

A PRE-COMPETITIVE VISION FOR THE UK'S FOOD & DRINK INDUSTRIES

Top 10 pre-competitive areas where research is needed



Building on existing cross-governmental work within the AgriFood space covering activities from the farm gate to consumer and specifically complementing “A UK Strategy for Agricultural Technologies” published in July 2013.

December 2013.



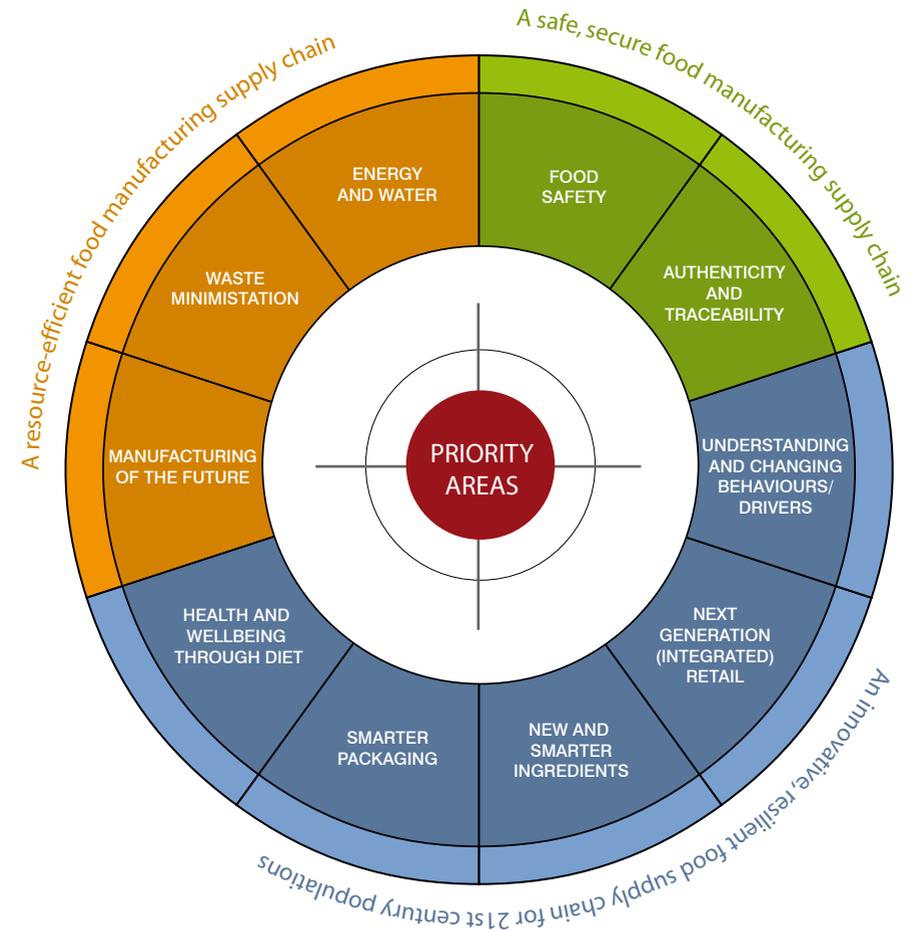
Technology Strategy Board
Driving Innovation





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PRIORITY AREAS FOR RESEARCH TO MAINTAIN AND ENHANCE THE UK'S COMPETITIVE POSITION IN GLOBAL FOOD MANUFACTURE





The UK food and drink manufacturing industries are of fundamental importance for the UK economy. Together they:

- Constitute our largest manufacturing sector, contributing over £96 billion per annum including 18% of the national GVA
- Support employment of over 3.3 million people
- Are responsible for a £19bn export market with healthy growth and act as a key partner for British farmers, buying two thirds of all the UK's agricultural produce

The UK food industry has a clear objective of producing high quality, safe and nutritious and affordable food at lowest environmental cost. It has an extremely broad technology base with supply chains extending from primary production, through processing, logistics and retail into restaurants, hotels, hospitals and the homes of the entire population. It exists within a global context addressing challenges such as reducing the environmental footprint of food products, reducing waste and producing more from less in response to increasing pressure on natural resources and higher demand from a growing world population.

The innovation and education base supporting this vital sector needs further investment. The expertise and capabilities in basic research and their application into fruitful innovation for the economic benefit of the nation need to be more closely aligned. The Government recently issued an innovation vision for the primary production component of the food supply chain in its agricultural technologies strategy (<https://www.gov.uk/government/publications/uk-agricultural-technologies-strategy>). The pre-competitive vision for the food and drink industries has been developed

to complement this strategy, describing the shared innovation priorities of the food and drinks manufacturing sector, intercalating with the agricultural technologies strategy through the whole supply chain to the consumer and also considering health and diet influences at an entire population level.

The Biosciences KTN have worked with the Food and Drink Federation (FDF) and the National Technology Platform for Food (NTP) throughout this exercise to maximise the range of inputs across the 6000-strong industry sector. We are grateful to everyone who contributed to the listing of research needs, initial prioritisation of these needs into 10 key areas and in particular to the volunteers who helped to shape the text describing the detail of the work required below each of the 10 headings. Input has been provided by most of the major names in the UK, by the industry associations, in particular Campden BRI, Leatherhead Food Research and the Scotch Whisky Research Institute; academic voices have included several universities, the EPSRC Centre for Innovative Manufacturing in Food and the National Centre for Food Manufacture at Holbeach. We would particularly like to thank the sponsors of the work the Technology Strategy Board and the Edinburgh Science Triangle for their welcome support in delivering this important document to help shape the development of collaborative research within and between the food and drinks industry, the academic base and the government departments responsible for food strategy within the UK.

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1 NEXT GENERATION (INTEGRATED) RETAIL



2 WASTE MINIMISATION



Changing consumer purchasing methods will alter how we purchase our food and drink, it is thought that most change will be driven by the retailers, but there is scope for both innovation and technology to drive positive changes. Such changes may lead to direct delivery of personalised selections and pack sizes, bespoke recipes, delivered direct to our homes from factories or distribution hubs, leading to a need to understand:

- The impact of internet shopping on the food industry and the routes to closing the gap between consumer need/unmet needs and food & drink production
- How to provide healthy personalised low cost food
- Products made to order from components/ingredients produced and stored in multiple, distributed facilities

Minimisation includes both lean manufacturing and waste/co-product recovery. The huge volumes of food wasted every year in the UK supply chain means this is an area where step changes are required and will be driven by pressure on land use, raw material costs and availability of food. This coupled with the adoption of a circular economy, creating value and uses for all components of the food chain drives a need for basic research to create:

- Better packaging and processes for shelf life extension
- Strategies for material re-work and cleanup of contaminated product or packaging
- An understanding of how complementary and competing businesses can co-operate both inter and intra business to benefit all
- Solutions for turning current waste streams into useful cost neutral, or higher value, commodities
- Improve resource efficiency (water and energy) with reduced greenhouse gas emissions in food processing (e.g. reduction of heating then cooling or wetting then subsequent drying steps across the food chain)

3 MANUFACTURING OF THE FUTURE



Common to all established industries, the current food & drink industry infrastructure has been developed over time and does not necessarily represent how it might best be designed if developed from scratch. Hence it is essential that innovative ideas, technologies and bolt on solutions are encouraged, researched, developed and implemented within the UK's industry to allow it to maintain its resilience, scalability and prevent obsolescence. We must invest in fundamental science so we can lead in the following areas:

- Use of new and developing technologies to transform ingredients into foods. Benefits will include lower energy use, maintenance of 'fresher' tastes, development of novel structures and enhanced shelf-life. Examples of potential technologies include high pressure processing, pulsed light, power ultrasound, pulsed electric field, non-compressor refrigeration
- Incorporation of sensor technologies (optical, broader electromagnetic spectrum, ultrasound) into closed loop process control systems. This will allow production to be controlled and adapted within defined parameters with the ultimate aim of removing unnecessary human interventions
- Better understanding of and integration between raw material properties and processing performance overcoming some of the implications for food and drink manufacturing of variability in available raw materials due to macroeconomic factors including climate change. A potential so far untapped is raw materials from aquaculture (e.g. hydrocolloids, proteins, fats)
- Distributed manufacturing – requiring process intensification, partially-formed structures, new cleaning/hygiene regimes. Design underpinning processes to remove the current repetitive energy inputs, for example wetting then drying, heating then cooling
- Design of food structures with radical changes in density of micro-nutrients, i.e. vitamins, minerals, essential fatty acids and essential amino acids, and targeted delivery to different regions of the digestive tract. Design of food structures with radical changes in bioavailability of macro-nutrients (fat and sugar) where they have structural and storage implications e.g. food structures with low glycaemic index or consumer-friendly foods with all the benefits of eating fruit and vegetables
- Factory measurement systems that feedback into primary production to provide data and on-farm measures that will improve yield and product quality
- Use of new and developing technologies to design a smaller production area thereby reducing energy costs, improving product safety and creating a more pleasant working environment e.g. manufacturing in a tunnel and lotus leaf effect surfaces
- Developing more flexible and agile manufacturing solutions that integrate the ability to late stage differentiate/personalise products whilst generating value from scaled manufacture

4 HEALTH & WELLBEING THROUGH DIET



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. The cost-effectiveness and reach of initiatives should be evaluated in parallel, to ensure the most effective approaches are sustained. We need to extend our understanding of nutrition and diet to do this we must:

- Carry out studies to validate biomarkers that can be used to assess the impact of nutritional changes on health
- Develop understanding of nutritional and dietary effects on health at specific life stages or conditions, e.g. childhood, old age, institutionalised
- Develop predictive models of the link between nutrition and health status
- Assess the extent of 'hidden hunger' in the UK (nutrient deficiencies in sectors of the population) and develop products to address the identified issues
- Maintain and improve nutritional quality of foods via modified processing conditions
- Investigate how the density of micro-nutrients such as vitamins, minerals, essential fatty acids and essential amino acids can be improved in foods and in the overall diet

- Investigate how the bioavailability of key dietary components can be retained or enhanced using the physical structure of food including targeting to different regions of the digestive tract
- Develop strategies for achieving the required nutrient density whilst maintaining palatability and safety
- Design and create fabricated foods with all the benefits associated with fruit and vegetables e.g. structure, bioactives etc
- Run translational market tests to understand how the consumers' holistic approach to health and wellbeing can be targeted by the right product & how these could be used to support consumer behaviour changes of benefit for population health



Packaging has two technical purposes: protection and functionality and therefore represents a key area to focus fundamental research and innovation. In its role to protect food from adulteration, spoilage etc. there is a balance between maximum protection to minimise product waste and excessive packaging becoming unwanted/non-reusable waste. In addition to its use to preserve food better, packaging can be used to communicate useful, commercially valuable and legal messages to the consumer thereby providing secondary applications without creation of additional waste. Advances are required in the following areas:

- Safety of packaging materials and their components; explore better ways of working across the packaging supply chain to ensure the requirements of the food manufacturing industry are fully understood by their suppliers
- Explore the potentials and the risks associated with increased use of recycled materials in primary, secondary and tertiary food packaging
- Smart sensors for product spoilage – directly measuring changes in safety critical attributes of the product, e.g. microbial activity, necrosis by-products, pH, oxygen levels, CO₂ levels etc.
- Authenticity and quality – anti-counterfeiting and tamper evidence using smart materials and sensors and origin trackers e.g. smart GPS / product journey trackers
- Smart materials – react to stimuli (e.g. environmental conditions) and adjust their protective functions accordingly (e.g. colour changes, barrier, chemical scavenging)
- “Flexible packaging” so that ingredient flexibility and/or distributed manufacturing is achievable
- Advanced mono-materials – materials of the same family that can have broad functionality and applicability
- Packaging for dispensability – resealable and tailored for assisted living for ageing or illiterate populations for example
- Improved durability – making packaging more reusable (e.g. improving cycles for returnable systems)
- Value added packaging solutions that once finished turn into a value added waste stream e.g. building blocks for housing
- Diet control – packaging that interacts with smart devices e.g. apps, sensor device to monitor dietary intake i.e. weight control, allergies, diabetes or to help portion control
- Personalised packaging solutions, providing customised shopping experiences through large scale ‘big data’ systems
- Connectivity – novel packaging solutions that connect consumers through e.g. interacting with their environments (music, friends etc.)



Food safety is a minimum standard for everyone in the industry but there is still a need for research aligned to the market changes we foresee, for example climate change, new sources of raw ingredients, emerging and re-emerging risks and new production processes with the potential to create harmful secondary compounds and components. Underpinning this essential pillar of food safety within the food supply chain the research base needs to consider:

- Achieve an appropriate balance between consumer protection and innovation. This will best be achieved by developing a specific food-based model, which can then be applied to the assessment of the relationship between foods, diet and health. A current example is the EU Nutrition & Health Claims Regulation, which, if its implementation continues in the current manner, will potentially lead to a disincentive for food companies (particularly SMEs) to invest in research into new products with specific health claims
- Food labelling legislation should provide consumers with accurate information, which encourages them to make healthy choices. Food companies will then have a framework, which allows them to benefit from development and promotion of healthy choices
- Overall need is to focus on supply chain compliance, i.e. a systems approach to traceability for both branded and own-label goods incorporating an appropriate balance of QA/QC activities, horizon scanning for threats including data mining/pattern recognition and a holistic approach to food safety management utilising all the tools available, e.g. GAP, TACCP, risk management, pre-requisites, HACCP

- Development of new sensing approaches for microbiological, chemical and physical contaminants; matched by thorough toxicological studies to provide the grounds for informed and proportionate policies
- Development of new antimicrobials/antibiotics to counteract declining options available to health professionals and recognising the levels of existing compounds already found in the food chain
- Use of coordinated hygienic design approaches to plant and equipment as well as integration of novel technologies to support and reinforce factory and personnel/personal hygiene

7

UNDERSTANDING & CHANGING BEHAVIOURS/PURCHASE DRIVERS



There is delicate balance between food for pleasure and food for health, future market changes may subvert this balance further 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
- Internet/low cost drivers
- Undertake cost-effective consumer research with the reach necessary to determine what nutrition/lifestyle messages will have the desired public health impact on chronic diseases
- 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
- Availability of protein and its origin including a range of sources such as animal, microbial or plant

8

AUTHENTICITY & TRACEABILITY



There are two clear strands to this area; (i) consumer demands (ii) consumer safety. The former focusses on the consumers' demand for assurance of what they are buying and that the information on pack accurately describes the product and, if a problem arises, the source of the problem can be quickly found and resolved. The latter is primarily about ensuring the legal framework that underpins food safety is adhered to. Tightening of stocks will lead to market premiums, larger financial gains to adulterate and ultimately increased risks, to mitigate this we must:

- Create a database of key physicochemical features of raw materials and risks associated with their supply. The information will enable rapid characterisation and verification and the risks register will promote accurate analysis of the impact of environmental and other factors, such as growing location, supply chain and handling; impact of other crops or industries associated with growing location e.g. allergens, changes in nutritional status, chemical contaminants
- Embrace technology developed in other sectors that can both track raw materials in real time through the supply chain and protect them at all stages from illicit actions

9 ENERGY & WATER



10 NEW AND SMARTER INGREDIENTS



Historically energy and water have been relatively cheap and consistently priced; as we look towards 2025 we need to recognise that these resources will become less abundant and the supply price more volatile on global financial markets. Current processes that take 10 litres of water to produce 1 litre of drink or generate significant waste energy as heat will not be possible, so to be ahead of these changes we must now:

- Investigate low energy, slightly wet processing
- Assess feasibility and consequences of potentially competing commercial entities co-locating to benefit energy use
- Water recovery and re use technologies
- Research new and developing technologies to develop a more energy/labour efficient system to achieve a final temperature of less than 5°C for packed chilled foods prior to dispatch (other than blast chilling)

Increasing food costs will open up the need for alternative and new raw materials and the requirement for them to be multi-functional for a more flexible and resilient food manufacturing supply chain, for the UK to lead this area we need to consider:

- Making better use of what nature provides to identify alternatives that will provide reductions in fat/salt/sugar
- Less-refined and energy-intensive ingredients that are equally as efficient as current ingredients
- Smart concentrates for distributed manufacture
- Ingredient strategies that incorporate emerging societal challenges and link into other consumer enablers e.g. personalisation through digital interfaces, linking ingredients into packaging and vice versa
- Ingredients as the driving force for moving from curative, pharmaceutical solutions to preventative positions e.g. diet and balanced lifestyle (addressing the gap of care)
- Ingredients that focus on wellness, functional delivery and weight control. The appetite for natural ingredients that can deliver health benefits to the substantial number of wellness-seeking consumers will be a differentiator going forward e.g. high potency sweeteners, natural antioxidants and pre/pro-biotics



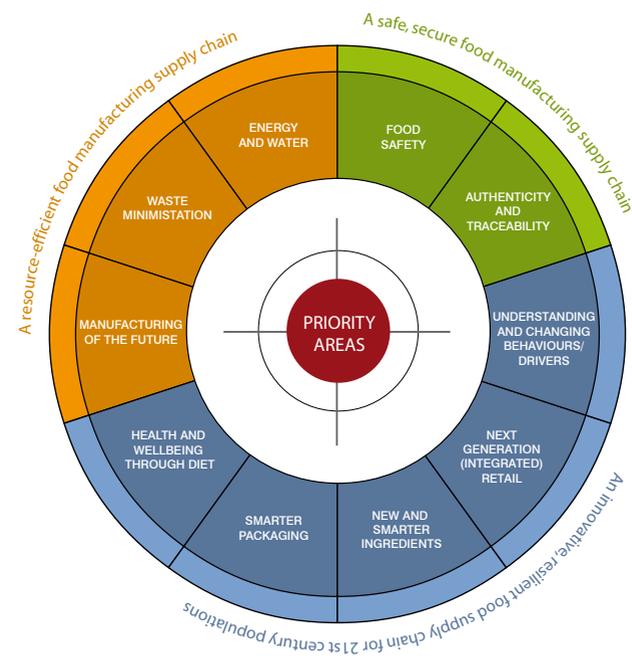
A PRE-COMPETITIVE VISION FOR THE FOOD & DRINK INDUSTRIES



- Natural ingredients that promote product longevity without the perceived 'unnatural' pressures e.g. natural preservatives
- Ingredients that act as 'traceability partners' to promote transparency and consumer / customer confidence as to origin, safety and quality
- Clear understanding of the interaction between functional properties and process requirements to ensure consistent product performance and to adjust production processes to variation in supply
- Promote sustainable ingredient production and application with full traceability through full life cycle provision on ingredients
- Ingredients that promote seasonality
- Natural ingredients offering new flavours and tangible health benefits
- New delivery systems that offer improved bioavailability and taste/flavour sensations
- Flavour development to meet growing consumer experimentation and acceptance of novel and exotic foods
- Novel sensory experiences driven by driving greater consumer promise delivery
- Catalytic ingredients that remove the need for additional energy or additional process steps

PRIORITY AREAS FOR RESEARCH TO MAINTAIN AND ENHANCE THE UK'S COMPETITIVE POSITION IN GLOBAL FOOD MANUFACTURE

Future food security is a key global challenge: we need to produce more, from less and with less impact to meet growing demand and the consequences of climate change. Using science and innovation will be critical to success. We have consulted widely with industry and academic stakeholders to identify the research priorities needed to maintain and enhance the UK's competitive position in global food manufacture. Progress in all these areas is essential for a resilient, resource-efficient and safe food manufacturing supply chain for 21st century populations, here and across the world.



SCOPE: This consultation, which took place from April-September 2013, covered activities from the farm gate to the consumer. It builds on the analysis in the 2011 UK Government Foresight report on the Future of Food and Farming and complements existing cross-governmental strategy work within the Agri-Food space (including Feeding The Future and the UK Strategy for Agricultural Technologies). It is also consistent with the aims of Horizon 2020 in the European Union.

A PRE-COMPETITIVE VISION FOR THE FOOD & DRINK INDUSTRIES



Why is the food and drinks manufacturing industry so important to the UK?

- Supports employment of 3.3 million people across the supply chain and accounts for 7% of UK GDP
- Generates turnover of over £90bn and GVA of £26bn (18% of total manufacturing GVA)
- Achieves exports of nearly £19bn per year with excellent growth potential

Why provide research funding to support this industry?

- Food production is diverse and fragmented with over 6,500 manufacturers and extensive distribution and retail chains
- The industry relies on a wide range of raw materials for which it cannot fund research solely at the company level. This results in a pre-competitive gap between primary agriculture and new product development in companies
- The potential for improved efficiency, reduced waste and better nutrition would benefit both consumers and the wider economy

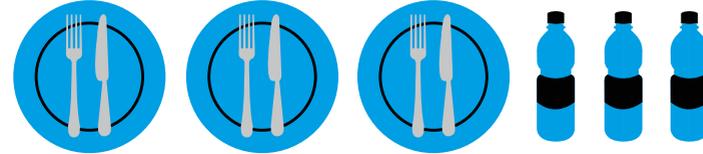
To maintain and improve the UK's position in global food manufacture we need:

A genuine partnership between industry, government and other key stakeholders for at least a five year period to commission and undertake the necessary research

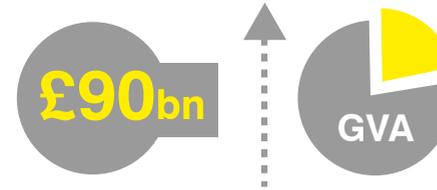
Fully effective and accountable delivery mechanisms, with clear responsibilities and timescales for outcome-driven targets

A legislative framework that enables innovation to reach the global market place quickly, safely and affordably, to meet consumer needs

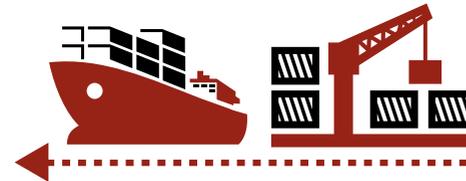
The UK food and drinks manufacturing sector:



Supports employment of **3.3 million** across the supply chain.



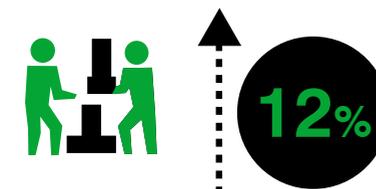
Generates turnover of >£90bn and GVA of £26bn which is **18% of the UK total**.



Exports nearly **£19bn p.a.** and is in growth.



Is a key partner for British farmers: buying **two thirds** of all the UK's agricultural produce.



Is the most productive in the food chain with the productivity of its labour force **growing by 12%** over the last 10 years.

Why does the industry need more support for pre-competitive funding?

- The industry relies on a wide range of raw materials for which it cannot fund research at the company level. This results in a precompetitive gap between primary agriculture and new product development in companies

Why should government assist the industry with additional support for pre-competitive funding?

Additional support will accelerate gains in efficiency, waste reduction and support better nutrition, these outcomes will benefit consumers and the wider UK economy

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Top 10 pre-competitive areas where research is needed