Technology offers sustainable nutrition solutions

Introduction
The Sustainable Development Goals were developed by the United Nations as a response to climate change, population growth, wealth increase and the concurrent need for greater prolonged human health. Their interaction with food supply chains is evident and demands significant innovation if these goals are to be met. Food is the most important lever to reduce environmental impact and initiatives are being taken to define dietary intakes within the planetary boundaries e.g. the EAT-Lancet Commission, which brings together researchers in nutrition, health, sustainability and policy from around the world with the aim of transforming the food system. This includes a shift to a more plant-based diet and the introduction of more diverse and sustainable primary produce. Recent reports have highlighted the enormous potential of biological sciences in understanding crop improvement and the role of diet in human health. However, crops must be converted to safe, stable and nutritious food. This is the role of the science and technology of food itself.

In previous studies undertaken for the International Union of Food Science and Technology (IUFoST), a country-membership organisation, which aims to be the global voice for this sector, we carried out a mapping exercise of how regions and countries included food science and technology in their strategies to deliver food and nutrition security. We developed an outline action plan, in the form of mission-orientated research and development, to identify critical needs for future food science and technology research to help find solutions to global challenges in this field. These missions, each with their own objectives, encompass routes to improved diet and health; requirements to improve understanding and control of food materials and their processing, including waste reduction; safety of all materials and products; and the use of big data to model and control the entire food chain. Through examination of the missions listed below, the details of new actions and new capabilities along the food chain have been identified, which

Peter Lillford of the University of Birmingham and Anne-Marie Hermansson of Chalmers University of Technology provide an update on recommendations made in a IUFoST study on the contribution of food science and technology to sustainable nutrition. The added immediate impact of the COVID-19 pandemic is also examined.

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will be necessary to increase sustainability of production and improve health provision. These advances are essential if the food chain is to play its part in meeting the Sustainable Development Goals.

Missions requiring critical input from food science and technology
- To introduce more diverse and sustainable primary production
- To develop new processes and systems to ensure more sustainable manufacture
- To eliminate material waste in production, distribution and consumption
- To establish complete product safety and traceability
- To provide affordable and balanced nutrition to the malnourished
- To improve health through diet
- To integrate big data, information technology and artificial intelligence throughout the food chain.

Now a new and unexpected driver has emerged, the global pandemic. This is a shock to all supply chains but can be considered as a global ‘stress test’ of the recommendations made in the IUFoST reports on long term strategic science priorities as far as the food chain is concerned. These recommendations require further scrutiny to assess how the pandemic will impact progress on their implementation.

It becomes immediately apparent that to accomplish the missions, new knowledge will be required, not only in food science and technology, but also in biology, medicine, engineering, sociology and the underpinning and rapidly developing information technologies. International collaboration across all relevant scientific disciplines will be required. This article focuses on the missions concerning sustainable nutrition and sustainable food manufacture and distribution.

Sustainable nutrition

Affordable and balanced nutrition
Two missions specifically address sustainable nutrition. The mission to provide affordable and balanced nutrition to the malnourished relates directly to goal SDG-2 Zero Hunger. This concerns a shortfall in both macro- and micronutrients, but there is hidden hunger in all societies, including the agrarian poor in low income countries as well as malnutrition in urbanised areas.

The most recent estimate shows that almost 750m people were affected by severe food insecurity in 2019. The COVID-19 pandemic may have added an additional 83-132m people to the ranks of the undernourished in 2020. In addition, 2bn people, or 25.9% of the global population, did not have regular access to safe, nutritious and sufficient food in 2019[11].

In rural areas it is essential to fully understand the local traditional foods and the availability of raw materials; planting of nutritious traditional crops should be encouraged. These crops are often being replaced by higher-calorie-yielding crops, such as rice and wheat[2-7]. Food technology can contribute to the fortification of traditional products with micronutrients, such as vitamin A, iodine, iron and zinc, where deficiencies are important public health problems with severe consequences for productivity, intellectual development, maternal and infant morbidity and mortality[12-24]. Food technology can aid the uptake of
micronutrients e.g. by enzymatic processing to break down inhibiting compounds, such as phytates and polyphenols, present in many crops and vegetables[15]. Downscaling of modern technology can also help to support local production and the cultivation of indigenous crops.

In urban areas the situation is quite different. The movement of people in search of job opportunities from rural areas to urban areas in low income countries results in the ‘transfer’ of poverty. The urban environment creates the need for cheap foods that require less home preparation. The consequence is a shift from rural diets to urban diets consisting of snacks, fast foods and street foods, which are energy dense and can unbalance diets leading to obesity. This is a global trend, but is particularly pronounced in poorer sectors of every society. There is pressure on manufacturing industry to improve the nutritional balance of foods by reducing fat, sugars and salt within individual products and maintaining or increasing vitally important micronutrients. However, this needs to be done and distributed at an affordable cost for the consumer. New ingredients could be extracted from existing side streams, simultaneously adding value to what are currently low value wastes. Any novel processing should pay as much attention to micronutrient protection as to safety and the preservation and shelf life of finished products.

To allow consumer choice to drive a move towards improved diets, it is vital that unbiased information and education are provided, explaining how and why food types deliver health, together with the sustainability of their manufacture and distribution.

**Improving diet**
The second mission for sustainable nutrition is to improve health through diet. It is quite clear that in addition to the effects of food production on the environment, food has a strong impact on health. Where the supply of calories is adequate, the rapid increase in overweight and obesity is a main driver for non-communicable diseases and these have grown to epidemic proportions, with over 4m people dying as a result of being overweight or obese in 2017 according to the global burden of disease. Today more people are obese than underweight in every region except sub-Saharan Africa and Asia[15]. Furthermore, obesity and obesity-related diseases have appeared as major risk factors in the ongoing COVID-19 pandemic.

Modern biology and multiomics* techniques are fast developing and can couple nutrient intake to metabolic needs for prevention of non-communicable diseases on an individual or group basis[15]. Biomarkers in blood, faeces or saliva that give responses to different foods and diets are being identified. This means that big data can be collected and used to create machine learning-based models for personalised nutrition that can be implemented in digital solutions and integrated with retailer systems.

This can aid consumers in making healthy food choices as 9 out of 10 consumers do not follow official dietary guidelines and consumers need guidance to eat healthily. Food technology is needed to provide new and healthier diets that are rich in sustainable plant-based ingredients, such as non-dairy ‘milk’ products, new green proteins, novel berry and cereal combinations and utilised side-stream ingredients. Even though a shift to plant-based foods is desired, there are nutritional obstacles as animal-based foods contain important and available nutrients, such as iron, zinc, vitamin B-12, marine omega-3 fatty acids, iodine and vitamin D.

High fibre intake, particularly from cereals is associated with reduced risk of cardiometabolic diseases. However, addition of fibre to foods will impact on the processability, texture, taste and colour of the products. A greater mechanistic understanding is needed to aid formulation of foods with optimised nutritional benefits for tailored diets.

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*Sustainability is a new approach in which the data sets of different ‘omic’ groups (genome, proteome, transcriptome, epigenome and microbiome) are combined during analysis.*

**Sustainable food manufacture, distribution and health benefits**
Food is not nutritious until it is eaten and most primary produce needs some kind of processing treatment, whether that be simple washing to improve safety of fruits or complex fabrication to provide common foods, such as bread, sausages and confectionary.

By virtue of economies of scale, industry can safely produce high volumes of attractive foods and distribute them globally at reasonable cost. However, this has required large scale provision of a small number of crop and livestock types, decreasing biodiversity and increasing mono cultures. To continue this trend is unsustainable. Further, current production methods are often not compatible with the retention of the levels of micronutrients and fibre required for health.

The challenges to manufacturing and distribution were spelt out in the first four mission statements. All of these are still valid, but the pandemic has put pressure on existing supply chains. The short-term aim of governments is to return to ‘business as usual’ in terms of supply and demand, but as explained above this is unsustainable in the longer term. There are two positive inputs from the pandemic: firstly the recognition that the

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food chain is vital and needs to be maintained at all costs, and secondly the observation that consumer awareness of locally available foodstuffs has increased.

In future, manufacturing must pay attention to efficient conversion of locally produced commodities, maintain levels of micronutrients and consider manufacture of attractive foods at lower calorie density. Traditional processes are linked to processing, energy density or to the presence of tested food additives of an individual food product.[21]

Even when products of better nutritional quality are made, there still remains the challenge of sustainable distribution. Waste and losses occur throughout any supply chain but food is perishable and requires special attention. Safety is mandatory for all foods whether they be prepared at home or in a factory. Rapid testing will have major benefits and a spin-off from the ‘track and trace’ efforts to control the pandemic will give new opportunity for: rapid safety and diagnostic tests within the chain, packaging safety sensors, and in-home methods. This in turn should reduce wastes that occur through uncertainties in material safety.

We have good documentation of where wastage occurs[22,23] and it is not globally uniform. Where losses of primary produce are large, technical solutions are available for local storage and preservation, but investment limits their application. In the developed world, waste is at the finished product stage and largely driven by safety fears or over purchasing[23].

A return to local production will shorten supply chains but will not eliminate the food waste problem until consumers are less profligate and suppliers accept that sales should relate to nutritional content, not just volumes sold. The economic damage of the pandemic is focusing consumers’ attention on their own waste, but is also promoting the use of on-line access to purchase and delivery, both locally and internationally. To achieve real benefits, sustainability must be measured in life cycles from at least farm to fork, yet there is still no international standard on how this should be performed. Global harmonisation will be necessary and should probably relate to the nutrient availability within foods, not just their type or brand. Like manufacturing, distribution also benefits from economies of scale and responds to consumer demand. There are already signs that manufacturers and retailers of finished foods will drive future branding via health benefits as well as the eating quality and cost. The pandemic is accelerating these trends, and it is likely that legislation will devote greater attention to nutrient values.

Conclusions
This commentary is an update of our previous recommendations for action within the food chain to improve global diet and health via innovation in food manufacture and distribution. The arrival of the global COVID-19 pandemic has changed the expected routes for their implementation but has accelerated the need for these actions. However, we do not believe that their long-term overall importance has been changed.

We wish to re-emphasise the importance of information and dissemination of these recommendations not only to active scientists throughout the many disciplines necessary to achieve these missions, but also to policy makers, grant funders and industry at global and regional levels. Finally, we stress that improved health is in the personal interest of every consumer. It is vital, therefore, that consumers are aware of the need for new technologies to improve the sustainability of the foods they consume and the importance of their own choices in helping to drive improvements in global health.