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I am currently an independent consultant to Food and Drink academic and industry groups as Director of 'Creating Food Meteorites Ltd' (2020-present). I have served in both industrial (Director of 'Delivery of Actives' Department (2003-2005) and Senior Scientist 'Food Structural Design' (2005-2007) of the Unilever Food and Health Research Institute, and Scientific Affairs Director at Campden BRI (2020-2022)) and academic (Reader and then Professor of Food Structure (2007-2020), Head of Division of Food Sciences (2014-2018), Director of the EPSRC Centre for Innovative Manufacture (CIM) in Food (2013-2019), co-creator and Leadership Team member of the Future Food Beacon (2016-2020) at the University of Nottingham) roles, and Associate Editor of the RSC's Food and Function journal (2012-2018). Throughout my career I have been an advocate for the design of healthy foods for all and have been involved in the writing of policy papers in recent years:

- KTN / TSB / FDF 'A pre-competitive vision for the UK's Food & Drink Industries' December 2013.¹
- Document drafted and industry input compiled by KTN Food Sector Group, 'Redesigning the food supply chain: choosing and producing healthy, nutritious and sustainable food', December 2014.²
- Innovate UK / KTN 'Food & Drink Sector R&D Needs and Priorities: Alignment with the Industrial Strategy', January 2018.³
- Midland Engine 'Future Food Processing Accelerator – Concept Brief', February 2020.⁴
- UKRI-IUK KTN 'Food Industry Priorities for a Sustainable Food System' September 2023.⁵
- Midlands Engine Food White Paper, February 2024
https://midlandsengine.org/wp-content/uploads/2024/02/Midlands-Engine_Food-White-Paper.pdf.⁶

In all of these documents, spanning the last decade, there has been a consistent message that healthier foods, affordable to all, should be made available. All have been penned in collaboration with the food industry, showing a long-standing desire to improve the health impact and outcomes of food, where food can be re-seen as preventative medicine.

"The UK food industry has a clear objective of producing high quality, safe and nutritious and affordable food at lowest environmental cost.... Despite the best intentions of diverse stakeholders, health and wellbeing messages do not easily translate into behaviour changes. The objective is to encourage behaviour change which reduces the risk of chronic diseases and other lifestyle-related conditions.... There is delicate balance between

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food for pleasure and food for health.... so we need to understand.... How new health and diet foods will be adopted and accepted by an ageing population and subsequently translate into societal benefits.... How best to deliver health and wellbeing messages for maximum, sustained effect as despite the best efforts of diverse stakeholders long-term benefits have not been maintained. Research is needed to find ways to deliver messages so that the population implements them in a prolonged and consistent way to address the problems of overweight and obesity".¹

"The food industry requests a partnership with the UK government to address major societal challenges through supporting fundamental, pre-competitive research for the benefit of all the UK population. The aspirations of such a partnership would be to transform the long-term health of the population by a) making healthy foods more pleasurable and pleasurable foods healthier b) creating a more resilient, nutritious food supply better able to cope with external perturbations such as national demographics and climate change".²

This document identified a challenge facing society being "Obesity and other population diet-related health issues. These form a major target for research-based interventions providing real financial, health and societal benefits to the UK", where "the key underpinning research required to meet the challenge are:

- A fundamental understanding of food structure,
- Knowledge based understanding of gut physiology and microbiology, the interaction between the two and how these might be optimised,
- An understanding of psychobiological parameters such as taste, appetite and satiety, and
- A real understanding of the process of food choice".

"The specific knowledge acquisition that this research will enable is as follows:

1. Maximising nutrition from composition and processing of foodstuffs both new and current and minimising waste,
2. Understanding the process of digestion from a multifaceted view including food, microbiota and host interactions,
3. Determining how food choices happen, how they develop and how to sustain changes,
4. Investigating links between population diet, specific disease states and overall health with health and disease biomarkers and technologies suitable for dietary rather than pharmaceutical interventions,
5. An understanding of the role of society and the individual within the food supply chain in economic, consumer health and sociological contexts".²

"Five areas have been identified by the Food Sector Group where there is an excellent UK research and industrial capability and global market potential.

1. Reducing food energy density - Consumer benefit: Insights to enable reduction in energy (caloric) density and uptake across product portfolios by 2020 (responsible great tasting products / maintaining customer enjoyment in line with nutritional guidelines),
2. Side-stream valorisation,
3. Sustainable new food sources for nutritional foods - Consumer benefit: Development of low-cost, nutritionally balanced, consumer-preferred products based on sustainable sources of new materials and protein,
4. Flexible and scalable manufacturing,
5. Digital manufacturing".³

"Food is a basic human need and there is growing consumer demand for healthier, ethically and sustainably produced, minimally processed and increasingly convenient food products. This trend has been defined by Mintel in their analysis of global food and drink trends in 2019, through the following terms which will lead momentum of global food and drink innovation:

- **Evergreen Consumption:** A circular view of sustainability that spans the entire product lifecycle requires action from suppliers to consumers.
- **Through the Ages:** Food and drink will build on today's dialogue about wellness and transition into more solutions for healthy ageing.
- **Elevated Convenience:** To match the premium expectations of consumers in the on-demand digital age; convenience food and drink will need a step change in healthiness and quality.

The UK food industry, in common with the global food production system faces fundamental challenges including:

- Reformulating and creating new products to meet diet and health requirements,
- Responding to changing consumer attitudes and behaviours.

To address these challenges, there are a number of barriers which science and industry can help address for example through:

- Big data and modelling to support decision making throughout the supply chain,
- Enhancement of resilience by improving the yield and nutritional quality of crops,
- Food diversification throughout the food system,
- Evaluation of the impact of sensory, economic and social factors in healthy food choice decisions,
- Creation of flexible and scalable manufacturing solutions for premiumisation and personalised nutrition".⁴

"Our 20th Century UK food system successfully met the need to deliver safe, affordable and available food. Today the food system and wider society face a number of challenges, from ingredient and energy costs to increasing incidence of diet-related disease. Now, we must create the solutions needed for a 21st Century food system. Crucially, we need to

deliver healthier affordable food that meets the changing needs of consumers. Nutrition for long term health as well as short term satiation is key, as is integrating sustainable sources of raw materials and energy, across the whole interdependent and connected food system. With an overarching mission of enabling the UK food system producing healthy, desirable and affordable food, two of nine priority areas are:

- Sustainable novel and alternative sources for nutritious desirable food
 - Increased diversity of sustainable food sources through the growing and transformation of a wider range of crops, including more fruit and vegetables and valorisation of side-stream materials, the use of biotechnology and aquaculture to produce sustainable, high- value, nutritious food ingredients.
- Personalised/stratified nutrition, consumer insight on life stage demands
 - Solutions to address consumer requirements for premium, personalised and life stage nutrition, and associated health benefits (e.g. healthy ageing).
- Insights to enable reduction in energy (calorie) density (responsible great tasting products / maintaining customer enjoyment in line with nutritional guidelines)".⁵

"Key priorities for manufacturers include responding to evolving consumer demand e.g., growing demand for healthier diets and balanced nutrition via reformulation and increasing the supply of naturally healthy food, e.g. fresh produce. Future innovation needs in the industry include considering consumer needs: responding to emerging consumer and market needs for new foods and sustainable production".⁶

Food industry collaborators to the above mentioned documents include: Unilever^{2, 3, 4, 5}, Cargill^{2, 3}, PepsiCo^{2, 3, 4, 5}, Sainsburys^{2, 3}, Marks & Spencer^{2, 3}, Nestle^{2, 3, 5}, Greencore^{2, 3}, Samworth Brothers^{2, 3, 5, 6}, Mondelez^{2, 3, 4, 5, 6}, Allied Bakeries^{2, 3}, Warburtons², Campden BRI^{2, 3, 4, 5}, Waitrose³, Quorn³, Devro³, William Jackson Food Group³, Coop³, McCain³, RSSL^{3, 5}, Food and Drink Forum^{4, 6}, Blue Skies⁵, 2Sisters Food Group⁵, Barfoots⁵, Oscar Mayer⁵, FreshLinc⁶, Sofina⁶, Alltech⁶, Moy Park⁶, Youngs⁶, SmartParc⁶, Murphy & Son⁶, Dyson Farming⁶, Pollybell Farm⁶, Worldwide Fruit⁶, NFU⁶, Bridge Farm⁶, Harrison & Griffiths⁶, More People⁶, Barclays⁶, HSBC⁶.

I was part of the discussions for the launch of the BBSRC Diet and Health Industry Club (DRINC) as Unilever's representative in 2006, and also later reviewed the programme upon its completion. It resulted in 57 new academic collaborations, 22 new academic-industry partnerships, but only 15% of publications co-authored with industry and 72 % of ECRs' next destination was within academia, 19% moved to industry, and 8% moved into a clinical setting. The objectives were admirable and a total of £22m was spent on 43 projects (~£500k per project) between 2008-2017. In the second phase (2013-2017) there were 8 projects on **Designing**

foods to maintain and improve health, 7 projects on **Understanding the relationship between food processing and nutrition** and 3 projects on **Understanding food choice and eating behaviour to improve health through diet**. However, the projects were individual, saw few progress beyond the lower TRL with follow-on TSB/IUK funding, had dissemination events open to only those groups funded and had very little connection with SMEs.

DRINC has been replaced by a new Diet and Health Open Innovation Research Club with 6 new innovation hubs which is being coordinated by the British Nutrition Foundation <https://www.nutrition.org.uk/our-work/who-we-work-with/diet-and-health-oirc/>. Membership of these is now free and open to all, but funding is only available for mobility awards (to support mobility between academia and industry funding up to £100k for a placement of up to 9 months duration), business interaction vouchers (funding up to £50k per project lasting up to 6 months help to initiate, develop and enhance collaboration between academics and industrialists), and proof of concept awards (to support new collaborations between an academic partner and an industry partner for a project with up to £100k). While these are ideal for initiating network building – substantial funds are required to provide meaningful, game changing outcomes. Industry core members of these hubs include: AB-Mauri, PepsiCo, Unilever, LettUs Grow, Quorn foods, Algenuity, New Era Foods, Samworth Brothers, Mondelez, ADM, Suntory, IFF, Herbalife, Beneo, Cargill, RSSL, New Food Innovation, Campden BRI, 4flour, Huel.

The **Transforming the UK Food System for Healthy People and a Healthy Environment Strategic Priority Fund Programme** has **invested £47.5m** in 4 Centres, a Centre for Doctoral Training and a 12 of smaller projects:

FixOurFood: A Yorkshire food system constituting regenerative and equitable healthy eating for young children, supported by regenerative hybrid food economies and regenerative farming <https://fixourfood.org/outputs/>,

Healthy soil, healthy food, healthy people (H3): Regenerative agriculture measures to protect and restore soil health, use innovative methods such as hydroponics and biofortification, considering consumer demand, public acceptability and affordability <https://h3.ac.uk/about/>,

Co-production of healthy, sustainable food systems for disadvantaged communities: Develop solutions that will provide people living in disadvantaged communities with improved access to fresher food and a balance of desirable, sustainable, affordable, and healthy products. Identify opportunities to prevent food loss from 'mainstream' supply chains and identify where increased sustainable production of primary food ingredients is needed <https://research.reading.ac.uk/food-systems-equality/>,

Transforming urban food systems for planetary and population health:

Transform the urban food system and its relationship with its regional economy in the West Midlands

<https://www.globalfood.cam.ac.uk/research/mandala-consortium-transforming-urban-food-systems>,

The UK Food Systems Centre for Doctoral Training: Develop the next generation of food system change makers for a healthy and sustainable food future, <https://foodsystems-cdt.ac.uk/>,

Smaller scale research projects

<https://ukfoodsystems.ukri.org/research-projects-training-reports/>.

From the above it can be seen that the food industry **has been and are** heavily involved in the need for a transformation to healthier food products, and that through sizeable funding from BBSRC (DRINC and OIRC), EPSRC (CIM) and the TUKFS-SPF, efforts are and have been made to build knowledge and skills capacity in the UK. **BUT** is this enough to have an impactful and long-lasting influence on the health outcomes of the UK consumer?

What else is needed? The small scale and lower TRL research projects need an opportunity for elevation, while industry is behind a pre-competitive focus to make a difference in creating healthier food options.

There is also a current precedent showing industry collaboration in The Food Consortium Collaborative Training Partnership (CTP) funded by BBSRC and aligned to their strategic themes: Bioscience for an integrated understanding of health, Bioscience for renewable resources and clean growth, Bioscience for sustainable agriculture and food. The CTP is Industry led (Mondelez, Nestle, PepsiCo, Samworth Brothers and Campden BRI (to also include Unilever from October 2025)) and will train 43 PhD students in four cohorts between 2022-2029 and will align both industrial and academic supervisors to pull together science/technology and policy whitepapers and horizon scanning activities. There are also other food related doctoral training programmes currently active: the Transforming UK Food Systems CDT (SPF), Agri FoRwArdS (EPSRC) and FoodBioSystems (BBSRC). In total this will be ~200 PhDs/thought leaders of the future being trained, and The Food Consortium is engaged in identifying shared activities.

When analysing Figure 7 of Hasnain, S., Ingram, J. and Zurek, M. 2020. Mapping the UK Food System – a report for the UKRI Transforming UK Food Systems Programme. Environmental Change Institute, University of Oxford, Oxford. ISBN 978-1-874370-81-9, it can be identified that the COVID pandemic saw a blurring of the lines (in red below) of what is 79% of the food industry (and comprises 82% of the workforce from Figure 9).

Figure: 7 Economic summary of the UK food system.



It also states that "UK has the highest consumption of ultra-processed foods in the EU countries. This contributes to obesity and poor health, with 63% of UK adults being obese or overweight". Given what I have shown above in this document I believe this can be seen as both a challenge and an OPPORTUNITY.

When I was Director of the EPSRC CIM in Food I was asked to operate as a National Centre and looking forward proposed a follow-on Manufacturing Research Hub (highlighted in Science in Parliament, Vol 74 No 1, Spring 2018: Science and Food Manufacturing), which sadly wasn't funded. However, to tackle the current issues my proposal would be to create 4 new Centres, acting as National Centres for the public good in the areas of:

- Manufacture of Sustainable & Healthy Food
- Nutritional Validation
- Consumer Behaviour & Supply Chain Logistics (following the unprecedented impact of COVID-19)
- A fourth Centre 'Innovation Ecosystem Actualisation' would link citizen scientists, start-ups and SMEs to the current bounty of food Nationals & Multinationals currently within the UK.

If each of these Centres were funded to the tune of £10m by Innovate UK with £2m matched funding (industry, venture capital, NGO,) then it would fund 20 3yr post-doctoral researchers (£9m at an average of £150k pa) and £3m support (clinical studies, operational and coordination costs, equipment and consumable supply for each Centre), provide the opportunity for a linkage of top research institutions (operating as National Centres) and provide a framework to attract additional leverage funding (the EPSRC CIM more than doubled its original income of £6.5m). There would then be a home for at least 80 of the thought leaders of the future highlighted in the Centres for Doctoral Training above. This would

leverage the excellent research in the lower TRL studies and elevate their outcomes to higher TRL opportunities for the socio-economic gain for the health of consumers and businesses alike.

Together with the Transforming UK Food Systems Centres & CDT and the Agri-tech Centres (soon to become one Centre/Catapult) would form a powerful 'Council' to advise UKRI (DSIT), Defra, FSA, DBT and the Food Sector Council to build the UK as a powerhouse for change, innovation and initially parity but ultimately leadership on the world stage.

Specifically addressing the UPF and HFSS conundrum

When in Unilever (2006) and working with nutritionists I convened 3 one-day back-to-back workshops on salt, sugar and fat reduction in Unilever's product portfolio at Schiphol airport to which R&D personnel from around the world attended. Strategies were put in place and leveraged the fundamental research happening in Unilever at the time. From a fat reduction perspective we studied it's replacement not by sugars (which was often the industry norm) but by 'water structuring' using materials such as citrus fibres, cellulose (a zero calorie non-fermentable polysaccharide) and plant, algal and bacterial polysaccharides (sources of fibre) and established that only 3% fat was required to provide the aroma profiles consumers expect during consumption and intelligent design provided products which keep consumers fuller for longer (all this work was led by Prof Ian Norton who became Unilever's Chief Scientist and upon leaving in 2006 became Professor of Chemical Engineering and led the Formulation Engineering Research Group at the University of Birmingham). Sugar and salt replacement is multi-factorial as they contribute to the safety, appearance (Maillard and caramelisation), texture and sensory evaluation of products as well as being contributors to taste and flavour (taste and aroma). I summarised this as a **TASTE** profile (**T**aste, **A**pppearance, **S**afety, **T**exture and **E**valuation) and the research challenges outlined above can help provide such a profile, and through societal consumer behaviour change activities, help shape the increase in the required portfolio of healthier food products that are accepted by and affordable to all consumers. Indeed, work at Unilever and subsequently at the University of Nottingham has shown that inclusion of air in products can maintain saltiness and sweetness perception at lower total salt and sugar levels. The issues here is that products are sold on weight not volume! Manipulation of salt and sugar crystal structures have also seen a maintenance of perception at lower overall inclusion.

UPF is in the spotlight at the moment and undoubtedly high calorie foods should not be over-represented in the DIET of consumers, and there should be a striving for a balanced DIET. If healthy foods were more pleasurable and pleasurable foods healthier (low calorie / low energy density) and thereby were consumer accepted and understood, alongside

a greater need for the consumption of fresh and wholesome foods, then a BALANCED DIET affordable for all is not unobtainable.

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