Alimentary Experiments: How Science Got Into Our Kitchens

by

Natalie Neumann, Romy Raad, Mihai Ciobanu , Selim Budeyri and Thomas Schmidt

Parsons, The New School of Design.

Abstract

Often considered only the domain of electronics and technology, innovation applies in every realm of human endeavor. This paper investigates the evolution of Molecular Gastronomy as a field demonstrating the principles of innovation. It examines this discipline's origination, diffusion, and widespread adoption. Four consecutive phases in its development are identified as: (1) Technology and Efficiency; (2) Experimentation with Food; (3) Haute Cuisine; and (4) Available for Everyone. These phases and phase transitions are closely analyzed using D. A. Norman and R. Verganti's theory of Incremental and Radical Innovation as well as E. M. Rogers' theoretical work on Diffusion of Innovation. As a result, the type of innovation of each phase of Molecular Gastronomy is identified and each phase change is directly related to a reduction in uncertainty. Further, diffusion within each phase is examined amongst different social systems in order to depict possible trajectories of the future evolution of Molecular Gastronomy.

Keywords: Molecular Gastronomy, Diffusion of Innovation, Spherification, Science and Food, Haute Cuisine, Molecular Cooking, Creative Cuisine, Modernist Cuisine, Radical Innovation.

Introduction

Molecular Gastronomy leverages chemistry and other science to manipulate ingredients at an elemental level fabricating novel food creations. This paper investigates this culinary innovation from its early beginnings to today's adoption - from evolving as a technical creation to transforming into an artistic revelation. Throughout its evolution, Molecular Gastronomy passed through four phases, defined here as: (1) Technology and Efficiency, (2) Experimentation with Food, (3) Haute Cuisine and (4) Available for Everyone.

Norman and Verganti state that an innovation can be created through a radical or incremental change either in technology, meaning, a combination of both, or through Human-Centered Design (Norman & Verganti, 2014). They categorize these as: *Technology-push Innovation*, *Meaning-driven Innovation*, *Technology Epiphanies,* and *Market-pull Innovation* (Norman & Verganti, 2014, p.90). Remarkably, the four phases of Molecular Gastronomy align with Norman and Verganti's four types of innovation.

Each phase transition relates directly to a reduction in uncertainty, which E. M. Rogers defines as "the degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives" (Rogers, 1983, p.35). The degree of uncertainty can be reduced by "obtaining information about (an) innovation", including its attributes. Rogers defines these as *relative advantage, compatibility, complexity, trialability and observability* (Rogers, 1983, p.265-266). To understand the reduction of uncertainty within each phase, the attributes of social, historical, technical, and economic contexts were analyzed.

Furthermore, Rogers defines the diffusion of an innovation as: "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1983, p.35). To understand how Molecular Gastronomy diffused within each phase, different social systems (adopters, opinion leaders and change agents) were investigated, along with communication channels (professional publications [press], public discourses [social media] and education [schools, programs, and books]).

Lastly, the knowledge stages of the adopters' innovation-decision process were examined. At each phase change of the innovation, the adopters' *awareness knowledge*[1] was singled out. This happened either through accidental exposure to the innovation or through the need felt once adopters learned about the innovation's existence. Uncertain, some adopters sought *how to knowledge*[2] over *principles knowledge,*[3] and vice versa (Rogers, 1983, p.167). Understanding knowledge through different stages completes the picture of the evolution of the innovation and outlines the aspects of the innovation-decision process (Rogers, 1983, p.164) in more detail.

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[1] Once exposed to *awareness-knowledge*, one is aware that an innovation exists. *Awareness-knowledge* motivates an individual to seek for *how-to knowledge* and *principles knowledge*.

[2] *How-to knowledge* is information, necessary to properly use an innovation. More complex innovations require a larger amount of *how-to knowledge* for adequate adoption.

[3] *Principles knowledge* consists of information dealing with the underlying principles of how an innovation works.

Technology And Efficiency (1950-1988)

Key Events:

1950s: Unilever pioneered spherification.

1970s: Adoption by the food industry.

The first, most renowned molecular cooking method, spherification, was discovered by scientists in a medicine laboratory seeking to increase manufacturing efficiency. This phase was thus defined as Technology and Efficiency.

Spherification is a chemical process where liquid matter is encapsulated in spheres by a gel membrane. When applied to foods, a palate-pleasing burst of flavors results at consumption - a surprising sensation as ultimate closure. The caviar-emulating creation provides boundless possibilities to discover familiar flavors in novel arrangements.

The process of spherification relies on the reaction between two chemical elements, calcium chloride and sodium alginate (Andres, 2014), and can be generated by two methods: basic and reverse (see Figure 1).

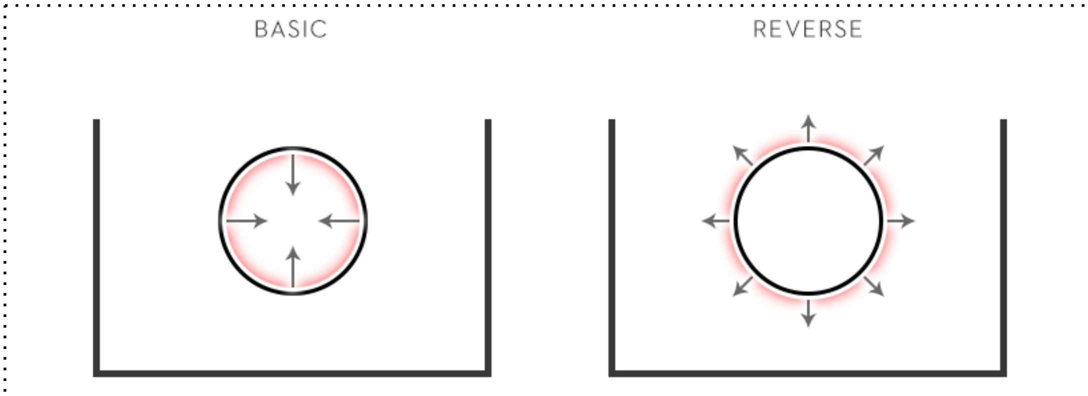

Figure 1: Basic and Reverse Spherification

In basic spherification, a membrane forms from inside the bubble. For this, the desired liquid mixed with sodium alginate is poured into a bath of calcium-infused water, forming an especially fragile membrane of which the consumer feels only the liquid, elevating the dining experience. The significant downside of this technique is that the chemical process cannot be stopped. As the solid gel membrane forms from within the sphere, the bubble turns solid without leaving a liquid center. Therefore, the food should be served immediately after its preparation and cannot be stored over a longer period of time.

For reverse spherification, the desired liquid is infused with calcium, then poured into a sodium alginate bath, forming the membrane from the outside. By placing the spheres into clean water, the chemical reaction can be stopped at any time, which provides more control over the process. The basic spherification technique only allows for non-calcium-containing liquids, wherelse reverse spherification allows a larger variety of liquids. The downside here is that the preparation process for the sodium bath can take up to twenty-four hours (Molecular Recipes, 2014).

Unilever pioneered spherification as part of a new drug delivery process (Potter, 2010). Their goal was to find a method shaping small beads of medicine with a thin outer skin retaining a liquid center. The technical context of this innovation was to create new hardware meeting an existing need - making the drug delivery process more effective while increasing manufacturing efficiency. The company increased investment in experimentation, research, and development, to gain the desired *how to knowledge.* The fundamentals about how spherification works and how it can be applied (*principles knowledge*) was thus established by chemists in their laboratories.

Later in this phase, the food industry started using spherification to re-engineer fruits, vegetables and meats, transferring it from medicine to food processing, in order to meet that industry's need for more efficient and consistent food production. Food scientists sought to convert ingredients into uniform shape and texture. Their solution was the *how to knowledge* already extant in the medical industry (*awareness knowledge*). By pureeing and subsequently spherifying ingredients, they were able to reach not just uniformity in product appearance but also substantial cost savings, using purees rather than whole foods. They were able to use ingredients with slight inconsistencies, e.g. irregular colors, and process these into comparable products, while maintaining consistent quality.

For both industries, this technical innovation allowed the mass production of goods in a homogeneous form (technical context). Furthermore, by manufacturing products of consistent quality at a low price point, high-quality items could be spread to a broad audience - supporting equality to everyone (social context).

The usage of spherification resulted in a substantial profit increase for the companies, subsequently generating jobs in the pharmaceutical as well as food production industries (economic context).

Overall, spherification emerged as a solution for mass-production promoting efficiency and effectiveness. Using this technique as a novel process for drug and food delivery was a radical change in technology, driven by specialists (in contrast to users) without changing the meaning of consuming medicine or food. Hence the innovation developed as a *Technology-push Innovation* (Norman & Verganti, 2014).

Experimenting With Food - Joining Science & Gastronomy (1988-2004)

Key Events:

1984: Harold McGee: An American Food Writer *On Food and Cooking*.

1986: Hervé This and Nicholas Kurti collaborated on their cooking experiments.

1995: Nobel Prize winner Jean-Marie Lehn invited Hervé This to create the first Group of Molecular Gastronomy in his laboratory at Collēge de France.

1996: Hervé This presented the first PhD in *Molecular and Physical Gastronomy* at the University of Paris.

1996: Culinology was introduced in the U.S. by the Research Chefs Association (RCA).

1996, May 29th: The School of Culinary Arts and Food Technology adopted a strategy to develop an undergraduate B.A. in Culinary Arts.

2000: The *Science and Cooking* menu was served during a lecture on Molecular Gastronomy by Pierre Gagnaire at the Academy of Sciences.

2001: The Ateliers Expérimentaux du Goût (experimental workshops on flavor) were created in French schools.

In the late 1980's, the use of spherification to spur efficiency was not novel anymore. The uncertainty surrounding it had decreased, allowing prospective innovators to find new utilizations. It was on the verge of its first phase change: Experimenting with Food. French chemist Hervé This and Hungarian physicist Nicholas Kurti authored the term *Molecular and Physical Gastronomy* in 1988.

Cooking is a critical aspect of living. However, people in developed countries still prepare food in the same way as their ancestors did. Despite science's huge impact on other aspects of living, scientific advances had little influence on cooking habits (Kroger, 2006). Some scientists though recognized the importance of scientific methods to understand food (Lavoisier, 1743-1794). They believed in improving the work of chefs by enhancing their tools in the kitchen (Thompson, 1753-1814). Some took a scientific and philosophical look at food (Brillat-Savarin, 1755-1826); others argued that cooking is a scientific technique (Pomaine, 1875-1964). One spur for their efforts was the social status of innovating.

Kurti and This can be considered innovators and change agents at the same time; they contributed substantially by creating new *how to knowledge* using their understanding of already existing technologies (*awareness knowledge*). They were the key individuals exploring the gap between food science and cooking, and defining a new sub-category of food science targeting restaurants and homes.

In the early 1990s, a unique confluence of science and food experts emerged (perceived as early adopters). Chefs reached out to scientists (and vice-versa) to enrich their practices and expertise in new meaningful ways. The social context can be described by this interaction of scientists with food experts, in an extraordinary food environment. Contrasting to the previous phase, this scientific quest focused away from the mass-market.

Another important factor of diffusion during this phase was how it was communicated and spread. In 1992, Kurti, This, and the food science writer Harold McGee organized the International Workshop on Molecular and Physical Gastronomy in Erice, Italy. The main goal was to establish a scientific program setting the objectives of this new discipline. It became a biennial tradition continued to the present.

1995 was the year when the now-renowned chef Ferran Adrià and Hervé This first met. As this moment, Hervé This was able to *plant the seed* of food science into the terrain of cooking. After Kurti and This had created a culture of cooking experimentation by introducing *Molecular and Physical Gastronomy* to food experts, Ferran Adrià brought these techniques into modernist cuisine in 1998 (Sperling, 2014).

When Kurti died in 1998, This shortened *Molecular and Physical Gastronomy* to *Molecular Gastronomy*, as, in his opinion, it should have been from the very beginning. He also added Kurti's name to the title of the international workshop (This, 2014).

During the phase of Experimenting with Food, very little income was generated for these innovators (economical context). However, from a socioeconomic standpoint, they gained benefits of prestige and recognition within science and the culinary world.

Applying Norman and Verganti, Kurti and This facilitated a *Technology Epiphanies Innovation*, a kind of innovation not initiated by users (Norman & Verganti, 2014). They enabled a change in meaning by using already existing technologies in a completely new context.

Haute Cuisine - A Fashionable Trend? (2004 - 2010)

Key Events:

2003: First dish using spherification was created at elBulli: The *Pea Ravioli*.

2003: elBulli's Signature dish appears: *The Melon Cantaloupe Caviar*.

2002 - 2005: A collaboration between European chefs, scientists, companies and culinary schools is launched through Inicon (a European technology transfer program).

2003: The New York Times (The Nueva Nouvelle Cuisine) and Le Monde (L'Alchimiste) feature cover stories about Ferran Adrià.

2006: The Foundation *Food Science & Culture* is established by Hervé This.

2006: The first Molecular Gastronomy PhD, earned in Ireland, funded through DIT (Dublin Institute of Technology) with an ABBEST scholarship.

2007: Concentration in culinary science offered by the food science department at the University of Massachusetts at Amherst.

2007: Bachelor of Science in Culinary Science offered by Drexel University.

2009: Molecular Gastronomy module - BA Culinary Arts DIT was launched.

2011: Molecular Gastronomy group in AgroParisTech (IAGMG) lead educational activities for primary schools, universities, and the general public, in the Institute National de la Recherche Agronomique (INRA) in France.

2012: 14 Culinology undergraduate degree programs were approved by the Research Chefs Association (RCA).

2012: The International Culinary Center (The French Culinary Institute) was founded.

2012: The Culinary Institute of America adopted Molecular Gastronomy.

The next phase is Haute Cuisine, mostly dominated by professional chefs (innovators as well as adopters), with a high openness to innovation. In addition, culinary educators, who developed an interest in spreading their knowledge about Molecular Gastronomy, played an important role as change agents (social system).

Inspired by Kurti and This, the innovator and opinion leader, Ferran Adrià, started experimenting with scientific techniques to create new food arrangements. He initiated Molecular Gastronomy at his acclaimed restaurant elBulli, considered "the most imaginative generator of haute cuisine on the planet" (The Observer, 2014) and persuaded further experimental restaurants to emerge.

Spherification was one of the first techniques he used at elBulli, resulting in the *Liquid Pea Ravioli* in 2003. What was to become his signature dish, *Melon Cantaloupe Caviar*, served in a Russian caviar tin, followed shortly thereafter. Adrià successfully elevated this technique by taking existing ingredients to create something entirely new - a luxurious good created by a scientific technique.

His achievements ignited the spread of spherification into the gastronomic world and initiated the decline of uncertainty in the phase of Haute Cuisine. Adrià paved the way for other culinary experts to adopt Molecular Gastronomy and sparked its usage within the fine dining industry across the world. Being professional chefs, these early adopters already obtained an eye for details, and so were able to overcome the difficulties of using such novel techniques (*complexity*). Consequently, they not only gained a higher social status (*relative advantage*), but were able to merge socio-cultural values, beliefs and previously introduced ideas into the consumer industry (*compatibility*). Accordingly, the usage of Molecular Gastronomy started creating high income for these people, due to the high prices of the upscale dining experience.

In 2003, Adrià joined forces with the scientist and gourmet Pere Castells, resulting in the Alícia Foundation. This platform to exchange knowledge through shared recipes and insights promoted collective efforts in the social context and significantly further reduced uncertainty. Moreover, a Scientific and Gastronomic Lexicon resulted from this association - a tool "to bridge the gap between … two worlds" (Adrià, 2003). This enabled more professional chefs to contribute to the general *how to knowledge* of this innovation, which created a favorable ground for even more adopters to embrace it.

In order to fully understand the rate of adoption by the social system (professional chefs), 80 chefs and restaurants were investigated, showcasing their work with molecular cooking techniques. First, the year of a chef's first exposure to Molecular Gastronomy was determined, then the number of chefs each year was mapped over time. (See Figure 2)

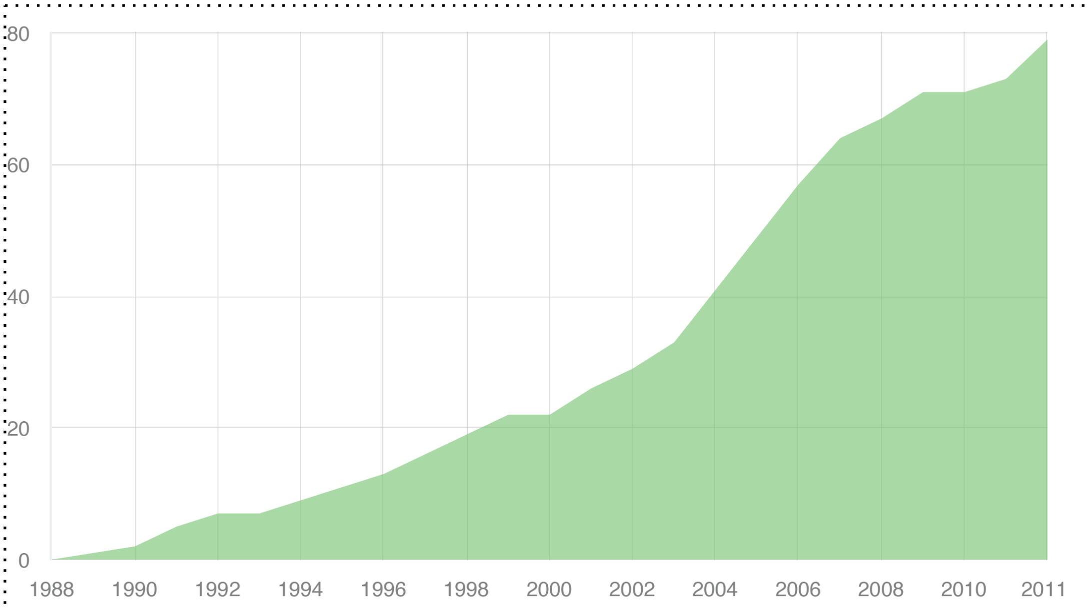

Figure 2: Number of chefs using molecular cooking techniques over time.

Starting with Ferran Adrià, there was a modest increase of chefs using Molecular Gastronomy, followed by steep growth between 2002 and 2007, indicating increasing adoption during that time. Between 2008 and 2009, the increase slowed. The economic crisis seemed to have heavily impacted the trend. For financial reasons, "people stopped going out to eat for intellectual stimulation. They stopped valuing Molecular Gastronomy for what it was" (Bignelli, 2014a). A slight increase from 2009 to 2011 was followed by a plateau after 2011.

Jon Bignelli, the Chef de Cuisine of Alder NY, indicated in an interview with the authors that "Molecular Gastronomy was never intended to be a trend, but rather a quest for knowledge" (Bignelli, 2014b). Many chefs considered this innovation as a way to understand how things are really made and why ingredients behave the way they do. In addition, it gave them an opportunity to craft new and innovative dishes. For instance, Ferran Adrià referred to himself as a *deconstructivist*. Bignelli explains that Molecular Gastronomy was about taking familiar dishes or ingredients "but reinventing them or reimagining them […] take the components and then rearrange them and apply new techniques to them" (Bignelli, 2014c). The aim was to experiment and challenge people's habitual eating behaviors. The experimentees should question what they were eating and be surprised with the profusion of flavors and textures.

This progressive art form (Bignelli, 2014d) quickly resulted in a fashionable trend as curious chefs started copying it. Caused by the subsequent interaction of chefs, entertainers and food enthusiasts (diners), it became the talk of critics, press, and trend hunters across the world (social context).

However, applying molecular cooking techniques is not easy. It requires constant learning and long years of commitment to become an expert and many chefs failed. They misperceived this quest for knowledge and only adopted it in order to stay en vogue. As a result, they performed weakly and got discouraged due to the high level of complexity.

While molecular cooking techniques diffused further, their wow-factor reduced and the innovation started to be considered commonplace in restaurants. Many chefs today use techniques like hydrochloride, gelling gum, and meat glue[4], without advertising them in a theatrical approach (Bignelli, 2014f).

Consequently, interest in using molecular cooking techniques for show declined, which caused many restaurants to close or stop exploring this trend. Henceforth, this innovation reached a point where it was no longer distinguished and celebrated as such, but was being adopted as part of the cooking routine. This also contributed to the plateauing of the trend, as the incentive for showcasing grew smaller than the effort it required.

As molecular cooking techniques became more commonplace across restaurants, the interest in professional education of these techniques increased. The number of culinary schools offering courses in molecular cooking techniques grew. Teachers in cooking schools (who we see as early majority) therefore played an important role in the diffusion of the innovation by communicating it to their students (late majority). They shared their *how to knowledge* with the apprentices, who needed such valuable information to apply Molecular Gastronomy correctly.

The frequency of Molecular Gastronomy mentions in books and professional publications can be further used to analyze the educational aspect of this innovation. (See Figure 3)

[4] Meat glue, is an enzyme that binds protein. For example, one can glue unequally sized pieces of fish together to later divide them into equal portions. - Jon Bignelli, interview by authors, personal interview, New York, April 9, 2014.

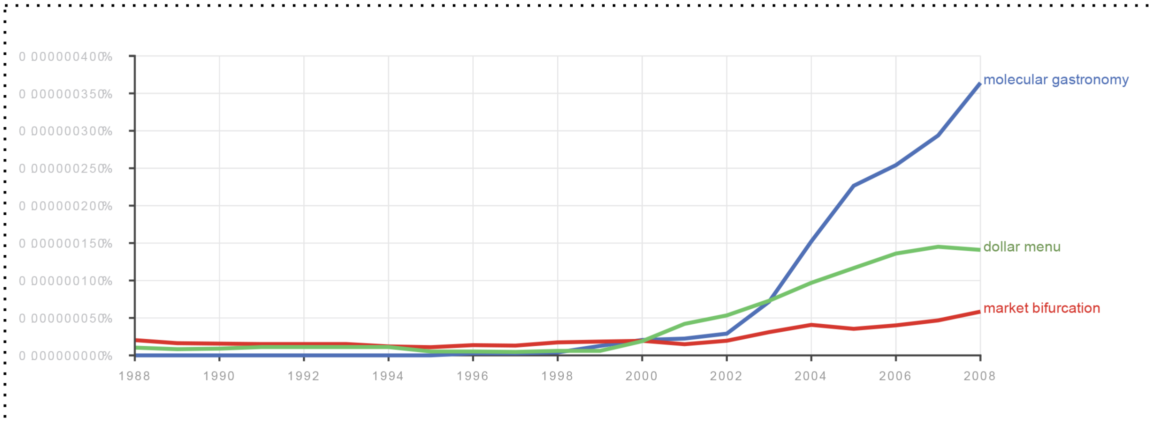

Figure 3: Google Books, Ngram Viewer, accessed April 23, 2014, https://books.google.com/ngrams.

The Google books Ngram Viewer graph for Molecular Gastronomy starts with a slight increase during the period of 2002-2004, followed by a steep rise until 2008. This shows that during the Haute Cuisine phase, the change agents (educators) spread their knowledge in written form in addition to lecture form (communication channels).[5]

To sum it up, Adrià gave rise to the meaning change manifested in the Haute Cuisine phase. This phase was identified as a *Meaning-driven Innovation*, whose decrease in uncertainty was facilitated by the diffusion of knowledge amongst chefs. Whether they were copying or inspiring each other, they transformed the dining experience into a unique and challenging one.

[5] Note: To generate more dynamic correlations, the term Molecular Gastronomy is here compared to other terms. This cuisine was adopted by the most elite restaurants, thus their customers were of a higher socio-economic status. Dollar Menu was chosen to showcase a contrast. Both terms represent Market Bifurcation, (also factored into the correlation), indicating that the market was in fact bifurcated. By examining the resulting graph, one can argue that there was a market demand for high-end products and services at that time.

Through "subtle and unspoken dynamics in the socio-cultural system" (Norman & Verganti, 2014, p.90), a radically new meaning for the techniques of Molecular Gastronomy was created.

Available For Everyone (2010-2014)

Key Events:

2010: Molecule-r Flavors Inc. launches first Molecular Gastronomy DIY kit to the market.

The final phase of this investigation is Available for Everyone. Its social system mainly consisted of end-users in private kitchens and diners served by professional chefs.

The word spherification started to become popular in Google Trends from 2008 onward and steadily increased up to today with a slight peak in 2013.

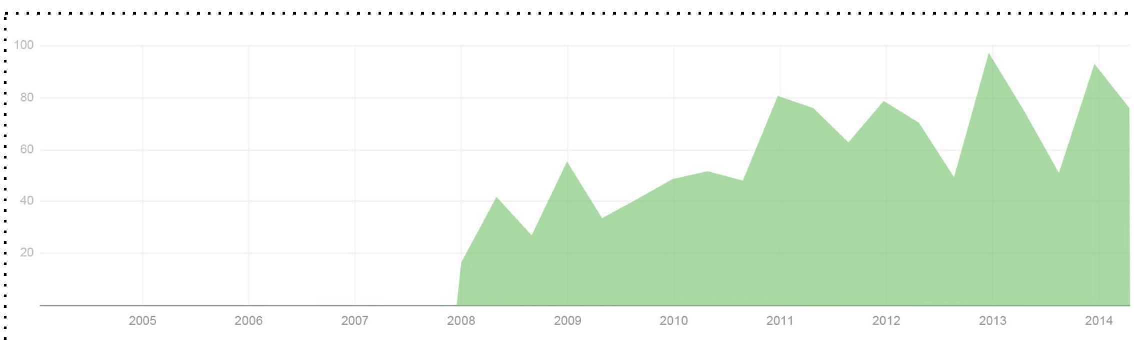

Figure 4: Google Trends, accessed April 23, 2014,

http://www.google.com/trends/explore#q=spheri.

This rise of interest in Molecular Gastronomy by private users gave birth to a new economic opportunity: The Do-it-yourself (DIY) market. Becoming aware of this trendy cooking technique, food enthusiasts started looking for ways to experiment. The *relative advantage* of this innovation in this phase was significant in terms of persuasion: An experience, previously available only to people who could afford to pay premium prices, was entering the mass market; becoming accessible to domestic kitchens. Bignelli states: “Certain people tried making money out of selling these kits to the world when it was really popular and people really wanted to learn how to do it” (Bignelli, 2014).

In this phase of Molecular Gastronomy, a fascinating shift from the traditional innovation paradigm, creator - innovation - adopter, can be observed. The usually-passive adopter of an innovation is presented with an opportunity to experiment with a new cooking technique. The adopter is now able to try, test, fail, and reinvent, and hence to innovate himself. This results in what could be called a paradigm cycle: creator - innovation - adopter - creator.

However, as pointed out by J. Bignelli, Molecular Gastronomy “... is really hard to do.” (c*omplexity)* *“*It takes years and years to figure out how to do these things. It is an ongoing process of learning. Like anything, you need to practice” (Bignelli, 2014) (*how to knowledge)*.

Despite the mass availability of the DIY kits, it is uncertain whether this innovation will diffuse to a critical mass. Although it is easy to acquire tools, instructions and resources to experiment with Molecular Gastronomy techniques (*trialability*), the *know-how* gap and the *complexity* remain large barriers. However, this phase of Molecular Gastronomy was initiated by the users' interest and subsequently met by the industry providing DIY kits. Therefore, it can be said that this phase emerged as a *Market-pull Innovation* (Norman & Verganti, 2014, p.90).

Ongoing Development

Key Events:

2011: After closing elBulli, Adrià scheduled to launch the elBulli Foundation in 2015.

April 2014: The Skipping Rocks Lab's Ooho water container won the Lexus Design Award 2014.

June 2014: Restaurant SubliMotion by chef Paco Roncero opened in Ibiza, Spain.

October 29, 2014: elBulli Foundation opened its exposition in Madrid, Spain.

March 2, 2015: elBulli Foundation was launched.

This section showcases the ongoing development of Molecular Gastronomy and introduces the most compelling projects found during the research for this paper.

elBulli Foundation

After closing in 2011, due to high financial losses, Adrià and the elBulli team dedicated themselves to spreading the word of Molecular Gastronomy. They aimed to sustain the innovations of elBulli by opening them to the public (Adrià, 2014).

They launched a project, the elBulli Foundation, with three components: elBulli 1846, elBulli DNA and BullePedia, which opened its exposition in Madrid in 2014. The project was initiated through a challenge addressing students from renowned schools including London Business School, Harvard, Berkeley, Columbia, and MIT. Through this, the comparatively small business of elBulli could access a high level of international knowledge without large financial investments, while lowering the uncertainty of its success.

elBulli 1846, a space to which people can come, stay for a period of time and collaborate with the elBulli team is scheduled to launch in September 2016. Its underlying goal of merging the past, present, and future of cooking, is echoed in the project's name: 1846; the number of dishes created at elBulli as well as the year Auguste Escoffier was born (known as the Van Gogh of the kitchen). The experience should be similar to entering a museum where visitors are able to modify the exhibits to reinvent their use.

elBulli DNA is a collaboration of the world's most creative chefs with professionals from other disciplines, such as journalists, architects or designers. Their projects revolve around deconstructing the process of creativity and sharing their creative processes using the language of cooking (Adrià, 2014a). The outcomes of this cross-disciplinary collaboration is shared online, open for the global community (Adrià, 2014b).

BulliPedia, the research laboratory and the online section of the project, should become an online tool for the culinary world. It is intended to be a public platform, where professionals from all backgrounds consolidate their ideas, contribute to the project and reflect on the idea of knowledge versus information. It should decode the culinary genome and its creative process (Adrià, 2014).

SubliMotion

The restaurant SubliMotion, which opened in June 2014 on the Spanish island Ibiza (SubliMotion, 2014a), promises to take its customers on a culinary journey engaging all senses (Shi Min, 2014).

In an intimate setting, renowned chef Paco Roncero creates a 20-course dining experience in front of his guests. Synchronized to each course, visual and audio projections stimulate the diners, while the temperature and humidity of the room is matched to the dishes (Shi Min, 2014).

With over two decades of experience in Molecular Gastronomy, Paco Roncero leverages molecular cooking techniques to create the dishes that are being served in this novel dining establishment. He describes SubliMotion's menu as "an experience for all the senses" that encompasses a "complete and unprecedented emotional experience" (Shi Min, 2014).

Ooho Water Container

The Skipping Rocks Lab's Ooho water container addresses the high amount of plastic waste produced globally. Ooho is based on an edible gel that can be used to encase water via a modified process of spherification.

By tweaking the method using frozen water and a double membrane, up to one liter of water can be stored in a bubble. In addition, the two layers allow the capsule to be labeled by placing something in between the two membranes (Nave, 2014a). The gel shell does not necessarily need to be eaten; it is made from a mixture of brown algae and calcium chloride and is entirely biodegradable when disposed off (Nave, 2014b).

Although it might appear fragile, the skin is similar to that of a fruit and its thickness can be modified according to the need. One of the inventors of Ooho, Rodrigo Garcia Gonzales, states that the skin can be made so thick that "you can even bounce the bubbles" (Nave, 2014c). There are still some issues to overcome regarding mass manufacturing and distribution, but the biggest strength of Ooho is that it is very easy to produce. "The project is licensed under Creative Commons so it's possible for everyone to do it at home. It's just like making a recipe (Nave, 2014d)."

Conclusion

Molecular Gastronomy diffused amongst different social systems within four consecutive phase changes. This provides a strong understanding of how the innovation came to exist as it is known today. It is likely that new phase changes will occur again, if the evolution of Molecular Gastronomy continues as it has. The development of the current phase, in addition to the projects and trends described in the previous section, give some indication of the direction these phase changes could take.

The current phase, Available for Everyone, presents some ambiguity regarding its status. It is still early to conclude if the development of the DIY kits is considered a successful innovation or not. The tools are not easy to use and require a high standard of precision; failure can result from poor instructions or a lack of accuracy (*complexity*).

As the phase of Available for Everyone is a *Market-pull Innovation*, the development of the DIY kits involved Human-centered Design (Norman & Verganti, 2014, p.90). This design method aims to overcome existing challenges by inventing innovative solutions addressing users' needs. If further design efforts would be made to lower the degree of *complexity,* the diffusion process could be positively impacted.

However, the elBulli Foundation, which opened in March 2015, can provide a more direct answer to the issue of complexity in Molecular Gastronomy. It will encourage the dissemination of information in a faster, more efficient way. Today, the expertise of molecular cooking techniques is limited to a few specialists. elBulli Foundation aims to transform the proficiency of Molecular Gastronomy into a publicly available platform, which will change the meaning of Molecular Gastronomy by catalyzing the flow of information between industry professionals and the public. Consequently, by leveraging new advanced information technologies (app as software, tablets as hardware), this project could take the form of a *Technology Epiphanies Innovation*.

On the other hand, the SubliMotion project is creating a new trend of "Hyper Haute Cuisine". Although it is limited in access, it is expected to have a strong future impact on the restaurant industry. This exclusive high-end experience changes the significance of eating from placing food in one's mouth to experiencing flavors with all senses. This is enabled by combining powerful design and advanced technology and could therefore emerge as a *Meaning-driven Innovation*. As Molecular Gastronomy was no longer exclusively celebrated by itself, this kind of project emerged as the answer to the need of moving it from low-end disruption (DIY kits to masses) to upscale markets (selective audience).

It is unknowable which of these two projects will be more successful, have a more significant impact and provide a higher competitive advantage. However, at least one of them seems likely to push the innovation towards further adoption within the culinary world.

The third project, the Ooho water container, aligns with the meaning of Molecular Gastronomy in terms of efficiency. Similar to what happened in the first phase of Technology and Efficiency, the technique of spherification is used to generate a novel delivery method - this time serving the basic human need for water. By improving the technique, once more scientists in a laboratory developed the *how-to knowledge* addressing a mass audience need. Therefore, this project can be seen as an incremental improvement of the method of spherification and its application.

Clearly, what starts as a discovery in a laboratory can go a long way. The observer of innovation trends should keep a curious eye on what will happen next.

Note From The Authors:

The name given to an innovation often affects its *compatibility* and therefore its rate of adoption (Rogers, 1983, p.227). In this paper, the discussed innovation is referred to as Molecular Gastronomy including molecular cooking techniques, as a consistent term throughout was needed.

In 1988, This and Kurti defined the term Molecular and Physical Gastronomy, which was later shortened by This to Molecular Gastronomy. According to This, chefs do not create knowledge, they create food. He therefore strongly suggested that chefs are not molecular gastronomists because they are not scientist (This, 2014). In turn, many chefs preferred to be called deconstructivist, and to use *modernist cuisine, avant-garde cuisine* or *techno-emotional cuisine* to describe their cooking style.

Ferran Adrià explains this as such: “To cook well, we must learn (its history, techniques, products, traditions and innovations, culinary processes, etc.), and then think, discuss, try out, reflect, choose... And then constantly question anything we assume is true. And if in the meantime we need to resort to science or history books or any other creative discipline, at least we shall acquire new information to reinforce our culinary philosophy” (Adrià, 2003).

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