Establishing Supply Chain for an Innovation: The Case of Prepackaged Salad

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The agrifood sector is subject to continuous innovations introduced by researchers or practitioners. Implementation of innovation requires a well-designed product supply chain that enables relentless innovation and meets consumer needs. Prepackaged salads are an important California-based innovation that utilize new technologies to design supply chains for new and improved products.

Food choices available to consumers have dramatically increased over the past 50 years, reflecting product and process innovations. Consumers can purchase exotic fruits and vegetables year-round, prepackaged salads and ready-to-eat meals, but innovations are ideas and concepts, so innovators face two challenges. The first challenge is to translate innovations into working processes and products—accomplished through the innovation supply chain. The second is to utilize these processes and bring products to market—done through the product supply chain. This article describes how both systems work, in general, and then illustrates them.

We illustrate the innovation supply chain through the case of controlled-atmosphere storage, and the product supply chain through prepackaged salads. We show that the wide array of ready-to-eat salads we enjoy today originated in experimental research that started in the early 19th century, both in the private and public sectors. Entrepreneurs applied these tools through further research and commercialization efforts that pursued value-added consumer products to meet the demand for convenience, taste, and freshness.

The Innovation Supply Chain

Practitioners or scientists at universities or in industry may originate innovations. Commercialization of innovations requires establishing working processes, upscaling them, and testing them for efficacy and safety. Research leading to a working output is gradual. Innovators may obtain patents or trade secrets and contribute to a growing body of knowledge through research literature.

Some public sector innovations (e.g., from USDA, research universities) may be made available freely to users. But public sector capacity to develop innovations is limited, and therefore universities establish offices of technology transfer (OTT) to transfer or sell the right to utilize their patents to the private sector. The exclusivity that the patents allow motivates firms to invest in their innovations.

Investment in the development of innovations is risky, and many patents do not find existing firms that want to develop them. In these cases, universities may sell rights to develop technologies to startups, sometimes involving the scientists who invented the product. In other cases, the OTT can sell to a firm the right to develop the technology. Some major companies, like Amgen, were launched based on university patents, and some startups based on University of California technologies were sold to large companies (e.g., Monsanto purchased CalGene).

The innovation process is time-consuming. It may start with discoveries of principles that are followed up with scientific experiments at different scales, which refine and expand the knowledge base, resulting in methodologies available for commercial applications. This process may be carried out by multiple organizations, both private and public, and benefit from the exchange of knowledge through publications and experience gained with early applications.

The Case of Controlled-Atmosphere Storage

The search for methods to maintain freshness in produce has been going on for millennia. For example, traders buried fruit underground, and ship captains kept them in unventilated holds. However, in 1820, a French chemistry professor, J.E. Berard, realized that fruits utilize oxygen and emit carbon dioxide, and denying oxygen delays the ripening process. Several practitioners applied this knowledge to develop storage facilities, but to use these efficiently, more quantitative applied research was required. Government researchers in Cambridge, England, established parameters for the preservation of different fruits in the 1920s.

Drawing on this research, UC Davis pomologists working with a private company experimented with cold storage facilities in Watsonville, mostly to preserve apples. Cornell and other universities conducted parallel lines of research, in which they established parameters of temperature ranges and oxygen levels to preserve various fruits. A key challenge was to control the atmosphere continuously, and Whirlpool Corporation, using its expertise in refrigeration, developed TECTROL®, a "total environmental control" system in the early 1960s—mostly for the purpose of storing and shipping fruit.

Dana Dalrymple's 1969 study of this history, "The Development of

Table 1. Packaged Salad Sales, 52 Weeks, 2015/16

Prepackaged Salad Sales		
Prepackaged Salad Varieties	Dollar Sales	Dollar % Change vs. Previous 52 Weeks
Packaged Salad (All)	$3,700,000,000	8%
Salad Blends	$964,308,383	-1%
Completes/Kits	$950,103,180	31%
Organic Salad	$715,774,511	12%
Premium Garden Salad	$425,867,408	-4%
Regular Garden Salad	$404,867,985	2%
Coleslaw	$116,481,678	2%
Broad Leaf Spinach Salad	$58,639,562	-1%
Broccoli Slaw	$33,669,723	3%

Source: Nielson Perishables Group FreshFacts, 52 weeks ending April 2, 2016.

an Agricultural Technology: Controlled-Atmosphere Storage of Fruit," suggests that the development of the technology was "the subject of years of publicly financed study…[o]nly after considerable laboratory work was the technique taken out for preliminary tests…[a]s the trials proved successful, commercial use expanded."

The innovation process leads to viable technologies, and TECTROL® is the technology used currently for controlled atmosphere storage. We will show how this technology has been applied to provide prepackaged salads, and furthermore demonstrate the evolution of the supply chain for this product.

The Product Supply Chain

Once the product and technology to produce it have been developed, the firm that owns it needs to develop the product supply chain. In the case of agrifood products, the supply chain may include many stages, including production of "feedstock," which is an agricultural product, processing the feedstock, shipping, wholesaling, retailing, etc.

The simplest supply chain has two stages, including on-farm production of an agricultural product and off-farm activities of processing and shipping. The firm that controls the technology is likely to design the supply chain to maximize its average return on investment adjusting for risk. Some constraints on these choices of the firm include credit availability, managerial capacity, access to labor and land, along with other inputs. The firm has to determine the productive capacity, namely the size of processing facilities and feedstock required. Furthermore, the firm must determine how much of the feedstock to produce in-house and how much to buy from others.

One strategy is to have a vertically integrated operation where the firm produces all feedstock and the final product. Another strategy is to concentrate on processing and obtain all or part of the feedstock from the market (i.e., contracting). Vertical integration may limit the size of the operation, but reduce the dependency on suppliers. Contracting feedstock reduces the costs of investment in capital for production of feedstocks.

Each strategy has a different risk profile and firms may take a mixed strategy. Frequently, innovators who introduce new products start at a small scale, controlling both feedstock production and processing, and perfecting both processes. Over time, they may engage in partnership in production of feedstock, or even processing. It is also possible that some may even sell the right to use the technology to others.

It is important to keep in mind that firms operate in a dynamic environment and the introduction of new agrifood products involves continuous learning and adaptation. Both the production costs and processing costs are likely to decline over time on a per-unit basis due to "learning by doing" at the firm level. Product characteristics may change when the firm is more aware of consumer preferences. Over time, a product may include more varieties to accommodate differentiated tastes among consumers.

When a product is successful, the scale of the operation increases over time, the number of processing facilities increases, and the product distribution network expands geographically. Quite frequently, once a new product is established, the initial innovator encounters competitors developing similar products. Every innovation has its own evolution process, and an effective way to understand the design of innovation and product supply chain is to learn from case studies. The case study of prepackaged salads illustrates some of the basic principles discussed above.

Prepackaged Salads and Fresh Express

Lettuce is one of the major crops produced in California, mostly in the Central Coast region. Bruce Church, Inc. was a family-owned major lettuce producer that produced 7% of the U.S. head lettuce supply in the 1960s. The company was concerned about the instability of the price of lettuce and was ready to venture into innovative activities. It also realized that, because lettuce was perishable, keeping it fresh during the shipping process was a major challenge; therefore, potential

gains existed if shipping and processing were improved.

The innovation was to apply controlled and modified atmosphere solutions, like TECTROL®, to preserve lettuce in storage and shipment. As we mentioned, Whirlpool Corporation owned the rights to TECTROL® so Bruce Church and Whirlpool Corporation established a research unit, TransFRESH Corporation, to develop and implement the technology for shipping lettuce in a controlled or modified environment.

In 1968 experiments using cut lettuce were initiated, and by the mid-1970s, a viable technology emerged. The research found the right formula to manage oxygen and carbon dioxide for mixtures of leafy greens inside the enclosure to preserve freshness. The new technology revolutionized the leafy green market.

Until the 1970s, leafy greens like lettuce went to market as trimmed or whole heads packed in cooled corrugated boxes. The new technology enabled the packaging of lightly processed leafy greens into large plastic bags for shipping to fast food outlets or large institutions. The package contained either all iceberg lettuce or a mixture of iceberg lettuce with shredded red cabbage and carrots. A company called TrimFresh was established to sell the processed leafy greens, obtaining the feedstock from Bruce Church and other farms.

However, as the innovation process continued to develop, the company realized another potentially more promising product line—prepackaged salads. Surveys showed that consumers were aware that they discarded much of the lettuce when they bought whole heads, and that they liked variety in the salad and disliked the preparation effort. The pursuit of convenience, taste, and health generated willingness to pay for prepackaged salads.

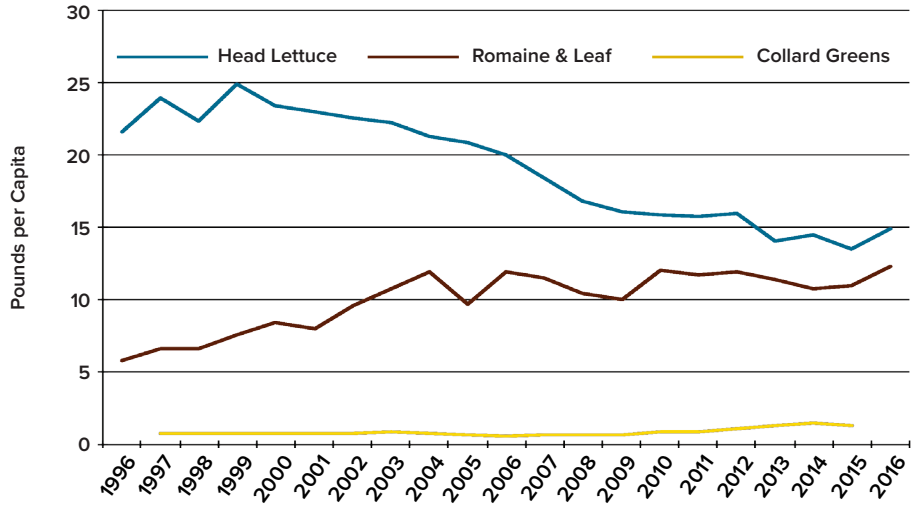

Figure 1. The Greens Americans Actually Eat

Source: United States Department of Agriculture.

By 1989 scientists were able to develop packaged salads to have a 14-day shelf life and introduced salad blends to the market. To introduce these new products, a new company named Fresh Express formed in 1986. In order to finance the expansion of prepackaged salad production, Bruce Church sold its farms and relied on other farms to provide the feedstock, which were different types of lettuce and other vegetables. The transition to prepackaged vegetables also led the industry to move away from free on board (FOB) pricing towards contracting. Over time, the length of the contracts increased and allowed growers to have more certainty.

To expand consumer demand for prepackaged salads, Fresh Express and others increased product diversity by adding in other vegetables, including spinach and carrots. To enhance the value of prepackaged salads, they added meat products, like chicken and bacon, as well as salad dressing. To increase product differentiation, entrepreneurs incorporated exotic products like kale and quinoa, which became prominent components in prepackaged salads. Over time, several competent companies entered the prepackaged salad market after obtaining the right to freshness technology or by developing their own formulas. Today, supermarkets may devote about 10% of their vegetable shelf space to these packages.

According to Nielson Perishable Group FreshFacts, in 2016 Americans bought twice as many prepackaged salads as whole lettuce heads. Prepackaged sales in the U.S. generated $3.7 billion in 2015 (see Table 1), and the rate of growth for prepackaged salads was 8%, with organic salads growing at 12%.

The improvement in the transport of leafy greens associated with TransFresh technologies also changed the composition of products consumed. In particular, there was a transition away from iceberg lettuce with a longer shelf life to both leaf and romaine lettuce, which are more attractive in salad kits (see Figure 1).

With prepackaged salads, there was an obvious increase in consumption of collard greens and spinach from the 1980s (spinach consumption slowed after major food safety incidents in 2008). While the consumption of kale is small, it has seen a remarkable 400% increase in appearance on restaurant menus over the past five years.

Growers are transitioning away from iceberg lettuce with a longer shelf life to leaf and romaine lettuce, which are more attractive in salad kits.

Prepackaged salads are now part of the ready-to-eat prepackaged fruits and vegetables sector, with estimated sales of $5.5 billion in 2014 and projected sales of $7 billion in 2018. The prepackaged salad revolution is now global, as sales of prepackaged fruits and vegetables in Europe are of the same order of magnitude as the United States. While still small, they are growing significantly in Asia as well.

Conclusions and Implications

The emergence of prepackaged salads resulted from both a continuous innovation supply chain that enabled a technology to be applied to leafy greens, along with a product supply chain to process, store, and distribute a growing range of value-added agrifood consumer products. The entire process, from the basic discovery of the principles of extending storage life for fruits and vegetables to the differentiated prepackaged salad product, has taken close to 200 years, and it continues to advance today.

Introduction of successful new products requires identifying features for which consumers are willing to pay, which in this case includes convenience, diversity, and healthfulness. The innovators need the capacity to take advantage of new scientific knowledge, obtain talent to develop it further, and obtain capital to invest in research and development activities, productive capacity, and distribution infrastructure. California has been at the forefront of these innovations because of its advanced agriculture, the availability of well-trained scientists, and the close collaboration between the private sector and universities.

The development of new products, like processed food and prepackaged salads, is also associated with the capacity to introduce new crops, as exemplified by kale and quinoa. Thus, development of new and appealing crops, as well as techniques to provide them as part of a large portfolio of products to consumers in a convenient manner, will be part of the challenge for the agrifood sector.

Prepackaged salad exemplifies the strong capacity of the industrial-education complex in California to come up with new innovations and develop the supply chains to implement them. Controlled atmosphere storage and prepackaged salads emphasize the importance of public-private collaboration in research and development. Additionally, it emphasizes the need to continually develop our scientific knowledge base, upgrade the skills and capacity to convert innovation to new products, and to design effective and profitable innovation and product supply chains. Understanding and applying sound economic principles are critical for the efficient allocation of resources between research and development, feedstock and processing and distribution capacity that leads to successful innovation and product supply chains.

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