Transformation Technologies and Translational Research

ILSI Southeast Asia Region

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A New Era in Advancing Sustainable Food System and Public Health Solutions

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Rapid technological advancement in the areas of biomedicine, agriculture, and food and nutritional sciences, and translational research of these emerging technologies, presents exciting potential to positively impact the overall food system, the environment, human health and disease prevention.

Understanding the development of these technologies and their applications, as well as public acceptance and societal impact in the coming era, will be critical in bringing science to market to provide better and more sustainable public health solutions. Acknowledging this, the International Life Sciences Institute (ILSI) Southeast Asia Region, in collaboration with the Agency for Science, Technology and Research (A*STAR) Singapore and CSIRO, Australia, held a symposium in Singapore on April 23, 2018, titled '**Transformation Technologies and Translational Research: A New Era in Sustainable Food System and Public Health Solutions**', as part of their annual meeting.

This symposium highlighted new technology used in agriculture and the food supply chain, environmental science, and health and biomedical research; explored the use of bioinformatics and other innovative digital technologies to capture and analyze data in food systems and public health research; and provided a platform to discuss and enhance multi-stakeholder partnerships in the advancement of new technologies and their applications in food systems. A total of 11 papers were presented.

Dr. Ralph Graichen, A*STAR, Singapore, opened the symposium with his keynote presentation '**Smart data and food innovation: potential for public health solutions'**. 'Smart data' is the next frontier for innovation in the food value chain. The sheer volume of data managed and generated every single day is a global phenomenon and brings with it considerable challenges to organizations - shortage of talent and infrastructure are only the beginning. However, smart data are already paying significant dividends for many industries and are now more and more readily applied in food science, food safety, and in securing the supply chain. Smart data offer increased opportunities in better decision making, helping to uncover underlying trends - from consumer insights, to operational issues, to innovation. Correlations and relationships are emerging that would typically not be available in one dimensional, unstructured data sets. Smart data are now seen as a driver of growth and innovation, used to screen for new functionalities and novel features. Potential applications and benefits are plentiful however a multitude of issues need to be addressed before being able to capture the full potential of smart data. Everything from data policies, collection and access, management and infrastructure needs to be addressed in the context of privacy, security, liability, and intellectual property.

An **evolutionary perspective on nutritional and human health: from reductionism to systems approaches** was presented by Professor Richard Head, University of South Australia, during the keynote session. Historically, humans have demonstrated remarkable inventive skills in and around the fundamentals of sustenance, mobility, shelter, and communication. Food and nutrition have featured powerfully in that inventiveness over thousands of years. Across areas of science and engineering, success has been the ability to achieve scale and concurrently to derive personalisation from complexity with sophistication. In nutritional sciences, we see an evolution of scientific method with a similar emerging pattern. In nutrition and particularly in nutritional deficiency states, the molecular characterisation of the single bioactive and the demonstration of efficacy has been a fundamental contributor to our knowledge and wellbeing. The emergence of an understanding of the pleiotropic properties of many nutrients, their potential influence on, and with, the genome, epigenome, transcriptome, proteome, metabolome, and microbiome, together with dietary behaviour and lifestyle, has stimulated Complex Systems thinking in this area.

The challenge will involve further evolution of the scientific method to meet an individual need for personalisation, clarity, and convenience from this scale and complexity, with the appropriate level of sophistication.

Transformation Technologies in Food Systems

Convergence is gaining popularity as a new approach to address complex cross-disciplinary problems in health. Often defined as the integration of the life sciences, physical sciences, mathematics, engineering, and information technology, convergence (research or science) has emerged as a strategic, cost-effective, and efficient way to develop potential medical, technological, manufacturing and processing breakthroughs. Dr. Chor San Khoo, ILSI North America, noted in her presentation '**Technology innovation: trends that are reshaping life sciences and health'** that this convergence approach has led to the proliferation of a new field of 'biologically-inspired engineering', an offspring of unification between the applied and physical sciences, engineering, computational and data sciences, which is accelerating development of novel and precise technology/tools for exploring biological systems and mechanisms. Often, convergence results in unexpected and synergistic transformations. The integration of Big Data, AI, computational sciences, sensor advancement, systems biology, cellular genomics, and nano- and material technologies has opened new doors for combination technologies targeted to customized applications. In the food and nutrition fields, the convergence approach has yet to be fully applied. Novel tools and technologies emerging from bio-inspired research and combination technology breakthroughs need to be explored for opportunistic applications in food and nutrition.

Today we face the challenge of how to sustainably feed the global population projected to increase to nearly 10 billion people by 2030. This will be accompanied by an increasingly ageing demographic profile, elevated health burden from diet and lifestyle-related chronic diseases, and likely impacts on food production from climate change and other environmental challenges. Growing demand from consumers across countries for foods with demonstrated health benefits is coupled with the digital explosion of data from populations relating to monitoring health and lifestyle behaviours. In combination these trends create the opportunity for a tailored, sustainable dietary approach as part of a proactive and precise health framework that aims to keep individuals healthy for as long as possible. Dr. Chris Downs, CSIRO Agriculture and Food, highlighted **CSIRO's new developments in elite grains and other crops**, including consideration of new technologies and the likely impacts on nutritional profiles under a range of possible climate change scenarios. Dr. Downs also presented **innovative processing technologies which can further modify nutritional profiles and physical functionality of new and existing grains**. Professor Lynne Cobiac, CSIRO Health and Biosecurity, discussed how an **inadequate/inappropriate diet is a major risk factor contributing to the burden of chronic diseases and a major determinant of the health of our gut microbiome**. When planning for producing food in the future, all these factors need to be integrated into one trans-disciplinary framework including industry, government, and research partnerships. CSIRO's newly announced **Precision Health** Future Science Platform is one such approach.

The ASEAN region is an important source of some of the world's key agrifood produce. Despite rapid economic growth, many of its member countries are highly vulnerable to disruptions in their agriculture and food supply chains. Food insecurity occurs concurrently with overweight and obesity among the growing urban middle-class population. Rapid urbanisation has resulted in loss of productive cropland and arable land per capita is among the lowest in the world. The region is prone to severe weather events such as tropical cyclones, and climate change projections indicate many countries with high future climate vulnerability. Professor Paul Teng, NIE International, Singapore, noted that against this backdrop, **sustaining agrifood systems in ASEAN will depend on increasing current agricultural productive capacity with natural resource conservation**, in consonance with **population growth and changing diet demands.** These challenges require that investments in science and technology, backed by infrastructure and human resources be made. Essential technologies include bio-based technologies (to narrow crop yield gaps, improve food safety, reduce losses and waste, adapt to climate change and improve nutritive value), physical technologies for improving productivity and efficiency, mechanical technologies (such as drones and environmental sensors to improve crop management), and digital knowledge technologies (such as models and

mobile devices). For ASEAN to fully utilize opportunities to increase productivity sustainably and meet the goals of biodiversity and natural resource conservation, a pragmatic approach to formulate evidence-based, supportive policy and regulations, is needed.

The food supply chain has experienced problems of data visibility, process optimization, and demand management for millennia, however systemic inefficiencies remain so that food fraud, food-borne illness and food waste prove difficult to track and prevent, and food shipping costs remain high. Blockchain provides a solution to the problem of monitoring asset ownership and the large magnitude of transfers within the food supply chain as a shared, replicated, permissioned ledger, bringing together multiple parties on an up-to-date, trusted network. Zelda Anthony, IBM Singapore, reviewed the **key concepts behind Blockchain**, providing real world examples of where Blockchain is being applied today with the aim of providing significant benefits to end consumers and to all participants in the food supply chain.

Reshaping Human Health Through Translational Science

Nutrition and health have taken centre stage in our lives. In response, food manufacturers have evolved several strategies to develop foods with specific health benefits and by **harnessing emerging technologies to develop foods with functional attributes**. These strategies, outlined by Professor Christiani Jeya Henry, Clinical Nutrition Research Centre, Singapore, include innovative food processing technologies, isolation of novel food ingredients from plants, and the development of new food ingredients. Disruptive food technology will enable us to manipulate the structure of food in a unique way in order to develop a range of foods with novel health benefits. The marriage of the nutrient profile of an individual with food selections in the supermarket aisle will enable all individuals to consume foods that are specifically tailored for their overall health and well-being. The 21st century may be seen as the century when disruptive food technology will impact significantly on human nutrition.

Oxygen free radicals and related 'reactive oxygen species' are fundamental to survival; they help drive evolution yet the damage that they can do ('oxidative damage') is involved in most, if not all, human diseases and in ageing itself. As a result, there has been a huge advertising and popularisation of antioxidant and other supplements. Professor Barry Halliwell, National University of Singapore, noted that unfortunately clinical trials have shown, with some exceptions, a general lack of effectiveness of supplements of antioxidants such as ascorbate, vitamin E and β-carotene, in decreasing risk or severity of human disease. There are multiple reasons for this, one being that these antioxidants are often ineffective in decreasing levels of oxidative damage in humans. Prof. Halliwell discussed **strategies to minimize oxidative damage in the human body**, with much of his research now focused on ergothioneine, a diet-derived antioxidant that is avidly retained by the human body and particularly accumulated at sites of tissue injury, where it may help to diminish tissue damage. He has conducted a detailed study of how ergothioneine, made by fungi and some bacteria, behaves when administered to humans or mice, presenting data on the potential relevance of ergothioneine to human neurodegenerative diseases and other conditions.

The 21st century is also an exciting time for biomedical scientists and bioengineers. With the advancement of deep sequencing technologies, the blueprint of human life, together with thousands of other genomes, have been laid out, starting from the beginning of this century. The wide availability of such big data is helping us to better understand our own development and diseases and enabling novel biotechnological innovations. However, we are witnessing yet another revolution in recent years with the rapid development of powerful genome engineering technologies, in particular CRISPR (clustered regularly interspaced short palindromic repeats)-Cas systems. While sequencing allows us to read the genome, CRISPR-Cas empowers us to write and redesign the underlying DNA. Professor Meng How Tan, Genome Institute of Singapore, discussed the **development and applications of CRISPR-Cas systems as novel tools for sculpting the complex genomes of plants and animals, including humans.** He outlined the challenges that the technology is currently facing, describing some solutions to solve these problems, and sharing thoughts on how the agriculture and healthcare industries may be disrupted in the future.

Transformation Technologies in Food Safety

Food safety is a global concern and the current estimated global burden of foodborne disease from microbiological food safety problems and the related social and economic costs remains high. Emerging tools useful in managing such problems have become increasingly sophisticated. However, challenges remain in outbreak investigations in linking illness to particular foods and ensuring the appropriate products are recalled. Dr. Masami Takeuchi, FAO Regional Office for Asia Pacific, highlighted **genome sequencing as one such tool that offers great potential for various food safety regulatory activities** including food inspection, outbreak detection/investigation and studies on antimicrobial resistance. Such benefits could significantly contribute to protecting public health and food security as it can save lives and prevent economic losses and food waste due to incorrect or imprecise implications of wrong products and commodities. However, while several industrialized countries have been moving forward with genome sequencing for food safety management, its application in developing and transitional countries is limited. Overcoming these challenges and ensuring that countries can reap the benefits of genome sequencing technology means that all parties need to be involved in the dialogue regarding its use in food safety management. FAO has developed a technical paper on the application of Whole Genome Sequencing in food safety management and convened a global meeting bringing together 175 participants from 50 countries, half of which were developing countries, and continues to address the needs and concerns that developing countries may face regarding this technology.

Food allergies caused by proteins are globally on the rise while at the same time novel or alternative protein sources enter the market and need to be tested for safety. Previous FAO/WHO guidelines for computational assessment of allergenic potential of proteins based on single hexamer peptide hits and linear sequence window identity thresholds produced a large number of false positives. The number of identified allergens in databases over the last decade has dramatically increased the chances of random hits of hexamers to the extent that, following the 2001 guidelines, up to 90% of all HUMAN proteins would be classified as potential allergens in 2017 due to random peptide hits. At the same time, true similarity in protein sequence and structure between allergens and non-allergens introduces yet another challenge to similarity-based methods for classifying allergenic proteins. Dr. Sebastian Maurer-Stroh, A*STAR Bioinformatics Institute, Singapore, and his team have **revisited the sequence and 3D structure features of known allergens in order to derive and test enhanced prediction methods.** Testing for allergenic potential of proteins using this novel computational workflow early in food production planning and product development can dramatically reduce costs and risks for food companies.

The Transformation Technologies and Translational Research symposium concluded with a panel discussion highlighting the importance of **multi-stakeholder partnerships in the development and application of new technologies in the food system**. Panellists discussed both the benefits and challenges of multi-stakeholder partnerships in the implementation of new technologies in the areas of agriculture/food safety/nutritional and biomedical science, in addition to strategies that could be used by different stakeholders to ensure effective communication to the public and other stakeholders on the use and safety of new technologies.

For more information on the symposium, visit ILSI Southeast Asia Region's website www.ilsisea-region.org