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Review

Challenges facing food engineering ☆

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ABSTRACT

Food engineering (FE) was identified as a promising field in the mid-20th century. In the succeeding years, demand for food engineers in industry has continued unabated, but the field, in an academic sense, has not quite lived up to its potential. Yet, the coming challenges of the 21st century offer many opportunities for persons with FE training. This article is based on a plenary session held during the Conference of Food Engineering 2012, in Leesburg, Virginia, USA, and consists of a compilation of opinions of the authors. In order to develop further, FE needs to shed its historical mindset, and embrace a broader vision of its scope to include product, internal human and industrial processes, equipment, package and sensor/automation engineering. Training in FE could be vital to helping address issues such as water availability and quality, health and wellness, food safety, energy and sustainability. A number of 21st century developments will drive this change, including world population growth and aging; the digital universe, "big data" and informatics; personalization, food, health and wellness; food security, environment, sustainability and social responsibility; and the innovation ecosystem (open innovation and partnerships). Food engineering education will also have to change to keep pace with the extraordinary expansion of knowledge, the availability of virtual tools, diminishing funding and laboratory resources, and the possibility of creating partnerships between industry and academia. Studying inner transport phenomena, utilization of new techniques, such as micro processing for modeling and simulation of the digestion system, bioavailability, satiety, DNA predisposition, and nutrigenomics offer unique opportunities. The case of FE in UK and Europe are addressed, where consortia involving different industries have been able to partner to focus on problems with a common scientific theme to leverage their efforts. Finally, the experience of one food company in hiring food engineers as well as chemical engineers is highlighted, together with their interview processes and criteria. While this represents a collection of the opinions of the individual authors, it is hoped that the discussion stimulates a more wide-ranging conversation about FE to enable it to develop further into the 21st century.

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1. Introduction

For Food Engineering (FE) it is the best of times: it is the worst of times. We have seen much success in the past two decades with the major and continuing development of alternative processing methodologies, new technologies, novel discoveries, and food sources (Knorr et al., 2009). Yet, the FE profession is at a crossroads. Continuously diminishing government and other agencies' support, together with lack of critical mass among university faculty (specifically in the United States) has taken a heavy toll on research activity, attractiveness to new students, and new academic positions. Noteworthy proliferation and flourishing of many bio-disciplines has highlighted the immediate acute need for the FE profession to reassess its vision, strategy and mission to reinvigorate the domain and to sustain its future.

FE emerged in the 1950s and 1960s, under the influence of agricultural engineering, and later came under the influence of chemical engineering (CE; Karel, 1997). A number of programs emerged in Latin America in the 1960s and 1970s, involving a blend of European CE programs and US food science (FS) programs (Simpson, 2004). Within the US, most programs reside within land-grant institutions, and food engineers are often divided between various departments (e.g., FS, Biological and Agricultural Engineering). FEs have been represented in a number of professional societies worldwide (e.g., Institute of Food Technologists, IFT, American Institute of Chemical Engineers, AIChE, Institution of Chemical Engineers, IChemE, International Union of Food Science and Technology, IUFoST, American Society of Agricultural and Biological Engineers, ASABE, and The European Federation of Food Science and Technology, EFFoST).

In the late 20th and early 21st centuries, there have been a number of retrospectives (Goldblith, 1995) and views of the future (e.g., Karel, 1997; Bruin and Jongen, 2003; Aguilera, 2006), and a more general review (Floros et al., 2010) including other areas of FS and technology (FST), but involving a number of FEs. These works are all relevant in assessment of the current state and self-image of FEs.

The FE profession is at a crossroads. It faces tremendous challenges due to shrinking public and industrial research funding, intensified competition and proliferation of other bio-disciplines and other domains (e.g., bioengineering, biotechnology, CE, material science). The recent escalating global economic crisis and social pressure provide only a marginal explanation for the deteriorating support. More important is the observation that FE suffers from a lack of vision culminating in a drop in student enrollment, scarce academic positions, low attractiveness, to count only a few. The exponential growth in both knowledge and its complexity, intertwined with breakthroughs in science and technology progressing at a mindboggling speed, call for the reassessment of the roles of FE to meet future needs and significant challenges and mandate concentrated and multidisciplinary efforts.

Unabated and accelerating recent scientific progress into new areas focusing on biological science (e.g., personalization, DNA, nutrigenomics, gene expression and metabolic understating) are changing the curricula and "traditional" engineering topics are often reduced to allow other more current subjects to be introduced. This transition is even more severe as less research is allocated to FE due to lack of resources, cost and expertise that shifts to other more "sexy" and appealing topics. If this trend continues, it is likely that in the foreseeable future, "classical" FE topics will be mostly taught by faculty members with knowledge based only on textbooks with limited or no real experience.

To facilitate and/or provoke frank discussion within the community regarding the FE collective future, the following is an alternative approach. It is not intended to disparage any individuals or their point(s) of view, rather it is principally to provide a different view and to facilitate discussions and other contributions.

While it is clear that FE has accomplished much in its relatively short history, its lack of growth as a discipline, particularly within academia in the US, is cause for concern. Certainly, the drivers exist: the food industry has need for engineers, which it fills with a variety of hires, including chemical engineers (CEs), food engineers (FEs) and agricultural engineers. Opportunities and challenges for food engineering abound: the drive towards health and wellness, concerns about fresh produce safety, and the need, in an ever-competitive global environment, to deliver high quality at reasonable cost. These should be reasons for food engineering to thrive, yet there is a sense that the field is failing to live up to its early potential. For instance, in the US budget cuts at most US universities have left them with minimal faculty in this area. Additionally, the relative paucity of grants has driven many faculty members to more lucrative bio-based processing or nanotechnology areas. Without university faculty to drive the next generation of engineers, we may be faced with limited prospects in the years ahead.

> *"It was the best of times; it was the worst of times."*
> Charles Dickens: *A Tale of Two Cities*

In the spirit of Charles Dickens, we propose that FE could be depicted as a tale of two narratives: one suggesting that it is the worst of times, another that it is the best of times.

(a) The worst of times narrative and its consequences

Given the many different forces shaping the field, FEs (either currently active or entering the profession) hear a negative narrative that influences their collective thinking and has the following general themes:

FE is considered largely to be a subset of CE, which it should try to (but never will) successfully emulate. It is unclear how this thinking has evolved, but it may have its origins in the past leaders of our field profess strong CE connections and continue to look to it for inspiration (Bruin and Jongen, 2003). However, the prolonged lack of consensus on the definition of the field has led to a de facto stratification. Often, faculty without engineering backgrounds are hired into food science departments, and deemed "food engineers". In other departments, engineers are hired but are compelled to dequantify their coursework to meet the needs of mathematically challenged students.

The Golden Age of FE occurred in the middle of the 20th century (from around 1950 to 1975), with subsequent developments being less significant. This line of thinking has resulted in a culture in which the field looks fondly at its past glories, at the expense of its present and future. Scientists from the past regardless of their current activity or breadth of vision regarding the field often recommend that we look outside the field for inspiration. This approach gives scant attention to the many developments that have occurred in our own field in the recent past and relegates FE to being a derivative discipline.

The consequences of the worst of times narrative on the culture of FE are: