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COMMENTARY

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Food industry and engineering—Quo vadis?

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Food engineering as part of the global food system has a particular responsibility to society. Indisputably, food matters for every single individual on this planet. It always has!

Unlike other manufacturing industries that have developed after the industrial revolution, the food industry, at its core, has always been about supplying a basic human, need.

The end of the 20th century and the global realization that nature's resources are finite introduced two new dimensions, other than profit, to the food industry, namely; environmental and sustainability issues.

A recent report from the Ellen MacArthur Foundation entitled *Cities and the Circular Economy for Food*, presented at The World Economic Forum in January 2019, puts a number on it; for every $1 dollar spent on food, $2 dollars is incurred to produce it (Ellen MacArthur Foundation, 2019).

A third of all edible food produce goes uneaten despite the fact that 10% of the global community goes hungry (FAO, 2020) and the rise in over-nutrition is leading to obesity and other diet related chronic diseases in many developing countries.

Although the industry has had many successes over the past 50 years in terms of scalability and offering abundance in food supply to many parts of the world, the food industry has primarily (d)evolved into a commodity driven, brand valued, and cost driven profit model.

Whether the above concerns are viewed from an economic, social, or political perspective, it is clear that the present model needs to change direction.

Despite Food (Process) Engineering's auspicious start creating the means for food manufacturing and the fact that the same discipline, at its heart, is still best placed to find processing solutions for the optimal use of agriculturally and biotechnologically produced raw materials, the profession seems to have lost its way in modern times.

Unlike other engineering disciplines, there is still no universally accepted definition of the term food process engineering in place (Kostaropoulos, 2012). Similarly, there is no specialized professional association solely dedicated to the interests of the discipline and being born by food engineers.

Food engineering, as a specialized engineering discipline, is no longer viewed as a worthwhile, prospective career choice. Indeed, food companies, increasingly been driven by quarterly profit reporting, do not see food process engineering anymore as being at the heart of their operation.

The drive for cheaper food production methods over the past 50 years has also driven other production cost-saving methodology such as Six Sigma (6σ), lean manufacturing, Kaizan, and so on. Although powerful tools for increasing manufacturing efficiencies, they are primarily based on incremental improvement and do not embrace either the need for radical change (the famous thinking outside the box has been replaced by follow the template) and or the innovative skills set that a food process engineer considers as his/her prime role.

While most "big food" companies still retain research and development departments, their spend is the lowest across a survey of the 15 biggest manufacturing sectors—indeed food companies invest far below 5% of their profits back into research (Department for Business Innovation and Skills, 2010; ElAmin, 2008; Statista, 2019). If one looks at research spending across a global list of the world's top 100 companies one would have to go to position 77 to see the first food company listed, namely Nestlé with a research spend of just 2.35% (Skillicorn, 2019).

Where before key drivers for growth and profitability in food were led solely by taste, price and convenience, new emerging drivers now include health and wellness, safety, social impact, and experience,

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with transparency becoming an overarching driver on all counts (Ringquist, Phillips, Renner, Sides, & Stuart, 2017).

Linking a very simple definition of engineering as being "to make things or make things better" with the discipline of Food (Process) Engineering perhaps the point has been lost by more recent numbers orientated management that a food process engineer's key role has always been to consistently reengineer food systems to achieve beneficial change.

"As 'the Fourth Industrial Revolution' starts to build on the so-called third digital revolution characterized by a fusion of technologies that is already blurring the lines between the physical, digital, and biological spheres, the pace of change is evolving at an exponential rather than a linear rate."

Likewise, population growth and the fact that 80% of all food production will be consumed in cities by 2050. The breadth and depth of these changes will herald the transformation of entire systems of production, management, and governance.

The need to reengineer our existing food system from a consumer's perspective, environmental concerns, future population and urbanization growth, and or a greater societal cost creates no doubt that a fundamental rethinking and radical redesign of the entire food chain and its practices is required.

How can this rapid pace of change be achieved in the food industry without dedicated food engineering skills?

The need for the food industry to re-engineer itself warrants a complete rethink of how we define Food Engineering relative to the same food system. As such, it is time to move forward with a more inclusive and forward-thinking paradigm for both the industry and a reinvented and re-innovated food engineering profession.

This change in direction needs to include educating a new breed of food (process) engineering professionals sooner rather than later. The food process engineering profession also needs to come together and take control of its own future, educational needs, professional development, and recognition.

While there has been movement in this direction such as in the US, and the formation of the Society of Food Engineering (SoFE in 2018).

SoFE was formed as an independent society to represent food engineers from diverse background. SoFE plans to work with AIChE, IFT, ASABE, and others to advance food engineering mission.

There are also moves a foot with other associated food professional bodies in the UK, Australia, and Malaysia. Informal discussions are now taking place with various Food SIG's (special interest groups) from IAgrE, IFST, IOP, SCI, IChemE, IOM^3, and others with a view to creating one central grouping representing the interests of all scientific, technical, and engineering professionals working in the food industry and food-related academia. Other organizations such as the International Society of Food Engineering (ISFE) and the European Society of Food Engineers both subsets of the International Union of Food Science and Technology (IUFoST) also need to become involved.

While various disciplines have been involved with food from the mid-19th century onward, it was only in the 1960s that food science and technology became a subject in its own right. This new group of professionals stopped identifying themselves as chemists, physicists, microbiologists, chemical engineers, and so on who happened to be working in food, but as food scientists or food technologists (Institute of Food Science and Technology, 2020). Today there are more than 46 third-level institutions in the UK offering over 88 courses by way of on-campus food science and technology courses. Unfortunately, there are just three UK universities offering food-engineering programs!

In the United States, MIT is the only top 5 university for *engineering & technology* to offer study opportunities in food engineering—albeit, as a subset of chemical engineering. The Georgia Institute of Technology supports the spirit of bringing food engineering back to its biosystems/agricultural engineering home with its Food Processing Technology Division. However, the key focus of this division is from farm to silo and barely takes the factory stage into account (Georgia Institute of Technology, 2021; MIT Department of Chemical Engineering, 2021; QS Quacquarelli Symonds Limited, 2020).

Similarly, various US LandGrant universities train food engineers as a part of academic programs in Food Agricultural and Biological Engineering as well as Food Science and Technology disciplines.

From a food process engineering perspective, apart from taking a leaf from the IFST PR book, when it comes to re-engineering existing food systems, thanks to food science research we know some of the "why" and the "what" that is required. The obvious challenge for the food industry and its engineers will be developing the methodology, or the "how," that can achieve this beneficial change on a volume basis, likewise, recruiting, educating, and training the "who" best qualified to implement the process changes required.

From an educational perspective, clear food engineering curricula need to be developed and to be brought to the attention of all concerned. A good example of the same being Niranjan's, "a possible reconceptualization of the food engineering discipline" (Niranjan, 2016). The University of Nottingham's approach as outlined later or IAgrE's open seminar events to inform and educate all.

Similar frameworks can also be developed for technical, apprentice engineering schemes, and so on. Other paths to create such curricula is to learn from countries where food engineering has a more defined educational position, such as Argentina, Chile, Germany, or Turkey.

As modern food and beverage manufacturing processes are highly sophisticated, involving all unit operations, mass, and transport phenomena across all types of materials. The same could be said of chemical process engineering and hence it's growing affinity with the food industry. However, it should be noted that the natural home of food engineering does not reside in the chemical engineering discipline, but rather in its agricultural roots and raw material supply (the historic home of the profession). Food production being one of human being's essential needs, as postulated by Maslow (1943) goes way beyond moles, chemical composition, mass and energy balances and entails several other aspects such as social, religious, and cultural norms.

As postulated by one of the authors of this commentary in defining a new draft definition for Food process engineering reflecting the above scope as given in Hefft (2019), stating:

> Food Engineering is a technical multidisciplinary profession that deals with the system and structures of food, production processes as well as physical, (bio) chemical, and biological transformation processes. It is based on scientific laws and economical, ecological and social, cultural and religious norms.

Responding to industry demand, and identifying the gap in educational needs the University of Nottingham recently introduced a new postgraduate taught program in Food Process Engineering also expanding their current MEng. degree programs in chemical engineering to include optional food processing modules. They have also been able to combine a food engineering specialization with existing expertise in chemical process engineering subjects, such as heat transfer and plant process design. Likewise, their expertise with environmental aspects such as water and waste. Having this holistic approach in food process engineering courses helps to create an engineer with the skillset not just to execute engineering tasks well, but also creating an engineer who considers the environmental (and societal) impact of their work.—Points of increasing importance looking into changes to come in the food industry of the future.

The department also sees its mission to provide the academic formation of a chartered engineer (CEng) status and to produce Master Food Process Engineering graduates who are technically competent, industrially aware, and good communicators, with the project management skills to take on leadership roles in a change environment.

The advantages of the above model are numerous;

- It draws on an existing pool of already qualified graduate engineers be they electrical, mechanical, chemical, or as is more common in Europe and developing countries such as China and India, undergraduate degrees in both Food Science and Engineering.
- It can create a new breed of food process engineering professionals, ready for industry, within an 18–24-month timeframe.
- Particular aspects or modules of the program can be re-packaged for block release as part of postgraduate schemes enabling existing food or other engineers to upskill to a Food Process Engineering master's level while still employed in industry.
- It can also become a new pipeline for PhD, EngD, and research students to pursue new methods of food process engineering.

A 2019 report from the UK's Food & Drink Federation entitled a recipe for Growth, Prosperity and Sustainability, "A Plan for Success" has an opening paragraph that states food is a matter of national security and is part of the UK's Critical National Infrastructure. It goes on to state that a government's first duty is to feed the country or as summarized by Jay Rayner: "If you can't feed a country you don't have a country" (Rayner, 2017).

As per the UK, if one applies the same critical food infrastructure debate on a global basis—given the macro forces at play, global population growth, rise of obesity and other lifestyle diseases, the shift from rural to urban life and food production's vulnerability to future climate change the same national security aspects applies to all.

All these concerns come back to the simple fact that, whether viewed from an economic, social, or political perspective, food availability has always been about supplying a basic human need as opposed to simply generating a higher return for shareholders.

As Accenture Strategy (2017) highlight in a recent report "The future of food; new realities for the industry", the food industry will soon look nothing like its former self and we will see more change over the next 10 years than we have seen in in the last 50.

The current Covid-19 pandemic has shown the world that we also need to develop an integrated approach of both land-based agricultural and food engineering disciplines, along with professionals in food science to lead to a more integrated, sustainable, and secure food supply chain.

A unified voice representing all stakeholders in food must lobby government to enable large scale funding opportunities for future food research and the means to engineer new food production systems to provide the same at scale.

When it comes to reengineering food systems, as per core competencies Food (Process) Engineering professionals have driven change in the food industry for more than two millennia.

They are best placed to lead and develop both the innovation and new production processes that will be required.

These facts are already well known by food process engineers.; to wit; A global web survey of the food engineering profession conducted in 2016 by Saguy, Singh, Johnson, Fryer, and Sastry (2013) addressing forthcoming challenges in the food sector, ranked the following key areas in terms of priority;

1. "More innovative profession offering better entrepreneurship & broader activities.
2. Broader/better applied education that could be utilized in food/ and other fields.
3. More professional opportunities to serve humanity."

The greatest challenge for food process engineers and our profession going forward is getting wider society to agree with us that from an economic, social, and or political perspective, it is clear that the present food model needs to change direction.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Daniel Hefft: Conceptualization; writing-original draft; writing-review & editing. **Ṡeamus Higgins:** Conceptualization; writing-original draft; writing-review & editing.

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Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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