this output. The data, sorted by total commodity supply, generally corresponds to the industry size described in the economic analysis.

Table 19. North Carolina Food-Related Distribution of Commodity Supply (in $ Millions).

IMPLAN Sector	Total Commodity Supply	Exports		Locally Met Demand	
		Foreign	Domestic	Intermediate	Institutional-Household
Food Manufacturing/Products					
Manufactured poultry meat products	$10,385.5	$577.5	$6,264.4	$1,832.7	$1,711.0
Beer, ale, malt liquor and nonalcoholic beer	$3,334.7	$242.6	$2,422.1	$27.6	$642.4
Manufactured animal (except poultry) meat and rendered by-products	$3,059.4	$547.2	$1,538.3	$517.0	$456.8
Soft drinks and manufactured ice	$1,805.5	$23.7	$110.8	$147.2	$1,523.8
Canned, pickled and dried fruits and vegetables	$1,588.6	$133.5	$1,090.7	$97.8	$266.4
Snack foods including nuts, seeds, and chips	$1,567.0	$46.7	$1,214.4	$23.6	$282.3
Cookies, crackers, and pasta	$1,296.9	$30.6	$879.0	$59.2	$328.2
Flour and malt	$1,206.2	$119.4	$740.9	$287.4	$58.5
Bread and bakery products	$1,113.5	$37.6	$658.1	$59.2	$358.7
Fluid milk and butter	$570.6	$3.6	$185.9	$56.0	$325.1
Coffee and tea	$516.8	$49.6	$352.0	$23.3	$91.9
Soybean oil/cakes and other oilseed products	$442.7	$176.8	$188.7	$74.7	$2.5
Flavoring syrups and concentrates	$361.7	$6.0	$19.5	$334.3	$1.9
Wine and brandies	$337.7	$25.2	$74.1	$64.6	$173.7
Non-chocolate confectioneries	$320.5	$19.0	$218.1	$9.2	$74.2
Breakfast cereal products	$315.8	$15.0	$200.6	$3.1	$97.1
Corn sweeteners, corn oils, and corn starches	$296.6	$51.9	$202.8	$38.4	$3.5
Seafood products	$241.8	$7.0	$117.2	$70.1	$47.6
Ice cream and frozen desserts	$222.2	$3.1	$84.1	$67.8	$67.4
Seasonings and dressings	$172.5	$8.7	$107.7	$24.9	$31.1
Frozen foods	$118.7	$7.4	$29.9	$7.9	$73.5
All other food manufacturing sectors/products	$1,108.7	$172.4	$609.2	$90.0	$237.2
Total	**$30,383.6**	**$2,304.7**	**$17,308.5**	**$3,915.7**	**$6,854.8**

Source: IMPLAN 2012 North Carolina Model.

One overarching concern with the level of these values is that most food manufacturing/product sectors, especially those with over $1 billion in commodity supply, are substantially dominated by a single or very small number of large, regional or national, corporate operations. While there are obviously smaller firms and new entrepreneurs operating in most, if not all of these sectors, the long-term future, stability, and growth of the food processing industry in North Carolina is strongly tied to the futures of these large corporate operations.

Processed poultry meat products account for more than one-third of the state's total commodity supply. Of this supply, 60 percent is shipped to other states in the U.S., 6 percent is foreign exported, with an additional 18 percent used for further production in the state (locally met intermediate demand). The ratio of locally met *intermediate* demand to the total of demand by non-North Carolina consumers (foreign and domestic exports plus local met intermediate demand) or, *downstream processing ratio*, provides some indication of the level of further added value being performed "in-sector" (in this instance, processing turkey and chicken into pre-package portions, deli meats, or other products). This ratio is currently at 21 percent for the processed poultry meat products sector, indicating an important share of product is retained in the state for further processing. A potential avenue of growth for the sector, however, would be continuing the push toward increasing the downstream processing and hence, added value, before shipping these products out of state.

The processed meat sector values appear lower than perhaps expected. This is likely due to a combination of the highly vertically integrated nature of the sector, where some of the value of this "industry" is also captured within hog production, as well as a data-derived "leakage" of value where some of the commodity value, actually produced in North Carolina, is assigned to Virginia, where Smithfield Foods corporate headquarters is located. Even with these potential issues with the data, the downstream processing ratio for the processed animal meat (for North Carolina, this sector is primarily pork production, but also includes beef production) reaches 20 percent. A similar focused effort to increase this ratio could lead to economic growth of this product sector in North Carolina.

The size of the beer and ale commodity sector, the next largest in terms of the value of total supply, is driven by the regional Miller Coors facility in Eden as well as the growing craft brew industry in the state.

The table also shows some particular areas of opportunity for North Carolina food processing. North Carolina is home to a variety of fruit and vegetable processors (including the national pickle producer Mt. Olive Pickles). With the expertise within the state, both in terms of private sector efforts, but also the fermentation and processing expertise within the state's research institutions, increasing the size and value of this product sector should be an avenue of growth for North Carolina.

The flavoring syrups and concentrates sector currently sells more than 90 percent of its output into further processing segments within the state. This indicates a market that could potentially look to serve "export" markets (both foreign and domestic) with overall increased production.

One area that currently shows limited North Carolina presence is in the frozen foods sector, which consists primarily of frozen fruits and vegetables, and frozen prepared entrees and meals. Accounting for less than half of one percent of total commodity supply, this channel for preservation, processing, and distribution, a growing sector globally, offers an area for further development within the state, both in terms of increased production of food crops suitable for developing "frozen" markets, as well as enhancing the private (and perhaps publically available) infrastructure to process foods in this manner.

To further understand the potential for increasing the North Carolina's food value chain, three sectors detailed in Table 19 will be examined more closely through value chain "flow" charts. These value chain charts illustrate the share of the sector's production value that is contributed by the value added manufacturing activities, which include every aspect of turning the food "inputs" into a valued and ultimately consumed product (e.g., chopping, grinding, slicing, portioning, inclusion into recipe-based products, pre-cooking, and packaging).[17] These charts also show the share of the total production value that is represented by costs to the manufacturers of these basic food inputs, as well as other input costs such as packaging supplies. These charts show every input that accounts for at least 2 percent of the sector's final production value.[18] It should be noted that for each of the three sectors represented there is an "intermediate processed" goods input sector that represents production from firms, also within the sector being discussed, selling to other in-sector companies somewhat further downstream.

A key take away is that for the food manufacturing industry sector to achieve maximum economic impact, North Carolina must strive to increase the share and complexity of the value added food manufacturing occurring within the state and to ensure, to the extent possible, that North Carolina-based companies are available to supply key inputs to in-state food manufacturers.

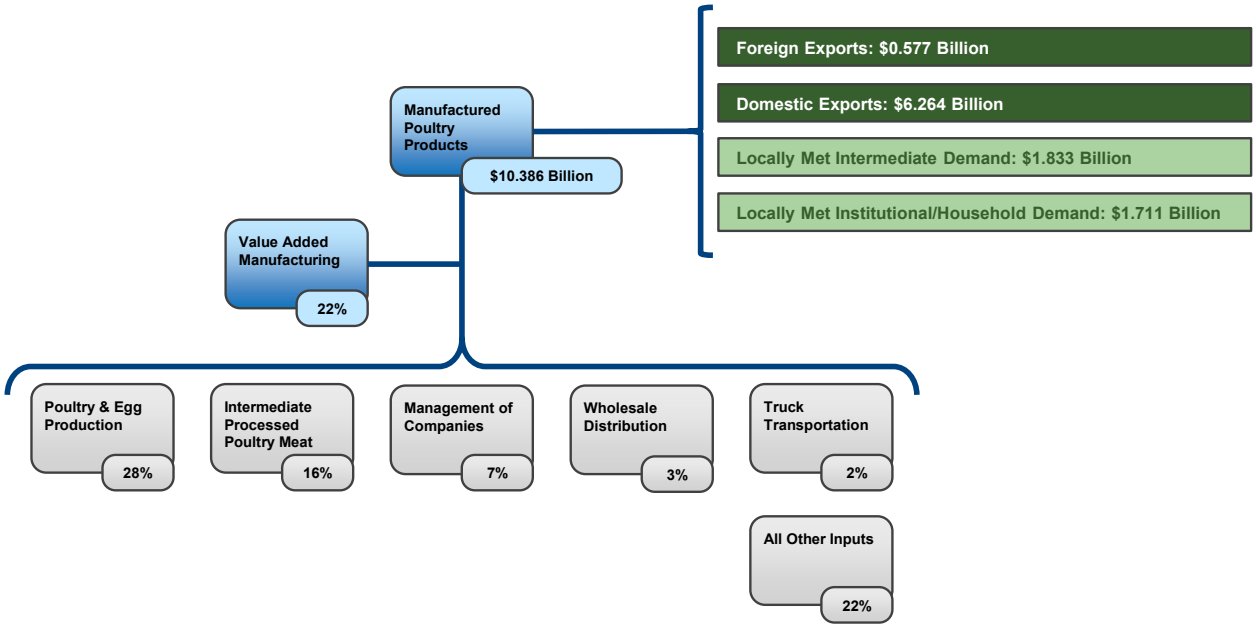
The input structure to manufactured poultry products is shown in Figure 17. Within this sector, purchased inputs account for 78 percent of the final production value—indicating value-added manufacturing within the sector accounts for 22 percent of the final value. This level of value added, though significantly larger than the meat products sector (see Figure 18), still constitutes a somewhat limited level of production-oriented value added. This value is primarily driven by simple processing and packaging of poultry products (e.g., whole packaged chickens or turkeys; cooked and sliced deli meats) versus significant processing into ready to eat entrees. This represents a significant opportunity for the further development of innovative food products and processes that would capture additional added value within North Carolina's food value chain.

Of the 78 percent from purchased inputs to the poultry products sector, 56 percent is captured in the five sectors with 2 percent or more of the value. Not surprisingly, farm-based poultry and egg production accounts for the largest share at 28 percent and intermediate processing accounts for a further 16 percent. Management and logistics activities account for an additional 12 percent.

The value chain for manufactured animal products, including pork and beef products, is shown in Figure 18. A key context of this value chain is the low level (6 percent) of value added manufacturing that occurs within this sector. This stems from the substantial context of "raw" or only slightly processed manufactured products within this sector (e.g., packaged meat cuts, smoked meat products, cooked and sliced deli meats). A key approach for increasing the value of this food manufacturing sector to the North Carolina economy will be through the development of further processed products that include pork and beef inputs (e.g., pre-cooked, recipe-driven meats such as packaged barbeque pork products, or other ready-to-eat entrees).

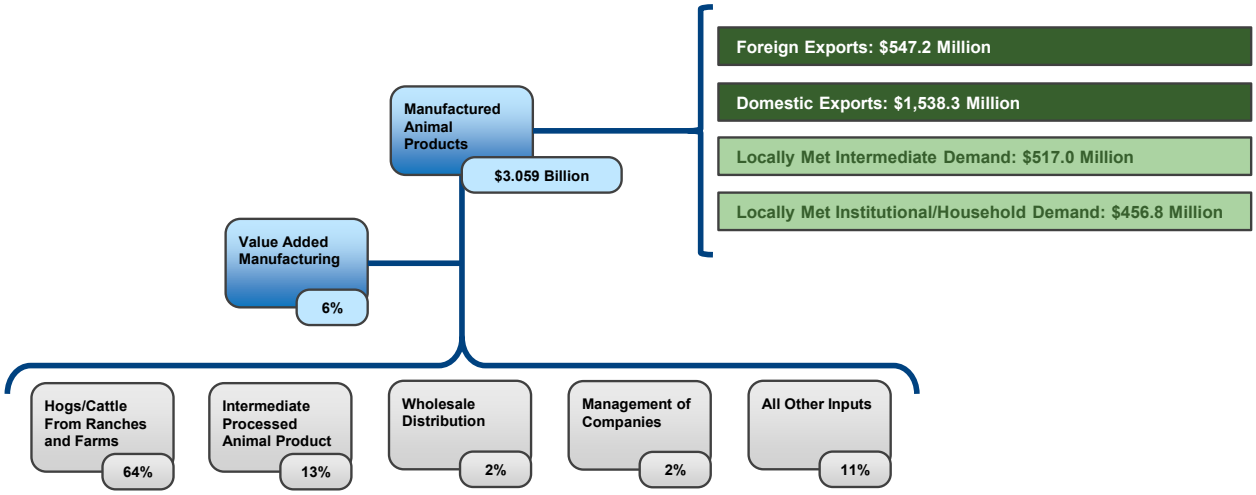
[17] These charts, while showing the production value, export and demand figures for North Carolina, represent the national sector context in terms of input shares.

[18] The remaining inputs are combined into the "All Other Inputs" within these diagrams.



Source: IMPLAN North Carolina Input/Output Model; Battelle analysis.

Figure 17. Manufactured Poultry Products Value Chain.

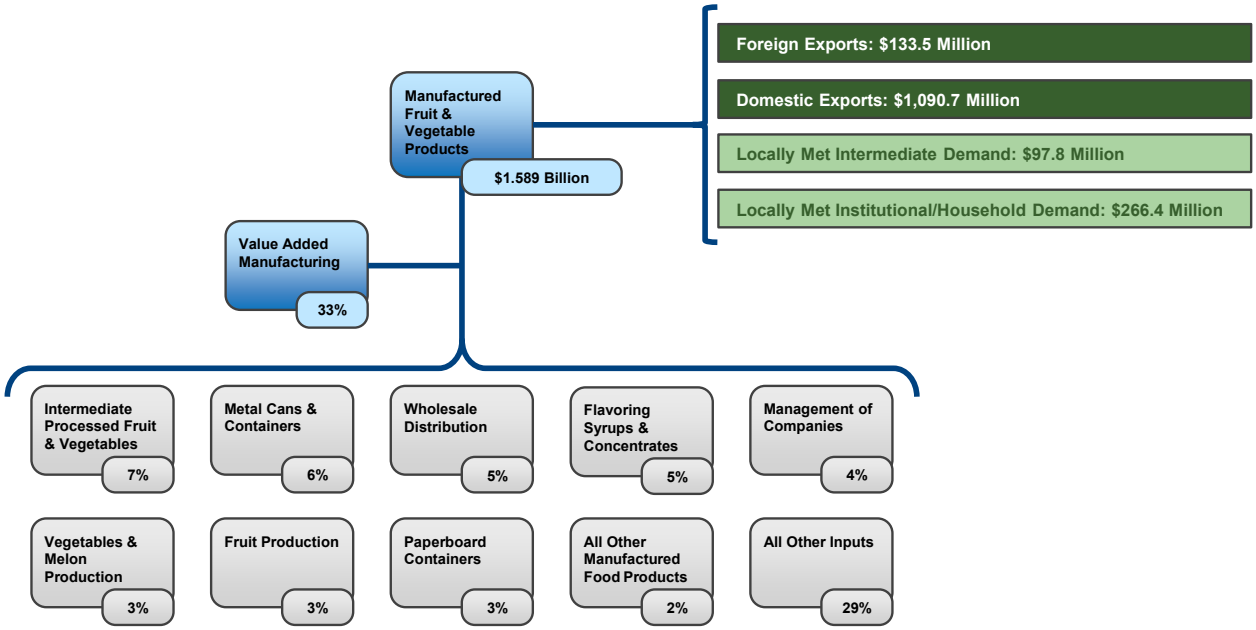


Source: IMPLAN North Carolina Input/Output Model; Battelle analysis

Figure 18. Manufactured Animal Products Value Chain.

Figure 19 illustrates the value chain for manufactured fruit and vegetable products (not including frozen vegetables). This sector is the largest of the three examined in terms of the role value added manufacturing plays in overall production value. Value added manufacturing accounts for 33 percent of the total value of the manufactured fruits and vegetable products sector. Overall, this sector is more geared toward “processing and manufacturing” than either the poultry or meat sectors—only 6 percent of the total production value comes from ag-based production (vegetable and melons; fruit) with an additional 7 percent from intermediate processing. The importance of packaging should be noted as

metal and cardboard containers combine to account for 9 percent of the total production value, more than the actual value of the farm-based agricultural inputs. The broadening of the products into more recipe-driven outputs can also be seen through the importance of flavorings and other manufactured food products being key inputs to this sector. Overall, the manufactured fruits and vegetable products value chain represents a significant opportunity for the further development of innovative food products and processes that would capture additional added value within North Carolina's food value chain.



Source: IMPLAN North Carolina Input/Output Model; Battelle analysis

Figure 19. Manufactured Fruit & Vegetable Products Value Chain.

North Carolina Situation – Opportunities to Leverage

Innovation in commodity processing and food manufacturing involves new product invention, development, product quality improvements, efficiency improvements, and food safety. Based on the innovation drivers found within North Carolina (detailed in the next section of this chapter) coupled with the commodities found within North Carolina and how they are currently being utilized as value-added products, North Carolina is uniquely positioned to add value to its agricultural commodities thereby driving economic growth.

By leveraging the experiences gained through the work with the sweet potato commodity, North Carolina can work to further develop value-added products for other commodities produced within the state. It will be critical to recognize that the sweet potato model was somewhat unique due to the large quantity of the commodity that was produced in the state. Other commodities do not have the same level of production. Therefore, it may be necessary to develop intermediary aggregators and processors in order to develop a critical mass, or economies of scale, to ensure the economic viability of such efforts. NC State's NC Growing Together project can serve as a valuable resource in that endeavor. It will also be critical to develop a public/private/academic partnership, similar to the sweet potato effort that was supported by the SweetPotato Commission, the Golden LEAF Foundation, and research undertaken at NC State.

Case Study: North Carolina Sweet Potatoes

Through a partnership between the North Carolina Sweet Potato Commission, NC State's Department of Food, Bioprocessing and Nutrition Sciences, local producers, and the Golden LEAF Foundation, technologies were developed using continuous-flow microwaves to process sweet potato puree, a product that is shelf-stable without refrigeration.

This added-value food product innovation has spurred the development of new products, new markets for sweet potatoes, and the development of new businesses in North Carolina that are taking advantage of the commodity production of sweet potatoes in the state to develop value-added products. In addition, the innovations also provides growers a market for what was largely a waste product since much of North Carolina's production was unable to be utilized due to lack of uniformity in size.

Areas of potential opportunity include a wide variety of fruit and vegetable purees, homogenates and pulps that can be sterilized rapidly and stored under ambient temperature conditions. In addition, dairy products, meat pieces in a variety of sauces, cheese dips and sauces, salsas, soups, and stews also demonstrate as viable candidates for continuous flow microwave sterilization and aseptic packaging.

Fostering the Growth of Food Manufacturing Entrepreneurial Endeavors

A number of studies point to the importance of entrepreneurship in changing regional economies. Starting with David Birch's work, and validated by the Office of Advocacy of the U.S. Small Business Administration (SBA) and further refined by studies commissioned in recent years by the Kauffman Foundation and others, it is clear that entrepreneurial activity is closely tied to a state or region's level of economic growth.

However, catalyzing entrepreneurial activity is a challenge for many states. It is often stated that entrepreneurship is a "contact sport", and the barriers and obstacles to being able to scale a firm are significant, particularly food processing and manufacturing firms. The three areas that entrepreneurs indicate are their greatest obstacles are talent, capital, and sales. Of these, the most significant obstacle to creating and growing entrepreneurial companies is the lack of experienced management talent. For many states, there simply is no cadre of experienced, food processing and manufacturing entrepreneurs who know how to turn a food product into a successful venture. Such serial entrepreneurs are needed not only to lead new ventures but also to serve as mentors to help fledgling entrepreneurs develop their skills and increase their chances of success. They have contacts in the food-related supply chain, can recognize quality products, and help to develop distribution networks and marketing relationships that generate sales.

The second challenge facing food processing and manufacturing entrepreneurs is access to specialized equipment and capital-intensive infrastructure. Entrepreneurs require access to equipment and specialized facilities at each stage of their development, from early-stage, product and process innovation

through to large-scale manufacturing runs. States that have limited to no access to specialized equipment and capital-intensive infrastructure leave entrepreneurial companies unable to take scale and reach their growth potential.

The third challenge that food processing and manufacturing entrepreneurs face is to find customers and markets. Entrepreneurship assistance programs usually focus primarily on providing financial, business planning, and incubator support to start-up companies to increase their chance of survival. And indeed, start-up companies face many obstacles. But, just because a start-up company remains in existence doesn't mean that success has been achieved. For many of these companies, the real challenges come when they are ready to grow. Once they have a management team and an organization in place, have obtained physical and financial capital, and are ready to move to the next level, fewer resources are available to assist these companies in finding customers, identifying new markets, and generally increasing sales – all factors that will determine the level of their contribution to the economic health of the communities in which they reside. In addition, firms have difficulty keeping up with the competition, being aware of new products and changing consumer behavior that may affect their markets, and supporting continued product development.

North Carolina Situation – Opportunities to Leverage

In conducting an entrepreneurial inventory analysis of programs/initiatives that exist to support value-added food processing and manufacturing entrepreneurs, it is discovered that there are many assets/efforts that a start-up company can leverage. Initiatives that support food-related entrepreneurial endeavors include:

- NC State's Entrepreneurial Initiative for Food (Ei4F) program works with small business owners and prospective entrepreneurs to manufacture and process quality food products safely. Ei4F provides a variety of services to start-up companies, including product testing, product classification, nutritional label and process authority letter development, label review, and consultation and training.
- North Carolina's Department of Agriculture and Consumer Services, which provides North Carolina food-related entrepreneurial endeavors both agribusiness development services and marketing initiatives, such as Goodness Grows in North Carolina, Got to Be NC campaign, and the NC Specialty Foods Association. The Department also oversees the State's Farmers Markets, which provide an avenue for small companies to market and sell their products.
- A number of regional shared-use commercial kitchens and/or food incubators, such as the Blue Ridge Food Ventures and the Piedmont Food and Agricultural Processing Center, in addition to several private sector co-packers who will conduct smaller batch runs for entrepreneurs.
- While not food processing/manufacturing specific, North Carolina also has developed more generalized entrepreneurial/small business development programs to aid in the growth of small businesses, including:
  - N.C. Community College System's small business centers that focus on start-ups and entities with fewer than 10 employees;
  - NC State's Industrial Extension Service (IES), a federal Manufacturing Extension Partnership (MEP) program, that focuses on assistance to manufacturers in production process, cost improvements and diversification;
  - Small Business and Technology Development Centers (SBTDC) that focuses on the full range of business sectors with respect to strategy, budgeting, marketing, operational processes and related issues; and,

- Military Business Assistance Center (MBAC) that focuses on companies interested in military contracting.

However, even with these resources, interviews with entrepreneurs suggest that it can be difficult to access entrepreneurial support services tailored to the unique food processing and manufacturing industry sector. And even when the various programs are accessed, they are often disconnected from one another, making it difficult and confusing to the entrepreneur who is seeking assistance.

The bottom line is that finding different and unique ways to support entrepreneurs and the growth of entrepreneurial food processing and manufacturing companies is an important component in North Carolina's efforts to develop the industrial base. Rutgers University has developed a specialized program that has now been operating for over a decade serving as a one-stop-shop for entrepreneurs in New Jersey. Additional benchmarks that are focused on value-added food related entrepreneurial activities can be found in Appendix C.

Rutgers University's Food Innovation Center

Rutgers University's main program for development of value-added food manufacturing is the Food Innovation Center, a combined pilot plant/incubator in Bridgeton. This is an economically depressed city in rural southern New Jersey, nearly two hours' drive from the main New Brunswick campus.

The overall Center opened in 2001, and the 23,000 square-foot incubator in 2008, with support partly from the USDA Rural Development Program. The Food Innovation Center is a unit of the cooperative extension function for agricultural and natural resources (formally, co-led with the School of Environmental and Biological Sciences).

Operating both as a "bricks and mortar" and "virtual" incubator, the Innovation Center offers technical assistance in business-concept development, mentoring/acceleration services for new launches, and networking with and among established food entrepreneurs. It also offers entrepreneurs shared access to cold, hot, and dry process areas operated to FDA/USDA standards, as well as assembly and packaging. It also includes a test kitchen, sensory evaluation center, microbiology and analytical laboratory, and capacity for consumer research and focus groups.

Additional revenue-generating services include on-line courses for entrepreneurs, established food companies, and farmers markets. The website includes links to many active commercial kitchens for rent, and to co-packers active in the state.

The Center is led by an executive with substantial food-industry experience, backed by the university's associate VP for economic development. It is staffed by a range of technical and business specialists, including one extension specialist affiliated with the Department of Plant Biology and Pathology.

Proactively Targeting Site Selection Attraction Opportunities within the Food Manufacturing Supply Chain

The increased number of mergers and acquisitions that have occurred in the food processing and manufacturing industry in the recent past – notably, the acquisition of Ralcorp Holdings by ConAgra Foods, Cargill being the winning bidder in the federal bankruptcy court auction of SFAs Foods ground

beef processing plant, and Flowers Foods acquisition of Hostess Bread Brands, Lepage Bakeries, and agreement with Mexico's Grupo Bimbo to receive exclusive license to the Sara Lee and Earthgrains brands – is creating a doubled-edged sword environment for economic development organizations.

The first edge of the sword has been a trend for several years for food processors to regionalize production rather than have a centralized facility. This developed as a result of steadily increasing transportation costs and quality concerns. Therefore, food processors are moving closer to population centers and toward the points of consumption. This will only be accelerated by the consolidation of brands under a single corporate entity. For example, Koch Foods expanded in Hamilton, Georgia, by purchasing Cagle's Inc.'s facility at a cost of $49 million. Koch Foods retained Cagle's existing 350 jobs and added 350 more. A second phase expansion by Koch will create 750 additional jobs.

The other edge of that sword is the consolidations, and possible subsequent job losses, due to these acquisition and improvements in food processing technology. An example is Hostess Bread Brands, which was acquired by Flowers Foods; Hostess came with 20 bakeries and 38 distribution centers. Flowers Foods is executing a very deliberate roll out that designates a number of sites to be closed.

The business environment makes efforts to attract industries complex for some states. One example is California, which is a leading state in food processing/manufacturing, but is facing challenges in its attempts to retain food processing industries, let alone attract new facilities. The chief issue in California is the greenhouse gas emissions law Assembly Bill 32 (AB 32), commonly called Cap and Trade. Briefly stated, AB 32 requires companies to reduce their greenhouse gas emissions to 1990 levels by 2020, and by 80 percent of that standard by 2050.

According to a recent study by the California League of Food Processors, the implementation of AB 32 is projected to cost California fruit and vegetable processors more than $150 million in direct costs and more than 2,000 jobs from 2012 to 2020. Direct costs to all industries in the state are projected to be in the $18 to $63 billion range over the same period of time, with employment impacts of 119,000 to 460,000 lost jobs depending on model assumptions and implementation impacts.

Additional carbon credits can be purchased at auction from the state, however, to allow businesses to continue to operate or expand. That gives food processors an expensive choice that will typically run in the millions of dollars. One choice for food processing companies is to spend millions of dollars in new equipment as they attempt to comply with AB 32 requirements. The alternative is to face the prospect of paying additional millions of dollars to "purchase credits" from the state. This is causing many food processors to review their long-term production options which provides opportunities for other localities to attract operations to their state.

While the food processing/manufacturing industry's site selection determinants are driven by concerns regarding food safety, cost control and access to a qualified labor pool, additional factors that didn't exist in the food processing industry 20 years ago, such as skyrocketing fuel costs, concerns among consumers over dietary health and food safety, adequate water availability in many locations, ever-growing and restrictive environmental regulations, energy costs, and sustainability, are now factoring in predominately in site selection determinations. The issue is that very few economic developers understand the complexity of the industry's business model.

North Carolina Situation – Opportunities to Leverage

North Carolina is in the unique position, due to both the environmental situation facing California as well as the consolidation of the food processing/manufacturing industry around the nation, to proactively leverage its unique biomass value-added production capabilities, including access to agricultural commodities, water, a trained workforce, and proximity to large population centers, to proactively pursue attraction opportunities. North Carolina's state government has proven through the years its ability to target key clusters in the pursuit of economic growth and diversification of its economy. This focus now needs to be applied to the attraction of key components of the food-related, value added supply chain.

Providing Regulatory Training and Outreach to the Food Processing and Manufacturing Sector

In 2011, the Food Safety Modernization Act (FSMA) was signed into law and heralded as the most significant reform to U.S. food safety standards in over 70 years. The act serves to enhance and strengthen the FDA's ability to prevent food safety issues in the U.S. in a number of ways. It gives the FDA new enforcement authority to ensure high compliance rates, as well as the authority to hold imported and domestic foods to the same standards. Key changes[19] brought about by the law include:

- Establishment of mandatory produce safety standards
- Granting the FDA authority to prevent intentional contamination of the food supply
- Establishment of mandatory food inspection frequencies based on the food facility and other factors
- Granting the FDA authority to issue a mandatory recall if a company fails to issue one after a request to do so by the FDA.

It will take time to implement these changes, however. The law was written with certain target dates for implementation, granting certain authorities to the FDA sooner than others. One of the bigger changes that food manufacturers will need to adjust to is the greater authority given to the FDA to access facility records and the requirement that additional records be kept by the food manufacturer. Food manufacturers have typically kept food safety records on paper. The new legislation may shift food manufacturers toward more electronic or cloud-based document storage to improve the speed at which these kinds of documents can be stored and retrieved.[20]

North Carolina Situation – Opportunities to Leverage

In interviews with small and medium size food processors and manufacturers, significant concern was expressed regarding their ability to understand and then comply with the vast regulations of the industry. The implementation of FSMA is only continuing to put a strain on the time, resources, and knowledge required to ensure that a company remains compliant with both the federal and state regulations. In particular, due to the roll-out nature of FSMA, companies, as well as inspectors, are finding it difficult to stay abreast of changes that are being implemented.

North Carolina, led by the efforts of NC State, is already well regarded for its regulatory training and outreach to both industry as well as state and federal inspectors. North Carolina has the opportunity to

[19] U.S. Food and Drug Administration. http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm239907.htm.

[20] Manufacturing.net http://www.manufacturing.net/articles/2011/06/q-a-what-fsma-means-for-the-food-industry.

further set itself apart from other states by proactively developing additional in-depth training, education, and outreach efforts relevant to the food processing and manufacturing sector and relevant inspectors, particularly as it relates to the ongoing roll-out of FSMA. By helping to ensure that the small and medium size food processors and manufacturers in the state, as well as those that are tasked with undertaking the inspections, have access to the knowledge required in an educational format that is tailored to their specific situation, North Carolina has the opportunity to create a competitive advantage for its industrial base by proactively helping to improve the business climate.

North Carolina's Food-Related Innovation Areas for Development and Growth

North Carolina's Innovative Food Processing and Manufacturing Drivers

To catalyze the development of North Carolina's food processing and manufacturing industry, it will be critical for the state's industrial base to be able to leverage the innovation assets/strengths in the state to help ensure global competitiveness and relevancy. The core competency analysis indicates that the state enjoys a research enterprise base that is both broad in terms of its areas of interest, but also nationally recognized for its concentration and expertise in select categories. However, a high-level overview of North Carolina's food-related innovation base needs to be supplemented by a micro analysis of specific areas food processing and manufacturing innovation activity is occurring. To this end, the Battelle TPP project team examined a series of data sources in order to identify innovative companies and areas of food processing and manufacturing R&D occurring in the state.

As a result of the analysis, five innovation drivers were identified as critical to the continued development of North Carolina's value-added food processing and manufacturing sector:

- Food products innovation
- Packaging technologies
- Flavors, extraction and sensory technologies
- Food safety technologies
- Functional foods.

A description of each of these key innovation drivers can be found in the narrative that follows.

Food Products Innovation

This innovation driver focuses on maximizing the capture of economic value within North Carolina from agricultural and livestock products. In order to catalyze the development of value-added agricultural processing and food manufacturing in North Carolina, significant innovation efforts will be required that are designed to increase value-added food products within the state.

Innovation in food products is being driven primarily by the industry's need to respond to consumer behavior preferences related to:

- New ethnic concepts
- Organic foods and health foods
- Fortification (i.e., addition of vitamins, minerals, bacterial cultures)
- Prepared meals

- New manufacturing techniques that improve sensory qualities such as minimal processing, heat treatments, freeze-drying, etc.

In addition, food product and process innovation is being driven by food packaging innovation, including:

- new packaging materials that improve product shelf-life, freshness and quality
- new packaging that presents the food product in new and different ways (i.e., new packaging shapes, new graphic design, etc.)
- new packaging that increases product versatility (i.e., packaging that can be used in the microwave and the oven)
- new packaging that increase ease of use (i.e., milk carton designs that are easily opened).

Due to the strengths of packaging innovation in North Carolina, it has been broken out as a separate innovation driver from production and processing innovation. The same is true for flavors, extraction and sensory. However, it is important to note that these three areas are tightly connected to one another. All of these areas require applied research and innovation to drive the development of new products and processes.

North Carolina's Innovation Position

As noted in the economic analysis, North Carolina has a significant base of industry engaged in value-added agricultural processing and food manufacturing. However, it is still the case as previously noted that a significant volume of primary agricultural commodities leave the state with limited value-added to them.

Table 20 connects the food production research data presented in the core competency assessment and identifies food product and process innovation as an area for continued development and growth. These data build upon the results of the OmniViz analysis, but further emphasize the multidisciplinary and integrated nature of the innovation areas.

Table 20. Research and Innovation in Food Product and Processing Innovation.

North Carolina Organization	Record Count	Publication	Patent Award	Patent Application	USDA CRIS-Food Related Research Grant
NC State University	61	51	5	2	3
Tipper Tie	9	1	7	1	
North Carolina A&T State University	7	5	1		1
Aseptia	4		2	2	
Chiquita	4			4	
University of North Carolina	4	4			
Bestsweet	2			2	
Duke University	2	2			
Novozymes	2		2		
Appalachian State University	1				1
Buhler Aeroglide Corporation	1			1	
Carrier	1			1	

North Carolina Organization	Record Count	Publication	Patent Award	Patent Application	USDA CRIS-Food Related Research Grant
Chic Pic	1		1		
Firsthand Foods	1				1
Fresh Express Inc.	1		1		
Morris & Associates	1		1		
Netcentrics	1			1	
Ocean's Flavor	1			1	
RDI Foods, LLC	1			1	
Research Triangle Institute	1	1			
Turkington USA	1			1	
Total Records*	**144**	**62**	**47**	**29**	**6**

* Includes records for individuals and other organizations; Some records are counted in more than one innovation area.

Food product and process innovation in North Carolina is a strong blend of university research (including some patent-related activities) and food processing-related patent activities within a number of private sector firms. Research and innovation in the food products and processing area range from specific food products to a variety of preparation and processing equipment including the sausage making machinery of Tipper Tie.

Numerous companies noted that many of the food product and process innovations realized in North Carolina over the years have stemmed from the work conducted by NC State's Department of FBNS, particularly as a result of the applied work conducted in its numerous pilot plants and research centers. The department offers seven different pilot plants, many dedicated to specific commodity areas. Six are located on the main campus (Schaub Hall) and used for food product and process innovations with respect to dairy products, fruits and vegetables, high viscosity/particulates, meats, and visual imagery. The seventh facility, the Center of Marine Sciences and Technology (CMAST), is focused on advancing innovative seafood technologies and is located in Morehead City, North Carolina. In addition, the USDA-Agricultural Research Service (ARS) has invested significant resources, including the Food Science Research Unit, which focuses on improving processes for the preservation and utilization of vegetables, including cucumbers, sweet potatoes, peppers, and cabbage, and the Market Quality and Handling Research Unit, also known as the "Peanut Lab", which conducts research on issues such as enhancing the flavor and shelf-life of domestic and export peanuts and peanut products by improving methods of handling, roast processing, and storage.

While the data analysis indicates a robust level of activity related to food product and processing innovation, it is important to note that many of the innovations realized in North Carolina over the years have been as a result of FBNS's open-access processing facilities and staff. Through collaborative research partnerships and open innovation, numerous products and improvements to processes have been developed, including: Scallop Medallions, Sweet Acidophilus Milk, Honey Roasted Peanuts, Pasteurized Liquid Egg, Ham Curing and Pickle Fermentation.

Food Product & Processing Global Market Potential – Opportunities to Leverage

The food product and processing market is quickly becoming a high-volume industry, motivated by increasing demand from developed nations, as consumers in these countries depend on meals that can be cooked in a limited amount of time.[21] In 2011 the global market for food processing equipment was valued at $8.1 billion, and is projected to reach $12 billion by 2018, with a CAGR of 5.8 percent. The North American market is expected to grow over the same time period with a CAGR of 7.6 percent. The largest segment of that market is meat processing equipment. Opportunities in the food processing equipment market exist in the developing nations in the Asia-Pacific region, as this region experiences favorable economic conditions and increased living standards.

Certain segments of the food manufacturing industry react differently during economic highs and lows, depending on the food that is being processed. The meat processing and canned fruit and vegetable processing market segments are outlined below:

- Being a food staple for most consumers, the demand for meat is less volatile than other market segments during economic downturns, evident by the past five years seeing the per capita consumption of meat falling only slightly. This translates to a steady demand for meat processing. From 2014 to 2019, meat processing revenue is slated to increase at an average of 0.7 percent per year, reaching a total of 228.9 billion by 2019. This increase is attributed to population growth, increasing consumer sentiment and strong meat exports. [22]
- The canned fruits and vegetables processing market has not fared as well as other market segments. The higher prices and reduced discretionary income that occurred during the “Great Recession,” as well as increased health awareness among consumers has served to reduce demand in this market from 2010 to 2014, with industry revenue expected to decrease 3 percent to 38.9 billion in 2014. To try and reach the more health focused consumer, canned fruit and vegetable processors have developed products with reduced fat, all natural ingredients and similar characteristics. For example, Campbell introduced a line of V8 products made with 100 percent fresh vegetable juice. These innovations have somewhat tempered the decline in revenue in the industries. [23]

The food processing equipment industry has seen a significant amount of new product development over the last 10–20 years. This innovation has been spurred on by a number of factors. A global increase in demand for ready-to-eat meals has pushed the industry to innovate in this sector, along with an increase in competition. Working within a demanding global market, food processing equipment manufacturers seek to stand out with sustainable processes and unique packaging, including equipment to debone and process pork shoulders more efficiently and machines that can produce packages of meat with modified atmospheres.

Packaging Technologies

As previously noted, much of the food product and process innovation that is driving the food processing and manufacturing industry stems from packaging technologies. This is because food production is under the ever increasing threat from issues such as population growth, climate change, competing land uses, erosion and diminishing supplies of clean water.

[21] BCC Research Report: Global Markets for Food Processing and Food Packaging Equipment.

[22] IBISWorld Industry Report 31161: Meat, Beef & Poultry Processing in the U.S.

[23] IBISWorld Industry Report 31142: Canned Fruit & Vegetable Processing in the U.S.

When food is lost or wasted, all of the natural resources that were expended in the supply chain are also lost, including the use of land, nutrients, synthetic fertilizers, water, and energy. As every new step in the value chain adds resources and emissions, the waste of cooked food at the consumer or food service level has the highest environmental impact.

One of the solutions to this dilemma is increased efficiency and waste reduction in the food supply chain. Approximately 40 percent of all food intended for human consumption in developed countries ends up as waste. While some of this is unavoidable waste from processing and preparation, much of it is avoidable. The reasons for food loss and waste at each stage of the supply chain include:

- **Agricultural production**: damage from pests and disease; unpredictable weather conditions; not meeting quality specifications
- **Post-harvest handling and storage**: not meeting specifications for quality and/or appearance; pest damage; spillage and degradation
- **Processing and packaging**: trimmings and other food preparation waste; production line start up; batch mistakes; inadequate remaining shelf life
- **Distribution (wholesale and retail)**: damage in transit/storage due to packaging failures; product spoilage; fresh produce not meeting specifications or damaged during handling; inadequate remaining shelf life due to poor stock rotation or low sales
- **Food service**: trimmings and other food preparation waste; poor inventory management (e.g. over-ordering); improper food handling; confusion over use-by and best-before dates; plate leftovers
- **At home**: trimmings and other food preparation waste; food spoilage; preparing too much food; past use-by or best-before dates; plate leftovers.

Interestingly, while food manufacturers generate a significant amount of waste, almost 90 percent is recovered primarily as animal feed or compost. The biggest opportunities for waste reduction and recovery are in other parts of the supply chain, particularly in distribution, food service, and in the home.

Packaging has a vital role to play in containing and protecting food as it moves through the supply chain to the consumer. It already reduces food waste in transport and storage, and innovations in packaging materials, design and labelling provide new opportunities to improve efficiencies.

Opportunities to reduce food waste through packaging improvements include:

- Distribution packaging that provides **better protection and shelf life for fresh produce** as it moves from the farm to the processor, wholesaler or retailer. This will require the development of tailored solutions for individual products.
- Improved design of secondary packaging to ensure that it is **fit-for-purpose**, i.e., that it adequately protects food products as they move through the supply chain. Packaging developers need to understand the distribution process and where and why waste occurs.
- A continuing shift to **pre-packed and processed foods** to extend the shelf life of food products and reduce waste in distribution and at the point of consumption (the home or food services provider). The packaging itself also needs to be recoverable to minimize overall environmental impacts.
- Adoption of **new packaging materials and technologies**, such as modified atmosphere packaging and oxygen scavengers, to extend the shelf life of foods.

- Product and packaging development to cater for **changing consumption patterns and smaller households**. Single and smaller serve products will reduce waste by meeting the needs of single and two person households.
- More synchronized supply chains that use **intelligent packaging and data sharing** to reduce excess or out-of-date stock.
- Increased use of **retail ready packaging** to reduce double handling and damage and improve stock turnover, while ensuring that it is designed for effective product protection and recoverability (reuse or recycling) at end of life.

North Carolina's Innovation Position

As previously noted in the economic analysis, North Carolina has a large, specialized, and diverse industrial base in food-related packaging. The subsector has a specialized employment concentration in six of its component industries with a diverse array of companies located within the state.

Part of the genesis of this packaging cluster stems from NC State's leadership in the Center for Advanced Processing and Packaging Studies (CAPPS), a National Science Foundation-initiated program designed to foster partnerships between industry and universities for the mutual benefit of both parties and the advancement of food processing and packaging research.

For over a decade, the focus of the Center has been to conduct packaging research that is applicable and relevant to industry. The Center uses an interdisciplinary approach to solve problems for industry. While originally led by NC State, Ohio State University is now the managing site for this multi-university center, in strong partnership with NC State and the University of California-Davis. Expertise in food chemistry, biochemistry, nutrition, microbiology and engineering are among the research strengths available through CAPPS. Current programs focus on emerging technologies such as ohmic heating, high pressure processing, ozone processing, continuous microwave heating, and aseptic processing of particulates.

Leveraging the NSF investment, North Carolina has positioned itself as a key leader in packaging innovation. Table 21 connects the packaging research and innovation data presented in the core competency assessment and identifies packaging as an area for continued development and growth. These data build upon the results of the OmniViz analysis, but further emphasis the multidisciplinary and integrated nature of the innovation areas.

Table 21. Research and Innovation in Packaging.

North Carolina Organization	Record Count	Publication	Patent Award	Patent Application	USDA CRIS-Food Related Research Grant
Tipper Tie	65	1	54	10	
NC State University	16	11	3		2
Caneel Associates	2			2	
Nomacorc	2			2	
Research Triangle Institute	2	2			
Wiser	2				2
Absolute	1		1		

North Carolina Organization	Record Count	Publication	Patent Award	Patent Application	USDA CRIS-Food Related Research Grant
Plastics					
Aseptia	1			1	
Firsthand Foods	1				1
Gilbarco	1			1	
Popseal	1		1		
Sirit Corp	1	1			
University of North Carolina	1				1
Wake Forest University	1	1			
Total Records*	**115**	**17**	**69**	**23**	**6**

* Includes records for individuals and other organizations; Some records are counted in more than one innovation area

It is important to note that the packaging innovation area is strongly connected to the private sector. The private sector context is led by the packaging-related patent activities of Tipper Tie, but also includes patent activities of a variety of other companies. Research activities are primarily driven by NC State, but also include SBIR activities of two firms – Wiser and Firsthand Foods.

Food Packaging's Global Market Potential – Opportunities to Leverage

With consumer preferences shifting towards sustainable packaging, and with the growing need for increased food quality and safety during increasingly long shipment times, the food packaging industry has had to evolve to meet these demands. However, the key issue facing the food and beverage packaging industry is the safe and reliable transfer of goods to the consumer. This issue holds in both the developed and developing markets, with the developed markets primarily concerned with "green" packaging and the developing markets focused on smart packaging to increase food safety.

Recent advances in food and beverage packaging include:

- Active packaging: techniques that safeguard products through gas scavenging, controlling moisture, preventing microbe development, etc.
- Controlled packaging: Packaging that controls the atmosphere within the package to maintain food quality.
- Intelligent packaging: techniques that allow for the monitoring of food packaging atmosphere and also contributes to loss prevention.

Large, international food retail companies such as Walmart and Target use advanced packaging technologies to extend the shelf life of their food and beverages while reducing the economic costs of rotten goods. Global growth in the retail food market and increasing consumer socioeconomic status has expanded the intelligent packaging technology market and created shifts in consumer demand worldwide.

The global market for advanced packaging solutions reached a value of $31.4 billion in 2011 and is expected to reach $44.3 billion by 2017 with a CAGR of 5.8 percent. The controlled packaging segment holds the greatest market share, with sales of almost $12.4 billion in 2011 and is projected to reach $17.6

billion in 2017. The North American market (comprising the U.S. and Canada) had the greatest regional active packaging market share with 46.6 percent, followed by the European markets at 29.9 percent and emerging markets at 23.7 percent.[24]

Flavors, Extraction and Sensory Technologies

Highly correlated to the success of new food product acceptance in the market place, flavors extraction and sensory technologies are a driving force in the value-added food processing and manufacturing industry. The chemical senses – more commonly known as taste, smell, and chemesthesis (the "feel" of a chemical; chemically provoked irritation) – are critically important factors to food preferences and intake. Humans seek out their preferred flavors in foods. Flavor plays an important role in determining whether someone accepts a particular food, and how much of it they choose to eat.

Today, flavors, extraction and sensory technologies are driving many food product innovations through the use of additives. Additives perform a variety of useful functions in foods:

- **Maintain or Improve Safety and Freshness:** Preservatives slow product spoilage caused by mold, air, bacteria, fungi or yeast. In addition to maintaining the quality of the food, they help control contamination that can cause foodborne illness, including life-threatening botulism. One group of preservatives -- antioxidants -- prevents fats and oils and the foods containing them from becoming rancid or developing an off-flavor.
- **Improve or Maintain Nutritional Value:** Vitamins and minerals (and fiber) are added to many foods to make up for those lacking in a person's diet or lost in processing, or to enhance the nutritional quality of a food. Such fortification and enrichment has helped reduce malnutrition in the U.S. and worldwide.
- **Improve Taste, Texture and Appearance:** Spices, natural and artificial flavors, and sweeteners are added to enhance the taste of food. Food colors maintain or improve appearance. Emulsifiers, stabilizers and thickeners give foods the texture and consistency consumers expect. Leavening agents allow baked goods to rise during baking. Some additives help control the acidity and alkalinity of foods, while other ingredients help maintain the taste and appeal of foods with reduced fat content.

North Carolina's Innovation Position

Nearly every company interviewed for this study that was involved in developing new food products noted the importance of product formulation and the role of flavors, extraction and sensory inputs. Numerous companies noted the beneficial resource found within the state, NC State's Sensory Service Center, which provides flavor research services, including targeted food testing and food evaluation, that helps companies solve flavor quality problems.

Research at NC State's Sensory Service Center is focused in two different areas: sensory analysis and flavor chemistry. Sensory analysis research is primarily focused on dairy products and how flavor varies with processing and storage and how this relates to consumer perception. Qualitative market research, descriptive analysis, consumer testing, and preference mapping are all used. Instrumental flavor chemistry analysis techniques including gas chromatography / olfactometry and gas chromatography / mass spectroscopy are also used to relate sensory properties to the chemical components of foods.

[24] BCC Research Report: Active, Controlled, and Intelligent Packaging for Foods and Beverages.

Fundamental research on methods development is conducted as well as application of these techniques to solve industrially relevant problems.

The Center works with companies to:

- Assess sensory needs and requirements
- Design and implement analytical sensory tests including difference tests, threshold tests, and descriptive sensory analysis
- Perform consumer acceptability and opinion testing via Consumer Testing Panels and Market Research
- Perform volatile compound extraction (headspace and solvent extraction capacity) with GC-MS and/or GC-O
- Administer analytical services such as nonvolatile component testing
- Develop expert statistical reporting and analysis and interpret the results.

Leveraging this Center, North Carolina has positioned itself as a key leader in flavors, extraction and sensory technologies. Table 22 connects the flavors, extraction and sensory technologies research and innovation data presented in the core competency assessment and identifies flavors, extraction and sensory technologies as an area for continued development and growth. These data build upon the results of the OmniViz analysis, but further emphasis the multidisciplinary and integrated nature of the innovation areas.

Table 22. Research and Innovation in Flavors, Extraction and Sensory.

North Carolina Organization	Record Count	Publication	Patent Award	Patent Application	USDA CRIS-Food Related Research Grant
NC State University	96	94		1	1
North Carolina A&T State University	13	8	1		4
University of North Carolina	10	10			
Chiquita	2			2	
Duke University	1	1			
East Carolina University	1	1			
Johnson & Wales University	1	1			
Novozymes	1			1	
Ocean's Flavor	1			1	
Panacea Biomatx	1			1	
Research Triangle Institute	1	1			
Van Hees	1			1	
Wake Forest	1	1			

University					
Total Records*	**129**	**114**	**2**	**8**	**5**

* Includes records for individuals and other organizations; some records are counted in more than one innovation area.

The flavors, extraction and sensory innovation area is primarily research driven with limited patent-related activities at present. NC State accounts for the majority of the publications in this area, though related research is also being performed and NC A&T State University and UNC.

Flavors, Extraction, and Sensory Global Market Potential – Opportunities to Leverage

As advancements in food product innovations, including the growing area of functional foods described below, as well as advancements in packaging and shelf-stability continue to push the envelope of our daily food consumption, the importance of flavors, extraction and sensory technologies and advancements continues to grow as well. For instance, the trend towards all natural ingredients has implications across the global food industry, including the market for flavors and fragrances. Recently, consumers have been concerned with the health effects and sustainability of synthetic flavors, leading to increased demand for products that are made with natural flavor sources. Flavor producers responded by producing natural flavors and creating ties between their flavors and general health awareness. Producing natural flavors is very expensive, however, and only a few natural flavor suppliers exist. The price difference between natural and synthetic flavors has led to innovations in natural flavor extraction, including the development of water-soluble extracts. These extracts can replace the use of oil-soluble extracts and have been useful in the beverage industry.[25]

Other advanced technologies have been developed in the flavor industry to manufacture value-added products using various extraction and processing techniques. One method, known as flavor encapsulation, is a method of protecting the flavor using certain coatings to safeguard the quality of the flavor from production to incorporation into the final product.

Although there's increasing demand for natural flavors, the synthetic flavor market is able to mass produce flavors at a consistent quality and at lower costs than natural flavor production. Because of this, demand for synthetic flavors is not expected to drop significantly. It is also feasible for some synthetic flavor producers to use alternative materials in production that are more environmentally friendly, which may improve consumer sentiment.

North America and Europe make up 56.4 percent of global flavor sales. The North American flavor market was valued at $3.3 billion in 2013 with an expected value of $4.5 billion by 2019, a CAGR of 5.2 percent over that time period. The beverages segment held the greatest market share in 2013, making up 35 percent of the flavor market and valued at $4.1 billion. The beverage segment is projected to grow at a CAGR of 6.9 percent, reaching a value of $6 billion by 2019. This segment also holds the greatest market share in the natural flavors market at 50.2 percent, with substantial growth coming from the sale of non-alcoholic beverage products. This growth in natural flavors has not been reflected worldwide, with the high cost of producing natural flavors hindering growth in this industry in developing nations. None the less, the overall increase in demand for processed foods driven by consumers in developing countries will lead to an increased demand for flavor products.

[25] BCC Research Report: Global Markets for Flavors and Fragrances.

Food Safety

Food can transmit disease from person to person as well as serve as a growth medium for bacteria that can cause food poisoning. Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent foodborne illness. Research and technologies related to food safety are broad, and include practices relating to food labeling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food and guidelines for the management of governmental import and export inspection and certification systems for foods.

As our food supply has become increasingly global in nature, the challenges to food safety also have become more complex. Different countries have different regulations about what defines a “safe” raw material or finished product, making it critical for companies to have a strong, well-defined food safety program – including the incorporation of cost-effective, technologically advanced, cleaning and sanitation programs. Failure to do so can lead to public health and safety issues and ultimately a loss of credibility with consumers.

Cleaning and sanitation in the production plant is sometimes a rushed event in order to get production back on-line. These procedures are often poorly defined and can lead to overlooked issues that in turn lead to larger problems with time. The establishment and implementation of comprehensive food safety standard operating procedures (SOPs) lead to greater efficiencies, consistent and safe products and brand protection within the industry.

North Carolina’s Innovation Position

The health and economic potential of any food processing and manufacturing industrial base is predicated on its ability to incorporate food safety technologies into its daily operating procedures. Therefore, the level of food safety research, innovation, and outreach found within the state can directly contribute the viability of the food processing and manufacturing sector.

Table 23 connects the food safety research and innovation data presented in the core competency assessment and identifies food safety as an area for continued development and growth. These data build upon the results of the OmniViz analysis, but further emphasis the multidisciplinary and integrated nature of the innovation areas.

Within North Carolina, the food safety innovation area is strongly research driven led by NC State. UNC and NC A&T State University also participate in the research activities related to food safety at a substantial level, with most of the state’s universities performing some related research. The private sector and NIEHS are also engaged in a variety of food safety-related research (including food plant-related toxicology studies).

Table 23. Research and Innovation in Food Safety.

North Carolina Organization	Record Count	Publications	Patent Awards	Patent Application	USDA CRIS-Food Related Research Grant
NC State University	148	130		1	17
University of North Carolina	29	28			1
North Carolina A&T State University	24	22			2
Research Triangle Institute	9	9			
NIEHS	6	6			
Wake Forest University	5	5			
Appalachian State University	4	4			
Duke University	4	4			
Pfizer Poultry Health	4	4			
BASF Plant Sciences	3	3			
Integrated Laboratory Systems	2	2			
Wiser	2				2
East Carolina University	1	1			
Firsthand Foods	1				1
Monsanto	1	1			
Morris & Associates	1		1		
North Carolina Central University	1				1
Total Records*	**248**	**219**	**3**	**2**	**24**

* Includes records for individuals and other organizations; some records are counted in more than one innovation area.

Food Safety Testing Global Potential – Opportunities to Leverage

With the incidence of foodborne illnesses remaining relatively high, and with advances in food testing technology leading to faster, more effective and less costly equipment, the global growth in the food safety testing market remains robust. In developed countries such as the U.S., the food testing industry is typically not impacted by changing economic conditions, as people still need to eat safe food. Together with increased consumer awareness of food supply issues and increasingly stringent food regulations, the industry is expected to achieve a market value of $13.6 billion in 2019 with a CAGR of 5.3 percent from 2014-2019. High revenues along with market growth greater than five percent has led to many companies to enter the market. However most companies in this industry don't specialize solely in food testing, but offer them in addition to pharmaceutical and other life science products.

The U.S. holds the greatest share of the food safety testing market with 44 percent. Europe is close behind at 37 percent, with the rest of the world making up the final 19 percent. The U.S. food processing industry holds to some of the strictest food safety standards in the world. Developing countries are typically where food contaminations occur. However, as more developing countries take active roles in monitoring their food supplies, the demand for food safety testing products will increase. For example, the

United Nations Industrial Development Organization is investing $5 million to develop a food safety center in the Philippines, making the country a major food safety hub for South East Asia.

Innovations in the food safety testing industry could not only save billions of dollars but could also increase consumer's quality of life. In the U.S. alone annual health costs generated by food borne illnesses reach $78 billion dollars. Reflecting an increasingly strict food regulation environment and a heightened awareness from consumers, food testing manufacturers are continuing to develop their technologies to become more accurate and affordable. For example, the development of food tracking technology has allowed for the use of genetic fingerprinting of meat. Using DNA analysis, the production stages of meat and animal carcasses can be tracked to verify the safety of the final product. As the price of antibody-based rapid assays has fallen, and their speed increased, the market has shifted towards increased use of rapid assays, which will lead to a CAGR of 5.7 percent over the next five years for the rapid assay market segment. Advances in food testing technology will not replace food testing or food inspections, but will help to insure that consumers are purchasing safe, quality food.[26]

Functional Foods

Utilizing North Carolina's agricultural products in the production of value-added food products, advanced/functional foods, and as the basis for the extraction of functional phytochemicals/nutrients for health products represent pathways to increasing the value of North Carolina's commodities and specialty agricultural products. Food companies, already under intense competitive pressure within their historic product lines, are looking at the functional food, beverage, and supplement market for help. Though the value-added food and health product industry is less than 10 percent of the total food industry, the market offers significant growth opportunities and wider profit margins. Overall, the increasing effectiveness of the new products entering the market in terms of satisfying health claims, along with growing consumer health awareness, and the promise of higher profit margins, is luring almost all of the major multi-national corporations into the market.

One of the reasons for this growing market is the fact that an increasing number of consumers are focusing on consuming functional foods and beverages, nutritional supplements, and alternative medicines as a means to maintain health and wellness. Value-added food and health products provide a potential means for consumers to reduce out-of-pocket costs for primary medical services and prescription drugs, as well as live a longer and healthier life. Moving forward, the market is expected to continue to grow at a strong rate for three primary reasons:

- **The elderly population is expanding:** More than 1 billion people globally will be over the age of 50 by 2015; this group is likely to experience one or more chronic age-related disease and seek some form of treatment through nutraceutical products. Longer life expectancies will also increase overall spending for these consumers.
- **Young consumers' focus on health:** Increased media attention and the increase of available online information is raising health awareness for the young. Increased awareness creates greater concern, which leads to purchase decisions. The recent debate regarding the U.S. health care system has also motivated consumers to engage in preventative health care.
- **Obesity epidemic:** The World Health Organization (WHO) reports that more than 500 million adults globally are obese and an additional 1.0 billion are overweight. Excess weight is the prime cause of hypertension and cardiovascular disease, along with many other conditions.

[26] BCC Research Report: Global Markets and Technologies for Food Safety Testing.

These specific diseases are the leading causes of death among adult populations. Both excess weight and its associated disease states can be treated with nutraceutical products.

Top trends driving the market for functional foods and beverages are:

- Specialty Nutritionals: As core supplement users continue to switch from supplements to fortified and functional foods, food marketers must keep pace with the growing demand for specialty nutritional ingredients. New/unique ingredients/formula claims have driven sales of the best-selling new supplements since 2012. Specialty nutritional ingredients are now second only to vitamins in terms of consumers' nutrition priorities.
- Get Real: In 2012, the term real/100 percent real exploded into the marketplace, topping the list of health claims driving the best-selling new better-for-you foods/beverages. Right after fresh and made from scratch, real is now the most appealing food descriptor. Six in 10 consumers look for ingredients they recognize while shopping for food, 57 percent search for foods made with simple, real ingredients, and the same percentage seek food made with natural ingredients. In addition, 41 percent look for a shorter list of ingredients, and 33 percent want products made with local/seasonal ingredients.
- The Protein Evolution: The Food Technology 2012 report on functional food trends cited protein as a strong mega trend, and in 2014, the protein market is still center stage and diversifying into a powerful next generation of high potential health opportunities. In 2013, 57 percent of consumers made an effort to get more protein, up 9 percent vs 2012. Those ages 18–34 and those 65+ were the most likely to try to get more protein. Forty percent of the best-selling new better-for-you foods/beverages in 2012 carried a high protein claim.
- Kid-Specific: With 41 percent of America's 32 million moms saying they always buy healthy foods/drinks for their kids and 88 percent claiming to do so at least sometimes, a wider range of healthy, convenient, kid-friendly foods/drinks – with nutrient and calorie levels specific to kids – will find a welcome market. One-quarter of 2013's best-selling new foods/drinks touting convenience were targeted to children.
- Pharma Foods: Eight in 10 consumers believe that functional foods can help prevent or delay the onset of heart disease, hypertension, osteoporosis, and type 2 diabetes; six in 10 associate it with benefits linked to age-related memory loss, cancer, and Alzheimer's disease. In 2013, 56 percent of consumers bought foods or beverages that targeted a specific condition; 62 percent of very health-conscious consumers did so.
- Alternatives: Eighty percent of households now eat meatless meals – defined as no meat, poultry, or seafood protein – for dinner on occasion. One in five meal preparers serve them regularly; 29 percent are eating more fish/seafood.
- Performance Nutrition: The explosive sports nutrition category has morphed into two distinct performance-driven opportunities. While hardcore athletes/body builders will remain a lucrative segment, a new, less intense but much larger mainstream market has taken shape. This new segment, which has driven sports nutrition sales growth over the past few years, is composed of recreational sports participants, casual athletes and gym exercisers, women who use these products to achieve their fitness/weight goals, Baby Boomers who want to age well, and moms looking for nutrition support for their children. Nearly six in 10 adults (58 percent) used a sports nutrition product in 2012.
- Weighing In: Consumers have taken a dramatic departure from deprivation-style weight loss diets by simply eating healthier and adding specific real food components and/or nutrients. Even commercial weight management programs are focusing on added health-promoting ingredients (e.g., whole grains, good fats, and real sweeteners) vs subtracting them.

- Gen Zen: Born between 1981 and 2000, Millennials view their food choices as healthier, more expensive, more natural/organic, less processed, and better-tasting than those of their Baby Boomer parents. Fresh is their most important food criteria. Use of functional foods and beverages is highest among the youngest consumers and decreases with age. Millennials are the most likely to believe that functional foods/beverages can be used in place of some medicines.[27]

Functional Foods Innovation Area

As might be expected, the functional foods innovation area has a strong nexus in the efforts of the North Carolina Research Campus, but extends beyond Kannapolis to the research and development activities occurring in the state's main campuses and also in private sector operations throughout North Carolina.

However, given the importance and connection of the North Carolina Research Campus to the future of North Carolina's food-related research and innovation, especially in the area of functional foods, Battelle developed a distinct OmniViz cluster graphic, specifically highlighting those "records" specifying a "Kannapolis" location for the research. These 73 Kannapolis-based records are colored blue in the cluster graphic in Figure 20. In conjunction with Figure 14, it shows the strong connection between the Kannapolis-based activities in nutrition (especially clusters 8, 12, and 17) and food chemistry (especially clusters 3, 16, and 30) with additional work extending into other areas such as food safety. Table 24 details these 73 records by the corresponding Kannapolis research institute or center.[28]

Table 24. Identified Kannapolis/North Carolina Research Campus Research Records within the OmniViz Cluster of North Carolina Food-Related Research and Innovation

North Carolina Research Campus Institutions	Number of Key NC Food-Related Records
Plants for Human Health Institute (NCSU)	26
Center for Excellence in Post-Harvest Technologies (NC A&T)	24
Nutrition Research Institute (UNC)	16
Human Performance Lab (Appalachian State University)	3
Human Nutrition Program (NC Central University)	2
Monsanto-Kannapolis Research	2
Total – Kannapolis-based Research Records	**73**

[27] Sloan, A. Elizabeth. "The Top Ten Functional Food Trends". Food Technology. April 2014. Volume 68. No. 4.

[28] It should be noted that during the January 2009 to September 2014 period used for this analysis the David H. Murdock Research Institute published 28 research articles according to Thomson Reuters Current Contents Connect database. These articles were primarily in the areas of chemistry, biochemistry and biomedical analysis and hence, were not included in the "food" context of the analysis dataset.

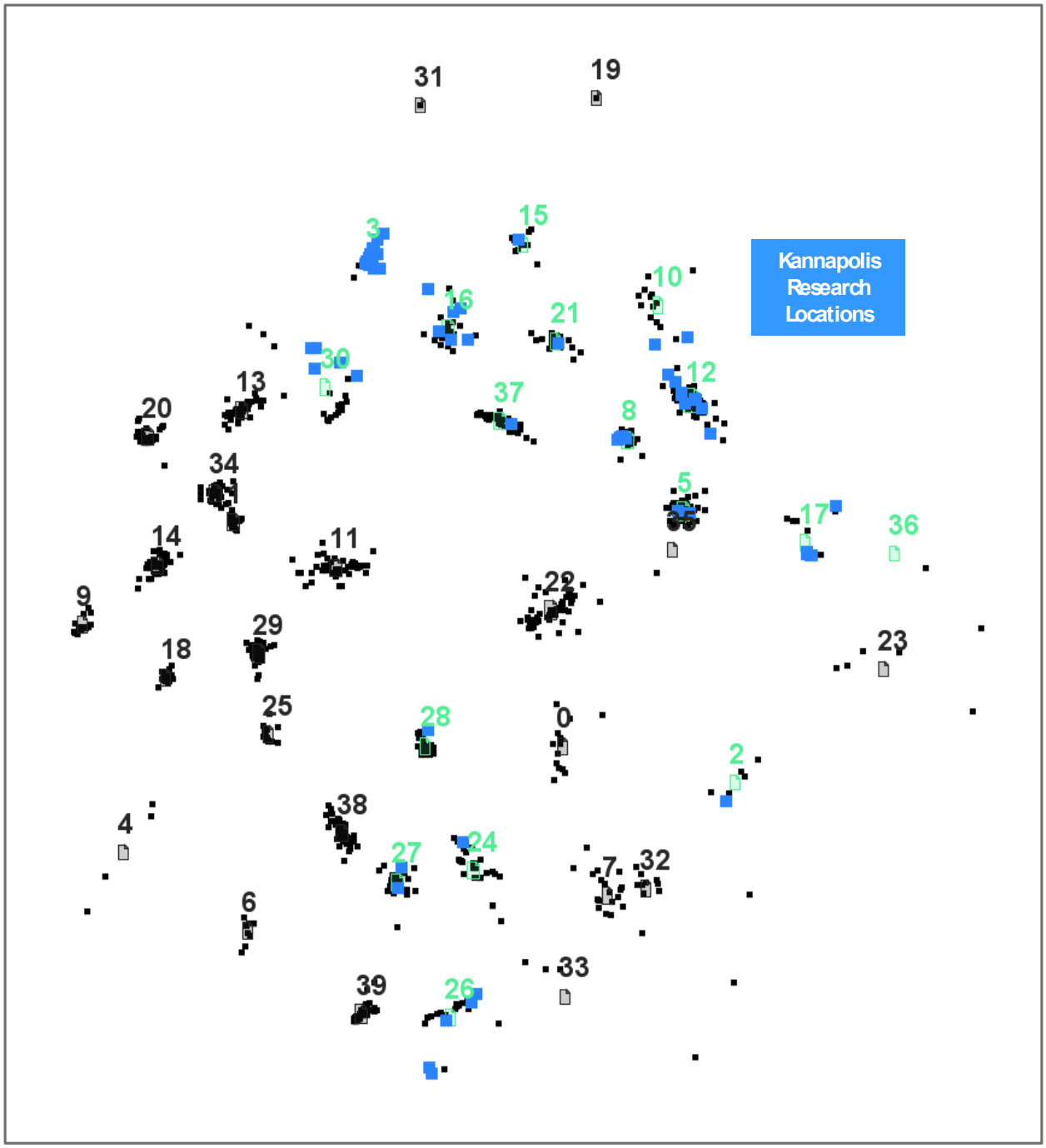


Figure 20. OmniViz Cluster Highlighting Kannapolis Research Locations.

The functional foods innovation area, however, extends well beyond these Kannapolis operations and accounts for more than 300 records from the overall North Carolina OmniViz food-related analysis Table 25). Though NC State maintains a significant involvement in this innovation area, its importance and potential for the state is also shown by the substantial involvement of other North Carolina research institutions, including those in the private sector and within federal government. Together, these institutions provide a rich and diverse approach to the context of functional foods. The challenge remains to leverage these activities to more fully establish the North Carolina Research Campus as a global "destination" for functional food related research, but to also engage the entire state's assets in these areas to for both human health and economic benefits for North Carolina and beyond.

Table 25. Research and Innovation in Functional Foods.

North Carolina Organization	Total Records	Publications	Patent Award	Patent Application	USDA CRIS-Food Related Research Grant
NC State University	144	134	3	2	5
University of North Carolina	46	45			1
North Carolina A&T State University	31	20	1		10
Duke University	22	22			
Wake Forest University	11	10		1	
East Carolina University	9	9			
Appalachian State University	8	8			
NIH – National Institute of Environmental Health Sciences	8	8			
North Carolina Central University	5	3			2
Research Triangle Institute	4	4			
Algaen Corporation	2	1		1	
BioLink Life Sciences	2	2			
Monsanto	2	2			
BASF Plant Sciences	1	1			
BestSweet	1			1	
Carolina Soy Products	1		1		
Integrated Lab Systems	1	1			
Panacea Biomatx Inc.	1			1	
RDI Foods	1			1	
Syngenta Biotechnology	1	1			
Van Hees	1			1	
Zen Bio	1	1			
Total Records*	**304**	**261**	**9**	**16**	**18**

* Includes records for individuals and other organizations; some records are counted in more than one innovation area.

Functional Foods Global Market Potential – Opportunities to Leverage

With the increased consumer interest in health solutions, there has been a shift towards producing foods that address personal health issues. Functional food, food that has one or more bioactive ingredient added to it, has been developed to answer this shift in demand. As a result, around the globe, traditional food processing and manufacturing companies are largely entering the value-added food and health product market to compensate for the lower margins being realized in the traditional food industry. For instance, while the nutraceutical market is comparatively smaller than the overall food market, it offers the opportunity for higher profit margins. Retail prices for such products are typically 25 percent to 500 percent above comparable conventional foods as consumers are willing to pay more for additional benefits.[29] Consumers are willing to pay higher prices as they become more educated about their health and how they can personalize their health maintenance.

Large beverage giants, seeing a continuous drop in sales of carbonated drinks over the past several years, are entering the functional beverage segment with noncarbonated sports and energy drinks. Functional beverages holds the top position in the global nutraceuticals market, with the functional food and dietary supplements markets close behind. The functional beverages market had a value of $59.4 billion in 2013, and is projected to grow to $92.8 billion by 2019, with a CAGR of 7.8 percent. The global functional food market is expected to have a CAGR of 6.6 percent over the same time period, with an expected value of $75.7 billion by 2019. Dietary supplements are expected to reach $72.6 billion by 2019, with a CAGR of 6.4 percent. The North American market held 37.7 percent of the global nutraceutical market in 2013, followed by Asia-Pacific and Europe with 30 percent and 27 percent respectively.

The functional food market has adapted over the years as consumer preferences and technology has changed. Earlier products in this industry suffered from a lack of appealing taste, which has caused functional food manufacturers to turn their attention to improving the taste of their products. Consumers may pay higher prices for functional food, but it must also taste good to sell. Interestingly, as a result, growth in the value-added food and health product market has implications for the flavors and flavor enhancers market due to their ability to mask the sometimes unpleasant taste of functional additives. Demand for flavors and flavor enhancers totaled $2.5 billion in 2010 based on advances of 3.6 percent per year[30], and is anticipated to grow at a steady state for the foreseeable future. More than 1,500 different flavoring materials are used by the food and beverage industry, and the final formulation of a flavor for use in an individual product may require more than 100 components.

[29] BCC Research. Nutraceuticals: Global Markets and Processing Technologies. July 2011.
[30] Freedonia. Food and Beverage Additives. August, 2011

Chapter 5: The North Carolina Food Processing and Manufacturing Initiative: A Significant Opportunity to Foster the Growth of the Food-Related Value Added Supply Chain in North Carolina

Food Processing and Manufacturing Initiative: Next Steps

From the prior analyses, it is clear that North Carolina has a unique opportunity to leverage its agricultural resources, industrial capacity, and research innovation assets to catalyze the economic growth of an important value-added industry. It is therefore proposed that a Food Processing and Manufacturing Initiative be developed that will serve to catalyze the development of the food value chain throughout the state of North Carolina. It is envisioned that the Food Processing and Manufacturing Initiative would be composed of four primary initiatives:

1. A Food Product & Process Innovation Center
2. A Value-Added Food Entrepreneurship Network
3. A Pro-Active Industrial Recruitment Campaign
4. Regulatory Training and Outreach.

Furthermore, due to the significant level of activity already undertaken by NC State's Department of Food, Bioprocessing, & Nutrition Sciences (FBNS) and the N.C. Department of Agriculture and Consumer Services (NCDA&CS) in support of the development of North Carolina's food manufacturing industry sector, it is proposed that the two organizations partner to establish a guiding coalition that will map a strategy to achieve the recommendations in this study. Other key stakeholders that will need to be part of the coalition include industry stakeholders, the North Carolina Department of Commerce, existing food-related entrepreneurial endeavors, research innovation assets located throughout the state of North Carolina at a variety of higher education and research institutions, and the workforce development and community college system. As a first step, FBNS and NCDA&CS should work to obtain funding to hire a project director to manage the development of a detailed strategic business plan to leverage and coordinate existing activities and design new programmatic efforts where required to implement the four primary initiatives of the North Carolina Food Processing and Manufacturing Initiative described in further detail below. It is anticipated that funding in the amount of $500k/year for a three-year period would be required to plan and develop the Food Processing and Manufacturing Initiative. As part of the strategic business planning effort, additional sources of funding would need to be developed and sought for build-out and programmatic implementation.

A Food Product & Process Innovation Center

The ability of North Carolina's food manufacturing industry to become more product-driven can be catalyzed by the development of a Food Product & Process Innovation Center that would serve as a statewide resource to increase the breadth, depth, and expertise in product development, as well as applying emerging technologies to solve real-world food security problems.

It is envisioned that the Food Product & Process Innovation Center would be comprised of food labs, GMP pilot plant facilities, intermediary food processing facilities, and demonstration facilities built around the specialized knowledge and expertise in North Carolina's five innovation drivers: food product and process innovation, packaging, functional foods, flavors, extracts and sensory technologies, and food security (see Figure 21). The Center would focus its activities on downstream pilot-plant and product production and applications support rather than the more basic research found within a typical academic department.

Figure 21. Food Product & Process Innovation Center Model.

It is envisioned that the Food Product & Process Innovation Center would leverage the existing capability of the NC State Department of FBNS, including the following assets:

- Pilot plants dedicated to specific commodity areas including dairy products, fruits and vegetables, high viscosity/particulates, meats, seafood, and visual imagery, in addition to the USDA ARS units focused on vegetables and peanuts.
- Center for Advanced Processing and Packaging Studies (CAPPS), a National Science Foundation-initiated program focused on conducting cutting-edge packaging research including emerging technologies such as ohmic heating, high pressure processing, ozone processing, continuous microwave heating, and aseptic processing of particulates.
- Sensory Service Center, which provides flavor research services, including targeted food testing and food evaluation, which helps companies solve flavor quality problems.
- The Southeast Dairy Foods Research Center (SDFRC), which develops and applies new technologies for processing of milk and its components into dairy products and ingredients with improved health, safety, quality, and expanded functionalities.

- Entrepreneurial Initiative for Food (Ei4F) program, which works with small business owners and prospective entrepreneurs to manufacture and process quality food products safely by providing services such as product testing, product classification, nutritional labeling, and label review.
- Plants for Human Health Institute (PHHI) on the N.C. Research Campus that focuses on research that utilizes food crops, not merely as sources of nutrients and calories, but as powerful resources for components that protect and enhance human health and well-being.

It is envisioned that in addition to working with a range of companies, encompassing every stage in the business life cycle, the Food Product & Process Innovation Center would also be charged with working with the various state commodity groups to ascertain which commodities would be best served by developing a value-added research and application program, similar to the work that was done with the North Carolina SweetPotato Commission. By leveraging the experiences gained by FBNS over the years, North Carolina can work to further develop value-added products for a variety of commodities produced within the state. It may be necessary to develop intermediary aggregators and processors in order to develop a critical mass, or economies of scale, to ensure the economic viability of such efforts. NC State's NC Growing Together project can serve as a valuable resource in that endeavor. It will also be critical to develop a public/private/academic partnership, similar to the sweet potato effort that was supported by the SweetPotato Commission, the Golden LEAF Foundation, and research undertaken at NC State. Areas of potential opportunity include a wide variety of fruit and vegetable purees, homogenates and pulps that can be sterilized rapidly and stored under ambient temperature conditions. In addition, dairy products, meat pieces in a variety of sauces, cheese dips and sauces, salsas, soups, and stews also demonstrate as viable candidates for continuous flow microwave sterilization and aseptic packaging.

As a next step, a business plan for the Food Product & Process Innovation Center needs to be developed, including the initial design and organizational planning. It is envisioned that the Food Product & Process Innovation Center would be located on NC State's Centennial Campus serving from a central location the needs of the food processing and manufacturing industry across the state. It would also be tasked with working across the gambit of food products. This will necessitate the need to determine what capacity will need to be relocated from Schaub Hall on the main campus of NC State to the new facility, as well as what additional capacity in various commodities, including meat specialties which is viewed as currently underrepresented, will need to be added. It is also envisioned that a satellite location would be cited on the N.C. Research Campus focused on product and process innovations related to functional foods, but with close ties to the packaging, flavors, extraction and sensory technologies, and food safety expertise located primarily in Raleigh.

Finally, it must be understood that the success of the Food Product & Process Innovation Center will be predicated in the end not by the physical capital that is sited at the facility but instead by the human capital that drives the product and process innovation. As a result, the greatest threat to the success of such an effort is the continuing decline and diminished capacity of the faculty of the FBNS Department. Moving forward, it will be critical that positions in food-related manufacturing and engineering positions be restored to previous levels and that specific expertise that can drive product and process innovation in North Carolina be sought.

A Value-Added Food Entrepreneurship Network

If North Carolina is to have the ability to scale entrepreneurial endeavors to a level in which economic development will be impactful, it will be critical to develop a seamless entrepreneurial services delivery system that provides all of the services required by an entrepreneur to ideate, develop, create, and scale their food processing and/or food manufacturing business. It is envisioned that a “hub and spoke” value-added food entrepreneurship network would be created to ensure that start-up companies were able to be assisted at a regional level while still ensuring that resources were not duplicated for capacity that can be more centrally located. To this end, it is envisioned that three nodes would be developed initially, one in each region of the state. All three nodes would provide a full range of business assistance and market development expertise. The three nodes would also develop intermediary processing capability that could be utilized by start-up companies from throughout their region and tailored to the specific agricultural commodities with the greatest demand for further processing/manufacturing. In addition, start-up companies that are obtaining business and marketing support from a regional node would also be able to gain access to more technical expertise located at the Food Product and Process Innovation Center.

Each regional entrepreneurial node would partner with a variety of different organizations, including NCDA&CS, regional Colleges of Business, and associated programs across the entrepreneurial development system to provide the following services:

- Organizational documentation, preliminary technology and market assessments, and start-up strategic planning
- Management and in-depth business planning support to entrepreneurs and start-up companies
- Link companies to mentors
- Conduct due diligence
- Provide consultation and ongoing entrepreneurial education
- Prepare companies to seek financing
- Link companies to sources of capital
- Support development of angel networks

By leveraging the existing support services currently provided across North Carolina, a value-added food entrepreneurial center could ensure that comprehensive, in-depth business development, product development, and commercialization support services are readily available and easily accessible to entrepreneurs and start-up food processing and manufacturing companies. Start-up and emerging value-added food companies need access to professional expertise, assistance in conducting market research and developing marketing strategies, and help in determining economic feasibility. They also need access to quality facilities with specialized equipment and laboratories, the ability to recruit key personnel, a support infrastructure familiar with food businesses, and access to small amounts of working capital.

It is proposed that the three proposed value-added food entrepreneurial centers serve as a regional single point of entry for food start-up companies that can assess their needs, guide them through the product and process innovation and commercialization process, and link them to a comprehensive network of food assistance services as appropriate. The ultimate goal for each entrepreneurial center would be to serve as the single point of entry for all within the region that are interested in pursuing

opportunities within the food value chain, thereby eliminating much of the confusion and uncertainty that currently exists with regards to where an entrepreneur can turn for help and/or assistance.

As a next step, a business plan for Value-Added Food Entrepreneurship Network, including the design of each node and the relationship between them, needs to be developed. Part of this initial planning will be to determine what services must be provided on a regional level versus those that can be centralized and incorporated into the Food Product and Process Innovation Center. Finally, the three regional nodes will need to be identified. Based on the existing analysis, it is recommended that Blue Ridge Ventures, located in Asheville, would be a strong partner as the Mountain Region's value-added food entrepreneurship node, and if selected, would also bring intermediary processing capacity to the network. It is further recommended that the Piedmont Region's value-added food entrepreneurship node be co-located at the Food Product and Process Innovation Center in order to leverage the research, innovation assets, pilot plants, and intermediary processing capacity that will be developed at that facility, as well as to develop a level of critical mass for the overall statewide endeavor. Finally, it is recommended that a value-added food entrepreneurship node be located within the Coastal Plains region, possibly leveraging the efforts of Ayden to develop a food manufacturing entrepreneurship center.

A Pro-Active Industrial Recruitment Campaign

As previously indicated, North Carolina is in the unique position to proactively leverage its unique biomass value-added production capabilities, including access to agricultural commodities, water, a trained workforce, and proximity to large population centers, to proactively pursue food manufacturing attraction opportunities. As a next step, the North Carolina Department of Commerce, in close partnership with the NCDA&CS, should either develop or recruit staff with food processing/manufacturing business model expertise and then proactively target potential candidates for relocation marketing efforts. In addition, the state's economic development toolkit will need to be examined to ensure that the current offerings are relevant to this industry sector and are on par with other state's incentive programs.

Regulatory Training and Outreach

In interviews with small and medium size food processors and manufacturers, significant concern was expressed regarding their ability to understand and then comply with the vast regulations of the industry. The implementation of FSMA is only continuing to put a strain on the time, resources, and knowledge required to ensure that a company remains compliant with both the federal and state regulations. In particular, due to the roll-out nature of FSMA, companies, as well as inspectors, are finding it difficult to stay abreast of changes that are being implemented.

North Carolina, led by the efforts of NC State, is already well regarded for its regulatory training and outreach to both industry as well as state and federal inspectors. North Carolina has the opportunity to further set itself apart from other states by proactively developing additional in-depth training, education, and outreach efforts relevant to the food processing and manufacturing sector and relevant inspectors, particularly as it relates to the ongoing roll-out of FSMA. By helping to ensure that the small and medium size food processors and manufacturers in the state, as well as those that are tasked with undertaking the inspections, have access to the knowledge required in an educational format that is tailored to their specific situation, North Carolina has the opportunity to create a competitive advantage for its industrial base by proactively helping to improve the business climate.

As a next step, NC State should leverage the relevant regulatory training, extension, and outreach work already being conducted to ensure that the training is up to date and continually redeveloped as FSMA is implemented. Trainings then need to be offered in a timely manner to companies and inspectors located throughout the state. The Entrepreneurship Nodes could serve as a location partner, helping to ensure that it is viewed as the portal for entrepreneurship training and educational needs.

Potential Economic Impact from Fostering the Growth of the Value-Added Food Manufacturing Industry in North Carolina

The value-added food manufacturing industry in North Carolina provides jobs for many employees across a variety of industries which represent a significant portion of state economic activity. Measuring this economic impact and the effect of projected future changes to employment levels in the state can serve as way of understanding the implications of strategic decisions to grow the industry through focused initiatives.

Overview of Economic Impact Analysis

Analysis of the economic footprint of an industry relies on tying employment in industry sectors to the economic output they produce. Output is defined as the dollar value of goods and services produced by a company, and summing output across all companies in an industry yields total industry output. The footprint of an entire industry in terms of its output is common known as the industry's economic impact, and can be categorized within the context of the state's larger economic output to determine the importance in driving overall state economic activity.

The economic impact analysis for North Carolina value-added food manufacturing industry makes use of a custom economic input/output (I/O) model that quantifies the interrelationships between economic sectors in the state economy. I/O data matrices track the flow of commodities to industries from producers and institutional consumers within the state. The data also show expenditure and consumption activities by workers, owners of capital, and imports. These trade flows built into the model permit estimating the impacts of one sector on all other sectors with which it interacts.

The measured economic impacts of the value-added food manufacturing in North Carolina consists of three types:

- Direct effect: The dollar valuation of all goods and services provided as output by a food manufacturing industry
- Indirect effect: The valuation of all of the inter-industry transactions between a food manufacturing industry and other companies that supply the materials or services required to produce output
- Induced effect: The valuation of household income supported by the food manufacturing industry through expenditures its employees make at other local industries

Together, these three effects comprise total economic impact. I/O analysis thus models the flow of funds that originate from North Carolina's food manufacturing industry expenditures in the state's economy and the ongoing ripple (multiplier) effect of these expenditures. In other words, economic impact models are based on the concept of the "multiplier" – every dollar spent in the economy is re-spent one or more times in the local economy, thereby generating additional economic activity and impact. I/O analysis represents the generally accepted standard for measurement of economic impacts.

The current estimated impacts of the food manufacturing industry were calculated using 2012 North Carolina-specific I/O models generated by the IMPLAN Group. The analysis builds upon a foundation of employment data included within the IMPLAN I/O model that is built primarily from the U.S. Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW, tied to unemployment insurance reporting). These data provide detailed intelligence on the number of establishments, monthly employment, and quarterly wages, by North American Industry Classification System (NAICS) industry, by county geography, by ownership sector, and for the entire U.S. The IMPLAN model employment data is further enhanced by U.S. Bureau of Economic Analysis data to account for sole proprietorships and other very small firms that fall outside of the QCEW data collection protocols.

For this analysis, a customized model was developed to quantify the direct, indirect and induced effects of the food manufacturing industry in the state. The model incorporates detailed subsectors of the food manufacturing industry and their interrelationships with more than 430 other individual sectors that cover the entire state economy. With these data, the analysis is able to show not only the overall impact on the state economy, but impacts on specific sub-sectors of the economy that are strongly dependent on economic activity generated by the food manufacturing sector.

The following data are output from each model: ***employment*** (combined number of full and part-time workers), ***personal income*** (measures cash, benefits and non-cash payments received by individuals in the economy), ***value added*** (the difference between an industry's or an establishment's total output and the cost of its intermediate inputs), ***economic output*** (the dollar value of sales, goods, and services produced in an economy, is sometimes referred to as business volume, and represents the typical measure expressed as "economic impact" in a standard economic impact study).

Current Impact of Food Manufacturing Industry and Recent Employment Trends

Employment totals by industry from the state 2009 and 2012 QCEW data releases were used to examine the economic impact of the food manufacturing industry in North Carolina. For a more detailed listing of the specific NAICS sectors used to represent the state's value-added food manufacturing industry and key supporting industry functions, please see Appendix A.

The IMPLAN model is built upon more than 430 sectors of the economy ranging from specific agricultural sectors to the U.S. Postal Service, and includes both private and public sector activities. Even at this level of detail, IMPLAN models many sectors at a 5-digit NAICS code level and many others at an even higher level of aggregation. To develop the impact model for North Carolina required Battelle to "map" the food manufacturing industry sectors and subsectors described in the previous economic analysis to the specific IMPLAN model sectors. This approach is much preferable than to aggregate the entire food processing/manufacturing industry into a single impact model industry.

Table 26 shows the 41 IMPLAN sectors used in the analysis of the NC food manufacturing industry and the total employment in 2009 and 2012 mapped to each one.

Table 26. North Carolina Employment by IMPLAN Sector in Food Manufacturing and Related Industries.*

IMPLAN Sector	2009 NC Employees	2012 NC Employees	Employment Change 2009–2012
41 Dog and cat food manufacturing	215	237	22
42 Other animal food manufacturing	1,117	1,161	44
43 Flour milling and malt manufacturing	931	884	−47
44 Wet corn milling	65	139	74
45 Soybean and other oilseed processing	83	257	174
46 Fats and oils refining and blending	173	0	−173
47 Breakfast cereal manufacturing	78	176	98
50 Chocolate and confectionery manufacturing from cacao beans	1	8	7
51 Confectionery manufacturing from purchased chocolate	192	106	−86
52 Nonchocolate confectionery manufacturing	353	559	206
53 Frozen food manufacturing	269	248	−21
54 Fruit and vegetable canning, pickling, and drying	2852	2680	−172
55 Fluid milk and butter manufacturing	423	446	23
56 Cheese manufacturing	10	10	0
58 Ice cream and frozen dessert manufacturing	318	494	176
59 Animal (except poultry) slaughtering, rendering, and processing	10,520	9,479	−1041
60 Poultry processing	21,978	21,496	−482
61 Seafood product preparation and packaging	603	671	68
62 Bread and bakery product manufacturing	5,201	4,702	−499
63 Cookie, cracker, and pasta manufacturing	2,426	2,267	−159
64 Tortilla manufacturing	167	247	80
65 Snack food manufacturing	1,426	1523	97
66 Coffee and tea manufacturing	533	598	65
67 Flavoring syrup and concentrate manufacturing	30	30	0
68 Seasoning and dressing manufacturing	173	203	30
69 All other food manufacturing	2,030	2,080	50
70 Soft drink and ice manufacturing	2,125	2,199	74
71 Breweries	1,019	1,280	261
72 Wineries	495	741	246
73 Distilleries	0	5	5
107 Paperboard container manufacturing	3,434	2,686	−748
108 Coated and laminated paper, packaging paper and plastics film manufacturing	421	483	62
109 All other paper bag and coated and treated paper manufacturing	735	632	−103
142 Plastics packaging materials and unlaminated film and sheet manufacturing	1,569	1,681	112
148 Plastics bottle manufacturing	906	822	−84
158 Glass container manufacturing	783	803	20
190 Metal can, box, and other metal container (light gauge)	419	399	−20

IMPLAN Sector	2009 NC Employees	2012 NC Employees	Employment Change 2009–2012
manufacturing			
207 Other industrial machinery manufacturing	296	183	−113
231 Packaging machinery manufacturing	352	297	−55
319 Wholesale trade businesses	26,662	26,705	43
340 Warehousing and storage	1025	967	−58
Total	**92,408**	**90,584**	**−1824**

* Note: Employment data presented here for primary agricultural product sectors does not include unincorporated farms.

Using the IMPLAN sector mappings for food manufacturing industry employment, the economic impact analysis results for the North Carolina food manufacturing industry's economic footprint in 2012 are shown below in Table 27.

Table 27. Economic Impact Results for 2012 NC Food Manufacturing Industry Employment.

Impact Type	Employment	Labor Income ($M)	Value Added ($M)	Output ($M)
Direct Effect	90,584	$5,465	$14,333	$41,650
Indirect Effect	95,639	$5,181	$9,205	$19,922
Induced Effect	66,554	$2,770	$5,277	$8,343
Total Impact	252,777	$13,416	$28,816	$69,914
Multiplier	2.79	2.45	2.01	1.68

This analysis shows that in 2012 the food manufacturing industry in North Carolina had the following economic impacts:

- $70 billion in total North Carolina economic output (business volume), comprising $42 billion in direct economic output and $28 billion in indirect and induced output.
- Employed 252,777 people in North Carolina, comprising 90,584 direct jobs and a further 162,193 jobs generated in the North Carolina economy via the employment multiplier effect.
- Direct and indirect employment generated personal income for North Carolina residents amounting to $13.5 billion annually. This is divided between direct income at $5.5 billion and indirect and induced income at $8 billion.

The effect that direct industry spending and employment has on economic activity across all other industries in the state is known as the industry's multiplier. One employee in the food manufacturing industry in 2012 supported approximately 1.79 additional employees (multiplier of 2.79) in other industry sectors, and every $1 in spending from the food manufacturing industry generated $0.68 in additional industry spending (multiplier of 1.68) across all other industry sectors in the state.

As indicated in Chapter 2, total net employment in the food manufacturing and support industries in North Carolina decreased by 2 percent from 2009 to 2012, driven largely by declines in animal product processing industries as well as the paperboard container manufacturing industry. During this same period, overall U.S. employment in these same sectors increased by 1.4 percent, indicating that the state saw much larger declines than expected given national trends. These declines are significant when compared against potential gains that could have been achieved had NC matched U.S. industry growth

rates in several key food manufacturing industries where they experienced the largest declines. Figure 22 shows the direct employment decline from 2009–2012 and its total associated employment impact.

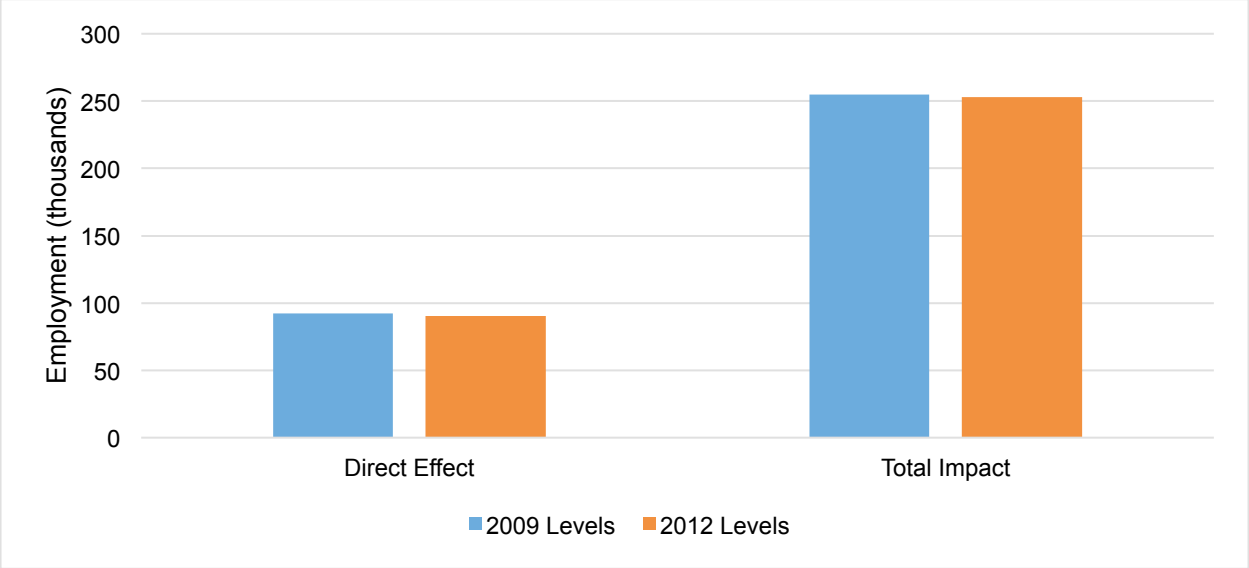


Figure 22. Direct Employment and Total Employment Impact for NC Food Manufacturing Industries in 2009 and 2012.

The 3,688[31] jobs in food manufacturing industries lost from 2009 to 2012 represent direct business output of almost $1.5 billion in state economic activity which in turn generated another $1 billion in indirect and induced economic activity. Although growth in other high output industries in the food manufacturing cluster mitigated the net effects of this output loss by 2012, the differences between the business activity lost in the state economy versus much lower expected losses given national trends highlight the importance of continued support to the food manufacturing cluster to ensure that it at least matches, if not exceeds, larger industry growth patterns.

Projections for Future Food Manufacturing Industry Employment Impact and Growth

Future changes to employment in key food manufacturing sectors can have a large impact on the overall economic footprint of the industry, and variability in future economic conditions creates a range of possible growth scenarios that North Carolina could experience. In order to assess the potential impact of employment changes on economic output of the industry, the impacts of three potential employment level scenarios were evaluated in terms of their effect on food manufacturing industry output by 2020. These scenarios correspond to varying perspectives on the future of economic conditions in the state, ranging from continuation of the declines in North Carolina industry employment experienced from 2009 through 2012, to expected growth projections from employment statistics agencies, to increased growth levels catalyzed by the establishment of initiatives to support, develop, and attract food manufacturing industry firms.

[31] This total does not include 173 jobs lost in IMPLAN sector 46: Fats and oils refining and blending since there was no industry data available in 2012 to estimate economic impacts.

Several sources of employment growth projections across various industries and geographies exist. The U.S. Bureau of Labor Statistics (BLS) publishes detailed 10-year employment and output growth projections at the industry level, and state employment statistics agencies often publish their own similar forecasts customized to account for state-specific characteristics and expectations about future economic conditions.[32] For the expected growth scenario, this analysis utilizes 10-year employment projections published by the North Carolina Department of Commerce's Labor and Economic Analysis Division (NC LEAD). These projections are refined annually based on observed statewide economic trends in order to guide expectations about future levels of employment and output. Projections at the 3-digit NAICS code level regarding the cumulative annual growth rate (CAGR) of employment in various industries were used to estimate levels of employment in the key components of the food manufacturing industry (e.g., food processing, packaging, wholesale, etc.) in 2020. The CAGR represents the estimated percentage change in employment totals for each year, compounded annually, and assumed to be observed every year until 2020. Using CAGR projections at the key component level, the net NC LEAD projected CAGR across the food manufacturing industry through 2020 is 1.4 percent.

The continuation of the recent North Carolina employment trend used the observed net decline in total state employment across all food manufacturing and related industries to calculate a CAGR of -0.5 percent for this time period, and assumed that this trend would continue through 2020 across all food manufacturing industries. Alternatively, the establishment of a focused initiative to support food manufacturing and support industries as well attract new firms to the state was assumed to result in higher than expected growth rates for the industry. For this scenario, it was assumed that such an initiative would result in individual industry growth rates that exceeded NC LEAD CAGR projections by 1 percent, resulting in a net total CAGR through 2020 of 3.5 percent across all food manufacturing and support industries.

The scenario rates and projected 2020 employment totals in the food manufacturing and support industry cluster are shown in Table 28. Note that the overall CAGRs discussed above and shown here represent the aggregate rate after combining all of the individually projected industry CAGR's which were used to calculate total changes in employment by 2020. These are provided as a reference point for comparing the overall changes in the various growth scenarios - calculation of specific economic impacts due to projected employment changes uses the industry level CAGRs to show the net impact of employment increases and decreases in individual IMPLAN industries.

Table 28. Assumptions of 10 Year Employment Projection Scenarios for NC's Food Manufacturing Industry.

Projection Scenario	Assumed Net Cumulative Annual Growth Rate (across all industries)	Projected 2020 Total Food Manufacturing Industry Employment
Continuation of 2009–2012 Decline in Food Manufacturing Industry Employment	−0.5%	87,043
Attain 10-Year Projected Growth Rates from NC LEAD	1.4%	95,883
Attain Higher Growth Rates Than Expected Due to Implementation of Food Processing/Manufacturing Initiatives	3.5%	103,768

[32] Unfortunately, these projections are often only at a 3- or 4-digit NAICS level, which can obscure specific sector and subsector differentiation in growth.

The IMPLAN 2012 model for North Carolina was used to evaluate the implications of these projected employment trends by 2020 to determine the potential economic output gains and losses that might be observed for the state economy.

Worst Case Scenario: Continued Decline of the Industry

Under assumed rates of continued decline, the total employment in food manufacturing is projected to shrink from 2012 levels by an estimated 3,541 employees. Economic impact results for this scenario are shown in Table 29.

Table 29. Economic Impact Results for 2020 Projected NC Food Manufacturing Industry Employment under Continued Decline Scenario.

Impact Type	Employment	Labor Income ($M)	Value Added ($M)	Output ($M)
Direct Effect	87,043	$5,251	$13,773	$40,022
Indirect Effect	91,900	$4,978	$8,846	$19,143
Induced Effect	63,953	$2,662	$5,071	$8,017
Total Impact	242,896	$12,892	$27,689	$67,181

The total impact of output losses to the state's economy under this scenario would be over $2.7 billion dollars, making it critical to alter the course of recent economic trends for the sector.

Status Quo Scenario: Industry Matches NC LEAD Projections

NC LEAD projects total employment in food manufacturing and related industries to grow by 5,299 employees through 2020. Economic impact results for this scenario are shown in Table 30.

Table 30. Economic Impact Results for 2020 NC LEAD Projected Food Manufacturing Industry Employment.

Impact Type	Employment	Labor Income ($M)	Value Added ($M)	Output ($M)
Direct Effect	95,883	$6,186	$16,041	$44,003
Indirect Effect	102,204	$5,526	$9,814	$21,307
Induced Effect	73,216	$3,048	$5,805	$9,178
Total Impact	271,303	$14,760	$31,660	$74,488

The total impact of projected growth in economic output to the state's economy by 2020 is estimated to be approximately $4.6 billion dollars. NC LEAD's 10 year employment projections for specific NAICS industries align fairly closely with overall U.S. projections published by BLS.

Best Case Scenario: Food Processing and Manufacturing Initiative is Implemented Catalyzing Development of the Industry

Given the implementation of a food processing and manufacturing initiative to catalyze industry development, the total employment in food manufacturing is projected to grow from 2012 levels by an estimated 13,184 employees bringing the total state employment in the industry cluster above 100,000 employees. Economic impact results for this scenario are shown below in Table 31.

Table 31. Economic Impact Results for 2020 Projected NC Food Manufacturing Industry Employment under Growth Initiative Implementation Scenario.

Impact Type	Employment	Labor Income ($M)	Value Added ($M)	Output ($M)
Direct Effect	103,768	$6,207	$16,139	$47,622
Indirect Effect	110,599	$5,981	$10,620	$23,057
Induced Effect	76,186	$3,171	$6,041	$9,550
Total Impact	290,553	$15,359	$32,800	$80,229

If even slight increases in individual industry growth rates over currently projected trends are achieved, particularly for those industries predicted to experience stagnant growth or slight declines, the stakes are large for North Carolina's economy. Battelle anticipates that if the initiatives prescribed in this report are implemented, by the year 2020 the annual economic impact of North Carolina's food manufacturing industry could be:

- $80.2 billion in total North Carolina economic output (business volume), comprising $47.6 billion in direct economic output and $32.6 billion in indirect and induced output.
- 290,553 jobs in North Carolina, comprising 103,768 direct jobs and a further 186,785 jobs generated in the North Carolina economy via the employment multiplier effect.
- Direct and indirect employment generating personal income for North Carolina residents amounting to $15.4 billion annually. This is divided between direct income at $6.2 billion and indirect and induced income at $9.2 billion.

Projected Impact

Battelle anticipates that the total direct and indirect impact of the food value chain, with the prescribed steps of this study implemented, will be an increase of 37,776 jobs and an increase in associated economic output of $10.3 billion by 2020.

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Chapter 6: Conclusion

A Call to Action

North Carolina's economy has a rich history in converting or transforming its biomass resources into value-added products. However, North Carolina's long-standing dominance in value-added biomass processing and manufacturing has been in a state of decline. Over the last two decades:

- The textile industry, which has historically been a key driver of North Carolina's economy, has faced significant employment decline in the state as a result of increased competition from foreign textile producers, which has resulted in either mill closings or the development of labor-saving machinery to drive down costs.
- North Carolina's long dominance in the furniture industry has been challenged by the increasingly global nature of furniture manufacturing, leading to North Carolina plant consolidations and shutdowns, and furniture production being offshored.
- The tobacco industry, a backbone of the state's agricultural heritage, has been laying off large numbers of workers and relocating their factories to less expensive areas.

This decline in value-added biomass processing and manufacturing industries has led to underutilization of capacity throughout the state of North Carolina, particularly within the rural regions of the state. This then begs the question as to whether or not it is feasible to transition this underutilized capacity to strengthen and grow another industrial sector – namely the value-added food manufacturing sector.

The answer to this question is, unequivocally, yes. By fully leveraging the existing value-added biomass processing and manufacturing capacity of the state, found particularly in the rural regions, along with North Carolina's key innovation drivers, the economic decline can be reversed by developing programs and initiatives that leverage North Carolina's unique opportunities and help it to overcome the market barriers and hurdles that are currently impeding the industry's development.

As a result of the analysis, it is clear that North Carolina has a unique opportunity to leverage its agricultural resources, industrial capacity, and research innovation assets to catalyze the economic growth of an important value-added industry. It is proposed that a Food Processing and Manufacturing Initiative be developed that will serve to catalyze industrial development throughout the state of North Carolina, it should focus on four primary objectives:

- Capture added-value from North Carolina's agricultural commodities through the development of innovative food products and processing technologies
- Foster the growth of food manufacturing entrepreneurial endeavors
- Proactively target site selection attraction opportunities within the food manufacturing supply chain
- Provide regulatory training and outreach to the food processing and manufacturing sector.

Due to the significant level of activity already undertaken by both NC State's Department of FBNS and NCDA&CS in support of the development of North Carolina's food manufacturing industry sector, it is proposed that the two organizations partner to establish a guiding coalition that will map a strategy to achieve the recommendations in this study.

A Coordinated North Carolina Ecosystem for Addressing Opportunities in the Grand Global Challenge of Feeding the World

As noted in the introduction of this report, as well as in a document written at the same time entitled *The North Carolina Plant Science Initiative: An Economic Feasibility Study*, among the most critical challenges facing humankind is the challenge of feeding the world's expanding human population in a sustainable manner. Meeting this grand challenge is no small task, with current estimates indicating a need to increase available food by 70 percent by 2050 in order to be able to feed the world's growing population. This challenge has to be met sustainably, without pressing more marginal lands into production, degrading the environment, or depleting scarce freshwater resources.

Three macro-areas of innovation and advancement are needed in order for the challenge to be met:

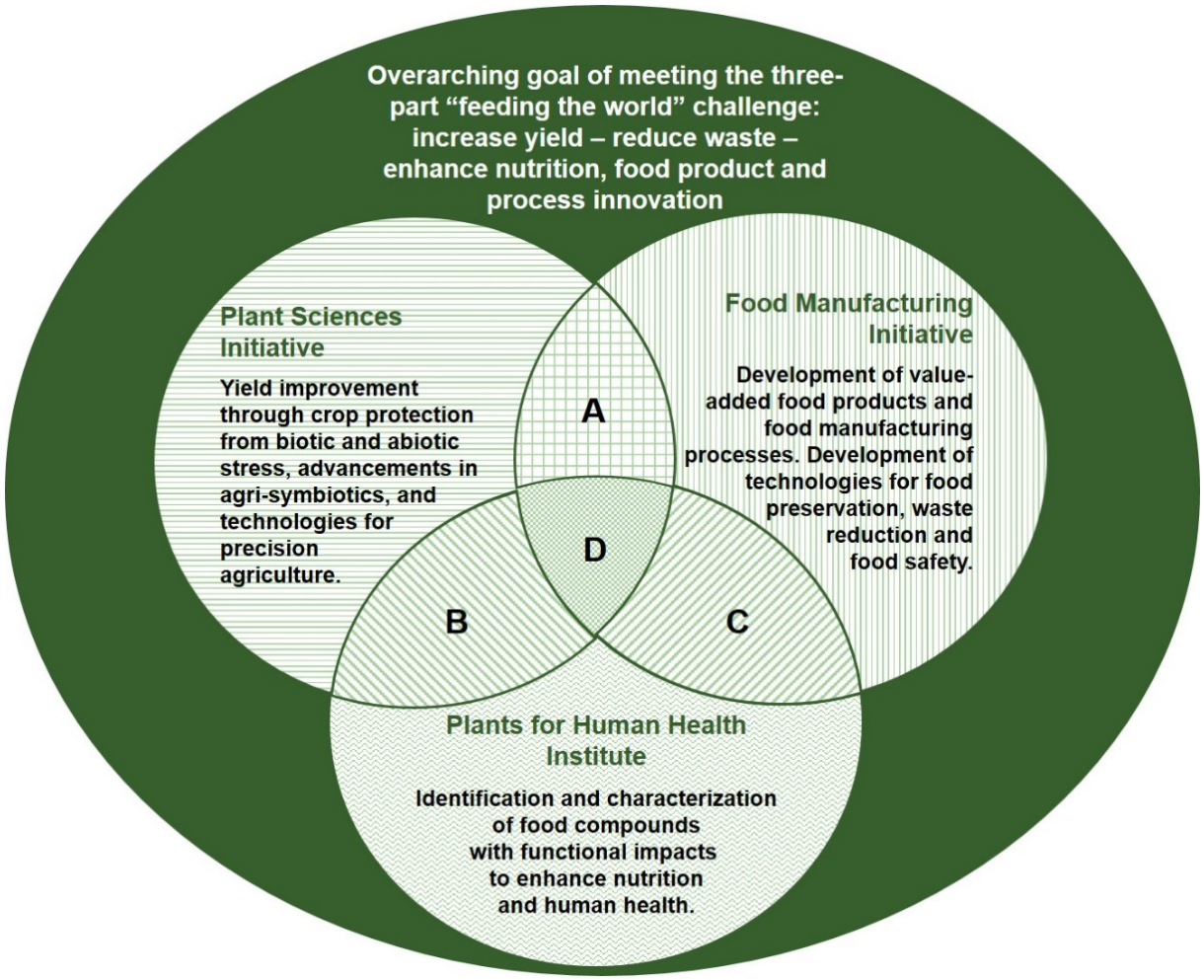
1. Increase agricultural yield and production efficiency
2. Reduce the significant volume of post-harvest food waste that occurs
3. Provide global consumers with highly nutritious, healthy and affordable food products.

North Carolina has a unique opportunity to be at the forefront of providing research-based solutions to the grand challenge and its three macro-solution areas. Each of three major initiatives – the Plant Sciences Initiative (PSI), the Food Manufacturing Initiative (FMI), and the existing Plants for Human Health Institute (PHHI) on the NC Research Campus – can be coordinated to provide a unique North Carolina science and technology development ecosystem for addressing the global food challenge. The individual initiatives, and their synergistic connection to the three-part solution equation of "increasing yield-reducing waste-increasing food product, process, and nutrition quality" and are shown in Table 32.

Figure 23 illustrates the potential integrated nature of North Carolina's ecosystem if these three initiatives are realized.

Table 32. North Carolina's Integrated Opportunities that Address Challenges of Feeding the World.

Increase Yield	Reduce Waste	Enhance Nutrition/ Food Product & Process Innovation
Plant Sciences Initiative		
An overarching theme of yield improvement accomplished through four principal platforms: • Crop protection from abiotic stress • Plant adaption to abiotic stress and marginal conditions • Precision agriculture and field data systems • Agri-symbiotics (beneficial plant symbiotic interactions with non-plant organisms).	Reduction of pre-harvest, in-field loss due to enhanced crop protection and stress management technologies and solutions. Potential to apply plant improvement technologies to identify traits and develop cultivars for improved post-harvest quality and resiliency characteristics that reduce waste, or morphology and other characteristics that improve downstream processability.	Potential to apply plant improvement technologies to identify traits and develop cultivars with enhanced functional nutrient content and improved sensory characteristics.
Food Manufacturing Initiative		
Application of plant improvement technologies to identify traits and develop cultivars with enhanced functional nutrient content and improved sensory characteristics.	Postharvest physiology and technology to extend shelf life. Advanced packaging technologies, such as ohmic heating, high pressure processing, ozone processing, continuous microwave heating, and aseptic processing of particulates, to extend shelf-life and reduce waste. Innovations in flavors, extraction and sensory technologies to enhance the ability to use additives to improve safety, freshness, and shelf-life.	Development and application of new product and processing innovations with regards to a wide variety of meat, fruit, vegetable, dairy, and beverage products with improved health, safety, quality, and expanded functionalities. Innovation in food products to enhance consumer desirability and nutritional content, including fortification of traditional foods (i.e. addition of vitamins, minerals, bacterial cultures). New manufacturing techniques that improve sensory and taste qualities such as minimal processing, heat treatments, freeze-drying etc. Innovations in flavors, extraction and sensory technologies to enhance the ability to use additives to improve nutritional value, and improve taste, texture and appearance of food products
Plants for Human Health Institute		
Identification of compounds in fruits and vegetables that are associated with certain health benefits, such as cancer prevention. Development of plant breeds that have higher levels of anti-carcinogenic and other beneficial compounds. Sequencing plant genomes to understand which genes are responsible for making the health-protective components in the plant.	Storage technologies to enhance functional food compounds.	Establish mechanisms of known and new bioactive compounds and microbes and elucidate how food structure contributes to bioactivity. Develop technologies for producing and distributing appealing, healthy foods and ingredients.



Intersection A: Potential to apply plant improvement technologies to identify traits and develop cultivars for improved post-harvest quality and resiliency characteristics that reduce waste, or morphology and other characteristics that improve downstream processability and product innovation.

Intersection B: Potential to apply plant improvement technologies to identify traits and develop cultivars with enhanced functional nutrient content and improved sensory characteristics.

Intersection C: Development of product innovations, processing technologies, food safety and preservation systems, etc., that preserve functional nutrient availability and quality throughout the production and distribution chain. Creation of value-added advanced food products and processes.

Intersection D: Improvement of plants with high nutritional value and functional health characteristics for processability, post-harvest preservation of nutrition content, food product innovations, etc.

Figure 23. North Carolina's Ecosystem.

It should be noted that while the above "feeding the world ecosystem" emphasizes plant-based agriculture for human consumption, the concept can be readily applied to livestock agriculture improvement as well. For example, the ecosystem could be applied to enhancing plant yield as feed commodities, improving the functional nutrition profile of feed, and technologies for reducing wastage, feed spoilage, or contamination in the feed chain.

Finally, while this ecosystem has global implications, it is also important to note that it has significant economic implications for North Carolina. By focusing holistically on the entire food value chain, the combination of the efforts ensures that the work does not stop at the farm gate, but instead continues through to food manufacturing and ultimately to the end consumer. By linking activities across departments within NC State CAL and other colleges and institutions across the state of North Carolina, the ecosystem avails itself of the broad and deep expertise found within a variety of scientific and technological disciplines, thereby helping to ensure the ultimate economic benefit to the state of North Carolina.

Economic Impact of Implementing the Food Processing and Manufacturing Initiative

The value of catalyzing the growth of the food processing and manufacturing industrial sector is that it will spur growth and competitive advantage within the state. Economic gains that are predicted if a robust, pro-active action plan for fostering the food-related value chain is implemented include:

- Rising productivity of companies in the value chain, creating a competitive advantage for the state
- Accelerated pace of innovation resulting in new products and processes
- More frequent start-up of new businesses with the potential for high growth
- Stronger supplier networks, increasing the economic multiplier impact of the value-chain for the state
- Larger pools of specialized workers and education and training programs geared to the particular industrial needs, introducing significant cost savings for firms and increasing the breadth and depth of employment opportunities for workers in the supply chain.

To advance the food processing and manufacturing industrial sector in North Carolina, it is critical to further public-private partnerships that align industry and university research core competencies with technology commercialization and new product development efforts within both large and small firms. In this way, North Carolina food processing and manufacturing firms will be better able to take advantage of growing and emerging global market opportunities.

By implementing the initiatives outlined in this study, North Carolina has the opportunity to catalyze food processing and manufacturing industrial development across the state. Battelle anticipates that the total direct and indirect impact of the food value chain, with the prescribed steps of this study implemented, will be an increase of 37,776 jobs and an increase in associated economic output of $10.3 billion by 2020. As summarized in Table 33, the benefits of developing a robust food value chain within North Carolina are significant.

Table 33. Benefits of a Robust Food Value Chain in North Carolina

Expansion of Economic Output and Economic Growth	Employment and Personal Income
Substantial economic activity is generated throughout the food value chain. Companies supplying inputs to manufacturing production generate significant revenues, as do the direct agricultural commodity and livestock sectors and all the business sectors that provide inputs to agricultural production. The direct expenditures of each value-chain element in turn generates indirect output as its suppliers also receive revenues and make expenditures in North Carolina.	Each component of the food value chain provides jobs and income for North Carolina employees and business owners. The wages and benefits generated by this value chain provide support for families in every county in North Carolina. Via the multiplier effect, the spending of income in North Carolina via the food value chain employees generates income for a broad range of other businesses and individuals in the state.
Local and State Government Revenues	**Economic Diversification**
Business taxes paid up and down the food value chain, together with personal income and property taxes paid by those employed directly or indirectly via the value chain, provide significant sources of revenue for state and local governments in North Carolina. Again, the broad geographic spread of the food value chain across North Carolina assures that all North Carolina counties, and the vast majority of individual municipalities and school districts, receive revenues directly and indirectly generated by the food value chain.	The food value chain, with its varied inputs and outputs, creates a broad spread of economic activity across the state. The sector provides a secure economic base for the state – one unlikely to sustain a significant impact from one structural shift. Furthermore, modern food science technologies are generating new products and innovations that will create new business opportunities for North Carolina, expanding the base of business and further diversifying the state's economy.
Enhanced State and Community Sustainability	**Reduced Social Costs**
The long-term growth and sustainability of North Carolina is, in part, secured by the impacts described above. The food value chain forms part of an integrated economic system that supports business revenues, business growth, personal wages and benefits, government revenues, health, and social welfare. This activity is woven into the overall fabric of state, county, and community economies contributing support for overall economic and social sustainability.	Without the food value chain, North Carolina would experience substantial economic dislocation and associated social costs. The geographic diversity of the sector provides family economic support across the state, into North Carolina's major cities and its smallest rural communities. Without the economic activity generated by the sector, North Carolina would experience substantial costs in social support programs, unemployment compensation, and human-capital retraining expenses.

APPENDICES

A. **Economic Analysis**
B. **OmniViz Clusters – Key Terms**
C. **Benchmarking Value-Added Food Processing Initiatives**

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Appendix A: Economic Analysis

Table A-1. NAICS-based Definition of the Food Value Chain and Key Subsectors

Industry Code	NAICS Description	Food Value Chain Subsector
424510	Grain and field bean merchant wholesalers	Agricultural Product Wholesale
424520	Livestock merchant wholesalers	Agricultural Product Wholesale
424590	Other farm product raw material merch. whls.	Agricultural Product Wholesale
311991	Perishable prepared food manufacturing	All Other Food Manufacturing
311999	All other miscellaneous food manufacturing	All Other Food Manufacturing
311111	Dog and cat food manufacturing	Animal Feed
311119	Other animal food manufacturing	Animal Feed
311611	Animal, except poultry, slaughtering	Animal Processing
311612	Meat processed from carcasses	Animal Processing
311613	Rendering and meat by-product processing	Animal Processing
311615	Poultry processing	Animal Processing
311811	Retail bakeries	Bakeries & Related Manufacturing
311812	Commercial bakeries	Bakeries & Related Manufacturing
311813	Frozen cakes and other pastries manufacturing	Bakeries & Related Manufacturing
311821	Cookie and cracker manufacturing	Bakeries & Related Manufacturing
311822	Mixes and dough made from purchased flour	Bakeries & Related Manufacturing
311823	Dry pasta manufacturing	Bakeries & Related Manufacturing
311830	Tortilla manufacturing	Bakeries & Related Manufacturing
424810	Beer and ale merchant wholesalers	Beverage Wholesale
424820	Wine and spirit merchant wholesalers	Beverage Wholesale
311920	Coffee and tea manufacturing	Beverages & Related Manufacturing
312111	Soft drink manufacturing	Beverages & Related Manufacturing
312112	Bottled water manufacturing	Beverages & Related Manufacturing
312113	Ice manufacturing	Beverages & Related Manufacturing
312120	Breweries	Beverages & Related Manufacturing
312130	Wineries	Beverages & Related Manufacturing
312140	Distilleries	Beverages & Related Manufacturing
311930	Flavoring syrup and concentrate manufacturing	Concentrates, Condiments, & Spices
311941	Mayonnaise, dressing, and sauce manufacturing	Concentrates, Condiments, & Spices
311942	Spice and extract manufacturing	Concentrates, Condiments, & Spices
311320	Confectionery manufacturing from cacao beans	Confectionary Goods
311330	Confectionery mfg. from purchased chocolate	Confectionary Goods
311340	Nonchocolate confectionery manufacturing	Confectionary Goods
311511	Fluid milk manufacturing	Dairy Products
311512	Creamery butter manufacturing	Dairy Products
311513	Cheese manufacturing	Dairy Products
311514	Dry, condensed, and evaporated dairy products	Dairy Products
311520	Ice cream and frozen dessert manufacturing	Dairy Products
333294	Food product machinery manufacturing	Food Machinery
424410	General line grocery merchant wholesalers	Food Wholesale
424420	Packaged frozen food merchant wholesalers	Food Wholesale
424430	Dairy product merchant wholesalers	Food Wholesale

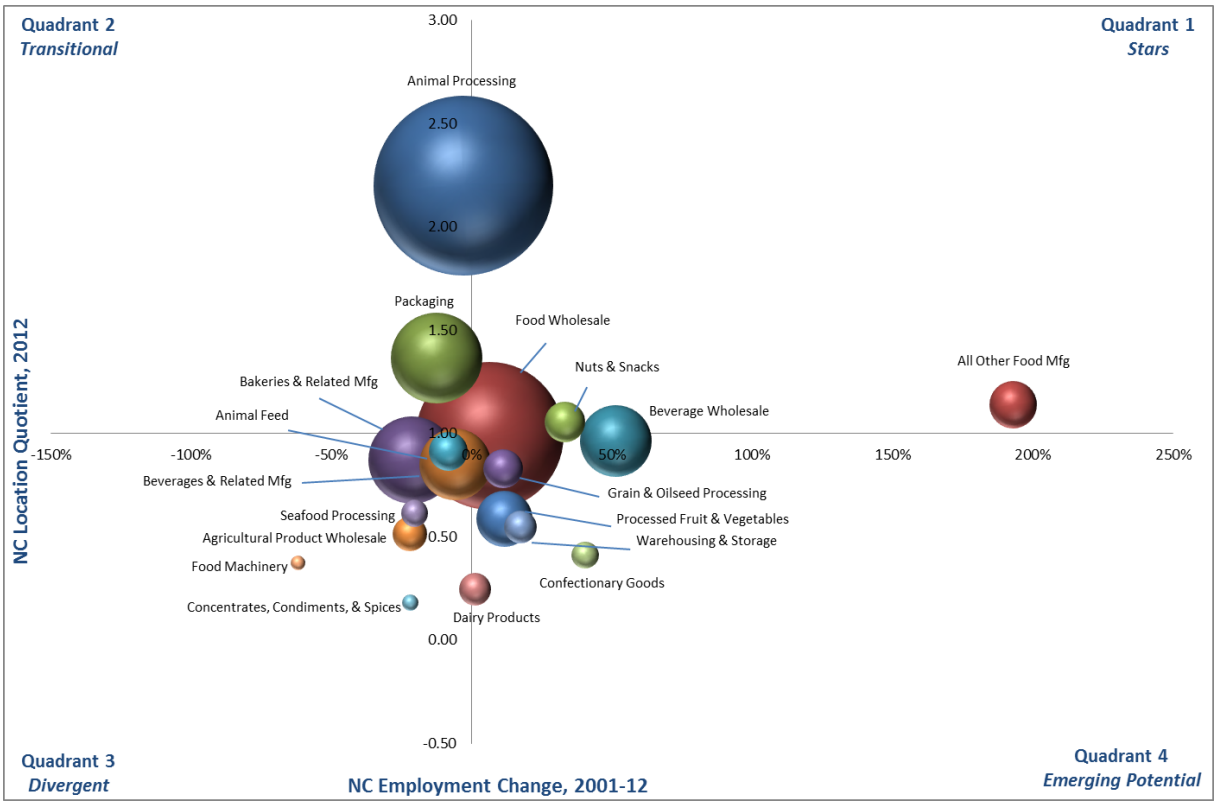
Industry Code	NAICS Description	Food Value Chain Subsector
424440	Poultry product merchant wholesalers	Food Wholesale
424450	Confectionery merchant wholesalers	Food Wholesale
424460	Fish and seafood merchant wholesalers	Food Wholesale
424470	Meat and meat product merchant wholesalers	Food Wholesale
424480	Fruit and vegetable merchant wholesalers	Food Wholesale
424490	Other grocery product merchant wholesalers	Food Wholesale
311211	Flour milling	Grain & Oilseed Processing
311212	Rice milling	Grain & Oilseed Processing
311213	Malt manufacturing	Grain & Oilseed Processing
311221	Wet corn milling	Grain & Oilseed Processing
311222	Soybean processing	Grain & Oilseed Processing
311223	Other oilseed processing	Grain & Oilseed Processing
311225	Fats and oils refining and blending	Grain & Oilseed Processing
311230	Breakfast cereal manufacturing	Grain & Oilseed Processing
311911	Roasted nuts and peanut butter manufacturing	Nuts & Snacks
311919	Other snack food manufacturing	Nuts & Snacks
322212	Folding paperboard box manufacturing	Packaging
322213	Setup paperboard box manufacturing	Packaging
322215	Nonfolding sanitary food container mfg.	Packaging
322221	Coated and laminated packaging paper mfg.	Packaging
322223	Coated paper bag and pouch manufacturing	Packaging
322225	Flexible packaging foil manufacturing	Packaging
322226	Surface-coated paperboard manufacturing	Packaging
326111	Plastics bag and pouch manufacturing	Packaging
326112	Plastics packaging film and sheet mfg.	Packaging
326160	Plastics bottle manufacturing	Packaging
327213	Glass container manufacturing	Packaging
332431	Metal can manufacturing	Packaging
333993	Packaging machinery manufacturing	Packaging
311411	Frozen fruit and vegetable manufacturing	Processed Fruit & Vegetables
311412	Frozen specialty food manufacturing	Processed Fruit & Vegetables
311421	Fruit and vegetable canning	Processed Fruit & Vegetables
311422	Specialty canning	Processed Fruit & Vegetables
311423	Dried and dehydrated food manufacturing	Processed Fruit & Vegetables
311711	Seafood canning	Seafood Processing
311712	Fresh and frozen seafood processing	Seafood Processing
493120	Refrigerated warehousing and storage	Warehousing & Storage
493130	Farm product warehousing and storage	Warehousing & Storage

Table A-2. Summary Employment Metrics for the North Carolina Food Value Chain, 2012 (with 2001–12 Longer-Term Employment Trends).

Food Value-Chain Sector & Key Subsectors	Establishments		Employment, 2012	Employment Change		NC LQ, 2012
	Count, 2012	Change, 2009–12		NC, 2009–12	US, 2009–12	
Total Private Sector	**250,607**	**3%**	**3,223,192**	**2.8%**	**3.3%**	**1.00**
Food Value-Chain, Total	**2,173**	**14%**	**90,584**	**−2.0%**	**1.4%**	**1.08**
Food Processing & Manufacturing						
Animal Processing	135	5%	30,975	−4.7%	−2.3%	**2.20**
Bakeries & Related Mfg	253	25%	7,216	−7.4%	3.4%	0.87
Beverages & Related Mfg	147	27%	4,823	15.6%	6.6%	0.85
Processed Fruit & Vegetables	39	11%	2,928	−6.2%	−2.2%	0.59
All Other Food Mfg	35	6%	2,080	2.5%	4.8%	1.14
Nuts & Snacks	28	22%	1,523	6.8%	9.0%	1.06
Grain & Oilseed Processing	25	0%	1,456	9.5%	1.2%	0.83
Animal Feed	62	9%	1,398	5.0%	2.0%	0.91
Dairy Products	39	39%	950	26.5%	1.2%	0.25
Confectionary Goods	34	31%	673	23.3%	2.0%	0.41
Seafood Processing	28	0%	671	11.3%	1.4%	0.61
Concentrates, Condiments, & Spices	16	23%	233	14.8%	6.0%	0.18
Food Wholesale & Warehousing						
Food Wholesale	931	14%	20,753	−1.9%	1.3%	0.99
Beverage Wholesale	144	21%	4,853	11.0%	6.2%	0.97
Agricultural Product Wholesale	105	3%	1,099	−2.5%	−0.4%	0.51
Warehousing & Storage	44	−2%	967	−5.7%	5.9%	0.55
Food Machinery & Packaging						
Packaging	102	−3%	7,803	−9.5%	−2.5%	**1.37**
Food Machinery	6	0%	183	−38.2%	4.8%	0.37

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN. Note: Location Quotients highlighted in Red indicate a specialized state subsector.

Figure A-1. Employment Size, Concentration, and Recent Trends within the Food Value Chain in NC, 2012 (with Longer-Term Employment Trends 2001–12).



Regional Food Value Chain Summary Employment Tables

Table A-3. Mountain Region Employment Data.

Mountains						
Food Value-Chain Sector & Key Subsectors	Establishments, 2012	Estab. Change, 2009-12	Employment, 2012	NC Empl. Change, 2009-12	US Empl. Change, 2009-12	NC LQ, 2012
Total Private Sector	**29,181**	**0.8%**	**309,681**	**0.5%**	**3.30%**	**1.00**
Food Value-Chain, Total	**242**	**16%**	**9,068**	**7.8%**	**1.40%**	**1.13**
Food Processing & Manufacturing						
All Other Food Mfg	5	436.5%	202	728.9%	4.8%	1.15
Animal Feed	4	-34.4%	147	-27.1%	2.0%	1.00
Animal Processing	14	7.7%	3,547	23.9%	-2.3%	2.62
Bakeries & Related Mfg	21	-2.2%	445	-30.9%	3.4%	0.56
Beverages & Related Mfg	34	27.4%	636	27.2%	6.6%	1.17
Concentrates, Condiments, & Spices	2	0.0%	15	-12.8%	6.0%	0.12
Confectionary Goods	7	-6.0%	113	-2.7%	2.0%	0.72
Dairy Products	6	0.0%	250	-10.6%	1.2%	0.67
Grain & Oilseed Processing	5	395.0%	62	262.0%	1.2%	0.37
Nuts & Snacks	4	26.4%	21	-67.3%	9.0%	0.15
Processed Fruit & Vegetables	10	36.4%	223	1.1%	-2.2%	0.47
Seafood Processing	2	3.7%	15	-71.1%	1.4%	0.14
Food Wholesale & Warehousing						
Agricultural Product Wholesale	4	39.0%	19	88.1%	-0.4%	0.09
Beverage Wholesale	17	86.6%	438	15.9%	6.2%	0.91
Food Wholesale	92	9.2%	2,271	20.1%	1.3%	1.12
Warehousing & Storage	2	98.9%	19	160.0%	5.9%	0.11
Food Machinery & Packaging						
Food Machinery	1	20.0%	64	481.1%	4.8%	1.35
Packaging	11	-14.1%	583	-47.8%	-2.5%	1.06

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN.

Table A-4. Piedmont Region Employment Data.

The Piedmont						
Food Value-Chain Sector & Key Subsectors	Establishments, 2012	Estab. Change, 2009-12	Employment, 2012	NC Empl. Change, 2009-12	US Empl. Change, 2009-12	NC LQ, 2012
Total Private Sector	**160,087**	**3.1%**	**2,205,008**	**4.2%**	**3.30%**	**1.00**
Food Value-Chain, Total	**1,246**	**14.8%**	**44,941**	**-5.5%**	**1.40%**	**0.79**
Food Processing & Manufacturing						
All Other Food Mfg	19	2.2%	1,508	4.2%	4.8%	1.21
Animal Feed	31	21.1%	705	8.2%	2.0%	0.67
Animal Processing	52	-5.4%	6,959	-29.1%	-2.3%	0.72
Bakeries & Related Mfg	175	25.4%	4,836	-10.0%	3.4%	0.86
Beverages & Related Mfg	81	29.3%	3,637	16.8%	6.6%	0.94
Concentrates, Condiments, & Spices	8	14.3%	187	28.1%	6.0%	0.21
Confectionary Goods	16	26.6%	473	31.7%	2.0%	0.42
Dairy Products	27	50.0%	592	63.4%	1.2%	0.22
Grain & Oilseed Processing	17	-1.0%	1,196	23.8%	1.2%	1.00
Nuts & Snacks	13	14.2%	874	-4.4%	9.0%	0.89
Processed Fruit & Vegetables	11	4.1%	299	-16.0%	-2.2%	0.09
Seafood Processing	2	107.4%	4	-58.2%	1.4%	0.00
Food Wholesale & Warehousing						
Agricultural Product Wholesale	40	12.0%	303	2.3%	-0.4%	0.21
Beverage Wholesale	100	20.0%	3,316	15.5%	6.2%	0.96
Food Wholesale	553	15.0%	13,006	-7.8%	1.3%	0.91
Warehousing & Storage	21	-16.5%	738	22.4%	5.9%	0.61
Food Machinery & Packaging						
Food Machinery	2	-20.0%	80	-47.9%	4.8%	0.24
Packaging	77	-1.0%	6,229	3.2%	-2.5%	1.59

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN.

Table A-5. Coastal Plains Employment Data.

Coastal Plains						
Food Value-Chain Sector & Key Subsectors	Establishments, 2012	Estab. Change, 2009-12	Employment, 2012	NC Empl. Change, 2009-12	US Empl. Change, 2009-12	NC LQ, 2012
Total Private Sector	**61,339**	**1.8%**	**708,504**	**-0.4%**	**3.30%**	**1.00**
Food Value-Chain, Total	**685**	**11.0%**	**36,575**	**0.4%**	**1.40%**	**1.99**
Food Processing & Manufacturing						
All Other Food Mfg	10	-21.4%	370	-33.7%	4.8%	0.92
Animal Feed	27	6.3%	546	14.0%	2.0%	1.63
Animal Processing	69	14.8%	20,469	3.3%	-2.3%	6.62
Bakeries & Related Mfg	57	39.5%	1,935	9.1%	3.4%	1.07
Beverages & Related Mfg	32	19.9%	551	-1.4%	6.6%	0.44
Concentrates, Condiments, & Spices	6	50.0%	32	-21.7%	6.0%	0.11
Confectionary Goods	11	82.8%	87	23.3%	2.0%	0.24
Dairy Products	6	50.0%	108	-0.7%	1.2%	0.13
Grain & Oilseed Processing	3	-54.0%	198	-42.9%	1.2%	0.51
Nuts & Snacks	11	30.4%	628	40.0%	9.0%	1.98
Processed Fruit & Vegetables	18	5.4%	2,406	-5.4%	-2.2%	2.20
Seafood Processing	24	-4.6%	653	19.9%	1.4%	2.72
Food Wholesale & Warehousing						
Agricultural Product Wholesale	61	-3.8%	776	-5.4%	-0.4%	1.65
Beverage Wholesale	27	1.5%	1,099	-2.2%	6.2%	0.99
Food Wholesale	286	12.1%	5,476	6.0%	1.3%	1.19
Warehousing & Storage	21	11.2%	211	-49.3%	5.9%	0.54
Food Machinery & Packaging						
Food Machinery	2	20.0%	39	-70.3%	4.8%	0.36
Packaging	13	-2.9%	991	-32.4%	-2.5%	0.79

Source: Battelle analysis of Bureau of Labor Statistics, Quarterly Census of Employment & Wages (QCEW) data; enhanced file from IMPLAN.

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Appendix B: OmniViz Clusters – Key Terms

MetaCluster Name	Cluster		Record		Topics		Other Ancillary Terms
	Num-ber	Name	Total Count	% with Bold Term	Major Topic	Minor	
Dairy/Cattle	13	Milk Production	42	90%	**milk,** dairy, bovine, fat	protein	
	20	Dairy Cattle	35	94%	**dairy, bovine,** milk, cattle, herd, train, lactation	holstein	production
	33	Animal Health – Dairy	5	100%	**cattle,** bovine, liver, dairy	body weight, beef, grow, gain, extracted, detection, anti-inflammatory	
Food Economics	7	Market/ Consumer Preferences	14	71%	**market,** social, purchase, income, farmer	preference	food, consumer
	28	Sustainable Agriculture	23	83%	**farm,** vegetable, farmer, harvest, market, corn, pathogen, agriculture, grow,	minimize, highly, cultivar, chemical, benefit, season, optimize, chemistry, production, plant,	field, food, management
Food Processing	9	Fermentation/ Pickling	15	100%	**fermentation,** lactic, acid, cucumber, bacterium, lactobacillus, yeast, vegetable, sodium, salt, chloride	storage, microorganism, organism, microbial	ph, acid, spoilage
	24	Preparation	36	67%	cook, beverage, foodstuff, dough, bake, flour, mold	**preparation,** edible, preservation, nutritive, non-alcoholic, modification, shape	food, product, process, quality
	34	Meat/Poultry Processing	34	85%	**meat,** poultry, fish, chicken	processing, butchering	product
	39	Packaging	75	84%	**package,** chute, clip, automate, net, meat, closure, clipper	unpacking, configure, computer program, operate, storage	material, product, apparatus, device, machine
Grain/ Oilseed Uses	15	Corn	10	80%	**corn**		food, feed
	21	Oil/Soybean	25	64%	**oil,** soybean, fatty acid, seed		food, protein
	31	Sorghum	1	100%	**starch, phenolic, grain, digestibility, cereal**		sorghum, glycemic, celiac

MetaCluster Name	Cluster		Record		Topics		Other Ancillary Terms
	Num-ber	Name	Total Count	% with Bold Term	Major Topic	Minor	
Food Chemistry	1	Whey	42	79%	**whey, flavor,** whey protein, concentrate, milk, sensory, cheddar, dairy, cheese, volatile, oxidation, lipid, dry, color, spray-dry, fat	stability, solid, storage, mass spectrometry, hydrogen peroxide, ingredient, gas chromatography , aroma	product, protein, manufacture
	3	Antioxidants	33	58%	**antioxidant,** anthocyanin, phenolic, flavonoid, polyphenol, extract	chemistry	
	11	Sensory-Flavor	43	67%	**sensory,** flavor, fat, cheese, dairy, milk, texture, taste, perception		food, product, consumer
	16	Extracts	29	100%	**extract,** antioxidant	chemical, constituent	food
	18	Whey Protein	26	81%	whey protein, lactoglobulin, thermal, microstructure	solution, gel, stability, gelation, rheologic, heat, water, strength	protein, food, property, isolate, form, ph
	23	Vitamins	5	100%	**vitamin,** liver, metabolite, load, kinetic, healthy	restriction, phosphate, amino, acid, severe, profile, female, enzyme	deficiency, concentration
	25	Sensory-Texture	14	93%	**perception,** texture, sensory, microstructure, mechanical	processing, gel, solid, soft	property, food, oral, behavior, mastication
	30	Peanut Allergens	23	100%	**peanut,** allergen, soluble, oil, flour, antioxidant	chemistry, processing, enzyme	protein, food, reduce, product
	35	Supplements	2	100%	**supplement**		investigate, trials
Food Safety	6	Foodborne Illness Outbreak	9	100%	foodborne, outbreak, food, safety, restaurant, meal	illness, protection, safe, prevention, contamination	food, disease, handling, behavior
	14	Bacteriology	46	67%	bacterium, pathogen, infection, lactobacillus, foodborne	bacterial	strain, food
	26	Listeria	21	81%	listeria, monocytogene, survival, serotype, pathogen, foodborne, outbreak	processing microbiology microbial tested biology	strain food resistance plant
	27	Pathogen Strains	27	69%	pathogen, escherichia coli, foodborne, anti-microbial, salmonella, fecal	prevalence, water,	food, disease, strain

MetaCluster Name	Cluster		Record		Topics		Other Ancillary Terms
	Num-ber	Name	Total Count	% with Bold Term	Major Topic	Minor	
	32	Toxicology	16	81%	toxicology	chemical, pharmacology, toxicity, male, incidence, female	food
Nutrition	0	Behavior	13	85%	eat, meal, healthful, obesity, dietetic, home	public health	food, age, diet, behavior
	2	Inflammation	6	67%	inflammation, intestine, tumor, necrosis, factor-alpha, nutritional, metabolite, liver, barrier	gene, expression, differential, biochemistry, anti-inflammatory	protein, diet, treatment
	4	Dietetic Standards	4	100%	dietetic, barrier		food, outcome
	5	Obesity	50	96%	obesity, body mass index, energy, income, dietetic		weight, food, health, diet
	8	Diabetes-related	30	77%	glucose, insulin, diabetes, obesity		diet
	10	Infant	14	79%	infant, maternal, mother, supplement, nutritional, lactation		child, intervention, food, feed, age
	12	Nutritional Composition	142	50%	fate, energy, obesity, nutrient		food, diet
	17	Metabolism	11	55%	metabolite, cancer, liver, nutritional		
	19	Infant	1	100%	infant, dry, cereal, breast, ascorbic acid	supplemental, prevention	fortify
	22	Fruits & Vegetables	50	92%	fruit, vegetable		food, consumption, diet
	36	Women	4	100%	nutritional, supplement	biomarker	woman
	37	Beverage Consumption	42	88%	beverage, drink, fruit, energy	sweeten	food, intake, consumption
Poultry	29	Farming/Production	59	86%	poultry, broiler, chicken, turkey		feed, age
	38	Animal Health - Poultry	41	59%	turkey, poultry, avian, virus, egg, infection, hen, chicken	animal health	disease

Key
Major Topics -- Significant and driving impact on cluster formation. Provide all terms in 30% or more of cluster's records.
Minor Topics -- Ancillary impact on cluster formation. Provide all terms in 30% or more of cluster's records.
Other Ancillary Terms -- No impact on cluster formation. Provide context on the records within the cluster. Provide key/unique terms in approximately 50% or more of cluster's records.

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Appendix C: Benchmarking Value-Added Food Processing Initiatives

Methodology

Background

This appendix summarizes findings and lessons from a benchmarking exercise conducted by Battelle Technology Partnership Practice to inform the North Carolina Food Processing and Manufacturing Initiative. The exercise attempts to identify important factors underlying the emergence of comparable university-based initiatives that emphasize the development and enhancement of value-added processing within a state's borders, by either entrepreneurial, "second stage," or larger established companies.

Choosing Benchmarks

The purpose of the benchmarking exercise was to generate case studies from which NC State can learn useful lessons as it designs its own Food Processing and Manufacturing Initiative for the Centennial Campus. For benchmarks to be useful analytically, they must share at least some features in common with the situation at hand. No single benchmark was going to be like NC State in all respects: some contexts were bound to be similar, others different, and the analysis requires an exercise in mix and match. Across the entire set, the project team aimed to achieve a balanced representation of factors relevant to the design decisions faced by NC State.

Key factors were a specific focus on encouraging more in-state value-added processing, beyond simply the presence of pilot plants or instruction in safe operation of food-processing equipment. To generate an initial target list, Battelle examined the graduate and undergraduate programs tracked on the website of the Institute of Food Technologists, and then briefly visited each website to try and discern the presence of a significant focus on encouragement of value-added processing instate. This list is dominated by public and land-grant universities, and this weighting seems appropriate since NC State itself exemplifies the same ethos of in-state service. Finally, Battelle also examined closely peer institutions and fellow southern universities identified by NC State's Office of Institutional Research and Planning.

In dialogue with the NC State campus steering committee, certain intriguing possibilities were excluded. For example, the Rutgers Food Innovation Center and associated activities on the main New Brunswick campus were excluded because New Jersey's rich endowment of large food-processing companies was thought to make the situations not directly comparable. Cornell's Institute for Food Systems was excluded because although it shares a name with a long-standing initiative that formerly bound together food science departments in two separately managed experiment stations, it now represents a complete "reboot" of the university's approach to the food sector, and it has not yet been determined what role it will play in economic development and outreach.

The Benchmark Set

Of the benchmarks that emerged in this way, only one (MSU) is formally considered a peer of NC State. Neither of the other two land grants is, and none of the three is located in the South or Southeast. Therefore the decision was made to add the new Auburn Food Sciences Institute, since Auburn is a

member of the Southern Universities Group tracked by the NC State Office of Institutional Research. This is a new program, with a not fully elaborated value-added program, but since the umbrella program is ambitious and has achieved early success with a large FDA training contract (in which NC State is a partner), and since the founding director is a former faculty associate at NC State it seemed appropriate to add Auburn as a fourth. Four institutions that remained after this process are summarized on the table on the following page.

Program	Peer Institution?	Mission Statement	Main Programs
MSU Product Center Food-Ag-Bio (established 2003)	Yes	"Accelerating innovation and growth for Michigan business, industry and entrepreneurs in food, agriculture and bio-manufacturing"	Venture development, counseling aimed at concept-stage business; and high impact venture action team, aimed at second-stage firms
OSU Food Innovation Center (established 1999)		"Advancing Northwest Foods"	Advice on product and market development, shelf-life testing, processing and packaging technology including RFID, and consumer sensory testing
UNL Food Processing Center (established 1983).		"To advance the value-added food manufacturing industry by partnering on technical and business development from idea through ongoing market support"	National Food Entrepreneur Program, beginning with 1-day "recipe to reality" seminar and proceeding to second phase of confidential services
Auburn Food Systems Institute (established as an initiative in 2011, as an institute in 2013)	Southern Universities Group	"To provide an infrastructure for promoting interdisciplinary research, teaching, and training opportunities relating to food systems among faculty in academia, personnel in industry, decision-makers in government, and consumers in the general public."	Main programs are currently on-line training (FDA inspectors) and other IT-focused initiatives. Also includes also an entrepreneurial initiative.

Program Origins and History

There proved to be great diversity in the origins of the benchmark programs. Possibly the most interesting origin story is that of the Oregon State Food Innovation Center, where the program was a direct result of an informal agreement between the dean of agriculture and the state commissioner of agriculture, both of whom believed that each entity could benefit from collocation of certain functions in an urban location, as opposed to the rural main campus or the existing network of generally rural experiment stations. It may also be noteworthy that the Michigan State Product Center had its origins not in the departments of food science or poultry science but in agricultural economics.

Program	Departmental Origins/Champions	Initial Supporters	Leverage
MSU Product Center	Championed by agricultural economist	Dean/directors group: $250k ea. from extension and research	USDA AIC for training extension agents
OSU Food Innovation Center	Agreement between college dean and the director of state Department of Ag to create a presence in metro Portland	State built 32,000 s.f. building, which operates as one of the college's experiment stations	State leased back about two-thirds for use by Department's market development units
UNL Food Processing Center	Emerged from dairy and poultry department early in history of department of FS&T		Initially, became a wide-ranging grant-seeking entity with economic development goals
Auburn University Food Systems Institute	Grew from earlier initiative in poultry food and safety, aimed at developing broader research capacity	Cofunded as an experimental initiative by the VPR and the Alabama Experiment Station	Has leveraged major FDA training contract (NC State is a co-awardee, as is Purdue).

Additional Programs

Beyond the basic set of consultation on new-product development, nearly all of these benchmarks offer laboratory or analytical services, and also seminars, short courses or certificates in various aspects of food processing and product development. Two of the programs (Michigan State and Auburn) also produce an annual conference or showcase for instate food producers and would-be entrepreneurs.

Program	Other Activities
MSU Product Center	"Making it in Michigan" specialty food show; economic impact research reports; web-based market-maker; USDA facilitation of new rural coopers or expansions
OSU Food Innovation Center	One-hour start-up consultation for $100. Same for any of four seminars on formulation, processing, packaging and food safety. Additional research programs in agricultural economics and marketing.
UNL Food Processing Center	Lab services, sensory analysis, professional certifications and workshops, "applied research and engineering" as translational bridge from research to industry
Auburn Food Systems Institute	Entrepreneurial Initiative focuses work of extension agents and local partners through an annual conference. "National Egg Products School" three-day hands-on course.

Facilities (Current)

While Michigan State began as a program without facilities, this year it joins the others in working from physical space designated specifically for interdisciplinary and academic/university interaction. Nebraska is also substantially increasing the profile of its food processing center, integrating it with parallel activities in engineering and other schools in a brand-new facility that will anchor its new research park. Program were generally unwilling to describe these facilities as food incubators, preferring to focus on short-term residency during a period of product development.

Program	Initial	Subsequent
MSU Product Center	From inception to this year, has been a program without facilities, sharing lab and pilot plant space in FSHN building	This year, adding $5.6m off-campus building with flexible processing floor dedicated to industrial uses by second stage businesses. Including USDA and FDA inspection so companies can sell.
OSU Food Innovation Center	About one-third of 32,000 s.f. building, with analytical and testing labs and 40x40 flexible processing area for short-term residency by companies. Most pilot plants remain on main campus, seafood at coastal station.	No recent additions
UNL Food Processing Center	Operates from the two FST academic buildings that comprise the Food Industry Complex on campus, second of which was built with a federal award to FPC dedicated to pilot and processing capacity	This year, adding interdisciplinary space including space dedicated to industrial interactions at the first building of the Nebraska Innovation Campus, research park on former state fair grounds. Summary space program in detailed profile below.
Auburn Food Systems Institute	Three suites in the 84,000 s.f. building in the research park, housing interdisciplinary programs focused on state economic development.	Assembly of the facility spurred creation of a brochure that for the first time lists all on-campus facilities that might be of interest to food entrepreneurs and food systems researchers

Target Constituencies

Program directors were very insistent that there was no specific crop or commodity group that stood out as the strongest single supporter of the activity. None really distinguishes potential clients by their size or ability to scale, though several centers observed differences in which services are of most interest to companies of diverse size ranges. Larger firms are more interested in “bridging” from science to production but prefer to hold product development in house. Small start-ups need the most help in product development. Second-stage or mid-sized firms fall somewhere in between.

Program	Strongest Sectoral Supporters	By Stage
MSU Product Center	Dairy, fruit & vegetable reflecting state’s climate and crop diversity	The Center does not pick winners or distinguish lifestyle businesses from scalable ones. No focus to date on large firms.
OSU Food Innovation Center	No specific preference by crop or food type	Small companies use start-up consultations and product formulation; larger companies hold those functions in house and instead use sensory testing
UNL Food Processing Center	Sees itself as a national program, only about half of engagements from in-state. Connectivity to in-state industry through an advisory board.	Center makes no distinction among customers based on size or potential to scale. No special focus on mid-sized or larger companies.
Auburn Food Systems Institute	No specific focus	Research program targets national and global companies; entrepreneurial program in-state

Staffing

Except for Auburn, which is the newest program, the remaining benchmarks are generally comparable in the number of staff on payroll: about 10 to 12. It is not uncommon for the center director to be the only full-time tenure-track faculty, or just one of a couple, while the balance of the staff roster is filled with professional research scientists, technical or managerial staff and support staff. Few of the centers directly employ what would normally be considered extension specialists, though most leverage their presence on and off campus (see further below).

Program	FTE	Composition
MSU Product Center	12	Faculty with "process authority" (typically one-third support); professional staff
OSU Food Innovation Center	10	Tenured faculty director, assistant professor, 5 professional staff including one "faculty research assistant" and three support staff.
UNL Food Processing Center	12	Down from peak of 25, including 3 food scientists, 2 pilot plant managers with1 assistant, 3 in the dairy plant and store; and 3 additional non-tenured research faculty.
Auburn Food Systems Institute	3	Faculty director plus staff assisting in grant-writing, accounting for funded projects, and assessment/accountability.

Partnerships

Following is a roundup of the partnerships the benchmark centers are using to extend the reach of their programming.

Extension

There is wide diversity in the nature of interaction with extension programs. Nebraska maintains the most distinct focus, preferring to leave routine activities to the extension network. Michigan has the closest relationship, being able to leverage the work of selected extension agents without actually having to pay for them on its own budget. Oregon State uses the extension network mainly for inbound referrals. Auburn is attempting to integrate into the Institute the existing few extension specialists who work with entrepreneurs and community kitchens.

Program	Relationship to Ag College's Statewide Extension Programs
MSU Product Center	Select group of 10 FTE (15 individual) extension agents in diverse locations have been trained to deliver Center's two key programs.
OSU Food Innovation Center	Obtains referrals from network of 30 statewide extension agents (entire set).
UNL Food Processing Center	Largely separate from the extension system. Leaves the latter to work with food coops or general entrepreneurship.
Auburn Food Systems Institute	Extension specialists, primarily in poultry science group, still provide majority of entrepreneurial counseling as they did prior to creation of institute, but now under this umbrella. Particularly strong partnership with extension agents serving community kitchen and value-added processing center in Chilton County.

Research

There was no example in the benchmark set of a value-added initiative focused tightly on a very specific area in which the campus has special research expertise (for example, NC State's historic role in aseptic

packaging). However, generally speaking – and most especially at Nebraska and Michigan State – co-applications between Center research staff and tenure-track departmental faculty is considered an important outcome, and an indicator of the relevance of having such a program. The Auburn initiative was initially designed to develop new research funding, but has deferred that goal while it works on assembling cross-school faculty teams.

Program	Relationship to Ag College's Key Research Strengths
MSU Product Center	FSNH faculty working in either food processing/quality enhancement or food safety/toxicology focus areas are typically the ones who co-apply with the Product Center for federal/industrial grants
OSU Food Innovation Center	Relies on FST Department on main campus for educational programming and subject matter expertise, especially in sensory evaluation, a core strength
UNL Food Processing Center	Particularly since the downsizing, very heavy focus on "applied research and engineering," serving as translational bridge between departmental strengths and industry needs. Tenure-track faculty co-apply with FPC research faculty on federal/industry awards.
Auburn Food Systems Institute	Entire Institute was conceived as a research-development initiative, intended to encourage cross-college collaboration by faculty from units that would not normally consider partnering with the state Experiment Station

State Agencies

Of the benchmark set, Oregon has the strongest relationship with the state agriculture department, which by design collocated its market development and commodity commission units with the Food Innovation Center. The other centers are recognized as resources by their respective state departments but do not exhibit the same closeness. Several state economic development departments target the food sector as a priority industry, but offer very little specifics on programming. It is clear that several of these centers are considered important stops when the department is able to tour a mid-sized or larger food-processing prospect through the state. Of the benchmarks, Alabama has the strongest state-driven effort to finance and form regional farmers' markets, but not an extremely close connection between that effort and AUFSI.

Program	Relationship to State Ag Department or Commerce Initiatives
MSU Product Center	Loose connection to ag department; MEDC identifies food processing as one of eight growth industries; no significant connection to regional farmers markets.
OSU Food Innovation Center	Department of Ag staff co-resident at same site provide linkage to the 24 commodity commissions, to a "farm to school" program to supply school cafeteria, and statewide network of farmers markets.
UNL Food Processing Center	Limited connection except as noted resource.
Auburn Food Systems Institute	The Chilton Food Innovation Center with which the Institute partners was created by the Department of Agriculture and Industries with funding form the USDA Specialty Crop Block Grants. The Department also supports a Farmers Market Authority. Food production is a priority industry of the Alabama Economic Development Partnership, but no programming specified.

Other

Connections with the state Small Business Development Center are the most common force-extender for these value-added centers, though Michigan noted that sometimes they can end up competing for the same kind of clients. Generally, the center directors were less familiar with the Manufacturing Extension

Partnership program, except in Nebraska where the university is in the process of taking over that portfolio from the state Department of Economic Development.

All the benchmark centers described healthy relationships with commercial copackers, noting that the latter appreciate the presence of an intermediary that helps new entrepreneurs design stabilized products and gain a clear idea of production runs. Copackers are not set up to provide this service. Likewise, all the centers had interest in working with kitchen incubators, but saw the sectors as of generally low quality. Their interest was in working to improve the options available to entrepreneurs.

Program	SBDC/MEP/Other	Copackers/incubators
MSU Product Center	SBDC runs hot and cold on food sector depending on what their funding needs are; MEP oriented only to auto	Copackers appreciate referrals of clients with stabilized products; Incubators are of uneven quality and center tries to work with them to shore up their offerings
OSU Food Innovation Center	SBDC provides generic start-up education, while Portland Community College offers "Get your recipe to market" course developed by FIC.	Actively refers to list of copackers. Pushing other regional actors to set up quality incubation programs, since center cannot accommodate indefinite residency. Active partnership with Northwest Food Processors Association.
UNL Food Processing Center	State MEP program, formerly run by Department of Economic Development, will move to the university, with FPC as a resource available to projects	FPC routinely sends clients to copackers because except for dairy store, sale of industry-produced products not allowed at campus pilot plants.
Auburn Food Systems Institute	In the research park, AUFSI is across the road from the incubator that houses the local office of the state SBDC, an additional resource for counseling.	The state has few copackers outside the seafood sector, which only underlines the importance of the university's relationship with the Chilton County community-kitchen facility

Financial Management (Including Pilot Plants)

There is an uneven level of budget data available from the benchmarks, but the pattern is that centers or programs that began with targeted state appropriations have generally shifted to discretionary allocation by the dean from the ag school's overall state budget, usually drawing equal shares from research and extension pools. The most complete budget data are available from Nebraska, where the director considered that his recent downsizing of staff from 25 to 12 placed an obligation of transparency on him. In this case we have absolute dollars and the percentage that comes from each kind of activity, and a breakdown by size of the client company. For example, from these data, the UNL FPC draws the conclusion that for viability two types of projects are necessary: high-value uses like Product Development and Pilot plant usage, which are contracted under large or long-term projects, but are few in number; a larger number of lower-value uses of laboratory services; and collaborative projects across the units.

Program	Total Budget	Main Revenue Streams	Role of Pilot Plant Revenues
MSU Product Center	$1.5m	Budget line item (GREEN) and general support through extension; grants and contracts; contributed extension services not on budget	Not included in the Product Center's budget
OSU Food Innovation Center	Undisclosed	Shares budget line with all experiment stations. Reports $500k in rental income from Ag Department, presumably targeted to building debt service	Not included in Food Innovation Center's budget.
UNL Food Processing Center	$325k revenue in latest semi-annual period	Half from industry; one-third from state through research and extension; 16% from foundation or association grants	Included as 18% of total center revenue, largest share after "applied research and engineering."
Auburn Food Systems Institute	Undisclosed	About half from grants, remainder from Experiment Station	Not included in AUFSI budget

Program Evolution

As time has passed and most of these programs have moved through successive cycles of support and then budget tightening, both Michigan State and UNL are moving aggressively to expand the size and sophistication of facilities available for industrial collaboration and, in the case of Nebraska, cross-disciplinary partnerships. Oregon State, which already operates a significant facility, has generally taken budgetary retrenchment as an opportunity to focus on delivering services for which companies will actually pay fees, and sees this as a healthy outcome.

Program	Main Points of Evolution
MSU Product Center	Shift from eschewing bricks and mortar to now adding a new building, with goal of taking on projects that yield $100m in incremental sales revenue and 300 jobs annually.
OSU Food Innovation Center	Seven or eight years of special appropriations to get the program started have ceased. USDA grant for multi-commodity value-added work expired in 2012. Center now much more fee-based.
UNL Food Processing Center	Purpose of new space in research park is to integrate across FST, Biological Systems and Engineering, Nutrition and Health Sciences, Animal Science, Mechanical and Materials Engineering, and FPC. Priority is to champion industry interaction by integrating all except dairy pilot plants and lay groundwork for multidisciplinary research on "food factory of the future" (targeting NIST M-TAC proposal) .
Auburn Food Systems Institute	As it became clear that the IT capabilities that were developed for the FDA training contract could be leveraged, new projects are emphasizing interactive instruction and "serious games." In recognition that early success has been in this field rather than large research awards, financial support from the VPR declined but remained non-zero in order to encourage cross-college collaboration

Evaluation

Michigan State and Nebraska are strongest among the benchmarks at tracking outcome metrics relevant to the advisory and entrepreneurial development mission. Nebraska adds some traditional academic measures of publication and student involvement.

Program	Comments
MSU Product Center	Tracks in detail counseling sessions, clients assisted with concepts, clients commending new business, clients using specialized service, and venture launches at new or existing businesses (sales, investment and jobs created or retained).
OSU Food Innovation Center	No formal evaluation metrics published. Informally, numbers interactions with entrepreneurs in the hundreds. Biggest success story Salt & Straw Ice Cream, based in Portland, now expanded to LA
UNL Food Processing Center	Tracks number of clients, projects, project revenues, participants in workshops and entrepreneur program, number of grad students advised by faculty, number of undergrads employed, number of manuscripts accepted for publication.
Auburn Food Systems Institute	None published to date

Governance

Except for Auburn, which was deliberately organized on a cross-school basis, all the benchmark programs report either formally or effectively to a dean's group comprising the dean of agriculture, the associate dean for research, and the associate dean for extension. In all cases, traditional academic functions pertaining to faculty rest in the home department of appointment. In some cases, this is the same department as that of the director, but not in all cases.

Program	Reports to
MSU Product Center	Formally, to the Department of Agriculture, Food and Resource Economics, but in practical terms to the dean and research and extension directors since projects can touch any CNR department
OSU Food Innovation Center	As with all experiment stations in the OSU system, governed as an independent unit reporting to dean's group. Academic appointments remain in the department, but latter has no say in FIC budgets
UNL Food Processing Center	One of 13 organized research units that report to the dean, the associates for research and extension, and the vice chancellor and associate vice chancellor for the Institute of Agriculture and Natural Resources. Three research faculty are part of the FST department and enjoy almost all privileges of the tenure-track faculty.
Auburn Food Systems Institute	Reports to an internal advisory board comprising eight deans (agriculture; engineering; science & mathematics; business; grad school; design and construction; nursing; and veterinary medicine) and one faculty member from the school of liberal arts.

Lessons Learned/Shared

Following is a summary of lessons shared by interviewed program directors:

Program	Comments
MSU Product Center	Getting campus and extension personnel to work together can be challenging. Product Center gives cooperating extension agents a sound reason for being because they have specialized training no one else has
OSU Food Innovation Center	Loss of targeted appropriations actually healthy because forced Center to start charging. Clients still come, but better prepared. Looks like USDA is prepared to re-focus on areas where FIC can contribute.
UNL Food Processing Center	Depth of service is a challenge because “there are only so many jams and jellies” that can be developed. Center has to tie to other academic interests (e.g., foods for health) while also maintaining capacity to deliver basic information on food technology. Has to be flexible and not overly dependent on one type of grant, nor overly diffused or opportunistic. Cannot serve only in-state businesses.
Auburn Food Systems Institute	It is important to sell faculty in other units on the benefits to them of collaboration. In some cases this may be grant-writing assistance, in others support on IT issues. Seed funding on its own did not work. When the right ideas emerged, then the right working groups coalesced around them, and these can meet virtually not necessarily in person.

Michigan State University Product Center

Summary

The Product Center Food-Ag-Bio (the Product Center) was created in 2003 by a memorandum of understanding among the MSU College of Agriculture and Natural Resources (CNR), MSU Extension (MSUE), and MSU AgBioResearch, the organizational successor to the state's Agricultural Experiment Station.[33] Its stated goal is "accelerating innovation and growth for Michigan business, industry and entrepreneurs in food, agriculture and bio-manufacturing."

It offers two main programs: Venture Development, counseling aimed at early stage businesses still at the concept stage, and a High Impact Venture Action Team, which manages more elaborate projects (feasibility studies, financial planning, market research and strategic planning) aimed at second-stage businesses (defined as between $1 million and $10 million in sales) interested in and capable of significant expansion.[34]

Until this year, the Product Center has been a program without dedicated facilities, sharing on-campus laboratory and pilot facilities in the Food Science and Human Nutrition building, which houses analytical labs and the campus dairy store, and other sites, such as meat pilot lines in other departments.

History and Motivation

Economic research conducted and posted recently by the Product Center shows that Michigan ranks 19th in food manufacturing, similar to its ranking in farm output, and last in the Great Lakes Region. Weakness in animal processing is compensated by relatively strong position in fruit and vegetable processing, reflecting the diverse climate base. The Product Center grew out of interest in capturing within Michigan more of the "value added" from what is primarily a commodity-oriented agricultural economy.

The founding director, Prof. Chris Peterson, is an agricultural economist, not a food scientist. He had been working with various larger "agribusiness" players in the state as the idea of specifically serving food processors emerged. In 2003 he proposed the Product Center to the "dean and directors group" at the CNR, which funded it with a $250,000 start-up grant, half from MSUE and half from MSU AgBioResearch. A subsequent $1 million competitive grant from the USDA Agricultural Innovation Centers program enabled the program to set up all its basic services, and to train a select group of local extension agents to be counselors in the field.

Additional Programs

- Specialty foods show focusing on "Making it in Michigan"
- Economic impact research reports
- Web-based market-maker for Michigan producers/processors/buyers etc.
- USDA-funded facilitation for formation of new rural coops or expansions

[33] See http://productcenter.msu.edu. Battelle also acknowledges with thanks an interview granted on Sept. 30, 2014, by Prof. Chris Peterson, the director of the Product Center and the Nowlin Chair of Consumer-Responsive Agriculture.

[34] The website shows conflicting thresholds. The electronic request for referral documentation shows $1 million in new sales or investment and 30 jobs. Other descriptions show $250,000 and 5 jobs respectively.

The Product Center originally planned a thrust in general entrepreneurial education but found that "entrepreneurs are not interested in being educated," and this thrust has withered in favor of one-on-one counseling. It does no traditional workforce development aimed at line workers, but the new facility (see below) may open up such opportunities.

Facilities

Currently, the Product Center has no dedicated facilities, though it promotes access to elements it shares with FSHN and the Department of Animal Science: a dairy foods complex; a fruit and vegetable processing line; a food sensory laboratory; an experimental foods laboratory; a cereal milling and product laboratory; a meat laboratory (in the separate animal science complex); and an artisan distilling program (also a standalone facility). See further below under program evolution.

Target Constituencies

The Product Center believes it has had strongest support from the specialty food processors in the dairy (including alternative dairy like goat cheese) and fruit and vegetable sectors. By policy the center does not "pick winners" or attempt to distinguish lifestyle businesses from those that could possibly scale, although it has seen a number of "serial entrepreneur" clients come through its program. A working paper by The Hale Group posted by the Product Center suggests that major opportunities in specialty foods can be found in five different consumer categories: wellness, indulgence, ethnicity, value and convenience.

The Product Center has not reached out extensively to larger food businesses.

Staffing

The Product Center masthead shows 6 personnel, but Prof. Peterson says the on-campus FTE count is 12. Among the paid personnel are faculty members (typically on one-third support) who assist the professional staff who run the analytical laboratories, and who have FDA "process authority" over certain kinds of production runs.

Partnerships

Extension

The Center conducts outreach throughout the state through a select group of extension agents (10 FTEs) who have been trained specifically in the two key programs. These individuals were selected at the same time as MSUE was reorganizing from a 60-county program into 14 regional districts. They represent part of 15 individuals across the state, and not necessarily in exactly the geographic sites that Prof. Peterson would have selected by his own preference.

Research

Both "Food Processing and Quality Enhancement" and "Food Safety and Toxicology" are two processing-related areas among the research strengths (four in total) identified by the MSU Department of Food Science & Human Nutrition. Faculty working in these areas are the ones who co-apply with the Product Center for federal and industrial grants.

State Agencies

The Michigan Department of Agriculture and Rural Development cites the Product Center as a resource for processors, but only one among many. The Michigan Economic Development Corporation identifies food processing as one among eight growth industries in which it has interest, but does not identify specific programs. There is a statewide association of farmers markets but not apparently directly supported by either agency.

Other

Collaboration with the state SBDC has "run hot and cold depending on what their funding needs are." Sometimes the SBDC looks for the same kind of clients, but at other times the two systems make mutual referrals. The state MEP is heavily involved with the automotive sector and to date has not been much interested in food manufacturing, but Prof. Peterson expects that competition may materialize in the future.

The Product Center has gone out of its way to partner with copackers, to steer them clients that have already been through the pilot phase, have a stabilized product, and know what their volumes will be. These are desirable customers for copackers.

With the local food movement, there have arisen a number of local kitchen incubators, of varying management quality. The Product Center tries to work with them to provide needed support to clients, to shore up the weaknesses, and intends to do more of that in the future.

Both graduate students and undergraduate seniors are involved in capstone courses (in agribusiness management, food industry management, and food science and packaging) that may take as their subjects Product Center client jobs.

Financial Management

At present, the Venture Development Program is financed through the state-funded Project GREEN (Generating Research and Extension to meet Economic and Environmental Needs), a collaboration between the MSU research and extension units and the Michigan Department of Agriculture and Rural Development.[35] The High Impact Venture Action Team is funded by Extension. Both streams are on a 5-year cycle before review for renewal.

The total budget between these funding streams and grant and fee income is $1.5 million, but the services of the extension field specialists are provided directly from the MSUE budget under the MOU that created the Product Center and are therefore not included in this budget. Prof. Peterson estimates this may amount to another $1.5 million in contributed value.

Pilot Plants

The FSHN and Animal Science pilot plants referenced above are not revenue sources for the Product Center so far as can be determined.

[35] See http://greeen.msu.edu/about.

Program Evolution

Although the Product Center until recently eschewed management of bricks and mortar, over the last three years the university has decided to build a new food processing and innovation center dedicated to industrial uses. This a $5.6 million project ($3.5 million for renovation, $1.75 for equipment, $0.25 million for first-year operations) involving major refurbishment of a building in Okemos, a mile off campus, that was formerly a food commissary for a regional restaurant chain and is now owned by the university (photo below). Renovation will begin next year and opening is scheduled for 2016.

Source: msutoday.msu.edu

Source: Fact sheet provided by Dr. Chris Peterson

The Product Center intends to use this facility to provide a flexible processing floor where those stage 2 businesses that don't otherwise have access to pilot facilities can use a pilot line without interference by academic uses. The goal is to create $15–20 million in sales growth and 50 new jobs for each project served. At full capacity of 5–10 clients per year, MSU projects annual economic impact of $100 million in sales and 300 jobs.

Construction capital is coming from the U.S. EDA ($2.7 million) with matching balances from the state's Michigan Economic Development Corporation and from MSU itself. However, the site will be managed on a fee-for-service basis and is expected to become self-sufficient.

There will be drop-down service lines from the ceiling to provide flexible connections, and main fixed equipment will comprise retort, kettles, IQF and spiral freezers). The building will have a separate staff of four professionals. Users will be expected to commit to between 3 days and 2 weeks of experimentation, and the site is *not* intended to serve as a long-term incubator. Furthermore, the facility will have USDA and FDA inspection capacity so that companies will be able to sell goods they produce there, which they cannot at on-campus facilities, which have exemption only for goods produced by the university itself.

Evaluation

Research published through the Product Center indicates that food processing accounts for 104,764 direct, indirect and induced jobs in the Michigan economy as of 2010, out of a total of 923,500 for all food, agricultural, floricultural/turfgrass, and ethanol jobs. Here is a summary of evaluation data for 2013, as published on the Product Center's website.

Services	Since 2004	Year 2013
One-on-one client counseling sessions	33,133	6,581
Clients assisted with business concept development	2,999	647
Clients commencing a new business or expansion	1,583	259
Clients using specialized services (testing, analysis, feasibility)	1,652	329
Venture launches at new or existing businesses	396	86

Source: 2013 evaluation data sheet provided by Dr. Peterson

Based on venture launches, the Product Center estimated increased first-year sales of $321.9 million, increased investment of $322.1 million, 1,147 jobs created and 644 retained.

Governance

Administratively the Product Center reports to the Department of Agriculture, Food and Resource Economics because that is Prof. Peterson's academic home, but in practice because of the funding sources and because projects can the CNR can touch any academic department in the CNR, the dean and the research and extension directors all consider themselves the Product Center's bosses as well.

Lessons Learned/Shared

- Prof. Peterson believes that the Product Center is unique in having achieved a balance between the scientific and technical resources of the central campus and the regional extension specialists who do both outreach and substantive business counseling. Getting campus and field extension people to work together can be more challenging than one would think even in a

land-grant environment. One reason for success is that the Product Center gives its cooperating extension specialists a “sound reason for being” and specialized training that no other agents have.

- Programs worthy of study include University of Nebraska Lincoln, Rutgers University, and Oklahoma State.

Oregon State University Food Innovation Center

Summary

The Food Innovation Center was created in 1999.[36] Its mission statement is "Advancing Northwest Foods." It has flexible processing space, but is mainly oriented to services: advice on product and market development, shelf-life testing, processing technology, packaging technology (including RFID work), and consumer sensory testing.

Consumer sensory testing is especially popular with larger companies – including those not necessarily engaged with food-science research at Oregon State in any other way – because the Center has developed cost-efficient access to a 20,000-person database of testers clustered around Portland metro, considered a home to highly sophisticated food consumers.

On the other hand, small companies mainly use the center's start-up consultations and its expertise in product formulation. These are functions that large companies prefer to hold in house, says Center director Prof. Michael Morrissey.

History and Motivation

The Food Innovation Center was created in 1999 by agreement between the College of Agricultural Sciences (CAS), its research and extension units, and the Oregon Department of Agriculture. At the time, the Oregon Agricultural Experiment Station had 10 experiment stations in 12 different locations, most of which were rural facilities focused on production agriculture.

The College and Department determined to create a new experiment station different from any of the others, focused on the agribusiness and processing industry, and situated in the heart of the Portland metropolitan area where most of the state's processor and food entrepreneurs are found.

The state built a 32,000 square foot building backed by $9.5 million in bonds and then turned it over (and defeased the debt) to the university. Finally, the state leased back about two-thirds of the building for use by the Department's development and marketing division, as well as units involved in certification, pesticide management, and export validation.

The director of the Food Innovation Center experiment station is Prof. Michael Morrissey, professor of food science and technology, who formerly directed the Marine Experiment Station in Astoria at the mouth of the Columbia River, near the coast.

Additional Programs

A basic, one-hour start-up consultation is offered for $110. The same fee is charged for any of a series of four fee-supported seminars on formulation, processing, packaging, and food safety. Finally, the Center supports a research program in agricultural economics and marketing.

[36] See http://fic.oregonstate.edu/. Battelle also acknowledges with thanks an interview granted on Sept. 29, 2014, by Prof. Michael Morrissey, the director of the center and professor.

Facilities

The Center's pilot facility is a flexible 40x40 room with electrical hookups allowing a wide range of process testing. While the building also includes analytical and testing laboratories, many crop-specific pilot plant assets (dairy, fruit and vegetable, and juice, beer and wine) remain back at the main campus in the small city of Corvallis (85 miles up the Willamette River, south of Salem) and seafood processing is based at the Marine Experiment Station. Sensory labs are at both Portland and Corvallis. There is no meat processing at Portland.

The Food Innovation Center usually has one or two food companies resident in its processing space for up to six months, but OSU's only formal incubator for food businesses is a dairy incubator at Corvallis. Although the Center actively refers its clients to a list of copackers, many of whom are also clustered around Portland, there is also need for companies to control their own space. Therefore the Center is pushing other actors in the region to set up quality incubation programs, Prof. Morrissey says.

Source: Dr. Michael Morrissey

Target Constituencies

The Center targets both early-stage entrepreneurs and established businesses in all size ranges. There is no specific preference by crop or food type.

Staffing

Other than the tenured faculty director, the Center also hosts an assistant professor, five professional staff of various titles (including one in the "faculty research assistant" track) and three support staff.

Partnerships

Extension, Research and State Agencies

The Center describes its primary partnerships as with:

- the Department of Food Science and Technology at the main campus for educational programming and subject-matter expertise, especially in sensory evaluation, a core strength;
- the resident staff of the state Department of Agriculture for linkage to the 24 commodity commissions, to a "farm to school" program to supply school cafeterias, and to a statewide network of farmers markets (which are not specifically state supported);
- the network of 30 extension agents statewide for referrals.

Other

In addition, the Center works with:

- the Oregon Small Business Development Center Network for start-up education for entrepreneurs
- Portland Community College on a targeted course on "get your recipe to market," which was created by the Center but now offered by the College.

Through its partners, the Center receives referrals from the rural counties. These companies are offered short courses either in the field or remotely by videoconference, but they are also encouraged to visit Portland for a half-day with the Center's product development group. Subsequently, advice on nutrition labeling or formulation can be handled over the Internet.

There is no major emphasis on workforce development or professional certification beyond the short courses offered. In Oregon a great deal of such effort is handled by the Northwest Food Processors Association, a large and powerful trade association.

Financial Mmanagement

The Food Innovation Center receives a budget like any of the other experiment station sites, which *collectively* receive $2 million annually in state appropriations, with no precise breakdown by station reported. Rental income produces about $530,000 annually, which presumably is applied to debt service on the building. There are occasionally small grants from one of the commodity commissions.

Pilot Plants

The pilot plants on the main campus and the seafood center as referenced above are not revenue sources for the Center so far as can be determined.

Program Evolution

The Center received seven or eight years of special appropriations to get the program started, but these disappeared after the financial crisis in 2009. A USDA grant for multi-commodity value-added work expired in 2012. As a consequence, the Center is now much more fee-based.

Evaluation

The Center does not publish an annual report or evaluation metrics. Informally Prof. Morrissey reports interaction with 300 to 400 food entrepreneurs a year, anywhere from nutritional labeling to full blown product development. The most prominent example of a client that was helped to grow fast is Salt & Straw Ice Cream, based in Portland and now expanded to Los Angeles.

Governance

As with the other 10 experiment stations, the Food Innovation Center is governed as an independent unit, somewhat analogous to a department on campus. Academic appointments and promotion and tenure decisions remain in the Department of Food Science and Technology, but the department has no say over budgets or priorities beyond service on the Center's advisory board. The director of the Food Innovation Center experiment station reports to the dean's group, and the dean has final say.

Lessons Learned/Shared

- Prof. Morrissey believes that the loss of targeted appropriations has been healthy because it forced the Center to start charging for what it would have given away for free. Clients still come, but they come better prepared with a list of questions so they will get value from their hour of paid consultation.
- He also believes that USDA went off track for a time with large grants on big-issues like obesity and climate change, but that it is returning to focus on areas where the Food Innovation Center can compete. There is currently a grant to work with start-ups.
- Prof. Morrissey considers as national models efforts at Rutgers, Michigan State, Ohio State, and Oklahoma State.

University of Nebraska Lincoln Food Processing Center

Summary

The Food Processing Center (FPC) at University of Nebraska Lincoln is a 31-year-old program, the oldest such program in the nation, embedded in the university's Institute of Agriculture and Natural Resources (IANR). The FPC mission is "to advance the value-added food manufacturing industry by partnering on technical and business development from idea through ongoing market support." The current director, Prof. Rolando Flores, has been in place 8½ years and is also head of the Department of Food Science and Technology.[37]

The FPC addresses all food groups and has managerial custody of the department's processing capacity. It is especially well known for its extrusion equipment. It serves as the department's primary vehicle for industrially sponsored and other applied research in the department. Its stated mission is "to advance value-added manufacturing industry by partnering on technical and business development."

The FPC's signature program, established in 1989, is the National Food Entrepreneur Program, which begins with one day "Recipe to Reality" seminar and proceeds to "Product to Profit," a second phase in which confidential services are provided to any participants who launch their own business. NFEP clients represent about 26 percent of the FPC total clients in 2013, according to the most recent evaluation report (see below)

The FPC also offers laboratory services (microbiological, acidified food testing, shelf-life testing); sensory analysis (both informal and consumer testing); concept and prototype development (including line extensions for existing processors); counseling on product and process scale up; advice on labeling; and "applied research and engineering," intended as the translational bridge between basic research and the food industry.

History and Motivation

The Department of Food Science and Technology is itself only 45 years old, and so the department was just 15 years old – and still emerging from the dairy and poultry department – at the time the FPC was created in order to capture within the state more of the value added from commodity crop production.

Additional Programs

FPC also offers a selection of courses, both online and in person, typically leading to professional certifications:

- Better Process Control School – Graduates are certified to FDA and are issued a certificate from FPC. $650.
- Food Microbiology Workshop – for those working in testing labs who have no formal training in microbiology. $795, with assistance to companies available through the Nebraska Workforce Development agency.

[37] See http://fpc.unl.edu/. Battelle also acknowledges with thanks an interview on Sept. 1, 2014, with Prof. Rolando Flores, Director of the FPC and Head of the Department of Food science and Technology .

- Food Processing Management Online Certificate Program – modules in food safety, processing and product development, and business growth strategies/human resources.
- Extrusion Workshop – introductory workshop combining extrusion theory and pilot plant exercises around real-world product development.

Facilities

Operates from the 60,000 square foot academic building which along with Filley Hall (which houses the Dairy Store) comprise the Food Industry Complex on the main campus. See below under program evolution. Currently available equipment elements include:

- Extrusion equipment, extensive array
- High-pressure pasteurizer
- Dairy equipment, extensive array
- Dehydration and drying
- Baking
- Confectionary
- Canning
- Filtration/separation
- Liquid processing (soups and sauces)
- Milling
- Vegetable processing
- Packaging

Target Constituencies

Discounted rates to the FEP and all services are provided to companies that are based in Nebraska, but the FPC sees itself as a national program, and overall about half the center's clients come from outside the state.

Generally, the center now targets customers ranging from single entrepreneurs to projects with Cargill. The FPC makes no distinction between lifestyle and scalable entrepreneurial start-ups. It does not have a special focus on mid-sized companies, but finds that the Nebraska Department of Development considers the FPC an asset in assisting such companies, and often puts the center on the itinerary for out-of-state recruitments.

Connectivity to industry is provided through an advisory board.

Staffing

According to Prof. Flores, the program migrated toward an orientation to technicians and others with economic development or business development background, and became heavily dependent on opportunistic grants.

When these sources began to dry up, the vulnerabilities in this approach became obvious, and Prof. Flores became concerned that the program had become too much about grant-chasing and not enough tied to the academic expertise of the department. Accordingly, he cut the staff head count in half from about 25 to about 12 and refocused on projects that exploit the department's specific expertise, with a renewed focus on "applied research" with larger companies so that faculty would not turn away from the FPC based on the perception it was only about "mom and pop" projects.

Staffing comprises 3 food scientists (managing entrepreneurial programs and the sensory lab); 2 pilot plant managers and 1 assistant in extrusion; 3 in the dairy plant and store; and 3 additional non-tenured research faculty (with responsibility for lab services, food safety, and distance learning).

Partnerships

Extension

Under the currently leaner configuration, the FPC takes the position that there are many other extension entities on campus that work with food coops, or do general entrepreneurship work, and it maintains a strict focus on value-added food processing.

Research

Under its current configuration, the FPC places strong emphasis on partnering its non-tenured research faculty with tenure-track faculty on applied research projects funded by industry or federal agencies.

State Agencies

The Nebraska Department of Agriculture does directly support a network of farmers markets, but this is not a primary emphasis does not locate any satellite facilities off the Lincoln campus. As noted below, the state Manufacturing Extension Partnership, previously run by the Nebraska Department of Economic Development, will move into the UNL structure. Whether food processing will be a primary interest is not yet known.

Other

The FPC sends qualified prospects to copackers, because most of its facilities *except* the Dairy Store are not permitted to allow third parties to sell products produced there, and the university does not want the liability.

Financial Management

According to the annual evaluation report published by the FPC (see further below), revenue in FY 2013 was 52 percent from industry, 32 percent from the state (through the extension and research divisions of IANR) and 16 percent from foundation or association grants. This represented a shift toward industry and grant support, as the state Department of Development has moved away from support through the MEP program.

However, as of 2014, management of the MEP has shifted from the state Department of Economic Development to the University. IANR is an explicit partner in the university's program, along with the

College of Engineering, and the FPC expects renewed support from the MEP program, though probably on a fee-for-service basis.

Entities that have supported projects currently active in the Applied Research and Engineering unit include: NE Dry Bean Commission; Midwest Dairy Association; NE Department of Agriculture; Kimmel Foundation; the Defense-funded National Strategic Research Institute also at the University of Nebraska; and USDA.

Pilot Plant

In FY 2013, the combined pilot plants under the jurisdiction of the FPC accounted for 18 percent of the Center's revenue, the largest share by unit operation after "applied research and engineering" (39 percent). This was slightly below average for the period FY 2009–2013.

According to the latest data, following is breakdown for H1 2014 of projects and revenue by all unit operations, showing an uptick in revenue share from "Product Development/Sensory Innovation":

Unit Operation	% of projects	% of Revenue	% of Projects <$1,000	% of Projects >$1,000
Lab services	39%	19%	62%	13%
Product Development/Sensory Innovation	33%	30%	25%	43%
Pilot Plants	14%	22%	4%	24%
Applied Research/Engineering	7%	20%	9%	5%
Food Entrepreneur Assistance Program	7%	9%	0%	15%

From these data, the FPC draws the conclusion that for viability two types of projects are necessary: high-value uses like Product Development and Pilot plant usage, which are contracted under large or long-term projects, but are few in number; a larger number of lower-value uses of laboratory services; and collaborative projects across the units.

Program Evolution

Originally the FPC was based in the department's academic building, but early in its history the university received a federal award to add a second, adjacent building which was dedicated to pilot and processing capacity. Now a third major expansion is in process.

A building to be known as the Food Innovation Center, incorporating the Food Processing Center and other aspects of the university research enterprise, will occupy the first building on the Nebraska Innovation Campus (NIC), on a nearby former state fair grounds. The NIC is the university's second try at a research park, this one closer to campus than the former Nebraska Technology Park which was sold to a private operator.

The concept document for the facility provided by Prof. Flores states that UNL has an opportunity to focus on "transforming Nebraska-grown commodities and specialty crops into valuable food, feed, fuel and fiber products." A central location will "unite portions of these resources in a preservation and transformation hub, not only for food but also for the other types of products, and to foster greater collaborations with all

the remaining portions." Companies will be offered residency in part of the space (see below), effectively creating an incubator.

Collaborating university units are listed as the Food Science and Technology, Biological Systems Engineering, College of Engineering Dean's Office, Nutrition and Health Sciences, Animal Science, mechanical and Materials Engineering, and of the Food Processing Center. Stated priorities are to continue the currently self-sufficient program of applied research, while adding champions for industrial interaction, and to lay groundwork for multidisciplinary basic research aimed at the "food factory of the future." Stated objectives include integrating FPC with the Loeffel Meat Lab, the Engineering and Science Research Support Facility, Wheat Quality Lab, Bio-fiber Development Lab, etc. and to reach out to adjacent industries such as pharmaceuticals, pet foods, biofuels, etc.

Space needs specified in the concept document are:

- 5,000 square feet for food-grade applied research, including extruders and much of the equipment in the current setups excluding dairy processing which (along with the Dairy Store) will continue to operate form the "Food Industry Complex" on the main campus;
- 2,500 square feet for nonfood-grade applied research, including equipment for the Industrial Agriculture Products Center, the Agricultural Research and Development Center, and other processing groups;
- 3,600 square feet (20-foot ceilings) of easily reconfigurable space for lease for equipment trials and "incubation" of food concepts;[38]
- 1,500 square feet for future BSL 3 labs depending on demand and utilization of the space on campus;
- flexible layout providing for rapid product testing – food-grade, non-food, and pathogenic – office and teaching space with a lecture room, and dedicated dry and cold (refrigerated and frozen) storage rooms;

Targets of opportunity specified in the concept document include a NIST-funded Manufacturing Technology Acceleration Center (M-TAC) addressing small and mid-sized food manufacturers. An architectural rendering and placement (#5) on a map of the NIC follows:

[38] Probably focusing on larger companies unless SBIR contracts can support partnerships, since the anticipated space rates are high;

Source: http://foodsciunl.edu/nic-move

Source: http://innovate.unl.edu/nic-map. Campus is about 2 miles to the east.

Evaluation

The FPC publishes an annual evaluation report.[39] Here are overview data from the latest:

Indicator	H1 FY 2014
Number of clients	135
Number of projects	203
Project revenue	$324,648
Participants in extrusion workshop	17
Participants in National Food Entrepreneur Program	36
Participants in Online Food Processing Management Program	6 new, 22 grads
Number of graduate students advised by FPC faculty	9
Number of undergraduates employed	35
Number of research manuscripts accepted for publication	1

The report further indicates that revenue has generally held steady in the low mid six figures since FY 1999 with the exception of a bump in 2010 due to completion of a large project with the American egg board. Number of clients has generally climbed since 2009, with about half from Nebraska and half outside the state.

Governance

The FPC is one of 13 organized research centers that report to the dean of the IANR, the associate deans for research and extension, and the vice chancellor and associate vice chancellor for IANR. The three research faculty are part of the department and enjoy almost all the privileges of tenure-track faculty.

It exists in parallel to industrial Agricultural Products Center, directed by a professor of biological systems engineering.

Lessons Learned/Shared

- Prof. Flores notes that depth of services the FPC can provide has been a challenge. " There are only so many jams and jellies" that a center can help develop, and one has to be provide more in-depth programs that tie to other academic interests – for example, extracting functional ingredients that improve health – while also maintaining capability to deliver basic information on food technology. Do not try to create a center without the academic component.
- The organization has to be flexible, able to adapt and change, be self-supporting but not overly dependent on one type of grant, or overly opportunistic about writing itself into other entities' grant proposals that are not fundamentally related to creation of value-added.
- The center has to be responsive to in-state stakeholders, but the way the world food trade works, it is not viable to say that "we're here only to serve Nebraska."

[39] Current edition at http://fpc.unl.edu/documents/4282805/8016965/FPC+Report+July+1+-December+31+2013.pdf/3dfdc366-fa2a-40b0-8bb2-82530c4921a7.

Auburn University (New Program)

Summary

The Auburn University Food Systems Institute (AUFSI)[40] is an interdisciplinary research program designed to contribute nationally and globally to better understanding and management of the entire food system – from growing through harvesting, processing, marketing, and distribution. The mission is "to provide an infrastructure for promoting interdisciplinary research, outreach, teaching, and training opportunities relating to food systems among faculty in academia, personnel in industry, decision-makers in government, and consumers in the general public." AUFSI scored early success with a $6.5 million FDA contract (shared with Purdue, NC State and University of Memphis) for a Virtual Food Systems Training Consortium aimed at qualifying inspectors for various foods regulated by the agency.

AUFSI functions mainly as a matchmaker and catalyst for teams of investigators not necessarily from the traditional agricultural disciplines but whose skills touch the food system at some point. Some 28 participating "core" faculty are listed, several from the Colleges of Engineering, Liberal Arts and other non-agricultural or veterinary departments, and a few from outside Auburn itself. AUFSI is still relatively small and new, and does not occupy very large facilities.

Included as an element of AUFSI's published strategic plan is an entrepreneurial initiative that currently sponsors an annual conference and aims eventually to create a regionally focused Center for Food Entrepreneurs. Like the research program, it also brings together faculty from across colleges including Business.

History and Motivation

The AUFSI began in 2010 as an experimental "initiative" staffed by a director and one person in charge of IT, co-funded by the Vice President for Research & Economic Development, and the Alabama Experiment Station (which like the Extension System is a collaborative among Auburn and Alabama A&M).

The AUFSI grew out of an earlier initiative in poultry-products food safety, and represents an attempt to transcend this silo and build a capability that faculty from other colleges were comfortable partnering with. However, it soon became apparent that a focus on safety alone would not distinguish the program from others around the nation more advanced and better endowed. Accordingly, a broader emphasis on food systems was adopted.

AUFSI is considered an initiative in health sciences, one of six broad strategic thrusts being pursued by the university. Its initial goal was essentially one of research development. This work continues, even though the early success has been in the area of online training and technology.

[40] See http://www.aufsi.auburn.edu. Battelle also acknowledges with thanks an interview conducted with Prof. Pat Curtis on Oct. 6, 2014.

Additional Programs

AUFSI includes also a “National Egg Products School” that offers a three-day hands-on training.

Facilities

AUFSI is based at the Hubbard Center for Advanced Science, Innovation and Commerce (CASIC), a 84,000 square-foot $28.9 million facility funded half by the National Institute of Standards and Technology, matched by a state appropriation through Auburn. CASIC is situated at Auburn’s research park. The building houses five interdisciplinary programs designed to contribute to Alabama’s economic development, of which AUFSI is one, and includes 20 lab suites, of which AUFSI occupies three. The Hubbard Center was selected as the home for AUFSI because campus accounting rules pertaining to the research park do not require certain university tenants to pay rent as a direct cost.

The lab suites in the Hubbard Center include:

- a Level 2 processing facility for research on pathogen interventions, built to USDA and FDA standards for multiple foods;
- a second lab for testing and detection of pathogens and analyzing food products;
- another suite targeted to engineering and microbial requirements for food traceability.

Processing equipment includes a retort and smoke house, and a pasteurizer is targeted next. Generally the lab suites have been fitted out in “flex” format with testing equipment that Prof. Curtis moved over from her own lab when she ceased an active research program in favor of the administrative role. For the most part, however, AUFSI leverages pilot plants (typically non-inspected teaching facilities in meat, poultry, etc.) that remain where they were on other parts of the Auburn campus. In the process of learning

what was available to its clients, AUFSI was able to publish a brochure that for the first time assembled lists of facilities that might be useful to food entrepreneurs and food systems researchers.

Target Constituencies

Although the research targets of the AUFSI are national and global, the entrepreneurial program aims to reach Alabama businesses. At the research park, AUFSI is across the road from the Auburn Business Incubator, which includes an office of the state Small Business Development Center. The latter serves as the outreach arm and provider of counseling services. The Auburn Incubator does *not* have any food-processing or kitchen capabilities.

Staffing

AUFSI's staff of three will assist affiliated faculty in grant-writing, accounting for projects, and assessment/accountability.

Partnerships

Extension

Until establishment of the AUFSI and its entrepreneurial initiative, all counseling of start-up food processors was provided by extension specialists, primarily in the Poultry Science group but also in certain regional extension offices. Counseling activities are still handle by the same individuals, but now being coordinated more closely through the AUFSI and its annual entrepreneurial conference.

One such regional initiative is the Chilton Food Innovation Center, a state-inspected community kitchen and value-added processing facility in Chilton County managed by a regional extension agent and representing a collaboration with the county government, as well as the Alabama Department of Agriculture and Industries, the City of Clanton, a local bank, and the Alabama Farmers Federation. There are not many commercial copackers in the state outside the fisheries sector, and this facility is expected to be important to the AUFSI entrepreneurial initiative.

Research

As noted, the AUFSI is itself considered primarily a research initiative. Otherwise, food processing is not a research specialty identified by the Alabama Experiment Station.

State Agencies

The Department of Agriculture and Industries includes a Farmers Market Authority that does provide grant support for establishment of farmers markets, but with no specific connection to food processing. The program that financed the Chilton Food Innovation Center is the USDA-backed Specialty Crop Block Grant.

Food production is recognized as a priority industry by the Alabama Economic Development Partnership, but no specific programming is specified.

Financial Management

About half the program budget is from grants. The remainder is mostly from the Alabama Experiment Station. The share from the VP for research has declined since it became clear that the program's early success would be in training and outreach rather than in large research grants.

Pilot Plants

Revenues from several existing pilot plants across the campus play no role in financing the AUFSI.

Program Evolution

The unexpected success at AUFSI with the FDA inspector-training project has led the AUFSI into other projects that can leverage the IT capabilities that were built to deliver on this contract. New projects include interactive instruction ("Virtual Chicken") and a food-safety game being developed in partnership with a San Francisco firm.

Evaluation

No formal evaluation data have been published.

Governance

AUFSI operates under an internal advisory board comprising eight deans (Agriculture; Engineering; Science & Mathematics; Business; Graduate School; Architecture, Design and Construction; Nursing; and Veterinary Medicine) and one faculty member (Liberal Arts).

Lessons Learned/Shared

- Prof. Curtis notes that having the university vice president for research involved by name has proved as important as funding from his office, because there are faculty in other colleges or units who would not otherwise have worked with the College of Agriculture or the Alabama Experiment Station, even though the latter is in theory interdisciplinary.
- She adds it is important to be able to sell faculty in other units on the benefits to them of collaboration. In some case, AUFSI provides grant-writing assistance; in others it lends support on IT issues. Seed funding itself did not work. When the right ideas emerged, then the right working groups coalesced around them comprising people with common or related interests. These groups can meet virtually not necessarily in person