EUROPEAN TECHNOLOGY PLATFORM

Food for Life

DRAFT STRATEGIC RESEARCH AND INNOVATION AGENDA

September 2011

INTRODUCTION

Background

In July 2005, with the encouragement of the European Commission, the European food industry initiated the European Technology Platform *Food for Life*, under the management of FoodDrinkEurope (then called CIAA, the Confederation of Food Industries of the EU).

Its aims were to:

- Increase R&D strategy and funding;
- Coordinate research in Europe and prevent duplication;
- Promote SME participation in research, specific programmes and networks;
- Focus, align and collaborate transnationally between stakeholders;
- Increase multidisciplinary / cross-sector education and;
- Optimise knowledge capture and dissemination of knowledge between Member States and towards SMEs.

This resulted in the publication in September 2007 of a Strategic Research Agenda (SRA), followed by an Implementation Plan in 2008. Throughout the 7th Framework Programme of the European Union, the research suggestions contained in these documents were widely adopted within the Knowledge Based Bio Economy research sub-sector (KBBE).

In 2011 the board of the European Technology Platform *Food for Life* initiated a review of the documents. The Strategic Research Agenda was now four years old, many of its topics had already appeared in research calls and the 8th Framework Programme, now called *Horizon 2020*, was being planned. Consequently, it was decided to update the Strategic Research Agenda and to add an Innovation Agenda to reflect its current emphasis in public research funding not only within the European Commission but also in national funding across Europe.

A similar working mechanism was adopted as for the 2007 document, namely, a series of six scientific working groups was set up, representative of both industry and researchers, to develop the initial research suggestions for public consultation amongst all stakeholders. The working groups were oriented around a series of research objectives and the tools required for their delivery. These are:-

1. Food, health, well-being and longevity;
2. Safe foods that consumers can trust;
3. Sustainable and ethical food production;
4. Food processing, packaging and quality;
5. Food and consumers;
6. Food chain management.

A seventh group on *Communication, Training and Technology Transfer* will work on the innovation chapter once the research sections have been agreed following the public consultation.

The draft document

The deliberations of the six scientific working groups form the six chapters of this draft document and will form the basis of the *Research* section of the update. To this, the *Innovation* section will be added.

In their discussions, the working groups adopted different methodologies which are reflected in the following six chapters now available for public consultation. Of course, the final version of the Strategic Research and Innovation Agenda will unify these into a single format. In addition, several topics arose at different times within different groups (e.g. food safety issues; sustainability issues) and these have been left for the moment within the chapters in which they arose. Once again, the final document will move such suggestions to their appropriate home.

Chapter 1 on ***Food, health, well-being and longevity*** proposes a series of research topics, together with their scope and expected impacts, which could be used immediately in any 'call for proposals' document.

Chapter 2 covers the theme ***Safe foods that consumers can trust*** and following a comprehensive general introduction, lists four safety goals under each of which a series of bullet points lists the future research required. Then follows six fully developed call suggestions that could be used immediately.

Chapter 3 deals with ***Sustainable and ethical food production*** and uses subthemes of 'sustainable production', 'sustainable consumption' and 'tools and methods' under each of which the future research requirements are listed as bullet points.

Chapter 4 is focused on ***Food processing, packaging and quality*** and following a general introduction, lists a comprehensive series of research needs as a list of bullet points.

Chapter 5 is on ***Food and consumers*** and details a series of fully developed projects under five subthemes.

Chapter 6 covers ***Food chain management*** and contains a comprehensive introduction and a set of seven goals under each of which are listed a series of research objectives.

Using the document and providing feedback

The purpose of the consultation process is to provide feedback to the working groups so that in revising the document, all suggestions made by stakeholders may be considered. Consequently, the readers should consider the following in determining their feedback:-

Chapter 1: Can you suggest any project titles that should be added ?
Chapter 2: Can you suggest any further bullet points to be added under each of the 4 goals ?
Chapter 3: Can you suggest any further bullet points that should be added under each sub-theme ?
Chapter 4: Can you suggest any further research needs in addition to those listed as bullet points ?
Chapter 5: Can you suggest any additional projects that should be added under any of the five sub-themes ?
Chapter 6: Can you suggest any additional research objectives that should be added under any of the seven goals ?

Feedback is invited from any stakeholder interested in future European research in food. For effective management of the feedback, each stakeholder is asked to limit this to **3 suggestions**.

CHAPTER 1: Food, health, well-being and longevity

A list of proposed research topics is detailed below.

Effects of diet/dietary constituents in delaying/preventing the decline of cognitive functions in the aging human brain

Scope and basic aspects

To prevent age associated decline of cognitive functions is of high societal relevance and will provide a substantial quality of life gain in seniors/geriatric patients to remain participative and independent as long as possible. The current knowledge base on the effects of diet and their individual constituents for maintaining brain functions in the elderly is insufficient for any concise dietary recommendations, for food product development or other public health measures

Expected impact

By combining longitudinal epidemiological studies with experimental studies (intervention studies) using tools of cognition science, basic knowledge should be gained that provides the basis for food product developments and dietary recommendations. A special emphasis may be given to lipids, other lipophilic food ingredients and/or antioxidants.

Understanding the variation in human metabolic energy efficiency - including the contribution of the gut microbiota to energy homeostasis

Scope and basic aspects

There is growing evidence from animal as well as human studies that the microbiota contributes substantially not only to immune functions but also to energy homeostasis of the host. In addition, a considerable variability in basal metabolic rate in humans is determining the response to a caloric load and affects long-term weight management. Most interestingly, these differences can yet not be explained neither by body composition analysis not by genetics or variables such as fidgeting. For a better understanding of those processes in human energy balance, new approaches are needed and call for a revival of human studies that target energy efficiency and energy balance.

Expected impact

Human obesity and associated diseases are key drivers for health care costs in the EU and affect quality of life and well-being and calls for better assessment tools that help to understand human variance in body weight responses to caloric intake and energy expenditure including consolidated knowledge on the role of the gut microflora. Delivered research should be targeted to improved methods to assess set-points in energy homeostasis, easy assessment methods and experimental methods proofing the role of the microbiota.

Better understanding of the effect of diet in pregnant women for the development of the offspring in view of obesity and diabetes predisposition and for optimising fetal and early postnatal development.

Scope and basic aspects

There is no doubt that intrauterine conditions and the nutritional environment (nutrition of mothers and placental funcions for nutrient supply) are controlling growth and development of the fetus and similarly postnatal early nutrition is of critical importance for long-term health perspectives. Our knowledge base for the effects of quality of fetal and postnatal nutrition are insufficient for health outcome predictions and the basic processes underlying the preconditioning of health outcomes via epigenetics and imprinting are far from understood.

Expected impact

A better understanding on how the nutritional environment affects health outcomes in later life, both on the mechanistic levels as well as via epidemiological tools to improve mothers and infant nutrition and health.

Stable isotope labeleing of food products for use in food sciences and human nutrition research

Scope and basic aspects

Advances in analytical techniques such as NMR and mass spectrometry allow isotopologue profiling on large scale. When stable isotopes are incorporated (random and full labeling) into food raw materials (different plant foods), the isotopes provide a wide range of applications in all areas of food and nutrition sciences. This incldues food processing technologies, food chemistry issues and use in human studies to trace the ingredients and metabolites produced. It is a project that should bing together experts accross discliplines (from plant sciences, food sciences and human nutrition with an emphasis on metabolomics approaches).

Expected impact

Concerted effort for large scale production of stable istope labeled food (raw materials and products) for future food processing and human nutrition research. Development of new algorithms for isotopologue tracing and metabolic modlling. Setting up of a repositry for isotope labeled food reference compounds.

Treatment of low grade inflammation by diet /dietary constituents in view of its central role in the pathogenesis of a variety of diet-dependent or affected diseases such as type 2 diabetes and other chronic diseases.

Scope and basic aspects

Low grade but chronic inflammation is a unifying process underlying most of the chronic diseases whether diet-dependent or not. However, organ-specificity in disease initiation and progression in the context of low grade inflammation is not well understood and biomarker research has not yet provided proper surrogates that can be applied in real life conditions. To which extent diets/dietary components that can prevent or at east dumpen inflammatory processes and thereby affect disease development has to be explored and new concepts that go beyond for example antioxidant actions are needed.

Expected impact

Better understanding of the individuals susceptibility to chronic inflammation in the context of nutrition and life style, a better understanding of the organ specificity of low grade inflammation and most importantly robuts biomarkers and new conepts by which dietary means inflammatory processes can be reduced.

Defining the nutritional and sensory and food texture needs and development of strategies for an adeqaute nutrition in the elderly and geriatiric patients

Scope and basic aspects

In advanced age, sensory and textural quality of food, nutrient density and bioavailability become most critical for an adequate nutrition of the elderly (at home or hospitalized). There is insufficient knowledge on the nutritional status of the advanced age groups in view of energy supply and needs for nutrient intake (vitamins, essential amino acids, fatty acids. minerals, trace elements). Moreover, new concepts for providing appropriate savory foods with proper textures, high nutritional quality and easy to handle (inculding packaging) are needed.

Expected impact

Knowledge base on nutritional status and needs of the elderly (70 or 80 plus) across the european population. Approaches to improve foods in view of the impairments in sensory perception in the elderly, their needs regarding texture and a high level of convenience with proper nutrient supply. Improved (cheap and easy) methods for assessing nutrtional status in the target groups are also needed.

Improve plant based protein sources for food production with qualities like animal-based products for a more sustainable food chain.

Scope and basic aspects

Emerging problems in food security within a growing world population, the impact of global food production on climate change and the needs of more sustainable food production systems in general will in particular address the quantity of animal products consumed by European consumers. Development of new plant derived products that can replace parts of the animal products in the diet with lower dependence on feed imports and more sustainable high quality food supply systems.

Expected impact

Crops grown in Europe that may not be used on large scale for food purposes (because of tradition or containing anti-nutritive components but providing high quality proteins and lipids) may be explored as food products (or by providing ingredients) that can replace parts of dietary fat and animal protein in high quality (sensory, dietary and environmentally friendly) food production systems of the future.

Defining the "etches" of human metabolic/homeostatic control in response to food intake with standardized challenge tests for obtaining (early) markers for deviation from normal with predictive quality for health maintenance

Scope and basic aspects

Biomarker approaches to assess human health status in context of food, diet and life style have not yet revealed the expected outcomes. It is an intrinsic problem to define human health, to measure it and it is even more difficult to show that healthy humans more healthy. This is actually also an intrinsic problem underlying "EU health claim regulations". Conceptually, human metabolic plasticity can overcome disturbances in the biological systems preventing biomarkers to be derived (so can experimental animals for example certain knock-out mice without any obvious phenotype). However, when the biological system is forced to its capacity borders for compensation, reliable changes can be observed. For human studies a highly defined and standardized challenge scenario should be developed and tested to derive biomarkers under capacity limits that better help to define health and that may be predictive.

Expected impact

Collaborative efforts of academia and industry should define and validate such studies for the sake of defining "normality" in responses to food intake challenges and for deriving novel biomarkers. This can conceptually be validated also with putative health-promoting incredients and should encompass measures that employ all available life science technologies.

Validation of *in vitro* models for the *in vivo* prediction of the behavior of food ingredients in digestion, absorption, distribution, function and elimination

Scope and basic aspects

The limits (capacity, money, regulations) in assessing the fate of food ingredients with respect to human metabolism and health are overcome by a more wider use of in vitro models simulating the human metabolism and response (i.e. artificial intestine) including in silico models. Although such models may be valuable, only very limited (if at all) validation has been carried out. As advantages these in vitro models may be, as limited they are. A concerted effort of academia and industry should validate some of the models, define their most useful applications and define the limits. This is of equal importance for academic researchers as well as R&D experts in industry.

Expected impact

Collaborative efforts of academia and industry should define and validate such studies for the sake of defining "normality" in responses to food intake challenges and for deriving novel biomarkers. This can conceptually be validated also with putative health-promoting incredients and should encompass measures that employ all available life science technologies.

Defining and cataloging the fate of plant secondary components as health-promoting ingredients in mammalian metabolism by assessing the role of CYP enzymes in ingredient handling, by applying stable isotopes for metabolic conversion analysis within the host and its microbiome and with improved (parallel) methods for detection and quantification of metabolites.

Scope and basic aspects

Effects of plant secondary components (phenolic acids, flavonoids, isothiocyanates, glucosinolates and others) are used in hundreds of studies (from cell culture to human interventions) with the goal to demonstrate health benefits. Yet, numerous studies demonstrate huge differences in bioavailability (even dependening on microbiota) and substantial metabolisms in phase I, phase II pathwas in intestine, liver and other tissues with minor amounts of the parent compound found at target sites. Enzymes (mainly CYP´s) and transporters in drug research are well characterised and each new compound has to undergo rigorous testing for handling by these proteins. It needs a similar effort for food constituents and in particular for the plant compounds which are xenobiotics for the humen system. Similarly, understanding heterogeneity in individuals (host and microbiome) in handling of these compounds is important as are new paralel methods for detection, identification and quantification needed including stable isotope labeled standards.

Expected impact

Better understanding of the fate of plant derived compounds in human metabolism, understanding heterogeneity, understanding parameters that determine bioavailability and cataloging xenobiotic enzyme reactions for secondary plant components in the human system. Development of improved analysis tools and data bases that provide the knowledge on metabolic conversions for representative structures from different subclasses of ingredients is expected. This calls for a concerted effort of industrial R&D with academic partners.

Assessment of food-drug interactions for risk-benefit-analysis in use of bioactives in food and on the role of foods in drug delivery and metabolism.

Scope and basic aspects

Bioactives in foods may use the same pathways in xenobiotic metabolism as drugs and this means that food ingredients can alter drug bioavailability and drug efficacy. The most impressive examples are the ingredients in grapefruit (1 glas of grapefruits juice) which were shown to alter drastically the plasma concentrations and functions of numerous drugs (some 30 different drugs) and these possible side effects are labeled in drug use leaflets (package insert). In an aging population with use of a large variety of drugs on a regular basis (because of multiple morbidities) food-drug interactions are a growing problem and this in particular with bioactive food ingredients. But also other food ingredienst (fat, protein etc) can alter drug availability, action and elimination. It is a necessity also for food industry to address this issue (liability) and create awareness. A research effort that addresses in proof of concept studies food-drug interactions with partnerships along pharma and food (R&D and academia) is needed to provide a knowledge base and create awareness for this growing problem.

Expected impact

This project is of high societal importance and crosses borders between pharma and food for the safety of the European consumers. Comorbidities are treated with a variety of drugs and in aging societies this issue adresses not only drug-drug interactions but also drug-food interactions. Impressive examples with normal food constituents and normal serving sizes affecting a multitude of different drugsin their efficacy are available but are largely neclected by the food industry. It can be foreseen that this issue will obtain more public attention and may become important also from a liability perspective.

CHAPTER 2: Safe foods the consumers can trust

General Introduction and Scope

The food safety challenge

One of the non-negotiables for Europe is the necessity for a safe food supply; it is an imperative for health, social, and economic reasons. While the food produced and consumed in Europe is now assumed safer than ever, there are still several critical gaps in our knowledge of food safety and contaminants that prevent us from accurately predicting and responding to food safety incidents.

Public food safety crises create a high degree of concern among consumers, and cause huge economic losses. A case in point is the 2011 European outbreak of a new variant of pathogenic E. coli that claimed thousands of cases of disease and several lives in Germany and in other countries. Another recent example concerns the melamine contamination of milk and powdered infant formula from China that impacted on infant health and worldwide food chains. Both incidents have seriously undermined confidence in the food industry. In addition to this there are other, more emotionally or politically influenced issues such as GMOs, hormones and some additives that influenced consumer confidence in a negative way. Consumer perception has evolved to a high level of awareness and a much reduced certainty, a combination which has led to this generalised lack of confidence.

Food safety is a major public health and economic issue for Europe both for foods consumed within the EU and those that are exported. The total costs attributable to failures in food safety are huge but notoriously difficult to estimate since they include costs associated with the consequence of the diseases themselves as well as losses of product (such as recalls, production stops, trouble shooting, brand value) and consumer confidence. For instance, the annual costs of Salmonella outbreaks alone have been estimated to be around $2 billion for the USA alone. This gives some idea of the economic losses for a single pathogen. Added to these costs are the considerable costs of measures set in place to control this pathogen in the food chain, including analyses, specific management and hygiene measures, research and surveillance.

It has been claimed that the majority of reported food borne cases are caused by food prepared in the home, with a high variation between countries. Food producers or retailers are often pointed out as responsible in food associated outbreaks, despite the fact that proper handling by the consumer would in many cases eliminate the risk. Therefore, knowledge about consumer behaviour is important for the company risk analysis for existing products. Also, knowledge about consumer handling would enable production of safer products through optimization of the products, packaging or labelling.

While food safety is far more in the public eye, spoilage of foods is as serious and economically impactful - if not more. As much as 40-50% of foods (raw materials to finished products) can be wasted because of spoilage issues. This causes an extensive environmental burden, and novel solutions to reduce this effect are central. Consumers become more demanding in terms of food quality in a broad sense, sometimes with conflicting demands and expectations. This includes minimal processing, longer shelf life, lower salt, fat and sugar contents, environmental aspects, use of preservatives, methods of pre packing and distribution logistics etc. Therefore industry and regulators have to ensure that safety and stability of foods are not compromised. In the rest of this document, when a reference is made to "food safety", it should be understood to include "food stability" (i.e., freedom from spoilage) also.

The control measures required by regulators, distributors and retailers are not necessarily always adequate for the protection of health and the economy. Such a situation represents a cost burden,

supported by producers and consumers, which does not necessarily contribute greatly to a reduction in morbidity. To adequately protect the health of the consumer and, at the same time, ensure competitiveness of the food industry it is essential to have effective and targeted control measures. It should also be taken into account that the measures needed may differ considerable as a function of the size of the actors involved, e.g. multinationals, mid-size companies and SMEs.

The above are just a few of the many reasons that make food safety an essential element of a competitive strategy for the European industry. The capacity of EU Member States to contribute to the maintenance of a safe food supply in an increasingly science and technology-driven society is intrinsically linked to its scientific resources in areas relevant to food safety. The desired model of a united, but diverse, continent requires that food traditions be both preserved and modernised. Competitiveness is essential within all parts of the EU food industry and at all levels; therefore, the science applied to support it must respond to the needs of the sector as a whole.

New tools and possibilities

Science is also progressing at a very rapid rate - especially in the areas of human, microbial and plant biology. The advances in "omics" technologies and Systems Biology tools allow scientists unprecedented access to correlating genomics to functional metabolomics to physiology and ecology. These powerful tools have the potential to transform our ability to predict the appearance of newer, more severe pathogenic species of microorganisms. Microbial activities may be deciphered for specific microorganisms at a molecular level leading to a novel and improved predictability of production of toxins, virulence factors, and spoilage capacity. At a second level it will be possible to understand and predict interactions within ecosystem (foods, human hosts and the environment). It will also provide real-time, rapid and reliable methods for detection and monitoring of contaminants in relation to foods (e.g., using DNA-based detection methods). Likewise, numerous applications of omics-approaches and other novel technologies and approaches apply to the field of chemical food safety and food allergy.

Taken together, recent scientific advances allow us to make a potential step change in our ability to conduct accurate risk assessments that can be used by both government and industry to set the appropriate, robust and consistent standards that enhance safety and foster innovative food product design.

Ensuring food safety

The European food and drink industry's response must be to develop an integrated and holistic approach to food safety & stability (see Figure). Safety is not guaranteed only by 'safe' product manufacture; the total chain has to be taken into account. Designing safety into foods requires the integration of know-how and interventions along the 'research to market' continuum. Research, which addresses the European food industry's needs over the coming years in relation to food safety, will be applied through this integrated, holistic approach. At the same time, there should be a focus on those aspects of understanding, development, application/implementation that will exert the biggest impacts on alleviation of food-borne safety issues. Such well-focussed research will provide a framework for rapid incorporation into practice in a manner which will bring maximum impact. Any such research endeavour should feel it absolutely necessary to use cutting-edge scientific tools and knowledge wherever these can be found and applied.

Current reality also thrusts the responsibility on the industry to ensure that food production processes conform to challenging sustainability goals that are being proposed worldwide. Any Strategic Research Agenda that the European industry sets up must, therefore, ensure that sustainability is a critical enabler for success. This provides an additional challenge to the food industry.

Important research areas

The research areas we propose broadly fall into the following 4 Goals outlined below. Two main categories are included; microbiological contaminants and chemical contaminants. Research is important for the gathering of intelligence, assessing the risks and assuring safety along the food chain

Goal 1. Predict and monitor the behaviour and fate of relevant known and emerging biological hazards and challenges.

Over the years, food microbiology research has uncovered a lot of knowledge on the behaviour of pathogens and spoilage organisms, which has led to the development of the current standards and regulations worldwide. However, microorganisms are moving targets. New variants emerge from mutation and adaptation, and long-forgotten microorganisms re-emerge. The interaction in ecosystems is complex. Goal 1 has been defined to address knowledge gaps as below.

- Improvement of our knowledge on the persistence of microorganisms (pathogens or spoilers) in food matrices and food processing environments is fundamental for improved microbial control. Understanding the mechanisms at a molecular level of interactions between microorganisms and with their surrounding environment will give new insight into the development of particular microbial profiles and activities. Understanding of the interactions between microbes and their human hosts is also an essential element of this part.
- The behaviour of microbes that cause spoilage needs specific attention for improved understanding of the evolution of destructive strains. The relationship between spoilage microorganisms and pathogens also needs to be understood in an ecological context.
- Understanding the impact of antibiotic resistance and other biocide resistances. This includes the recycling of antibiotic resistant microorganisms through the food production chain e.g. though the use of surface waters and manure. In addition, resistance to biocides such as disinfectants is an increasing concern. Research is needed to understand the development of resistance to antibiotics and biocides and its transfer to between microorganisms.
- The intended use of microbiological biocides such as phage or protective cultures exerting a controlling effect on pathogenic microorganisms has great potential to control harmful microorganisms. In depth understanding is needed to fully understand and explore this potential
- Possible consequences of global warning should be taken into account, e.g. the appearance of new bacteria and viruses due to climate changes (e.g. blue tongue).

Goal 2. Predict and monitor the behaviour and fate of relevant known and emerging chemical hazards including toxins of biological origin.

Chemical hazards include crop protection agents, veterinary pharmaceuticals, persistent organic pollutants (POPs), packaging residues, process products such as heat-generated toxicants, heavy metals, biological toxins and numerous natural constituents of our food; they represent known and potential health hazards to humans, most commonly by long-term exposure, through the consumption of foods in which they are presents. The manner in which these hazards are currently controlled is sub-optimal for two main reasons: firstly, there is a large knowledge gap as to the identity and risk of many chemicals at the quantities at which they occur in foods, and secondly, detection and monitoring are often complex and expensive.

The risk of chemicals need to be evaluated considering the entire food chain, giving a particular attention to the conditions of agricultural practice, which is a main source for contamination of foodstuffs with biological and chemical hazards. There is a need to develop knowledge on the occurrence of chemical agents as well as their complex interactions in various foods, and to develop an innovative and holistic approach to chemical food safety.

Within Goal 2, we propose to focus on the following major issues:

- We believe that foods should be treated as complex mixtures when addressing the generation of chemical toxins in situ or as introduced externally. Thus, tools to carry out safety assessment of such complex mixtures need to be developed. This also includes the assessment of novel food structures - e.g., such as those developed through nanotechnology applications.

- Inherent toxins, e.g., plant toxins - like alkaloids - in crops and weeds are a growing problem and should be assessed as a high priority.

- Understanding the generation of cooking or heat-induced contaminants like trans fatty acids is also a priority.

- While allergens are very high in priority, we believe that efforts to reduce levels of allergens would not be successful. Better information for the consumers is the way to follow. Thus, robust Quantitative Risk Assessment of allergens needs fine tuning and this is included in Goal 3.

- For sustainable innovative food production, alternatives for animal based food protein production are needed. Novel proteins however potentially pose high allergenicity risks. Methods to assess and predict allergenicity of proteins are needed.

- Possible consequences of global warning should be taken into account, e.g. the appearance of new mycotoxins or their Northward shift.

Goal 3. Develop and implement robust and cost-effective Risk Analysis (RA) concepts based on sound, cutting-edge scientific understanding.

Quantitative risk assessment is the knowledge base for building a food safety strategy. The tools being developed within this area (including predictive modelling) are important competitive instruments that underpin innovation in the development of novel products. Research in this area will be important both to further develop the science and to make these tools more widely available within the food industry. The approach will need to address the increasing complexity of food products and it is certain that the trend will be towards risk-benefit assessment. As an aspect of benefit, economical aspects need to be considered.

We propose to broaden the scope by including Benefit Analysis also within this Goal. European society will need to approach these research challenges in a well-integrated manner. Applying risk-benefit analysis in a holistic way is the means to evaluating the real impact of the total of a food (or dietary pattern) to human health and well-being in its many forms, as an alternative to focusing on the individual toxicological characteristics of each molecule.

The background scientific knowledge necessary to carry out reliable, robust and rapid risk-benefit analyses is essentially generated as part of Goals 1 and 2 and through various scientific activities across the industry and academia. Goal 3 addresses the development of novel technologies for the mitigation of relevant chemical and biological risks. This includes the following aspects:

- As discussed above, allergens continue to be a very high priority. However, we believe that efforts to reduce levels of allergens would not be successful. Better information for the consumers is the way to follow. Thus, robust Quantitative Risk Assessment of allergens needs attention and reliable data must be available for use. It is proposed that one of the key activities within this goal should be the development of a Quantitative Decision Tree for Allergen Assessment and Management.

- The holistic concepts elucidated in Goals 1 and 2 should seamlessly feed into appropriate Risk-Benefit Assessments.

- New and emerging issues need to be identified, addressed and appropriate RA tools developed. Examples include new proteins, new and emerging pathogens, new food structures and matrices, etc. More realistic RA models are needed for complex food matrices.

- One important knowledge gap is on the risks associated with food-borne viruses. Very little knowledge is available, and in most cases, risk assessment is based on "surrogate" bacterial species.

- Risk-Benefit evaluation of functional foods as it relates to consumer use/misuse (over and under-consumption) should be addressed in this goal reinforcing both *in vitro* and *in vivo* studies.

- Identification of trends of growing importance and development/application of tools to carry out Risk-Benefit Assessments. Examples include climate change, water shortage, changing trends in consumer preferences, rural, traditional, organic and ethnic foods.

- Develop methodologies and concepts for effective Risk Management decision making, preferably based on quantitative tools.

- Renew focus and on and develop tools for Risk-benefit assessment of Genetically Modified Organisms (GMOs) and their perception by consumers. This is especially true in the face of food shortages in the future.

Goal 4. Develop real-time & rapid detection tools to ensure safety and security of the food chain, including food defence.

- The aim of this goal is to further improve the safety of competitive foods in the market place by developing and making available tools for prevention and control of specific hazards, traceability, authenticity and food defence (adulteration and bioterrorism) at appropriate points in operational food chains. These should preferably be in- or at-line. This will provide the technologies on which harmonised, focussed and cost-efficient management activities and safety policies can be implemented. The understanding and knowledge generated from the research needs identified in Goals 1, 2 and 3 above, will be employed in the development of technologies.

- There is also the need for harmonised policies and methods to be prepared for problems related to bioterrorism.

- New techniques for detection of hazards or their controlling parameters are constantly being sought to improve food safety assurance. Successful new approaches frequently represent new opportunities for surveillance, tracing of sources of hazards and many other areas of research, which have a direct impact on food safety at a societal level. Research on new or

improved measurement of hazards will have a multiplier effect and these lines of study should always be advanced wherever they show genuine promise. Advanced technologies for safety interventions throughout the food chain will provide new options for control over the safety of raw materials, processes and finished products. Their development, validation and implementation must cover all aspects of food production.

SUGGESTED NEW TOPICS

Topic 1: Understanding bacterial colonization of food: control of contamination on fresh unprocessed foods

Introduction: Fresh unprocessed foods including meat, dairy, fish and vegetables produce (*e.g.* salads, fruit) may be contaminated with a wide range of pathogenic bacteria as they progress along the food chain from "farm to fork" posing a risk to consumer health as recently demonstrated with the German crisis. Despite this, there remains a very poor understanding of the frequency and nature of bacterial pathogen association to these foods and the mechanisms of interaction at cellular and molecular levels remain unknown. It is a prerequisite that to allow development of rational, innovative and efficient strategies to control contamination requires a better understanding of these bacterial attachment / colonisation mechanisms. In development of new approaches to prevent / limit bacterial associations with food consideration must also be given to the environmental impact of such treatments.

Objectives: This topic aims at providing enhanced understanding about the interaction of key food-borne pathogens (namely EHEC, *Salmonella spp*., *Staphylococcus aureus, Listeria monocytogenes*) at cellular and molecular levels with fresh and ready-to-eat foods Besides molecular analysis and functional genetics, the heart of the project will be based on integrated biology approaches (combining genomics, transcriptomics and proteomics as well as state-of-the-art microscopic technics). Alternative and innovative strategies for controlling food contamination will be further evaluated. The environmental impact of these treatments needs to be fully considered in a context of sustainable development.

Innovative character and solution to problems: Fill the gap in the understanding of foodborne pathogenic bacteria interaction with fresh unprocessed food products at cellular and molecular levels. Identifying innovative strategies to control bacterial contamination of food products (fresh and unprocessed) with information on their environmental impact.

Justification: Protect consumer safety and public health. Meet requirements for sustainable development and food safety considerations. EU leadership on major threat in consumption of fresh food produce (*e.g.* EHEC in meat and vegetables).

Expected impact:

- Improved bacteriological safety of foods for consumers
- Assurance of safety by food-producing company protecting them from the economic fallout from food contamination events
- Control of the environmental impact of decontamination treatments
- Contribution to EU microbial food safety policy, prevention of food contamination crises

Topic 2: Elimination of Enterohaemoragic E.coli (EHEC) from the fresh produce production chain

During the last two decades, fresh produce has become increasingly popular among European consumers. This growing market is facing constant challenges to ensure that these foods are safe for

human consumption. Fruits and vegetables are unique foods in that they are often consumed raw or with minimal preparation. Thus, microbial intervention strategies previously developed for other foods are inadequate at providing the appropriate measures to eliminate the microbial food safety hazards associated with consumption of fresh produce. The occurrence of repeated European outbreaks of EHEC associated with consumption of fresh produce is of particular concern. To develop an effective strategy to prevent contamination of fresh fruits and vegetables with this pathogen, one must obtain detailed knowledge on the sources of contamination and entry points of the pathogen in the production line, as well as increased knowledge on the factors that allow bacteria to survive on the surface of fresh produce. New knowledge in this area is essential to decrease the occurrence of future outbreaks associated with fresh produce and sustain consumer reliance and to develop new systems (safe, no-toxic, active and natural packaging, entrapment of biomolecules or useful microorganisms) capable to prevent or limit microbial contamination, and concurrently to improve the shelf life of fresh and highly perishable foods.

Expected impact: Decreased incidence of EHEC outbreaks and protection of consumer safety and public health. Increase product safety leading to increased producer competiveness as compared to non EU producers. Consumer health benefits by sustained consumer consumption of healthy food.

Topic 3: Microbial Persistence (Biofilms in the food chain: bacterial interactions and novel preventive actions)

Biofilms are communities of microorganisms attached to a surface. In most real-life situations, microorganisms are present in multispecies consortia on surfaces. Biofilms in the food chain are considered to be a major source for bacterial recontamination thus providing challenges for food safety, quality and spoilage; the formation of biofilm can also mean the potential pathogenicity of bacteria (Quorum sensing activity). The physiology of surface associated microorganisms differs from their planktonic counterparts, as surface adhered bacteria are more resistant to environmental stress including disinfectants. Due to the significance of bacterial biofilms, identification of the microbiota of biofilms in various food production chains should be addressed. Their role for surface adherence and biofilm formation of potential pathogens/spoilage bacteria including bacterial interactions, mechanisms and metabolites responsible for biofilm development, physiology and properties should be identified. Sources and contamination routes of the biofilm associated bacteria are important for being able to provide targeted actions towards biofilms. Increased knowledge on biofilm formation mechanisms could provide effective strategies for the prevention of biofilm formation and/or removal or inactivation of biofilms in the food chain, also through use of biomolecules or beneficial bacteria, or through the development of functional and safe packaging materials with antimicrobial and antiquorum sensing activity.

Expected impact:

- Increased food safety.
- Reduced spoilage and thus reduced food waste
- Strengthening of the competitiveness of European food

Topic 4: Reduce the food waste in the value chain

In the last few years there has been an increasing focus on waste generation in food value chains nationally and internationally, especially related to reduce starvation in developing countries and greenhouse gas emissions from agriculture and food production and distribution in the developed countries.

Food waste is a result of a complex mix of consumer preferences and choices; technologies for producing, distributing, storing and preparing food; trends and knowledge.

Defining and understanding of the correct shelf life for products and the risks related to managing product quality in relation to shelf life seems to be a key issue with regard to food loss in retail shops and by consumers. A survey conducted among Norwegian consumers indicates that 30 % don't understand the difference between the two different shelf life labelling used in Norway, "best before" and "use before". Present use and understanding of shelf life predictions and labelling contribute to big amounts of waste from the households and retail sector. Changing shelf life labelling will have consequences for the safety for some food products.

Food waste, mainly vegetables and fruit, can constitute the basis for the recovery of an extraordinary amount of functional biomolecules with high added value, that could be used into the development and formulation of new functional foods and as natural preservatives in food processing and manufacturing, as substitutes of chemicals

Expected impact: Identification of which measures are most efficient and effective in preventing generation of food waste in the value chain and still ensure safe food products.

Understanding how changes in labelling strategies can ensure safe products and influence on the choices and attitudes by consumers. Recovery of vegetable food waste for food and pharmaceutical purposes.

Topic 5: Realistic microbial shelf life determination

Realistic shelf life estimates are essential for reducing the food waste and maintaining consumer confidence. The consumer should be able to use the information about best-by-date, as a realistic indication of microbial quality. The expected shelf life of food products is frequently underestimated, leading to unnecessary waste and an increased environmental load. A science based model for shelf life determination is needed.

Most of the specifications used for determining the limits of shelf life of a microbiologically unstable product are based on general counts (e.g. the total aerobic count) of food products. High numbers of a total count do not necessarily result in the development of overt spoilage such as off odour. Very often, food products are judged as unacceptable for consumption although the food is still sensorial acceptable. Results from experimental work such as challenge testing using pre cultured inoculums in food models or real food for the estimate of growth, deviates sometimes dramatically from naturally inoculated products. In particular the lag phase in food using standardized inoculums or predictive models can be shorter than for naturally contaminated bacteria. This hampers the use of challenge testing and predictive models for the determination of realistic shelf lives. It also limits the value of challenge testing for the validation of risk management approaches. Novel approaches for realistic experimental designs are needed for an improved estimation of microbial response during laboratory conditions reflecting actual growth. New knowledge about lag phase of spoilage bacteria will be fundamental for an improved understanding of how it may be controlled. By this it can also be possible to extend the lag phase in real food by formulation, processing and interactions in complex microbial communities.

Expected impact: Novel approach for estimates of growth of food spoilage provides realistic determination of product shelf life. Will reduce food waste.

Topic 6: Assessment of microbial contamination

In the assessment of food spoilage and safety of food products, information about growth, survival and inactivation is collected along the production chain. This provides information about changes in

bacterial number as affected by processing, storage, packaging conditions etc. Contamination frequently occurs during processing, by direct contact with contaminated or surfaces, water or hands, or indirectly via air. The extent of contamination has an important impact on safety and spoilage, but is not sufficiently understood. New knowledge is needed on routes and sources of contamination. In this context the role of biofilms should be studied, and also the role of airborne microorganisms in droplets. Furthermore, the mechanisms of bacterial attachment, detachment and persistence on surface (including food) should be elucidated. How is the microorganisms affected during transitions from surface, air to food and how is the growth ability on the food affected? Models of contamination should be developed with significant factors identified to calculate the probability of food contamination along processing. Significant factors could be temperature, humidity, cleaning routines, air flow etc.

Biofilm detachment needs to be understood and introduced in model for different types of food and food contact surfaces.

Expected impact: Reduced contamination and increased safety and shelf life

CHAPTER 3: Sustainable and ethical food production

The area "Sustainable and ethical food production" is extremely broad and covers a multitude of different disciplines; hence the research needs are also distributed broadly. In order to help the communication a structure based on what we want to achieve rather than traditional science areas is used. Many research areas will require a multi-disciplinary approach which complicates the matter even more. In Figure 1 the structure is depicted.

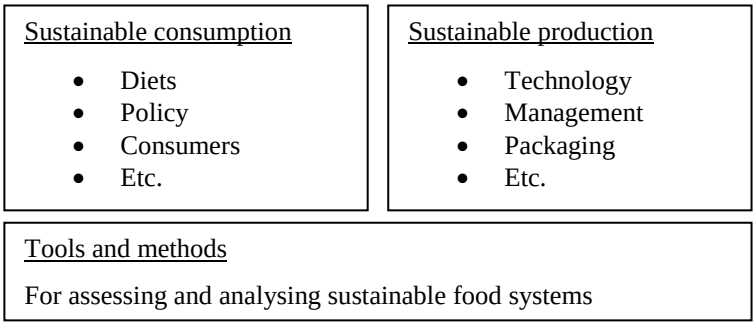

Figure 1. Structure of how the research areas are organised

Obviously there need to be a sustainable production system in order to reach sustainable consumption, but this structure makes it easier to distinguish research areas that logically are connected even if they are not within the same scientific area. The area "Tools and methods" covers developing ways of scientific sound assessment of sustainability and stretches over the other two areas. In the following text, some research areas within "sustainable consumption and –production" can be assigned to "Tools and Methods", which is noted in the text.

SUSTAINABLE PRODUCTION

Avoid / reduce food losses and waste

As has been shown, a large share of food produced globally is lost; approximately 1/3 of food leaving the field is never consumed. Increasing the raw material efficiency in all steps of the chain and improving food chain management could be a significant contribution to reduced environmental impact, increased global food security and higher value creation in food chains. There are a number of difficulties however, connected to technological, managerial, economic and behavioral aspects that need to be addressed. Specific research areas are:

- Optimisation and reduction of food waste in a food chain perspective (the food technology aspects are covered under the heading "Developing sustainable processing, preservation, packaging and logistic systems" below).
- Biodegradable packaging materials made of food waste or other raw materials that does not compete with food production, e.g. by use of by-products and waste.
- Assessments of the drivers of food chain waste, economical, technological and social drivers should be covered. Also research on how to impact on these drivers is needed.
- Management instruments to ensure sustainable food losses and waste in chains, e.g. provisions in contracts, cross compliance policies, etc.

Production systems for alternative protein sources

Protein supply is nutritionally crucial and environmentally even more so, linking climate change and biodiversity loss through nitrogen fertilizer production and degradation (ammonia emissions), respectively[1]. Livestock products have disproportionate impacts on depletion of natural resources and constitute ideal targets for replacement by inherently less resource intensive products from plants or invertebrates. However, there are a number of behavioral, economic and technological issues that need to be addressed, cross-linking this area with sustainable consumption, for example. Specific research areas are:

- Protein sources:
    - novel plant proteins from crops such as soy and lupine
    - insects such as locusts and mealworms
    - marine sources such as algae and seaweed
    - blue biotechnology
- Consumer acceptance and use of alternative protein sources:
    - replacing animal protein with plant protein, including hybrids
    - economic instruments such as subsidies and taxes
    - health aspects
    - international cooperation, technology transfer to developing countries

Sustainable water consumption

Globally, water scarcity is a critical issue, even though the regional variations are large. Moreover, in a future facing climate changes the predictions are clear that water availability will be even more limited, especially in already water stressed areas. This will be a challenge for global food production, hence also European. Areas where research is needed are:

- Prediction of water use and possible mitigation options for food chains/products.
- Tools & Method: Global water management through food chain signals (water footprints, virtual water etc.).
- How will the "water debate" influence the future of sustainability of food production? What innovation can it lead to?

Sustainable primary food production in Europe

All food industry is dependent on reliable and efficient production of raw materials, and sustainability of food supply systems needs to include also primary production as agriculture, aquaculture and fisheries. The more detailed parts as agronomic research of this research area should preferably be dealt with in agricultural research, but parts of it needs to be coordinated with food research. Important research areas, that are crucial to understand sustainability of food chains include:

- Reduction of environmental impact of animal biomass production. New ways of more sustainable, less resource demanding methods.
- How are the multiple land use requirements for the bioeconomy (e.g. biochemicals, biofuel) influencing the sustainability of food production?
- Research and creation of database on quality of agricultural products as a way to better value the initial sustainability of ingredients. Quality – energy, protein and nutrient.
- *Tools & Method:* Methods for land use issues in sustainability assessments (e.g. Bioenergy vs Food).

[1] Aiking, H. (2011). Future protein supply, Trends in Food Science & Technology 22, 112-120.

- *Tools & Method:* Research on finding good measurement of an integrated indicator for "quality value of the initial agricultural ingredients".

Developing sustainable processing, preservation, packaging and logistic systems

A core aspect of the challenge to improve the sustainability performance of food systems is energy-, water- and resource efficient technology and logistics. There is a long history of developing such systems. But since a lot of that development have been focused on unit processes and not production systems new research with a sustainability focus including a systems perspective (looking at processes, packaging and logistics as a whole) is needed. Areas that deserve extra attention are:

- Food processing technologies that improve food chain sustainability:
  - Non-thermal processes (use micro/macro nutrients, bioactive compounds etc.)
  - Small scale processing with high performance
  - Energy- and water efficient processes
  - Waste minimisation, "management of clean flow" (avoid mixing and contamination of side streams)
- Packaging design to improve sustainability; easy to empty, environmentally friendly materials, design for recycling, design to increase efficiency in logistics/storage etc.
- Biodegradable packaging materials made of food waste or other raw materials that does not compete with food production.

European food production and supply chain

Besides technological measures to improve sustainability in food chains there are large scope for improvements in how entire food chains or networks are managed. There are probably large gains in making food chains as a whole work more integrated and efficient, reducing wastage, energy use and improve competitiveness. This is however an area that previously has been more or less neglected, hence there is a great need for food chain focused research:

- Production management in a chain perspective (production, storage, distribution, cooking etc) to facilitate sustainability improvements (Management, technology)
- Pathways to develop resilience and flexibility in food production.

Developing scenarios of future European food production and supply chain

A major issue in recent and future food markets and supply chains is the rapidity and unpredictability of changes in prices, development paths and technologies. This will be even more so in the future. In such a context, strategic decisions by the EU will become more and more critical, but, at the same time, more difficult to be taken. Research is needed in devising potential scenarios and connect them to decision support tools suitable to support EU and local level decision making. Advances are sought in both methods and understanding of costs and benefits in alternative technologies. Specific research areas are:

- Devising food scenarios for Europe in different time frames: context, supply, demand, technologies, trade flows, policies
- Understanding, using scenario methodologies, the influence of BRIC on: food demand and prices; food security; environmental issues; health (global and EU)
- Identifying key technology areas for decision support, e.g. waste to biomass fractionation for green chemicals and fuels

- Providing a very broad and holistic assessment of sustainability issues attached to GM food, including both negative and positive consequences
- Exploring different approaches concerning urban – rural interaction in the field of wastes (e.g. recycling of urban waste in agriculture), considering a broad spectrum of issues such as food quality and safety, energy balance, economic sustainability, and citizens' and farmers' attitudes.

SUSTAINABLE CONSUMPTION

Understanding consumer and their behavior regarding sustainable food consumption (Sustainable European Consumption)

It is very likely that an efficient way of increasing the environmental sustainability in European food systems is changing consumption patterns, away from resource demanding products towards less demanding. This also have large long term implications for global food security and hence to global equity and social stability. Diet changes will however have repercussions on social and economic aspect in the food sector, both within EU and globally. Diet changes are extremely difficult to implement, for a number of reasons, and research is needed to understand the processes behind such changes. Another important research area in this field is how to quantify the impacts of large scale diet shifts, since such shifts will inevitably have large impact on how food chains are built up and managed. There is a need for social- and natural sciences as well as economics to answer these pressing questions. Detailed research areas are:

- How will future challenges of feeding the population ensuring health, impact the sustainability challenges of production? This area covers increased productivity, food secure products and more balanced diets. Here scenario studies are an efficient tool.
- Can "Less is more" be used as a concept of sustainable development in the food sector? How to implement such a radical shift and what measures are needed?
- Research on synergies and conflicts between changed consumption patterns, including environmental, social and economic aspects.
- Research on trends on social innovation connected to shorter circuit from farm to consumers, as regional foods. This includes all three pillars of sustainability.
- *Tools & Methods:* Development of useful indicators for "Sustainable nutrition", e.g. environmental impact, related to different diets effects on human.
- How to involve consumer society and other stakeholders in research and innovation on reducing household food waste and researching the concept "Sustainability intelligent" (knowledgeable) consumers and stakeholders.

Diet change in Europe

A trend all over in the world, we observe that consumers shift to a "Western" diet relying more heavily on meat consumption when the income increases. The adoption of such "Western diet" is impacting negatively the planet as well as the human health. Obesity among the health problem is becoming endemic in a number of European countries, and changing diet to a healthier one is inevitable. While understanding the consumer behaviour will help finding a strategy, research should focus on:

- How to speed up the diet change, through actions of individual actors as well as their concerted actions.
- How to value the cost of status quo to health programme in governments & individuals versus cost of implement to change as a potential trigger to change?

- Potential learning from consumer behaviour change in other sectors that could be transferred for diet change (e.g. health programme, marketing new product, etc.)
- Acceptance and use of alternative protein sources, e.g. animal vs. plant protein
- Innovation in institutions and policy (new future instruments)
- Role of human behaviour; wants vs needs, societal norms and values

TOOLS AND METHODS

Development of new tools and methods for assessing and analyzing sustainable food systems

In 1987 the report of the UN World Commission on Environment and Development (or Brundtland Commission) indicated that sustainable development «meets the needs of the present without compromising the ability of future generations to meet their own needs». The chapter dedicated to food issues focused on the necessity to sustain the great agricultural potential achieved with the Green Revolution, and to attain a better distribution of food production. After 25 years, the number of undernourished people has not been reduced and the potential of the world food production has become much more uncertain. The constraints of energy, land and water resources have found only partial solutions. Moreover, the food industry is confronted with new challenges imposed by increasing urbanization of world population and changing lifestyles: the capacities of producing, processing, and delivering food should be enhanced without compromising safety and quality of supplies, and the promotion of sound dietary habits has to be supported.

The basic notion of sustainability is universally accepted and does not need to be redefined. Nonetheless, these concepts should be reinterpreted in the perspective of tackling both the old unsolved and the new emerging food issues. This will be the starting point for improving the capacity of stakeholders to understand and assess the wide and multi-faceted implications (environmental, social, and economic) of sustainability in the food systems.

- Reinterpret the sustainability concepts to indicate solutions for the current and emerging food issues. It is a dynamic matter, which is evolving and is context and time dependent. This needs to be understood in order to make sustainability an operational concept.
- Find out new useable tools for measuring sustainability (taking into account the four pillars approach, where sustainable development is based on economic development, social development, environmental protection and cultural diversity). New measuring tools should be: a) Simple/cheap, b) Acceptable, c) Trustable and d) Enforceable
- Develop specific instruments for the sustainability assessment of new technologies.
- Social and environmental impacts of globalization and deregulation of food trade.
- Develop methods for food scenarios (Local, Regional, Global and combinations thereof)
- Develop methodology and processes to perform multi-disciplinary research projects ranging from nano- to global scale.

CHAPTER 4: Food processing, packaging and quality

The area of food, quality and manufacturing was seen as playing a central role in the new structure of the ETP. For a more effective fit, the title of the Working Group was modified from that used in the first SRA, i.e. 'Food Quality and Manufacturing (FQM)' to 'Food Processing, Packaging and Quality (FPPQ)'. While the old title contained the term 'manufacturing', this was considered too narrow to define the field, as this implies that processes of change in the food product stop when the food product is made, but that is not the case. Indeed, in terms of the food product, we need to look beyond the current structure of the food once manufactured and thus, the term processing was considered more appropriate in the title of the Working Group. Processing in general refers to the process of changing a food structure to obtain new desired properties and qualities or to prevent undesired changes in quality, and furthermore, to include the term packaging, because in addition to being an integral part of processing, it plays a crucial role in communication, logistic, freshness and safety monitoring. This approach encompasses the whole life-cycle of processed foods.

Definition: Food Processing and Packaging

This is based on recognition of the contribution of food structure and function, arising from food processing and packaging, to nutrient bioavailability and impact on host physiology, thus appreciating that food processing does not stop when the food is manufactured, or indeed when it is placed in the mouth, given the role of food structure and functionality to the performance of the food in the gut. Changes in food structure, texture, composition and quality continue in the food product following manufacture, during storage, meal preparation, following consumption as well as during digestion (gastro-intestinal processing), and furthermore, are impacted on and monitored by the types of food packaging technologies used. The concept of farm to fork is too limited, and needs to be expanded to that of from farm to farm.

Aim

The aims of the Working Group are A) to define processes and packaging for management of the food structure life cycle to obtain high quality products with new properties (aimed at PAN-achieving preference, acceptance and fulfilling needs) related functionality, aimed at aspects of the three KTs: (1) Improved Health, Well Being and Longevity ("Life to years"), 2) Consumer Trust in the Food Chain, and 3) Sustainability) and B) to describe what the physiological impact of changes in food structure is, in the context of the process-structure-functional property relationships in order to prevent deleterious changes, which negatively affect product quality, nutrient bioavailability and functionality.

Objectives of the research

1) To generate information leading to an EU Food Industry capable of achieving

- optimum sustainability,
- optimum efficiency (on economic, technological and ecological levels)
- extended delivery of food products with new properties and functionality aimed at fulfilling preference, acceptance and needs of consumers (by reverse engineering approach).

2) To have greater integration in research between processing, food quality and safety, nutrition/health and sustainability. This could be achieved by making it mandatory for research programmes to foster collaboration between disciplines, particularly in large research programs like Marie Cure schemes, therefore bringing together scientists such as nutritionists, clinicians,

environmental and/or consumer specialists with technologists and process engineers. The topics should be integrative for a trans-disciplinary approach, not the sum-total of interests of the participating disciplines. The logic should follow processing creating / transforming structure and structure determining properties to be specifically categorized within nutritional / health supporting and environmental food standards. Such pioneering work should finally also support standardization by the WHO/FAO - Codex Alimentarius.

3) To update training of food science/-engineering students, in order to avoid exclusive specialization, and enable initiating research across the borders of scientific disciplines. This should in particular involve the integration of knowledge from disciplines, such as nutrition, medicine and physiology, pharmaceutical and cosmetics technology as well as material science, health science and resource economics.

4) To strengthen an SME innovation platform. - Innovation is not just about new ideas, but how to use and combine process and material aspects in new manners. Innovation efficiency by SMEs can be improved based on infrastructural improvements reducing "time to market". Often there is a gap between researchers developing new technologies and SMEs to be more efficiently bridged. In some cases, innovation by SMEs is low and infrastructural improvements are necessary, as SMEs do not have the capacity to take up new technologies from the research. In other cases, the situation is exactly the opposite, and an example of this is the very successful model in Switzerland, referred to as the 'CTI projects'. These are open for SMEs, universities and start-ups where the government pays the half and the participating large companies the other half. The IP is for the small company which should be strengthened. The win-win for the larger ones is that certain processes, methods and new science & technology, which will not find in-house investment and support, can be developed by universities and SMEs which will bring the results to market. It builds on the creative strengths of SME and university in quite a practical sense.

Research Needs: the research has to address real needs of consumers, as only through this, a PAN approach makes sense.

- Nutrient Security. Nutrient security is of paramount importance. It is a framework rather than a technology or approach. New research shows that normal diets (represented in public databases) exhibit nutrient security when all food items are regularly use (5000 years of food production development has nicely compensated for uneven distribution of essential nutrients). This is also the "common consumer" view. "Eat balanced and you eat healthily". However, processed foods do not always comply with a nutrient secure usage (i.e. essential nutrients are lost or only kept under the price of increased health sensitive nutrients, like fats, salts, sugars, etc.). The research should provide lead-edge knowledge, i.e. kinetics of degradation & stability, novel preservation technologies through active packaging, robust and minimal processing optimized through precision processing and modelling, biotechnological replacements of outdated chemical-engineered approach, etc.
- Food processing aimed to manage the food structure lifecycle to obtain foods with PAN-adjusted properties (i.e. modelling process and products onto sensory insight of the consumer).
- Design of new properties of foods, based on processing, aligned to consumer-relevant PAN profiles.
- Quantitative understanding of food structure – functionality relationships, enabling to tailor functional properties.

- Structural life cycle engineering of food (build it up/break it down): From structure synthesis in-factory to structure disintegration in the GI-tract.
- Achieving the PAN goals with ingredients and processes as "natural" as possible. "Natural" is a basic assumption by the consumer when he/she speaks about nutritious food.
- Processing technology developments to "preserve" the highest amount of essential nutrients by simultaneously achieving food safety.
- Sustainable exploitation of the endogenous potential of new plant-based raw materials via related exploitation of existing and new methodologies.
- Development and use of high throughput methodologies for evaluating the health-related and sensory performance of processed food systems.
- A property-targeted full chain approach: Exploitation of food raw materials by process-based enhancement of specific functional characteristics.
- Robust technologies for flexible use in raw material processing (e.g. with altered composition and functionality (arising from new agricultural techniques) and exploitation of indigenous methods and tools, e.g. solid state fermentation.
- Redefining traditional processes with respect to optimizing local traditional foods in order to improve their specific functionality. This requires understanding of the traditional processing mechanisms and subsequent transfer into appropriate modern industrial processes.
- Technologies towards extending the funnel of raw materials (e.g. insects-unleashing the availability of new raw materials).
- Re-evaluation of existing technologies with respect to recent insight into process-structure-property relationships and adaptation of respectively optimized new technologies.
- Improved understanding of structure-life history.
- Next generation modelling, taking into account the whole chain in multiphasic properties of food components.
- Multi-scale modelling for improved understanding of characteristic length- and time scale interactions in food systems in order to support decision-making for food process and product optimization.
- Multiscale modelling of food process-structure-property relationships
    - for hypothesis testing.
    - for engineering/reverse engineering approaches (e.g. starting from targeted nutrient bioavailability or sensorial property perception and ending up with structure engineering of complex foods materials in industrial manufacture or in food formulation engineering).
    - effective food process optimisation by integrated modelling of food chain related unit operations, based on kinetic data and related models describing structure and quality changes during food production and storage.
    - integrated processing and modelling approaches, taking complexity of the food structure and related functionality into account.
    - modelling the whole food chain, to integrate/collect the concepts of quality and safety.
    - handling of databases including data mining and pattern recognition.
    - modelling to understand the relationships between structure and sensory attributes like sweet/salty.
    - developing knowledge representation and decision-making tool based on stakeholders PAN (not only consumers) of the whole processing chain and on the development of knowledge reasoning models and tools that will go until the resolution of conflicts (interface with ITC).
- Intelligent process management for retention of health relevant compounds and their bio-accessibility in end products.

- Engineering food structures with physiological beneficial impact, via gastro intestinal engineering approaches for digestion and metabolism-relevant processing (including probiotics, prebiotics, aspects and gut microbiota characteristics). Gut models of digestion and gut function include batch and continuous fermentations, seeded with human microbiota or candidate probiotics, into which micro and macro nutrients can be introduced and their metabolic fate followed. Animal models would provide more complex physiological responses giving immune and metabolic (metabolomics) readouts.
- Engineering approaches on tailor-made products for gut microbiota (e.g. effect of the food matrix structure on the functionality of foods modulating the gut microbiota. (Using direct microbiota population shifts and trancriptional and metabolic micobiota responses to specific nutrients including commercial ingredients and micro and macronutrient groups. Such studies will also look at metagenome and metatranscriptome in individuals fed specific diets. Such studies are particularly relevant at the extremes of life ie in infant and elderly)
- Process control by off-line/in-line analytical tools and process sensors in the context of life history structure-life-cycle, that follow the food material testing for damage of the product (post-harvest optimised design) applicable for equipment in thermal and non-thermal processing.
- Exploiting the wide field of packaging's innovation potential by combining rational environmental and health concerns with advanced technologies:
    - holistic approach to develop sustainable food packaging solutions by integrating the whole food chain processing, while anticipating safety issues (sensitivity balance).
    - reducing cold / frozen chain use (energy consumption and carbon emission) for fresh (low processed) foods by developing novel modified atmosphere technologies and smart intelligent /communicative packaging solutions (to reduce energy consumption, preservatives intake and food wastes).
    - in-package food processing: (re) inventing food processing technologies based on using packaging e.g. as simplifying factor (for reducing physical-chemical stabilization treatments).
- Exploiting the wide field of packaging's innovation potential by combining rational environmental and health concerns with advanced technologies: It is necessary to adopt a holistic approach to develop sustainable food packaging solution by integrating the whole food chain processing, while anticipating safety issues (sensitivity balance). Another important area of development is the reduction of cold chain use (energy consumption and carbon emission) for fresh (low processed) foods by developing novel modified atmosphere technologies and smart intelligent/communicative packaging solutions to reduce energy consumption, preservatives intake and food wastes. In-package food processing opens new research area by (re) inventing food processing technologies based on using packaging for example as simplifying factor (for reducing physical-chemical stabilization treatments).
- Increase biodiversity in order to derive plant based-new technologies which may allow for the exploitation of raw materials not currently useful, thus broadening the raw material base.
- Increase efficiency in production of plant-based proteins.
- Re-engineering by rescaling of existing processes (e.g. use of multiple small-scale units in series, instead of large units).
- Rethinking ways of processing for functionality retention.
- Post-shopping technology and food preparation at-home approaches.
- Point-of-sale retailing and processing (including distribution).
- Point-of-use processing (PAN Concept - based).
- Overcoming process related hurdles for novel foods.
- Interdisciplinary research on water (environmental aspects of water use in food processing, water processing/cleaning and management)
    - water use ((de-)salination, in-food processing water).

    - waste water and recycling.
    - minimising water use (e.g. in blanching, separation processes by new membrane technologies, dry-cleaning of lines as alternative to using water)
    - water as a vehicle for transportation.
- Search for traditional small-scale food processing techniques (both EU and outside of EU).
- Upscaling of pilot plants.
- Downscaling of industrial production techniques to SMEs and households.
- Re-evaluation of existing processes in terms of sustainability
    - to save energy in processing (e.g. by reduction of process temperature, use of membranes, etc.).
    - alternative drying to avoid phase transition processes, e.g. osmotic drying to remove water and avoid phase transition.

CHAPTER 5: Food and consumers

Background
The Food and Consumer Group of the European Food Technology Working Group, has identified a number of key research topics that would require further research attention at the European level. Given the broadened focus on Strategic Research *and Innovation,* the research agenda encompasses research needs which link thorough and theoretically grounded understanding of consumer behaviors related to food choice with concrete and actionable policy relevant to product development, (for example, integrating consumer preferences into the design of novel foods) chain innovation, (improving the sustainability of food production systems in line with consumer preferences) and policy innovation, (developing interventions designed to improve consumer health and quality of life). In other words, the "innovation trajectory" associated with novel foods development needs to integrate technological possibilities with consumer and policy priorities if societal and market acceptance of novel products is to occur.

Structure
The research priorities are organized around five key areas with multiple themes within them leading to the research priorities detailed below:

A. Societal challenges, including food safety and security, health and sustainability
B. Behavioral changes, related to consumer decision making
C. New Developments, relating to consumer engagement and price (sensitivity)
D. Methodological innovations, relating to disciplinary integration, longitudinal approaches and EU wide standard and tools
E. Dissemination, for SME applications

AREA1: SOCIETAL CHALLENGES

Theme 1.1 Food safety and security

Project 1.1.a. Food sovereignty, local production and social impact

Food sovereignty, the assurance that European member states can produce adequate food to ensure availability in the face of global crises, or in the context of climate changes, is an important element of improved food security. It also raises important consumer issues. Food sovereignty may entail costs, or food chain innovations, to "localize" the food supply. Technological innovation may also be required in developing new foods which are amenable to local production, as an alternative to reducing the range of available consumer products, overall and seasonally. Research is needed to understand consumer preferences for the implementation of European food sovereignty, (for example, in terms of product range and product choice) as well as communication policy (for example, tracing and labeling locally produced products). Information about local and European-wide social impacts (for example, relevant to local and national employment, or the economic and logistic structure of the food chain) is also required as part of the research conducted. The research will establish the relationships and parameters that are keys to coherent European food security and sovereignty policy.
Expected impact: A theoretically based understanding of the advantages and disadvantages food production will be used to underpin policies facilitating food sustainability and food security through increasing localization of production. Socio-economic impact as well as consumer issues associated with food availability and technological innovation in production systems will be assessed.

Project 1.1.b. Trust, confidence and governance

Different governance frameworks are applied to different food production approaches within Europe. The regulatory framework applied to many traditional food production technologies is simple than that applied to some areas of technological innovation (for example, genetic modification of plants and animals). At the same time, some technological innovations (for example, genomic mapping of food species) requires little additional input in terms of regulation. An important issue relates to understanding the extent to which applying different regulatory approaches to innovation in the food chain enhances consumer trust and confidence in food security. A second issue is focused on the extent to which benefit, as well as risk, can be incorporated into governance frameworks,(for example in relation to risk assessment, management and communication), across a range of food production technologies, whilst simultaneously developing and maintaining consumer confidence in regulatory practices. Research is needed to map and compare the impact of different regulatory practices on consumer confidence in food chain innovation, and to predict the potential effects of risk-benefit analysis on consumer trust and confidence. The research should also address approaches to metricise social and economic assessment in addition to health and environment.

Expected impact: The results will allow optimal governance to be developed in the agri-food sector, through the development of policy frameworks which have demonstrated to maximize consumer confidence in the food chain innovation, whilst simultaneously addressing both benefits and risks associated with agri-food innovation.

Project 1.1.c. Trust, authenticity and naturalness

European consumers trust natural and authentic products more than they trust products that they perceive as highly processed, as employing advanced technology, as modified or altered. This preference for the natural and the authentic has given room for niche production in the range of local and traditional foods, but at the same time creates problems for consumer acceptance of other food products that are safe, healthy and nutritious, but that consumers reject because of a lack of perceived naturalness and authenticity. This project will investigate how consumers develop trust based on the perception of naturalness and authenticity, and how consumers form perceptions of naturalness and authenticity. Based on these insights, this project will identify key elements of food production processes that support notions of authenticity and trust, and that can increase consumer trust in the food production process. This project will work with a variety of food products, both traditional and novel, combining expertise in food processing technology with expertise in the analysis of consumer impression formation.

Expected impact: Better ability of food producers to design production processes that will be perceived as congruent with demands for naturalness and authenticity; Insights into which factors, both in production process design and in communicating about it, will be perceived as indicating naturalness and authenticity; More consumer trust in the food chain.

Theme 1.2. Health

Project 1.2.a. Social impact of food-related diseases and the mitigation potential of functional foods

Health is strongly influenced by food consumption. This suggests that a clear understanding of the balance between economic costs and health benefits for foods, new food technologies and diets is needed to allow policy makers and producers to make the best choices for supporting health. An important question then relates to assessing the economic impacts of diet and dietary choices, in terms of the functioning of individuals, households, health care systems and society in general. In the pharmaceutical situation the focus is on disease as identified by medical science. The foods situation differs from this in a number of ways. For foods both disease reduction and positive health benefits are relevant. Furthermore, for foods a broad set of benefits including physiological benefits but also psychological benefits related to health and well-being are relevant. Another challenge is the generalizability of clinical trials to real-life consumer situations. Thus, the development of a food-appropriate health economics approach is called for. Such an approach could be extended by combining it with the assessment of the social impact of food-based health interventions.
This proposal then suggests that the health economics approach should be developed to be applicable to food. The new approach should allow for multiple types of benefits to be included. In particular Quality of life and other consumer-relevant health benefits such as, for example, quality of sleep should be included.

Expected impact: The development of a health economics approach for foods will allow policy makers and producers to optimize the health impact which foods can have for the European population.

Project 1.2.b. Consumer acceptance of reformulated foods

For a large number of European consumers diet is unbalanced with an excess consumption of fat, salt and low-size sugars. One way to solve this problem is to reduce the content of these potentially negative ingredients in foods where they are particularly abundant and frequently eaten. This could be done by a simple reduction of these ingredients or by compensating these ingredients by other ingredients. Both types of reformulations still concern a limited number of food products. Moreover, even when this is possible from a technological point of view, simple reductions are rarely used by manufacturers who are worried about its negative impact on consumers' acceptance. Compensation strategies are not necessarily well perceived by consumers and maintain the preference for the taste of these negative ingredients. However, the optimal levels of these ingredients could be overestimated due to the methodology used to test reformulated products (comparison with the original products, short-term tests on small quantities). Thus, there is a need to develop more ecological approaches to test reformulated products. There is also a need to compare different approaches for introducing these reformulated products on the market: one is to reduce significantly the content of these negative ingredients and labeling these new products, the other one is to reduce progressively without specific communication on such reductions. There is a need to compare the long-term efficiency on these two approaches on different profiles of consumers and in particular on the most vulnerable population, i.e. those who are high consumers of the products with high contents of these ingredients and are not necessarily the most health-oriented population. Socio-economic parameters (prices, market segments) must also be taken into account for analyzing the success of reformulated products. Collaborations must be established with projects aiming at monitoring the current supply of packaged foods and the market structure for each product family.

Expected impact: To encourage the various players in the food industry (manufacturers but also retailers) to adopt strategies aiming to improve the nutritional quality of the food supply. To develop a platform for exchanging data

Project 1.2.c. Healthy ageing and individual differences

Elderly malnutrition appears today and will be for the next years as a real public health stake. Malnutrition is more frequent for elderly who are partly or totally dependent concerning food purchase, food choice and food preparation. Physiological factors among which the decrease in sensory abilities (in particular in taste and olfactory perception), psychological factors (in particular depression), and socio-economic factors (in particular loneliness, mobility, income) can contribute to reduce food intake and decrease diet variety. There is not only a need for specific products from a nutritional point of view but also a need to find solutions to avoid loss of appetite or re-instate appetite, desire to eat and pleasure in eating. Today there are few specific or adapted foods for the elderly people and they are not developed taking into account the likes or desires of this population. These products for elderly are rarely tested on the undernourished elderly target, and specific methodologies to test them are to be developed. Besides optimizing product palatability, there is also a need to identify solutions for increasing intake. New and more ecological approaches are needed to analyze diminishing flavour perception, changing sensory specific satiety and satiety signals and their impact on intake. The different factors influencing reduced intake and consequently malnutrition should be representative of those currently pertaining at European level, with a view to contributing to better strategy in public health. The research will aim at augmenting scientific understanding in the determinants of malnutrition and will aim at providing innovations in terms of products and recommendations. This will be achieved thanks to a combination of different approaches and a multidisciplinary collaboration of researchers in nutrition, sensory, anthropology as well as with food producing enterprises.

Expected impact: This research will help to increase understanding of the importance of different factors to overcome malnutrition for elderly with different levels and different types of sensory, physical and cognitive impairments. The results would support development of food products specifically designed for the very old malnourished European population. This research would also provide ways to prevent malnutrition. This research will help to support recommendations for service providers in charge of elderly care at home or in nursing homes.

Theme 1.3. Sustainability

Project 1.3.a. Sustainability communication

Much of the sustainability value of food products remain essentially hidden to the consumer unless communicated to them through information on the food packaging and/or at the point of purchase. Transparency is crucial when the purpose is to enhance the informed sustainable choice on the part of the consumer, and on-pack information is an important way to achieve this. As sustainability is a multidimensional concept, including issues related to environmental (e.g. sourcing, processing, manufacturing, and logistics), social (e.g. fair trade), and animal welfare considerations, effective communication that promotes consumer understanding, is a complex process. Across Europe a variety of sustainability-related food labelling schemes are available, sometimes induced by national governments, individual food companies or retailers, and/or industry wide initiatives, often in close collaboration with certification bodies (e.g. Fair Trade). However, the effectiveness of these labelling schemes in moving food consumer behaviour into a more sustainable direction overall is still unknown. Also, more research is needed into the cross-cultural dimensions of sustainability

labelling schemes, to ensure that for the individual consumer transparency does not stop at the country border. This project will provide fundamental insight into the effectiveness of alternative sustainability labelling schemes in enhancing informed sustainable food choices. It should take a European perspective, including an inventory of existing (inter-)national labelling schemes and their underlying rationale and evidence. If should define and empirically illustrate the underlying consumer decision making processes that enhance and/ or hinder the effective communication, and should include European-level segmentation to identify the most appropriate sustainability labelling scheme for different (vulnerable) segments within the European population.

Expected impact: Baseline knowledge on the effectiveness of alternative sustainability labelling schemes and their impact on sustainable food choice, Europe-wide. New insights into possibilities for the science-based design of a European standard(s) in sustainability communication.

Project 1.3.b. Trade-offs between sustainability and other consumer benefits

Sustainable food production may be defined to include the maintenance of a supply of safe and secure foods, as well as those which deliver nutritional, environmental, and ethical benefits. Thus consumers may need to make decisions about properties of foods simultaneously. As part of this, they may need to also consider broader societal issues associated with innovations in food technologies targeting improved consumer or environmental health. Important research questions relate to understanding how different attitudinal and perceptual determinants influence sustainable and healthy food choices, and how these vary across different demographic groups within the population. In particular, simultaneous consideration of the risks and benefits (to health, the environment, socio-economic factors, and ethical concerns) of food consumption may be representative of how people operationalise consumption decisions. The lack of validated theoretical predictive models of consumer food-related behavior, which consider decision-making in the context of both sustainability and environment, is an area which requires further development, as well as policy translation into actionable recommendations relevant to both industry and government.
Expected impact: Information will be delivered, relevant to policy development, addressing co-development of both healthier and more sustainable food choices across European consumers. In addition, information will be provided to industry to enable the design of healthier, more sustainable food production systems and products.

Project 1.3.c. Animal welfare

European citizens and consumers are increasingly sensitive to animal welfare as a process and product characteristic of food and derived products from animal origin. Previous projects have developed methods and tools to assess animal welfare in livestock production, e.g. Welfare Quality. Animal welfare concerns extend beyond the traditional terrestrial livestock species, such as pigs, poultry and cattle, to aquatic species including wild and farmed fish. The implementation of the newly developed tools raises questions concerning farm level profitability, stakeholder and supply chain members' interests and consumers' willingness-to-pay. A first important research question is whether it is economically feasible to implement the latest tools to monitor and assess animal welfare standards while maintaining European livestock industry competitiveness. A second research question is whether and to what extent European consumers are willing to pay for extra guarantees related to animal welfare, relative to other process-related attributes. Third, the most effective and efficient means of communicating about animal welfare (e.g. through product

labelling or quality marks) need to be addressed. The study will aim to address the feasibility of policy decisions related to animal welfare from the perspective of food producers, food chain members, food consumers and European citizens.

Expected impact: Information will be delivered to assist policy decision-making with respect to the implementation of animal welfare standards in livestock production, while maintaining industry competitiveness, meeting European citizen concerns regarding this issue, and satisfying European consumers' demand for animal welfare-related information and product characteristics.

Project 1.3.d. Protein supply

Animal protein consumption is well-established in most European consumers' diets, despite being often criticized for its negative impact on human health (e.g. World Cancer Research Fund reports), animal welfare and environmental sustainability (e.g. externalities and carbon footprint from livestock production). An increasing number of European consumers are interested to lower their meat consumption frequency and amount, but their intention may not be realised owing to several real and/or perceived burdens. Besides mapping European consumer interest in lowering meat consumption and related motives and expectations, this topic also addresses the real and/or perceived burdens for doing so. These may relate for example to the availability of alternatives for animal protein consumption (e.g. meat replacers), personal attitudes and perceptions viz-à-viz available alternative protein sources (e.g. insect protein), lack of information and knowledge, as well as socio-demographic, economic, cultural and anthropological factors that shape current and future protein consumption in Europe. Experiences from other cultures beyond Europe with different protein consumption habits should be integrated in this project.

Expected impact: Insight will be delivered in European consumer interest for lowering meat consumption and perceived barriers for adopting meat replacers. The research will help to understand related motives and barriers, as well as information needs as perceived by European food consumers. The research will provide recommendations for both European meat industries in terms of possible adaptations, and European food supply chains and industries dealing with meat replacers and alternative protein sources.

AREA 2: BEHAVIOUR CHANGE

Theme 2.1: Consumer Decision Making

Project 2.1.a. Nudging: affecting consumer decision at the point of purchase

Much of consumer decision making at the point of purchase and point of consumption is based in habitual and routinized processes, often associated with a limited degree of information processing and deliberation (i.e. "low involvement"). For consumers with a higher level of involvement on societal impact of their food choice decisions, information transparency and public communication campaigns may be appropriate. However, such information may go largely unnoticed by the low involvement food consumer, thereby reducing the effectiveness of informational approaches. Recent developments in academic and policy circles are beginning to focus on relatively small changes in the so-called "choice architecture" that can stimulate healthy and responsible choices among consumers, without restricting their freedom of choice. These so-called "nudging" approaches build on implementing implicit social norms and /or selectively changing just the accessibility (rather

than availability) of healthy and responsible options within the choice context. The project should provide an inventory of the potential of nudging approaches to enhance the healthy and responsible food choices among consumers and empirically identify the underlying consumer behaviour processes and mechanisms, and come up with policy advice to how selective nudging approaches can be implemented at the European level. The project should actively involve the retail and catering sector as well as food manufacturing industry to map out the multi-stakeholder potential of this approach. There should be due attention to the ethical aspects of nudging.

Expected impact: Basic knowledge on the potential of nudging approaches in effectively stimulating consumers' healthy and responsible food choice and consumption. A policy document outlining the key managerial, policy and ethical issues among the various stakeholders (catering sector, governments, retail, food manufacturing companies, consumer organisations) involved in a joint approach at the European level to move nudging forward.

Project 2.1.b. Out-of-home consumption

Out of home consumption is increasing. This increase is driven by changing demographics, changing work patterns, and changing meal patterns. Out of home consumption covers eating in canteens and institutional cafeterias, at fast food restaurants, at gourmet restaurants, and on the go. It covers a wide variety of forms of food intake, and a wide variety of products with vastly differing degrees of healthiness and quality. Nevertheless, most efforts to encourage consumers to eat in ways that are compatible with desires for good health and quality of life have been aimed at food choice in the retail domain and in-home meal preparation. This project will provide basic knowledge on drivers of out of home consumption, different types of consumption, and the motives and decision-processes that will lead consumers to choose particular forms of out-of-home consumption. It will also analyze the effect of out of home consumption on nutrition and health, and characterize different forms of out of home consumption in terms of their nutritional impact. On this basis, and in cooperation with actors in the catering sector, it will provide guidelines for new forms of healthy out of home eating that will find consumer acceptance.

Expected impact: Baseline knowledge on determinants of out of home food consumption choices and their impact on health and well-being. New insights into possibilities of improving public health by new out of home eating concepts. Science-based innovation in the catering sector.

Project 2.1.c. Meal patterns and eating habits

Identifying the determinants of meal patterns, that is, when, what and how much is eaten, in the context of abundant food supply, is fundamental to understanding and influencing healthy and unhealthy dietary behaviour. Despite the enormous range of foods and food products available and the many potential eating opportunities open to consumers on a daily basis, individuals tend show a relatively restricted and repetitive pattern of choice and intake. Nonetheless, changes in meal patterns (and fatness) occur with major changes in life circumstances (e.g., leaving home for college, change of job and migration). Investigation of determinants of meal patterns will involve longitudinal, cross-sectional and experimental studies to analyse the roles of characteristics of the food (composition, portion size, etc), the environment (home, canteen, restaurant, watching TV, etc) and the person (age, BMI,

genetics, physical activity level, stress, self-control, weight concern, etc). Such studies would be expected to reveal how cognitive, learned and physiological controls interact to influence hunger and satiety, food and portion size choice decisions and the timing of eating episodes, and in turn contribute to knowledge guiding interventions for achieving successful dietary change, healthy weight control, and product innovation and development.

Expected impact: Generation of evidence on major influences on daily food and portion size choices and food intake. Generation of a knowledge base for product innovation and for development of strategies for achieving healthy dietary choices and healthy weight.

AREA 3: NEW DEVELOPMENTS

Theme 3.1. Consumer engagement

Project 3.1.a. The role and value of social media and social networking to encourage and support longer term behavioural change in respect of healthy life styles.

Is it possible to change nutrition, health and lifestyle behaviours with social media? What type of cross-functional effort that includes off-line and in-person interactions might be needed for true change? On the other hand, many of the external conditions and individual behaviours that are the root for health and disease are learned or shared from our closest contacts. So what is the role of social media and on-line networks in magnifying or inhibiting social and behavioural determinants of health?
The aim of this project is to valuate current uses of social media in public health that can be tied to measureable and effective outcomes and impact on behavioural change – what has been shown to work, and what has not worked
.
Expected impact: A better understanding of the role of social media and social networks in public health campaigns, interventions and policies, and examples of best practice.

Project 3.1b. Engaging consumers with (innovative) consumer research approaches

What is the most effective way to engage and communicate with consumers on new food-based technologies? Various methods have been proposed to involve consumers in the development of new food technologies and associated products, ranging from a range of methods focused on consumer and citizen engagement (such as citizens juries or consensus conferences) through to exploitation of new social media. An important research question relates to the extent to which the application of such approaches has an impact on agri-food policy on one hand and consumer behaviour on the other. Research is therefore needed to develop assessment methodologies relevant to measuring the impact of such interventions on policy development associated with the introduction of novel food technologies, as well as consumer behaviours related to innovative new food products developed using them.

Expected impact: the potential impact of novel engagement and communication approaches will be understood, and can be used to successfully engage the public in general, and specific consumer segments in particular, in the food innovation process associated with novel technologies, thereby increasing the potential success of commercialisation strategies.

Theme 3.2. Price (uncertainty) as a determinant of food choice

Project 3.2.a. Consumer response to food price instability

Over recent years, food commodity prices have been subject to major oscillations, mainly due to weather patterns, fluctuations in energy prices and rising demand from emerging economies. Although commodity price volatility is generally mitigated by price transmission mechanisms along the food chain, its combination with the overall economic instability can generate relevant adjustments in consumer choice and diet quality, especially for vulnerable groups, although little evidence exists. This project will provide quantitative evidence on the extent of these impacts in terms of food purchases and overall dietary quality. The quantification of consumer response should be addressed at a sufficient level of disaggregation across food products, considering the overall diet outcome, accounting for differences across European regions and making use of official secondary data-set and commercial retail-level data, if necessary. Quantification of consumer response should be based on appropriate economic models, but also addressing the influential role of psychological variables related to perceptions, attitudes and information processing, as well as lifestyles. The results are relevant to policy-making and to marketing strategies in the food sector.

Expected impact: Generation of quantitative evidence on the impact of price fluctuations on dietary and health outcomes. Contribution to policy initiatives related to supporting vulnerable groups towards a healthier diet. Generation of knowledge for pricing and marketing strategies along the food chain.

AREA 4: Methodological innovation

Theme 4.1. Networking the Food Consumer Science Capability across Europe

Project 4.1.a. Integrating scientific disciplines and databases

Increased differentiation of (European) populations on socio-economic grounds may increase vulnerabilities in some target populations, and this might be exacerbated by genetic differences across populations. For example, some sections of the population are more vulnerable to diet related diseases through the course of the entire lifetime (for example, population groups with a lower socio-economic status, socially excluded groups, some immigrant communities and ethnic minorities) and differentially vulnerable during critical periods throughout life, such as pregnancy, lactation, infancy, childhood and older age. More effective collaboration between the natural and social sciences is required, as many of the issues and emerging problems may be caused by biological and socio-economic factors. Models which systematically integrate determinants of appetite (including over- and under-eating), hedonic responses to foods and food choice originating in the natural and social sciences are urgently needed if effective policy is to be developed regarding optimisation of consumer health. Understanding the determinants of healthy food choice would be a long term goal of research in this area. Although there has been extensive research in different disciplinary areas focusing on this topic, integration is poor and resulting policy fragmented. An initial integrating activity would involve developing a network of excellence which will enable researchers from different disciplines to collaborate and set up joint data bases for further analysis. Additional activities might include developing standardised approaches to assessing the impact of chronic diet-related diseases on Quality of Life, Economic Functioning of individuals and households, Health Service Impact, and Perceived Individual wellbeing, harmonizing methods to assess key psychological determinants of health, risk-benefit perceptions associated with specific food choices, and standardized behavioral indicators regarding what food choices are being made. Biological and psychological determinants of appetite and food choice can be studied using a variety of methods,

including genetic analysis, behavioural ecological modeling, neuro-imaging (e.g., FMRI) and experimental studies (e.g., measurement of eye-movements to study attention). A key challenge is to bridge the gaps between the relevant research disciplines to enable dialogue and collaboration in the study of decision making in relation to dietary behaviour.
Expected impact: An important outcome will be to design the infrastructure for long term prospective studies which can track change and the impact of policy interventions in European populations in the future. A set of standardized methodological approaches in both the natural and social sciences can be developed, which will facilitate long term collaboration between biological and social sciences relevant to understanding European food choices.

Project 4.1.b.. Defining EU-wide standards and tools in Food Consumer Science

There are a large number of psychological variables relevant to the study of food choice by consumers and to the impact of those choices on health. At the present time, no validated and standardized measures are available to facilitate integration of findings across different studies and secondary analysis of pooled data. As a consequence, research into the determinants and health consequences of food choice is limited. Lack of standardized research tools also limits co-operation between research groups, and the creation of joint data-sets etc. , as data cannot be easily compared. Thus, a structured approach aimed at improving the availability of validated measures in key areas is needed.

The variety of possible measures is large. This suggests that in the first place existing measures should be collected, evaluated and made available through a generally accessible database. This can be followed by strategic analysis to identify key variables for which additional measures are needed. Key areas might include evaluation of quality of life and consumer understanding of. A rigorously tested and robust set of assessment measures can be made available to researchers within the European research area.

Expected impact: The identification, development and dissemination of measures for key variables will enable effective research. As the results are based on standard measures they will provide more effective input for policy.

Theme 4.2. Longitudinal analysis in consumer science research

Project 4.2.a. Dietary change and obesity determinants: evidence from longitudinal analyses

The time dimension of the factors driving dietary quality and obesity rates in Europe has been overlooked in research, mainly because of the paucity of adequate longitudinal data. However, evidence from other countries and especially the US suggests that few factors have shown relevant changes over the last two decades, mainly technical progress, income distributions and relative prices, while the time variations of psychological and social factors has received little attention. Furthermore, longitudinal analysis and the application of the appropriate econometric techniques will shed light on the role played by habit formation and time discounting in determining unhealthy behaviours, as well as the potential feedback effect of health status. The objective of this project is to explore the time patterns of food choice and its drivers and outcomes, in order to capture the key determinants and enable evidence-based policymaking in the medium and long term, including the evaluation of policy measures adopted in recent years. To this purpose, the project will combine, match and merge existing secondary longitudinal and repeated cross-sectional data-sets in different domains into a comprehensive pseudo-panel data-set, considering all European regions and different population segments, including available information on time patterns in the

economic, lifestyle, social and psychological determinants, as well as the relevant health indicators. The project shall develop and apply appropriate dynamic models to capture the aforementioned longitudinal effects.

Expected impact: Generation of an extensive evidence basis for medium and long-term policies to improve diets and health. Generation of knowledge on the interaction of economic, lifestyle and psychological factors in determining dietary and health outcomes.

AREA 5: DISSEMINATION

Theme 5.1. Dissemination to European SME's

Project 5.1.a. Making food consumer science actionable for SMEs

Food consumer behaviour related research-based knowledge has substantially been developed over the last few years. Its exact nature and extent can be adequately captured by a review of published outcomes, and peer reviewed publications still been considered as a primary vehicle for dissemination of such knowledge. Nonetheless, it is still questionable whether European SMEs (either market research firms or food industry) have fully adopted and exploited the innovative outcomes and/or the method advances that have been produced and been published in academic outlets. Possible reasons for delays in their adoption may relate to their characteristics as the outcomes or methods may have been seen as not offering a relative advantage, not been compatible, or being complex to current practices and knowledge; difficult to experiment, even on a trial basis; not been sufficiently visible; or probably involving risk and adverse experiences for any potential adopters.

The objective of this project will be to develop a 'metrics' instrument that will be used to assess the innovativeness characteristics of the food consumer behaviour related research-based generated knowledge (either funded by EU funds or not but published in peer reviewed academic outlets) as perceived by potential adopters, either in the market research or food industry sectors. Related to this objective, another aspect will be to investigate what are any other barriers, internal or external to SMEs that delay adoption of such knowledge and what vehicles can be used to overcome any barriers or/and accelerate adoption. Second, to investigate the time-duration related aspects of the diffusion adoption (by the SMEs) curve(s) that published knowledge follows and the dynamics of such adoption curve(s). Third, to assign an economic value to what such knowledge and methods have generated through their adoption by European SMEs. A pan-European coverage is necessary.

Expected impact: Generation of an extensive evidence basis for the innovativeness characteristics of the outcomes and methods food-consumer behaviour related research as these are perceived by European SMEs; a plan for action to diminish the impact of barriers and accelerate the impact of facilitating factors; identification of the economic value produced by European SMEs that relates to published research-based outcomes and methods.

CHAPTER 6: Food chain management

Challenges in Food Chain Management

The food sector as a whole is faced with major challenges that arise from changes in the sector's economic and non-economic environments, from changes in lifestyles, from global increases in food consumption, and from a diminishing production base due to, e.g., the loss of arable land or its divergence for non-food production alternatives. The challenges cannot be met by any individual enterprise but require concerted actions and coordination of initiatives. Food Chain Management (FCM) provides support for the identification and realization of 'best' concepts for such actions and co-ordination needs. This support, in turn, provides enterprises with the means for improving their own and the sector's competitiveness, sustainability and responsibility towards the expectations of its customers and the society.

In meeting its challenges the **sector needs to innovate in organizational relationships** that reach beyond innovations in process improvement by building on the innovation potential inherent in enterprise networks and their flexibility in responding to customers' and consumers' demands. There is an urgent need to adjust the trend towards increased process integration along the value chain to the organization of a flexible and responsive network approach by utilizing the potential of technological change, of information and communication systems, and of institutional change.

Food Chain **Management support is towards the actors** that represent the food value chain, suppliers, primary producers, processors, manufactures, and retailers which have consumers as the final customers. Its support can focus on operational improvements or on strategic development perspectives (Strategic Food Chain Management) that involve major investments and long-term commitments. A specific strategic development perspective concerns the investment in sector-wide infrastructures such as electronic networks for food safety assurance, quality assurance and transparency in business communication as well as towards consumers.

Such infrastructures could serve and benefit the sector as a whole but are beyond the investment capability of any single group, especially if their benefit depends on participation of a majority of enterprises, including SMEs which might take time to materialize. For the infrastructures to become feasible and to deliver the envisaged benefits not just for enterprises and the industry but for society as a whole the investment in conceptual design, organizational agreements, and financial responsibilities require complementary engagement of groups from outside the value chain including research and policy, i.e. a Food Chain Management view that **integrates policy and management initiatives** alike.

Specific issues the food sector and its individual actors need to deal with for timely and appropriate response to the sector's challenges.

- To adapt rapidly (through changes in resource use, products, processes, services, and governance structures) to changing scenarios (markets, policy, resource availability etc.) and their requirements within a sector organization that is difficult to co-ordinate as its enterprises are rarely confined to well-structured chain relationships with established communication and co-ordination mechanisms but are usually part of an open enterprise network where enterprises may change their suppliers and customers at will.
- To overcome the sector's structural problem with its large number of SMEs. Their ability to innovate and interact successfully with the large and multinational enterprises, especially in agricultural supply industry and retail, depends on co-operation initiatives and the provision of external co-ordination support.

- To focus on changing consumer needs. These depend on a continuous adaptation of new developments in technology, production, management, communication, organisation or cooperation and on the establishment of trust between all stakeholders along the food value chain including the consumer.

The **challenge for Food Chain Management** is to integrate and balance the interests of all stakeholders, including enterprises, consumers, and society as a whole considering of all of the relevant factors for successful integration e.g. economic efficiency, environmental control, process organization, food safety, marketing or transaction rules, etc.

Four interrelated strategic **research domains** have been identified as decisive for the sector's ability to meet its future challenges and to overcome its inherent development problems. They focus on serving:

- **consumers** through the provision of quality and diversity in food they can afford and trust,
- **food chains** through better transparency for advancements in governance, trust, efficiency, and innovation dynamics,
- **SMEs** through better integration into the global and regional value chains, and the
- **sector** through better understanding of the dynamics in those critical success factors that will improve competitive performance and sustainability in times of globalisation and change.

These research domains constitute the challenge for **Food Chain Management research** which

- is **building on** *system analysis* and *optimization;*
- is **focusing on** e.g. *business relationships* between actors, on *partnership* formation and *networking organization*, on *cost-benefit* and *risk management*, and on *organization;*
- is **dealing with** e.g. present and future *food chain scenarios*, with *reduction of waste* in resources, products, packaging, and time, with *trust* throughout the food chain, with *emerging chains*, with *structural change*, with *demographics*, and with *governance*;
- **having an impact on** e.g. *competition* in the 'new world scenario', *employment* (new and better jobs), *SMEs* (generation changes, gender development, survival, R&D), *sustainability* (reduction of resources: water, waste and packaging), *climate change* (reduction of energy, CO2,etc.), and *structural dynamics*.

Actual priorities for Food Chain Management research can be captured in 7 major goals and a number of objectives related to them:

<u>Goal 1: Reduction of waste</u> (dealing with diminishing resources)

Reduction of waste is, in times of diminishing resources a very first step in dealing with emerging scarcities. Waste is a broad concept which covers in principle all resources used during the production and distribution of food as well as food itself. The priority research areas are considered to be the reduction of waste through the utilization of waste from products and packaging and the reduction in resource use and especially in the use of energy and water.

Objective 1A: Utilization of waste from food products (innovation in logistics)

Waste can become a resource for energy creation. Food chains generate large amount of waste and therefore, new and innovative approaches are required to consider maximizing energy creation. The opportunities for this energy creation can be identified by "mapping" the areas of the food chain where waste is generated at large and by illustrating which products can generate energy under a more efficient and environmental-friendly manner.

Objective 1B: Reduction of Waste from Packaging (innovation in distribution)
Packaging generates vast amounts of waste especially consumer packaging (dealing with the final product, e.g. bottles, cans). The concept of "reverse logistics" is relevant here as it aims to maximize the reuse and recovery of the final products whilst food waste recovery can support the further optimum use of products in different ways. Dealing with consumers will be a key aspect of this topic as they will need to be incentivized / convinced / motivated / considered for any approaches followed.

Objective 1C: Reduction of Waste in Energy (processes, logistics/distribution)
Considering the vast amounts of energy required in the food chain and the current scarcity of resources, further work in reduction of energy waste is required. A "total chain" approach is needed where chain members will be identified responsible for both large energy consumption but for large energy waste too. The reasons for that waste will be identified including the energy "bottlenecks" or "hot spots" where efficiencies can be achieved. It will be useful to examine possible collaboration models between these chain members at either horizontal, vertical, dyadic or network level too.

Objective 1D: Reduction of Waste in Water (processes, trade in virtual water)
Water is becoming a scare commodity and contemporary food chains should be water conscious aiming to minimize its usage and maximize its alternative use too. The key chain members responsible for the larger amounts of water waste should be examined. A slightly different but fully integrated methodological thinking may be required as various chain members will have different types, purposes and priorities of water usage (water usage by farmers versus manufacturers versus retailers).

Goal 2: Assuring trust within the chain for better serving society and consumers

Trust is a critical success factor within the chain but also between the chain and consumers. Distrust and the loss of trust are disrupting markets and are as such major challenges for the sector. It is a problem especially in commodity markets (or markets where product ingredients build on commodity products) were branding is of limited protection. Research in Food Chain Management would focus on trust generating and trust preserving activities and focus on the following four principle objectives:

Objective 2A: Building trust through transparency and awareness
Transparency throughout the chain and awareness of consumers is a core requirement for improvements in chain sustainability, for efficiency in logistics and for the preservation of trust with consumers. It depends on knowledge about what constitutes transparency but also on knowledge on the organization of communication schemes and institutional environments that could make it work.

Objective 2B: Assuring support of claims (organization of information and communication systems)
Claims on the safety, quality or sustainability of products or processes refer to issues that are not easily verifiable by customers or consumers. Trust in the claims is a pre-condition for their effective used. The objective does focus on the identification and evaluation of organizational alternatives of claim support incl. certification schism, information systems of various kind etc.

Objective 2C: Dealing with communication schemes that integrate consumers all along the chain
Communication with consumers for better meeting market requests, for better reacting to emerging needs and for improving competitiveness is of relevance for enterprises all along the chain. Furthermore, it is a core concept in support of *open innovation*. Newly emerging network

capabilities including social networks open new opportunities that need to be identified, analyzed, and integrated with food chain needs.

Objective 2D: Assuring and communication of tracking and tracing ability within networks
This objective deals with an on-going challenge. The establishment of tracking and tracing ability requires an integrated view where organizational issues, issues of technologies, institutional set-ups, standardizations, and the political and legal environment need to fit together to make it work. The objective is to provide a system view that reaches beyond the traditional focused type of analysis. Of specific concern is the complementation of the classical backward look with a forward look that supports enterprises in making informed decisions and the evaluation of risks on their distribution activity.

Goal 3: Supporting present and future food chain scenarios

The volatility of markets, the challenges posed by increasing production needs within limited resource availability, the globalization of markets with increasing competition, and the challenges posed by society's request on lowering negative impacts on environmental (e.g. climate change) and social concerns pose new challenges to food chain actors that require responses not yet dealt with in research.

Objective 3A: Dealing with the volatility of markets

Food Chain Management is faced with increasing volatility of markets due to resource competition and changes in the geography of demand and supply of food. Volatility involves risks. *Food Chain Management Research* deals with the development of risk strategies of various kinds (sourcing, organization, etc.) and the provision of decision models that could support management in dealing with the risk.

Objective 3B: Dealing with emerging environmental and social concerns
Climate change and other environmental issues of major concern require the engagement of all stages of the food value chain in reducing its impact through emissions of e.g. CO2 and equivalents. Hot spot analysis, and life cycle analysis provide the base for action, optimization of improvement strategies by *Food Chain Management Research* delivers decision support. Social concerns might ask for upper or lower limits regarding specific concerns (e.g. wages) but are subject to optimization in a multi-criteria decision situation where social concerns are embedded in issues of regionalization, development etc.

Objective 3C: Responding to demands for traditional food and food of certain origin
Increased interest in regionalization, in the preservation of identities, and in the identification with food products and their origin is supporting demand for traditional food and food of certain origin. This contradicts traditional developments towards unified food products that could be efficiently produced and marketed on large scale. As the production of traditional food and of food of certain origin is limited in volume it is very much a domain of SMEs. The support of SMEs in the integration of production and distribution networks that could compete in the market is a core challenge for EU policy and a focus activity of *Food Chain Management Research*. One of the challenges in this research is the organization of networks that are efficient and sustainable and of information loops that support trust and provide guarantee on origin.

Objective 3D: Dealing with limitations in the availability of affordable food
Limitations in the availability of affordable food require the development and operation of ad-hoc chain organizations that deal with the situation and reduce the short and long term effects of

deficiencies in food availability. Efficient action models and reference systems with global reach are required that provide support in case of needs.

Objective 3E: Dealing with emerging types of competition
With global markets developing, new competition from emerging markets is entering the European Union challenging the established food chain networks. *Food Chain Management Research* will identify and analyze developments and their impact on the European food system.

Objective 3F: Dealing with new types of food consumption
New types of food consumption including a tendency towards convenience products and an increase in out of home consumption (catering activities) have an effect on the organization of food networks. New logistics and information systems are emerging that require support to assuring efficiency in resource use and limitations in environmental impacts from the very beginning. *Food Chain Management Research* could identify, analyze, evaluate and optimize opportunities for providing development support.

Goal 4: Supporting Newly Emerging Chains (analysis and optimization)

The classical view on food chains leading to the common food products is changing. Diversifications in the needs of customers and society regarding products or services, changes in demographics, increases in cultural diversity etc. have a profound effect on the organization and operation of chains. Food Chain Management Research needs to analyze such emerging chains and provide a base for sustainable development.

Objective 4A: Dealing with New Information Markets
The increasing relevance of information drives developments towards information markets. The provision of information that support claims on the safety and quality of products might differ between products and 'owners' of information might require reimbursement for their collection and monitoring activities. Furthermore, information might be detached from products as in the '*book and claim*' development resulting in markets independent of the product market. *Food Chain Management Research* will need to identify, analyze and evaluate alternatives and provide support in linking them to various scenarios.

Objective 4B: Dealing with distribution systems for personalized products
The responsiveness to changes in markets and market needs and the ability to serve the increased diversity in needs (due to demographics, cultural diversity, etc.) becomes a major concern in the food industry's competitiveness and has been brought forward as a critical challenge since some time. *Food Chain Management Research* will take up the challenge and identify, analyze, and evaluate new types of efficient and responsive coordinated production and distribution systems incl. production and distribution 'on demand' as well as developments towards the provision of 'tailor made goods'. These research initiatives need to integrate developments in organization and technology.

Objective 4C: Dealing with flexible and market driven chains: production based on the combination of functional food components according to needs
This objective is a focused one linked to objective 2B. Its focus is on chains where products based on functional food ingredients are being provided on an individualized basis according to needs. This leads to different types of chains that build on functional food ingredients and a production activity at chain's end. *Food Chain Management Research* will identify, analyze, and evaluate the newly emerging types of chain relationships.

Objective 4D: Dealing with chains focusing on Ethnic Products

Food chains focusing on ethnic products have not yet been dealt with in a sufficient way. *Food Chain Management Research* will identify, analyze, and evaluate such chains. Furthermore, it will provide support in their integration into the classical European food chain environment.

Goal 5: Coping with demographics

Changes in demographics in most of Europe and beyond will have a decisive effect on the needs for services and products which in turn will affect the organization of food networks. These developments are aggravated through the urbanization of societies.

Objective 5A: Dealing with increasing urbanization: urban chains
Increasing urbanization combined with changes in demographics constitute new challenges. Older population and the expected increase in disabled people in urban concentrations requires new distribution concepts and formats that focus on serving lower mobility people. The integration of e.g. e-commerce, social (technology) networks, institutional arrangements, and adapted food chain organizations might allow new opportunities for support. *Food Chain Management Research* could identify, analyze, evaluate and optimize opportunities and provide development support.

Objective 5B: Better serving urban concentrations while protecting the environment
Urban concentrations ask for innovations in logistics and packaging that might differ from traditional production and distribution activities. Developments in other sectors might provide references on which to build. *Food Chain Management Research* could identify, analyze, evaluate and optimize opportunities and provide development support.

Objective 5C: Urban food systems involving agriculture and food production
Objective 5C reaches beyond the tasks in objective 5B and asks for a complete rethinking of food production and distribution. Vertical agriculture and roof agriculture are some of the brainstorming initiatives that need to be dealt with in further analysis. Short chains and the linkage of chain activities with social networks are discussed for food production and distribution. *Food Chain Management Research* could identify, analyze, evaluate and optimize opportunities and provide development support.

Goal 6: Coping with structural change

Objective 6A: Integrating the food system with life styles, regional identification, regional development perspectives, and occupation policies
This objective touches a broad range of issues. *Food Chain Management Research* could provide a broad mapping of opportunities and potential impacts in support of policy initiatives.

Objective 6B: Serving regional development (cohesion and inclusion policies)
Food chains and especially the early production and the later distribution stages are always linked to regional activities. Movements towards further regionalization increase chains' identification with and their impact on regional developments. This supports the integration of SMEs, the creation of job opportunities, and the contribution to the development of regions. *Food Chain Management Research* may identify, analyze, evaluate, and optimize suitable regional chains and evaluate their impact on regional development depending on the development status and the economic scenario of regions.

Objective 6C: Internationalization of food enterprises
With the internationalization of enterprises, new challenges arise especially for SMEs or SME groups. The identification of needs supports the necessary re-structuring of enterprises. *Food Chain*

Management Research will identify organizational and managerial needs and analyze opportunities. It will specify reference models that provide a basis for organizational and managerial activities.

Goal 7: Improving on Governance and Innovation

In dealing with the challenges ahead, the sector does not only need to respond but to actively move forward through changes in governance and innovation that could change the situation.

Objective 7A: Management needs *from a perspective of SMEs (*incl. management rules fitting for SMEs and GMP management needs)
Most management support concepts and tools are linked to the needs of large enterprises or multinationals with strategy divisions and a clear identification and separation of leadership groups. There is a lack in transformation concepts that make these concepts and tools suitable for use by SMEs and their management practices, including those linked to GMP (good management practice). *Food Chain Management Research* will design and test appropriate concepts and tools which allowed SMEs to link up with other SMEs and large scale enterprises.

Objective 7B: Promoting knowledge networks for innovation support
It is of clear evidence that, in principle, network organizations support the identification and realization of innovations. Knowledge networks are supported by on-going technological developments which facilitates networking. *Food Chain Management Research* will identify, analyse and evaluate various network concepts and provide information on suitable organizational developments.

Objective 7C: Dealing with management information systems for better cooperation, control and risk management in enterprises, chains, networks, and sectors
Dealing with the organization of information networks the objective identifies needs, opportunities and institutional requirements.

Objective 7D: Dealing with lean management concepts through improved knowledge and information exchange
Improvements in knowledge and information exchange support the ability of management in performing its tasks. Best practice case study analysis may provide references on opportunities and improvement potential.

Objective 7E: Institutional infrastructures for SME management support
The design of organizational infrastructures does build on the identification, analysis, and evaluation of best practice experiences.

Objective 7F: Flexibility for optimal response to emerging risks
The objective does focus on the design and evaluation of flexible organizations, infrastructures and management models that support swiftly adaptation to changes in sourcing, in lifestyles, needs, risks or societal requirements.