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The emergence of gastronomic engineering

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ABSTRACT

Modern consumers increasingly derive their foods from away-from-home sources. Rising incomes, the emergence of chefs as innovative actors in the food scene, and the growing consumer demand for culinary experiences, are the main driving forces behind *haute cuisine*. At the same time, food engineering is in urgent need to expand its scope and engage in new collaborations and partnerships. Gastronomic engineering (GE) means using the vast body of knowledge accumulated in food engineering and food materials science to propel the curiosity and creativity of chefs to what is technologically feasible and environmentally sustainable. GE opens new opportunities for food engineering, a discipline that has been mostly oriented to the food processing industry. This article describes the emergence of GE or a new branch of food engineering, as a space of co-creation between chefs and food engineers in a university set-up. Our GE unit consists of an experimental kitchen headed by a chef, a food engineering area and a materials science laboratory. The impact of GE on academic activities (teaching and research) and outreach experiences is discussed.

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1. Introduction

Food engineering emerged in the 1950s as the application of engineering principles to manufacturing and operations in the food industry (Heldman & Lund, 2011; Barbosa-Cánovas & Juliano, 2005). Food process engineering flourished in the first couple of decades after its inception as the emphasis of an expanding industry was on high-volume throughput and cost reduction. In the 1980s, with the advent of the consumer as the pivot of the food chain, the focus changed from efficient processes to safe products that conveyed pleasure, health and convenience (Bruin & Jongen, 2003). This paradigmatic shift reduced the length scale of intervention from the meters of processing equipment to the microns of food product microstructures. As a result, food materials science became a key topic for food engineers as it refers to the properties and structure of food products (Bhandari & Roos, 2012; Aguilera & Lillford, 2008). In the 21st century it is imperative for food engineering to continue expanding its vision and scientific base to face the challenges of the profession (e.g., decreasing student enrollment and research funding) and exploit new opportunities (Saguy, Singh, Johnson, Fryer, & Sastry, 2013).

A trend that represents well the dynamics stimulated by the needs and expectations of the modern consumer is the increasing practice of "eating out" (Binkley, 2006). A recent survey on out-of-home dining trends carried out in 63 countries showed that 48% of the global contestants ate away of home weekly or more often (Nielsen, 2016).

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Unfortunately, data depicting the evolution of this trend on a worldwide basis are difficult to access. Information for food consumption patterns in the United States is amply available and as shown in Fig. 1, American consumers increasingly derive their foods from away-from-home sources. Today, the food service industry in the U.S. (restaurants, fast-food outlets, cafeterias in schools and universities, hotels, vending machines, etc.) is almost equal in size to food retailing, meaning that about half of every food dollar is spent on food not cooked at home. Full-service restaurants account for 40% of the total sales value of the food service industry (ERS-USDA, 2016). The National Restaurant Association projects that total sales of this segment for 2016 ($782.7 billion) will double those of year 2000 (NRA, 2016). Fine dining restaurants represent approximately 10% of the total U.S. sales of the restaurant business (Ban, 2012).

It is quite unfortunate that this trend towards fine dining has been almost ignored by food engineers. Acclaimed chefs possess many characteristics appreciated by engineers: they dominate cooking techniques, have lots of creativity, are rapid in their decisions during the development of dishes and fast to move into production (Lane, 2014; Bro Pedersen, 2012; Ottenbacher & Harrington, 2007). Many cooks are progressively intrigued by the scientific insights of cooking and rely on innovation to continuously renovate their menus. Several of them created a cooking style based on local novel ingredients (Inwood, Sharp, Moore, & Stinner, 2009) that quickly extended to lesser-known restaurants and the public, as is the case of Rene Redzepi and his celebrated *Noma* restaurant in Denmark (Abend, 2015). Some elite cuisine chefs are close to consumers and accepted by the general public (e.g., participate in TV cooking shows, teach cooking on line, write newspaper columns, and publish best selling recipe books). Moreover, chefs know how to transform raw food materials into meals that people actually eat and enjoy. Unfortunately, all these facts that make chefs and modern gastronomy attractive subjects in today's scenario of foods, are not well documented in the scientific literature (Duram & Cawley, 2012).

On the other hand, there is a lot of engineering going on in the kitchen and in the interior of dishes (Aguilera, 2012). For example, cooking foods involve all main modes of heat transfer, mass transfer is central in extraction, impregnation and the appreciation of flavor, and momentum transfer is ubiquitous at times of agitating liquids and thick sauces, making emulsions and reducing the size of food raw materials. More important perhaps, are the potential opportunities to introduce other unit operations such as distillation, spray drying, cryo-concentration, freeze-drying and extrusion at the culinary scale (Ruiz, Calvarro, Sanchez, & Roldán, 2013).

Well-known are the associations between some acclaimed contemporary chefs and physicists and food chemists. This trend may have started with Prof. Nicholas Kurti's seminal lecture "*The Physicist in the Kitchen*" to fellows of the Royal Society (Kurti, 1969) and expanded with the introduction of the concept of molecular gastronomy (MG) by the French chemist Hervé This (This, 1995) (see below). Top-ranked chefs such as Adriá, Blumenthal and the Roca brothers have or have had "laboratories" in their own premises. Books presenting a scientific perspective of cooking, such as those authored by H. This (2006), H. McGee (2004) and P. Barham (2001) are bestsellers and have been translated to many languages. A peer-reviewed *International Journal of Gastronomy and Food Science* focusing on the interface of both disciplines was launched in 2012, and has in its editorial board reputed scientists and several chefs holding Michelin stars.

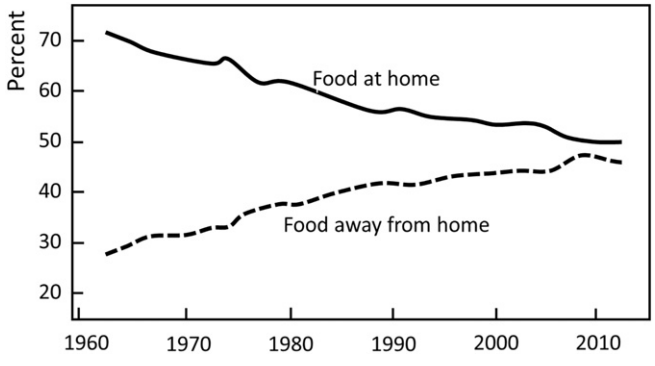

Fig. 1. Expenditures for food consumed at home and food consumed away from home in USA (ERS-USDA, 2016).

On the academic side, engineering education needs to expand beyond its foundations and the disciplinary topics to include innovation and entrepreneurship (Byers, Seelig, Sheppard, & Weilerstein, 2013). However, the food industry does not fare well in innovation. In a recent study by the Boston Consulting Group no food company appears among the top 50 most innovative ones (BCG, 2015) and a past vice president of a major food company recently declared that …*the food industry is not really innovative* (Traitler, Coleman, & Burbidge, 2017). On the other hand, creativity and innovation is omnipresent in the high-end restaurant segment where top ranking chefs are compelled to rapidly update their menus to please commensals and protect themselves against plagiarism (Bro Pedersen, 2012; Ottenbacher & Harrington, 2007).

The purpose of this article is to describe the opportunities that exist at the interface between food engineering and gastronomy, and discuss the experience of launching, in an academic environment, a unit that combines the creativity and talent of chefs with the technological capabilities of food engineers.

2. Science meets gastronomy

The relation between cooks and science may be traced back to chef Joseph Favre who conducted research at the University of Geneva and founded in 1877 the newspaper *La Science Culinaire*. Later in 1907, the famous French chef Auguste Escoffier stated that "…*cooking, without ceasing to be an art, will become scientific and subject its often empirical formulas to a method and a precision that will leave nothing to chance*." (Lavelle, 2014). Today, it is advocated that science and technology - which is knowledge, methods and tools - should be increasingly added to culinary techniques representing skills and practices (Lavelle, 2015).

Celebrated chefs and scientists came closer together at the end of the past century with the advent of molecular gastronomy or the application of scientific principles to unveil secrets behind cooking and the exploration of new possibilities for the culinary arts (Barham et al., 2010; This, 2006). Some cooks became interested in the use novel raw materials and functional ingredients, as well as on processing technologies leading to amazing textures and unique flavor sensations. A number of restaurants that adhered to a more scientific approach in their cooking were later recognized as top in the world (Barham et al., 2010). Innovative chefs were diligent in implementing in their kitchens several techniques such as controlled-temperature heating in water baths (*sous-vide* cooking), vacuum cooking and impregnation, liquid nitrogen freezing and grinding, gelation (*spherification*), edible films and high-power mixing (Marx & Haumont, 2016; Barham et al., 2010). Chefs, institutional cooks as well as a few amateur cooks now implement routinely some of these technologies in specially designed kitchen-size equipment (Cassi, 2011; Rodgers, 2007).

The mounting awareness that science and technology applied to cooking may contribute to a healthy and pleasurable eating has resulted in several initiatives, with some examples presented in Table 1. In education (school and university levels), foods are regarded as exciting materials to teach science (Donald, 2004; Swinbank & Parker, 2004) whereas gastronomy has become a study case to encourage innovation (Norton, Villanueva, & Wathieu, 2008). Some large companies have added to their R&D centers the activities of a "research chef" to bring in the culinary dimension to the product development process. At the same time, some restaurants are developing their own test kitchens