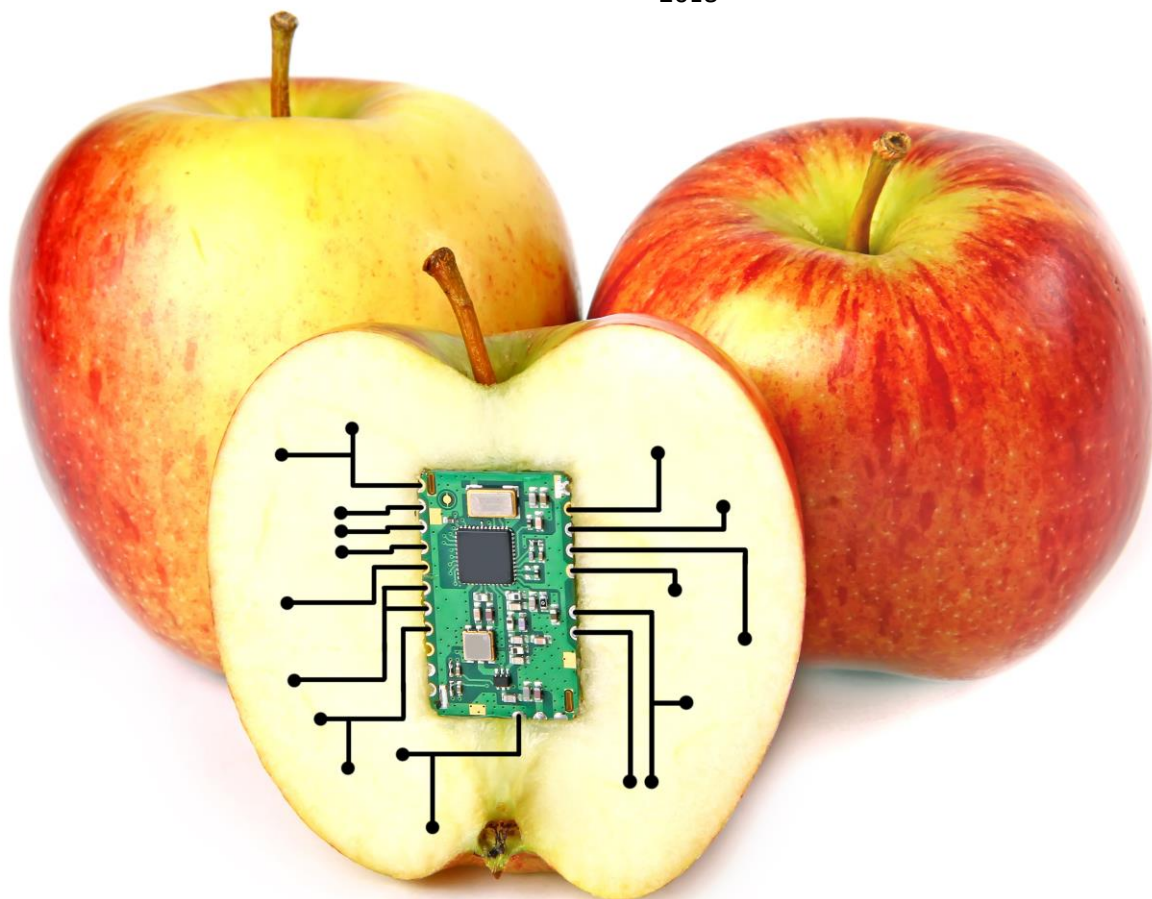


JRC SCIENCE FOR POLICY REPORT

Delivering on EU Food Safety and Nutrition in 2050 - Future challenges and policy preparedness

Kalliopi Mylona, Petros Maragkoudakis, Anne-Katrin Bock,
Jan Wollgast, Sandra Caldeira, Franz Ulberth

2016



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Delivering on EU Food Safety and Nutrition in 2050 – Future challenges and policy preparedness

Abstract

The foresight study 'Delivering on EU food safety and nutrition in 2050 - future challenges and policy preparedness' aims to aid policy makers in their assessment of the resilience of the current food policy and regulatory framework with a time horizon to 2050, contributing to ensuring that EU citizens continue to enjoy high standards of safe, nutritious and affordable food.

The study employed the methodology of scenario development. The scenarios were constructed based on different developments of specific drivers that can significantly impact and bring change to the food system; these are global trade, EU economic growth, agro-food chain structure, technology uptake, social cohesion, food values, climate change, depletion of natural resources and world population growth.

For each scenario, a number of food safety and nutrition challenges were identified and prioritised based on their importance and likelihood to occur. On this basis, scenario-specific policy options were developed as suggestions to policy-makers on how to address these challenges to ensure the resilience of the future EU food safety and nutrition regulatory framework. Research needs were also identified to complement the proposed policy options, as well as a set of food-chain related indicators that could inform in advance if the EU is headed towards one of the study's scenarios.

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Foreword

The competent services of the European Commission strive to ensure the health and well-being for the more than 500 million European citizens while allowing them to pursue their various social and economic interests. Access to safe and nutritious food to meet individual citizens' choices is a key element of health and well-being; but striking the balance between facilitating the widest possible choice of foodstuffs and guaranteeing the safety of an ever-growing variety of origins, ingredients and production methods is a delicate task.

While a broad range of forward-looking studies and reports examine food security by addressing the question of food production for a growing human population, future challenges in food safety and nutrition quality are usually not particularly studied. Still, food safety cannot be taken as automatically granted, despite the fact that today, our regulatory system in the EU guarantees a very high level of food safety. The key to ensuring food safety also in the future is a forward-looking approach. This involves anticipating challenges and developing strategies promptly to tackle emerging risks – both biological and chemical – as well as addressing regulatory and market failures, while also considering overarching challenges such as climate change, migration flows and the declining biodiversity. Looking into the major drivers of future developments should help identify the areas of highest future risks and provide the basis to analyse the existing legal and policy framework within the context of future vulnerabilities and foreseeable challenges. A longer-term perspective should help seek solutions in a proactive and anticipatory manner, pre-empting preventable crises and complications, and also defining the main problematic areas related to the healthy nutrition of future generations.

This report is a stepping-stone in this process, neither its end nor its beginning. It does not aim to compete but rather to add to the on-going discussions by well-established contributors in the area of forward-looking studies, be it the European Commission's Scientific Committee on Agriculture Research (SCAR) or the dedicated publications of the United Nations Food and Agriculture Organisation (FAO).

By analysing four scenarios and their underlying drivers and resulting challenges, this report aims to identify policy options both within and outside the remit of the European Commission. While allowing for a global perspective, the objective is to feed into the process of defining concrete measures and tools for solving the major challenges within the European food regulatory and policy context.

This report is, therefore, a substantial contribution by the European Commission to the identification of future challenges in the global food system, with a unique focus on its inherent tasks in the area of food safety and nutrition. The intention is to engage in the global debate, stimulate forward thinking and subsequently provide input to global policy design and implementation that reflects Europe's leading role in food safety.

Finally, I would like to thank the teams from the Joint Research Centre and DG SANTE for their excellent, and in some aspects, pioneering work towards this achievement and wish all of you a rewarding and insightful reading.

Ladislav Miko

Deputy Director General for Food Safety

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Executive summary

The foresight study “Delivering on EU food safety and nutrition in 2050 - future challenges and policy preparedness” aims to aid policy makers in their assessment of the resilience of the current food policy and regulatory framework with a time horizon to 2050, contributing to ensuring that EU citizens continue to enjoy high standards of safe, nutritious and affordable food.

The study employed the methodology of scenario development. The scenarios were constructed based on different developments of specific drivers that can significantly impact and bring change to the food system; these are global trade, EU economic growth, agro-food chain structure, technology uptake, social cohesion, food values, climate change, depletion of natural resources and world population growth.

For each scenario, a number of food safety and nutrition challenges were identified and prioritised based on their importance and likelihood to occur. On this basis, scenario-specific policy options were developed as suggestions to policy-makers on how to address these challenges to ensure the resilience of the future EU food safety and nutrition regulatory framework. Research needs were also identified to complement the proposed policy options, as well as a set of food-chain related indicators that could inform in advance if the EU is headed towards one of the study’s scenarios.

“Global food” scenario

“Global Food” is in some way a projection to 2050 of the situation in which the EU finds itself in 2015; an even more interconnected global food chain with increased global trade and a more concentrated food industry. However, climate change and depletion of natural resources have a significant impact on primary production and sourcing of raw materials. Global trade, technologies and innovation compensate for the barriers these factors pose to the food system. The mainly urban population in Europe, with its increased sedentary behaviour, decreased physical activity and over-consumption of highly processed foods rich in energy, fats, sugar and salt, faces significant health challenges, such as increased prevalence of obesity and non-communicable diseases. The main food safety and nutrition challenges and related policy options in “Global Food” are summarised in Table 1.

As the challenges faced in “Global Food” are in essence an amplification of issues already encountered today, many of the policy options do not introduce new measures, but rather aim to improve existing policies and provisions and enhance their implementation. Harmonisation of food safety standards at the global level, improved risk assessment based on global cooperation, vulnerability analysis, enhanced implementation, inspection and controls along the entire food chain (both intra-EU and internationally) would allow a smoother functioning of the global food market.

Table 1 - “Global Food” main challenges and related policy options

| Main Challenges | Policy Options |
|---|---|
| <i>Differences in the handling of food in third countries due to diverging food safety standards</i> | Build efficient food safety standards that also include implementation details |
| | Promote co-regulation or enforced self-regulation by food business operators |
| <i>Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and current maximum residue levels)</i> | Enhance collaboration between risk assessment bodies at EU and international level |
| | Use horizon scanning to identify vulnerabilities in the supply chain |
| <i>Ability to perform official food-related controls</i> | Invest in long-term funding mechanisms |
| | Expand third country controls |
| | Enhance surveillance to ensure food safety during transportation |
| | Improve traceability employing technological developments |
| <i>Increased sedentary behaviour and snacking due to changed lifestyles</i> | Introduce fiscal measures such as food taxation or other financial incentives |
| | Promote reformulation towards healthier food options |
| | Introduce zoning and incentives for establishment of fresh food markets |
| <i>Diets based predominantly on highly processed foods and decreased availability of fresh produce</i> | Implement standards and guidelines for healthier options in public food procurement |
| | Fund national and European actions on balanced diets and access to fresh produce |
| | Improve nutrition education |
| | Improve the provision of nutrition information |
| <i>Abundance of voluntary food information and increased opportunity for misleading information</i> | Promote harmonisation of labelling at international level beyond language barriers |

Appropriately designed and monitored “co-regulation” i.e. sharing of specific regulatory tasks between regulatory authorities and the food industry, would allow for better use of the available public resources, while giving more flexibility to the food industry and facilitating innovation. Urgent action would need to be taken in relation to nutrition and the diet-related public health issues anticipated in this scenario. Implementation of nutrient profiles combined with incentives to improve food products via reformulation, more harmonised approaches in the provision of food information, improved nutrition education, as well as potential fiscal measures (taxation and incentives to respectively limit the consumption of certain nutrients (e.g. sugar or fats) or promote the consumption of healthy foods (e.g. fruits and vegetables)) may all have to be considered to avoid poor diets and their impacts on public health, state finances and workforce productivity.

“Regional Food” scenario

In “Regional Food”, the 2050 EU food chain looks quite different from the current one. Climate change and depletion of natural resources, coupled with an increasingly aware and concerned population, result in significant EU policy changes towards self-sufficiency, a circular economy model and the abandoning of major international trade agreements (the focus of this scenario has been the EU (as in 2015), however “regional” could stand for any region of the world that chooses to move towards self-sufficiency, abandoning global free trade). In this scenario, food is highly valued and is produced locally or regionally employing advanced technologies. Citizens are involved in food production even in urban settings and peer-to-peer trade becomes increasingly prevalent in this society. Food waste reduction and re-use are of particular importance, while diets are more environmentally sustainable through reduced consumption of animal protein and short food chains. Diets can

be less diverse due to the occasionally limited availability of fresh produce. The main food safety and nutrition challenges and related policy options in “Regional Food” are summarised in Table 2.

In the local and fragmented food system of “Regional Food”, while the food industry is expected to maintain its high level of food safety performance, the large number of individuals engaging in primary production and food preparation, lacking the safety know-how of the organised food industry, could result in an increased incidence of food-borne outbreaks at local level. Such challenges may require adaptation of the present legislative framework to also apply to individuals producing food, as these are currently not considered food business operators. Proactive education and accreditation initiatives to ensure a minimum level of food safety awareness and technology understanding for anyone engaging in food production would be necessary to mitigate the safety challenges of these food chains. At the same time, monitoring, enforcement and traceability systems would need to be re-organised and enhanced at Member State level, to effectively control the local and fragmented food production and distribution channels. Action may also be required to ensure that all consumers receive information on safety and nutrition aspects of their food, for example when food is obtained directly from the producer without any packaging and labelling. ICTs and social networks could be further exploited for this purpose. Finally, to ensure fresh produce availability and a varied diet all-year round or when temporary disruptions of local production occur, appropriate mechanisms such as food re-distribution and corrective market mechanisms such as the introduction of production quotas and stock maintenance might need to be established in the EU. These mechanisms can also be combined with consumer education on the seasonal availability of foods and their nutrition values.

Table 2 - “Regional Food” main challenges and related policy options

| Main Challenges | Policy Options |
|---|---|
| <i>Greater reliance for food safety on individuals engaging in food production</i> | Expand the scope of the General Food Law, hygiene regulations and related controls to include individuals engaging in food production Implement the registration and vaccination of all livestock Establish a list of “high-risk” products Improve food safety education |
| <i>Failure to provide appropriate food safety information to the consumer</i> | Promote the use of social networks and ICTs by individuals engaging in food production to provide food information to their peers |
| <i>Re-introduction of food waste and organic side-stream products in the food chain</i> | Expand the scope of the General Food Law and feed hygiene regulations to individuals engaging in food production Establish communal food waste handling or recycling centres Educate individuals engaging in food production on the re-use of food waste |
| <i>Temporary shortages of fresh produce and food poverty in a self-sufficient food system</i> | Establish emergency mechanisms for food re-distribution Introduce production quotas to ensure balanced diets during temporary shortages Educate consumers to ensure adequate nutrition during temporary disruption of fresh produce |

“Partnership food” scenario

“Partnership Food” is characterised by an economically weak EU with close trade and food policy ties with a strong global player (for this scenario the US and Canada were used assuming that the existing ties would facilitate such a move) and little trade with the rest of the world. The stagnation of the European economy contributed to the EU losing importance in geopolitics and trade, especially in agriculture and food. EU citizens embrace technological innovation in the agro-food sector, which is however mostly developed in the US and Canada, since food technology innovation and R&D investments are at an all-time low in the EU. The European society in 2050 does not value food highly; food choice is driven by price and convenience and characterised by a food culture focused on the consumption of highly processed foods and out-of-home eating. Activities in the agro-food chain concentrate on efficiency, mass production and climate change resilience. The main food safety and nutrition challenges and related policy options in “Partnership Food” are summarised in Table 3.

In “Partnership Food”, the loss of scientific and technological expertise in the EU can have serious repercussions for the food system: increased vulnerability to food fraud, inappropriate use of novel technologies leading to food safety hazards, as well

as negative impacts on the EU economy due to the central role the food sector has in it. This loss of technological know-how resulted from reduced investment in R&D and from barriers to innovation, such as consumer scepticism and resistance to new technologies or a cumbersome legal framework. The suggested policy options discuss how to lift barriers to innovation, e.g. by reducing the cost of regulatory compliance, increasing co-operation between authorities and food business operators and further improving consumer perception of new technologies. In the future, the EU society may need to select where to best focus its limited investments and prioritise between equally important aspects of the food system. In “Partnership Food”, food safety and nutrition literacy will deteriorate, impacting on basic hygienic food preparation and the capacity to make informed and healthy dietary choices. Policy options to address this include mandatory food safety and nutrition courses in schools and continuous education via life-long learning ICT-based programs. Strengthening exchanges between the partners’ consumer organisations (by analogy to Transatlantic Consumer Dialogue) has also been proposed as a means of sharing information and practices. “Partnership Food” faces nutrition challenges and public-health issues similar to those encountered in “Global Food”, and therefore, the measures suggested to tackle them are similar.

Table 3 - “Partnership Food” main challenges and related policy options

| Main Challenges | Policy Options |
|---|--|
| <i>Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information</i> | <ul style="list-style-type: none"> Introduce mandatory food safety and nutrition education and information on food technology advances Increase exchange between consumer organisations |
| <i>Diets based predominantly on highly processed foods and decreased availability of fresh produce¹</i> | <ul style="list-style-type: none"> Introduce fiscal measures such as food taxation or other financial incentives Promote reformulation towards healthier food options Introduce zoning and incentives for establishment of fresh food markets Implement standards and guidelines for healthier options in public food procurement Fund national and European actions on balanced diets and access to fresh produce Improve nutrition education Improve the provision of nutrition information |
| <i>The loss of scientific and technological know-how in Europe</i> | <ul style="list-style-type: none"> Foster innovation and competitiveness by improved food governance mechanisms Reduce cost of regulatory compliance Improve consumer understanding of innovative products and technologies through transparent communication Increase co-operation with food business operators |
| <i>Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)</i> | <ul style="list-style-type: none"> Re-enforce risk-benefit assessment and management Streamline risk assessment by increasing the collaboration between all actors |

¹ This challenge in “Partnership Food” is of similar nature as in the “Global Food” scenario, and therefore the policy options proposed fit both scenarios equally well. Further discussion on this issue in Section 1.2.4.

“Pharma food” scenario

“Pharma Food” describes a world with globalised trade and a strong EU economy, and a population that strives for a healthy lifestyle. To achieve this in a context where fresh produce may be limited due to climate change effects, people turn to functional, processed foods and even foods with added pharmaceutical substances (“phoods”), in a personalised diet regimen aimed at optimising their health status. Multinationals control most of the food chain as the investments needed for research and placing such foods on the market are too high for small and medium sized enterprises. Decades of careful attention to food safety, as well as inspiration from the rigorous quality and safety controls applied in the pharmaceutical sector, result in a highly controlled, transparent and traceable EU food chain and this ensures trust and technology acceptance by the consumers. The main food safety and nutrition challenges and related policy options in “Pharma Food” are summarised in Table 4.

The challenges in “Pharma Food” mainly arise from the global liberalised trade system and the predominance of personalised nutrition and “phoods” in EU diets. Difficulties to perform official food-related controls in this scenario stem from the globalised sourcing of food and pharmaceutical ingredients that are present in “phoods”, as well as the production of foods and “phoods” by individuals at home, using novel technologies. Also, regulatory authorities will face difficulties to keep up with the fast-paced development of such new products and technologies. Policy options that may address these include, respectively, expanding third-country point of origin controls, introducing a certification scheme for home “phood” manufacture

and implementing post-market monitoring of new products and technologies. The need to provide a legal framework that could cover the nature of personalised diets and “phoods” in this scenario has also been identified. Additionally, the high complexity and number of active compounds, including pharmaceuticals, present in foodstuffs, bear a high risk of adverse health effects due to cocktail effects; therefore, to address the challenge of performing risk assessment related to cumulative and mixture effects (antagonism and synergy), the improvement and expansion of existing *in silico* computational tools will be needed.

Conclusions

Within the boundaries of this study, the EU legislative framework governing food safety appears to be robust and appropriate. However, certain elements would need to be strengthened to better prepare for future challenges: harmonisation and streamlining of risk assessment approaches and inclusion of risk-benefit assessment, need for a benchmarking system to monitor the performance of the EU’s regulatory system related to food safety and nutrition, an effective early-warning system for emerging hazards, adaptation of official controls and inspections to future needs, provision of clear food information to the public and investment in food and nutrition education. The latter has also been identified as a cornerstone of a society able to tackle current and future challenges in nutrition and health, along with crucial backing by governance that – together with all stakeholders – maintains nutrition and health high on the agenda.

Table 4 - “Pharma Food” main challenges and related policy options

| Main Challenges | Policy Options |
|---|--|
| <i>Potential drawbacks of personalised nutrition and “phoods”</i> | Adapt or create an effective regulatory framework Redefine health and nutrition claims |
| <i>Ability to perform official food-related controls</i> | Regulate “phood” manufacture by introducing a “Phood licence” Enhance post-market monitoring and “nutrivigilance” controls Expand third country controls |
| <i>Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)</i> | Deal with cumulative effects and long term exposure |

Introduction

Food safety and nutrition in the EU

The provision of safe, nutritious, high quality and affordable food to the EU consumer is the goal of EU policy covering food production, supply and consumption. The EU food policy and legislative framework enforces or proposes respective standards and requirements that not only ensure a high level of food quality but also position the EU in the competitive global market.

EU food legislation is based on an integrated and comprehensive approach, and covers all steps of the food and feed chain (“from farm to fork”): primary production, food processing, packaging, storage, transport and placing on the market. In addition to food safety requirements, regulations in the area of food labelling and nutrition aim to protect consumers, particularly those who are vulnerable and to guarantee their right to information so that they can make informed choices about the food they consume. EU food legislation is harmonised across the EU in order not to pose barriers to internal trade and to ensure the efficient functioning of the internal market, also with a view to the economic importance of the agro-food sector (including food & drink industry, agriculture) for the EU. The sector employs approximately 20% of the European workforce and the EU is currently the biggest exporter and importer of food and drink worldwide¹.

Today, EU citizens enjoy one of the highest levels of food safety in the world, but the past and recent crises linked to bovine spongiform encephalopathy (BSE), the Enterohaemorrhagic *E. coli* (EHEC) or the horsemeat scandal highlight vulnerabilities that can compromise these high standards. Also new food safety challenges can emerge from the increasing complexity of the food chain. Substantial public health and economic gains can be reaped by improving diets and lifestyles in the EU, given the increasing rates in overweight, obesity, poor diets and physical inactivity.

These risk factors are known to raise the likelihood of diet-related non-communicable diseases such as cardiovascular diseases, diabetes and cancer, costing the EU an estimated 196, 100 and 126 billion euros per year, respectively² and accounting for 77% of the disease burden³. Resulting diminished resources within families, prolonged disability, reduced productivity and capital formation⁴ have negative implications for quality of life and the economy. The significant socio-economic inequalities seen between the Member States and

different population groups must also be considered in the context of the EU food safety and nutrition frameworks.

The EU General Food law is currently being reviewed in the context of the European Commission’s Regulatory Fitness and Performance programme (REFIT)⁵. The exercise assesses among others the effectiveness of this act based on past experiences. The review of other food-related legislation might follow. However, possible future developments will also have an impact on the functioning of the regulatory framework. Food production and consumption are part of a complex food system, which is influenced by many different factors. Apart from demographic developments such as worldwide population growth or environmental developments such as climate change, other important factors such as technological advances or the global economic and trade framework could potentially result in new challenges for the food system or in exacerbating existing challenges. The policy must be able to respond to slow and gradual or pressing and fast-changing developments and this may only be achieved through preparedness and proactive policy-making, requiring anticipation of possible future changes and challenges.

Aims and scope of the study

The foresight study ‘Delivering on EU food safety and nutrition in 2050 - future challenges and policy preparedness’ aims at complementing the REFIT exercise with insights on possible future challenges and their policy implications. The study was carried out by the Directorate General Joint Research Centre (JRC) with and for Directorate General for Health and Food Safety (DG SANTE) between January 2014 and December 2015. It took stock of a previous scoping study⁶ and engaged many Commission colleagues and more than 30 external experts and stakeholders⁷ working on the many diverse aspects of the food system.

Specifically, the study aims to aid policy makers in their assessment of the resilience of the current food policy and regulatory framework over the next 3 to 4 decades. The study includes:

- the development of scenarios for the EU in 2050 that systematically illustrate possible combinations of future developments;
- the identification of critical challenges to food safety and nutrition in each of the scenarios and their potential implications;
- a set of indicators that can flag particular scenario-related developments and the potential for the critical challenges to take place;

¹ Eurostat (2011) From farm to fork

² Estimates by the European Heart Network 2012, OECD 2014 and Luengo-Fernandez et al, Lancet, 2013.

³ WHO Europe (2011). Action plan for implementation of the European Strategy for the Prevention and Control of Noncommunicable Diseases 2012–2016. (http://www.euro.who.int/__data/assets/pdf_file/0003/147729/wd12E_NCDs_111360_revision.pdf)

⁴ World Economic Forum on the global burden of NCDs. (http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf)

⁵ http://ec.europa.eu/smart-regulation/refit/index_en.htm

⁶ European Commission (2013): Scoping study: Delivering on EU food safety and nutrition in 2050 – Scenarios of future change and policy options; http://ec.europa.eu/food/food/docs/final_report_scoping_study_en.pdf

⁷ See acknowledgements

- proposals for possible policy options and related research needs for the development of a more resilient EU food safety and nutrition policy and legislative framework.

The study focuses on aspects such as food product safety and nutritional quality as well as food consumption habits. It thus complements several other forward-looking studies that have been carried out with a strong focus on food security regarding primary production and food availability.

How this report is organised

The present report summarises the results of the study. It first describes in detail the foresight methodology and the process that was used. This is followed by an overview of the current EU food safety regulations as well as the nutrition and public health-related policies that govern the food chain and consumers' health in Europe. These are described in more

detail in the JRC report "Overview of the food chain system and the European regulatory framework in the fields of food safety and nutrition". Subsequently, the different factors that may/will affect and shape our food system – called drivers – are briefly described. These drivers and their possible future developments are at the heart of the four scenarios developed in this foresight study. Each 2050 scenario and the way EU developments have shaped it are consistently described. Also, all the challenges that were identified as possibly affecting the food chain in these scenarios are listed and their impacts on food safety and nutrition described (detailed descriptions can be found in the Annex). For those challenges that were prioritised and further developed, policy options are proposed, that could ensure the resilience of the food system. The report also presents scenario-specific indicators; data on these indicators can provide early signals for specific developments and allow policy makers to implement appropriate policy options promptly. Finally, the main conclusions of the study are presented.



Foresight approach and process

The foresight approach

Future-oriented reflections are essential for any policy to meet new challenges proactively. Foresight is a process aimed at providing the necessary anticipatory intelligence to shape medium- to long-term policies. It enhances forward-looking thinking by gathering a wide range of stakeholders and knowledge sources and by systematically exploring alternative perspectives on the future to guide today's decision-making. In contrast to predicting the future, Foresight considers the future as something that can be created and formed. In this sense, Foresight supports actors and stakeholders in actively shaping the future.

Foresight methods (i.e. vision building, scenario building, Delphi, etc.) are used to structure the debate on possible futures to ensure the emergence of collective intelligence from all relevant stakeholders and experts. Also, Foresight methods are designed to help thinking escaping the constraints of established pathways.

Scenario development and analysis

In the present study, the 'scenario development' method was used. Scenarios are tools to illustrate possible combinations of developments from the present to the future and to explore their potential impacts. The introduction of views that go beyond the well-known linear projections can foster a better understanding of alternative pathways and possible implications of today's actions.

To be effective, scenarios need to meet four requirements:

- plausibility, i.e. the scenario falls within the limits of what might conceivably happen;
- consistency, i.e. the various elements and factors in a scenario should not conflict and threaten its credibility;
- diversity, i.e. the scenarios should be structurally different to cover distinct directions of possible future developments;
- decision-making utility, i.e. scenarios should contribute insights into the future, facilitating decision-making on the questions at hand.

The four scenarios developed for this Foresight study are exploratory, i.e. they do not represent a certain vision or necessarily a desirable future. On the contrary, to make the scenarios useful for assessing the resilience of the current EU food safety and nutrition framework, the scenarios need to include potentially challenging developments. Furthermore, in the scenarios some developments are pushed to the extreme to emphasise the differences between the scenarios and the distinction to today's situation. Taken together they represent four divergent directions the EU could pursue, while the reality might turn out to combine elements of different scenarios. Along the same lines, these scenarios do not necessarily represent the only plausible futures; other combinations of driver developments and resulting scenario variations are possible.

For example, economic stagnation in the EU does not necessarily go hand in hand with close trans-Atlantic ties, as described in one of the scenarios in this study.

The scenarios in this study were developed based on the drivers identified in the scoping study. That study identified 10 'key drivers' for food safety and nutrition based on literature review and an expert workshop. These key drivers, with some adaptations⁸ to ensure the necessary comprehensiveness and precision, were taken as the basis for the in-house development of four distinct scenarios.

In a first step, the drivers were analysed to identify the possible future directions of their development. At a one-day internal JRC workshop involving JRC experts with expertise in food, agriculture, foresight, engineering, behavioural and social sciences, different combinations of possible future evolutions of the drivers were tested against the four basic requirements indicated above, i.e. plausibility, consistency, diversity and utility. Emphasis was put on those driver developments that could have a challenging impact on the food chain. To limit the complexity of the exercise but simultaneously creating a strong background pressure on the food system, it was decided to use similar projections for global population growth, depletion of natural resources and climate change for all four scenarios. The starting points for the following scenario development were the drivers Global Trade and Food Values, being equally important for both food safety and nutrition. The other drivers were then added in constellations that gave rise to meaningful scenarios. Once the driver constellations per scenario were determined, smaller subgroups developed more detailed scenario outlines.

Table 5 provides an overview of the main characteristics of the drivers in each scenario.

The study team further developed the scenarios and described the evolution towards, as well as the situation in 2050, focussing on the European food system and its actors. They are not aimed at predicting the future or describing preferred futures.

The following additional considerations were taken into account for building the scenarios:

- The scenarios focus on the EU without taking into consideration national or regional differences within the EU.

⁸ The driver 'global economy and trade' was changed for the sake of more precision into 'global trade' and 'EU economic growth'; 'Global cooperation and standard setting' was subsumed under global trade as a requirement for a functioning global market; 'EU governance' was not used since EU regulation and EU governance was assumed to remain more or less unchanged; 'New agro-food chain structures' was kept; 'Demography and social cohesion' was kept as two distinct drivers; 'Consumer attitudes and behaviour' was kept as 'Food values' (extent to which food production, offer and choices reflect environmental and health values); 'New food chain technologies' was kept and further specified as 'Technology uptake'; 'Competition for key resources' and 'Climate change' were kept; 'Emerging food chain risks and disasters' was not used as we understood it rather as a test for the resilience of the system than as a useful driver to develop scenarios to identify future challenges.

Table 5 - Overview of driver characteristics per scenario

| Driver | “Global Food” | “Regional Food” | “Partnership Food” | “Pharma Food” |
|--------------------------------|---|---|-----------------------------------|---------------------------------------|
| Global trade | Full liberalisation | Disrupted and fragmented | EU trade focus on the US & Canada | Full liberalisation |
| EU economic growth | Medium | Decoupled, GDP no longer used as indicator | Stagnation | High |
| Agro-food chain structure | Concentration | Diversification, alternative food chains | Concentration | Concentration |
| Technology uptake | High | High with focus on environmental sustainability | High | High with focus on nutrition & health |
| Social cohesion | Low | High | Limited to local community | High |
| Food values | Low | High with focus on local production & quality | Low | High with focus on nutrition & health |
| Climate change | 2°C threshold of temperature increase will be reached by 2050 | | | |
| Depletion of natural resources | Progressive natural resource depletion towards 2050 | | | |
| World population growth | World population will increase to about 9 billion by 2050 | | | |

- Since the objective of the study is to assess the resilience of the EU legal and policy framework the scenarios are based on the assumption that the EU will continue to exist in its current form in 2050. This does not exclude changes in the internal organisation of the EU, e.g. further integration.
- Technological development will continue in all scenarios, particularly in information and communication technologies (ICT). ICT are assumed to permeate many aspects of daily life in all the scenarios and EU citizens have knowledge in using these technologies. Also food related technologies will develop further in all scenarios; however, focus and uptake differ.
- So-called wild cards, i.e. low probability, high-impact events such as conflicts, major harvest failures, or the break-up of the EU have not been considered. Such game-changing events would most probably shift attention away from food safety and nutrition towards food availability/security or would go against the objectives of the study in the case of the EU break-up. At a later stage meaningful stress-test of the scenarios using wild cards could bring additional useful information regarding the resilience of the prevailing food systems in the different scenarios.

The scenarios were discussed, agreed and analysed in two workshops, organised between March and October 2015, involving a total of about 70 experts and stakeholders. The participants from academia, Member State and European regulatory authorities, public health institutes, consumer organisations, food industry and the European Commission

covered a broad range of backgrounds reflecting the diversity of relevant aspects linked to food safety and nutrition: nutrition & diets, behavioural sciences, functional foods, life cycle assessment, agriculture, aquaculture, food technologies, food contact materials, food safety, EU food law.

The first workshop (18 & 19 March 2015) aimed at exploring, debating and improving the four alternative scenarios developed by the JRC. The finalised scenarios were then used for identifying the challenges for food safety and nutrition in each scenario.

The JRC further developed the identified challenges as input to the second workshop (12 & 13 October 2015). Participants of that workshop were tasked with discussing and complementing the food safety and nutrition challenges per scenario before selecting those they considered most important for each scenario. The prioritised challenges were then used to assess the readiness of the current food safety and nutrition regulatory and policy framework in addressing them. Also, relevant related knowledge gaps were identified, as well as indicators that would help policymakers anticipate which of the four scenarios the EU is heading to.

An overview of the study process is given in Figure 1. A full description of the challenges identified per scenario can be found in the Annex. The scenarios and the prioritised challenges and policy options are described in detail.

Study process overview

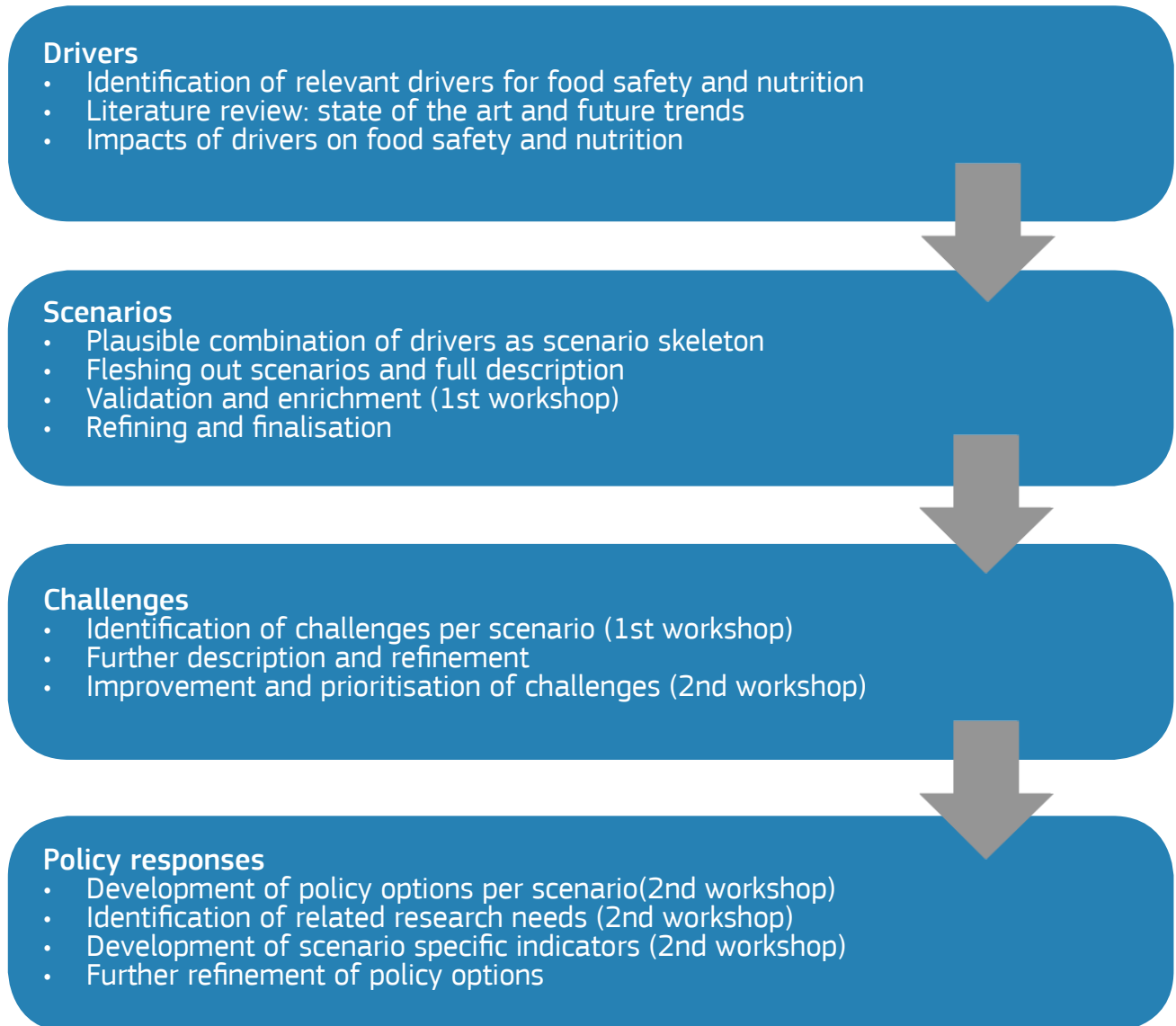


Figure 1 - Study process overview and details of each stage

The EU food chain and the food safety and nutrition regulatory framework

The food chain

The food system is complex and too broad to be addressed here in its entirety. The food chain is a part of it and while it is often defined as “from farm to table” or “from farm to fork” it also encompasses more than that. Inputs into primary production, such as water, soil, plant and animal reproductive material constitute the starting point of this chain that includes as well chemicals used as plant protection products, veterinary medicines and fertilisers. Primary production refers to the production of food of plant origin and feed, as well as products of animal origin, eggs and milk, followed by their harvesting and use for further processing or direct storage for short or longer time. At the manufacturing step of the food chain, different processes take place, resulting in products consisting of single raw materials or more complicated process flows with the incorporation of chemical additives for different purposes. Waste generated in this step of the food chain may be used in the manufacture of other products. Finished products are subsequently packed and labelled and stored again before being placed on the market through different channels. The food chain, however, does not stop at the point of sale, but rather at consumption, where food is further prepared and served at restaurants or further stored and processed by the consumer at the household level. Another important aspect of the food chain is transportation that takes place in all the steps of the food chain, from the raw materials to the handling of food by the consumer after purchase.

Figure 2 provides a model of the food chain system (modified from (EU, 2013⁹)). This food chain model can apply to all different food categories, however simple or complex.

The food safety and nutrition regulatory framework

Ensuring the highest standards of food safety is a key policy priority in the European Union (EU) as indicated in the White Paper on food safety¹⁰. This is based on an integrated and comprehensive approach and achieved through the implementation of food legislation across all the steps of the food and feed chain. The European legislation is based on the foundations of risk analysis and its three components, risk assessment, risk management and risk communication. By using the highest quality of scientific advice in risk assessment, as provided by the European Food Safety Authority and employing the precautionary principle in risk management, also through independence, excellence and transparency, a regulatory framework has been built that assures EU citizens of the integrity of their food supply.

⁹ EU, 2013. Commission SWD (2013) 516 final, A fitness check of the food chain: State of play and next steps

¹⁰ COM, 1999, 719 final. White paper on food safety

The food safety legislation is harmonised in the European Union in order not to pose barriers to internal trade within the Union. Food safety is a shared responsibility between different stakeholders in the food chain and in the feed chain as well. The primary responsibility lies with food business operators and food manufacturers. Traceability is another important aspect highlighted in the White Paper and incorporated in the General Food Law (Regulation (EC) No. 178/2002¹¹) towards ensuring food safety. The White Paper makes reference to other factors that should be considered in decision making to ensure consumer health protection. These include animal welfare, sustainability, product quality, consumer expectations and consumer information on product characteristics and their production methods.

In the area of nutrition, a coherent and comprehensive Community Strategy to address the issues of overweight and obesity and reduce the risks associated with poor nutrition and limited physical activity was introduced in 2007, focussing on the action that can be taken at local, regional, national and European levels¹². It has resulted in or affected a range of EU policies that influence and provide means of improving nutrition, encompassing *inter alia* rules on content and marketing of food products and information to consumers to ensure the effective functioning of the internal market whilst providing a high level of consumer protection. It also relates to policies in the areas of agriculture, transport, information society, education and culture, regional policy and research. Also, action-oriented partnerships between the Member States, the Commission and the World Health Organisation or between the public and private sector and between the food industry and different parts of the civil society have been put into place. These involve exchange of information and best practices, agreeing on common frameworks and committing to shared goals and targets as well as by putting forward voluntary commitments. Given the complexity and interaction of factors influencing consumers' nutrition and lifestyle behaviours and ultimately health, these integrated multi-faceted approaches involving all parts of the society are favoured as effective ways to address common EU health challenges¹³. Finally, the Commission in partnership with Member States and the WHO has set up monitoring and reporting mechanisms, using existing national and global indicators and monitoring systems to take stock of policies and activities, as well as to monitor and evaluate developments in risk factors and health outcomes.

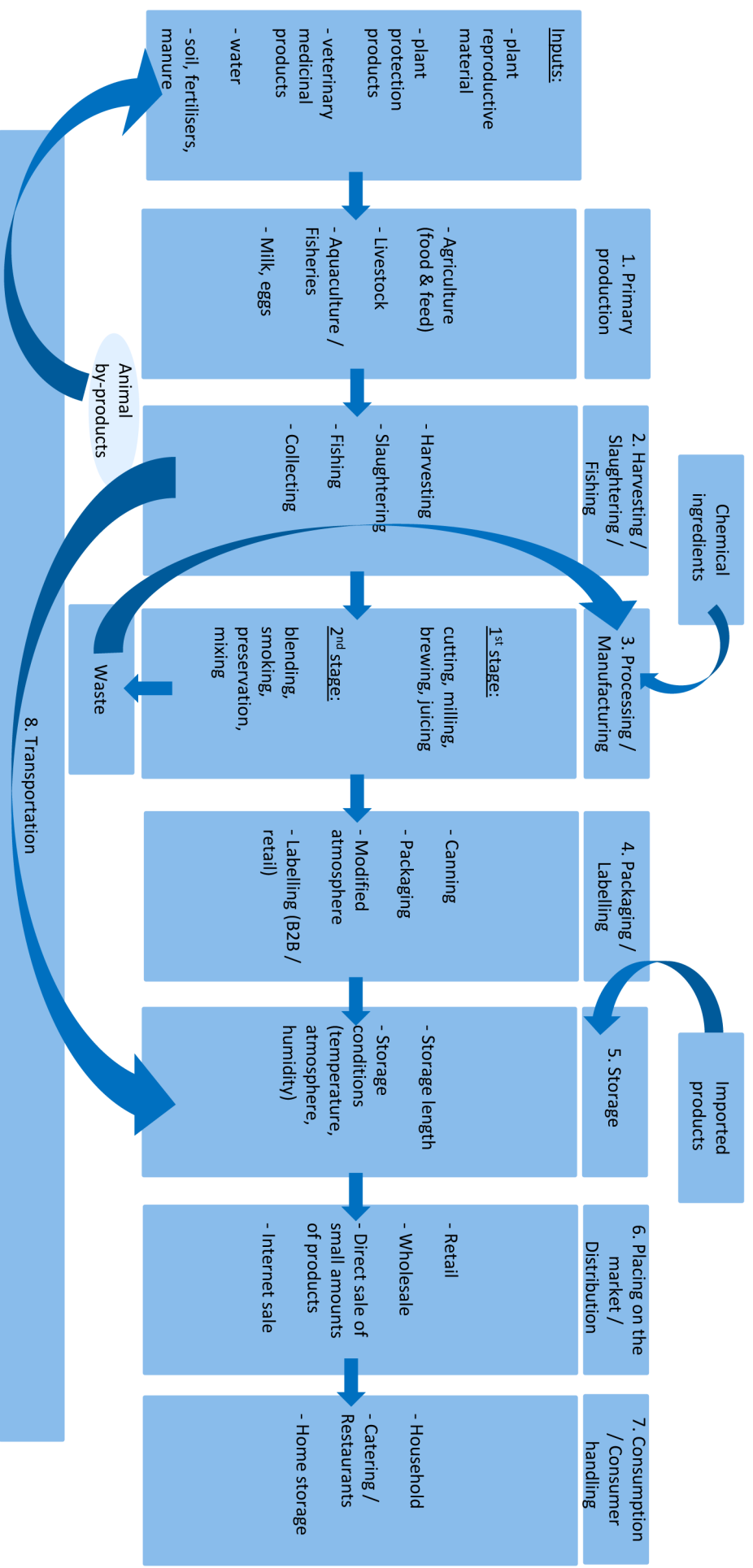
The functioning of the food chain system for the delivery of safe and nutritious food is based on the effective implementation of food legislation.

¹¹ Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

¹² COM (2007) 279 final. White paper on a Strategy for Europe on Nutrition, Overweight and Obesity related health issues

¹³ Council conclusions on nutrition and physical activity. (2014/C 213/01)

The food chain overview



Modified from: Commission SWD (2013) 516 final 'A fitness check of the food chain: State of play and next steps'

Figure 2 - Overview of the food chain

To ensure the appropriate implementation of European legislation, the Member States maintain a system of competent authorities and official controls. These authorities are responsible for monitoring and enforcing food safety through the national control systems, while the Commission is responsible for evaluating the performance of the different competent authorities. Important information for risk analysis can be gathered from controls, surveillance, laboratory analytical results and epidemiological studies and must be provided in a timely and reliable manner to allow for decision-making. Continuous monitoring and management of this information allows for the early identification of potential hazards and, therefore, empowers the Commission to respond pro-actively in preventing crises. The proper operation of these systems is monitored and audited by the Food and Veterinary Office, which is part of DG SANTE.

Food safety and nutrition legislation overview

The General Food Law that lays down the general principles and requirements of food law and establishes the European Food Safety Authority, as well as the legislation on official controls (Regulation (EC) No. 882/2004¹⁴), are regulatory documents described as horizontal, implying that they apply to all the steps of the food chain. Additional specific requirements are laid down by specific Regulations on issues such as food additives, veterinary medicinal products, food hygiene, genetically modified organisms, food contact materials, food information to consumers, etc.

Figure 3 provides an overview of the current food safety and nutrition legislative framework in Europe and is set around the model of the food chain system of Figure 2, also capturing the major food safety and nutrition legislation areas. These are depicted along the food chain and placed immediately before the step where they are perceived as being of more direct relevance. The system presented here has been tested in a subsequent step under different future scenarios, to assess its resilience to any expected or unexpected developments and challenges.

The detailed JRC report “Overview of the food chain system and the European regulatory framework in the fields of food safety and nutrition”¹⁵ summarises the existing legislative framework in the fields of food safety and nutrition, structured following the food chain system overview of Figure 3.

Drivers

The food system is dynamic, constantly influenced and shaped by several factors such as the environment, climatic condi-

tions, global political and socio-economic situation, scientific and technological developments and consumers’ demands and preferences. The specific drivers used for the construction of the scenarios in this study are briefly described below, in terms of importance to the food system and future trends.

World population growth

World population growth is important in terms of future food demand, relating to sufficient food production and food security, given the prospect of resources becoming potentially limited in the future. In parallel, demographic characteristics of the EU population such as household size and ageing levels can affect eating habits and dietary needs.

Main trends: Global population is expected to increase by 35% (compared to 2007) and reach 9.6 billion by 2050, with growth taking place particularly in Africa and Asia. The EU population is expected to remain more or less stable until 2060; both global and EU population will continue to age. The average household size in the EU-28 in 2013 was 2.3 persons/household; population age, fertility rates and rate of household formation and dissolution influence household size. Based on these factors, future households are not expected to exceed 1.9 persons on average.

Social cohesion

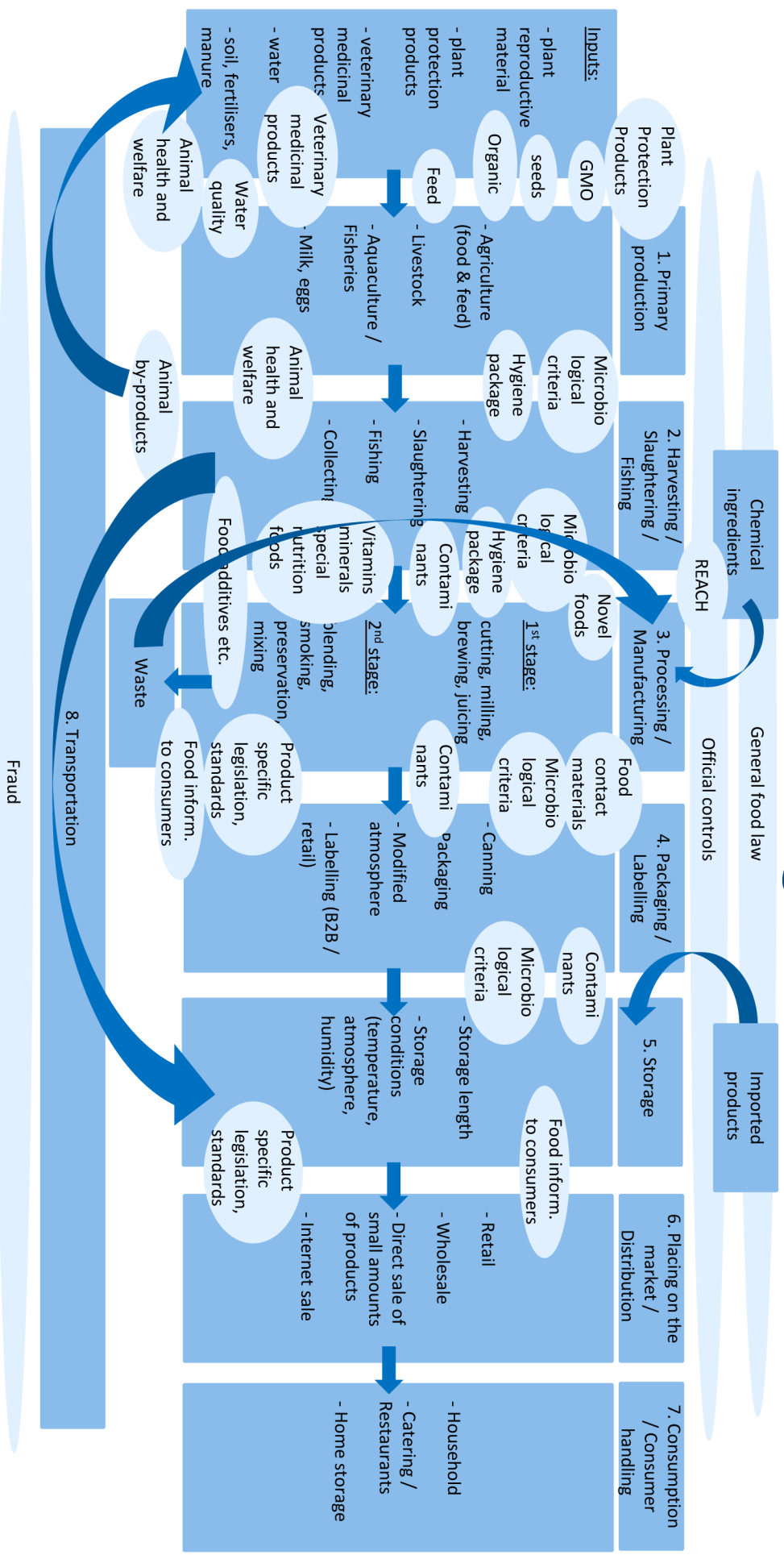
Household income inequalities and employment levels of the population are major indicators of social cohesion and reflect how the society deals with inequalities and possible social redistribution, particularly healthcare, education and other public services. Socio-economic status is linked to dietary quality, i.e. income inequalities can affect access to healthy diets; the resulting dietary inequalities can potentially lead to further social inequalities, threatening social cohesion.

Main trends: The average income gap in OECD countries is 1:9 (comparing the poorest 10% to the richest 10%, 2008 to 2011). In 2012 in the EU-28, on average the top 20% (highest equivalised disposable income) received 5.1 times as much as the lowest 20%. In 2012, 17% of the EU-28 population was at risk of poverty. This figure was slightly higher than in previous years with 16.5% in 2010 and 16.9% in 2011. The groups most affected by poverty are the unemployed and the retired; hence, the household structure can be an important determinant in buffering or exacerbating the poverty effects in such groups. For the period 2018-2050, the effect of an ageing population is expected to lead to a decline in total employment in Europe, which could translate into shortages in the labour market. This trend is exemplified by the fact that in 1990, older workers (over 55 years) provided 10 % of the global workforce, and in 2010, the figure rose to 14%. By 2030, this proportion could reach 22 %, and expected to surge even further to 40 % by 2060. Unemployment is predicted to fall in the EU-27 from 9.7 % in 2010 to 6.5 % in 2060; a similar trend is expected in the euro zone.

¹⁴ Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules

¹⁵ Mylona K., Livaniou A., Maragkoudakis P., Bock A.-K., Wollgast J., Caldeira S. and Ulberth F.; Overview of the food chain system and the European regulatory framework in the fields of food safety and nutrition. EUR 28033 EN. Publications Office of the European Union, Luxembourg, 2016, ISBN 978-92-79-60536-9, doi:10.2787/410688.

The food chain and legislation overview



Modified from: Commission SWD (2013) 516 final 'A fitness check of the food chain: State of play and next steps'

Figure 3 - Overview of the food chain system with the major food safety and nutrition legislation fields

Food Values

Food values reflect the importance consumers give to price, taste, convenience, environmental sustainability, health effects, fair-trade, ethical practices, animal welfare, etc. when choosing their food. They thus impact diets and food demand. For example, food values are strongly linked to individual health and wellbeing in general and play an equally important role at a societal level as well. Major non-communicable diseases like obesity, type 2 diabetes and cardiovascular diseases, which are a major burden for population health and national health systems are directly linked to unhealthy diets.

However, food values can also have a significant impact on environmental sustainability; diets rich in animal protein put further strain on diminishing natural resources, especially water and arable land. Food values and the dietary habits they result in is, therefore, an indispensable driver to consider in any expanded food system with significant impacts on multiple levels; personal, societal and global.

Main trends: An “average” EU consumer declares to understand the general concepts of a healthy diet, feels confident and well informed about food, and purchases food mainly from supermarkets, taking into account predominantly food quality, price and appearance. When thinking about food, taste and pleasure come first in mind but in general the EU consumer is also concerned about food quality, global food security and food origin. The EU consumer perceives food poisoning, chemicals, pesticides and toxic substances as the most important food safety risks. In general, EU consumers buy portioned, packaged, ready-made and convenience food, spending less time cooking at home and more time in out of home eating.

Across Europe, average availability of calories per capita from meat, vegetable oils and sugar has increased in the latter half of the 20th century. Fruit and vegetable consumption also varies significantly, with higher consumptions reported in Southern Europe. However, based on an EU average, fruit and vegetable consumption is in decline and remains below recommended levels, while EU Mediterranean countries have drifted away from their traditional diets towards increased consumption of meat, sugars, animal fats and non-olive vegetable oils.

Technology uptake

The extent to which new technologies are taken up and applied by food chain actors influences food production, the environmental and economic performance of the food chain, as well as food offer. Technological innovation can aim at various food and food-related aspects, including increasing productivity, increasing shelf life, inactivating pathogens or reducing allergenicity, coping with environmental challenges (e.g., climate change, natural resource scarcity), changing the nutrient composition (e.g., macro- and micronutrients, adding/enriching with functional compounds, energy content) or physicochemical properties (e.g., texture/sensory properties, processing suitability) of foods, improving functionality of food packaging, etc. Consequently, new technologies may provide answers to existing and emerging challenges in food safety/security and nutrition. However, new technologies may also include new risks for food production.

Strong scepticism by consumers towards new food and food-related technologies may prevent food chain actors from applying new technologies or investing in research and technological innovation.

Main trends: In general, it can be expected that continuous innovation leads to increasing development and use of new food and food-related technologies. However, whether societies would accept certain technologies is less clear; for example genome editing or genetic modification of organisms, synthetic biology, and nanotechnology. Potentially, in 2030, biotechnology could contribute to half of agricultural production and almost all of aquaculture and plantation forestry, for a total contribution of approximately 50% of primary production output within the OECD region in 2030. Regarding nanotechnology, investments and numbers of patents/patent applications are rapidly increasing, particularly in the area of food packaging to improve functionality. According to one forecast, by 2020, nanotechnology could bring about radical new approaches to assist crop production and storage. Finally, rapid developments are observed in the area of ‘functional foods’ and the dividing line between food and medicine may become blurred. It is envisaged that the development of functional foods will continue to grow in industrialised countries, fuelled by increasing life expectancy, higher prevalence of non-communicable diseases, increasing healthcare costs and the acceptance of the strong link between diet and health.

EU economic growth

The future development of the EU economy in terms of GDP not only determines the living standard and purchasing power of its citizens, which has a direct influence on diets, but also its influence and power in international standard setting, in a potentially highly competitive market for depleting natural resources. Also, the status of the EU economy will influence public spending not only on public healthcare, public services, education and research and development, but also on official controls and monitoring mechanisms in the food chain. These have an impact on nutrition and diets, innovation in the food system, as well as on the implementation of the legal framework on food safety and nutrition.

Main trends: The European Commission forecasts stable GDP growth rates for the EU for the future: until 2020, annual growth rates of 1.5% are foreseen, between 2021 and 2030 increasing to 1.6%/year, and slowing down to 1.3%/year up to 2060. Concerning the budget spent on healthcare, without policy changes for the EU, a further increase in healthcare spending of about 3% GDP until 2030 has been projected. The EU-27 share of global GDP in 2010 of 23% would decrease to 17% in 2025 and to 12% in 2050. Similarly, the US share would drop from 25% to 17% to 9% in 2050, while China’s GDP share would increase from 10% in 2010 to 22% in 2025 to 33% in 2050.

China is expected to become the largest world economy by 2050, and will, together with the EU and US represent 54% of global GDP. India will be the fourth largest world economy. OECD countries will represent 42% of global GDP, down from 77% in 2000.

Russia is expected to overtake the US in terms of GDP per capita by 2050; the EU27, Japan, and China will come close to US values, whereas Brazil and India will be at around 45% and 31%, respectively.

Global trade

The future extent of global trade liberalisation, including agriculture and food products, will affect the availability of resources and food products on the EU market, and might impact on the structure of the agro-food industry. Depending on how global trade develops, the ability of the EU to set food-related standards will be influenced. The food safety and food quality standards valid in the trade context, in turn, will affect the food supply from which the European consumer can choose.

Main trends: Over the past decades, global trade, measured as gross dollar value has grown sharply, on average nearly twice as fast as world production. Overall, world trade grew on average by 5% per year between 1990 and 2010.

At the same time, the dynamics of global trade changed: developing countries increased their share in global exports, while the share of industrialised countries decreased. During the same period, China has seen the largest increase, from 1% in 1980 to 11% in 2011. The EU, in 2013, accounted for 15% of global trade in goods (excluding internal EU trade), thus yielding the largest share of world trade (US: 12.9%, China 13.7%) with a trade value of USD 8.5 trillion. The main trading partners of the EU belong to the G20, with the US, China and Russia representing about 33% of EU export destinations (2012). China, with 16.2% ranks as the biggest source of imports to the EU, followed by Russia (11.9%) and the US (11.5%).

Regarding agro-food product trade, global agricultural production has nearly tripled since 1970, growing more quickly than the world population during the period. Growth was largest in emerging and developing countries, which today produce more than 50% of the world agricultural production. Global food transport has increased faster than food production, while at the same time the share of processed and branded food products increased compared to agricultural raw materials and staples. The EU is the largest importer of food, with vegetables and fruit (26.5 % of total food and beverage imports in 2010), fish, crustaceans and molluscs (21.9 %) and coffee, tea and cocoa (17.4 %) being the largest categories in terms of value.

Forecasts assume that world trade will continue to grow until 2030, with China and India each doubling their global market share during this period, both totalling about 25% of world trade, while the share of all developing countries would account for 65%. Developed countries are expected to face a decrease in their world market share, down to 35%, with the EU share declining by 10 percentage points due to weak economic growth; OECD projections assume that OECD countries will lose ground until 2060, particularly on trade in manufactured goods (including food) and services with emerging countries in Asia and Africa playing a much larger role.

Agro-food chain structure

The structure, i.e. the level of concentration of primary agricultural and livestock production, food industry, retail and food services sector is central to the food system, due to its potential impacts on food governance, employment, as well as accessibility and affordability of food.

Main trends: In the EU, one out of five people in the workforce in 2008 was employed in the food-chain sector, comprising 17 million holdings/enterprises and accounting for EUR 751008 million of added value (approx. 6% of EU27's GDP).

The EU agriculture sector accounted for more than 80% of all holdings/enterprises in the EU food chain in 2008, employing 55% of its workforce. Considerable variations exist in the size of commercial holdings between Member States; in southern Europe, the average commercial size was less than 10 hectares, while in central Europe over 100 hectares. In 2007, 16.4 million people worked on a regular basis in commercial agricultural holdings across the EU, with most of them (89%) being farm owners or their family members.

With a turnover of EUR 1048 billion, employing 4.2 million people and comprising 286000 companies, the EU food industry is the largest manufacturing sector (14.6% of total) in the EU and the leading employer (15.5% of total). Almost half (51.6%) of its turnover comes from SMEs, which also are the primary (64.3%) food and beverages employer. With a trade balance of EUR 23 billion, the EU food and beverages industry is a net exporter of food and drink products.

In the EU, "supermarketisation" is a growing trend, with the parallel reduction in specialised, independent grocery stores; non-specialised retailers account for the majority of food sales, despite the existence of independent grocery stores in southern Europe. Consolidation of the major brands is another observed trend, which can vary however between northern (high percentages) and southern (low percentages) Europe. Other observed trends include the reduction of supermarket sizes, matched by the appearance of mini-market grocery stores owned by supermarket brands, as well as "white" and "private" labels on food. Consolidation is foreseen to continue in the future, with the supermarkets expected to be the key players in food retailing.

The EU food sector is fragmented, mainly consisting of micro- or small-size holdings. However, regional variations exist, such as in northern Europe where food and beverage chains are fast becoming more prevalent. The food services sector is dominated by restaurants, mobile food and beverage services. Finally, food services account for approximately one-third of total EU consumer food expenditure.

Depletion of Natural Resources

Natural resources such as coal, oil, fertile land, water and minerals are largely considered finite. Apart from the few resources considered as inexhaustible (will not run out in the foreseeable future) such as solar radiation, geothermal energy, and air (though access to clean air may not be), they might

become scarce in the future. Quantity and quality of future food supply will be constrained by the limits of its main inputs, including land, water, energy and fertilisers.

Main trends: Land resources are likely to remain an important concern in food production in the next decades; moreover, due to global population growth, there will be a need to produce more food either by using more land or by improving yields. Currently, ca. 11% of the world's land surface is used to grow crops. Expansion of land is limited in the future since most of the productive land is already allocated to the production of crops and livestock. Water is another critical input for agricultural production, especially irrigated agriculture. In 2011, a total of 318 million hectares was equipped for irrigated agriculture, accounting for 22% of the total arable land. In the long term, FAO estimates that by 2030 total actually irrigated land can come close to this potential, i.e. increase to 314 million hectares, and also that this increase will be largely driven by an expansion in developing countries.

By 2050, water stress will mainly occur in North Africa and South Asia. In Europe, freshwater is mainly used for agriculture (42%), industry (23%), as well as urban use and energy production (both 18%). Future projections for Europe foresee that freshwater for irrigation use will not increase, especially in Southern Europe, and that it may even decrease under environmental pressures or due to urban demand.

N (Nitrogen), P (Phosphorus) and K (Potassium) are three essential nutrients for plant growth. Their availability in the form of fertilisers represents a key factor in the overall question of global food security as we move towards a population of 9 billion. Moreover, over 90% of population growth between 2010 and 2050 will occur in developing economies. It is legitimate to assume that in a more rapidly changing geopolitical situation and a less stable world, the question of the security of NPK supply could one day become relevant, at least in some regional context. Based on current demand, usable reserves in P will be reduced by 25% in 2100. These usable reserves will be further reduced if demand for (P) will have more than doubled in the meantime.

Climate change

The extent of global average surface temperature increase projected to take place in the 21st century and the immediate consequences in climatic conditions (temperature extremes, sea level rise etc.) might have severe impacts on our food systems, as well as on human health and the world economy. Dramatic and diverse effects of global warming can potentially

threaten the integrity of the food chain from farm to fork, affecting safety, quality and quantity of food production. Effects can range from flooding of river basins and lakes and increased sea levels for some regions on the one hand, to decreased freshwater availability, rising temperatures and desertification of previously cultivated land on the other. Also, temperature and humidity changes could lead to the emergence of new or re-emergence of old plant, animal or human biological hazards.

Main trends: Since the 1950s, observed climate change effects are unambiguous and unprecedented. Surface temperature is foreseen to increase by 1.0 - 2.0 °C by mid-21st century, compared to the end of the 20th century. It is very likely that heat waves and extreme precipitation events will occur with a higher frequency and intensity. Sea levels will keep on rising while the oceans will continue to warm and acidify. In the EU, in the first decade of the 21st century, average temperatures were 1.3 °C higher than preindustrial levels, and the rise is expected to exceed 2.0 °C. In the early-mid 21st century (2021-2050), a 1.0 °C to 2.5 °C temperature increase (compared 1961-1990) is foreseen. Temperature increases will vary among European regions.

Climate change is expected to impact the EU food chain in various ways; changes in geographical location and yields of crop production, threats to plant health, effects on livestock yield and health, as well as direct threats to human health due to food-borne diseases. Also, climate change might imply a greater need for cropland expansion both globally and in Europe due to projected crop yield losses. Under the effects of climate change, crop yields are expected to decrease, with some regional exceptions, and the impacts are expected to be more severe for rice and groundnut.

In a business as usual scenario with no climate change effects, food prices are expected to remain fairly stable in the 2005-2050 period. Under a severe climate change scenario, the price of agricultural commodities will increase, especially for crops; the extent, however, is quite uncertain. Climate change effects are foreseen to result in reductions of availability of kcal per capita per day globally by 1.5-3%. Demand for animal calories, however, is expected to increase.

In the RCP8.5 climate change scenario¹⁶ used in this study, and without considering any yield increases due to CO₂ fertilisation, crop yields (coarse grains, oilseeds, wheat and rice, that are 70% of global crop harvested area) are expected to decline by 17% due to climate change impacts. Intensifying management practices and increasing production area could, however, compensate resulting in a minimal overall reduction in yields.

¹⁶ Representative concentration pathways (RCPs) are greenhouse gas concentration scenarios, adopted by the 5th Assessment Report of IPCC. According to RCP2.6, GHG emissions peak in 2010-2020, then decline significantly; in RCP4.5 emissions peak around 2040, and then decline; in RCP6 emissions peak around 2080 before declining; and in RCP8.5, emissions continue to rise. The numbers in RCP title refer to the amount of radiative forcing produced by GHGs, measured in W/m².



Future food scenarios and implications

Food safety and nutrition challenges,
policy options and research needs

Introduction

This chapter presents four comprehensive scenario-specific packages which include i) scenario descriptions, ii) specific food safety and nutrition-related challenges, iii) possible policy options to face these challenges, iv) a number of key indicators that provide early warnings of the rise of specific challenges in food safety and nutrition and v) potential associated research needs.

Scenarios

All the scenarios presented are based on different possible combinations of future developments of the drivers. For ease of reference, a summary of the drivers' developments characteristic of each scenario is presented at the outset of each scenario. This is followed by a narrative that explains how a series of possible developments can lead from the present to 2050 and a thorough description of the EU and global *status quo* in 2050 as well as of the EU food chain.

Challenges

Common or scenario-specific critical challenges for food safety and nutrition have been identified for all scenarios (see Annex). Some have been prioritised for their potential impact and the likelihood of occurring and are further discussed and analysed in-depth in a scenario specific context in the next pages. Certain challenges are addressed in more than one scenarios however they may take on a different aspect, given the different scenario settings.

Policy options

As possible responses to address or prevent the prioritised challenges, we present a number of policy options that could safeguard the resilience of the future food system. These policy options are suggestions to the policy maker, framed along the current legislative and policy structure on how to address the challenges ahead. They are to be considered for implementation before 2050; the timeline for impact assessment and implementation may differ depending on each scenario and issue at hand. Due to the methodology used, these policy options were drafted to address specific challenges in a particular scenario; some may nonetheless be valid options for other scenarios as well.

Depending on the scenario and challenge discussed, policy options differ in nature and approach; some policy options are highly preventive in nature, others include measures to improve preparedness and facilitating the handling of future challenges, building on opportunities that may arise or diminishing negative consequences and their impacts on the EU food system.

Finally, some of the policy options proposed may contrast contemporary views of EU governance or the trends in the EU food system; to be implemented they may require modification of the existing EU legal framework. While acknowledging that the potential implementation of such ideas may be difficult in our 2016 context, upcoming developments and challenges may justify their consideration. These options should be seen through the lens of a specific scenario and the challenges it entails.

Indicators

Some key indicators are also suggested in this chapter; their aim is to provide early warning of the rise of specific challenges in food safety and nutrition or to highlight EU developments that relate to particular scenarios or their characteristics. In using these indicators as an "early warning" system, the policy maker may opt to consider the different policy options at hand and develop new ones to those challenges not addressed here.

Research needs

To better understand certain challenges and/or to support some of the proposed policy options there is a need to fill in specific knowledge gaps. Relevant research needs that should be addressed for this purpose are listed at the end of each Scenario discussion. The research needs presented here are by no means exclusive and other options that are not mentioned here could be pertinent.



Oklahoma Indian Tacos

"We used to get these at county fairs in Oklahoma when I was growing up! So good! A delicious chili mixture served on top of out-of-this-world fried bread and trimmed with your favorite taco trimmings, like shredded cheddar cheese, lettuce, chopped tomatoes, black olives, and salsa."

- 2 pounds ground beef
- 1/4 onion, chopped
- 1 cup mayonnaise
- 3 tablespoons dry ranch salad dressing mix
- 1 (10 ounce) can diced tomatoes with green chile peppers
- 1 large tomato, chopped



Chicken Fiesta Salad

This is a... of veg... qui...

1

"Global Food"



The Earl's Sandwich

"This is a quick, delicious sandwich that's sure to get you hooked."

- 1 (12 ounce) package uncooked tri-color rotini pasta
- 10 slices bacon
- 1 cup mayonnaise
- 3 tablespoons dry ranch salad dressing mix
- 1/4 teaspoon garlic powder
- 1/2 teaspoon garlic pepper

Table 6 - Driver developments in "Global Food" scenario

| Driver | Main characteristics |
|--------------------------------|---|
| Climate change | <ul style="list-style-type: none"> • 2°C threshold of temperature increase will be reached by 2050 |
| Depletion of natural resources | <ul style="list-style-type: none"> • Progressive natural resource depletion towards 2050 |
| World population growth | <ul style="list-style-type: none"> • World population will increase to about 9 billion by 2050 |
| Social Cohesion | <ul style="list-style-type: none"> • Low social cohesion • Stronger inequalities between lower and higher socio-economic groups particularly regarding diet related non-communicable diseases |
| Food values | <ul style="list-style-type: none"> • Society does not value food quality and is not responsive to food-related health and environmental issues • Food choice is driven by price, taste and convenience • No significant reduction in consumption of meat and other animal products • Increase in out-of-home eating, snacking, and consumption of ready-made meals with parallel decrease of cooking skills |
| Technology uptake | <ul style="list-style-type: none"> • High technology uptake and acceptance by consumers • Less stringent approval procedure and governmental control • Technology development is focused on: <ul style="list-style-type: none"> ○ Increasing productivity, energy efficiency, reducing cost, and optimisation ○ Primary production and transport ○ Preservation for shelf-life extension |
| EU economic growth | <ul style="list-style-type: none"> • Moderate growth of GDP • EU is one of many global players due to the growth of emerging economies |
| Global trade | <ul style="list-style-type: none"> • Fully liberalised global trade - tariffs and non-tariff barriers to trade reduced to a minimum • Global convergence of standards, legislation, approval procedures |
| Agro-food industry structure | <ul style="list-style-type: none"> • Concentration at all stages of the food chain and considerable decrease of SMEs, small-scale farmers, groceries • Large market shares for international food manufacturing and retail corporations • Affordable, standardised, mass-produced processed foods are supplied by international food corporations to cover basic nutritional and caloric needs |

1.1. "Global Food" in 2050

The way towards 2050...

Climate change negotiations at the beginning of the 21st century have not resulted in any effective global climate change mitigation efforts, and some national and regional efforts were not able to reduce emissions sufficiently to slow climate change. This was also due to the fact that fossil energy reserves were still available and affordable to fuel the economies. However, with no strong mitigation policies, or immediate need for alternative energy sources, climate change impacts (e.g. weather extremes, floods) became increasingly visible. Primary production in many parts of the world became more volatile, evidenced in yield reductions and harvest failures because of droughts, heat waves or flooding. Also, concern about access to critical raw materials grew. In climate-change-affected areas of the world, people were slowly forced to abandon rural areas and to move to cities and expanded urban agglomerations due to direct weather effects that disrupted local economies. In Europe, by 2050, more than 80% of the population lives in urban environments. Against this background, trade more and more developed into a tool to balance supply shortages and to secure access to essential materials. With the strong support of the European Union (EU), and in collaboration with the newly emerged economies, in 2040, a major World Trade Organisation (WTO) negotiation round is successfully concluded, removing the last trade barriers and simplifying trade rules worldwide. In this context, the global food industry gradually concentrated into a few international corporations.

Between 2015 and 2050 BRIC (Brazil, Russia, India and China) countries gained global economic power with China becoming the world's largest economy, followed by the United States of America (US). A growing part of the population in the emerging economies adapted "Western" eating habits, with increasing demand for animal proteins and processed convenience food, mirroring the path that OECD (Organisation for Economic Co-operation and Development) countries followed in the past. As global trade further increased, the food chain gradually became global as well. Intensified food production systems, geared towards efficiency and cost effectiveness in production became necessary under the stress of climate change impacts and the reduced natural resources. Societies embraced technologies as a further means of balancing climate change, supporting the global trade system needs and focusing on efficient utilisation of resources. These developments favoured large, multi-national integrated corporations, which were capable of mass-producing affordable processed foods, as they could secure land for agricultural production in various parts of the world and efficiently access primary inputs and raw materials.

By 2050, food had become a trade commodity. In parallel, the trend towards convenience food has continued, also exacerbated by busy life-styles in urban centres and consumers in Europe lost their connection to agriculture, food production, traditional diets and cooking; the societal value of food beyond calories continually decreased. Frequent unemployment, low wages and minimum social security, marginalised a significant

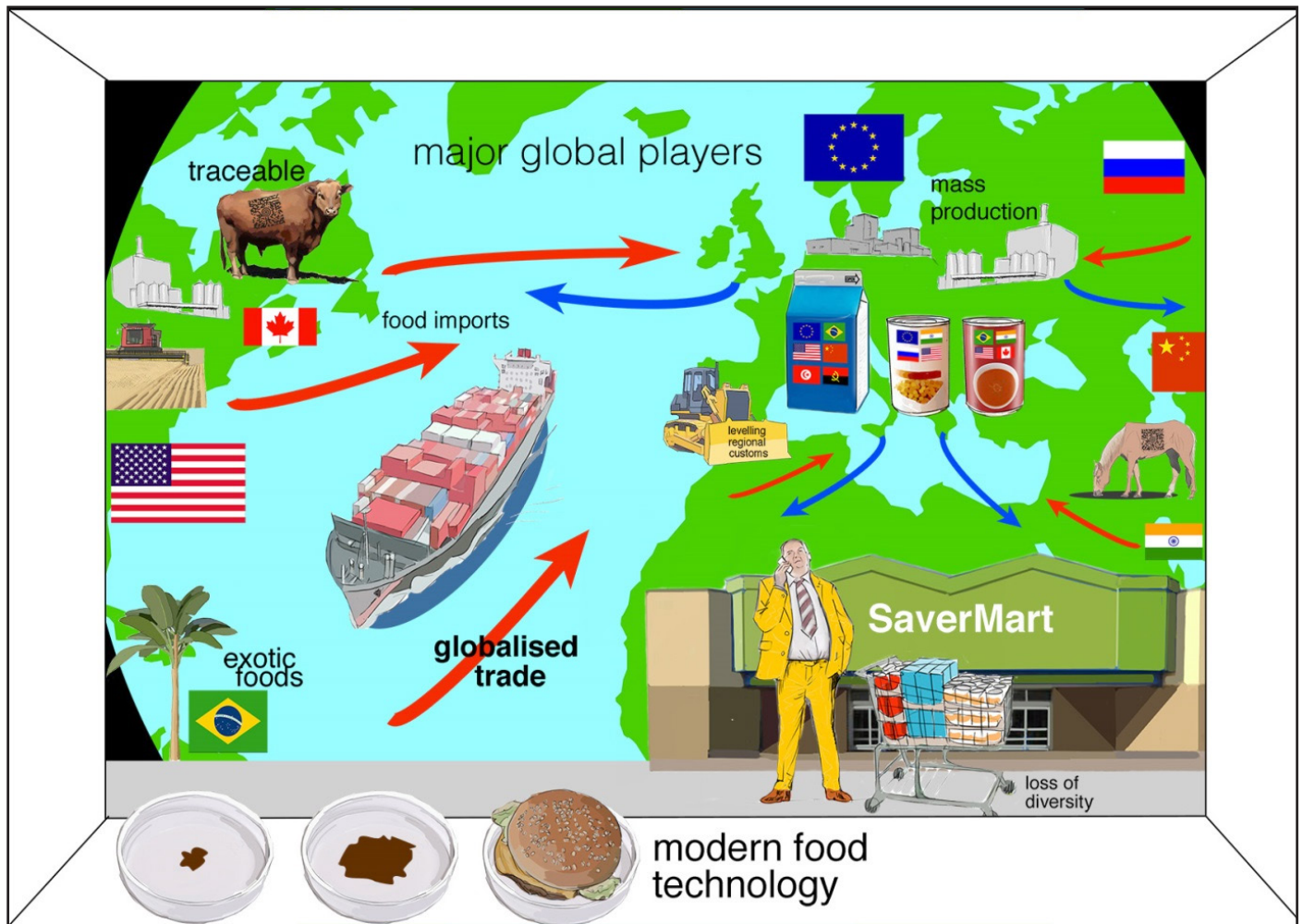


Figure 4 - Illustration of the “Global Food” world in 2050

share of citizens who could not keep pace within a globalised environment.

The EU in 2050

In 2050, Europe faces the impacts of climate change, as do many other parts of the world, particularly with increasingly scarce natural resources putting a strain on agricultural inputs and commodities and to the whole food system. Urbanization takes place faster than anticipated. The global and EU food chain is dominated by international companies, which can secure resources at global level, and are able to mass produce affordable, processed food. This is made possible by the liberalised trade and the technological developments in all steps of the food chain that facilitate cost-efficient production and transportation of food around the world. At the consumer level, diets are driven by price, taste and convenience and for the majority food has no value beyond calories. Social policies are at basic levels and social cohesion within European states is low, with large inequalities between higher and lower socio-economic groups, which are also reflected by the health status.

The context

Without strong mitigation policies, the +2°C temperature increase (compared to the end of the 20th century) threshold

was exceeded by 2050¹⁷. Climate change is taking its toll on natural ecosystems, and together with chronic over-exploitation, they impact on the availability of agricultural land and water and, thus, the food system. The EU is not exempt from weather extremes such as floods and droughts, which vary in frequency and intensity in the different European regions. The South faces extreme heat events during the summer, while droughts and soil desertification have impacted on rain-fed agriculture, thereby increasing the need for irrigation systems. In contrast, the changed climatic conditions have favoured the northern expansion by several hundred kilometres of agricultural production and apart from the possibility to cultivate plant varieties formerly unknown in the region, some crops have even slightly increased yields. However, North Europe faces increased precipitations and floods, especially in lake and river basins. On a general level and across the EU, yields of crops have been significantly reduced due to temperature sensitivity and other direct climate change effects or due to lack of water and appropriate soils and agriculture inputs. A liberalised global trading system partially compensates for the reduced production in the EU by importing those agricultural resources that are not cost-efficient or possible to produce within Europe; also novel technologies have contributed to buffer decreases in crop yields. Even so, agricultural commodity prices have increased.

¹⁷ Based on the Representative Concentration Pathway (RCP) 8.5 greenhouse gas concentration trajectory, from the fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change.

Globally, trade has been fully liberalised, with tariff and non-tariff barriers reduced to a minimum. As a result, there is a general convergence of trade standards and approval procedures, and this extends to food trade. These globalised standards are set by international institutions such as WTO and Codex Alimentarius. However, implementation of standards and rules still differs across the world. The agro-food industry is a major player in these discussions. As a consequence the elements of the global trade and food standards framework differ in their effectiveness. Within this context, with the formerly emerging economies having gained much more influence, the EU has partially lost negotiating power; now it is one of the several global powers from both, OECD and BRIC countries. The EU is well integrated into this global trade network.

The agro-food chain

The food chain is long and complex and its various components are dispersed in different macro-regions or continents. In 2050, the food system is truly global, and a number of multinational food manufacturing and retail companies increasingly dominate various steps of the food chain; in a world under the stress of climate change, and reduced natural resources, securing inputs for food production is a major advantage, as is the capacity to maintain a global supply system. Some of these multinational companies own agricultural land all over the globe, allowing them to intensively grow crops and rear livestock as well as manufacture food where it is cost-effective and efficient. This occasionally causes local tensions, especially for regions already affected by climate change. Consequently, some efforts are being made by these multinational companies to invest in the local community to placate protests. The difficulty in securing resources for food production has also impacted on global geopolitics; agricultural resources can now be used as a means of exerting political pressure from those entities or nations who have access to them against those that face difficulties, i.e. the so called "weaponisation" of food.

Technological developments in the agro-food industry are mainly aiming at increasing productivity, efficient energy use and cost reduction and in general optimisation in all steps of a complex food chain, taking into account that resources can be sourced globally. Examples include GM crops or animals adapted to specific climatic conditions or resistant to disease. Technologies are also focused on alternative food sources, e.g. proteins from insects or *in-vitro* meat, as well as on applications that support the global food trade and transport system, ensuring the smooth functioning of trade and guaranteeing the safety during long-haul transport of raw materials for agriculture and all kinds of fresh, frozen or processed foods. This includes faster and more efficient intermodal transport methods, cold-chain maintenance improvements, intelligent and real-time long distance monitoring systems, advanced tracking systems, as well as novel preservation techniques on all steps of the food chain, from post harvesting storage to retailing. Advanced sanitation and preservation techniques are especially important, given the increased global temperature and variable climatic conditions (e.g. dry vs humid) of different geographical regions that primary materials or foodstuff may be subject to from production to consumption. Advanced intelligent-reactive nanotechnologies are extensively used in these preservation techniques, constantly monitoring safety

parameters (e.g. water activity, temperature, microbial growth via metabolites etc.) in storage containers or food packaging and accordingly reacting by controlled release of appropriate food-grade preservative agents and modified storage conditions. Technological innovations have also been adapted at the end of the food chain, to minimise waste and encourage the re-use of packaging materials or food waste where possible, thus allowing thus the food industry to further reduce costs.

The fast technological uptake is also made possible by less stringent approval procedures and intellectual property rights that safeguard the return of the investments made in developing such technologies; food technology patents are particularly strong in this scenario.

In the EU, primary food production takes place where it is economically viable, under the prevalent climatic conditions; what is not cost-effective to produce within Europe is imported from other parts of the world; the EU is still one of the largest food importers, despite the emergence of other economies, mainly due the climate change impacts in primary production of horticulture and livestock. Europe's main imports are dominated by fruits and vegetables (with a parallel decline in exports) and seafood, while there has also been a recent boom in imports of beef from the north most areas of the US, Canada and Russian Federation; the impact of climate change in these northern latitudes have made it possible to establish intensive livestock breeding. The EU has found new markets for exporting a great variety of high-quality traditional food products, especially in the areas of dairy, cured meats, sweets, as well as alcoholic beverages, due to higher purchasing power, changing lifestyles and increased interest from the strong economies of the former BRIC bloc.

Also, since significant primary production also takes place outside Europe, there is no major increase in agricultural land use compared to 2015. The range of livestock and crop variety produced differs, depending on the sub-region of Europe. For example, in Southern Europe it is no longer viable to rear cattle due to increased water and pasture requirements and therefore livestock production is restricted to poultry, pigs and smaller ruminants, especially goats that are better adapted to prolonged dry spells and reduced grazing needs. Reduced freshwater resources in the EU has reduced inland aquaculture, and prompted an increase in off-shore fish breeding in some coastal areas in Europe; nonetheless, a large part of the fish and seafood used for human consumption is imported from aquacultures outside Europe; wild fish catches have decreased and wild fish is considered a luxury.

Various small regional food chains still exist, providing local primary agriculture products or traditional foods that are not convenient for multinational companies to produce in-house due to specific characteristics or due to higher costs involved. These local and traditional food products are also traded globally, but as gourmet delicacies and at a premium price. The large food manufacturing companies are matched by large retail companies, which control the market, strongly influencing food standards and the range of products that are offered to the consumers; private label and white label brand products form a major part of the available food choice. Apart from classical hyper-markets, other retail forms include virtual retail shops or booths, e-shopping and home delivery, or advanced

vending machines with expanded food selection and ready to eat meals. These are particularly needed in the big urban centres to cater for the “food on the go” needs of the adult population working longer hours.

For the majority of consumers, food choice is driven by price, taste, and convenience, and there is no concern about fair-trade practices, animal welfare conditions, the origin of the food that is purchased, or about the environmental impact of primary production. This mentality is also reflected in the amount of food waste at the household level, which, compared to 2015, has not been reduced to any extent. On the contrary, food waste has increased slightly; despite some modest reduction in food waste in primary production, manufacture and retail, on average, there is no significant food waste reduction in the EU food chain compared to 2015.

For the more interested consumer, the advanced traceability systems make all related information available for each product. Furthermore, digital applications are regularly used to search the best prices on online food markets, get alerted on the best offers from restaurants, canteens and street vendors. Food delivery is very popular; a limited number of internationally active online platforms provide access to large retailers and international brands as well as regional or local European brands and information on the nearest vendor, customised based on personal preferences, price etc. Advanced payment options and real-time delivery tracking via driverless vehicles in predetermined collection points or at home, complement the service.

Mass-produced processed foods are generally affordable by the majority of consumers, and ensure sufficient kcal/capita/day availability and macronutrient intake; since taste is one of the major drivers of food choice, the manufacturing sector ensures that foods are tasty and appealing to consumers. Consequently, most mass-produced foods include taste enhancers and aromas in their ingredients; beyond that, however, the lower socioeconomic status groups have difficulties in obtaining fresh produce as a regular diet component; this can lead to micronutrient deficiencies that are only partially alleviated by some micronutrient-enhanced foods.

Eating habits fit people’s schedules; employment in the EU is characterised by long working hours, frequent teleworking and in general blurring of private and professional life, at the expense of the former; As a consequence, out of home eating and snacking are dominant; eating at home instead translates mainly to ready-to-cook meals or delivery services, with a parallel loss of cooking skills and an understanding of basic food hygiene. In parallel, consumption of red meat and animal products in general is still high, notwithstanding the unfavourable land and water use associated with rearing cattle. As a result, unhealthy diets are widespread, and coupled with mainly sedentary lifestyles, result in significant impacts on the health status of the population and the tight budget allocated to healthcare. In effect, this combination of unhealthy diets and lifestyles and basic access to health care further accentuates social inequalities, resulting in large health inequalities between and within EU Member States. A small fraction of consumers still seeks quality, traditional or fresh foods, which are still available but sold at premium rates since they are considered a delicacy that could not be afforded

on a daily basis for the majority of the consumers. Similarly, some aspects of personalised diets exist, however, they come at premium price. In effect, whatever type of food is outside the range of mass-produced processed foods supplied by the food industry, it is not readily affordable, with the exception of those local products that are abundant in specific geographical settings.

1.2. The challenges ahead and policy preparedness

The analysis of “**Global Food**” shows that this scenario may be accompanied by a series of challenges for food safety and nutrition; these are listed in Table 7. A description of each challenge and its impact on the food system (including the consumer) is given in the Annex. The challenges highlighted in bold have been selected for their high likelihood to occur and their negative impact on the system we are studying. In the next pages, these selected challenges are further discussed and different options on how policy-makers can address these challenges are suggested.

1.2.1. Differences in the handling of food in third countries due to diverging food safety standards

“**Global Food**” is characterised by a globalised food chain with ingredients being sourced by the highly concentrated agro-food industry from all over the world and different processing steps taking place in various parts of the world before a finished product appears on the EU market. However, food regulations and their enforcement may still differ in different parts of the world. This could allow for raw materials or food products that do not conform to EU standards to enter the EU food chain.

Policy Options

For a food system such as the one of “**Global Food**” to function with a minimum of regulatory burden and cost, harmonised global food safety standards would be needed. This would facilitate trade and the worldwide sourcing of raw materials and would assist the global food industry in its operations, reducing barriers and extra costs for local compliance, benefiting consumers by lowering food prices. Thus, an important action for the EU to prepare for such a future would be to promote the development of harmonised global food safety standards, while promoting the EU food safety policy principles. Achieving harmonised global standards, however, may not be easy. Therefore, the development of harmonised standards and other options to help reduce the challenges arising from diverging food safety standards in different countries are discussed below.

**Table 7 - Food and nutrition-related challenges identified in the "Global Food" world
(in bold those prioritised)**

| |
|---|
| Emerging biological risks: |
| a) The introduction of known pathogens causing (bio)chemical safety hazards in geographical areas where they were not previously known |
| b) Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains |
| Shortage of quality water |
| The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies |
| Ability to perform official food-related controls |
| Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism |
| Failure to provide appropriate food safety information to the consumer |
| Abundance of voluntary food information and increased opportunity for misleading information |
| Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels) |
| Increased sedentary behaviour and snacking due to changed lifestyle |
| Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information |
| Increased use of chemical substances in the food chain |
| Increased exposure to chemicals and nanomaterials from food contact materials migrating in food and from the environment via packaging waste |
| Diets based predominantly on highly processed foods and decreased availability of fresh produce |
| Intensive animal and plant production systems: Disease transmission and nutritional quality |
| Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks |
| Food of different safety and quality classes |
| Differences in the handling of food in third countries due to diverging food safety standards |

- **Build efficient food safety standards that also include implementation details**

Although differences in standards or regulations may lead to disputes in international food trade, they may also lead to improvements in food safety systems. For example, harmonised global food safety standards that ensure the highest level of food safety could be developed using, as a starting point, Codex standards (where they exist) and building on them using the strongest points of the different international food safety standards. Also, where differences between approaches can give rise to trade difficulties, further agreement could be achieved by applying the mutual recognition principle. This however could come with certain difficulties at international level, considering that already within the EU there are problems with the full application of this principle^{18,19,20}.

¹⁸ Regulation (EC) No 764/2008 of the European Parliament and of the Council of 9 July 2008 laying down procedures relating to the application of certain national technical rules to products lawfully marketed in another Member State and repealing Decision No 3052/95/EC.

¹⁹ Evaluation of the application of the mutual recognition principle in the field of goods. Final report, 2015. <http://ec.europa.eu/DocsRoom/documents/13381>

²⁰ COM(2012) 292 Final: Communication from the Commission to the European Parliament and the Council. First report on the application of Regulation (EC) No 764/2008 of the European Parliament and of the Council of 9 July 2008 laying down procedures relating to the application of certain national technical rules to products lawfully marketed in another Member State and repealing Decision No 3052/95/EC.

However, even if different jurisdictions adopt certain standards, such as HACCP, as their guiding principle for ascertaining food safety, their specific implementation may result in different outcomes, even within the same food industry sector. A more detailed definition of the safety requirements of the food safety standards appears appropriate to facilitate the implementation of the provisions of the World Trade Organisation's Sanitary and Phytosanitary (SPS) agreement related to the equivalence of measures to achieve adequate consumer protection, particularly in the "Global Food" scenario. Also, prevention measures, including vulnerability analysis of individual food chains and regular benchmarking of the performance of the global food safety standards and the related structures (i.e. enforcement bodies) could stimulate continuous improvement and ensure their efficiency.

The food and drink industry is likely to support such harmonisation of standards as they would ensure best safety practices but also facilitate global sourcing and in return immediate access of food products to the global market.

If the EU wishes to promote its principles in the development of global food safety standards, there is a need to enhance its international presence. In the competitive environment of "Global Food" where the EU is only one of many global players, if the EU desires to influence international developments, e.g. at the level of Codex Alimentarius, EU participation in all international discussions on food safety related issues must be strong, with proposals that represent a clear EU voice, in particular for new products or new technologies. Emphasis

can also be put in strengthening the permanent representation of EU food safety experts in third countries (i.e. EU Delegations). This would help in acquiring knowledge of food safety standards and the performance and attitudes of food business operators in third countries, facilitate food trade and ensure that imported food complies with EU legislation. Moreover, by engaging with local authorities and providing scientific and administrative support to food business operators, the EU could contribute to the adoption of internationally agreed food safety principles by third countries. Therefore, initiatives such as the *Better Training for Safer Food* programme, or other assistance, training, capacity building and outreach activities may need to be further enhanced in the future to help third countries meet new standards. The use of novel technologies in the food chain or the impacts of climate change may cause difficulties in compliance with certain requirements (e.g. maximum residues levels of substances in primary production) and may require the training of producers in third countries to use more efficient prevention and control techniques.

- **Promote co-regulation or enforced self-regulation by food business operators**

The food regulatory framework is intricate; it consists of a multitude of regulatory acts laying down requirements for horizontal issues (General Food Law, official controls, etc.) as well as vertical (category-specific) requirements (food additives, packaging materials, etc.). Certain regulatory tasks could be devolved to food business operators. An example of self-regulation in the European food arena is the EU Pledge²¹, restricting marketing of food and beverages to children based on the Pledge commitments that consider common nutrition criteria. Extending self-regulation to food safety is possible to a certain extent, but would rather be a form of “co-regulation” or “enforced self-regulation”. In such a scheme, regulators define specific food safety standards. The implementation, including risk management, monitoring and compliance checking is then performed by the food business operators in a way that is suitable for the specific industry. The application of the HACCP concept is an example of successful industry co-regulation or enforced self-regulation.

Co-regulation or enforced self-regulation could also develop based on existing voluntary private food safety standards such as ISO 22000²², BRC²³, IFS Food²⁴, SQF²⁵, etc. and an additional input of all relevant stakeholders, as a starting point. These standards have been developed by international organisations or food business operators’ associations for managing food safety along the whole food chain or in specific sectors (e.g. retail) to compensate to some extent for the differences resulting from the absence of harmonised standards at international level or from the lack of specific implementation details in the regulations. They are based on in-house

risk assessments and allow food business operators to ensure similar levels of safety for all the materials they source or use from all over the world. However, it has been argued that they often impose stricter requirements than those established in legislation and that they often become “mandatory” due to market forces or for promotional reasons.

Co-regulation presents certain advantages for food business operators, policy makers and consumers alike; however there are also certain difficulties in its implementation^{26,27}. As it depends on the resources of the operators, it is expected that it will be easier to implement in multinational companies. In the “**Global Food**” scenario where a concentration of food industries is anticipated, this format may be suitable, provided of course that well-defined rules are established and public surveillance is adapted to respond adequately. At the same time, co-regulation could free public resources that could be used to assist smaller and more local food business operators with compliance. The big food corporations could also assist the smaller players to achieve compliance with these requirements, as in “**Global Food**”, this concerns both sides as certain difficulties may arise in the sourcing of raw materials by global and niche market players.

1.2.2. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

In recent years, the rhythm of technological developments and innovations in the food system has accelerated and this trend is expected to continue, possibly at an even faster pace towards 2050. At the same time, the regulatory process for the approval of new substances and technologies may require a long time for single substances to be approved for use in food products, challenging the capacity of the current EU risk assessment system, in particular at a time where innovation in the food sector is needed. On another front, the future suitability of exposure data used today has also been questioned. The exposure to chemical substances may differ considerably within the European population, depending on the regions where they live or their dietary choices. Therefore, the exposure data currently used may not be relevant in the future. The quality and quantity of epidemiological and dietary intake data reported by the Member States differ due to the disparities in human and financial resources available to invest in the collection and processing of this information. This, coupled with newer insights on the effects of exposure to mixtures of chemicals of varying nature (stemming from environments and diets e.g. natural toxins, chemical residues and contaminants, additives, bioactives) further compound the challenge.

Hence, in a “**Global Food**” world where technological innovation in the food system is needed to counteract the

²¹ <http://www.eu-pledge.eu/>

²² ISO 22000 food safety management from the International Organisation for Standardisation. <http://www.iso.org/iso/home/standards/management-standards/iso22000.htm>

²³ BRC: British Retail Consortium global standards. <http://www.brcglobalstandards.com/>

²⁴ IFS Food: International Featured Standards for food. <https://www.ifs-certification.com/index.php/en/>

²⁵ SQF: Safe Quality Food standards by the SQF Institute: <http://www.sqfi.com/>

²⁶ Garcia Martinez, M., Feame, A., Caswell, J.A. and Henson, S., 2007. Co-regulation as a possible model for food safety governance: Opportunities for public-private partnerships. *Food policy* 32, 299-314

²⁷ Hutter, B.M. and Amodu, T., 2008. Risk regulation and compliance: food safety in the UK

impacts of climate change and depleting natural resources and to allow for the availability of affordable food, risk assessment procedures need to be appropriate to address the increasing complexity of the risks encountered without delaying assessment and authorisation. It is thus anticipated that risk assessment will be mostly challenged in this scenario.

Policy Options

The approval process for new substances or new food technologies in Europe (i.e. chemicals for different uses, pesticides, fertilisers, veterinary residues, food additives and preservatives, micro-nutrients, bio-actives, antimicrobials, new GMOs, health claims on foods) relies on a thorough risk assessment and approval procedure, with the European Food Safety Authority as a risk assessor and the European Commission (DG SANTE) as a risk manager. Approval results in an unconditional authorisation or an authorisation subject to maximum residue levels or other limits established for the different substances in foods. To address the **"Global Food"** scenario, EU risk assessment procedures could benefit from:

- **Enhance collaboration between risk assessment bodies at EU and international level**

To ensure food and feed safety, the General Food Law (Regulation (EC) No 178/2002) requires the coordination of uniform risk assessment methodologies by the European Food Safety Authority (EFSA). Also, EFSA is required to provide scientific and technical assistance to improve cooperation between the European Commission, applicant countries, international organisations and third countries in the fields of its mission.

The mandates of EFSA and other organisations such as the European Medicines Agency (EMA), the European Chemicals Agency (ECHA), the European Centre for Disease Prevention and Control (ECDC) and the European Environment Agency (EEA), are clearly defined in legislation. There are areas where the need for interaction and collaboration is necessary such as the risk assessment of chemical substances for use in food (ECHA), veterinary drugs and their residues in food (EMA) or risk assessment in the field of zoonotic diseases (ECDC) and more importantly on subjects with global relevance such as antimicrobial resistance, chemical and microbiological risk assessment, emerging risks, zoonoses, databases etc. In recent years, EFSA has signed agreements²⁸ to enhance scientific cooperation with the above organisations, which are reflected in its multi-annual programmes. A closer collaboration in the field of risk assessment between the different authorities could be stimulated by explicitly indicating it within the existing Regulations, where appropriate. This would likely result in more efficient use of knowledge and resources.

Open-minded collaborations with non-EU regulatory authorities could also result in the sharing of valuable experience, examples of success stories and best practices. This is particularly relevant with the food safety authorities of food markets

outside the EU, e.g. US, Canada, Japan or Australia. The EC could host platforms to bring together such regulatory authorities as well as NGOs from across the world.

Collaboration at international level is also particularly important for ensuring access to up to date exposure data (e.g. dietary intake or environmental exposure) held by the different organisations. Collaboration is also essential with regard to risk assessment approaches, particularly on the combined exposure to multiple chemicals (cocktail effects). Presently, the General Food Law requires collaboration in the field of data collection, but collaboration is not as clearly prescribed for data management and use in risk assessment. The inclusion of such a requirement in the Regulation, possibly accompanied by other policy instruments on how to ensure closer collaboration would be a first step towards making the current risk assessment procedures fit for the **"Global Food"** system. The resulting access to world data would facilitate efficient risk assessment that meets the challenges of a global food chain, maintaining the precautionary principle and proportionality of measures as set out in the current EU legislation. Also enhanced collaboration could be achieved by granting risk assessment agencies direct access to international collaborative research programmes (EU and international).

- **Use horizon scanning to identify vulnerabilities in the supply chain**

In addition to the efforts already in place by EFSA and other European structures, more early warning systems and detection and identification of emerging risks will be needed. Horizon scanning, foresight exercises, addressing vulnerabilities in the food chain system and anticipating how possible future challenges from biological or chemical risks and technologies could impact food safety could also be significant. These exercises should also extend beyond the European borders as emerging food safety risks surfacing in any part of the world could affect Europe within a very short time in the **"Global Food"** world.

1.2.3. Ability to perform official food-related controls

Official controls (inspection as well as laboratory analysis) are of particular importance throughout the food chain as they are one of the main ways to verify compliance with food and feed safety legislation, ensure consumer protection and guarantee fair practices. The structure of the food system in the **"Global Food"** world is more complex than today and the ability to monitor, inspect and enforce official controls may be compromised.

To improve our ability to perform official controls in the 2050 **"Global Food"** Europe, the following policy options may be considered:

²⁸ Memorandum of understanding between EFSA and the EMA (2012), Memorandum of understanding between EFSA and the ECHA (2009), Renewed Memorandum of understanding between EFSA and the ECDC (2014)

Policy Options

• Invest in long term funding mechanisms

Regulation (EC) No 882/2004 requires that official controls are carried out at any stage of production, processing and distribution of food and feed while specific provisions relate to controls on products imported into the EU. The ability to perform such controls is to a large extent linked to the availability of resources, the lack of which is the main reason for insufficient food controls being carried out²⁹. Long-term funding mechanisms that encompass sharing of the financial burden among actors in the food chain could be considered.

• Expand third country controls

In the case of EU imports, controls could be shifted to third country pre-export checks. Food imported into the EU has to comply with the requirements laid down in Regulation (EC) No 178/2002 on General Food Law, and must be of the same or equivalent standards with food produced inside the EU. Reg. (EC) No 854/2004³⁰ already lays out relevant specific rules, whereby products of animal origin can be imported into the EU only if they have been shipped from, and obtained or prepared, in accepted third country establishments from specific countries authorised for exporting, are accompanied by a health certificate from the third country's relevant authority, and are subject to inspection controls in the EU country of arrival. Imported plants or plant-based products must be accompanied by a certificate, undergo customs inspections and can only be imported into the EU by a registered importer. In the future interconnected global food chain of the **"Global Food"** world, it could become increasingly resource-intensive in terms of budget and qualified personnel to perform controls at the point of entry into the EU for all ingredients and food products that are obtained from suppliers outside the EU.

With the aim to enable a better control of the quality of imports, the existing scheme for auditing the food safety control systems of third countries and the approval of establishments handling food of animal origin in third countries as foreseen in Regulation (EC) No 854/2004 could be extended to all foods imported into the EU. First steps are already under way in the proposal for a new Regulation on official controls³¹.

²⁹ COM SWD (2013) Final: Commission Staff Working Document, Executive Summary of the Impact Assessment accompanying the document 'Proposal for a Regulation of the European Parliament and of the Council on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health, plant reproductive material, plant protection products and amending Regulations...'. http://ec.europa.eu/dgs/health_food-safety/pressroom/docs/official-controls-es-ia_en.pdf

³⁰ Regulation (EC) No 854/2004 of the European Parliament and of the Council laying down specific rules for the organisation of official controls for products of animal origin intended for human consumption.

³¹ COM/2013/0265 final - 2013/0140 (COD). Proposal for a Regulation of the European Parliament and of the Council on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health, plant reproductive material, plant protection products and amending Regulations (EC) No 999/2001, 1829/2003, 1831/2003, 1/2005, 396/2005, 834/2007, 1099/2009, 1069/2009, 1107/2009, Regulations (EU) No 1151/2012, [...]2013 [Office of Publications, please insert number of Regulation laying down provisions for the management of expenditure relating to the food chain, animal health and animal welfare, and relating to

EU import controls could then be waived or relaxed in these cases. The extension of controls at the point of production, combined with a simplification of the certification process, e.g. by using accredited third party certification bodies, could help further improve the efficiency of official controls.

• Enhance surveillance to ensure food safety during transportation

In addition, the EU could enhance surveillance mechanisms to ensure that food safety standards are maintained during transportation. This is particularly important in the **"Global Food"** scenario, as certain ingredients and products will need to travel long distances to reach the European market and can be achieved through ensuring that transportation vehicles meet safety standards and that multiple uses of food containers are not allowed.

• Improve traceability using related technologies

Ensuring traceability along the entire food chain is a requirement of the General Food Law and delivering on this provision will be a challenge for the future, particularly in the complex food chain of the **"Global Food"** scenario. Policy adaptation is most likely not necessary; technology will have to provide the solution. Investment in research will be needed to develop appropriate traceability systems for the global trade in food and agricultural commodities that enable the management of hazards related to food borne disease and animal health, but also to ensure product integrity (authenticity) and improve supply chain management. Enhanced traceability together with a global harmonisation of standards and ensuring inter-operability of the IT systems would increase both the effectiveness and the efficiency of controls for better risk mitigation and targeting.

1.2.4. Increased sedentary behaviour and snacking due to changed lifestyles

Increased time spent online or in virtual environments for leisure activities is foreseen to increase in the future across all scenarios. In the **"Global Food"** world, the majority of the urban population in Europe has busy lifestyles and relies heavily on fast and convenient highly processed meals. Also, the sedentary behaviour and increased screen-time likely results in lower dietary quality and unhealthier behaviours through e.g. "web dinners" or "TV dinners", increased snacking and decreased physical activity, resulting in increased incidence of non-communicable diseases. Apart from the health burden, non-communicable diseases entail a staggering economic cost, foreseen to incur a cumulative output loss of US\$ 47 trillion by 2030, representing a 75% loss of global GDP in 2010. Cardiovascular diseases and diabetes alone accounted for US\$ 863

plant health and plant reproductive material], and Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC, 2008/120/EC and 2009/128/EC (Official controls Regulation)

and 500 billion respectively in 2010; the losses are estimated to rise to US\$ 1 trillion and 745 billion by 2030³².

Policy Options

Food-related policy options that can be considered to address this challenge are of similar nature to those that address the challenge below. Both will be discussed under that challenge. Measures to address the levels of sedentary behaviour – and possibly physical inactivity – that are expected in the **"Global Food"** world must also be considered. Given the focus of this report on the food system and the breath of the challenge and possible responses, such measures are not detailed here. Topical areas include addressing sedentary transportation and sedentary work styles, favourable urban infrastructures and ensuring sufficient physical activity (including moderate to vigorous physical activity) in children in the school setting.

1.2.5. Diets based predominantly on highly processed foods and decreased availability of fresh produce

Food offer in the **"Global Food"** world relies mostly on cost-efficient, mass-produced and highly processed foods; fresh produce is more difficult to access by a large part of consumers. Food processing ensures preservation, increases variety and availability and can bestow improved nutritional and sensory quality. Highly processed foods can be energy-rich and have high contents of sugar, salt, fat (HFSS). Certain food components may be lost during food processing; highly processed foods can be poor in micronutrients or fibre. Highly processed foods usually contain refined food components, which require less energy to be metabolised. The decreased availability of fresh produce will also affect dietary quality e.g. micronutrient deficiencies. High consumption of HFSS foods, on the other hand, can result in higher prevalence and earlier onset of non-communicable diseases; hence resulting in negative public health impacts. Finally, low socio-economic status groups can particularly be at risk leading to health inequalities.

Policy options

Nutrition-related policies and other policy initiatives aimed at improving peoples' diets are a mix of regulations such as the food information to consumers Reg. (EC) No 1169/2011³³, nutrition and health claims Reg. (EC) No 1924/2006³⁴ and "softer" actions directed to making healthier food choices available, such as voluntary reformulation of highly processed

foods to reduce fat, sugar and salt, information and awareness campaigns to educate and empower the consumer, etc. The latter leave room for the consumers to decide freely on their dietary choices, as these are affected by individual, social, and cultural factors. As it stands, such softer approaches are favoured in many instances but have not yet resulted in improved diets and a halt in the rise of related non-communicable diseases.

Policy initiatives in relation to nutrition are part of public health and currently falling under national competences. However, in a global world like the one of **"Global Food"**, national initiatives might lack in effectiveness, given the presence of a global food industry and the constraints that may be posed in different parts of Europe by the scarce natural resources and the impacts of climate change. There is thus a clear need for collaboration between the various stakeholders, particularly between industry, policy makers and consumer organisations, not only in the EU, but also at international level. The complexity associated with this challenge requires multi-component, multi-national and multi-stakeholder approaches such as those proposed below:

- **Introduce fiscal measures such as food taxation or other financial incentives**

There are recent attempts to introduce taxation of specific macronutrients (e.g. "fat" or "sugar" tax) at a Member State level, which are linked with efforts to tackle obesity and related diseases by triggering a reduction in the consumption of products containing high levels of these macronutrients. The effectiveness of such taxes regarding health impacts is difficult to be assessed in the short-term; such measures are relatively new, with no long history of implementation and although there is some evidence to support them, there is a lack of consensus on their application. Notwithstanding, taxation of sugar-sweetened beverages, for example, has been recommended as an effective measure to address childhood obesity by a recent WHO report³⁵. Taxation can be coupled with financial incentives in other food categories, e.g. fruits and vegetables. Revenue generated by taxing could be used to support these incentives or the national health system, educational campaigns, etc. As it stands, the EU has only limited competences in the area of national taxation, mainly related to running the single market; the application of such fiscal measures at a European level would have to be accompanied by high-level amendments to the current EU competencies. The above could also be combined with tax-subsidy measures in national health insurance schemes in accordance with population health behaviour/NCD determinants (obesity, nutrition, physical activity, alcohol consumption) profiles.

- **Promote reformulation towards healthier food options**

An alternative approach to fiscal measures could be the promotion of production of foods with higher nutritional value, including "healthier" snacks – particularly to address

³² The Global Economic Burden of Non-communicable diseases (2011). A report by World Economic Forum and the Harvard School of Public Health.

³³ Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004

³⁴ Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods

³⁵ Report of the commission on ending childhood obesity (2016) – World Health Organisation

the snacking behaviour challenge described above. Voluntary reformulation initiatives could be encouraged. Also, incentives towards innovation for healthier food profiles could be provided to the food industry, as these may entail increased costs. Supporting measures by other EU policy areas, notably the CAP, could also help to move towards a more sustainable agricultural production which also considers nutrition-related health objectives.

- **Introduce zoning and incentives for establishment of fresh food markets**

From a public health perspective, zoning could contribute in promoting healthier dietary practices or restricting unhealthier ones. For example, measures could be taken that reduce the expansion of fast food establishments in a particular area by setting limits on their numbers and geographical distribution, e.g. in lower socio-economic areas or near schools. This could also be accompanied by business incentives for establishing fresh produce local food markets and grocery stores and assist in avoiding the creation of food deserts in Europe, particularly for the lower socio-economic status segments of the population. Zoning could also include restricting or banning vending machines, snack bars or fast food establishments (or the sale by these outlets of HFSS foods) inside or near schools, as is the case already in certain EU countries³⁶.

- **Implement standards and guidelines for healthier options in public food procurement**

A significant part of the European population works or regularly visits public establishments such as hospitals, schools, train stations and airports and consumes meals at work or 'on the go'. Public authority establishments spend approx. 2 trillion Euros annually (19% of the EU's gross domestic product)³⁷. This purchasing power and control of a significant part of the market could be used to select healthier food and catering services, canteens and restaurants. Adopting public procurement guidelines (voluntary or mandatory) that ensure healthier food profiles for food and catering services in state establishments can contribute towards healthier eating at work or when outside of the home. These procurement guidelines could also act as a lever and a strong signal for provision of healthier food options and responsible marketing for food business operators.

Green Public Procurement guidelines exist which include specific recommendations for the purchase of food and catering services, taking into account environmental, animal welfare and food waste issues³⁸; the recommendations proved successful as in cases where they were followed, cities reaped significant budget savings, apart from environmental benefits. A guideline or toolkit for public food procurement that would promote healthy diets could be integrated with the existing one with expected public health and healthcare budget benefits.

³⁶ Mapping of National School Food Policies across the EU28 plus Norway and Switzerland; JRC Science and Policy Reports (2014)

³⁷ European Commission Green Public Procurement website, http://ec.europa.eu/environment/gpp/what_en.htm, accessed 20/01/2016

³⁸ European Commission Green Public Procurement training Toolkit – Module 3: Purchasing Recommendations for Food and Catering

- **Fund national and European actions on balanced diets and access to fresh produce**

EU structural funds could be of increased importance when there is a lack of dedicated resources for such actions at Member State level and could be used to support Member State-level actions towards balanced diets and access to fresh produce for the majority of the population. Under the 2014-2020 plan, EU structural and investment funds already cover certain health actions that are eligible for funding, such as health promotion, active and healthy ageing, cross-border healthcare, etc. Food and diet-related actions could be specifically included and explicitly mentioned under this bundle.

- **Improve nutrition education**

Consumers' understanding of nutrition and the associated health impacts is paramount for making informed dietary choices. This is based to a large extent on food and nutrition education that should be an integral part of school curricula. A detailed discussion on how to implement such a measure is presented in 3.2.1. Educational campaigns should also target specific consumer groups, particularly vulnerable groups including low socio-economic status groups. These campaigns should go beyond the provision of information and also incentivise and motivate the population towards adopting healthier diets and behaviours. A wider adoption of the "Health in all policies" concept will be required in all policies within the EU, but possibly also at the international level, to ensure that the environment is equally favourable to these changes. Consumer demand could, in turn, push the food industry to develop healthier products including healthy snacks.

- **Improve the provision of nutrition information**

Nutrient profiling of foods accompanied with interpretative signposting could allow for easier communication of nutrition information to the consumer. These are currently used in some Member States, e.g. front-of-pack traffic light schemes. Their potential application across Europe has failed in the past; hurdles associated with nutrient profiling, include lack of consensus on its effectiveness, the difficulty to label foods that can be part of a healthy diet but nonetheless contain high amounts of a particular nutrient (e.g. fruit juices and sugar) as well as the lack of a consensual nutrient profile scheme. An alternative option is the usage of "positive" signposting only, health or healthy choice logos that indicate products adhering to strict nutrient profile criteria or best in class products in a particular food category. For any of the alternatives to be considered at the European level, an EU-wide accepted nutrient profile setting scheme must also be adopted (the WHO Regional Office for Europe³⁹ has proposed such a model and several other initiatives such as the EU Pledge as well).

³⁹ WHO Regional Office for Europe nutrient profile model (2015)

1.2.6. Abundance of voluntary food information and increased opportunity for misleading information

Future food labelling schemes may contain a lot of information, voluntary or obligatory, increasing the complexity of food labels. Manufacturers may wish to provide information on a variety of novel processes or materials (e.g. foods from cloned animals, synthetic foods), the presence of bioactive or pharmaceutical substances, health claims, etc. This is also relevant to products sold without packaging (fresh or dried fruits and vegetables, dairy products, raw or processed meat/fish) in retail stores or served in restaurants, canteens and buffets. Also, the potential demand for country of origin labelling for individual ingredients in the complex food chain of the **"Global Food"** scenario could be challenging to achieve and to describe.

It is also envisaged that some labelling information will be detached from the product and made available only online (e.g. via Quick Response codes). As a result, the consumer might need to go to extra lengths to obtain the required information.

The complexity of the labels may negatively impact on consumer understanding and consequently consumers' choices and diets. Also, food fraud and the provision of misleading information to the consumers is against the principles of food law, can potentially impact on production and marketing of specific products and may even pose direct health concerns to the consumer (e.g. melamine to increase apparent protein content, substitution of ethanol by methanol etc.). More complex mandatory labelling could also become an additional burden for food business operators, impacting disproportionately small producers, potentially affecting variety and food prices.

In parallel, food fraud in the form of intentional provision of misleading information could also be of concern. Fraud can occur with regard to compositional quality, expensive food products and possible imitation products, origin information, products meeting specific standards, or misleading the consumers regarding the properties of foods and related health claims. This is particularly important if food ingredients are sourced worldwide or where food of higher quality may be sold at a premium.

Policy options

The following option can be considered to facilitate consumer information and ensure consistent labelling, thus also reducing trade barriers:

- **Promote harmonisation of labelling at international level beyond language barriers**

Harmonisation of labelling, despite the difficulties to achieve at international level due to the language barrier, could facilitate the provision of food information to consumers. In overcoming the language barrier, a globally harmonised system based on numbers, symbols and pictograms could be used instead of words that need to be translated into different languages to suit different markets. Another alternative could be to use codes that can be scanned by any intelligent device of the future, directing consumers to the related information online in their language. These suggestions would help food business operators to overcome the effort and investment required in labelling for different markets. Similarly, this would allow consumers to make informed choices on what they consume anywhere in the world and where they may purchase the product.



1.3. Is Europe heading towards “Global food”?

For the policy options above to be useful, they shall be considered and their impact and potential effectiveness assessed, long before the challenges referred above impede the proper functioning of our future food system. Table 8 proposes a series of simple indicators that can signal European developments towards this scenario, or to phrase it more correctly towards *particular elements* of this scenario; sources that could potentially supply the relevant data for monitoring these indicators are also included. Reflecting the character-

istics of “Global Food”, these indicators mainly refer to the concentrated structure the EU agro-food chain as well as the decreased value attributed to food (as well as food-related health and environmental issues) by the EU consumer.

1.4. Research needs

For our future policy and regulatory framework to be fit to respond to the challenges presented in 2050 by the “Global Food” world, it could benefit from more research in the areas mentioned in Table 9.

Table 8 - “Global Food” specific indicators and potential sources of data¹. ↑ or ↓ indicate an increase or decrease compared to 2016

| | | | | | |
|---------|---|--|--|--|---|
| ↑ | % of EU food market revenue generated by multinationals | % of populations living in urban centers | % of exports and imports of processed foods and food ingredients | % of overweight obese children and adults | Volumes (tons) and value (Mio €) of GM foods sold in the EU |
| Sources | FDE ² , UEAPME ³ | World Bank, FAO ⁴ , EEA ⁵ | WTO ⁶ , OECD ⁷ | WHO, OECD | Eurobarometer, BEUC ⁸ |
| ↓ | Daily intake (g) of fruit and vegetables per capita | Sales revenue (Mio €) of organic food products in the EU | % of small farm holdings in primary production and grocery shops in retail | % of consumers thinking of environment, animal welfare and fair trade when buying food | % of EU consumers regularly preparing food at home |
| Sources | WHO, FAO, EFSA ⁹ | IFOAM ¹⁰ | COPA-COGECA ¹¹ , EuroCommerce ¹² | Eurobarometer, BEUC | Eurobarometer |

1 For all of these indicators, ESTAT or relevant EU DGs such as SANTE, AGRI, TRADE etc. would be the first choice for monitoring of data relevant to these indicators; what is indicated therefore in this table are potential additional data sources, from relevant specialised stakeholders or organisations ↑ or ↓ indicate an increase or decrease compared to 2016.

2 Food Drink Europe, EU food and beverage industry association

3 European small and medium enterprises organisation

4 Food and Agriculture Organisation of the United Nations

5 European Environmental Agency

6 World Trade Organisation

7 Organisation for Economic Co-operation and Development

8 European consumer organisation

9 European Food Safety Authority

10 European organisation for organic food and farming

11 European farmers and agri-cooperatives organisation

12 European Retailer association

Table 9 - Research needs per challenge in "Global Food"

| |
|---|
| Differences in the handling of food in third countries due to diverging food safety standards |
| Learn from other regulatory systems: Research (and gap analysis) in the strong and weak points of other regulatory systems around the world to identify appropriate elements to be used towards international harmonisation of food safety standards. |
| Identify opportunities for industry-government-civic society organisations (CSOs) collaboration in standard development: opportunities should aim at jointly developing food safety standards, and consequently working towards international harmonisation. Identify examples of such collaboration in standard development and lessons that can be learned from relevant successes or failures. |
| Increase transparency with regards to ethical issues in the global food chain: Further research is needed to understand the ethical issues associated with animal welfare and child labour standards in various parts of the world and their implementation when production takes place overseas. This can also help increase transparency in the global food chain. Also research is needed to elucidate whether the implementation of and adherence to ethical standards has any effects on food price. |
| Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels) |
| Inter-operable harmonised infrastructure for food composition and consumption databases: In the context of the globalised and interconnected food system, harmonising food composition and consumption database infrastructure across the globe, and exploiting "big data" capacities using ICT tools or "crowdsourcing" platforms for data collection, could assist in calculation of exposure levels and inform risk assessment procedures. |
| Knowledge gap on maximum residue levels: The increased sensitivity of analytical methods can detect and quantify tiny amounts of residues. It is important to understand how this affects risk assessment and decision making, for example in the above case this may lead to the establishment of lower and lower maximum residue levels (MRLs) for certain substances in different products, making it increasingly difficult for products to be compliant. This may be particularly challenging in the future, in particular for substances that may be impacted from climate change. |
| Abundance of voluntary food information and increased opportunity for misleading information |
| Alternative means of information: There is an interest from different stakeholders in potential alternatives to current labelling schemes, e.g. use of pictograms, etc. Their use is not easy and straight-forward, and there is a need to investigate the potential benefits and drawbacks related to consumer understanding in comparison to existing schemes. Therefore, further research on the effective delivery and cognition of food related information (ingredients, nutrition information and nutritional value versus price) is necessary. |
| Increased sedentary behaviour and snacking due to changed lifestyle & Diets based predominantly on highly processed foods and decreased availability of fresh produce |
| Food research in reformulation and innovation: More research would be needed on how to reformulate processed foods in order to make them healthier while preserving taste, convenience and low-priced options adapted to the lifestyle of the future consumer. |
| The potential of behaviour sciences: There is a need for more research on behavioural science insights on consumers and the food industry. Best practices and "success stories" could be assessed for potential use and implementation in policy-making in order to improve consumer diets and increase physical activity. Also, research is needed on how to design behavioural science-informed policy options taking into account the potential dietary habits and physical activity of consumers in 2050. |



2

“Regional Food”



Table 10 - Driver developments in "Regional Food" scenario

| Driver | Main characteristics |
|--------------------------------|---|
| Climate change | <ul style="list-style-type: none"> • 2°C threshold of temperature increase will be reached by 2050 |
| Depletion of natural resources | <ul style="list-style-type: none"> • Progressive natural resource depletion towards 2050 |
| World population growth | <ul style="list-style-type: none"> • World population will increase to about 9 billion by 2050 |
| Social Cohesion | <ul style="list-style-type: none"> • High social cohesion • Solidarity is a key value |
| Food values | <ul style="list-style-type: none"> • Society values food and its integral role in nutrition, health, environment, culture and social cohesion • Food choices primarily driven by health, environmental sustainability, local production, fair trade/ethical, animal welfare • Diets mainly comprised of food products produced locally/seasonally, lower consumption of animal proteins including red meat and dairy products • Cooking skills and nutrition education are considered important |
| Technology uptake | <ul style="list-style-type: none"> • Selected uptake of technological advancements • Thorough environmental and health risk assessment • Technology development is focused on: <ul style="list-style-type: none"> ○ Optimisation of existing technologies ○ Local and sustainable food production ○ Mitigation of resource scarcity and climate change ○ Renewable energy sources ○ Overcoming vulnerabilities of circular economy ○ Waste reduction/re-utilisation, including the food chain |
| EU economic growth | <ul style="list-style-type: none"> • Circular, largely self-sufficient economy, with recognised vulnerabilities • GDP as an indicator of economic performance has been replaced by other indicators including environmental performance and social well-being |
| Global trade | <ul style="list-style-type: none"> • Disruption and fragmentation of international trade, no global food system • Intra-EU trade and targeted bilateral agreements to satisfy specific needs (e.g. raw materials) • Tariff and non-tariff barriers (both import and export) in place to buffer food prices, to protect local production, and to keep high safety standards for food products and technology applications |
| Agro-food industry structure | <ul style="list-style-type: none"> • Low industry concentration and SMEs thrive across the shorter, more local food chains • Alternative/informal food businesses increase (direct food exchange, purchase from producers) • Higher food prices due to lower economies of scale • Lower variety of foods both processed and fresh available due to reliance on short food chains • Potential occasional shortages of fresh produce due to climate change effects and fragmented trade |

2.1. "Regional Food" in 2050

The way towards 2050...

Discussions in the 2010s on climate change mitigation and resource depletion did not lead to the necessary changes to stop the trends. Developed countries enacted some adjustments and the so-called emerging economies continued to grow rapidly, largely based on the use of fossil fuels. The growing world middle class shifted, as forecasted, towards a more westernised diet rich in animal proteins, vegetable oils and processed foods, contributing to the increasing pressure on natural resources. Against the background of progressively felt climate change and the worldwide inaction regarding pressures on the environment, citizen groups in the EU started advocating for a change of policy and responsibility of the individual. The EU with its population size and economic weight was perceived by the citizens of the Member States as the

only opportunity to influence world development. Global trade resulting in influx of products using novel and often not publicly accepted technologies contributed to additional concerns for EU citizens. Nonetheless, the other global economic heavyweights such as China, India and the US did not change their policies. On the contrary, because of international rules, as well as bilateral trade agreements, it was an up-hill struggle for the EU to implement any framework that would move the EU economy swiftly towards a pathway of environmental sustainability including responsible use of natural resources. Also the actors of an increasingly global and complex food chain did not support any restriction regarding trade and use of resources. Towards 2035, access to natural resources became an issue, and incidences of trade disruptions in particular for food were considerably more frequent, caused by export bans following harvest failures, food price volatility as well as scares and scandals related to food quality and safety.

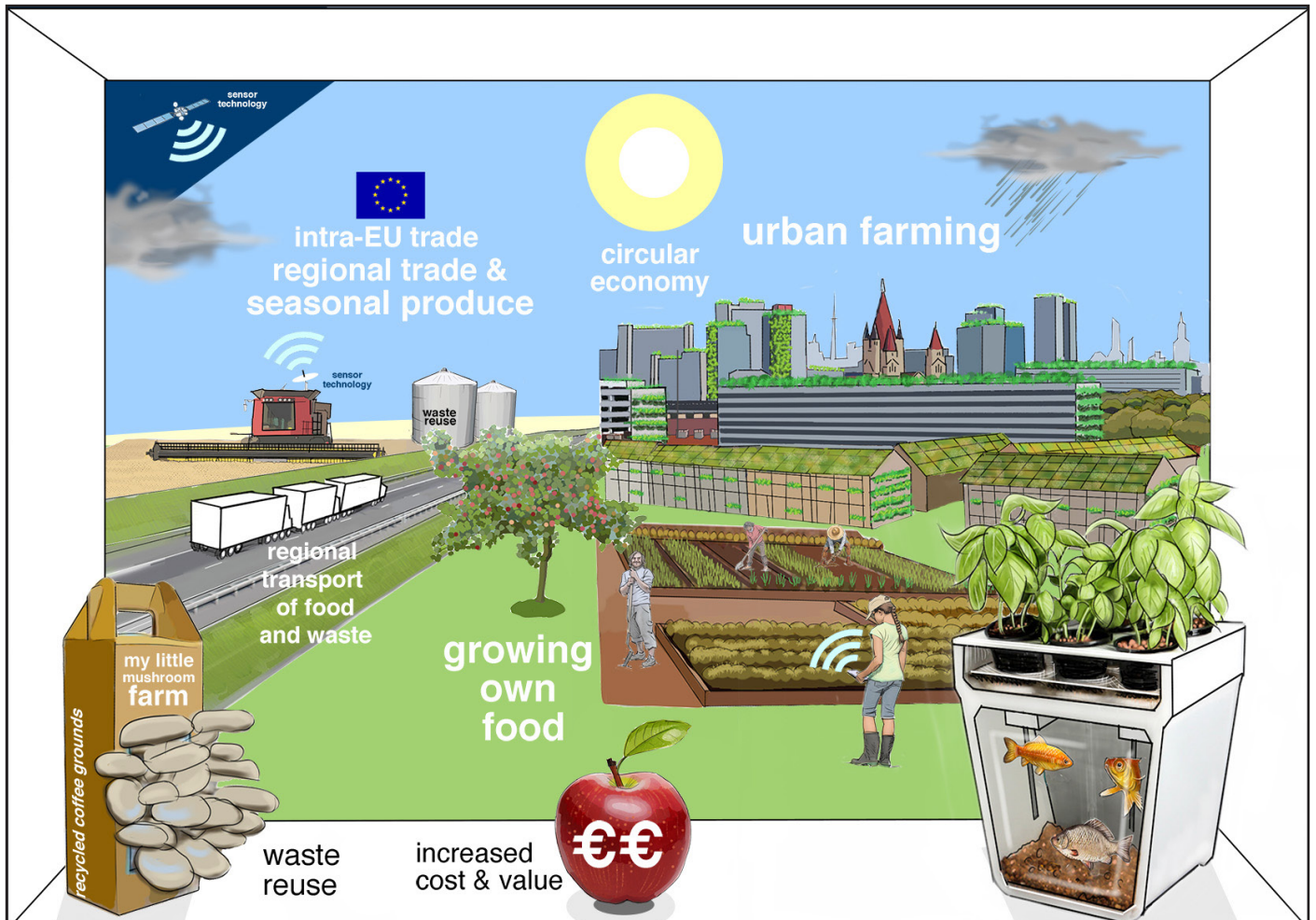


Figure 5 - Illustration of the European food system of “Regional Food” in 2050

Worldwide, many countries and regions moved towards securing food supply based on domestic or regional production, abandoning global free trade and weakening international institutions. Trade barriers, which in the 2010s seemed to get dismantled, resurfaced in a strengthened way. This only reinforced the resolve of EU citizens, long dissatisfied with the global agro-food developments of the past, and as a result, the EU follows suit; in 2040, after a referendum, the EU abandons bilateral and international trade agreements and focuses its efforts on food self-sufficiency⁴⁰.

The EU in 2050

Increasingly unfavourable conditions for food production led the EU and its citizens to turn their back on global trade and restructure the economy towards sustainability and food self-sufficiency. Food in 2050 is perceived as a valuable good and its production has become much more local and regional than in the past. Citizens have a more active role in food production, many of them using their gardens, cellars and rooftops to grow food. Reduction and re-use of food waste as well as bio refineries are a common element in this society. Technologies such as biotechnology are used to create crop

and livestock varieties better adapted to the changed climatic conditions and to improve efficiency of production processes, and shelf life of products. Diets are largely plant-based.

The context

By 2050, climate change has increased average temperatures in the EU beyond the 2 degrees Celsius threshold⁴¹. As a result, the EU experiences more frequent heat waves, particularly serious in southern Member States. Linked to a decrease in rain falls, the South experiences more droughts, making agricultural production more and more dependent on irrigation, and temperature and drought resistant varieties, while susceptibility to (new) pests is increasingly becoming an issue. Soil erosion and desertification pose additional challenges. Temperature increase, though, has allowed expansion of agriculture further north, partly making up for yield reductions in the south. However, heavy rainfalls and increasingly frequent flooding events or water shortages in summer, render harvests more volatile than in the past. Long-term storage and food stocks in general become more important for food security and have been increased accordingly. A considerable decrease in livestock production and meat consumption facilitates buffering volatile harvests.

⁴⁰ In this scenario we assumed this course of events to take place in the EU, as in its 2015 status; however, in principle, this could be possible for any region of the world that chooses to move towards a self-sufficient food supply chain based on regional or domestic food production, abandoning global free trade.

⁴¹ Based on the Representative Concentration Pathway (RCP) 8.5 greenhouse gas concentration trajectory, from the fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change.

After most countries and macro-regions abandoned bilateral and global trade agreements 10 years ago, trade happens mainly within the EU, including agricultural products and foodstuffs, instead of being directed towards third parties. Some critical raw materials, such as rare earth elements and components of mineral fertilisers such as phosphate, fuels including natural gas, still need to be imported from e.g. China, Brazil, Morocco or Russia, and specific EU-level policies and agreements are in place to ensure supply. This is tightly linked to international cooperation in case of food supply emergencies. Exports from the EU to the rest of the world are negligible and what few EU food products are found outside Europe are considered niche luxuries.

The move towards self-sufficiency and substantive reduction of trade has challenged the EU economy. However, in line with the societal goal of sustainability, growth of GDP is no longer considered to be the only measure of success, and other elements such as environmental quality and quality of life are considered more important. EU Member States agreed on a long-term approach and a far-reaching package of harmonised legislative and fiscal measures. Realising that bottom-up local and regional incentives are a major driving force for success, citizen initiatives are supported with expertise and logistics. The fiscal package in place taxes the use of resources and internalises environmental costs, while minimising labour taxes. This makes labour cheaper, facilitating employment, while incentives are provided to make production as efficient as possible. Prices for goods (and resource-intensive services), in particular food, have gone up; food now represents an important share of the household budget. Border controls had to be stepped up to prevent trade with low-cost products not complying with EU rules.

A smart, i.e. information and communication technologies-based, efficient manufacturing sector across all sectors of industry has experienced a revival. Automation is far advanced, so most of the jobs can now be found in the service sector. In an ageing society with longer working lives, unemployment is an issue. Reduced labour costs make health and elderly care more affordable, all the more important since it is an area where human contact is valued and automation is still not accepted.

Public services such as healthcare have been reduced to cover the essential tasks and access to new medical treatments is subject to strict cost-benefit assessments. Prevention has been given much more emphasis. Instead, investments into research and development towards resource efficiency, alternative energy sources, replacing depleted resources, recycling procedures, mitigation and adaptation of climate change etc. have been strengthened substantially, and are showing some results.

By way of restructuring towards more sustainability and relying on approaches adapted to regional and local needs, the EU economy has become more regional/local. However, basic rules, and standards and relevant policies are developed at EU level, so that the overall objectives and frameworks are harmonised. Also the sustainability assessment of new technologies and their probable applications is carried out centrally. This is matched by a stronger engagement of citizens towards their local community on the one hand, and towards the EU on the other hand, striving for the development and exchange on

best practices and effective approaches to common problems. Social media facilitate this bottom-up engagement.

The agro-food chain

The EU primary food production sector in 2050 is a diverse one with a mix of large, rural entities, smaller peri-urban and urban farming facilities, complemented by advanced homesteading. Sophisticated technologies are used, including automation and precision farming. Urban farming entities use urban material flows such as sewage and profit from closeness to consumers to market their products. Alternative production by individuals in their private homes, cellars, balconies, garden, rooftops etc. adds to the supply of mostly vegetables and some animal proteins. Automation facilitates this advanced form of homesteading, and plant and animal care services have been established as a new low-cost business sector. Food chains overall have become more fragmented and on a local scale, affecting also certain operative aspects of horticulture and livestock production. For example, past centralisation of slaughterhouses resulted in lack of regional and local infrastructure; individual, small producers now slaughter themselves if they have the capacity or book mobile abattoirs. Intensive livestock production has continued its decrease, in particular cattle and pigs, since protein-rich feed imports have been increasingly difficult and expensive in the past and are now next to non-existent. Also the demand for meat and dairy has gone down substantially as consumers became environmentally more aware of the implications intensive meat and dairy production has.

More food processing by-products are channelled into livestock feeding, further decreasing the need to grow feed crops. However, the expanded EU aquaculture production, replacing to some extent the fish imports of the past, is a competitor for feed made from waste from food production processes. Insects, which are now also cultivated to produce feed for aquaculture, ease the pressure on livestock feed. Wild fish has still not recovered sufficiently to allow large catches, and fishing is a highly controlled activity; very little wild fish is still used for feed in aquaculture. Intensive research efforts using advances in molecular biology have resulted in new fish breeds being better adapted to aquaculture, even under the new climatic conditions. For livestock species it has been more difficult to increase disease resistance, since climate change has facilitated the spread of several, in the EU formerly unknown pests.

In addition, as many individuals and local communities engage in "gardening" for food production, local plant varieties are being cultivated. Digital platforms support crowd funding and local initiatives for do-it-yourself biotech resulted in additional plant varieties with better agricultural characteristics and new tastes to broaden food variety. Also specialty crops are developed and cultivated, geared towards specific industrial applications. Usually, these specialty crops are not food crops, and segregation rules and thresholds are in place. Bio-refinery infrastructures have been set up to make use of these specialty crops and other biomass, including food waste, to produce chemicals, energy, etc.

Fertilisation is, as far as possible, based on manure (where available), and recycled mineral components of fertilisers

such as phosphate and potassium from wastewater streams. Still, some mineral fertiliser needs to be added to maintain crop yields. Sensor technology allows a targeted application according to individual plant needs, in the field and even easier in urban farming systems. Also the supply of micronutrients to the plants has become an issue and soil in some areas still needs to be enriched with specific fertilisers. Pest pressure is an issue that is still difficult to control, and crop rotation and ever more targeted pesticides are often not sufficient.

A new line of production is insects for food preparations, which after considerable difficulties in establishing this on the EU food market due to very low consumer acceptance, starts to become a viable niche production.

With less need for feed crops, more area can be dedicated to food crops, and in particular fruits and vegetables. New varieties are tested to enlarge the currently limited diversity, and to find varieties that are better adapted to water scarcity and increased temperatures and that can help to ensure supply over a larger part of the year. Still, the variety of especially horticultural products has decreased compared to 2015 and the volatility of the weather leads to occasional shortages of fresh produce, only partially counteracted by greenhouses and urban farming systems. With the advance of demand for local/regional food and the requirements for sustainable production and transport, small and medium-sized, innovative and local producers flourished while large multinational food manufacturers were slow to react, lost market shares, and partly chose to concentrate on the large markets in Asia and Africa, instead of the more difficult one of the EU. Overall, there is a large variety of companies, developing new ways of producing food in a sustainable way with less and less waste and resource use.

Due to advancements in information and communication technologies, and the coming of age of the technology-savvy generation of 2010s and 2020s, retail has been largely moved to online shopping; also local and individual producers who seek to sell directly to the consumers offer their products online. Similarly, online peer-to-peer food exchange platforms, aiming to alleviate high food prices and reduce food waste are regularly used by the majority of the citizens. Packaging and storage conditions have been improved to reduce waste, and to keep produce fresh and appetising for a longer time; product specifications are less stringent to help reduce waste. Shelf life of products has been extended, the “best before” label has been abandoned; smart sensors are much more precise indicating the edibility of packaged food products. Also, the organisation of online retail enables a much better monitoring of demand, and thus planning of production and storage, to avoid overcapacities and waste. Shopping can be picked up at certain collection sites or is delivered home.

Still, despite increased efficiency and automation of many processes, due to higher costs for the use of natural resources and inputs, food prices are such that food represents a considerable share of a household's budget. This further supports the high value that is given to food by the consumers, and consumers avoid food waste. Flexible food packaging facilitating purchase of suitable quantities on the one hand and the use of refillable/reusable containers on the other helped to reduce waste to a minimum.

Citizens are well connected at a local, regional and EU level. The sometimes difficult environmental conditions and economic limitations are balanced by a strong community response. Throughout the EU solidarity is high, e.g. if due to a heat wave in Southern Europe more energy is needed for cooling, people in Northern Europe make efforts to reduce their consumption a little bit more to free energy capacity. In urban but also in rural environments, initiatives have gained ground that organise the living together, with the aim to facilitate social services and care, either by professional carers or volunteers. This includes elderly care and health care at home, or care for children.

In 2050, the average EU citizen works in the service sector, often in flexible working time arrangements, from home or some local offices. In addition, reflecting the value of food, farming has become an attractive profession, seeing a renewed boost of interest from younger professionals. Skilled food technologists are in demand to set up and monitor the variety of highly controlled, closed-loop food production systems, such as aquaponics and vertical farming. A lot of mobility is observed in the labour market, and in fact the EU citizen knows the EU pretty well, having travelled and lived in different Member States of the EU.

Monitoring health and environmental footprint is a daily routine and performances of different communities are analysed and published to identify and share best practices and to motivate people to improve behaviour. Ownership is less important and a culture of and infrastructures for sharing have developed, e.g. for tools, objects, or facilities.

Food and joint meals are an integral part of living together. Since food represents an important share of most household budgets, reduction of costs through joint shopping and sharing of meals is common. Online shopping facilitates access to food also for elderly citizens. But also neighbours or the local farmer offer foodstuffs, mostly via specific websites, sometimes in exchange of a service. Food services exist that provide ready-made meals, prepared ingredients, or just the right amount of ingredients for a certain recipe. Since labour costs are low, automated kitchens did not yet take off, nor did the 3D printing at home.

Food production and nutrition is part of school curricula so most people know how to cook the most common dishes, using the variety of food that is readily available. Food safety incidents in the past led to better education and knowledge as well, but now consumers rely more and more on technology to tell them if food is fit for consumption. Apart from generally longer shelf life, this has helped to reduce avoidable food waste to a minimum.

Diets, largely plant-based, usually consist of cereals, potatoes, animal proteins in form of mostly chicken meat, some pig and beef meat and fish (or insect burgers) and some dairy products and seasonal fruits and vegetables. More exotic fruits are more expensive and not always available, and are consumed less often than apples or dried fruits and vitamins. Supplements in general are provided to make sure micro-nutrient needs are met. Sweet, fat-rich food is not as common as formerly, and is rather used as a special treat.

Food waste at any stage of the food chain has been greatly reduced compared to 2015, in order not to waste resources. Unavoidable waste at the household level is collected and fed back into the system, be it through fermentation as energy, as feed, or as fertiliser after composting. Larger entities have decentralised systems in place to use their waste for biogas production and fertilisation of their (rooftop) fields.

Healthier eating habits, including the higher consumption of plant-based protein instead of animal protein, coupled with a health policy geared towards prevention and nutritional education in schools have led to a decrease of the incidence of diet-based non-communicable diseases and obesity in children and adults. However, the older adult generations still bear the marks of unhealthy dietary habits, with higher prevalence of cardiovascular diseases and type 2 diabetes.

2.2. The challenges ahead and policy preparedness

There are several issues that can compromise the food system of **"Regional Food"** and they are listed in Table 11. A description of each challenge and their impact on the food system (including the consumer) is given in the Annex. The challenges highlighted in bold have been selected for their high likelihood to occur and their negative impact on the system we are studying and the next pages further discuss a selection of these and propose different options on how policy-makers can address them.

2.2.1. Greater reliance for food safety on individuals engaging in food production

In the **"Regional Food"** it is anticipated that primary production will be much more local and regional within Europe than today, with citizens being actively involved in producing food in all spaces within the urban environment (urban farming), alongside the larger agro-food industry. Thus, a larger share of food safety responsibility will rely on individuals engaging in food production that may not have the technical know-how and resources currently found in the organised large-scale agro-food industry. This may lead to food safety concerns in the future due to the inability to implement an appropriate food safety culture or good manufacturing practices by individuals. Ensuring plant and animal health in urban gardening will be difficult as well. It is also anticipated that increased backyard livestock production could pose significant risks of spreading of animal diseases (e.g. bird flu, etc.) and even risks of transfer of zoonotic diseases to humans (swine/bird flu) in cities.

This challenge will be even more prominent due to the reduced possibility of performing appropriate controls in this situation where products change hands on a peer-to-peer level and due to the challenges imposed by the self-sufficient economy of **"Regional Food"**.

Policy options

Peer-to-peer trade of food will be extensive in **"Regional Food"**. Two approaches can be followed to ensure that the offered food is safe: a regulatory approach and a "softer" approach based on education. As for all other policy options discussed, a thorough evaluation of the costs, risks and benefits

**Table 11 - Food and nutrition-related challenges identified in the "Regional Food" world
(in bold those prioritised)**

| |
|---|
| Emerging biological risks: |
| a) The introduction of known pathogens causing (bio)chemical safety hazards in geographical areas where they were not previously known |
| b) Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains |
| Shortage of quality water |
| The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies |
| Ability to perform official food-related controls |
| Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism |
| Failure to provide appropriate food safety information to the consumer |
| Abundance of voluntary food information and increased opportunity for misleading information |
| Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels) |
| Re-introduction of food-waste and organic side-stream products in the food chain |
| Introduction of environmental contaminants in the food chain from primary production in the urban environment |
| Greater reliance for food safety on individuals engaging in food production |
| Temporary shortages of fresh produce and food poverty in a self-sufficient food system |
| Diets based predominantly on plant based products |
| Imbalanced diets due to over-reliance on (perceived) "healthy foods" or specific dietary regimes |

associated with each approach could help determine the most appropriate action. In **“Regional Food”** the suggested options would need to be adapted, taking into consideration Member States’ own capacities and specific needs in relation to local products and related risks.

- **Expand the scope of the General Food Law, hygiene regulations and related controls to include individuals engaging in food production**

Regulation (EC) No 178/2002 defines food business operators as the persons (natural or legal) that are responsible for ensuring that the requirements of food law are met within the food business under their control. The business, defined as an undertaking that implies a certain continuity of activities and a certain degree of organisation, may be for profit or not, public or private and carrying out any activity related to any stage of production, processing and distribution of food. However, primary production for private domestic use and the domestic

preparation, handling or storage of food for private domestic consumption, are excluded from the scope of the Regulation. The Regulations on the hygiene of foodstuffs ((EC) No 852/2004⁴²) and hygiene of foodstuffs of animal origin ((EC) No 853/2004⁴³) exclude from their scope private production and consumption as well as the direct supply, by the producer, of small quantities of primary products to the final consumer or to local retail establishments directly supplying the final consumer. Reg. (EC) No 853/2004 additionally excludes the direct supply of certain meat products. These are regulated at Member State level by the establishment of specific rules. The hygiene regulations also require that the food business operator notifies the authorities of the food producing and handling establishments and in certain cases approval after on-site visits by food inspectors is required.

To be able to ensure the safety of the food produced in all cases, a broader legal definition of “food business” and “food business operator” could be envisaged, to also include the distribution among peers of privately produced and prepared food, whether



⁴² Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs

⁴³ Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin

for financial gain or payment in kind (peer-to-peer business). Food offered via these channels could therefore be subjected to the existing registration and control requirements. The same effect can be achieved by removing the exemptions for direct supply of small quantities of primary products from the hygiene regulations. Proportionate and realistic measures need to be taken though that can achieve the required level of food safety without resulting in over-regulation and unnecessary burdens.

Notwithstanding the above regulatory amendments, to effectively control individuals engaging in food production and peer-to-peer trade would be difficult, would require significant investments and cannot constitute an obstacle for individuals to produce primary products. The current official controls system would need to be re-organised and enhanced at Member State level and more attention would be needed at local and regional level, to build the capacity and resources required to reach into peer-to-peer trade and the different distribution channels of the **"Regional Food"** world (web-based exchange platforms, social media and food banks). A local register of food producers accompanied by a license/certificate could be useful for control and traceability purposes and also for facilitating the communication to all producers of best practices, guidance and other safety information and expert knowledge. This could be supported by the establishment of a regulated "online exchange network". Such measures could also build more confidence in the local food operators to source raw materials from individuals engaging in food production locally, still fulfilling the traceability requirements. They would also contribute towards achieving an equal treatment in relation to food controls, for everyone producing food. However a determining factor in the applicability of such policies would be the associated costs and the resources, financial and human, which would be needed for their implementation.

• Implement the registration and vaccination of all livestock

In **"Regional Food"**, animals for food use are also expected to be reared in urban settings, where space could be limited, increasing the possibility of transmission of diseases to humans. All livestock could be registered at birth and vaccinated against the most significant diseases, irrespective of the number of animals that a producer may own or the size of the farm. This could be done using as a basis Regulation (EC) No 1760/2000⁴⁴, which establishes a system for the identification and registration of bovine animals and rules on the labelling of beef and beef products and was implemented after the BSE (bovine spongiform encephalopathy) crisis to assist in traceability and enhance consumer confidence. From one side, there may be difficulties in the implementation of such a measure due the big numbers of certain animals (chickens, rabbits, etc.), their small meat yield or short life-span. On the other hand however, a more extensive reach of ICTs and mobile applications in the future, combined with existing platforms for the exchange of such information, could reduce the effort needed

for the functioning of such a system, thus making it more viable. This would facilitate controls and the exchange of information for traceability purposes in case of a safety incident.

• Establish a list of "high-risk" products

An alternative way to avoid the possibility of transmission of animal diseases to other animals or humans via urban farming and to ensure food safety and public health could be the establishment of a list of "high-risk" products which should not be produced by individuals, based on a risk-assessment.

• Improve food safety education

As an alternative to the regulatory approach of registration and control of individuals engaging in food production, who may not necessarily have the knowledge of food safety needed, a proactive way to deal with this challenge in **"Regional Food"** could be through educating all producers to acquire enough competences for ensuring a basic level of food safety, at least to Good Manufacturing Practice (GMP) level. Certain Member States already require training for small scale food producers, which could be extended to individual producers and made a legal requirement at EU level as well. Training could be complemented by the provision of advice and information on the safe handling of food and extend to animal health and welfare, good practices related to the use of plant protection products for primary production, control requirements, slaughtering, food preparation and processing technologies and religious requirements (kosher, halal, etc.). Training could be provided not only through the participation in face-to-face courses but also via webinars, massive open online courses (MOOCs) and other channels such as the "online exchange network" mentioned above. Individuals engaging in food production could be provided with a certificate or license that attests to their capacity to provide safe food. Guidance on participatory agricultural food production or information on Research and Development (R&D) funding for innovation, all aimed at providing insights to small-scale producers towards both better food safety and improved production capacity could also be provided to individuals engaging in food production.

Education of individuals engaging in food production would also need to include access to and safe use of future food-related technological developments. These would enable them to produce food safely while requiring less food-producing skills and making best use of the available resources in the circular economy of **"Regional Food"**. A prerequisite for this will be the guaranteed safety – through improved market surveillance – of available technology in the internal market, that will need to be conformity assessed (CE mark).

In this case, also consumers will need to be better informed. Even if individuals are putting their best efforts in being responsible for the safety of the products they provide – based on their high food values and food safety culture, backed by the minimum food safety and hygiene training received by the authorities – consumers should be aware that it is the individual producer that guarantees the safety of these products⁴⁵.

⁴⁴ Regulation (EC) No 1760/2000 of the European Parliament and of the Council of 17 July 2000 establishing a system for the identification and registration of bovine animals and regarding the labelling of beef and beef products and repealing Council Regulation (EC) No 820/97

⁴⁵ <http://www.slowfood.com/slowlife/wp-content/uploads/ING-Il-cibo-locale-conta.pdf>

2.2.2. Failure to provide appropriate food safety information to the consumer

The need for receiving essential and mandatory food safety and nutrition information such as expiry dates, information on the safe handling and storage of food, allergen information, food composition and nutrient values is of particular importance. In the **“Regional Food”**, where many products may be purchased directly from the farmer or producer without packaging and labelling, thus without this information, food safety hazards could occur as a result of the consumer mishandling of the foods. Shelf life and expire dates will be even more significant in the future given the increased average temperatures expected.

Policy options

- Promote the use of social networks and ICTs by individuals engaging in food production to provide food information to their peers

Where labelling may be limited, especially in the case of fresh primary produce obtained directly from individuals engaging in food production, the use of ICTs and social networks could be further exploited. This could be used not only for the provision of information by the authorities on best food handling practices, but also for the provision of essential product information, e.g. use of certain nutrients/ingredients, recommendations for storage and preparation to consumers. According to Regulation (EU) No 1169/2011 on the provision of food information to the consumers, food information is defined as information concerning food and made available to the consumer by means of a label, other accompanying material or any other means including modern technologies or verbal communication. The use of ICTs and social networks for the provision of food safety information to the consumer could thus be accepted by the authorities in special cases; for example individuals engaging in food production could provide the necessary safety and nutrition information to their peers in this way. This information systems could also be approved and even recommended by the authorities; therefore for individuals engaging in food production or for the irregular supply of food products, a general recommendation to make such information available using these means would be sufficient, while from a certain “trade volume” of peer-to-peer transactions on, it would be required; in the latter case, a threshold of such trade volumes would need to be established.

2.2.3. Re-introduction of food-waste and organic side-stream products in the food chain

In the context of a circular-based economy as the one envisaged in **“Regional Food”**, food-waste (former-food no longer suitable for human consumption) and other agricultural side-stream products (such as animal by-products) are expected to be re-introduced into the feed-food chain, in particular for use as feed or organic fertilisers, in order to increase the sustainability and resource efficiency of the production process. The types of food and by-products that can be re-introduced in the food

chain are restricted in order to prevent disease transmission to animals and humans. However, unawareness of the risks may lead to the use of hazardous waste by individuals growing their own food or feeding their own animals in the **“Regional Food”**. This could lead to the introduction of different chemical and biological safety hazards in primary production and could also facilitate the transmission of zoonotic diseases.

Policy options

To avoid safety risks from the re-introduction of food waste and by-products in the food chain, action could again be taken at two levels: regulation and/or support through education initiatives:

- Expand the scope of General Food Law and feed hygiene regulations to individuals engaging in food production

Regulation (EC) No 178/2002 defines feed business operators similarly to food business operators. The feed hygiene Regulation ((EC) No 183/2005⁴⁶) does not apply to the private domestic production of feed for animals kept for private domestic consumption, to the feeding of animals for private domestic consumption or direct supply of small quantities to the final consumer nor to the direct supply of small quantities of feed at local level by the producer to local farms.

To ensure the safety of the feed, the above provisions could also be extended to individuals engaging in the production of feed from waste, ensuring however that appropriate and proportionate measures are implemented that do not result in over-regulation and unnecessary burdens. As discussed above, the possible introduction of a local register of small-scale feed producers could allow improved communication of best practices and guidance to even the smallest producers and would also enhance traceability and control, allowing the local food industry to confidently use the local feed supply chain, further reducing local waste.

- Establish communal food waste handling or recycling centres

The establishment of communal food waste handling systems where local food waste is gathered for further processing in a more organised manner, by professionals, guaranteeing the safety of the product (feed, organic fertiliser etc.), could help in centralising waste management and re-use by the local communities in **“Regional Food”**. Current recycling regulation and systems are largely inadequate particularly given the micro-structure of the food chain in this scenario.

⁴⁶ Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene.

- Educate individuals engaging in food production on the re-use of food waste

Training and education initiatives could also provide guidance on the suitable types of waste that can be used for different product categories commonly produced by individuals and on how to minimise the associated food safety hazards. Information is already provided by Regulation (EC) No 767/2009⁴⁷ on placing on the market and use of feed. However, more detail and guidance on how certain provisions could be used and applied by individuals engaging in food production within the context of the food system of **"Regional Food"** would be very useful to avoid safety risks appearing at household and local community levels.

2.2.4. Temporary shortages of fresh produce and food poverty in a self-sufficient food system

Agricultural production as well as availability of and accessibility to food may be challenged in a food system dependent on local and self-sufficient production (including home-grown foods and/or urban farming). Climate change, extreme weather events, natural resources scarcity and seasonality, can lead to less variety of foods available locally, especially in the case of fresh produce. Due to different impacts of climate change and natural resource depletion across Europe, some regional/local food chains may be more affected than others and it is likely that not all urban regions in the EU will be able to ensure local production systems or urban farming by 2050.

At the same time, the lack of economies of scale in a local and short food chain system such as the one of **"Regional Food"** may increase the cost of agricultural produce with subsequent transmission to retail prices and direct impacts on household budget allocated to food purchase. Therefore a local and largely self-sufficient production system may face resilience issues and this could negatively impact the availability and accessibility of agricultural products, leading to food poverty, nutrition inequalities and malnutrition for a part of the population and local or temporary food security issues. Loss of variety in diets can affect dietary quality leading to micronutrient deficiencies.

Policy options

To ensure the sustained availability of safe food of adequate nutritional quality and to avoid incidents of temporary food poverty in local self-sufficient systems in the EU the following mechanisms could be designed:

- Establish emergency mechanisms for food re-distribution

Although global trade is limited under this scenario, inter-regional and intra-EU trade of regionally produced food will still satisfy a significant part of demand and ensure diversity of diets. However, in cases where regions and Member States flag food-related shortages (or possible shortages based on predictive models) a mechanism needs to be available which allows calling for aid from other regions or Member States with sufficient or surplus produce.

- Introduce production quotas to ensure balanced diets during temporary shortages

Albeit many past issues related to the establishment of quotas, there may be merit in reconsidering their re-introduction in the **"Regional Food"** setting to ensure that products with key nutrients for a balanced diet are supplied in sufficient amounts and there is no wasteful over-production of other products.

- Proactive nutrition education

In addition to the above, proactive action can also be implemented to ensure consumers can confront possible shortages in the availability of fresh produce in **"Regional Food"** scenario. The above measures could be supplemented with nutrition education and nutrition advisory programmes. These would educate consumers about the variety of available foods that can be grown locally in the different seasons and how those foods can cover individual dietary needs. The population would be further instructed to identify key macro- and micro-nutrient sources and learn how to ensure an adequate nutritional status during temporary disruptions in the production of certain horticultural or livestock products. Smart steering of EU food production together with proper nutrition literacy should allow ensuring a food and nutrition secure population even under challenging conditions linked to climate change and resource scarcity.

⁴⁷ Regulation (EC) No 767/2009 of the European Parliament and of the Council of 13 July 2009 on the placing on the market and use of feed, amending European Parliament and Council Regulation (EC) No 1831/2003 and repealing Council Directive 79/373/EEC, Commission Directive 80/511/EEC, Council Directives 82/471/EEC, 83/228/EEC, 93/74/EEC, 93/113/EC and 96/25/EC and Commission Decision 2004/217/EC.



2.3. Is Europe heading towards the “Regional Food”?

The policy options above shall be considered and their impact and potential effectiveness assessed before the challenges identified impede the proper functioning of our future food system. Table 12 proposes a series of simple indicators that

can signal European developments towards this scenario, or to phrase it more correctly towards *particular elements* of this scenario; sources that could potentially supply the relevant data for monitoring these indicators are also included. Reflecting some of the main characteristics of “**Regional Food**”, these indicators mainly refer to the more local nature of the EU agro-food chain (including own production of food), the reduction of food waste, as well as the shift to healthier dietary habits by the EU consumer.

Table 12 - “Regional Food” specific indicators and potential sources of data¹. ↑ or ↓ indicate an increase or decrease compared to 2016

| | | | | | |
|---------|---|--|---|---|--|
| ↑ | % of EU consumers growing or producing their own food | % of EU protein consumption of plant (and insect) origin | % market revenue generated by SMEs | % EU of small farm holdings in primary production | % of EU population living in rural areas |
| Sources | BEUC, CO-PA-COGECA, Eurobarometer | EFSA, FAO | UEAPME, FDE | COPA-COGECA | World Bank, FAO, EEA |
| ↓ | Volumes (tons) and value (Mio €) of imported foods | % of food waste generated across all steps of the food chain | % of food waste not re-introduced in the food chain | % of overweight and obese children and adults | Consumption (g) of high fat, salt and sugar foods per capita |
| Sources | WTO, OECD | FAO | FAO | WHO, OECD | EFSA, FAO, WHO |

¹ For all of these indicators, ESTAT or relevant EU DGs such as SANTE, AGRI, TRADE etc. would be the first choice for monitoring of data relevant to these indicators; what is indicated therefore in this table are potential additional data sources, from relevant specialised stakeholders or organisations.

2.4. Research needs

In order for our future policy and regulatory framework to be fit to respond to the challenges presented in 2050 by the **"Regional Food"** world, it could benefit from more research in the areas mentioned in Table 13.

Table 13 - Research needs per challenge in "Regional Food"

Greater reliance for food safety on individuals engaging in food production

Limits to home food production: Research is needed to identify which food products are most likely to be produced by 'amateurs' in their backyards for direct consumption or distribution to their peers and what are the associated risks/hazards for individual and public health, to establish the list of "high-risk" products should not be produced by individuals.

Monitoring: Need for research on collection, storage and validation of data necessary for monitoring food safety in a fragmented food production system to ensure traceability and a reliable implementation of HACCP. Need to understand how to connect data from different monitoring systems, e.g. apps combined with simple sensors from individuals engaging in food production. In addition it is important to ensure the compatibility of such applications and sensor systems and the need for harmonisation or standardisation.

New technologies for better official controls: explore the viability of technology-driven applications including nano-packaging, labelling, food-omics or molecular biology advances (e.g. DNA microarrays) and culture-independent techniques, or other rapid screening systems, on a large scale with reduced cost and easier mode of operation, adapted to small scale or home producers.

Food safety education: Need to better understand how to provide more efficient and effective education on food safety, hygiene and nutrition, how and when to deliver this and by whom. Combined with behaviour research, communication and education initiatives could achieve food safety behaviour change of individuals engaging in food production.

Re-introduction of food-waste and organic side-stream products in the food chain

Re-introduction of food waste: Need to investigate what type of food waste or waste from food production processes in general (water, organic side-stream products etc.) can be reused as input into food production or recycled; what type of processes must be put in place to ensure food safety and minimise environmental impact, as well as identification of potential risks that may be involved.



3

“Partnership Food”



Table 14 - Driver developments in "Partnership Food" scenario

| Driver | Main characteristics |
|--------------------------------|---|
| Climate change | <ul style="list-style-type: none"> • 2°C threshold of temperature increase will be reached by 2050 |
| Depletion of natural resources | <ul style="list-style-type: none"> • Progressive natural resource depletion towards 2050 |
| World population growth | <ul style="list-style-type: none"> • World population will increase to about 9 billion by 2050 |
| Social Cohesion | <ul style="list-style-type: none"> • Social cohesion limited to local communities and rural areas |
| Food values | <ul style="list-style-type: none"> • Society does not value food highly – food choice is driven by price, time availability, taste and convenience • No significant reduction in consumption of meat and other animal products • A common food culture developed with diets rich in calories, saturated fatty acids, salt and sugar • Loss of culinary values and cooking skills |
| Technology uptake | <ul style="list-style-type: none"> • High technology uptake and acceptance by consumers • Less stringent approval procedure and governmental control • Technology development is focused on: <ul style="list-style-type: none"> ○ Production efficiency ○ Mass food production ○ Enhanced/functional foods |
| EU economic growth | <ul style="list-style-type: none"> • Slow GDP growth • Stronger economic growth of emerging economies and the US • Declining public spending |
| Global trade | <ul style="list-style-type: none"> • Trade zone between EU, US and Canada • Convergence in food policy and legislation between the partners • Beyond this partnership trade zone, tariff and trade barriers exist between the EU and third partners limiting trade |
| Agro-food industry structure | <ul style="list-style-type: none"> • Continuing concentration in the agro-food sector compared to today • Strong presence of US companies and acquisitions of EU companies • Proportionally fewer SMEs, small retail shops still exist and service niche/specialised needs • Low cost, mass produced processed foods ensure sufficient intake of macro- and micro-nutrients, as well as kcal/capita |

3.1. "Partnership Food" in 2050

The way towards 2050...

After the economic crisis of 2007/2008 and the resulting prolonged austerity, the EU had difficulties establishing a stable economic growth; periods of growth alternated with stagnation or recession. This had an impact in limiting public investment in research and development, including new technologies. Against the background of a conservative EU mind-set towards in particular food related technologies, the EU became increasingly unattractive for high-skilled professionals and a gradual but significant brain-drain occurred towards regions with more possibilities. In parallel, climate change effects became gradually evident, while natural resources became scarcer, due to overexploitation, mismanagement and climate change stress; as a result, this impacted on agriculture and primary food production. Direct or indirect climate change effects, as well as the continually ageing European population and the relative unattractiveness of the EU for skilled immigrants, contributed to the long-term economic stagnation. As a consequence, the EU gradually lost importance as a geo-political and trade player on the global scene. To leverage the power of the emerging economies, and to secure better access to the diminishing natural resources, the EU sees the need for close collaboration with a stronger partner⁴⁸.

⁴⁸ This kind of collaboration, against the background of different assumptions on future developments, could in principle be possible with any of the anticipated

The economies of US and Canada fared better, but faced stronger competition from emerging economies. The EU, the US and Canada, building upon the existing ties, turned towards each other for mutual benefit. By 2020, many trade limitations in tariff and non-tariff barriers with the US and Canada were already lifted by the Transatlantic Trade and Investment Partnership (TTIP) and the Comprehensive Economic and Trade Agreement (CETA) agreements, respectively, and any remaining barriers were abolished by 2040 by expanding the original TTIP agreement. The close trade ties and the removal of non-tariff barriers resulted also in harmonised food and nutrition policies and legislation, strongly influenced by the US due to its comparatively favourable position in terms of economic growth, technology development and geopolitical influence.

The firm ties and the need to combat climate change impacts and tackle the scarcity of natural resources gradually led to a shift in the European outlook to technological innovation in the agro-food sector; from cautious acceptance after thorough evaluation, to fast uptake with reduced concern about potential long-term health or environmental negative impacts. In parallel, European consumers continued to drift further away from traditional European dietary habits and food culture; climate change impacts, economic limitations, and especially

major global players in 2050. In this scenario, we assumed a continuation and strengthening of the existing ties between the EU and the US and Canada which results in the described choice of partners.



Figure 6 - Illustration of the European food system of “Partnership Food” in 2050

strong agro-food trade ties with the partners contributed to the creation of a common food culture, which was however dominated by US customs and driven by price and convenience.

The EU in 2050

This scenario is characterised by a setting where global warming exceeded 2°C in 2050, and now evident climate change impacts and natural resources scarcity pose significant challenges for Europe. The EU economy is stagnating, and having lost importance globally in geo-politics and trade, Europe has strong trade and policy ties with the US and Canada, especially in agriculture and food. Europe has a favourable outlook towards technological innovation in the agro-food sector and readily uptakes new technologies, mostly developed by the partners. In the EU, the application of the precautionary principle in food and nutrition policies and legislation has been gradually relaxed. The European society in 2050 does not value food highly, and food choice is driven by price and convenience; this is reflected also in the agro-food chain, focused on efficiency, mass production and climate change resilience.

The context

In this scenario, the +2°C temperature increase (compared to the end of the 20th century) threshold has already been

exceeded in 2050⁴⁹, which, together with over-exploitation, resulted in reduced natural resources availability (e.g. water, soil) as well as direct and indirect impacts in European agriculture and food production. In 2050, the largest temperature increases occur in North and East Europe during winter and in South Europe during summer. Flood events are taking place in large parts of Europe; in parallel northward expansion of agricultural production, especially Mediterranean crops, has been observed. Extreme heat waves and drought events are more common in Southern Europe and the Mediterranean, with increased soil erosion and desertification as well as reduced river flows and precipitation. In addition, there is a marked reduction of rain-fed agriculture and increased dependence on irrigation, resulting in reduced crop yields, both due to water constraints as well as due to temperature sensitivity of crops. In Northern Europe, the northward expansion of agriculture results in the potential to cultivate species where it was previously not possible, as well slight increased yields in some crops; however, floods occur more commonly affecting agriculture in river and lake basins. Across the EU, yields of crops have been reduced; this has been somewhat mitigated by intensification of management practices and use of novel technologies. Overall, as inputs and farming become more costly, agricultural commodity prices have increased.

⁴⁹ Based on the Representative Concentration Pathway (RCP) 8.5 greenhouse gas concentration trajectory, from the fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change.

The EU experiences economic stagnation, which results in tight public budgets and decreased member state social spending, impacting social security, provision of healthcare and education, but also less investments in research and development of new technologies. To tackle social inequalities, grass-root initiatives have been developed to provide some social protection. These bottom-up efforts occur within the context of the neighbourhood, the immediate local area or by like-minded interest groups via social platforms, and not state- or EU-wide.

On a global level the EU and the US and Canada have developed strong ties, including in agriculture and food; the strong trade ties gradually expanded into policies and legislative approaches. Tariff and non-tariff barriers still exist between the EU and other trading partners (non US/Canada), and EU-third party trade is still taking place, albeit in a limited manner and for selected goods, (e.g. minerals and mineral fuel imports from Russia or machinery and appliances from China). The expansion of TTIP took account of the latest technological developments in agriculture and food production and liberalised the trade zone fully, completing the gradual harmonisation in food standards and procedures between Europe and the North American partners. There are even some discussions of creating a single food safety authority by merging EFSA, the US Food and Drug Administration (FDA) and the Canadian Food Inspection Agency (CFIA), similarly to the Food Safety Australia New Zealand (FSANZ) model operating since the beginning of the 21st century. Furthermore, the EU quality food labels are not enforced any longer and thus have lost relevance; US producers can freely manufacture and sell, both internally as well as in Europe, foods that were once protected by EU quality labels and tied to specific geographical regions, ingredients or processes. The original, formerly protected European products are still available on the EU and international markets, but only as premium niche foods.

Global food and trade governance is still present, in the form of WTO and Codex Alimentarius, and global food safety standard still exist. The EU, being a regional power, has lost significant leverage in these and similar international institutions; new players such as India, Russia and Brazil (the once called "emerging economies") hold much more sway. The US standing is better, but it has been surpassed by China as the largest economy and has lost the dominant role that it enjoyed in the beginning of the 20th century. The US-Canada-EU partnership, with a common and advanced market comprising of little less than 1 billion consumers, is therefore a win-win situation for all three partners on the international scene, providing access to a large market and more weight in international negotiations. The EU, however, with its weaker economy and slow technological innovation, is considered as the junior partner in the partnership and has less influence.

Europe has now a positive attitude towards the use of new technologies in the food chain, with rapid uptake across the food chain by all actors, including the consumers. Most of these new technologies were developed in the US. The high technological uptake is facilitated by less stringent approval conditions and reduced concerns about potential long-term health or environmental effects. This, coupled with the removal of non-tariff and procedural barriers between the partners, has led to a recent and gradual relaxation in the practical

application of the precautionary principle in EU policies and law-making. Technological developments are focused on improving the efficiency and resilience of food production, combating climate change and natural resources scarcity impacts in agriculture, such as decrease yields of major crops (e.g. wheat and maize) as well the emergence of new (or intensification of existing) plant pests, invasive alien species or animal pathogen attacks that caused substantial losses in the past. Genetically modified organisms, advanced cloning applications or other novel biotechnologies are applied in crops, livestock and aquaculture.

Technological innovation is also focused on improving the nutrient content in primary production, as well as improving the efficiency and cost-effectiveness of mass food processing and functional foods at the manufacturing stage.

The agro-food chain

The structure of the food chain within the EU is characterised by concentration into larger businesses. This applies to primary production, where farms increased in size, and in some Member States farmland is now owned to a larger extent by non-EU entities. Some support to small farmers has been put in place, reflecting US and Canadian subsidies to the farming sector, enabling small farmers and agricultural cooperatives to survive. Concentration in the manufacturing and retail sector has however left space for SMEs and small retailers which serve niche, or regional markets.

The focus in primary production is on efficiency and resilience; concerns about potential biodiversity effects, or long-term human health or environmental risks are only taken into account when solid science can substantiate them beyond doubt. Highly efficient pesticides and fertilisers are employed in agriculture, while techniques such as fumigation and irradiation are routinely used to reduce post-harvest losses. In livestock, older practices, like promoting growth with hormones and antibiotics or chemical disinfection techniques like chlorination of carcasses, are used where necessary to supplement recent technological developments of GM technologies or nanotechnologies. The EU manages to cover most of its needs in livestock. Cattle and beef, however, is mainly imported from the US and Canada. This is made possible by application in livestock of technologies like GM animals and use of alternative feed sources (e.g. from bacterial biomass), and due to beneficial climate change effects due to higher temperatures in the northern latitudes of the American continent (Canada and its northern islands, Alaska) that allow intensive and efficient livestock breeding. While inland aquaculture faces difficulties due to increased water needs for agriculture and contamination of inland waters from floods, off-shore aquaculture has developed significantly, with novel biotechnology approaches and practices, including specific resilient GM fish breeding using alternative or GM-feed. Wild fish, with decreased catches due to climate change effects, are significantly reduced as a source of feed in aquaculture or as human food. The EU manages to cover its needs in basic crops or fruit and vegetables, with the assistance of technological innovations in agriculture; however, this comes with a parallel decrease in species biodiversity. For example, there is less variety available for each fruit

or vegetable (e.g. only few types of oranges or apples are commonly available, compared to the multitude of 2015), as climate change impacts and the economic situation do not allow for a wide application of new technologies.

Food manufacturing industries are also geared towards efficiency, mass-producing affordable processed foods that ensure sufficient intake of calories, and macro- and micro-nutrient availability. Most large food manufacturing industries operating in Europe are based in the US or are owned by US companies; the exception being SMEs, which however share a rather small percentage of the food market. Similarly, research and development of novel food technologies and products mostly takes place in the US and Canada, and as a consequence there is decreasing demand for e.g. qualified food scientists, and nutritionists in the EU. There is significant technology involvement in the manufacturing stage, with enhancement of shelf life, taste and appearance, nutrient content, packaging techniques etc. Nonetheless, food and drink marketing promotes overconsumption of calories and large portion sizes, and there is no longer a drive to reformulate foods and reduce saturated fatty acids, salt and sugar in processed foods; on the contrary, fat, salt and sugar content help make the taste of mass produced food more acceptable, with the help of flavour and aroma enhancers. Beef, both raw or in processed foods, is mainly imported from the US; edible oils used for food processing and mass restoration cooking are mainly imported from the US (soybean, canola) or from South East Asia (palm oil). Climate change impacts have negative effects in the olive-oil producing countries, and as a result the traditionally wide consumption of olive oil in the south of the EU has decreased and olive oil has become a premium delicacy in 2050. Fruits and vegetables are consumed from what is imported from the partners and from what is available from local production.

Retail is dominated by concentration of power in hypermarket chains, most of which are owned by US/Canadian companies, and heavily uses technological innovations to preserve the cold chain, in view of higher temperatures. On-line food sales, food deliveries and food collection points are mixed with traditional supermarkets, while smaller food retailers or grocers exist on a local level and serve specialised needs. Digital applications are regularly used to find the best prices in online food markets, restaurants, canteens etc. Food delivery is common; most of the orders are done via US owned global online systems, connected with popular chain food giants as well as smaller EU brands.

Food waste has been moderately reduced, compared to 2015; the main reduction comes from more efficient technologies in primary production and manufacture (improved handling, storage and transport); moderate household level reduction stems mainly from more careful spending of on average lower household budgets.

There are few public efforts to educate consumers on lifestyles and diets, while on the other hand marketing policies of food industry are strong. Food choice is driven by price, time and convenience; food consumption largely takes place out of home, where snacking or fast food is dominant, and reflecting the hectic lifestyles of 2050 which leave little to no time to think about diet: the share of task-based jobs of limited contract

duration has increased considerably and an on-demand, flexible labour market has developed. Overall, automation and low economic growth have contributed to a constantly high unemployment rate across the EU.

In the US and Canada, from 2015 and onwards, dietary habits improved slightly, but this effect is limited to the more affluent parts of the society, which can afford varied diets that includes consumption of fresh fruits and vegetables and incorporate elements of the once-dominant Mediterranean diet from Southern Europe; instead, and due to the close EU-US ties, foods commonly consumed on both sides of the Atlantic range from pizzas, sandwiches, steaks and hamburgers to “westernised” versions of Mexican, Middle-Eastern or Asian popular dishes; local snacks or traditional European street foods are popular in their regions of origin and available as premiums in the rest of Europe. These eating habits, as well as the higher proportion of processed foods in the diets, have resulted in nutritional imbalances, i.e. overconsumption of macronutrients like proteins and fats, coupled with decreased consumption of micronutrients like vitamins and minerals. At home, eating mainly involves ready to cook, frozen and canned foods; cooking from fresh ingredients has significantly declined. Consequently, cooking skills have declined and people are ever more dependent on intelligent home appliances with the capacity, to sensor, alert and autonomously react in order to guarantee safe storage and kitchen hygiene. However, not all EU, US or Canadian citizens are happy with this food culture or with the way food is being produced; as a result, smaller alternative food chains or black markets have evolved to try and satisfy consumer demand for fresh, organic and local food production; these however operate on the fringes of the main food chain, and are therefore not officially certified or controlled, from a food safety perspective.

The dietary habits and nutritional imbalances described above have further exacerbated the rise of obesity and diet- and lifestyle-based non-communicable diseases in the decades since the 2000s, a development, which has not been halted by the public health efforts of the EU and its Member States. In the EU of 2050, dietary inequalities are an important factor for increasing health and social inequalities, affecting citizen health, social health care systems, and ultimately social cohesion and well-being.

3.2. The challenges ahead and policy preparedness

Also a “Partnership Food” world will face challenges that affect the food chain as well as environmental and human health and these are listed in Table 15. A description of each challenge and their impact on the food system is given in the Annex. The challenges highlighted in bold have been selected for their high likelihood to occur and their negative impact on the system we are studying and the next pages further discuss a selection of these and propose different policy options to address or prevent their consequences.

**Table 15 - Food and nutrition-related challenges identified in the "Partnership Food" world
(in bold those prioritised)**

| |
|---|
| Emerging biological risks: |
| a) The introduction of known pathogens causing (bio)chemical safety hazards in geographical areas where they were not previously known |
| b) Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains |
| Shortage of quality water |
| The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies |
| Ability to perform official food-related controls |
| Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism |
| Failure to provide appropriate food safety information to the consumer |
| Abundance of voluntary food information and increased opportunity for misleading information |
| Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels) |
| Increased sedentary behaviour and snacking due to changed lifestyle |
| Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information |
| Increased use of chemical substances in the food chain |
| Increased exposure to chemicals and nanomaterials from food contact materials migrating in food and from the environment via packaging waste |
| Diets based predominantly on highly processed foods and decreased availability of fresh produce |
| Intensive animal and plant production systems: Disease transmission and nutritional quality |
| Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks |
| The loss of technological knowhow in Europe |
| Food chain impacts due to over-reliance on one or few trade partners |

3.2.1. Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information

Food safety and nutrition literacy may further deteriorate in the future. At the same time, the sources and quality of information available are crucial for consumer food choices. In the context of the "**Partnership Food**" world, Europe and its Member States have not prioritised and failed to provide sufficient and reliable information on physical activity, balanced diets and healthy lifestyles in general.

Lack of nutrition literacy can weaken the consumer's ability to choose a balanced and healthy diet. In this world of information overload from different sources and stakeholders, including those with vested interests, the quality of food safety and nutrition information that reaches the consumer may be suboptimal albeit crucial for informed choices. Over-reliance on technology, home delivery, ready-to-(h)eat foods further alienates people from food preparation skills, culture and traditions.

Lack of food safety literacy and safe cooking skills can contribute to the introduction of food safety hazards during food production or preparation by the consumer as well as weaken their ability to make informed and healthy dietary choices. This can result in poor quality dietary habits, malnutrition and consequent health issues. Intentional misinforma-

tion and fraudulent behaviours can exacerbate the above issues. Also, the loss of food traditions and cooking skills can weaken a major socio-cultural aspect of Europe and negatively impact the EU food industry.

Policy options

- **Introduce mandatory food safety and nutrition education and information on food technology advances**

To improve food safety and nutrition literacy and therefore tackle the negative impacts described by the challenge above, education efforts could be stepped up by making these subjects mandatory in school curricula. This measure was also recently recommended by the WHO report on ending childhood obesity⁵⁰. The EU does not have the competence to adopt legally binding acts that require the harmonisation of education legislation at national level but instruments such as the High Level Group on Nutrition and Physical Activity could be used to ensure buy-in from the Member States. Seeing the complexity of the issue and the need to address regional and national characteristics, guidelines that would set out the main goals (e.g. topics to be taught, range of hours per week, potential age groups) to be achieved would be useful, leaving the Member States to devise their specific legislation on how to better achieve the scope.

⁵⁰ World Health Organisation, 2016. Report of the commission on ending childhood obesity.

Apart from food safety and nutrition education, information on food technological advances could help make consumers more tech-savvy and improve their understanding of food technologies and their potential benefits and risks. Also, a similar point can be made for the inclusion of food safety and nutrition courses in universities, technical/professional schools and other higher education establishments for health, public health and other professionals. Consideration of these topics in adult and life-long learning programs (including MOOCs for example) would also be in order.

- **Increase exchange between consumer organisations**

The dialogue between consumer organisations of the three partners could be enhanced by analogy to the Transatlantic Consumer Dialogue (TACD). TACD, founded in 1998, is a forum for US and EU consumer organisations to exchange, discuss and propose joint recommendations to the US government and to the EU. The activities of such a platform could be further increased and strengthened in **“Partnership Food”**, especially in sharing best practices and adopting common policy

approaches aiming at increasing consumer food literacy and combating the communication of misleading and unreliable food information.

3.2.2. Diets based predominantly on highly processed foods and decreased availability of fresh produce

Just as in **“Global Food”**, also in the **“Partnership Food”** world cost-efficient, mass-produced and highly processed food dominates the market, making fresh produce more difficult to access for a large part of consumers. In this setting, this challenge gains importance as prime quality EU products, including high quality fresh produce and protected designation of origin (PDO, or other quality schemes) foods could be diverted to the US market because of their higher purchasing power, while the majority of the EU consumers could be left with second best market offers. This issue is also reflected in the challenge “Food chain impacts due to over-reliance on one or few trade partners” (see Annex).



Policy options

A series of policy options to address this challenge have been proposed in Section 1.2.4, "Increased sedentary behaviour and snacking due to changed lifestyles". These include fiscal measures, incentives for food reformulation, guidelines for food procurement and provision of nutrition education. All measures proposed previously are also applicable to the setting of the **"Partnership Food"**. Some may, however, deserve a special focus to address the potential diversion of EU products to the US and Canadian market. Cases in point are the use of fiscal measures and particularly of financial incentives for fresh produce and other European products to remain in the European market and guidelines for public food procurement that favour the use of local, regional or European produce. However, this might be challenging to implement as it may constitute an obstacle to trade. The origin of products could be made clearer with, for example, front of pack sign-posting and encouraging local consumption could also be included as a topic in education and funding campaigns.

3.2.3. The loss of scientific and technological knowhow in Europe

The loss of scientific and technological expertise in the EU can have serious repercussions for the EU food system. It can lead to increased vulnerability of the chain to food fraud or inappropriate use of certain imported technologies. It could also lead to the introduction of safety risks at the different steps of the food chain where these imported technologies are used. In the face of climate change effects, EU's incapacity to develop specialised technologies to mitigate primary production issues would further hinder primary production in terms of yield and safety for example. The loss of technological know-how in Europe would also be a major blow for the food and drink European sector, a recognised area of excellence and a major employer of the EU workforce, impacting trade, employment and economy. This loss of technological know-how is expected to stem from reduced investment in R&D but also from barriers to innovation, such as consumer scepticism and resistance to new technologies or from a cumbersome legal framework.

Policy options

Recently, a joint statement on unlocking the potential of the EU agricultural and food industry, signed by major EU food chain stakeholders⁵¹, stressed the importance of fostering innovation, including its significance for employment, and the need to ensure that innovation is at the heart of the EU agro-food policy-making, urging policy makers to reduce the administrative burden of the regulatory framework. For instance, novel food authorisation processes can take on average 3.5 years to be completed. The REFIT exercise aims to address this burden and it is likely that the regulatory framework may need to be updated in the future while broadening its scope to cover new technological developments which could also help in reducing

⁵¹ Food For Thought – A vision of unlocking the potential of agriculture and the food industry in the EU (2014) – Food chain associations: CELCAA, CEMA, COCERAL, COPA-COGECA, EUROPABIO, European Crop Protection, ESA, FEFAC, Fertilisers Europe, IFAH,

innovation barriers in the EU. Similar conclusions were drawn by another analysis⁵² on the impact of the EU regulatory system on innovation (not specific to food), after remarking that regulation can indeed foster innovation by providing both negative and positive impetus, depending on the adoption of rigid vs. more flexible legislator approaches and reducing uncertainty in the business environment.

• Foster innovation and competitiveness by improved food governance mechanisms

Since the EU General Food Law was conceived with the main focus on food safety and a functioning internal market, one approach would be to assess whether Reg. (EC) 178/2002 or other pieces of food legislation are successful in ensuring high food safety standards and foster innovation and competitiveness at the same time. In addition, it would be useful to assure that EU impact assessment methodologies of policy options in food safety and nutrition, both in ex-ante and ex-post evaluations, are done in a holistic systems approach, and that effects on innovation are prominent in these exercises. Another aspect that could be considered in this holistic approach is the cost of regulatory compliance, which could negatively impact the food industry, particularly SMEs, potentially putting another barrier to innovation in the EU. The possibility for protection of proprietary rights in certain new technologies would be another way to safeguard innovation.

• Reduce cost of regulatory compliance

Calculating the costs of regulatory compliance for all actors and sectors in the food chain is not straightforward; for example, a study examining the cost of regulatory compliance for farmers, with respect to the animal welfare, food safety and environmental EU legislation, concluded that it is difficult to draw general conclusions since regulatory compliance costs change depending on the legislation in question, the farm's type of output (e.g. horticulture or livestock), or even on the type of livestock grown⁵³. Nevertheless, reducing these costs could potentially lift one of the barriers to innovation in Europe. While large food companies are often well-equipped to address regulatory compliance, SMEs – the backbone of the EU food industry – usually are not and do not have the means to achieve regulatory compliance in highly innovative areas.

• Improve consumer understanding of innovative products and technologies through transparent communication

When dealing with consumers and innovation, it is important to examine how consumer perceptions are formed with respect to innovative products; public engagement is essential to improve understanding and ultimately acceptance of innovation and novel technologies. It has been argued that the lack of under-

⁵² Centre for European Policy Studies Special Report, No.96/2014: Does EU regulation hinder or stimulate innovation?

⁵³ Assessing farmer's costs of compliance with EU legislation in the fields of Environment, Animal Welfare and Food Safety – Final Report (2011). Centro Ricerche Produzioni Animali, Thuenen Institute of Farm Economics, International Farm Comparison Network on Dairy, University of Ghent. Commissioned by DG RTD

standing of how technologies, novel ingredients, etc. are developed is one of the reasons for consumer resistance and rejection of some food-related technologies in Europe. Participatory approaches and public engagement can come from citizen science and interactive projects or awareness-raising campaigns targeting the general population or tailored to specific groups. Of equal importance is communicating in a transparent and clear manner the individual as well as public benefits that certain food ingredients or technologies could have. Similar engagement approaches should be put in place before proposing new legislation initiatives or specific trade agreements.

- **Increase co-operation with food business operators**

A joint approach between regulatory authorities and food business operators could be envisaged as a way to simplify approval processes (reducing approval procedures that can hinder investment in innovation by the industry), as well as reduce regulatory compliance costs, thereby removing existing barriers. Such an approach could also save time and resources for the regulatory authority. A phased application process with pre-submission meetings between the applicants and the regulatory authority (EFSA/risk assessment authority) meetings could help discuss how to best build application dossiers. Also, meetings during the approval process for guidance and support could help streamline the procedure. This is further discussed in the following section under “Streamline risk assessment by increasing the collaboration between all actors”. Presently, the joint approach described above may, however, be perceived as lack of independence of the risk-assessment mechanism.

3.2.4. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

Novel technological developments in the “**Partnership Food**” system may include fish genetic modification (in aquaculture), edible food packaging, novel foods, addition of substances with health properties or new packaging/storage technologies. The issue in this case is that the need for harmonisation of standards to reduce barriers to trade between the partners could push towards convergence of different risk assessment approaches between EU, the US and Canada, with the possibility to adopt the North-American one, currently viewed as least restrictive. It could be argued that some convergence is already taking place, e.g. the introduction of controls at different points in the US food chain instead of only a final product control. The possibility of convergence of food standards between both sides of the Atlantic has been publicly debated recently, though not well perceived by part of the EU population. On the other hand, the economic dominance of the partners would inevitably force a convergence of rules and, eliminating other governance obstacles, would expedite authorisation procedures due to economies of scale and scope.

Just as in the “**Global Food**”, the lengthy regulatory process for the approval of certain foods, food-related substances and technologies (i.e. new food additives, novel foods, health claims) can also be problematic in “**Partnership Food**”, in particular affecting innovation, which is crucially needed for the food sector. Less restrictive approaches may result in products reaching the market that may pose unforeseen short- or long-term health challenges. At the same time, lengthy or inefficient approval processes may prevent the use of required technologies in the food chain. Equally difficult decisions may be linked to the establishment of maximum residue levels allowed in the food. Climate change, resource scarcity and environmental and water pollution effects (e.g. floods or the use of low quality raw materials such as phosphate rock for fertiliser preparation) can increase the levels of food contamination. In a constrained world, vulnerable to these factors, strict food safety criteria (such as low maximum residue levels of plant protection agents or other contaminants) may lead to unacceptable food waste and food security issues by “legally” limiting the availability of food for human consumption.

Alternatively, a more innovation-friendly environment, coupled with a more accurate evaluation of current negative externalities, could foster the use of more environmentally and resource sustainable production methods, such as the use of precision agriculture which would significantly reduce the presence of contaminants.

Policy options

- **Re-enforce risk-benefit assessment and management**

Climate change impacts on the food chain and scarcity of natural resources, as well as unfavourable innovation environment specific to the “**Partnership Food**” world, may require EU and Member State governments to select where best to focus efforts and investments and they may be forced to prioritise between equally important aspects of the food system. For example, strict food safety standards may no longer be compatible with having access to sufficient affordable foods or with fostering innovation. Policy makers and risk managers may need to consider these “trade-offs”, e.g. the potential benefits of the approval of particular products and technologies vis-a-vis the risks of rejecting them or control them via strict standards. Both benefits and risks may not only be related to health, but also to environmental, social, financial factors. Impacts on innovation should, therefore, be examined in a holistic, systematic and transparent manner to ensure consumer trust.

EFSA has published a guidance document⁵⁴ outlining basic principles and methodologies on performing health risk-benefit assessment of foods. It noted that there is less experience in risk-benefit assessment compared to only risk assessment, and recommended a stepwise approach similar to risk assessment; i) initial risk assessment, to address whether risks far outweigh benefits or vice versa, ii) refined assessment, for providing semi-quantitative or quantitative estimates of risks and benefits at relevant exposure, iii) comparison of risks and

⁵⁴ EFSA Journal 2010; 8 (7): 1673

benefits using metrics such as disability – adjusted life years (DALYs) or quality-adjusted life years (QALYs) to express the outcome of the assessment as a single health impact value. EFSA also recommended frequent discussions between the risk-benefit assessor and the risk-benefit manager, e.g. at the checkpoints described above, as well as using or developing internationally agreed metrics to ensure harmonisation and recognition of all assessments. These guidelines are limited to health risks and benefits and the development of a wider risk assessment/management framework that incorporates a broader perspective on social costs-benefits, including the impact of innovation and health on economic or more holistic metrics like life-quality.

An EU-level risk-benefit assessor would need to be defined. Transparent and clear communication of risks, benefits and uncertainties, in this case, would also be essential and a dedicated independent structure for such communication should be considered. Public engagement would be crucial once more.

- **Streamline risk assessment by increasing the collaboration between all actors**

EFSA could assume a more active role in assisting and guiding food business operators during an approval process; facilitating EFSA-applicant co-operation during application processes, including pre-submission and post-submission "checkpoint" meetings could result in shorter and leaner approval procedures. EU legislation could be amended to make much pre- and post-submission co-operation a legal requirement, laying down

specific conditions and rules on when and how it should be implemented. This would safeguard EFSA's independence and guarantee the transparency and validity of the process.

An additional example of closer stakeholder collaboration is the Innovative Medicines Initiative (IMI); IMI is Europe's largest public-private initiative, a joint effort between the EU and the European Federation of Pharmaceutical Industries and Associations (EFPIA), aiming to speed up the development of better and safer medicines for patients. The platform supports collaborative research projects and builds networks between the European Medicinal Agency (EMA), patients associations as well as industrial and academic experts to boost pharmaceutical innovation in Europe. Such a model could be used as a blueprint to the food and drink sector, involving stakeholders, regulatory agencies, consumer organisations and food business operators of the partnership, assisting in designing and implementing R&D approaches that are in line with regulatory requirements, ensuring increased ownership by all stakeholders as well as transparency (and increased validity) in all interactions.



3.3. Is Europe heading towards the “Partnership Food”?

The policy options above shall be considered and their impact and potential effectiveness assessed before the challenges identified impede the proper functioning of our future food system. Table 16 proposes a series of simple indicators that can signal European developments towards this scenario, or to phrase it more correctly towards *particular elements* of this scenario; sources that could potentially supply the relevant data for monitoring these indicators are also included. Reflecting some of the main characteristics of “Partnership Food”,

these indicators mainly refer to the increased presence of US food business operators in the EU, the reduced investment for- and development of food technologies in the EU, as well as dietary habits characterised by energy rich, high fat, salt and sugar foods and beverages.

3.4. Research needs

In order for our future policy and regulatory framework to be fit to respond to the challenges presented in 2050 by the “Partnership Food” world, it could benefit from more research in the areas mentioned in Table 17.

Table 16 - “Partnership Food” specific indicators and potential sources of data¹. ↑ or ↓ indicate an increase or decrease compared to 2016

| | | | | | |
|--------|--|---|--|--|--|
| ↑ | Consumption (g) of high fat, salt and sugar foods per capita | % of overweight obese children and adults | Price (€) of traditional EU quality scheme foods (e.g. PDOs) | % volumes (tons) and value (Mio €) of hormone-treated beef and GM foods from the US sold in the EU | % volumes (tons) and value (Mio €) of foods imported from the US |
| Source | EFSA, FAO, WHO | WHO, OECD | FDE | BEUC, Eurobarometer | WTO, Euromonitor International |
| ↓ | % of EU-owned FBO, compared to US ones, operating in the EU | Private and public investment (Mio €) into food R&D in the EU | Number of new agro-food technologies developed in the EU | % market share revenue of SMEs and grocery stores | Intake (g) of fruit and vegetables per capita |
| Source | FDE, UEAPME | FDE, UEAPME, REA ² , ERC ³ | IUFoST ⁴ , JRC IRI scoreboard ⁵ | FDE, UEAPME | EFSA, FAO, WHO |

1 For all of these indicators, ESTAT or relevant EU DGs such as SANTE, AGRI, TRADE etc. would be the first choice for monitoring of data relevant to these indicators; what is indicated therefore in this table are potential additional data sources, from relevant specialised stakeholders or organisations.

2 European Research Executive Agency

3 European Research Council

4 International Union of Food Science and Technology

5 European Commission's Joint Research Centre Industrial R&D Investment Scoreboard

Table 17 - Research needs per challenge in "Partnership Food"

Diets based predominantly on highly processed foods and decreased availability of fresh produce

Factors affecting food prices: Considering the climate change effects foreseen for 2050, elucidate the role and importance of the factors affecting food prices, especially for fresh produce, as well as track and elucidate price transmission along the food chain on Member State and EU level. This analysis should take into account world market prices and in particular the relative market power of the individual partners.

Development and application of preservation technologies for fresh produce.

Reformulation: An impact assessment of reformulation actions on fat, sugar and salt, and especially considering the kind of replacements to be used, including food technology aspects, public health and economic impacts.

Precision farming: The use of precision and climate controlled farming technologies as an alternative to declining agricultural productivity and potential shortages in key nutritional ingredient.

Role of retail: Elucidate the role of retail in the food chain, especially with respect to its level of influence on food manufacturing industry and its impact on availability and accessibility of fresh produce; what aspects may change from today with a view to the food system of 2050?

"Soft" processing techniques: Research in improved food processing techniques to minimise the impact of processing (e.g. temperature, pressure) on nutrient quality. In addition, investigate ways to reduce the scale-up costs and successfully market foods produced with soft processing, including SMEs in the research (often cost from the pilot plant to scale-up is prohibitive).

The loss of scientific and technological knowhow in Europe

Understanding consumer behaviour: There is a need for more evidence on consumer behaviour and on the factors that can drive acceptance or fuel rejection of novel food technologies. In addition, evidence is needed to confirm whether consumers that are better informed on the benefits of innovation and on how technologies are developed are indeed more open to innovation, as suggested, or not.

Consumer view of trade-offs: Research the willingness of informed consumers to accept potentially lowering of food safety standards and a margin of risk, in return of faster innovation that would lead to technologies with benefits, e.g. in health, food cost, environmental sustainability.

Role of retail: Assess the role of retailers as a barrier to innovation; it has been suggested that retailers often assume and pre-judge what could be the potential stance of consumers on a specific product (acceptance or not), and can therefore reject the marketing of innovative products on the assumption that consumers would not accept it.

Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

Feasibility of post-market surveillance: Feasibility of using consumers and IT personal applications for data collection in post-market rapid testing and surveillance (including nutri-vigilance) of novel technologies or novel foods.

Analysis of global risk assessment procedure: State of the art report on risk assessment procedures around the globe; best practices, "success" and "failure" stories. This would include also a state of the art analysis of the US and Canadian (or other) food safety and nutrition regulatory framework, including a comparison with the EU one, and an investigation on how differences in approaches or standards reflect on public health and consumer protection.

Develop risk assessment indicators: Develop indicators in order to compare risk assessment systems across the globe, especially those of the EU, US and Canada.

Alternative to Randomised Controlled Trials (RCTs): Develop alternative methodologies to RCTs that could be better suited for investigating the role of nutrition and diets in public health, or for assessing health claims on foods.

Better understanding of the impact of austerity on risk assessment: Risk assessment procedures could possibly be hindered by an economic crisis on EU or Member State level. Research is needed on the impact of the recent economic crisis and on the capacity to perform risk assessment, as well as what lessons could be learned in order to make risk assessment more resilient in future situation of economic hardships.

General

Legitimate factors: Understand and better define in food law those legitimate factors mentioned in the legislation (e.g. societal, ethical, environmental, economic etc.) that are beyond conventional risk assessment but that need to be taken into account in risk management decision-making (CODEX - EU).



4

“Pharma Food”



Table 18 - Driver developments in "Pharma Food" scenario

| Driver | Main characteristics |
|--------------------------------|--|
| Climate change | <ul style="list-style-type: none"> • 2°C threshold of temperature increase will be reached by 2050 |
| Depletion of natural resources | <ul style="list-style-type: none"> • Progressive natural resource depletion towards 2050 |
| World population growth | <ul style="list-style-type: none"> • World population will increase to about 9 billion by 2050 |
| Social Cohesion | <ul style="list-style-type: none"> • High social cohesion and intergenerational solidarity measures being aimed at helping people to help themselves and contain the increasing social cost due to the demographic imbalances |
| Food values | <ul style="list-style-type: none"> • Society values food highly as a means to support health • Personalised diets are a reality and functional/enhanced/nutraceutical foods are mainstream |
| Technology uptake | <ul style="list-style-type: none"> • High uptake and consumer acceptance of new technologies • EU is strong in technology development • Technology development is focussed on: <ul style="list-style-type: none"> ○ Personalised nutrition regimens ○ Functional foods, foods with medical characteristics ("phoods") ○ New production technologies such as 3D printing |
| EU economic growth | <ul style="list-style-type: none"> • Strong economic growth in terms of GDP supported by a highly skilled, strong work ethic labour force with low morbidity, high life expectancy and flexible retirement arrangements to maintain productivity in a high social cost economic environment. • The EU remains a major global trading and political power |
| Global trade | <ul style="list-style-type: none"> • Fully liberalised global trade - tariffs and non-tariff barriers to trade reduced to a minimum • Global convergence of standards, legislation, approval procedures • EU companies are the global market leaders for functional foods and "phoods" |
| Agro-food industry structure | <ul style="list-style-type: none"> • Food and health industries interface has grown significantly and a new industrial sectors have emerged including conservation and preparation technologies, nutrigenics and personalized foods • Traditional agro-food industry is facing stiff competition from high-tech nascent "phood" sector • Agro-food industry concentration to rationalise overcapacity and exploit economies of scale such as utilisation of big-data and production and approval of functional foods • "Phood" manufacturing industry has a strong market position and political influence |

4.1. "Pharma Food" in 2050

The way towards 2050...

Despite a number of government initiatives to improve dietary habits and physical activity of EU citizens, the prevalence of diet-related chronic diseases remained a problem throughout the EU and with it public expenditure on healthcare. Adding to this were the burgeoning public health deficits stemming from the demographic imbalances (large ageing population and low birth rates). Thus, efforts were stepped up including investments in research targeted at understanding better the food-health interactions, and at improving dietary advice towards a personalised diet to reduce morbidity and medical costs while increasing life expectancy and the pensionable age. At the same time, the younger segment of the EU population became increasingly health aware, confronted with the limitations of their own poor health or that of the elderly population. Preventing ill-health in this situation would also increase lifetime productivity and financing of the social and healthcare system while preserving an acceptable standard of living. When around 2030, research results and technical developments finally opened the possibility to enhance food items in an evidence-based, targeted way and to personalise diets, this was taken up – on the one hand by the pharmaceutical

and the food manufacturing sector, on the other hand by consumers. Efficient marketing and advertisement strategies from food producers resonated with a substantial part of Europe's population, interested in the concept of health-promoting foods out of need or fashion.

Health became more and more important as a driver dictating food-related behaviours and choices. For many, food started to matter for its nutritional components only; often, especially during working days meals were substituted by products that provide in one serving (in powder or liquid form) all nutritional needs personalised to taste and easily prepared at home or the office. Other more complex or refined preparations (in terms of taste, structure and function) were also developed; expensive at first, prices decreased steadily as the offer increased, and by 2050 personalised diets became quite popular. The merging of pharmaceutical and food manufacturing companies further pushed the development of foods with pharmaceutical ingredients, commonly referred to as "phoods".

This move to personalised diets, including to a large extent "phoods", changed the perception of food towards a health promoter, and was linked to the broad acceptance of use of novel technologies in food production. The health minded European consumer also cared for the environment and natural resources (should be captured in the drivers as suggested

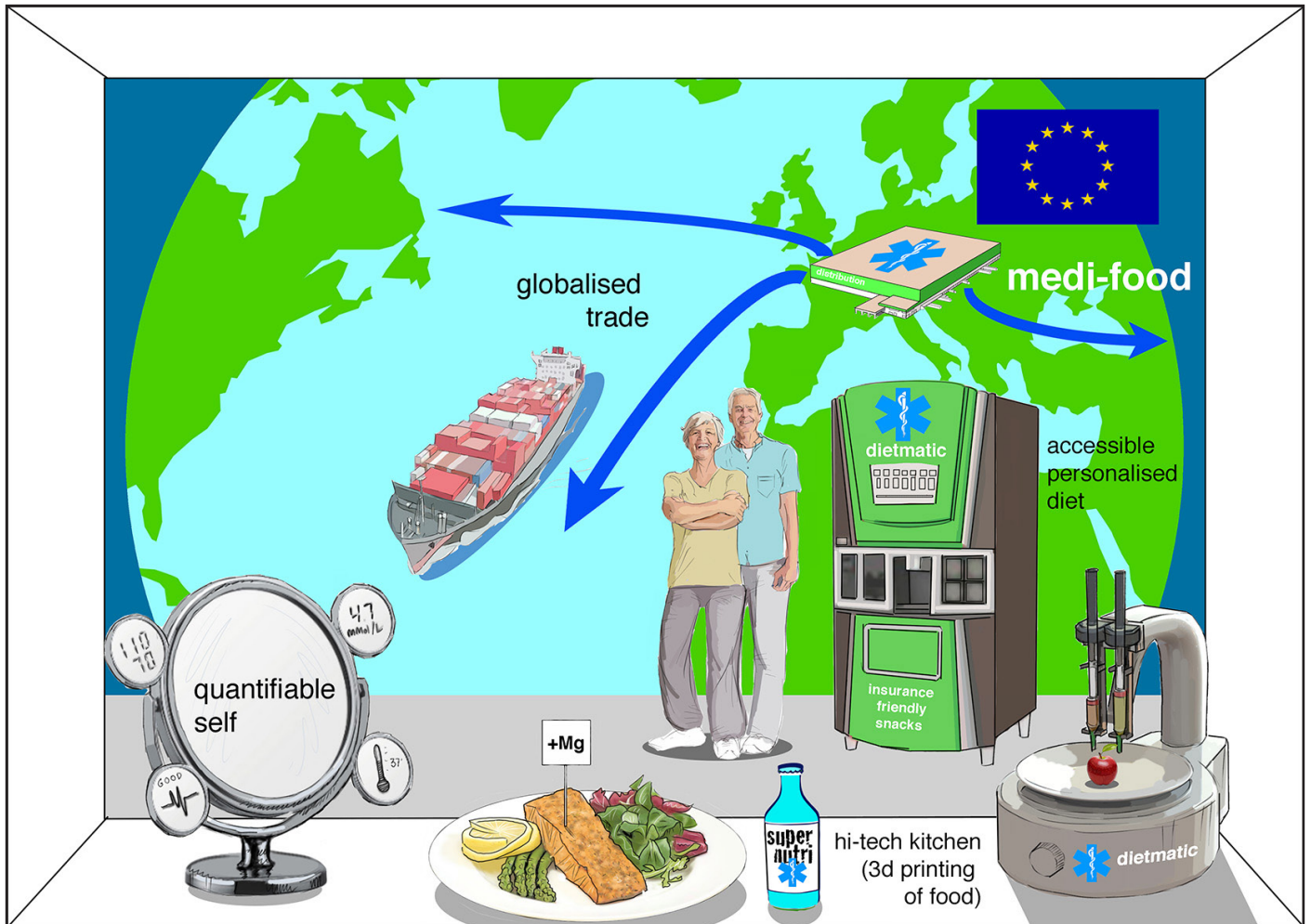


Figure 7 - Illustration of the European food system of "Pharma Food" in 2050

above) and the impact that food related and other personal choices have on it; nonetheless – albeit not to extremes – access to natural resources diminished which meant that the access to abundant and varied fresh food became more difficult throughout Europe and fresh produce was not easily accessible to all. Primary production, manufacturing and retail and food services adapted to the diversified demand. In this setting, big multi-national pharmaceuticals, food and drink, mobile health (m-Health) and electronic health (e-Health) industries flourished and fed a solid EU economy. Overall, as EU companies invested early on in this field, they were able to develop a market leader position world-wide for personalised food, also based on the ability to combine functional and medical food with well-known European food traditions; by 2050 full liberalisation of trade facilitated access to foreign markets.

The EU in 2050

This scenario is characterized by a strong EU economy that capitalises on the need to maintain a healthy workforce population. Food values have changed – food and the “act of ingesting nutrients and energy” are highly valued for their health implications. Climate change and natural resources depletion also take their toll; in a context where fresh produce is not abundant people turn to functional, processed foods, often personalised to optimise their health status. Strong multi-nationals control most of the food chain as the investments needed to research and place such foods on the market

are much too high for small medium enterprises (SMEs). Throughout the world, pharmaceutical and food and drink industries converge to exploit this market and so do high-tech information and communication technology (ICT), robotics and bio-monitoring industries. Europe is a strong player in this arena; decades of careful attention to food safety as well as inspiration from the tight pharmaceutical quality and safety controls result in a highly controlled, transparent and traceable food chain and this ensures trust and technology acceptance by the consumers.

The context

Climate change has increased average temperatures in the EU beyond 2 degrees Celsius⁵⁵, compared to the end of the 20th century. Heat waves and droughts in the South make agricultural production more and more dependent on irrigation and drought and temperature resistant crop varieties; susceptibility to (new) pests is increasingly becoming an issue. While agriculture has expanded further north, partly making up for yield reductions in the south, heavy rainfalls and increasingly frequent flooding events or water shortages in summer, render harvests more volatile than in the past.

⁵⁵ Based on the Representative Concentration Pathway (RCP) 8.5, greenhouse gas concentration trajectory, from the fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change.

On a global level, trade is fully liberated; the volumes of imports and exports for primary agricultural and livestock produce aimed at direct human consumption have decreased. Trade has however increased in the manufacturing sector (Business-to-Business) and for processed health-promoting foods. The EU, due to its growing economy and the capacity to combine the rich European food culture with functional food technology is the global market leader in this sector, followed by Japan and the US. Furthermore, the strong economies and purchasing power of the former BRIC countries provide new markets for EU food manufacturers as well as the opportunity to develop customised functional foods and "phoods" based on the food traditions in the targeted markets. The EU has increased its imports of processed food ingredients, including pastes and powders necessary for phood production.

Food standards are globalized in this world – they are mostly imposed by the food producers themselves given their control of the market and strong lobbies. They are nevertheless high and respectful of quality and safety throughout the chain and European companies have a strong lead and crucial role in upholding these high standards. They are essential to maintain high consumer trust along with consumers' acceptance of new products and technologies. In Europe, they are also the natural response to firm public health policies and high corporate social responsibility.

The agro-food chain

Fresh agricultural produce is highly seasonal and variety and availability are not always guaranteed. European fruits and vegetable production for direct fresh consumption diminishes both in volume and in variety, due to climate change effects in agricultural production. In parallel, the European population is strongly focused on health and disease prevention. The maximization of healthy life years is where the need of the individuals meets the needs of the state; leading long and active lives on one hand, reducing the burden for public health care systems on the other. Public and private health insurance schemes incentivise (via fee reductions or extra coverage programs) citizens to monitor their health and lead healthy lifestyles. In addition there is a strong peer pressure, but also a lot of available support via social networks, to adopt healthy lifestyles and to optimise one's health, also with a view to justify receiving any support from social security systems.

Food is highly valued in this context – beyond the provision of energy and nutrients it is mostly seen as a means to physical health. Functional/fortified foods cater for personalised nutrition which aims at optimising individual health status; personalised meals are popular in Europe and as a result the EU has a strong share of this market. Diets are personalised based on individual needs; this can range from more generalized schemes aimed at supplying the right mix of macro- and micronutrients necessary to maintain a healthy organism at all stages of life (e.g. infants, children, teenagers, adults, old and very old adults), to more specific diets for individuals with particular needs (from allergies and intolerances to other nutrient needs associated with genotypes, high or low physical activity (e.g. before/after high intensity sports or preparations that mimic the benefits of physical activity). In addition, specific food products and diets are available for a range of morbidities,

co-morbidities, medication regimens, etc. Mental and social well-being aspects of individual's health status are however less catered for. In addition, ethical human enhancement issues (physical, cognitive, personality enhancements or even life extension) are now discussed within the realm of the food system too as a means to further promote total factor productivity.

The use of advanced technologies such as 3D printing (industrially or at home) has significantly contributed in simplifying the availability of personalised meals. 3D food printers, producing enhanced versions of traditional foods, are available for different needs, from industrial printing to catering purposes in public or office canteens or restaurants, to smaller scale models used for domestic purposes. Insect or legume-based "meat" is a commonly printed protein source. Micro- and macronutrients as well as bioactive compounds are also available as easy-to-mix and dissolve formulas which allow for convenient preparation of nutrient rich meals targeted to individual needs (e.g. a runner before the race, an older adult, or a student undergoing exams but also a genotype-based meal preparation).

The food chain also relies on other technologies that Europe has historically been more resistant to accept such as GMOs, synthetic biology or nanotechnologies. Indeed, with the change of attitude towards food, European consumers have developed a positive outlook towards use of technology, with rapid uptake across the food chain by all actors. The growing economy, benefitting from the strong demand for the integrated food, health, ICT and food services, allows both public institutions and the private sector to allocate much needed resources to research, further triggering innovation. Reliable biomarkers and advances in miniaturisation and (bio)sensors coupled to ICTs allow for real-time monitoring of physiological functions and nutritional needs, facilitating targeted, optimised dietary solutions for the individual consumer. To achieve such personalised diets, individual data on health parameters as well as genetic and other biological-relevant data is collected, monitored, and translated in nutritional advice. Ownership of personal data and data protection is an issue. On the one hand, the individual shares his/her data with private companies specializing in collecting these data and transforming them into nutritional advice. To exploit the convenience of the personalised nutrition supporting systems to the full, the data may also be stored in the cloud or multiple devices and its use granted to retailers and food-providers; similarly, data is ceded to public or private health insurance schemes, especially if the citizen desires to take advantage of the various bonus schemes (which only are given to monitored individuals). Strict privacy contracts bind the service provider not to disclose data to third parties and define the terms of use of this personal health and diet data; however, citizens are encouraged to give consent to service providers to provide data to third parties, in order to gain targeted advertisement products and discounts in goods or costs of personalised regimes.

Regarding food production, technological development focuses on the production of a large variety of customary functional foodstuffs, ranging from classical health-claim foods aiming at improving body functions, maintaining health or preventing disease (e.g. micronutrient- or bioactive substances-enhanced foods, anti-oxidant drinks, fermented milk and meat probiotic

products, cholesterol lowering spreads etc.) to advanced therapeutical medifoods for which prescription may be needed (e.g. “biopharmed” animal and plant foods).

Primary production has been able to adapt to climate change with the help of new crop and livestock varieties and precision farming technologies that facilitate an efficient use of water, pesticides and fertiliser. Logistical solutions have been found to deal with the increased varieties of enhanced crops and specialty crops. Livestock breeds have been geared towards production of leaner meat, but in-vitro meat production allows an even more nutritionally targeted meat production, so that livestock production has been reduced considerably. Algae-derived fats or protein has developed into another promising production line. Overall, the agro-food industry is highly concentrated, also in the food manufacturing sector where large food/pharma companies dominate - the time and resources needed for big-data handling and analysis necessary for individualised diets, as well as research and market authorization from the competent authorities for health-promoting foods, are simply too high for small companies. The retail sector is characterised by hyper-retail structures, physical or virtual, which allow bringing the full array of different functional, fortified, medical food products to the consumer. They also operate advanced vending machines (selling everything from snacks to ready-made meals, but also preparing meals on the spot based on personal needs of buyer) and nutrient rich liquid dispensers, enable on-line shopping with collection points or house delivery, as well as small neighbourhood food stores. However, on-line shopping has become the main way of shopping since it provides the easiest way through the plethora of different food

products. The food service sector is quite broad and ranges from street vendors, vending machines or small restaurants to brand restaurant and cafeteria chains.

Fiscal state policies incentivise environment and health-promoting behaviours in various areas, including food choice. As a result, prices for goods and services that are resource-intensive have increased. Although general, fit-for-all enhanced functional foods are affordable for all, food can represent an important share of the household budget in households that wish to strictly follow optimised personalised nutrition regimens while maintaining the “look and feel” of once-traditional meals regarding taste, odours, texture, colours, consistency.

Food waste has been significantly reduced, compared to 2015; the main reason include increased efficiency in food manufacture, on-demand food production technology and longer shelf life through intelligent monitoring and packaging techniques, and reduced consumption of fresh and whole foods.

This innovative and blooming food and health industry employs a high share of the working force. Despite high automation in many sectors, there are new service and support-related jobs in a variety of sectors: research, education, qualified food inspectors, product development, quality management, logistics and tracking systems, e- and m-Health data management and interpretation, personalised nutrition consultants and health coaches etc. The high use of functional components and pharmaceutical substances in foods has also resulted in a need to improve or maintain food taste and texture, resulting

Table 19 - Food and nutrition-related challenges identified in the “Pharma Food” world
(in bold those prioritised)

| |
|---|
| Emerging biological risks: |
| a) The introduction of known pathogens causing (bio)chemical safety hazards in geographical areas where they were not previously known |
| b) Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains |
| Shortage of quality water |
| The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies |
| Ability to perform official food-related controls |
| Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism |
| Failure to provide appropriate food safety information to the consumer |
| Abundance of voluntary food information and increased opportunity for misleading information |
| Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels) |
| Increased sedentary behaviour and snacking due to changed lifestyle |
| Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information |
| Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks |
| Risk of overconsumption of nutrients or other food ingredients |
| Increased consumer dependency on digital services for dietary choices |
| Potential drawbacks of personalised nutrition as a predominant dietary practice |
| Shift of responsibility for diets from consumer to counsellor/coaches |

in more demand for the food additive industry providing stabilisers, preservative and colouring agents, emulsifiers, sweeteners, gelling agents etc.

4.2. The challenges ahead and policy preparedness

The **"Pharma Food"** world will again face food safety and nutrition challenges that affect the food chain and these are listed in Table 19. As in other scenarios, the full description of each challenge and their impact on the food system is given in the Annex. The challenges highlighted in bold have been selected for their high likelihood to occur and their negative impact on the system we are studying and the next pages further discuss a selection of these and propose different options on how policy-makers can address them.

4.2.1. Potential drawbacks of personalised nutrition and "phoods"

The effective personalised nutrition regime envisaged in this scenario requires consumer access to specific food products, digital/mobile applications, nutrition coaches/professionals as well as analysis and monitoring of physiological and food consumption data. While designed with health as the main goal, the widespread use of personalised nutrition or "phoods" could also have negative health, privacy/legal and social implications. The concept will also encompass performance and human enhancement claims – possibly raising ethical and inequality issues.

A fully supported and completely personalised diet system can be costly and hence unavailable to less privileged citizens. Low-cost personalised dietary services or discount "phoods" may be available, but these may not be completely customised to the individual and can increase health and social inequalities, or even constitute a health risk. Also, lower quality, cheaper second best products or fraudulent products can enter the market. In this scenario, fraud can take many forms: from non-qualified nutrition and lifestyle coaches to inapt mobile applications, non-personalised dietary advice, "phoods" with counterfeit or inactive pharmaceutical ingredients, hazardous components obtained from illegal suppliers. Such fraudulent practices could result in serious health risks, given the pharmaceutical components (and not only food ingredients).

Large differences in quality and safety of personalised nutrition may exist within and between Member States, further exacerbating inequalities. Health insurance schemes may also require citizens to adopt personalised diets and "phoods", to avoid an increase in health insurance costs. Other challenges relate to the quality of the sources of information and advice used in personalised nutrition counselling services, either by e-consultation or by face-to-face visits. Data protection issues may also arise with potential misuse of sensitive individual and diet information. Finally, depending on how widespread personalised regimens and "phoods" are, consumers who cannot or do not want to follow a personalised nutrition regime or consume "phoods" to achieve improved health (e.g. looking for whole foods, traditional diets etc.), may face difficulties securing a

healthy diet, due to lack of variety in the available alternatives. This may lead to under- or over-nutrition and this population may also face marginalisation.

Policy options

To start addressing some of the issues above, it will be crucial to decide which regulatory framework governs the field of "phoods". The options available include adapting the current food regulatory framework, adapting the current pharmaceutical regulatory framework, or the development of a third dedicated regulatory system. Aspects of where and how "phoods" will be advertised and marketed, whether their purchase will be controlled by prescription or not, professional qualifications for "phood"-related services and other related issues should be dealt with under such frameworks.

- **Adapt or create an effective regulatory framework**

An effective regulatory framework requires a definition for "phoods", distinct from foods or medicines. Another important aspect of such a framework is that it should provide for simple and flexible regulatory approval procedures, a challenge in itself, given the scientific complexity of the issue. It would need to respond quickly, consider complex risk assessments, cover specifications for personalised nutrition that include certification of food production appliances/machinery, software and related apps validation, data quality and coaches certification, ingredients-based management, also taking into account the traceability of raw ingredients which could be sourced globally.

The current EU legislation covering food and pharmaceuticals encompasses the principles of what would be needed to address personalised nutrition and challenges related to the dominant role of "phoods" in this world. As a result, one policy option is to examine the existing food and pharmaceutical regulatory framework and determine where adaptation is needed; this would have the advantage of avoiding the introduction of new legislation in the field. Reg. (EC) 1924/2006⁵⁶ covers health and nutrition claims and lays down specific rules and conditions for their approval, wording, modality of use, allowed categories of claims, etc. Reg. (EU) 2285/2015⁵⁷ on novel foods, lays down rules for foods that have not been consumed to a significant degree in the EU before 1997, and these include newly developed, innovative food or food produced using new technologies and production processes. It also covers foods that are eaten traditionally outside the EU. From the pharmaceutical point of view, apart from Reg. (EC) No 726/2004⁵⁸ specifying rules for the authorisation and

⁵⁶ Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods

⁵⁷ Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods, amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001

⁵⁸ Regulation (EC) No 726/2004 of the European Parliament and of the Council of 31 March 2004 laying down Community procedures for the authorisation and supervision of medicinal products for human and veterinary use and establishing a European Medicines Agency

supervision of medicinal products for human and veterinary use and establishing EMA, a variety of legislative acts govern the field, e.g. regulations relating to authorisations, paediatric products, advanced therapy, herbal medicines etc., as well as directives, relating to good clinical practice in the conduct of clinical trials, additives to medicinal products, pricing, use of GMOs etc. As a result, a novel category of “phoods” could potentially be defined and governed by adjusting existing food and pharmaceutical regulatory frameworks, deciding, for example, whether “phoods” should be classified as medicines or foods, and adapting the relevant legislations to include those aspects that are novel and not already covered.

The alternative policy option would be to design a new legal framework just to cover “phoods”; the reasoning is that although certain aspects may already exist in the current EU food and pharmaceutical legislation, it is likely that the complexity and the transversal nature of “phoods” would necessitate the extensive adaptation of existing legal acts (including the introduction of new elements); for example, the Health Claims Regulation would likely become obsolete or would require considerable adaptation. Ultimately, a new regulatory framework may need to be developed.

A new legal framework should also foresee governing and attributing responsibility for the various certifications procedures, i.e. an established authority, self-certification by the industry or third party inspection/audit and certification. The new legal framework should ideally incorporate the best approaches from the related food and medical legislation, which nonetheless need to remain in place – to cover “vintage” (early 21st century) foods and medicines.

A new legal framework should be implemented at an EU level, potentially with a relevant EU Regulation defining clear rules and conditions. Addressing the issue at Member State level could give the freedom to each State to take into account regional and national characteristics. However, it would also introduce more complexity in the field, give rise to potential inequalities and affect intra- and extra-EU trade. An EU-level regulatory framework, on the other hand, would ensure harmonisation and support the barrier-free trade of personalised dietary components and “phoods” within the EU, as well as facilitate global exports; it would also ensure that no inequalities in access arise between and within the Member States due to different implementations levels.

• Redefine health and nutrition claims

As a part of the regulatory framework mentioned above, and to address the salient issue of performance and health enhancement claims as well as references to prevention, treatments or cure of specific diseases, the current health and nutrition legal acts (Reg. EC 1924/2006) will need to be revised. One possibility emerges whereby, rather than designing separate authorisation systems, a single system could be envisaged, with different levels of claim strength relating to the different level of strength of supporting scientific evidence (e.g. soft vs. hard claims). For example, health claims could be i) “hard” health claims authorised by a food/health authority after examining the evidence submitted, ii) health claims that are based on authoritative statements from scientific

non-governmental bodies such as medical associations, and iii) “soft” health claims based on emerging, plausible, evidence which however lack an official endorsement by an authority. Such a layered approval procedure could ensure safety and consumer protection on the one hand, while still supporting innovation and fast-paced developments on the other.

4.2.2. Ability to perform official food-related controls

As described previously (1.2.3), official controls are crucial to verifying compliance with food and feed safety legislation and ensuring consumer and environmental protection as well as guaranteeing fair practices. Controls can be implemented at different steps of food production and handling (e.g. storage, transport) along all stages of the food chain (e.g. imports, primary production, manufacture, retail, consumption) through food and feed safety legislation and ensure consumer protection. In the “**Pharma Food**” world, characterised by large imports and exports of ingredients, complex manufacturing processes that combine food ingredients with pharmaceutical substances, as well as home food production, there can be many challenges for official controls.

In parallel, public or private 3D-food printers or “phood” dispensers will enable individuals to store and mix various types and quantities of ingredients, many of which are expected to possess functional or medicinal properties. Such types of future home food manufacture, however, could entail unprecedented food safety and health risks. The potential of small-scale peer-to-peer trade of such “phoods” could further add to the complexity of such a situation.

Finally, the cost of an evidence-based personalised diet with specialised functional or pharmaceutical foods may be prohibitive for the lower socio-economic status groups, potentially leading citizens to low-cost but unregulated alternative means of purchase (counterfeits, black markets, physical or web-based). Control of global internet sales of medicinal products and counterfeits is a challenge nowadays; this may be further exacerbated in the ICT-based, high volume import global market of the “**Pharma Food**” world, raising the issue of where and how to perform official controls. Although the root of this issue is not related to food controls, it can result in the inability of controlling such parallel markets, increasing the potential for fraud, counterfeited products and consequently food safety and health risks.

The convergence between food and pharmaceuticals, with a significant amount of “phoods”, could also impact on the ability to perform the monitoring, inspection and enforcement aspects of official controls, especially if the regulatory status of “phoods” (medicines or foods) has not been clarified in a timely manner.

Policy options

Regulate “phood” manufacture by introducing a “Phood licence” Although the future EU consumer certainly will use his/her common sense in food preparation, the preparation of “phoods” will pose specific challenges which deserve some attention

from public regulatory bodies. Because of the functional or medicinal nature of some of the ingredients used and the potential health consequences of their misuse, "phoods" preparation may be sensitive. A formalised framework for "phood" education could be envisaged to govern this field; similar to the acquisition of a driver's licence, individuals following specific technical courses could obtain a "phood licence" or "certification" to be able to safely mix and combine ingredients and operate advanced home appliances such as 3D food printers or "phood" dispensers. A similar measure – albeit a different content has been proposed to address private rearing and production of food in the **"Regional Food"** world (Section 2.2.1). Future household "phood" producers/consumers may need to accept that home "phood" preparation may not be entirely risk-free and accept a shared responsibility for unfortunate developments such as overdosing or adverse effects.

Certified individuals could consider selling "phood" products to others; currently, Reg. (EC) 852/2004 on the hygiene of foodstuffs does not apply to the direct supply by the producer of small quantities of primary products to the final consumer or to local retail establishments that directly supply the final consumer. Individual "phood" producers could be certified through similar licences as mentioned above, that in this case, go beyond the certification for domestic use only and address issues related to catering, "phood"/food transport, delivery, storage, advertising, etc.

- **Enhance post-market monitoring and "nutrivigilance" controls**

This world of fast-paced innovation and "phood" development may not be compatible with long and complex risk assessment of new products before being released to the market since data for long-term exposure may be lacking in the short term. As a result, similarly to pharmacovigilance, "nutrivigilance" could be considered. Post-market monitoring by consumers, "phood" service providers, health professionals and/or relevant authorities (e.g. EMA, EFSA) could be introduced to efficiently monitor and detect adverse effects due to "phood" consumption, overdose and cocktail effects. The exact format of such a process, e.g. deciding what to classify as an adverse event and defining how to harmonise and facilitate reporting, is an important consideration. Also, determining which Institution(s) would be responsible for the post-market surveillance system needs consideration; to include universities or other research institutions could be an added-value, ensuring transparency and independence of the process on one hand while providing funds to such establishments and bridging the gaps between research and policy on the other. Self-monitoring and reporting of adverse (or beneficial) effects by consumers could also be made easy by ICT and promoted using effective incentive schemes.

- **Expand third country controls**

The potential options for regulating "phoods" are discussed in 4.5.1. As in the **"Regional Food"** world, the large volume of controls envisaged in the complex "phood" chains of the **"Pharma Food"** world may affect the functioning or the safety of the chain. The measures proposed in 1.5.3 are equally appli-

cable to the **"Pharma Food"** world but ought to be complemented by yet another layer that addresses the pharmaceutical components of "phoods". Some of these are bound to be produced outside the EU. Under the current regulatory system, for the import of an active pharmaceutical ingredient in the EU, a written confirmation by the competent authority of the production country is required, confirming that the country's manufacturing standards are equivalent to those of the EU; in addition, all batches of medicinal products imported from a third country must be re-tested in the EU, unless a mutual recognition agreement is in place. Hence, similarly to what has been discussed in Section 1.2.1, the expansion of mutual recognition agreements with third countries including the implementation of testing before export should be sought to alleviate the burden of re-testing active pharmaceutical ingredients as they enter the EU.

4.2.3. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

While the issue of risk assessment has been discussed in all different scenarios, the **"Pharma Food"** world may witness a situation where regulatory authorities will be outpaced by technological developments, due to the complexity associated with personalised nutrition and the merging of foodstuffs and medicines to "phoods". For example, the time and efforts needed for the health claims approval process would be further exacerbated in the future if one takes into account performance or health enhancement claims (i.e. beyond maintaining health) from "phoods" (see above Section 4.2.1).

The case of designer drugs is a good current example of yet another issue that could be experienced in this future; the production of untested and unauthorised imitation "phoods" with potentially harmful effects that, in this case, could reach many consumers. The potential for "nutrition/food terrorism" has also been highlighted in this context.

Of significance are also potential health issues caused by chronic overconsumption of particular macro- or micro-nutrients added to foods (fortification) as well as bioactive components; the higher the complexity and the number of active compounds present in foodstuffs, the higher the risk for adverse health effects as the antagonistic and synergistic interactions within the cocktail mixtures can have important health implications, even more so in products consumed frequently and for prolonged periods. The lack of a history of safe use due to the novelty of some of these products further adds to the complexity of risk assessment.

Policy options

As a consequence of this high-uptake, fast-paced and evolving "phood" system, post-marketing surveillance or nutrivigilance may be imperative in this scenario. It may not be possible to perform an extensive risk assessment on all "phoods" before marketing. For some (or all) "phoods" a fast track procedure

could be envisaged, which would then be coupled with post-marketing evaluation and nutriviigilance. The potential for fraud and terrorism should not be under-estimated. All measures detailed previously as a response to this challenge are clearly applicable in the context of the **“Pharma Food”** world. Also, the measure below addresses the methodological aspects of risk assessment whose limits are tested in this setting.

- Deal with cumulative effects and long term exposure

To remain effective, the risk assessment system of the **“Pharma Food”** world would need to address a number of issues related to the predominance and potential overconsumption of those “phood” ingredients that can potentially affect health, alone or in combination with the physiological effects of other food components. Cumulative and mixture effects need to be addressed, examining multiple agents or stressors, from chemical additives to minerals, micro-nutrients, bioactive components and pharmaceutical substances, characterising and quantifying their combined risks to health. This would also need to take into account long-term exposure due to chronic consumption. *In silico* computational tools, could be further developed for use as screening

tools and could be particularly effective, given the nature of risk assessment in this scenario, involving acute and chronic toxicity. As a consequence, the pressure on the development and more extensive use of alternative testing methods may increase, especially in the case of integrated testing strategies involving combinations of existing data, *in vitro* tests and quantitative structure-activity relationships (QSARs). The EU is already making significant research investments⁵⁹ in the development of these innovative tools. EFSA is also taking steps in cumulative risk assessment, developing a software tool for exposure assessment of multiple pesticides with the help of European partners. In the long term, EFSA aims to incorporate high-level cumulative risk assessments into its annual analysis of chronic and acute risks of pesticides for human health⁶⁰. The JRC is also active in developing and evaluating innovative safety assessment approaches based on the integrated use of biologically-based exposure modelling, *in vitro* testing and QSAR modelling. Also, to support the Commission’s Communication on the Combination Effects of Chemicals⁶¹, the JRC is working towards the establishment of a consistent assessment approach across different sectors of the EU chemicals legislation (industrial chemicals, plant protection products, biocides, food contact materials, etc.)⁶². Such tools could therefore be further developed to assist in the cumulative risk assessment needs of the “Pharma Food” world.



⁵⁹ E.g. the the Horizon 2020 Euromix project (<https://www.euromixproject.eu>)

⁶⁰ EFSA external scientific report (2016). Monte Carlo Risk Assessment (MCRA) made scalable for large cumulative assessment groups.

⁶¹ EC (2012). Communication from the Commission to the Council , COM/2012/0252 final: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX-%3A52012DC0252>

⁶² JRC (2014). Assessment of Chemical Mixtures – Review of regulatory requirements and guidance: <http://publications.jrc.ec.europa.eu/repository/handle/JRC90601>

4.3. Is Europe heading towards the "Pharma Food"?

As in the previous cases, the policy options above shall be considered and their impact and potential effectiveness assessed before the challenges identified impact our societies. Table 20 proposes a series of simple indicators that can signal European developments towards this scenario, or to phrase it more correctly towards *particular elements* of this scenario; sources that could potentially supply the relevant data for monitoring these indicators are also included. These indicators refer to some of the main characteristics of the "Pharma Food"

scenario, e.g. merging of the food and pharmaceutical industries in the EU, reduce intake of unprocessed foods, home mixture of food ingredients using advanced technologies and personalised nutrition as the predominant dietary practice.

4.4. Research needs

In order for our future policy and regulatory framework to be fit to respond to the challenges presented in 2050 by the "Pharma Food" world, it could benefit from more research in the areas mentioned in Table 21.

Table 20 - "Pharma Food" specific indicators and potential sources of data¹. ↑ or ↓ indicate an increase or decrease compared to 2016

| | | | | | |
|---------|---|--|--|--|--|
| ↑ | % intellectual property rights related to foods with medicinal purposes | % of EU market turnover of novel and health-claim foods, food supplements or total-meal-replacement beverages and bars | % of volumes (tons) and value (Mio €) of EU exports of supplements and foods having medicinal properties and health claims | % of EU businesses or professionals offering personalized nutrition solutions / coaching | % of consumers regularly producing food at home using 3D printers, powder and ingredient mixers etc. |
| Source | FDE, EFPIA ² | FDE, UEAPME | FDE, UEAPME | FENS ³ , EFAD ⁴ , | Eurobarometer |
| ↓ | Intake (g) of unprocessed, fresh foods | Volumes (tons) of agricultural and livestock production for direct human consumption | % of retail market share of grocery shops or physical supermarkets due to increased online purchases ⁵ | % of consumers concerned about personal data use/ privacy issues | % of consumers thinking of origin and organic production while purchasing food |
| Sources | EFSA, FAO, WHO | COPA-COGECA | Eurocommerce, ERA ⁶ | BEUC, Eurobarometer | BEUC, Eurobarometer |

1 For all of these indicators, ESTAT or relevant EU DGs such as SANTE, AGRI, TRADE etc. would be the first choice for monitoring of data relevant to these indicators; what is indicated therefore in this table are potential additional data sources, from relevant specialised stakeholders or organisations.

2 European Federation of Pharmaceutical Industries and Associations

3 Federation of European Nutrition Societies

4 European Federation of the Associations of Dietitians

5 Referring to shops being physically present ("brick and mortar") in the market and involving a face to face interaction of the seller/buyer

6 Electronic Retailing Association

Table 21 - Research needs per challenge in "Pharma Food"

Ability to perform official controls in different future food systems

Intelligent food contact materials (FCM) for "phoods": Developments of intelligent food contact materials and packaging, especially suited for monitoring "phoods" and their conditions during transport and retail.

Designing Official control systems for "phoods": Review official control systems for pharmaceuticals world-wide and assess their suitability for controlling "phoods".

Potential drawbacks of personalised nutrition and "phoods"

Inequalities and personalised nutrition: Research the level and extent of dietary, health and social inequalities that could be generated by a personalised nutrition system.

Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

Risk-benefit biomarkers: Develop methods and specific end points to quantify health claim benefits on healthy consumers.

Organs on a chip: Develop validation methods for the use of "organs on chip" (or organisms on chip) to simplify or eventually replace clinical trials and speed up approval procedures.



Conclusions



The current EU food safety policy is based on an integrated approach, covering all segments of the food chain from farm to fork. Key elements are the precautionary principle, science-based risk analysis, protection of animal health and welfare and plant health, the free movement of food products within the EU and the protection of consumer interests. An effective mechanism for implementing the policy is founded on the following components: food safety laws and regulations, which identify mandates and areas of responsibilities; science-based food safety standards, which, when implemented properly, shall guarantee a high level of public health protection; food inspection, laboratory and enforcement services to ensure proper application of food safety regulations; education, information and communication to all stakeholders of the food chain, including consumers.

Contrary to the extensive legal framework governing food safety in the EU, the policy framework for nutrition is mainly a national competence albeit subject to a coherent and comprehensive Community Strategy, focusing on local, regional, national and EU-level actions to address the issues of overweight and obesity and reduce the risks associated with poor nutrition and limited physical activity. The ability to tackle challenges related to nutrition at EU level depends *inter alia* on the division of competences between the EU and the Member States as defined by the EU founding treaties. The Community Strategy includes collaborative efforts with key stakeholders to influence Member States policies, industry voluntary efforts and partnerships and is complemented by EU legislation in certain areas (e.g. food information to consumers, health claims). In pursuing its goals, the Strategy follows an integrated multi-faceted approach involving all stakeholders to also influence policies outside the remit of health and food safety.

Because various drivers of change such as population growth, globalisation, climate change, resource scarcity and others are expected to put pressure on the EU food system and consequently on the EU food safety and nutrition regulatory and policy framework, it is important to assess the resilience of these frameworks to possible future challenges. These can be manifold.

An analysis of the individual scenarios, challenges and related responses described in this study identified a number of issues that were pertinent in multiple scenarios, despite the fact that they represented different directions of future developments. Those key insights could form the starting point for adapting the current food safety and nutrition policy framework.

Key insights

The legislative framework governing food safety in the EU is robust and appropriate

The general principles of EU food safety legislation cover all essential elements to ensure the safety of the feed-food chain. Implementation could be improved in certain areas by giving better guidance or through legislative acts. For example, implementation of the Hazard Analysis Critical Control Points (HACCP) concept varies among the EU Member States as well as the food business sectors.

Action needed for improving the effectiveness of EU nutrition policies

In view of an anticipated increase in the incidence of nutrition-related non-communicable diseases and the related massive health and socio-economic impacts, any future EU nutrition policy framework will have to intervene via a number of regulatory or non-regulatory actions. Measures will be needed to improve social cohesion, food values and nutrition literacy to avoid deterioration of diet quality and health. Should these measures be insufficient, possible complementary regulatory options are fiscal measures (taxation of food high in certain nutrients, incentives for purchasing certain foods), mandatory nutrition education, additional mandatory nutrition information or creating environments, e.g. in the vicinity of schools, where the availability of certain types of food is restricted ('zoning').

Harmonisation of risk assessment approaches and inclusion of other legitimate factors such as health benefits and socio-economic consequences

The EU risk assessment could be improved by widening the evidence base through efficient sourcing of relevant data, further development of approaches to address the cumulative effects of long-term or chronic exposure to low levels of chemicals or chemical mixtures, better collaboration between different national and EU authorities as well as with stakeholders. More flexible, simplified and streamlined assessments would increase efficiency and foster innovation in the food chain. Future risk assessment procedures should allow weighing, in a proportionate manner, health benefits against risks and appropriately consider socio-economic consequences, food security, environmental factors and impact on innovation. Such a risk-benefit approach could become even more crucial in case current food safety standards can no longer be maintained without drastic impacts on food availability and affordability.

A suitable and harmonised metric for benchmarking and monitoring food safety performance in the EU needs to be established.

In whatever direction the future develops, appropriate indicators will be needed to characterise how well the food safety system functions across the EU. The developments captured by certain indicators, e.g. incidence of foodborne illnesses, the number of novel food technologies patented, the number of food recalls, etc. will inform policy makers on the necessary adaptations to restore performance of the system in dealing with stressors. This may be complemented by modelling of the food system to identify optimal solutions including governance structures for maximising benefits and minimising risks.

An effective early warning system for emerging hazards at EU level is missing

The Rapid Alert System for Food and Feed is effective for sharing alerts among the competent authorities of Member States; it is, however, a reactive system. A pro-active instrument is needed that could capture weak signals transmitted from different sources such as electronic media, web-searches (i.e. on information about syndromes in human or animal populations), etc., and translate them into useful information that could allow an early-on identification of a developing food safety incident.

Adaptation of official control and inspection services to future needs

To respond better to future requirements, control systems shall focus more on preventive process control and not on end-product testing. On-farm testing, audits and inspections (also in third countries), improved traceability systems, data sharing, modelling and forecasting are elements that can help enhance the performance of the current system. Also, to control local food chains, the system should be adapted to deal with e-commerce and peer-to-peer business.

Investment in providing food safety and nutrition education to the public

Education is a key element of several proposed policy options, necessary for preparing the food safety and nutrition system for the future. It is evident that consumers will benefit from improved information on how to produce, use, choose, prepare and store food. This would allow them to protect themselves and their peers from food safety incidents if they wish to engage in any form of food or feed production for private use or sharing. Also, providing objective and comprehensive information constitutes the basis for engaging consumers in processes of shaping the future food system, including an informed debate about novel foods and technologies. Nutrition education can empower consumers to make informed and healthy dietary and lifestyle choices, enabling them to support health prevention strategies to tackle the current and future diet-related public health challenges.



Annex: Extended description of the food safety and nutrition challenges identified per scenario

This Annex presents an extended description of all the food safety and nutrition challenges identified in this study. An overview of these challenges is presented in Table 22.

| Table 22 - List of all identified challenges (includes those prioritised) across all scenarios | | | | |
|--|---------------|-----------------|--------------------|---------------|
| Challenge Title | “Global Food” | “Regional Food” | “Partnership Food” | “Pharma Food” |
| Emerging biological risks: | | | | |
| a) The introduction of known pathogens causing (bio)chemical safety hazards in geographical areas where they were not previously known | x | x | x | x |
| b) Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains | | | | |
| Shortage of quality water | x | x | x | x |
| The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies | x | x | x | x |
| Ability to perform official controls in different future food systems | x | x | x | x |
| Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism | x | x | x | x |
| Failure to provide appropriate food safety information to the consumer | x | x | x | x |
| Abundance of voluntary food information and increased opportunity for misleading information | x | x | x | x |
| Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels) | x | x | x | x |
| Increased sedentary behavior and snacking due to changed lifestyle | x | | x | x |
| Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information | x | | x | x |
| Increased use of chemical substances in the food chain | x | | x | |
| Increased exposure to chemicals and nano-materials from food contact materials migrating in food and from the environment via packaging waste | x | | x | |
| Diets based predominantly on highly processed foods and decreased availability of fresh produce | x | | x | |
| Intensive animal and plant production systems: Disease transmission and nutritional quality | x | | x | |
| Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks | | | x | x |
| Food of different safety and quality classes | x | | | |
| Differences in the handling of food in third countries due to diverging food safety standards | x | | | |
| Re-introduction of food-waste and organic side-stream products in the food chain | | x | | |
| Introduction of environmental contaminants in the food chain from primary production in the urban environment | | x | | |
| Greater reliance for food safety on individuals engaging in food production | | x | | |
| Decreased availability of fresh produce and food poverty in a self-sufficient food | | x | | |
| Diets based predominantly on plant based products | | x | | |
| Imbalanced diets due to over-reliance on (perceived) “healthy foods” or specific dietary regimes | | x | | |
| The loss of technological knowhow in Europe | | | x | |
| Food chain impacts due to over-reliance on one or few trade partners | | | x | |
| Risk of overconsumption of nutrients or other food ingredients | | | | x |
| Increased consumer dependency on digital services for dietary choices | | | | x |
| Potential drawbacks of personalised nutrition as a predominant dietary practice | | | | x |
| Shift of responsibility for diets from consumer to counsellor/coaches | | | | x |

“Global Food”

1. Emerging biological risks:

1a. The introduction of known pathogens causing (bio) chemical safety hazards in geographical areas where they were not previously known

In the future certain pathogens could move to different regions within Europe as a consequence of the effects of climate change, such as rising ambient and water temperatures, changes in rainfall patterns, droughts etc.

- Plant pathogens such as *Aspergillus flavus* or *Fusarium verticillioides* could move to central and northern Europe from southern regions and contaminate crops with various mycotoxins, substances that are toxic to humans and animals.
- Also the appearance of harmful algal blooms may become more frequent in Northern Sea coastal waters due to an increase in sea surface temperature. Certain algal species produce marine biotoxins that contaminate shellfish and can cause shellfish poisoning to humans when consumed.
- Increased global trade could also facilitate the introduction into Europe of toxin-producing pathogens from other parts of the world.

Impact: As these hazards may not be previously known or common in certain parts of Europe, their presence may not be immediately detected as they would not form part of the normal regional monitoring, inspection and control procedures and could lead to illness and toxic effects in humans and animals.

1b. Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains

The virulence of microorganisms (the capacity of a micro-organism to cause disease), their ecology or their stress responses can be affected by changes in environmental factors which may also lead to the appearance of new strains.

- This could be further promoted from climate change impacts such as rising temperatures, changes in rainfall patterns, draught stresses etc. For example, an association has been observed between salmonellosis incidents and an observed increase in ambient temperature or vibriosis incidents related to increased water temperatures in northern waters.
- Also, due to intrinsic factors such as gene transfer between microorganisms, their virulence can increase and they may become more resistant possibly also leading to antimicrobial resistance.

Impact: Proven control mechanisms such as the “hurdle concept” and antibacterial or other substances used at different steps in the food chain may prove inefficient to control new or resistant strains, potentially leading to unsafe products in the market and impacts on consumer health.

2. Shortage of quality water

Water of appropriate quality is required in all steps of the food chain, ranging from primary production (drinking water

for animals) through the processing environment (cleaning of fresh produce, fish, surfaces, equipment etc.), to the transportation (cleaning of transportation vessels) and the preparation of food by the consumer.

- The quality of water is expected to be adversely affected by the impacts of climate change, for example floods may lead to increased transfer of environmental contaminants and chemical residues in groundwater and coastal waters.
- The use of water of inappropriate quality in irrigation may lead to the contamination of crops and fresh produce with pathogens which may be difficult to inactivate in further steps of the food chain and is of particular importance for products that are intended to be eaten without further treatment.
- Also over-extraction of water may lead to the use of water that contains high levels of heavy metals or high salt content (salination of aquifers).

Impact: The shortage of quality water could introduce microbiological and chemical risks at all steps of the food chain where water is used and impact on the safety and hygiene of produced food.

3. The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies

New protein sources (such as in-vitro meat, the use of insect proteins in feed or food etc) are expected to be introduced in the European food and feed market, as a response to the increasing protein demand from a growing world population and the need for a more resource-efficient production.

- At the same time technologies for the extraction and use of these proteins in food will continue to be developed.
- While protein production under strictly controlled laboratory conditions may be considered safer than the conventional farm production due to the avoidance of animal diseases, safety risks could still be introduced from the raw materials and mediums that will be used during the production process.
- Also, it is anticipated that the use of purer substances, synthesised food components or processes that may expose allergens differently could lead to increased immune responses and allergies

Impact: The food safety risks associated with alternative protein sources and related technologies are not well known to date, but they may contain chemical contaminants (i.e. pesticides, heavy metals), pathogenic microorganisms, possibility for allergenic potential, depending on the safety of the feed/mediums and materials (e.g. food waste, manure, blood, etc.) used for their diet/production. This may lead to chemical residues, allergens or the presence of pathogenic microorganisms in the processed products where they are used. Overall, they can introduce acute food safety hazards or cause health impacts due to long-term/chronic consumption, which is difficult to foresee and evaluate in advance.

4. Increased use of chemical substances in the food chain

The use of chemicals in the food chain is expected to increase in the future at the different steps of the food chain for different reasons.

- Increased fertiliser input could be observed in primary production as a result of more widespread use of intensive production systems to increase yields but also in order to compensate for the unavailability of certain nutrients in the soil
- Antibiotics may also be used on a preventive basis in animal production and aquaculture in order to inhibit the spread of diseases, in particular in intensive production systems.
- More chemicals may also be needed to control pest or plant pathogens' outbreaks which are expected to increase in the future due to the rising temperatures and the increased CO₂ concentration in the atmosphere resulting from climate change
- More chemicals may also be used in the manufacturing step in order to extend product self-life during extensive storage and transportation, to improve the organoleptic properties of products or in order to add desirable properties (colour, functionality etc.).

Impact: The increased use of chemicals in the food chain will also result in increased levels of residues in foods (pesticides, fertilisers and veterinary drug residues, additives and preservatives, antimicrobials in aquaculture, etc.) due to direct addition or due to the accumulation of residues in effluents from intensive production sites which may enter the trophic chain via soil and water. This will further result in higher population exposure to chemical substances through their diet.

Also the preventive use of antibiotics may lead to the development of anti-microbial resistant strains of pathogens such as antibiotic-resistant *Salmonella*. This may have very significant consequences for public health depending on the disease and its effects on animal and human health; for example zoonotic microbes are of special concern as they will affect animals and humans as well.

5. Increased exposure to chemicals and nano-materials from food contact materials migrating in food and from the environment via packaging waste

Chemical substances and nano-materials used in packaging materials may find their way into food products more in the future.

- The extended storage and transportation times anticipated in this scenario will result in extended contact of food products with their packaging materials, which may be longer than anticipated, also considering that future products may be developed with longer shelf-life. This may lead to increased migration of substances from the packaging materials to the food.
- Food packaging and its waste is increasing in recent years and this trend is expected to continue. This may lead to the release of chemical substances as well as of nano-materials into the environment. These may be ingested by animals and find their way onto our plate.

Impact: This may lead to the higher exposure of people to residues of chemicals (additives, monomers, oligomers, nano-materials) used in packaging materials.

6. Diets based predominantly on highly processed foods and decreased availability of fresh produce

Food variety, and in particular the availability of fresh produce could be affected in scenarios where diets are predominantly based on highly processed foods

- While food processing ensures preservation, increases variety and availability and can bestow improved nutritional/sensory quality, highly processed foods can also be energy rich and have high contents of sugar, salt, fat (HFSS). Certain food components may be lost during food processing - highly processed foods can be poor in micro-nutrients or fiber. Highly processed foods usually contain refined food components, which require less energy needed for their metabolism.
- In a globalised food system, cost-efficient mass production of highly processed foods may dominate the food offer, making fresh produce more difficult to access to a large part of consumers.

Impact: Decreased availability of fresh produce can affect dietary quality leading to micronutrient deficiencies. High consumption of HFSS foods can result in higher prevalence and earlier onset of non-communicable diseases and have negative public health impacts. Low SES groups can be particularly at risk leading to further health inequalities

7. Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks

Processed foods have been associated with different chemical and microbiological hazards in recent years.

- Certain processing technologies have resulted in the appearance of contaminants in the finished products, such as acrylamide, furan, 3-MCPD, etc. New processing technologies could result in the appearance of new processing contaminants in different product categories.
- Also, even though processing technologies have generally improved the safety of the food chain, still certain processed ready-to-eat products such as uncooked refrigerated processed meat products, ready-to-eat smoked or cold-salted fish have been associated with e.g. *Listeria monocytogenes* incidents.
- The possible increased future consumption of processed and ready-to-eat products could increase the chances of chemical or microbiological hazards.

Impact: This may lead to population exposure to chemical hazards that may not be previously known until their presence is identified or to food-borne disease outbreaks.

8. Increased sedentary behavior and snacking due to changed lifestyle

Lifestyles with increased time spent online or in virtual environments for leisure activities are foreseen to increase in the future, and could likely be associated with

- fast and convenient meal preparation and overconsumption, e.g. "web dinners" (as in "TV dinners")
- increase in snacking behaviour (and increased calorie intake)
- decreased physical activity and increased sedentary behavior

Impact: The above can translate into lower dietary quality and more sedentary lifestyles with decreased physical activity leading to weight gain and increasing the risk of non-communicable diseases.

9. Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information

The current gradual loss of food safety and nutrition literacy may worsen further in the future. At the same time the source and quality of information available are crucial for consumer food choices.

- Lack of nutrition literacy weakens consumer ability to choose a balanced and healthy diet.
- Beyond nutrition literacy, food safety education is particularly relevant when individuals wish to grow, handle, store and trade their own food or for the safe preparation of meals at home.
- Over-reliance on technology, home delivery, ready-to-(h) eat foods further alienates people from food preparation skills, culture and traditions
- In an era of information overload from different sources and stakeholders, including those with vested interests, the quality of food safety and nutrition information reaching the consumer is doubtful, even though crucial for informed consumer choices (no control or authentication and with a risk of fraudulent behaviours).

Impact: Lack of food safety and nutrition literacy as well as cooking skills can contribute to the introduction of food safety hazards during food production or preparation by the consumer as well as weaken their ability to make informed and healthy dietary choices, resulting on poor quality dietary habits, malnutrition and consequent health issues; intentional misinformation can exacerbate the above issues. Also, the loss of food traditions and cooking skills can weaken a major socio-cultural aspect of Europe.

10. Intensive animal and plant production systems: Disease transmission and nutritional quality

Intensive production systems are aimed to increase crop yields or number of animals reared in a given size of land, using different technologies.

- Population density and the reduced genetic diversity of animals (livestock and aquaculture) or plants in intensive production systems may facilitate the transmission and spread of diseases.
- Disease transmission in intensive primary production systems could also be accelerated by climate change and the increase of average temperature and humidity. Such conditions cause stress to different plant species and reduce their resistance, while they also predispose certain animal/plant species to certain diseases (such as cattle and mastitis, cultured shrimp and early mortality syndrome, wheat and fusarium head blight).
- The transmission of animal diseases is more important in the primary production step of the food chain, even though it can also occur during transportation, if animal welfare conditions in relation to the number of animals are not properly followed.
- Higher yield varieties (of crops, fruits and plants) are usually favoured in intensive production systems; this

however does not ensure that such varieties also contain the right balance of other nutrients (most dry weight is carbohydrates). Intensive production systems also accelerate depletion of nutrients and organic matter from the soils, with a further negative impact on the nutrient quality of primary produce.

Impact: Intensive production systems could allow certain animal and plant diseases to enter the food chain and affect humans consuming certain food products that have not been appropriately processed (e.g. non-pasteurised milk in the case of cattle affected by mastitis, or fusarium mycotoxins in wheat). It can also lead to increased input of chemicals in the food system in order to prevent or control the transmission of diseases, leading to increased residues in primary produce. Intensive production systems may also lead, in the long term, to poor soil quality resulting in crops and horticultural products of poor nutritional value. Declining nutrient concentrations in horticultural products, the richest source of micronutrients in our diets, can lead to micronutrient deficiencies and malnutrition.

Apart from food safety and nutrition, intensive production systems can have a significant impact on biodiversity in agricultural production as well as on the environmental sustainability of the food chain, potentially leading to a less resilient agricultural system.

11. Failure to provide appropriate food safety information to the consumer

The need for receiving essential and mandatory food safety information, such as expiry dates, information on the safe handling and storage of food, or allergen information or information in relation to the nutritional value of food will remain and may even be more significant in the future.

- This is very important if one considers that packaging may be reduced in certain future scenarios. For example in this scenario people may increasingly eat out for example from food buffets where labelling of safety or nutritional information may be limited.
- Intelligent packaging materials are being developed, communicating safety information such as shelf-life to the consumer based on sensors etc.
- “Intelligent fridges” or other technologies and applications may allow for the mandatory safety and nutrition information to be made available to the consumer by scanning a bar-code.
- Also increasing average temperatures resulting from climate change may make the safe storage and handling of food more important and consequently the provision of relevant information to the consumer via labelling.
- The increasing prevalence of food allergies in the population will further increase the need for appropriate allergen information.

Impact: The unavailability of appropriate food safety and nutrition information either due to unlabelled products or due to failure of intelligent technologies may result in mishandling of food by the consumer and food safety hazards at consumption.

12. Abundance of voluntary food information and increased opportunity for misleading information

Food labels can already contain a lot of information beyond basic safety and nutritional content that the manufacturer wishes or is obliged to communicate to the customer; this can increase the complexity of food labels. In parallel, food fraud could also be of concern, in the form of intentional provision of misleading information (in particular with regard to quality or origin information or with regard to products meeting specific compositional requirements or standards).

- Future food labelling schemes, voluntary or obligatory, may provide information on a variety of novel processes or materials (e.g. GM foods, foods from cloned animals, synthetic foods, and 3D printed foods), presence of bioactive or pharmaceutical substances and health claims, further increasing the complexity of food labels.
- The above is also relevant to products sold without packaging (fresh or dried fruits and vegetables, dairy products, raw or processed meat/fish) in retail stores or served in restaurants, canteens and buffets.
- In the view of such complexity, it could be envisaged that some label contents are detached from the product and available only online (e.g. via Quick Response codes). As a result, the consumer might need to go to extra lengths to obtain the required information.
- Potential demand for country of origin labelling for individual ingredients in complex food chains could be challenging to achieve and to describe.
- Fraud can occur across both production and consumption levels in particular with regard to compositional quality, expensive food products and possible imitation products or with compliance with any of the above quality schemes that add value to food products.
- Opportunities for fraud may also be associated with product adulteration and with misleading the consumers on the properties of enhanced foods and the related health claims.

Impact: The potential complexity of the labels may negatively impact consumer understanding and consequently consumers' choices and diets. In addition, food fraud and the provision of misleading information to the consumers is against the principles of food law, can potentially impact production and marketing of specific products and may even pose direct health concerns to the consumer (e.g. melamine to increase apparent protein content, substitution of ethanol by methanol etc.). More complex mandatory labelling could also become an additional burden for the food industry, impacting disproportionately small producers, potentially affecting variety and food prices.

13. Differences in the handling of food in third countries due to diverging food safety standards

In a global food chain where raw materials and ingredients are sourced from all over the world and where different processing steps may have taken place in different parts of the world before a finished product appears on the market, the different actors in third countries might adhere to different safety standards.

- Private/industry standards compensate to some extent for these differences, however food regulations and their enforcement in different countries may still differ in different parts of the world.

Impact: This could allow potentially unsafe – for European standards – raw materials or products to enter the food chain in Europe if they fail to be examined at the points of entry.

14. Food of different safety and quality classes

The further concentration of the food industry, combined with the impacts of climate change and resource scarcity could lead to the appearance of significantly different classes of food offered by the big food manufacturing companies, to serve the different socio-economic classes.

- Cheap food with reduced nutritional benefit could be widely available and affordable.
- Food of better quality made with more expensive raw materials (e.g. sustainable, responsibly sourced, local, natural etc.) and with higher nutritional value could be available for the wealthier consumer at a premium.
- Under extreme situations of resource scarcity and disruption and where the cost of specific food safety measures becomes too high, food of different “safety classes” in relation to today's perceptions might appear.

Impact: This would lead to increased availability of low nutritional quality and potentially unsafe products on the market, further enhancing the diet-related health issues and potentially presenting safety hazards.

Challenges to the regulatory and policy framework – Horizontal challenges

1. Ability to perform official food-related controls

Official controls (inspection as well as laboratory analysis) are of particular importance throughout the food chain as it is one of the main ways to verify compliance with food and feed safety legislation and ensure consumer protection.

- The structure of the food system differs in the four future scenarios; for example, in “Global Food” the future food system is much more complex and global than today.
- This, in combination with the governance in the different food systems could impact on the ability to perform the monitoring, inspection and enforcement aspects of official controls.

Impact: Inability to perform appropriate official controls could allow food safety hazards to enter at all steps of the food chain and, since uncontrolled, they could reach the consumer with significant consequences to human health.

2. Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism

Information and Communication Technologies are increasingly used in the food chain for the communication of information for traceability purposes.

- In case of a temporary failure of such technologies it could be possible that information in relation to the origin, properties, treatment, detected food safety hazards or individual requirements of materials or different products may be lost or miscommunicated. This could further impact the ability to perform official controls.
- The achievement of traceability may also be challenged towards 2050 depending on the structure of the food

chain system in the different future scenarios.

- Also the possibility of hacking or manipulating such systems may make the food chain and its actors including consumers or even countries very vulnerable and would facilitate fraud.

Impact: The temporary failure of ICT technologies used for ensuring traceability in the food chain could allow the introduction of safety risks at different steps of the food chain.

3. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

The approval of new substances or new food technologies in Europe (i.e. chemicals for different uses: pesticides, fertilisers, veterinary residues, food additives and preservatives, micro-nutrients, bio-actives, antimicrobials, new GMOs) relies on a thorough risk assessment procedure. Approval results in the unconditional authorisation or on an authorisation subject to maximum residue levels or other limits established for the different substances in foods. However the suitability of the current risk assessment approach in Europe has been challenged for the following reasons:

- Technological developments and innovations in the food system have accelerated in the last few years and new foods, processes and technologies continue to develop at a very fast pace (such as the extension of genetic modification in aquaculture, edible food packaging, novel foods, addition of substances with health properties or new packaging/storage technologies).
- At the same time the regulatory process for the approval of certain food-related substances and technologies (i.e. new food additives, novel foods, health claims) becomes lengthier and may require years for single substances to be approved for use in food products.

- The suitability of exposure data used today in the risk assessment and decision making process for use in the future has also been challenged. For example epidemiological and dietary intake data are considered fragmented; the dietary intake of substances in different parts of the population may depend on consumers' income and may differ under different future scenarios. Also old consumption data may be not relevant anymore, due to change in patterns of consumption of chemicals that were more widely ingested in the past or due to the increase in ingestion of urban contaminants.
- Also newer insights become available on the effects of dietary exposure to mixtures of chemicals of varying nature (natural toxins, chemical residues and contaminants, additives, bioactives).
- The ability to perform risk assessment could differ in different scenarios, for example it could be compromised in a scenario with significant financial constraints, introducing thus challenges in the food chain.
- Finally the need for harmonisation of standards in order to reduce any remaining barriers to global trade and facilitate the sourcing of products from around the world could also push towards convergence of different risk assessment related approaches in different parts of the world, including the possibility to adopt the least restrictive one.

Impact: The above could result in products not properly evaluated reaching the market that may pose short- or long-term health challenges. At the same time other technologies much needed in the food chain may be delayed by lengthy approval processes also taking up the available resources of risk assessment bodies. This would impact all steps of the food chain, depending on the technologies concerned and their application. Other impacts could be observed on the establishment of maximum residue levels of different substances in food.

“Regional Food”

1. Emerging biological risks:

1a. The introduction of known pathogens causing (bio) chemical safety hazards in geographical areas where they were not previously known

In the future certain pathogens could move to different regions within Europe as a consequence of the effects of climate change, such as rising ambient and water temperatures, changes in rainfall patterns, droughts etc.

- Plant pathogens such as *Aspergillus flavus* or *Fusarium verticillioides* could move to central and northern Europe from southern regions and contaminate crops with various mycotoxins, substances that are toxic to humans and animals.
- Also the appearance of harmful algal blooms may become more frequent in Northern Sea coastal waters due to an increase in sea surface temperature. Certain algal species produce marine biotoxins that contaminate shellfish and can cause shellfish poisoning to humans when consumed.

Impact: As these hazards may not be previously known or common in certain parts of Europe, their presence may not be immediately detected as they would not form part of the normal regional monitoring, inspection and control procedures and could lead to illness and toxic effects in humans and animals.

1b. Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains

The virulence of microorganisms (the capacity of a micro-organism to cause disease), their ecology or their stress responses can be affected by changes in environmental factors which may also lead to the appearance of new strains.

- This could be further promoted from climate change impacts such as rising temperatures, changes in rainfall patterns, draught stresses etc. For example, an association has been observed between salmonellosis incidents and an observed increase in ambient temperature or vibriosis incidents related to increased water temperatures in northern waters.
- Also, due to intrinsic factors such as gene transfer between microorganisms, their virulence can increase and they may become more resistant possibly also leading to antimicrobial resistance.

Impact: Proven control mechanisms such as the “hurdle concept” and antibacterial or other substances used at different steps in the food chain may prove inefficient to control new or resistant strains, potentially leading to unsafe products in the market and impacts on consumer health.

2. Shortage of quality water

Water of appropriate quality is required in all steps of the food chain from primary production (drinking water for animals) through to the processing environment (cleaning of fresh produce, fish, surfaces, equipment etc.), transportation (cleaning of transportation vessels) and the preparation of food by the consumer.

- The quality of water is expected to be adversely affected by the impacts of climate change, for example floods may lead to increased transfer of environmental contaminants and chemical residues in ground waters and coastal waters.
- The use of water of inappropriate quality in irrigation may lead to the contamination of crops and fresh produce with pathogens which may be difficult to inactivate in further steps of the food chain and is of particular importance for products that are intended to be eaten without further treatment.
- Also over-extraction of water may lead to the use of water that contains high levels of heavy metals or high salt content (salination of aquifers).

Impact: The shortage of quality water could introduce microbiological and chemical risks at all steps of the food chain where water is used and impact on the safety and hygiene of produced food.

3. The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies

New protein sources (such as in-vitro meat, the use of insect proteins in feed or food etc.) are expected to be introduced in the European food and feed market, as a response to the increasing protein demand from a growing world population and the need for a more resource-efficient production.

- At the same time technologies for the extraction and use of these proteins in food will continue to be developed.
- While protein production under strictly controlled laboratory conditions may be considered safer than the conventional farm production due to the avoidance of animal diseases, safety risks could still be introduced from the raw materials and mediums that will be used during the production process.
- Also, it is anticipated that the use of purer substances, synthesised food components or processes that may expose allergens differently could lead to increased immune responses and allergies

Impact: The food safety risks associated with alternative protein sources and related technologies are not well known to date, but they may contain chemical contaminants (i.e. pesticides, heavy metals), pathogenic microorganisms, possibility for allergenic potential, depending on the safety of the feed/mediums and materials (e.g. food waste, manure, blood, etc.) used for their diet/production. This may lead to chemical residues, allergens, or the presence of pathogenic microorganisms in the processed products where they are used. Overall they can introduce acute food safety hazards or cause health impacts due to long-term/chronic consumption, difficult to foresee and evaluate in advance.

4. Increased use of chemical substances in the food chain

The use of chemicals in the food chain is expected to increase in the future at the different steps of the food chain for different reasons.

- More chemicals may be needed to control pest or plant pathogens' outbreaks which are expected to increase in the future due to the rising temperatures and the increased CO₂ concentration in the atmosphere resulting

from climate change.

- In particular in **“Regional Food”**, individuals growing their own food at small scale level could contribute through uncontrolled/inappropriate use of chemicals.

Impact: The increased use of chemicals due to a possible increase in the number of plant pathogen or pest outbreaks or due to inappropriate use by individual farmers will result in increased levels of residues in foods (pesticides, plant protection products) which may enter the trophic chain via soil and water. This will further result in higher population exposure to chemical substances through their diet.

5. Failure to provide appropriate food safety information to the consumer

The need for receiving essential and mandatory food safety information, such as expiry dates, information on the safe handling and storage of food, or allergen information or information in relation to the nutritional value of food will remain and may even be more significant in the future.

- This is very important if one considers that packaging may be reduced in **“Regional Food”** and many products may be purchased directly from the farmer/producer without any packaging and thus without any safety or nutritional information.
- Also increasing average temperatures resulting from climate change may make the safe storage and handling of food more important and consequently the provision of relevant information to the consumer.
- The increasing prevalence of food allergies in the population will further increase the need for appropriate allergen information.

Impact: The unavailability of appropriate food safety and nutrition information in products sold without labels may result in mishandling of food by the consumer and food safety hazards at consumption.

6. Abundance of voluntary food information and increased opportunity for misleading information

Food labels can already contain a lot of information beyond basic safety and nutritional content that the manufacturer wishes or is obliged to communicate to the customer; this can increase the complexity of food labels. In parallel, food fraud could also be of concern, in the form of intentional provision of misleading information (in particular with regard to quality or origin information or with regard to products meeting specific compositional requirements or standards).

- Future food labelling schemes, voluntary or obligatory, may provide information on a variety of novel processes or materials (e.g. recycled materials in packaging, reuse of food waste or water in food production), as well as issues such as method of cultivation, sustainability rating etc. further increasing the complexity of food labels.
- The above is also relevant to products sold without packaging (fresh or dried fruits and vegetables, dairy products, raw or processed meat/fish) in local/farmer market stalls.
- Potential demand for country of origin labelling for individual ingredients could be challenging to achieve and to describe.
- Fraud can occur across both production and consumption levels in particular with regard to compositional quality,

expensive food products and possible imitation products or with compliance with any of the above quality schemes that add value to food products.

- Opportunities for fraud may also be associated with product adulteration and with misleading the consumers on the properties of enhanced foods and the related health claims.

Impact: Consumers' choices and diets involve a range of products for which quality information is required. This may be difficult to provide in this scenario due to a large part of products being sold or exchanged between peers without packaging. In addition, food fraud and the provision of misleading information to the consumers is against the principles of food law, can potentially impact production and marketing of specific products and may even pose direct health concerns to the consumer (e.g. melamine to increase apparent protein content, substitution of ethanol by methanol, etc.).

7. Re-introduction of food-waste and organic side-stream products in the food chain

Food and other waste from the food chain can be re-introduced for different uses in the food chain in order to increase the sustainability and resource efficiency of the production process.

- The types of food waste that can be re-introduced in the food chain are restricted in order to prevent disease transmission to animals.
- Consumer unawareness of certain risks may lead to the use of types of waste that may introduce safety risks to the food chain when growing their own food, as opposed to more industrialised systems where more expert knowledge is available

Impact: This could lead to the introduction of different chemical and biological safety hazards in primary production that facilitate the transmission of zoonotic diseases.

8. Introduction of environmental contaminants in the food chain from primary production in the urban environment

Certain contaminants such as Polycyclic Aromatic Hydrocarbons and dioxins from contaminated land (industrial sites, landfills, sewage treatment plants) but also heavy metals such as Pb, Cd and As are common in urban environments.

- Increasing farming and cultivation in urban environments may lead to the increased uptake of such substances from crops and animals via soil, water and air.

Impact: This will lead to the increased presence of substances with toxic or carcinogenic potential in primary production and, if undetected, in processed products as well, with potentially severe health impacts.

9. Greater reliance for food safety on individuals engaging in food production

In **“Regional Food”** it is anticipated that primary production will be more small-scale and localised.

- The responsibility for food safety will be with individual small-scale producers who may not have the technical know-how and resources currently found in the organised large-scale food industry.

Impact: This may lead to potentially lower food safety standards being more common in the future. This problem will be further more prominent due to the reduced possibility of performing appropriate official controls in such a fragmented food chain where products change hands on a peer-to-peer level.

10. Temporary shortages of fresh produce and food poverty in a self-sufficient food system

Efficiency of agricultural production, as well as availability and accessibility of food may be challenged in a food system characterised by dependence on localised and self-sufficient production (including home-grown foods and/or urban farming)

- A food system based predominantly on regional and local food chains and self-production, and with limitations imposed by climate change, natural resources scarcity and seasonality, can lead to less variety of foods available locally, especially in fresh produce
- Due to different degrees of climate change and natural resources impacts across Europe, some regional/local food chains may be more affected than others.
- Not all urban regions in the EU may be able to fully support local production systems or urban farming by 2050
- Lack of economies of scale in a local/short food chain system may potentially increase agricultural input cost with subsequent transmission to retail prices and direct impacts on household budget allocated to food purchase.

Impact: A localized and self-sufficient production system may face resilience issues and this could negatively impact the availability and accessibility of agricultural products, potentially leading to nutrition inequalities and malnutrition for a part of the population. Especially for fresh produce, loss of variety in diets can affect dietary quality leading to micronutrient deficiencies (e.g. iron, zinc, vitamin A, D, vitamin B12, folic acid and iodine).

11. Diets based predominantly on plant-based products

Predominantly plant based diets are recognised as a crucial element of healthy and sustainable eating; however, health issues could potentially arise in diets based mainly or exclusively on plants

- Certain micro-nutrients may not be easily obtained in plant-based diets, especially with restricted/limited number availability of plant foods (e.g., in strict vegetarian/vegan dietary regimes, or as a result of high costs of- or unavailability of food items); nutrients of concern may include iron, vitamin B12, vitamin D, n-3 polyunsaturated fatty acids, calcium, zinc.
- Although diets relying predominantly on plant-based foods are recognised as healthy, they may carry the risk of increased exposure to pesticide residues; the issue therefore in such a case could be on how to assess and weigh the risks and benefits for consumer health.

Impact: In a situation where diets of a large part of the population are based predominantly or even exclusively on plants, micronutrient deficiencies could become an issue, in particular in certain vulnerable groups (children, elderly, people with disease or using drugs); in addition, health benefits coming from plant-based diets could be potentially hampered due to increased pesticide residues.

12. Imbalanced diets due to over-reliance on (perceived) “healthy foods” or specific dietary regimes

- Plant-based diets have a positive, health-promoting image which may motivate the development of convenience, snack-, fast-, or otherwise highly-processed plant-based foods, responding to consumer goals for health. However, plant-based diets including a large share of such foods may not be necessarily healthy; processed foods based on plants may still contain high levels of salt or sugar, while processing can also remove valuable nutrients.
- Attempts to follow certain dietary regimes (with some or no scientific basis) to lose weight or improve performance/health, such as ‘low-carb’, ‘high-protein’, ‘low-fat’, ‘gluten-free’, ‘raw food’ etc. may lead to imbalanced diets.

Impact: Both developments may result in micronutrient deficiencies, excessive intake of certain nutrients, or more general metabolic disturbances (blood pressure, blood lipids, inflammation, etc.).

Challenges to the regulatory and policy framework – Horizontal challenges

1. Ability to perform official food-related controls

Official controls (inspection as well as laboratory analysis) are of particular importance throughout the food chain as it is one of the main ways to verify compliance with food and feed safety legislation and ensure consumer protection.

- The structure of the food system differs in the four future scenarios; for example in “**Regional Food**” the future food system is much more fragmented and localised in comparison to today.
- This, in combination with the governance in the different food systems could impact on the ability to perform the monitoring, inspection and enforcement aspects of official controls.
- For example, in “**Regional Food**” it is anticipated that a considerable share of food may be purchased or even exchanged between individuals, outside of any official sales channels, significantly reducing the possibility to perform official controls.

Impact: Inability to perform appropriate official controls could allow food safety hazards to enter at all steps of the food chain and, since uncontrolled, they could reach the consumer with significant consequences to human health.

2. Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism

Information and Communication Technologies are increasingly used in the food chain for the communication of information for traceability purposes.

- In case of a temporary failure of such technologies it could be possible that information in relation to the origin, properties, treatment, detected food safety hazards or individual requirements of materials or different products may be lost or miscommunicated. This could further impact the ability to perform official controls.
- The achievement of traceability may also be challenged towards 2050 depending on the structure of the food

chain system in the different future scenarios.

- Also the possibility of hacking or manipulating such systems may make the food chain and its actors including consumers or even countries very vulnerable and would facilitate fraud.

Impact: The temporary failure of ICT technologies used for ensuring traceability in the food chain could allow the introduction of safety risks at different steps of the food chain.

3. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

The approval of new substances or new food technologies in Europe (i.e. chemicals for different uses: pesticides, fertilisers, veterinary residues, food additives and preservatives, micro-nutrients, bio-actives, antimicrobials, new GMOs) relies on a thorough risk assessment procedure. Approval results in the unconditional authorisation or on an authorisation subject to maximum residue levels or other limits established for the different substances in foods. However the suitability of the current risk assessment approach in Europe has been challenged for the following reasons:

- Technological developments and innovations in the food system have accelerated in the last few years and new foods, processes and technologies continue to develop at a very fast pace (such as the extension of genetic modification in aquaculture, edible food packaging, novel foods, addition of substances with health properties or new packaging/storage technologies).
- At the same time the regulatory process for the approval of certain food-related substances and technologies (i.e. new food additives, novel foods, health claims) becomes lengthier and may require years for single substances to be approved for use in food products.

- The suitability of exposure data used today in the risk assessment and decision making process for use in the future has also been challenged. For example epidemiological and dietary intake data are considered fragmented; the dietary intake of substances in different parts of the population may depend on consumers' income and may differ under different future scenarios. Also old consumption data may be not relevant anymore, due to change in patterns of consumption of chemicals that were more widely ingested in the past or due to the increase in ingestion of urban contaminants.
- Also newer insights become available on the effects of dietary exposure to mixtures of chemicals of varying nature (natural toxins, chemical residues and contaminants, additives, bioactives).
- The ability to perform risk assessment could differ in different scenarios, for example it could be compromised in a scenario with significant financial constraints, introducing thus challenges in the food chain.
- In particular in **"Regional Food"** certain farming and production practices may be used based on their history of safe use, rather than on a detailed risk assessment process.

Impact: The above could result in products not properly evaluated reaching the market that may pose short- or long-term health challenges. At the same time other technologies much needed in the food chain may be delayed by lengthy approval processes also taking up the available resources of risk assessment bodies. This would impact all steps of the food chain, depending on the technologies concerned and their application. Other impacts could be observed on the establishment of maximum residue levels of different substances in food.

“Partnership Food”

1. Emerging biological risks:

1a. The introduction of known pathogens causing (bio) chemical safety hazards in geographical areas where they were not previously known

In the future certain pathogens could move to different regions within Europe as a consequence of the effects of climate change, such as rising ambient and water temperatures, changes in rainfall patterns, droughts etc.

- Plant pathogens such as *Aspergillus flavus* or *Fusarium verticillioides* could move to central and northern Europe from southern regions and contaminate crops with various mycotoxins, substances that are toxic to humans and animals.
- Also the appearance of harmful algal blooms may become more frequent in Northern Sea coastal waters due to an increase in sea surface temperature. Certain algal species produce marine biotoxins that contaminate shellfish and can cause shellfish poisoning to humans when consumed.

Impact: As these hazards may not be previously known or common in certain parts of Europe, their presence may not be immediately detected as they would not form part of the normal regional monitoring, inspection and control procedures and could lead to illness and toxic effects in humans and animals.

1b. Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains

The virulence of microorganisms (the capacity of a micro-organism to cause disease), their ecology or their stress responses can be affected by changes in environmental factors which may also lead to the appearance of new strains.

- This could be further promoted from climate change impacts such as rising temperatures, changes in rainfall patterns, draught stresses etc. For example, an association has been observed between salmonellosis incidents and an observed increase in ambient temperature or vibriosis incidents related to increased water temperatures in northern waters.
- Also, due to intrinsic factors such as gene transfer between microorganisms, their virulence can increase and they may become more resistant possibly also leading to antimicrobial resistance.

Impact: Proven control mechanisms such as the “hurdle concept” and antibacterial or other substances used at different steps in the food chain may prove inefficient to control new or resistant strains, potentially leading to unsafe products in the market and impacts on consumer health.

2. Shortage of quality water

Water of appropriate quality is required in all steps of the food chain from primary production (drinking water for animals) through to the processing environment (cleaning of fresh produce, fish, surfaces, equipment etc.), transportation (cleaning of transportation vessels) and the preparation of food by the consumer.

- The quality of water is expected to be adversely affected by the impacts of climate change, for example floods may lead to increased transfer of environmental contaminants and chemical residues in ground waters and coastal waters.
- The use of water of inappropriate quality in irrigation may lead to the contamination of crops and fresh produce with pathogens which may be difficult to inactivate in further steps of the food chain and is of particular importance for products that are intended to be eaten without further treatment.
- Also over-extraction of water may lead to the use of water that contains high levels of heavy metals or high salt content (salination of aquifers).

Impact: The shortage of quality water could introduce microbiological and chemical risks at all steps of the food chain where water is used and impact on the safety and hygiene of produced food.

3. The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies

New protein sources (such as in-vitro meat, the use of insect proteins in feed or food etc) are expected to be introduced in the European food and feed market, as a response to the increasing protein demand from a growing world population and the need for a more resource-efficient production.

- At the same time technologies for the extraction and use of these proteins in food will continue to be developed.
- While protein production under strictly controlled laboratory conditions may be considered safer than the conventional farm production due to the avoidance of animal diseases, safety risks could still be introduced from the raw materials and mediums that will be used during the production process.
- Also, it is anticipated that the use of purer substances, synthesised food components or processes that may expose allergens differently could lead to increased immune responses and allergies

Impact: The food safety risks associated with alternative protein sources and related technologies are not well known to date, but they may contain chemical contaminants (i.e. pesticides, heavy metals), pathogenic microorganisms, possibility for allergenic potential, depending on the safety of the feed/mediums and materials (e.g. food waste, manure, blood, etc) used for their diet/production. This may lead to chemical residues, allergens, or the presence of pathogenic microorganisms in the processed products where they are used. Overall they can introduce acute food safety hazards or cause health impacts due to long-term/chronic consumption, difficult to foresee and evaluate in advance.

4. Increased exposure to chemicals and nano-materials from food contact materials migrating in food and from the environment via packaging waste

Chemical substances and nano-materials used in packaging materials may find their way into food products more in the future.

- The extended storage and transportation times anticipated in this scenario will result in extended contact of food products with their packaging materials, which may

be longer than anticipated, also considering that future products may be developed with longer shelf-life. This may lead to increased migration of substances from the packaging materials to the food.

- Food packaging and its waste is increasing in recent years and this trend is expected to continue. This may lead to the release of chemical substances as well as of nano-materials into the environment. These may be ingested by animals and find their way onto our plate.

Impact: This may lead to the higher exposure of people to residues of chemicals (additives, monomers, oligomers, nano-materials) used in packaging materials.

5. Diets based predominantly on highly processed foods and decreased availability of fresh produce

Food variety, and in particular the availability of fresh produce could be affected in scenarios where diets are predominantly based on highly processed foods

- While food processing ensures preservation, increases variety and availability and can bestow improved nutritional/sensory quality, highly processed foods can also be energy rich and have high contents of sugar, salt, fat (HFSS). Certain food components may be lost during food processing – highly processed foods can be poor in micro-nutrients or fiber. Highly processed foods usually contain refined food components, which require less energy needed for their metabolism.
- In a globalised food system, cost-efficient mass production of highly processed foods may dominate the food offer, making fresh produce more difficult to access to a large part of consumers.

Impact: Decreased availability of fresh produce can affect dietary quality leading to micronutrient deficiencies. High consumption of HFSS foods can result in higher prevalence and earlier onset of non-communicable diseases and have negative public health impacts. Low SES groups can be particularly at risk leading to further health inequalities

6. Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks

Processed foods have been associated with different chemical and microbiological hazards in recent years.

- Certain processing technologies have resulted in the appearance of contaminants in the finished products, such as acrylamide, furan, 3-MCPD, etc. New processing technologies could result in the appearance of new processing contaminants in different product categories.
- Also, even though processing technologies have generally improved the safety of the food chain, still certain processed ready-to-eat products such as uncooked refrigerated processed meat products, ready-to-eat smoked or cold-salted fish have been associated with e.g. *Listeria monocytogenes* incidents.
- The possible increased future consumption of processed and ready-to-eat products could increase the chances of chemical or microbiological hazards.

Impact: This may lead to population exposure to chemical hazards that may not be previously known until their presence is identified or to food-borne disease outbreaks.

7. Increased sedentary behavior and snacking due to changed lifestyle

Lifestyles with increased time spent online or in virtual environments for leisure activities are foreseen to increase in the future, and could likely be associated with

- fast and convenient meal preparation and overconsumption, e.g. “web dinners” (as in “TV dinners”)
- increase in snacking behaviour (and increased calorie intake)
- decreased physical activity and increased sedentary behavior

Impact: The above can translate into lower dietary quality and more sedentary lifestyles with decreased physical activity leading to weight gain and increasing the risk of non-communicable diseases.

8. Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information

The current gradual loss of food safety and nutrition literacy may worsen further in the future. At the same time the source and quality of information available are crucial for consumer food choices.

- Lack of nutrition literacy weakens consumer ability to choose a balanced and healthy diet.
- Beyond nutrition literacy, food safety education is particularly relevant when individuals wish to grow, handle, store and trade their own food or for the safe preparation of meals at home.
- Over-reliance on technology, home delivery, ready-to-(h) eat foods further alienates people from food preparation skills, culture and traditions
- In an era of information overload from different sources and stakeholders, including those with vested interests, the quality of food safety and nutrition information reaching the consumer is doubtful, even though crucial for informed consumer choices (no control or authentication and with a risk of fraudulent behaviours).

Impact: Lack of food safety and nutrition literacy as well as cooking skills can contribute to the introduction of food safety hazards during food production or preparation by the consumer as well as weaken their ability to make informed and healthy dietary choices, resulting on poor quality dietary habits, malnutrition and consequent health issues; intentional misinformation can exacerbate the above issues. Also, the loss of food traditions and cooking skills can weaken a major socio-cultural aspect of Europe.

9. Intensive animal and plant production systems: Disease transmission and nutritional quality

Intensive production systems are aimed to increase crop yields or number of animals reared in a given size of land, using different technologies.

- Population density and the reduced genetic diversity of animals (livestock and aquaculture) or plants in intensive production systems may facilitate the transmission and spread of diseases.
- Disease transmission in intensive primary production systems could also be accelerated by climate change and the increase of average temperature and humidity.

Such conditions cause stress to different plant species and reduce their resistance, while they also predispose certain animal/plant species to certain diseases (such as cattle and mastitis, cultured shrimp and early mortality syndrome, wheat and fusarium head blight).

- The transmission of animal diseases is more important in the primary production step of the food chain, even though it can also occur during transportation, if animal welfare conditions in relation to the number of animals are not properly followed.
- Higher yield varieties (of crops, fruits and plants) are usually favoured in intensive production systems; this however does not ensure that such varieties also contain the right balance of other nutrients (most dry weight is carbohydrates).
- Intensive production systems also accelerate depletion of nutrients and organic matter from the soils, with a further negative impact on the nutrient quality of primary produce.

Impact: Intensive production systems could allow certain animal and plant diseases to enter the food chain and affect humans consuming certain food products that have not been appropriately processed (e.g. non-pasteurised milk in the case of cattle affected by mastitis, or fusarium mycotoxins in wheat). It can also lead to increased input of chemicals in the food system in order to prevent or control the transmission of diseases, leading to increased residues in primary produce. Intensive production systems may also lead, in the long term, to poor soil quality resulting in crops and horticultural products of poor nutritional value. Declining nutrient concentrations in horticultural products, the richest source of micronutrients in our diets, can lead to micronutrient deficiencies and malnutrition.

Apart from food safety and nutrition, another important impact could be the loss of biodiversity in agricultural production, potentially leading to a less resilient agricultural system.

10. Failure to provide appropriate food safety information to the consumer

The need for receiving essential and mandatory food safety information, such as expiry dates, information on the safe handling and storage of food, or allergen information or information in relation to the nutritional value of food will remain and may even be more significant in the future.

- This is very important if one considers that packaging may be reduced in **“Partnership Food”** where people may increasingly eat out for example in restaurants, canteens, food buffets, where labelling of safety or nutritional information may be limited.
- Intelligent packaging materials are being developed, communicating safety information such as shelf-life to the consumer based on sensors etc.
- “Intelligent fridges” or other technologies and applications may allow for the mandatory safety and nutrition information to be made available to the consumer by scanning a bar-code.
- Also increasing average temperatures resulting from climate change may make the safe storage and handling of food more important and consequently the provision of relevant information to the consumer via labelling.
- The increasing prevalence of food allergies in the population will further increase the need for appropriate

allergen information.

Impact: The unavailability of appropriate food safety and nutrition information in unlabelled products or due to failure of intelligent technologies may result in mishandling of food by the consumer and food safety hazards at consumption.

11. Abundance of voluntary food information and increased opportunity for misleading information

Food labels can already contain a lot of information beyond basic safety and nutritional content that the manufacturer wishes or is obliged to communicate to the customer; this can increase the complexity of food labels. In parallel, food fraud could also be of concern, in the form of intentional provision of misleading information, (in particular with regard to quality or origin information or with regard to products meeting specific compositional requirements or standards).

- Future food labelling schemes, voluntary or obligatory, may provide information on a variety of novel processes or materials (e.g. GM foods, foods from cloned animals, synthetic foods, and 3D printed foods), presence of bioactive or pharmaceutical substances and health claims, as well as issues such as environmental footprint, fair trade, animal welfare etc., further increasing the complexity of food labels.
- The above is also relevant to products sold without packaging (fresh or dried fruits and vegetables, dairy products, raw or processed meat/fish) in retail stores or served in restaurants, canteens and buffets.
- In the view of such complexity, it could be envisaged that some label contents are detached from the product and available only online (e.g. via Quick Response codes). As a result, the consumer might need to go to extra lengths to obtain the required information.
- Potential demand for country of origin labelling for individual ingredients in complex food chains could be challenging to achieve and to describe
- Fraud can occur across both production and consumption levels in particular with regard to compositional quality, expensive food products and possible imitation products or with compliance with any of the above quality schemes that add value to food products.
- Opportunities for fraud may also be associated with product adulteration and with misleading the consumers on the properties of enhanced foods and the related health claims.
- Fraud may also be related to the existence of parallel food markets for products considered not as mainstream and to how these could be regulated.

Impact: The potential complexity of the labels may negatively impact consumer understanding and consequently consumers’ choices and diets. In addition, food fraud and the provision of misleading information to the consumers is against the principles of food law, can potentially impact production and marketing of specific products and may even pose direct health concerns to the consumer (e.g. melamine to increase apparent protein content, substitution of ethanol by methanol, etc.). More complex mandatory labelling could also become an additional burden for the food industry, impacting disproportionately small producers, potentially affecting variety and food prices.

12. The loss of scientific and technological knowhow in Europe

The loss of scientific and technological expertise in Europe (brain drain) and the increase in importing technologies from across the Atlantic in a North-Atlantic partnership scenario could occur as a result of a possible extended economic stagnation in Europe.

- This could also lead to the inappropriate use of certain imported technologies, unless technical assistance is provided from the US for the correct and safe use of the imported technologies and their products (GM, nano, fumigation).

Impact: This could lead to the introduction of safety risks at the different steps of the food chain where these technologies are used.

13. Food chain impacts due to over-reliance on one or few trade partners

An EU food system that is not self-sufficient and is solely or mainly dependent on a single or few trading partners can face certain challenges.

- If the exclusive trading partner(s) has more buying power, it can be a more attractive market than the EU for high quality foods produced in the EU
- As a result the majority of EU consumers may have mainly access to low cost foods high in salt, sugar and fat, since most local quality products would be exported or available at higher prices.
- The EU food system can be at risk of intentional (trade embargoes, boycotts, import/export bans etc.) or unintentional (extreme climate change effects, crop failures) disruption of imports from trade partner(s)

Impact: Disparity between the EU and its trading partners, as well as dependence on a single or few trading partners, can jeopardize consumer access to healthy diets, as well as decrease the resilience of the EU food system.

Challenges to the regulatory and policy framework – Horizontal challenges

1. Ability to perform official food-related controls

Official controls (inspection as well as laboratory analysis) are of particular importance throughout the food chain as it is one of the main ways to verify compliance with food and feed safety legislation and ensure consumer protection.

- The structure of the food system differs in the four future scenarios; for example, in **“Partnership Food”** there is an assumed future need for international harmonisation in the food system.
- This, in combination with the governance in the different food systems could impact on the ability to perform the monitoring, inspection and enforcement aspects of official controls.

- At the same time, consumer rejection of certain technologies (such as GMOs, cloned animals, synthetic foods, novel food components or processing technologies) in **“Partnership Food”** may lead to the development of parallel, alternative food chains for obtaining the desired products that may be to a certain extent unregulated as no-longer mainstream.

Impact: Inability to perform appropriate official controls could allow food safety hazards to enter at all steps of the food chain and, since uncontrolled, they could reach the consumer with significant consequences to human health.

2. Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism

- Information and Communication Technologies are increasingly used in the food chain for the communication of information for traceability purposes.
- In case of a temporary failure of such technologies it could be possible that information in relation to the origin, properties, treatment, detected food safety hazards or individual requirements of materials or different products may be lost or miscommunicated. This could further impact the ability to perform official controls.
- The achievement of traceability may also be challenged towards 2050 depending on the structure of the food chain system in the different future scenarios.
- Also the possibility of hacking or manipulating such systems may make the food chain and its actors including consumers or even countries very vulnerable and would facilitate fraud.

Impact: The temporary failure of ICT technologies used for ensuring traceability in the food chain could allow the introduction of safety risks at different steps of the food chain.

3. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

The approval of new substances or new food technologies in Europe (i.e. chemicals for different uses: pesticides, fertilisers, veterinary residues, food additives and preservatives, micro-nutrients, bio-actives, antimicrobials, new GMOs) relies on a thorough risk assessment procedure. Approval results in the unconditional authorisation or on an authorisation subject to maximum residue levels or other limits established for the different substances in foods. However the suitability of the current risk assessment approach in Europe has been challenged for the following reasons:

- Technological developments and innovations in the food system have accelerated in the last few years and new foods, processes and technologies continue to develop at a very fast pace (such as the extension of genetic modification in aquaculture, edible food packaging, novel foods, addition of substances with health properties or new packaging/storage technologies).

- At the same time the regulatory process for the approval of certain food-related substances and technologies (i.e. new food additives, novel foods, health claims) becomes lengthier and may require years for single substances to be approved for use in food products.
- The suitability of exposure data used today in the risk assessment and decision making process for use in the future has also been challenged. For example epidemiological and dietary intake data are considered fragmented; the dietary intake of substances in different parts of the population may depend on consumers' income and may differ under different future scenarios. Also old consumption data may be not relevant anymore, due to change in patterns of consumption of chemicals that were more widely ingested in the past or due to the increase in ingestion of urban contaminants.
- Also newer insights become available on the effects of dietary exposure to mixtures of chemicals of varying nature (natural toxins, chemical residues and contaminants, additives, bioactives).
- The ability to perform risk assessment could differ in different scenarios, for example it could be compromised in a scenario with significant financial constraints, introducing thus challenges in the food chain.
- Finally the need for harmonisation of standards in order to reduce any remaining barriers to global trade and facilitate the sourcing of products from around the world could also push towards convergence of different risk assessment related approaches in different parts of the world, including the possibility to adopt the least restrictive one.

Impact: The above could result in products not properly evaluated reaching the market that may pose short- or long-term health challenges. At the same time other technologies much needed in the food chain may be delayed by lengthy approval processes also taking up the available resources of risk assessment bodies. This would impact all steps of the food chain, depending on the technologies concerned and their application. Other impacts could be observed on the establishment of maximum residue levels of different substances in food.

“Pharma Food”

1. Emerging biological risks:

1a. The introduction of known pathogens causing (bio) chemical safety hazards in geographical areas where they were not previously known

In the future certain pathogens could move to different regions within Europe as a consequence of the effects of climate change, such as rising ambient and water temperatures, changes in rainfall patterns, droughts etc.

- Plant pathogens such as *Aspergillus flavus* or *Fusarium verticillioides* could move to central and northern Europe from southern regions and contaminate crops with various mycotoxins, substances that are toxic to humans and animals.
- Also the appearance of harmful algal blooms may become more frequent in Northern Sea coastal waters due to an increase in sea surface temperature. Certain algal species produce marine biotoxins that contaminate shellfish and can cause shellfish poisoning to humans when consumed.
- Increased global trade could also facilitate the introduction into Europe of toxin-producing pathogens from other parts of the world.

Impact: As these hazards may not be previously known or common in certain parts of Europe, their presence may not be immediately detected as they would not form part of the normal regional monitoring, inspection and control procedures and could lead to illness and toxic effects in humans and animals.

1b. Differences in the virulence of microorganisms and parasites, increased occurrence of antimicrobial resistance and appearance of new strains

The virulence of microorganisms (the capacity of a micro-organism to cause disease), their ecology or their stress responses can be affected by changes in environmental factors which may also lead to the appearance of new strains.

- This could be further promoted from climate change impacts such as rising temperatures, changes in rainfall patterns, draught stresses etc. For example, an association has been observed between salmonellosis incidents and an observed increase in ambient temperature or vibriosis incidents related to increased water temperatures in northern waters.
- Also, due to intrinsic factors such as gene transfer between microorganisms, their virulence can increase and they may become more resistant possibly also leading to antimicrobial resistance.

Impact: Proven control mechanisms such as the “hurdle concept” and antibacterial or other substances used at different steps in the food chain may prove inefficient to control new or resistant strains, potentially leading to unsafe products in the market and impacts on consumer health.

2. Shortage of quality water

Water of appropriate quality is required in all steps of the food chain from primary production (drinking water for animals) through to the processing environment (cleaning of

fresh produce, fish, surfaces, equipment etc.), transportation (cleaning of transportation vessels) and the preparation of food by the consumer.

- The quality of water is expected to be adversely affected by the impacts of climate change, for example floods may lead to increased transfer of environmental contaminants and chemical residues in ground waters and coastal waters.
- The use of water of inappropriate quality in irrigation may lead to the contamination of crops and fresh produce with pathogens which may be difficult to inactivate in further steps of the food chain and is of particular importance for products that are intended to be eaten without further treatment.
- Also over-extraction of water may lead to the use of water that contains high levels of heavy metals or high salt content (salination of aquifers).

Impact: The shortage of quality water could introduce microbiological and chemical risks at all steps of the food chain where water is used and impact on the safety and hygiene of produced food.

3. The development of new alternative food sources i.e. insect proteins, in-vitro meat, 3D printed food and related technologies

New protein sources (such as in-vitro meat, the use of insect proteins in feed or food etc) are expected to be introduced in the European food and feed market, as a response to the increasing protein demand from a growing world population and the need for a more resource-efficient production.

- At the same time technologies for the extraction and use of these proteins in food will continue to be developed.
- While protein production under strictly controlled laboratory conditions may be considered safer than the conventional farm production due to the avoidance of animal diseases, safety risks could still be introduced from the raw materials and mediums that will be used during the production process.
- Also, it is anticipated that the use of purer substances, synthesised food components or processes that may expose allergens differently could lead to increased immune responses and allergies

Impact: The food safety risks associated with alternative protein sources and related technologies are not well known to date, but they may contain chemical contaminants (i.e. pesticides, heavy metals), pathogenic microorganisms, possibility for allergenic potential, depending on the safety of the feed/mediums and materials (e.g. food waste, manure, blood, etc) used for their diet/production. This may lead to chemical residues, allergens, or the presence of pathogenic microorganisms in the processed products where they are used. Overall they can introduce acute food safety hazards or cause health impacts due to long-term/chronic consumption, difficult to foresee and evaluate in advance.

4. Safety challenges of processed and pre-packaged food: appearance of new processing contaminants and new food-borne disease risks

Processed foods have been associated with different chemical and microbiological hazards in recent years.

- Certain processing technologies have resulted in the

appearance of contaminants in the finished products, such as acrylamide, furan, 3-MCPD, etc. New processing technologies could result in the appearance of new processing contaminants in different product categories.

- Also, even though processing technologies have generally improved the safety of the food chain, still certain processed ready-to-eat products such as uncooked refrigerated processed meat products, ready-to-eat smoked or cold-salted fish have been associated with e.g. *Listeria monocytogenes* incidents.
- The possible increased future consumption of processed and ready-to-eat products could increase the chances of chemical or microbiological hazards.

Impact: This may lead to population exposure to chemical hazards that may not be previously known until their presence is identified or to food-borne disease outbreaks.

5. Increased sedentary behavior and snacking due to changed lifestyle

Lifestyles with increased time spent online or in virtual environments for leisure activities are foreseen to increase in the future, and could likely be associated with

- fast and convenient meal preparation and overconsumption, e.g. “web dinners” (as in “TV dinners”)
- increase in snacking behaviour (and increased calorie intake)
- decreased physical activity and increased sedentary behavior

Impact: The above can translate into lower dietary quality and more sedentary lifestyles with decreased physical activity leading to weight gain and increasing the risk of non-communicable diseases.

6. Inadequate food safety and nutrition literacy, loss of food traditions and increased exposure to unreliable sources of information

The current gradual loss of food safety and nutrition literacy may worsen further in the future. At the same time the source and quality of information available are crucial for consumer food choices.

- Lack of nutrition literacy weakens consumer ability to choose a balanced and healthy diet.
- Beyond nutrition literacy, food safety education is particularly relevant when individuals wish to prepare meals at home.
- Over-reliance on technology, home delivery, ready-to-(h) eat foods further alienates people from food preparation skills, culture and traditions
- In an era of information overload from different sources and stakeholders, including those with vested interests, the quality of food safety and nutrition information reaching the consumer is doubtful, even though crucial for informed consumer choices (no control or authentication and with a risk of fraudulent behaviours).

Impact: Lack of food safety and nutrition literacy as well as cooking skills can contribute to the introduction of food safety hazards during food production or preparation by the consumer as well as weaken their ability to make informed and healthy dietary choices, resulting on poor quality dietary habits, malnutrition and consequent health issues; intentional misinformation can exacerbate the above issues. Also, the

loss of food traditions and cooking skills can weaken a major socio-cultural aspect of Europe.

7. Failure to provide appropriate food safety information to the consumer

The need for receiving essential and mandatory food safety information, such as expiry dates, information on the safe handling and storage of food, or allergen information or information in relation to the nutritional value of food will remain and may even be more significant in the future.

- This is very important if one considers that in “**Pharma Food**”, food may increasingly contain added nutrients or bioactive ingredients while labelling of safety or nutritional information may be limited when people eat out or purchase convenience products.
- Intelligent packaging materials are being developed, communicating safety information such as shelf-life to the consumer based on sensors etc.
- “Intelligent fridges” or other technologies and applications may allow for the mandatory safety and nutrition information to be made available to the consumer by scanning a bar-code.
- Also increasing average temperatures resulting from climate change may make the safe storage and handling of food more important and consequently the provision of relevant information to the consumer via labelling.
- The increasing prevalence of food allergies in the population will further increase the need for appropriate allergen information.

Impact: The unavailability of appropriate food safety and nutrition information due to reduced label space or unlabelled products, or due to failure of intelligent technologies may result in mishandling of food by the consumer and food safety hazards at consumption.

8. Abundance of voluntary food information and increased opportunity for misleading information

Food labels can already contain a lot of information beyond basic safety and nutritional content that the manufacturer wishes or is obliged to communicate to the customer; this can increase the complexity of food labels. In parallel, food fraud could also be of concern, in the form of intentional provision of misleading information, (in particular with regard to quality or origin information or with regard to products meeting specific compositional requirements or standards).

- Future food labelling schemes, voluntary or obligatory, may provide information on a variety of novel processes or materials (e.g. GM foods, foods from cloned animals, synthetic foods, and 3D printed foods), presence of bioactive or pharmaceutical substances, health claims, as well as issues such as environmental footprint, fair trade, animal welfare etc. further increasing the complexity of food labels.
- The above is also relevant to products sold without packaging (fresh or dried fruits and vegetables, dairy products, raw or processed meat/fish) in retail stores or served in restaurants, canteens and buffets.
- In the view of such complexity, it could be envisaged that some label contents are detached from the product and available only online (e.g. via Quick Response codes). As a result, the consumer might need to go to extra lengths to

obtain the required information.

- Potential demand for country of origin labelling for individual ingredients in complex food chains could be challenging to achieve and to describe
- Fraud can occur across both production and consumption levels in particular with regard to compositional quality, expensive food products and possible imitation products or with compliance with any of the above quality schemes that add value to food products.
- Opportunities for fraud may also be associated with product adulteration and with misleading the consumers on the properties of enhanced foods and the related health claims.

Impact: The potential complexity of the labels may negatively impact consumer understanding and consequently consumers’ choices and diets. In addition, food fraud and the provision of misleading information to the consumers is against the principles of food law, can potentially impact production and marketing of specific products and may even pose direct health concerns to the consumer (e.g. melamine to increase apparent protein content, substitution of ethanol by methanol, etc.). More complex mandatory labelling could also become an additional burden for the food industry, impacting disproportionately small producers, potentially affecting variety and food prices.

9. Risk of overconsumption of nutrients or other food ingredients

Enhanced food products with different health properties are anticipated to represent a large share of the food offer in the future.

- There is a potential for intentional or unintentional overconsumption of nutrients, minerals, vitamins, bioactives, either intended to achieve specific health benefits or accidental through addiction/preference to specific food products.
- Health risks can also result from potential interactions of multiple novel food compounds in the human organism, especially relevant with increased consumption of micro-nutrients, bioactives or pharmaceuticals, present in the same or different foods.

Impact: The synergistic or antagonistic effects (interaction, synergistic/cocktail effect) arising from the increased consumption of a range of nutrients, the possible drug side-effects or addiction may lead to undesired health outcomes.

10. Increased consumer dependency on digital services for dietary choices

The use of digital or other monitoring and advisory services (automated or not) for dietary choices may be helpful in cases where individuals want to maximize the health potential that food can offer but is also prone to issues arising from low-quality of services, error or intentional manipulation/misinformation and fraud.

- In the context of the establishment of personalised diets the appearance of new professional services are assumed, such as relevant or nutrition and lifestyle software applications or coaches;
- Such digital nutrition services would require high quality data and algorithms with the likely need of continuous updates, as well as specialised personnel/software to handle such data

- Increased dependency on such services for dietary choices may make the consumer vulnerable to unintentional misinformation or intentional fraud and manipulation.

Health impact: Increased consumer dependence on digital services for dietary choices, coupled with nutritional illiteracy may confuse and/or intentionally mislead consumers and weaken their ability to make informed and healthy dietary choices, resulting in poor quality diets and consequent health issues.

11. Potential drawbacks of personalised nutrition as a predominant dietary practice

An effective personalized nutrition regime likely requires consumer access to specific food products, digital/mobile applications, nutrition coaches/professionals as well as analysis and monitoring of physiological and food consumption data.

- A fully supported and completely personalised diet system can have increase costs and make it unavailable for some citizens
- Low-cost personalized dietary services may be available, however these may be of lower quality or not completely customised to the individual; this would increase health inequalities, or even produce adverse effects in parts of the population
- Large differences in quality and safety of personalised nutrition proposed may exist within and between countries, further exacerbating inequalities.
- Data protection issues may arise with potential misuse of sensitive biological and dietary/personal information
- Consumers that cannot or do not want to follow the dominant personalised nutrition regime, may face difficulties securing a healthy diet, due to lack of variety in the alternatives available (e.g. leading to under or over nutrition), and may also face potential marginalisation.

Impact: Widespread use of personalised nutrition without taking into account the above issues could have negative health, privacy/legal and social implications.

12. Shift of responsibility for diets from consumer to counsellor/coaches

Consumers may no longer feel that they are themselves responsible or accountable for their dietary habits

- In a high-technology environment diets can be constantly monitored and adjusted for optimal health via a combination of digital applications, biosensors, and professional nutrition coaching services.
- Consumers might come to believe that it is without consequences to have unhealthy dietary habits, since their personalized nutrition system can compensate for such unhealthy habits and provide a solution anyway

Impact: This can lead to unhealthy dietary practices, which may cancel out the benefits of having a fully personalized nutrition system in place.

Challenges to the regulatory and policy framework – Horizontal challenges

1. Ability to perform official food-related controls

Official controls (inspection as well as laboratory analysis) are

of particular importance throughout the food chain as it is one of the main ways to verify compliance with food and feed safety legislation and ensure consumer protection.

- The structure of the food system differs in the four future scenarios; for example in **“Pharma Food”** there is an assumed approximation between food and medicines, with some products at the borderline between the two categories.
- This, in combination with the governance in the different food systems could impact on the ability to perform the monitoring, inspection and enforcement aspects of official controls.
- At the same time, consumer preference for certain food products such as unhealthy snacks in a world where healthy food is mainstream in **“Pharma Food”**, may lead to the development of parallel, alternative food chains for obtaining the desired products that may be to a certain extent unregulated as no-longer mainstream.
- Also in **“Pharma Food”**, the cost of a complete and scientifically supported personalised diet with specialised functional or pharmaceutical foods may be prohibitive for the average consumer, leading to low cost or “black market” alternatives and increasing health risks.

Impact: Inability to perform appropriate official controls could allow food safety hazards to enter at all steps of the food chain and, since uncontrolled, they could reach the consumer with significant consequences to human health.

2. Increased dependence on ICT technologies for ensuring traceability in the food chain and the possibility of temporary failure or fraud and terrorism

Information and Communication Technologies are increasingly used in the food chain for the communication of information for traceability purposes.

- In case of a temporary failure of such technologies it could be possible that information in relation to the origin, properties, treatment, detected food safety hazards or individual requirements of materials or different products may be lost or miscommunicated. This could further impact the ability to perform official controls.
- The achievement of traceability may also be challenged towards 2050 depending on the structure of the food chain system in the different future scenarios.
- Also the possibility of hacking or manipulating such systems may make the food chain and its actors including consumers or even countries very vulnerable and would facilitate fraud.

Impact: The temporary failure of ICT technologies used for ensuring traceability in the food chain could allow the introduction of safety risks at different steps of the food chain.

3. Suitability of the current EU risk assessment procedures for new food ingredients, food products and food-related technologies (including suitability of exposure data and maximum residue levels)

The approval of new substances or new food technologies in Europe (i.e. chemicals for different uses: pesticides, fertilisers, veterinary residues, food additives and preservatives, micro-nutrients, bio-actives, antimicrobials, new GMOs) relies on a thorough risk assessment procedure. Approval results in the unconditional authorisation or on an authorisation

subject to maximum residue levels or other limits established for the different substances in foods. However the suitability of the current risk assessment approach in Europe has been challenged for the following reasons:

- Technological developments and innovations in the food system have accelerated in the last few years and new foods, processes and technologies continue to develop at a very fast pace (such as the extension of genetic modification in aquaculture, edible food packaging, novel foods, addition of substances with health properties or new packaging/storage technologies).
- At the same time the regulatory process for the approval of certain food-related substances and technologies (i.e. new food additives, novel foods, health claims) becomes lengthier and may require years for single substances to be approved for use in food products.
- The suitability of exposure data used today in the risk assessment and decision making process for use in the future has also been challenged. For example epidemiological and dietary intake data are considered fragmented; the dietary intake of substances in different parts of the population may depend on consumers' income and may differ under different future scenarios. Also old consumption data may be not relevant anymore, due to

change in patterns of consumption of chemicals that were more widely ingested in the past or due to the increase in ingestion of urban contaminants.

- Also newer insights become available on the effects of dietary exposure to mixtures of chemicals of varying nature (natural toxins, chemical residues and contaminants, additives, bioactives).
- Of significance are also any the potential health issues caused by chronic overconsumption of macro- or micro-nutrients added to foods
- The ability to perform risk assessment could differ in different scenarios, for example it could be compromised in a scenario with significant financial constraints, introducing thus challenges in the food chain.

Impact: The above could result in products not properly evaluated reaching the market that may pose short- or long-term health challenges. At the same time other technologies much needed in the food chain may be delayed by lengthy approval processes also taking up the available resources of risk assessment bodies. This would impact all steps of the food chain, depending on the technologies concerned and their application. Other impacts could be observed on the establishment of maximum residue levels of different substances in food.

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