JRC FORESIGHT STUDY

Tomorrow’s Healthy Society
Research Priorities for Foods and Diets

Annexes

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Abstract
Healthy diets play a role in health promotion and disease prevention, and this is increasingly recognised as crucial, both socially and economically, in the face of strained healthcare systems, an ageing population, and the high individual and economic costs of diseases. The Foresight study ‘Tomorrow’s healthy society — research priorities for foods and diets’ was initiated to inform the selection of research challenges that will receive funding under the Horizon 2020 programme. The exploratory scenario-building approach focused on the European consumer — with the year 2050 as a long-term time horizon. Four different future scenarios were developed using the extremes of two main drivers — agricultural commodity prices (low or high) and societal values (community spirit or individualistic society). These provided the basis for the identification and prioritisation of research needs to address the challenges and opportunities arising from the different scenarios. This document provides supporting material, e.g. background information on diets and health and relevant drivers as well as scenarios overviews and scenario narratives.
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1. Foods, diets and health

Sufficient food of good quality is one of the important prerequisites for a healthy life. Today in the EU, the quantity, variety and safety of foods available to most consumers is unprecedented. However, this does not necessarily lead to a diet and food choice that promotes health and well-being. While life expectancy in the EU has steadily increased to currently 77 years for men and 83 years for women, roughly one-quarter of this lifespan is spent with limitations and a poorer quality of life largely due to **non-communicable diseases** (NCDs). NCDs comprise a group of chronic diseases, including heart disease and stroke, cancer, lung disease and diabetes, which account for 86 % of deaths and 77 % of disease burden in Europe. They not only cause death or reduce the quality of life but also put an increasing strain on healthcare systems and economic development. This is due to direct healthcare costs as well as losses resulting from diminished resources within families, prolonged disability, reduced productivity and the creation of capital. In this context, it is noteworthy that mental health issues alone are estimated to account for half the economic loss. Although mental health and NCDs might require distinct strategies and action plans, recent findings increasingly suggest that both share common risk factors, including obesity and poor dietary habits. While tobacco use, harmful use of alcohol, physical inactivity and unhealthy diet are all recognised major modifiable risk factors of NCDs and are interconnected, this chapter focuses only on the main health issues related to foods and diets in the EU, including but not limited to NCDs.

1.1 Dietary patterns and health

Combination of the four unfavourable behavioural risk factors for NCDs – mainly poor diets and lack of physical activity and, to a lesser extent, tobacco use and alcohol abuse – lead to **four key metabolic/physiological changes:** raised blood pressure, overweight/obesity, hyperglycemia and hyperlipidemia. On a global scale, these are among the leading NCD risk factors in terms of attributable deaths, and a large part of the European population carries one or more of them:

- **The prevalence of overweight and obesity** among adults now exceeds 50 % in no less than 15 of 27 EU Member States.
- **As for hypertension**, between 1980 and 2008, systolic blood pressure levels decreased in most European countries. Nevertheless, the prevalence of hypertension estimated at the beginning of the 2000s was close to 50 % in six European countries.
- **As for hyperlipidemia**, the best available health data are linked to total blood cholesterol; although it has been declining since 1980, the prevalence of raised blood cholesterol in the World Health Organization (WHO) European region is still high at 54 %.
- **The EU average prevalence of manifest diabetes** is 8.7 % of the population and is expected to increase to 10.3 % in 2025. A further 10 % of the population has been diagnosed with impaired glucose tolerance (IGT), a form of pre-diabetes, which is also projected to increase over the next 20 years. The increased prevalence of overweight and obesity in children and adolescents is expected to contribute to a higher prevalence of type 2 diabetes among that population group. Moreover, it should be noted that an estimated 50 % of diabetes cases remains undiagnosed, a percentage that may be even higher for IGT, implying the problem of hyperglycemia would also appear to be substantial.

1.1.1 Dietary patterns and nutrient intake

Not surprisingly, dietary patterns and nutrient intake vary greatly between EU Member States and regions. The most important characteristics of these

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4. Trivedi B (2012) Food for thought: Eat your way to dementia
10. WHO Global Health Observatory (GHO) - Raised Cholesterol (accessed in June 2012)
dietary patterns and consequent nutrient intakes which have health implications are the following:

- With respect to intake of macronutrients, diets among the European population are characterised by intakes at or up to twofold the population reference intake of protein\(^8\), too-high intakes of fat – more specifically, saturated fat\(^7\) – as well as too-high intakes of simple carbohydrates (sugars) and too low intakes of complex carbohydrates\(^8\). In addition, the intake of essential polyunsaturated fatty acids (PUFA), in particular omega-3 PUFA, are generally too low; intakes of dietary cholesterol are widely unproblematic being at or below recommended threshold values; trans fatty acids (TFA) intakes have generally fallen to below the recommended thresholds in Europe. Nevertheless, for the latter it is likely there are still parts of the population, in particular those individuals consuming a diet at ‘high risk of TFA’ (fast foods, processed foods with partially hydrogenated fat still used as ingredients), with critically high TFA intakes\(^9\). As regards the obesity epidemic, it is surprising that the European Nutrition and Health Report 2009\(^5\) reported energy intakes of all age groups in most countries below the German-Austrian-Swiss reference intakes (for the year 2000: 10.5 to 12.5 MJ/day in males and 8.5 to 10.0 MJ/day in females). However, in addition to the possible under-reporting of food intake, the level of physical activity may also have been low in many cases, hence the increase in overweight and obesity in Europe. In fact, leisure time physical activity was described as having a clear south-north upward gradient and was also associated with age and education\(^1\).

- With regard to micronutrients, Vitamin D and folate intakes were generally low in nearly all age groups. Issues resulting from low intakes were also observed for calcium, magnesium, selenium, iron (in women), iodine (in some age groups), as well as, less frequently and only in some age groups, for Vitamin B12, Vitamin C, copper and zinc\(^2\). The sodium intake, in form of sodium chloride (i.e. salt), was above the recommendations in all EU Member States.

- Regarding intake of specific foods or food groups, Europeans generally consume too few fruits and vegetables (mainly cereals, potatoes and pulses) and too much meat and meat products. Large differences exist for fruit and vegetable intakes between the south of Europe (highest supply) and the north of Europe (lowest supply), and between seasons; food supplements are taken by an increasing proportion of the population, in particular by women and by the 35-50 years age group.

1.1.2 Health consequences – overweight and obesity

The WHO ‘World Health Statistics 2012’ report\(^3\) has confirmed that obesity continues to be a major health threat worldwide: 12 % of the world’s adult population is obese. The distribution is not homogeneous and, as can be seen in Figure 1.1 which illustrates the distribution of obesity prevalence among females worldwide, in many European countries the prevalence of obesity is well above that value.

Similar data presented by the International Association for the Study of Obesity (IASO) shows that the levels of overweight children and adolescents in many EU Member States are equally high – on average, above 25 % of boys and girls\(^4\). In the UK, projections indicate that 60 % of adult men, 50 % of adult women and about 25 % of all children under 16 could be obese by 2050\(^5\). A more recent study\(^6\) forecasts a 33 % increase in obesity prevalence and a 130 % increase in severe obesity prevalence over the next two decades in the US. It is reasonable to assume that this upward trend will be replicated in most other countries worldwide.

Obesity increases the risk of a range of chronic diseases, particularly type 2 diabetes, stroke and coronary heart disease as well as cancer and arthritis. Healthcare costs associated with obesity are another important factor to be considered. As reviewed by the OECD\(^7\), these include the costs of obesity per se as well as the costs stemming from the higher incidence of chronic illnesses. Estimates suggest that obesity is responsible for approximately 1 % to 3 % of total health expenditure in most countries, except in the US where obesity may account for 5 % to 10 % of health expenditure\(^8\). An obese person incurs healthcare expenditures at about 30 % higher than a person of normal weight, according to a range of studies from a variety of countries\(^9\). There is a time lag between the onset of obesity and the related need for healthcare, suggesting that the rise in obesity in recent years will mean higher healthcare costs in the future. For example, the UK obesity foresight study\(^10\) estimates that National Health Service costs attributable to overweight and obesity will double to £10 billion a year by 2050. The wider costs to society and business are estimated to reach £49.9 billion a year (at 2007 prices). Thus, the issue is high on the agenda worldwide and the WHO’s European Charter on Counteracting Obesity\(^11\) calls for “visible progress, especially relating to children and adolescents” and indicates that it should be possible to reverse the obesity trend by 2015 at the latest.

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2. EFSA Journal 2012:10:2557
3. EFSA Journal 2010:8:1461
4. EFSA Journal 2010:8:1462
9. IASO (accessed June 2012) Pre- and post-adolescent overweight and obesity in Europe
12. OECD (2010) Obesity and the Economics of Prevention: Fit not Fat
**Causes of obesity**

Obesity is a disease (E-66 in ICD10) of great complexity. At the individual level, the most simplistic way to consider it is as an energy balance that arises when energy intake ($E_{in}$ energy taken from food in the form of calories) exceeds energy expenditure ($E_{out}$ energy consumed in resting energy expenditure, thermic effect of food and physical activity). Energy balance can be affected by genetic, behavioural and environmental factors, particular disorders or drugs and medications throughout development and adulthood. Some of the factors related to obesity are illustrated in Figure 1.2.

Not all causes are well studied or understood. For example, there is currently much debate regarding the contribution particular food components make to obesity; some think that calories from fructose are more readily metabolised to fat than calories from other sources. Also, energy expenditure involves more than simple physical activity. Brown adipose tissue (BAT) thermogenesis is now recognised as an important contributor to energy expenditure, and the manipulation of BAT is seen as a novel means of targeting obesity and the development of metabolic disease (see also Section 1.5 for pharmacological obesity treatments).

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29 WHO Global Health Observatory Map Gallery (accessed in July 2013)
1.1.3 Health consequences – other non-communicable diseases

Although obesity is arguably the main focus of nutrition-related public health policy, there are many relations between diet, health and chronic diseases that are directly linked to dietary quality, i.e. how foods are combined resulting in more or less “healthy” combinations of nutrients. In Europe, dietary patterns vary considerably. Nevertheless, there are certain characteristics in the diets across Europe that can explain part of the burden from NCDs.

From a nutrient point of view, those characteristics relate to a high total fat intake – in particular an unfavourable fatty acid pattern in the diets – the high intake of simple sugars at the expense of complex carbohydrates and fibres, as well as a high sodium intake. Some of these relations are described below:

- There is convincing evidence that reducing saturated fatty acids (SFA) and TFA lowers the risk of coronary heart disease through a decrease in LDL (bad) cholesterol and in the total/HDL (good) cholesterol ratio. This effect is particularly strong when SFAs are replaced with PUFAs and less so with mono-unsaturated fatty acids (MUFA)\(^{33}\). There is also a potential link between SFA intake and breast cancer development\(^{34}\). Efforts are ongoing in many EU Member States to improve the dietary fatty acid profile, and further progress towards reformulations as well as the substitution of foods and food ingredients in processed foods and ready meals are expected, based on a common EU structure\(^{15}\). Scientific evaluation of progress and their effects on public health will be critical in monitoring the effectiveness of these public health interventions.

- PUFAs have other beneficial effects on blood lipids and cardiovascular health\(^{35}\). Moreover, omega-3 PUFA, in particular intakes of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) also benefit blood pressure\(^{36}\). Other proposed additional benefits for omega-3 PUFAs concern the immune system, reduction of inflammation, glucose tolerance and insulin sensitivity, body-weight control, cognitive function and cancer prevention. Some scientists suggest that today a too-high omega-6 to omega-3 PUFA ratio in typical European diets explains part of the burden from NCDs\(^{36,37}\). This reasoning may influence future dietary recommendations or efforts towards food reformulation, although more research is needed to establish solid causality links.

- The health benefits of dietary fibre, such as a lower risk of constipation, diverticulosis, colon cancer, gallstone formation, overweight, hypercholesterolaemia, diabetes mellitus type 2, cardiovascular diseases, and atherosclerosis have long been recognised and have led to recommended intakes of 25-35g/day in the EU and elsewhere\(^{38}\). Today, dietary fibre intake is based mainly on fruits, vegetables and whole grains. However, there is potential for future food reformulation and development of foods bearing health claims in Europe following the favourable opinion expressed by the European Food Safety Authority (EFSA) related to beta-glucans from oats and barley\(^{39}\).

- The nutrient-health relation is not straightforward for sugars (mono- and disaccharides). The suggested implications on dietary energy and nutrient density, on body weight, glucose tolerance and insulin sensitivity, serum lipids, cardiovascular disease, type 2 diabetes and dental caries were all reviewed by EFSA\(^{40}\). It states that “frequent consumption of sugar-containing foods can increase dental caries” and that intakes of more than 20 % of total energy intake (E %) in the form of sugars may have adverse effects on blood lipids. However, an upper limit for sugar intake could not be established from the available data. Also, for the other proposed health effects EFSA considers the current evidence of a causal link insufficient to set an upper limit. Nevertheless, some authorities, such as those in the Netherlands, United Kingdom or in Northern Europe, recommend limiting daily (added) sugar intake to below 10 E %. The need to reduce sugar intake for public health reasons continues to be discussed\(^{31}\). If public health action in the future focuses on reducing sugars in the diet this is likely to influence food product composition and nutrient intake. More scientific clarity on the relationship between sugars and health would benefit future policy decisions.

- In the past, several countries have taken action to reduce dietary sodium intake, in particular in the form of salt. Parts of the observed lowering of blood pressure and, via this risk factor, also heart disease, have been attributed to reductions in sodium intake. It is noteworthy that the EU has agreed a salt reduction framework and Member States are now starting to implement measures, which means that results are likely to be seen in the coming years\(^{42}\).

- Beyond its established role in bone health in combination with calcium, Vitamin D has also been linked to innate and adaptive immune function, inflammation (especially related to obesity), cancer, glucose metabolism and metabolic risk, hypertension, diabetes, cardiovascular diseases, cognitive decline, as well as infectious disease outcomes, including respiratory infections\(^{43,44}\).

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\(^{33}\) WHO/FAO (2008) Interim Summary of Conclusions and Dietary Recommendations on Total Fat & Fatty Acids

\(^{34}\) German Nutrition Society (DGE, 2006): Evidenzbasierte Leitlinie (Evidence-based guidelines, in German)

\(^{35}\) High Level Group on Nutrition and Physical Activity (2012) 15th plenary meeting

\(^{36}\) EFSA Journal 2010 8:1796

\(^{37}\) Alhaid et al. (2008) Br J Nutr 100:461-470


\(^{39}\) EFSA Journal 2011 9:2207

\(^{40}\) European Commission DG Health and Consumers (2012): Implementation of the EU Salt Reduction Framework

\(^{41}\) Cashman et al. (2011) Br J Nutr 106:1617-1627

Since there is a risk of acute toxicity from high Vitamin D intake and possible adverse effects of long-term high Vitamin D intake below acute toxicity levels, future research is needed to fill existing gaps in the understanding of Vitamin D’s role in prevention beyond those of rickets in children and osteomalacia in adults. Nevertheless, some countries already have mandatory or voluntary Vitamin D food fortification in place and an increasing number of Europeans take Vitamin D supplements, a trend that should be critically monitored. Moreover, nutrient requirements also vary widely between individuals within any such sub-groups. In fact, particularly amongst the elderly, variability in both functional capacity and energy expenditure appears higher than in younger adults. This is reflected in dietary recommendations for different life stages and gender groups46. However, precise data is often lacking, thus requiring interpolations and extrapolations. In this respect, future advances in science may improve dietary reference values and enable more targeted dietary advice. Progress in identifying and systematically applying valid biomarkers in nutritional research is likely to have a particular role to play in the future46.

Besides healthy individuals in the ‘general population’, many people live with some form of ill health, often with multiple disorders, allergy or intolerances forcing them to follow special diets or making it impossible for them to consume certain foods. Similarly, medication can also interfere with appetite, nutrient bioavailability, energy and nutrient metabolism, etc.

People with endocrine, nutritional and metabolic diseases are often restricted in the foods they can eat. In particular, inborn errors in metabolism can affect basically every part of nutrient metabolism. Such errors are quite rare individually, but when considered as a group are estimated to affect 1 in 1000 individuals. Special diets and supplements are often used in their treatment as supportive therapy47.

It is very difficult to get sound data on incidence of food allergy or intolerance, as concluded in a recent meta-analysis, due to big differences in study data and between assessments ranging from self-reported hypersensitivity to objective measurements such as skin prick test (SBT) or IgE assessments46. Figures for self-reported hypersensitivity to any food ranged from 3 to 35 %, from 4 to 6 % for IgE assessment and from 7 to 17 % for SBT measurements, with similar orders of differences for intolerance/allergy to milk, eggs, peanuts, fish and shellfish. Notwithstanding the high uncertainty in the data, the high self-reported prevalence of food allergy gives an indication of the dimension of this challenge since this reflects probably the part of the population that will respond in their food choice and diet composition.

An important and increasing amount of food is eaten out of home. Studies have shown that for voluntary out-of-home eating (e.g. restaurants), diets tend to be too high in fat, saturated fats and sugars and too low in fibre, calcium and vitamin C48,50. Other, less voluntary forms of out-of-home eating, such as food given to

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43 Rizos et al. (2012) JAMA 308:1024-1033
44 Bjelakovic et al. (2007) JAMA 297:842-857
45 EFSA Journal (2010) 8:1458
46 Intern. Life Sciences Institute (ILSI Europe) – Marker Initiative in Nutrition Research (accessed in July 2012)
47 Encyclopaedia Britannica – Metabolic Disease (accessed in July 2012)
children and adolescents in day-care or education facilities, have been the focus of past research and policy interventions. There still appears to be a significant unexploited potential for delivering better foods and diets to patients, the elderly, the disabled and people in need of food aid. For example, in 2010, more than 18 million people in participating EU Member States received food through the EU’s ‘Food for the most deprived programme’. In the past, because of legal constraints, Member States could not distribute certain foods, including fruit and vegetables, fish or meat, in their national programmes. The legal base changed in 2012 and, as a result, from the 2012 annual plan onwards Spain, for example, will also distribute olive oil, pulses, canned tuna, fruit juice, canned fruit without added sugar, and canned green beans together with more ‘traditional’ cereal-based products.

1.2.2 Special diets and eating disorders

Due to the variation in nutritional needs of the respective individual, recommendations for a healthy diet can only provide general advice concerning the combination of foods or groups of foods in the context of existing dietary habits. Pending the EFSA’s development of European food-based dietary guidelines, EU Member States either follow their own recommendations or refer to those of other sources. Most of them include general advice, such as to:

i) eat a varied diet;
ii) increase fruit and vegetable intake;
iii) eat plenty of cereal products (preferably whole grain) and potatoes;
iv) frequently consume milk and dairy products, preferably reduced-fat alternatives;
v) moderate intake of meat and meat products;
vi) limit consumption of sugary and saline products;

vii) drink enough (preferably water and unsweetened liquids);
viii) aim to keep or achieve a healthy bodyweight and follow an active lifestyle.

The effectiveness of adherence to such recommendations in preventing chronic diseases has been repeatedly and convincingly shown in the scientific literature – in some cases, the benefits of diet and lifestyle interventions were even more effective than pharmacological treatment and persisted beyond the intervention period, such as for diabetes and cardiovascular diseases. Nevertheless, many people seek a diet that is healthy or fulfils other purposes, such as weight loss, environmental sustainability, animal welfare, religious rules, or is based on other reasoning (scientific or otherwise). The dietary patterns that result from these concerns may have advantages over average current dietary practices, in particular if these are varied or mainly plant-based diets, although they can also lead to nutrient deficiencies, especially if practised for extended periods and imposed on vulnerable groups such as children.

Across the EU, weight-loss diets are a growing market in which people are often confronted with aggressive promotions of special diets, such as high-protein low-carbohydrate or the opposite, low-fat diets or diets based on blood groups, etc. While numerous publications can be found to prove or disprove these diets, evidence from long-term studies with solid study designs show no difference in weight loss from different macronutrients in isocaloric diets. Rather, it is the individual’s behaviour that is essential to successful weight loss. These studies also show little difference in other secondary health parameters, such as blood lipids or insulin sensitivity. However, recent epidemiological studies have associated increased cardiovascular risk with low-carbohydrate diets among Swedish populations.

While the science of personalising diets based on genetic or metabolic testing is still largely in a phase which is too early to translate the findings into sound personalised nutrition recommendations, the market already offers – and an increasing number of people are also looking for and following – personalised recommendations. Media and popular science books have their share of the many different and often contradictory diet recommendations that reach the public. There is a growing interest among the population in the role of diet in managing their own health. Therefore, it is highly desirable to ensure consumers can access truthful and science-based dietary information and education.

1.3 Food safety

Current EU legislation and precautionary measures are effective in maintaining the low risk of food-borne diseases or non-biological contaminations in the food chain. The latest RASFF (Rapid Alert System for Food and Feed) report refers to 3812 original notifications, mostly triggered either by controls at the outer European border.
In 2010, as reported by the EFSA\textsuperscript{69}, a total of 5262 food-borne outbreaks were reported in the EU, causing 43 473 human cases and 25 deaths. Most of the reported outbreaks were caused by Salmonella, viruses, Campylobacter and bacterial toxins. The most important food sources were eggs and egg products, mixed or buffet meals, and vegetables and products thereof. The number of outbreaks caused by vegetables and vegetable products has increased compared to previous years although the number of salmonellosis cases in humans has decreased over the past six years in a statistically significant manner. It should be noted that the numbers only reflect those cases that were reported and may therefore be an underestimate of the actual cases of food poisoning. While they may provide some reassurance, strict controls are needed, as the 2011 Shiga toxin-producing \textit{E. coli} outbreak has shown. This was one of the largest food-borne outbreaks reported in Europe in decades and was linked to more than 50 deaths\textsuperscript{69}.

When considering food safety, the use of antibiotics in farming animals is also important. These are used not only to treat infections but also to prevent disease and promote animal growth. Their (over)use has been linked to increased antibiotic resistance to (human) pathogens and although health authorities are moving towards tighter regulation on the use of antibiotics on farms\textsuperscript{70}, antibiotic resistance may still linger on farms even after the drugs have been discontinued\textsuperscript{71}. Fraudulent adulteration of food products will probably remain a concern as some feel that economic conditions and a higher cost of living may promote such practices\textsuperscript{72}. A closer look at water and the safety of drinking water may also be needed, in particular regarding long-term exposure to low levels of chemicals.

In addition, the emergence of novel infectious agents and zoonotic diseases must be considered. Animals are an important source of infectious agents: about 75 % of new diseases that have affected humans over the past 10 years have originated from animals or products of animal origin\textsuperscript{73}. Many of these are food-borne or can be transmitted through direct contact or proximity to edible animals. Previous outbreaks of transmissible spongiform encephalopathies or avian influenza illustrate the importance of zoonotic diseases.

1.4 Socio-economic aspects

Health is largely determined by the socio-economic, cultural and environmental conditions in which we live. Although EU citizens today live, on average, longer and healthier lives than previous generations, the Union is faced with an important challenge: the inequalities in health which exist between and within EU Member States\textsuperscript{74}. Research has shown that health inequalities are mainly caused by higher exposure of lower socio-economic groups to low income, health risks in the physical environment, psychosocial and behavioural risk factors\textsuperscript{75}. In particular, inequalities in mortality from cardiovascular disease account for almost half of the excess mortality in lower socio-economic groups in most countries. This is particularly severe in vulnerable and socially excluded groups, such as people from some migrant or ethnic minority backgrounds, the homeless or the disabled.

Food-related ill health may contribute to this phenomenon. The diets of low-income groups are more likely to be inadequate because they often have problems gaining access to a variety of healthy, safe and nutritious foods\textsuperscript{76}. In 2006, an estimated 43 million people in the EU-25 faced food poverty or were at least at risk of it\textsuperscript{72,77}. Food poverty is defined as people eating what they can afford, and often results in poor diets which, in rich countries, increases the risk of developing obesity, cardiovascular disease and other NCDs\textsuperscript{78}. Food poverty is even more critical for vulnerable population groups, such as children, adolescents, pregnant and lactating women, as they have greater physiological needs, or those suffering from the impaired bioavailability and metabolism of nutrients, such as older people and those with a disease.

There are indications that health inequalities may be growing in the EU. As a result of the persistent economic crisis, the purchasing power of many is decreasing, unemployment in the EU reached 11 % in 2012\textsuperscript{79}, and social benefits have been reduced. It remains to be seen how this situation will affect food choice, diets and lifestyles and, as a consequence, the health of Europeans. Possible increases in food prices, in particular for cereals, meat and dairy products, could further aggravate the situation for the lower income layer of society\textsuperscript{80}.

\textsuperscript{69} EFSA Zoonotic diseases (accessed in October 2012)
\textsuperscript{70} Communication from the European Commission on Solidarity in Health: Reducing health inequalities in the EU COM(2009) 567 final
\textsuperscript{71} UK presidency of the EU (2006) Report: Health Inequalities: Europe in Profile
\textsuperscript{72} Robertson, A. (2001) Public Health Nutr 4: 1371-1373
\textsuperscript{73} European Parliament (2006) P6_TA(2006)0125 Declaration on supplying approved charities working to implement the European food aid programme for the most deprived
\textsuperscript{74} Food Ethics Council (2012) Food Poverty (accessed in June 2012)
\textsuperscript{75} Eurostat (2012) Statistics in focus: Populations and social conditions
\textsuperscript{76} European Commission (2008) COM(2008) 321 final: Communication on “Tackling the challenge of rising food prices Directions for EU action”
1.5 Progress in science, technology and medicine

Understanding the relationship between diets and health is not a simple exercise and the field of nutritional sciences often witnesses controversies and conflicting evidence. One of the reasons that may underlie seemingly contradictory data is the inherent genetic differences between individuals and populations and how these may result in very different responses to nutrients. Equally confounding may be epigenetic differences (induced prenatal or post-natal) and the microbial composition of the gut flora81, 82. Understanding the interactions between these factors and our response to foods is an emerging field, although the rapid development of genomic (and other -omic) tools and sciences predict important advances in this area. Whole genome analyses are becoming increasingly available and now allow for a deeper understanding of gene/metabolism interactions (both in terms of macro- and micronutrients). Tailor-made dietary recommendations and personalised nutrition counselling are already available to the consumer. However, given the lack of solid data behind these recommendations, they are still met with scepticism by most experts. This is likely to change as research efforts shed light on individual responses to foods and diets.

There are indications that food taste and food acceptance can be influenced early in life. Individual acceptance towards the taste and texture of foods seems to be partly determined by inherited willingness and moderated by cultural background. Modelling and flavour conditioning may contribute to a better understanding of the mechanisms influencing food acceptance, and could support effective health-promotion programmes83.

Future advances in nutrition science will probably pinpoint some solutions to the food-related health problems we are facing today. For example, stronger preventive measures could come from clearly identifying dietetic ‘culprits’ in target populations and limiting them in diets (e.g. salt, sugar, trans and saturated fats). The opposite approach, i.e. exploiting the beneficial properties of some foods or their components and promoting their consumption is equally valid. Moving towards understanding the physiologic responses to nutrients at the individual level may mean adapting preventive public health measures to target individuals rather than whole populations. It is also likely that we will witness further developments in and the increased uptake of therapeutic drugs (e.g. anti-obesity drugs) and medical devices or interventions (e.g. bariatric surgery) for diet-related health issues. For example, the market for obesity treatments is expected to more than double (and even triple in the US) between 2012 and 201984. Therapeutic drugs can be taken as pills or capsules or – as is already the case – extracted from foods or given together with foods (e.g. cholesterol-lowering products). The existence of effective therapies for food-related illnesses may, however, have an important drawback. Knowing that a ‘cure’ exists may reduce even further the likelihood that people will follow healthier dietary and lifestyle patterns. The reimbursement of such treatments may also be controversial and will determine the extent of their uptake.

The use of foods and diets as vehicles for delivering health-promoting (or disease-preventing) agents is already practised today via functional or bioactive foods. There are currently 222 authorised health claims in the EU85. The numbers illustrate the interest in the market but also the great potential for its development. In this context, nanotechnology is a promising technology although there is still work to be done concerning the evaluation of the safety of certain nano-sized materials. Nanoparticles can be used, for example, to enhance nutrient delivery or as contamination sensors. The application of nanoparticles to improve texture and flavour may also have health implications as they can be used to improve stability, for spreadability (replacing fats) and also to enhance flavours like salt or sweet or to block bitter tastes. Furthermore, the continuous discovery of new natural or artificial food additives can also promote the consumption of healthier foods by, for example, providing or enhancing pleasurable tastes and/or blocking and modifying unpleasant ones.

The genetic modification of crops has so far resulted in few applications targeting the consumer. Apart from the potential to increase food production and reduce hunger, genetic modification could also contribute to healthier diets. Golden Rice is probably the most popular and controversial example (modified rice with higher levels of β-carotene to help prevent vitamin A deficiency)86, but there are many other potential applications for the technology, such as the enrichment of tomatoes with health-promoting anthocyanins87. In addition to genetically modifying existing foods, the introduction of new foods must also be considered. Insects as an additional source of proteins are the focus of investigation88 and there are examples of commercially viable insect or worm caterers, such as Don Bugito in the US89. Algae also have great potential in the development of new foods either as foods per se or for the production of food commodities such as oils, protein and starch. The health implications of the introducing these foods into Europe are not clear, but it is worth noting

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84 Driscoll, P. (2012), MEDCITY news: Trends in obesity treatment going in different directions in the US vs. Europe
85 European Commission DG Health and Consumers - EU Register of nutrition and health claims made on foods (accessed in July 2012)
87 Butelli et al. (2008) Nat Biotechnol 26, 1301-1308
88 European Commission (2011) PFP Cooperation Work Programme: Food, Agriculture and Fisheries, and Biotechnologies
89 Don Bugito webpage (accessed in July 2012)
that grasshoppers, caterpillars and several algae species are part of the diet in other parts of the world. In vitro, laboratory-produced meat may be another viable alternative source of animal protein which is currently being explored\textsuperscript{90}. The technology should allow for the fine-tuning of the meat nutrient composition to create a healthier profile.

2. Consumers

What food we consume determines to a great extent how healthy we are (see Chapter 1). Even though most people seem to know, more or less, what combination of foods make up a healthy diet, many do not apply this knowledge in their daily lives. Numerous factors influence diet and lifestyle choices, and although interconnected, can be broadly divided into two categories: those that are external, shaping the environment around the consumer, and those that stem from the consumer and influence interactions with the environment.

2.1 The European consumer

The heterogeneity between different EU Member States, as well as the differences observed on a regional level, make it inherently difficult to describe a single, representative European consumer. Therefore, the following general demographic and economic characteristics are to be taken as indications.

The EU population is projected to increase only slightly from 502 million in 2010 to about 526 million in 2040, before declining until 2060 to reach 517 million. Developments are not equal across the different Member States: for example, the strongest population growth is projected in Ireland (+46 %), Cyprus (+41 %), the United Kingdom (+27 %) and Belgium (+24 %), and the sharpest decline in Bulgaria (-27 %), Latvia (-26 %), Romania and Germany (both -19 %). In addition, the EU population is ageing and the number of people over 65 will almost double in the next 50 years (to 152.6 million in 2060), with the numbers of those aged 80 or more almost tripling (from 23.7 million in 2010 to 62.4 million in 2060), thus becoming as numerous as those in the 0-14 years group (12 % and 14 % respectively). This will result in demographic old-age dependency of 52.5 % by 2060, up from the current 26 %\textsuperscript{91}.

The EU consumer is mainly a city dweller – 75 % live in urban environments, and this is expected to rise to 80 % by 2020\textsuperscript{92}. According to Eurostat\textsuperscript{93}, each household in the EU-27 has on average 2.3 persons, and the average age for leaving the workforce is 61.4 years\textsuperscript{94}. The average unemployment rate is 12.0 %, ranging between 4.9 % (AT) and 5.3 % (DE) to 26.2 % (ES) and 27.6 % (EL)\textsuperscript{95}. Another important characteristic is the consumer’s economic power, which can directly affect the choice of food purchases. In 2012, the EU-27 average gross domestic product (GDP) in Member States ranged between 47 % (BG) to 263 % (LU)\textsuperscript{96}, while the GDP at market prices expressed as purchasing power standards (PSS) per inhabitant was EUR 25 600 and EUR 27 700 on average for the EU-27 and the euro zone respectively in 2012, but ranging from EUR 12 100 (BG) to EUR 67 100 (LU)\textsuperscript{97}.

Adding to the inherent variation is the movement of EU citizens between Member States (2.5 % of the total EU population), as well as the number of immigrants coming from regions and countries outside the EU (4.0 % of the EU population)\textsuperscript{98}, who may have different dietary needs and preferences. Figures for 2008 indicate Morocco, China, India, Albania and Ukraine as the main countries of origin, but any political and environmental crisis could easily change that picture\textsuperscript{99}.

Finally, the education level of the EU consumer is another important characteristic to consider. In 2010 in the EU, 79 % of people aged 20-24 had completed at least an upper secondary education, while 26.7 % of consumers aged 24-64 held a university level qualification. The latter figure has increased since 2000\textsuperscript{100}.

2.2 The consumer environment

The current consumer environment is an obesogenic one, i.e. it promotes or favours, either directly or indirectly, the spread of the obesity epidemic (see Section 1.1). It is characterised by energy-dense foods and increasing portion sizes coupled with non-active lifestyles. The access to foods that constitute a healthy diet depend not only on the physical presence of those foods in retail or catering services but also on how affordable they are to the average consumer in terms of price\textsuperscript{101}. Often, the less healthy food choices, such as ready meals, vending-machine snacks or fast foods, are cheap and readily available, while fruits and vegetables may not be available in the vicinity, therefore incurring extra cost in terms of time and money. The decrease in the number of purchases from small grocery stores, as a result of consumer preference for super- and hypermarkets\textsuperscript{102} (Fig. 2.1), may result in fresh foods not being readily available in the immediate vicinity of low-income

\textsuperscript{90} Post, M. (2012) Meat Sci 92, 297-30
\textsuperscript{91} European Commission (2012) The 2012 Ageing Report
\textsuperscript{92} European Environment Agency (2006) Urban sprawl in Europe
\textsuperscript{93} Eurostat - Number of persons in households web page (accessed in July 2013)
\textsuperscript{94} Eurostat - Harmonised unemployment rate (accessed in July 2013)
\textsuperscript{95} Eurostat - GDP per capita, consumption per capita and price level indices (accessed in April 2013)
\textsuperscript{96} Eurostat - Gross domestic product at market prices (accessed in July 2013)
\textsuperscript{97} Eurostat - Migration and migrant population statistics (accessed in June 2012)
\textsuperscript{98} Eurostat (2011) Migrants in Europe
\textsuperscript{99} Eurodico Network and Eurostat (2012) Key Data on Education in Europe 2012
\textsuperscript{100} Ericksen, P. (2008) Global Env Change 18,234-245
\textsuperscript{101} Eurostat (2009) Consumers in Europe
neighbourhoods, creating the so-called ‘food deserts’. This is already happening in the United States, although the situation in the EU is less clear. With the advent of mass media in the last century and the explosion of internet-based communications over the last two decades, the information directed at or made available to the consumer has increased dramatically to the point of creating an overload of information and an overexposure to advertising. Food labelling is also providing consumers with an increasing volume of information. In addition, the liberalisation of world trade and the European single market have both increased the volume of products and information now available. However, this plethora of information on diets and well-being does not correlate with increased nutritional literacy. On the contrary, lack of information about what we eat and what constitutes a healthy diet, as well as the accessibility of contradictory and confusing information account for 43 % of the reasons that make a healthy choice difficult for consumers.

This overexposure to information often leads to misinformation, confusion and false beliefs. In addition, dubious ‘trendy’ diets and drastic or easy solutions focusing on losing weight (20 % of EU citizens were on a diet during 2006) find fertile ground in consumers who are increasingly wary of nutrition-related disorders such as obesity. In spite of the above, EU consumers claim to understand the basics of a healthy diet (Fig. 2.2), and 66 % (ranging from 25 % in BG to 79 % in the NL) actually think that it is easy to eat a healthy diet. However, this understanding is not sufficiently translated into behaviour, judging by the high number of overweight and obese individuals in the EU (see Section 1.1.2).

Nutritional misinformation in particular can confuse and steer consumers away from healthy diets and lifestyles. Mass media, such as the press, radio and television, rarely provide enough context so that the consumer can correctly apply the advice offered. In addition, the expansion of web usage has led to quasi-scientific, semi-anonymous nutritional advice and opinions of questionable value. The European Commission aims to increase citizens’ awareness of consumer issues in order to empower them and help them make the healthy choice. A recent survey revealed that 70 %, 60 % and 50-60 % of consumers feel confident, knowledgeable/well informed and protected by consumer law, respectively, while revealing geographical divisions within the EU, whereby consumers from Northern Europe feel more empowered than Southern Europeans. As regards food labelling, the main obstacles preventing consumers from reading and understanding the nutrition-related information on food packages is the lack of both attention and motivation. Health-conscious consumers are more likely to focus on and understand food labels.
The private food sector provides information directly to consumers, either via direct advertisement, promotional material and campaigns or on labelling (food packaging, menus). In addition, advertisement in schools and to sensitive population groups, such as children, plays an important role in shaping current and future consumer beliefs and habits. In the media, strategies such as product placement "have created an environment in which children and adults are assaulted with visions of eating and drinking that are creating global shifts in food demand". Television advertising features child-oriented persuasive techniques: "most advertisements promote unhealthy foods, high in total energy, sugars and fats, and low in nutrients". Internet-based media are also employed by the private sector to indirectly influence consumers, e.g. through social networks focused on products or company websites featuring games for kids. Authorities at the EU or national level have imposed rules to protect the most sensitive consumers, such as children, and regulate the information flow. However, to date no such control has been possible for the internet, which is being used more and more for information searching related to shopping (27 % of consumers) and online shopping (18 % visit online shops), online information provision, and e-health services and applications.

Consumers' economic purchasing power is another major factor influencing the accessibility of healthy diet components. The percentage of household budget dedicated to food and non-alcoholic beverages provision is not homogenous throughout the EU-27 (Fig. 2.3). Consumers from countries with less purchasing power seem to spend a higher proportion of their budget on food and drink. In addition, during periods of economic depression the consumers' purchasing power is reduced, so food expenditure may need to be cut, resulting in cheaper and perhaps poorer dietary choices.

In a study examining the effect of the 2008 Iceland economic crisis on consumer health behaviour, it was found that health-compromising behaviour (e.g. smoking, heavy drinking, consumption of sugared soft drinks, sweets and fast food) was reduced. In addition, certain health-promoting behaviour increased (e.g. consumption of fish oil) while others decreased (e.g. consumption of fruits and vegetables). Prices seemed to play a large role.

Various non-governmental, bottom-up social initiatives counter-movements and approaches have also been implemented to dampen the effects of economic depression on food availability.

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109 Popkin et al. (2012) Nutr Rev 70:3-21
110 United Nations Human Rights Council (2011) Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter
112 Ásgeirsdóttir et al. (2012) Nat Bur Econ Res, working paper 18233
114 The Last Minute Market movement in Italy (accessed in June 2012)
2.3 Diets and lifestyle

Our society is characterised by sedentary lifestyles where convenience, time and low prices have become priorities, as evidenced by the spread of the fast-food and takeaway/delivery sector in recent decades, at the expense of healthy eating habits. In fact, “the lifestyle of EU citizens seems to be the main obstacle to healthy eating”103 (Fig. 2.4), in particular the length of time associated with choosing and preparing a healthy diet, as well as the ‘lack of control’ over what a person eats in the context of food prepared by others or regularly eating out of home (among younger and more active groups). As a consequence, out-of-home eating services (fast foods, catering) are important players in determining our dietary options. Out-of-home eating in general is associated with sedentary lifestyles, an increased intake of total energy, fat and sugar, and a lower intake of micronutrients115,116,117. Fast food in particular has been linked with both, increased energy intake and portion sizes118,119.

In the EU, the time allocated to food preparation at home varies between 11 minutes and 97 minutes101. For comparison, the average US citizen spends 75 minutes eating and drinking, and 34 minutes preparing food and cleaning up each day120. Spending less time preparing food at home may have other, unforeseen, side effects for the younger generation, such as reduced nutritional and food literacy121, and perhaps even less understanding of the basic principles of good hygienic practices for preparing food at home. In addition, novel, post-modern ways of preparing food (e.g. the so-called “molecular cuisine”), while currently representing a niche environment that few may be interested in or can afford, could take on a more mainstream aspect in the future and change our dietary habits, directly influencing our eating frequency, portion sizes or energy/nutrient intake.

Cultural differences play a role in the way out-of-home eating is done or perceived: in Southern Europe, as a leisure weekend activity where the food choice differs from home cooking as against during-the-week out-of-home eating, similar to in-home cooking, in Northern Europe20. Restaurants in particular affect our dietary habits: portion sizes, availability of vegetables on the menu, caloric labelling and prices can all influence consumer behaviour.

Ageing is one of the key determinants affecting consumer lifestyle. Mental and physical decline changes eating, and more generally, consumption

Fig. 2.3: Percentage of household budget spent on food and non-alcoholic beverages in EU countries 2005, CZ not available (Source: 101, page 143)

115 Dfranos et al. (2009) Eur J Cl Nutr 63:5239-262
117 Dfranos et al. (2007) Publ Health Nutr 10:1515-1525
121 EFIC (2010) From Farm to Fork: Food and the Consumer, A Shared Responsibility
behaviour. It can physically impede the ability to eat and to be physically active, as well as reduce the perception of taste and the will-power required to adhere to a healthy lifestyle. This applies especially to the institutionalised elderly, over 70 years old, who are often undernourished (30-65 %). Suggested ways of improving nutritional status in this sub-population are: (i) adapting the social context of a meal; (ii) appropriate nutritional care; and (iii) ensuring the palatability of nutrient-rich foods (i.e. they need to be tasty)\(^{122}\). The direct social environment also has an effect on the eating habits and lifestyles of the elderly, e.g. social isolation is associated with nutrient deficiencies.

Apart from ageing, our societies are also characterised by consumerism, i.e. purchasing goods in larger quantities than needed and beyond what may be environmentally sustainable. This is related to prosperity and could potentially change according to consumers’ economic situation. Coupled with this phenomenon, wasting food is having a serious impact on household resources, besides its negative effects on the sustainability of the food system – 50 % of edible foods are wasted in the EU, nearly half of which occurs at the household level\(^{123}\).

Currently, 12 % of the EU population live in one-person households, while over 4 % are single parents\(^{124}\). Although few in number, all projections concerning future household structures for developed countries foresee a drop in the average number of people per household and an increase in the percentage of single parents. As a result, in future changing household structures\(^{125}\) might lead to different eating habits and lifestyles.

2.4 Consumer needs, preferences and expectations

Unlike preferences, consumer needs concerning diet and health are fundamental and refer to access to safe, sufficient, affordable and quality food. Consumer requirements in the EU go beyond safety or quantity as the availability of food (in kcal/person/day) is currently sufficient\(^{126}\) and worldwide hunger is declining and will continue to decline, at least until 2050\(^{127}\). Therefore, an important consumer need for Europeans is to have healthy diets and foods that deliver adequate amounts of macro- and micronutrients. Although micronutrient deficiencies are not a major public health concern in Europe, they do exist\(^{128}\).

In addition, certain groups in society have increased needs for specific nutrients and require specialised nutrition, e.g. the elderly, people with specific diseases (including obesity), allergies, lactating women, and children (see Section 1.2.1).

Furthermore, there is a need for clear, non-misleading information on nutrition and health claims\(^{129}\) and what constitutes a healthy lifestyle and eating pattern in general.

The most important factors for consumers when shopping for food are quality and price, followed by appearance/freshness, taste and health\(^{101}\) (Fig. 2.5). Obviously, since health is also both a need and a preference for the consumer, there is a large and growing market for products that contribute, or claim to contribute, to improving health, as illustrated by

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\(^{122}\) Van Staveren et al. (2011) J Am Coll Nutr 80: 429s-437s


\(^{124}\) OECD (2008) The Future of the Family to 2030

\(^{125}\) German Institute for Economic Research (2007) Research Note: Household Patterns

\(^{126}\) WHO European health for all database (HFA-DB) (accessed in June 2012)

\(^{127}\) FAO (2012) Food outlook towards 2050

\(^{128}\) European Commission, Joint Research Centre (2012) How can science support policy makers in addressing nutritional challenges of Europe? EUR25165EN

\(^{129}\) EFSA (2012) Health claims: looking beyond the label (accessed in June 2012)
a report on the emerging functional-food market in the US\textsuperscript{130}, or by 44 000 health-claim applications submitted to the European Food Safety Authority (EFSA) for evaluation.

**Taste** has always been a major motivation for selecting (or not) a certain food\textsuperscript{131}. Foods high in sugar, fat and salt tend to have the highest hedonic (liking) rankings. In addition, the lack of taste seems to be an important factor that makes choosing a healthy diet more difficult (Fig. 2.4), especially for the youngest (27 %) and the oldest (25 %) consumers\textsuperscript{103}.

The price of food is important and the demand for cheap foods is likely to increase following the financial crisis that has affected many European economies. When measured per calorie, unhealthy diets seem to be cheaper, as the current perception seems to imply. However, a recent report commissioned by the US Department of Agriculture (USDA) showed that when the price is based on the “edible weight” or “average portion size” the cost of a healthy diet is much lower\textsuperscript{132}.

**Food safety** is another factor influencing consumer choice (Fig 2.6). In 2010, consumers perceived a possible “risk of food damaging one’s health” as being “very likely” (11 %) and “fairly likely” (37 %). The latter is an 11 % increase compared to 2005\textsuperscript{133}. Another motivation in food selection is **convenience** which often reflects unhealthier options as such products are processed (refined grains, added sugar, lower micronutrient content) and designed (prepared, packed and marketed) for immediate consumption and, as a consequence, provide easy access to calories. **Online shopping** for groceries is an upcoming type of convenience that is expected to grow in popularity in the coming years\textsuperscript{134}.

Foods and diets in Europe can have strong **cultural** or **traditional roots**, and can be **regional** or **national**. This is reflected by the number and variety of protected geographical indication (PGI) and protected designation of origin (PDO) specialised food products, varying between 90-250\textsuperscript{101, 135} in countries like France, Italy, Greece, Spain and Portugal. Even though European diets may have strong traditional roots, **foods and diets are changing** with time and may become less healthy as they deviate from the original, e.g. the **Mediterranean diet**\textsuperscript{136}. In addition, there is a demand for **variety**, in parallel with consumer expectations to be able to buy their favourite products all year round. **Family preferences** or **habits** were also mentioned as factors for food selection. New dietary styles have been introduced by non-EU **immigrants** and in some cases diets may also have **religious roots** (kosher, halal).

**Ethical factors** are becoming more important in consumers’ buying decisions\textsuperscript{137}. Among these are **sustainability**, e.g. the slow food movement\textsuperscript{138}, ‘localism’/km-0 foods produced locally, **animal welfare**, **organic foods** or **fair trade** foods (aiming to ensure honest prices for local producers, such as banana, coffee and cocoa farmers). Worldwide ethical consumerism is forecast to grow at 10 % and 25 % per year until 2015 for organic and fair trade foods, respectively\textsuperscript{139}. In addition, ethical foods currently command higher prices, although these margins are expected to narrow because of high consumer demand and the entry of multinational food companies into this market. The latter could pose a risk to the credibility of ethical foods, due to their reputation and marketing approaches\textsuperscript{139}.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{fig2.5.png}
\caption{Factors that consumers take into account when buying food (Source: 101, page 134)}
\end{figure}

\textsuperscript{101} PricewaterhouseCoopers (2009) Leveraging growth in the emerging functional foods industry: Trends and market opportunities
\textsuperscript{131} International Food Information Council Foundation (2011) Food & Health Survey
\textsuperscript{102} US Department of Agriculture (2012) Economic Information Bulletin No.96 - Are Healthy Foods Really More Expensive? It Depends on How You Measure the Price
\textsuperscript{132} European Commission (2010) Special Eurobarometer 354: Food-related risks
\textsuperscript{133} Food Navigator USA Article (29/08/2012) - Online grocery shopping still small, but growing rapidly, says Nielsen (accessed in August 2012)
\textsuperscript{134} European Commission DOOR database: list of PDO/PGI products
\textsuperscript{135} Vardavas et al. (2010) Eur J Cardiovasc Prev Rehab 17:440- 446
\textsuperscript{137} Slow Food movement website (accessed in June 2012)
\textsuperscript{138} Australian Government Rural Industries Research and Development Corporation (2012) Ethical Foods: International situation assessment, opportunities and threats; RIRDC Publication No 11/147
2.5 The psychology of food choice

In economic considerations, it is assumed that people usually act rationally to maximise the benefits of their actions. However, humans are not always rational and are prone to biases when it comes to behaviour. The certain immediate hedonic pleasures from eating and drinking but also smoking or being inactive often outweigh the possible, but long-term burden from chronic diseases, prolonged disability or a poor well-being appearing later in life. Still, the decision to choose short-term gratification over long-term health benefits also includes rationality: people make trade-offs when deciding what to eat, with health not necessarily being the driving force. Such rational choices include buying more of a food when it becomes cheaper, buying convenience food when time is an issue, giving less weight to health, and discounting distant possible negative consequences at a young age. It is therefore important to understand the psychology of food choice and to know how it can play a role in improving diets and contributing to weight management and health.

Food choice involves considerations such as what, how much, where and with whom, and might develop and change over time. Understanding food choice is complex and involves many disciplines, including biology (including genetics), psychology, sociology, anthropology, economics, marketing, history and medicine. One of the difficulties is that research into food choice often tends to study the impact of the different factors in isolation. The first thing that comes to mind when people think about food is taste and pleasure, followed by hunger and health in third and fourth place (Fig. 2.7). The innate preference for energy-dense foods, associated with sweet taste and fatty texture, is considered a biological mechanism related to energy regulation. This makes sense from an evolutionary point of view within the scope of survival in surroundings where food is scarce. The sensing of fat has recently been associated with obesity: a low taste sensitivity of fatty acids has been related to a higher intake of fat in the diet and a higher BMI. Other biological ‘signals’ are the feelings of hunger and thirst linked to a lack of energy and water, respectively. In addition, there is some evidence of the presence of a third system sensing sodium deficit. The preference for these attributes, presented by visual cues as well as smell, is a strong subconscious trigger that attracts people to consuming energy-dense foods. The intake of these foods might activate neural pathways similar to those for drugs (dopamine system), which may explain the craving for or addiction to certain highly palatable foods. Tasty foods can also affect a person’s mood, thereby influencing (short-term) well-being.

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Fig. 2.6: Consumer perception on food-associated risks (%), EU-25, 2005 (Source: 101, page 155)
Most of the research in the field of food psychology is about the regulation of food intake and its failure in obesity and eating disorders, and more particularly on meal onset and termination. Important aspects include the degree of hunger, the amount of food available, palatability, variety, the social setting, the occasion, cultural rules about appropriate amounts to eat, times to eat, time and competing activities, as well as memory of recent eating.

Behaviour is influenced by attitudes (what is the individual’s belief about the consequence/outcome), normative beliefs (what is the individual’s belief about what his/her social surroundings think), and control beliefs (the perceived ease or difficulty of performing the particular behaviour/self-efficacy). Eating and living healthily might be well understood and looked upon positively (attitude), but the ease of performing accordingly (self-efficacy) might be overvalued as people seem to overestimate their fruit and vegetable intake and underestimate their fat consumption.

A factor related to our biological instinct is the fear of hunger, i.e. running out of foods in times of crises, and is based in human primal instincts. An increase in food price and the subsequent worry that foods will become inaccessible has been associated with social unrest conditions that can trigger riots.

Eating disorders have been associated with an obsession concerning the consumption of either very little (anorexia) or excessive (binge eating, bulimia) amounts of foods, or even only eating foods perceived as pure and healthy (orthorexia). Recent trends show stability in the incidence of eating disorders in Europe, although there are reports that ‘Westernisation’ spreads eating disorders (e.g. among Asian women in America).

Recently, policy-making options have emerged that take into account insights from consumer behaviour and behavioural economics in particular, and may present alternative options for the future, considering how traditional policy-making has failed to curb major public health issues, such as the obesity epidemic.

3. Food retail and service

Until reaching the final consumer, food passes through various food and beverage retailers or food consumer services like hotels, restaurants, canteens, etc. Within the food and beverage retailers, the general distinction is made between specialised retailers (such as bakers or butchers) and non-specialised retailers (grocery stores, supermarkets). Traditionally, consumers travel to the retailer to buy products over the counter or by self-service; however, they can also choose to order via the internet or phone. A key component of ongoing food system changes is the industrialisation of retailing linked to new developments in packaging, distributing, selling, trading and cooking food.
3.1 Concentration in the retail sector

In recent years, the trend has been to give consumers the opportunity to do the majority of their shopping (including both food and non-food commodities) under one roof, which is a process often called supermarketisation or hypermarketisation. This is leading to the disappearance of local, independent grocers who cannot benefit from the cost advantage of a centralised purchasing system and are thus less price-competitive. The speed and current stage of this process across the EU Member States depends on the maturity, the cultural or the geographical characteristics of the local market. In 2008, in the EU as a whole, non-specialised retailers accounted for 86.1% of turnover for the retail sale of food, beverages and tobacco. Between 2004 and 2009, the number of small local grocery shops (with less than 10 employees) fell by 3.7%.

Another principal trend in food retail in recent years has been the tendency to consolidate, leading to an increasing domination by the major owners. In most EU Member States, the market share of the top three retailers ranges from 30% to 50% in Northern Europe has higher concentration levels (up to almost 90% of the top three retailers’ market share in Denmark and Finland) than Southern or Eastern European Member States (e.g. from 23% market share of top three retailers in Italy to nearly 40% in Portugal). However, since the 1990s, the degree of concentration in Eastern Member States has grown rapidly (in 2010, the market share of the top five retailers was 21.8% in Poland and 42.1% in the Czech Republic).

Although ‘traditional’ supermarkets are the leading retail outlets in the euro area (over 33% of grocery sales), the large retailers pursue diversification and multi-format strategies. The discount format is becoming increasingly successful – for instance, in Germany discounter achieved 41.3% share of sales in 2010 and 46.6% share of all outlets in food retailing in 2011 (a 9.5% increase since 2006).

After years of increasing average store sizes, the past few years have seen the growing popularity of small food stores within urban environments. Large retail chains diversify their store formats and develop small-format convenience stores that attract customers with the ease of shopping and proximity. They have emerged in response to changing consumer lifestyles and shopping patterns. A shift to smaller stores, with no room for unproductive inventory items, is also seen as one of the potential consequences of urbanisation. Smaller store formats are more effective in attracting niche consumer segments and can be more easily tailored to meet various demands.

Implications of the consolidation and expansion of retail chains are significant for consumers, manufacturers and producers alike. The food supply and value chains are often illustrated by a funnel whose bottleneck represents a small number of companies that control the dynamics of the whole industry. An example is the case of the major UK retailers which effectively blocked the market for genetically modified products by deciding not to stock them in response to consumer concerns.

3.1.1 Impact on suppliers

A key element of supermarkets' competitiveness is the modernization of procurement in order to allow a large reduction in costs and prices. This transformation covers centralisation of procurement, the decline of the traditional wholesale system (vertical integration of the wholesale and retail level), and the shift to the use of preferred supplier systems (lists of farmers and food processors). As a result of a growing control over the agri-food value chain, supermarkets increasingly set up and oblige their suppliers to get certified according to demanding private standards. Private standards have emerged in response to strict public regulations shifting responsibility for food safety to the private sector and as a way of product differentiation, making use of consumer demands for safety and quality of food. They refer to food safety, integrity of food systems, food provenance, environmental impact, social impact, animal welfare etc. and are frequently more stringent and extensive than public standards. They are set by individual firms (mainly large food retailers) or by collective organisations operating at national (e.g. British Retail Consortium (BRC) standards) or international level (e.g. International Food Standard (IFS)); however, since they are adopted across the food supply chain, each of them may have an international reach. Their presence has raised several concerns; small producers which supply large supermarkets may have difficulties to meet them (too complex and too expensive); they could act as barriers to entry into international markets for developing countries; they could challenge the position of established international public institutions; and they could drive the process of consolidation and integration of the agri-food chain further, thus enhancing the power of dominant firms.
Retailers increasingly contract manufacturers to produce goods that are sold under the retailers’ brand name or as a white label product. Currently, Europe is the world leader in private-label sales with a share of 23% in 2009 (40% in UK, 35% in Germany). Traditionally, these goods have been perceived as a lower-price and lower-quality alternative to branded products. However, over time their quality has improved and they are frequently developed as sophisticated product lines targeting consumers focused on gastronomic quality, health, environment or social values. For supermarkets, private labels provide higher profits than national (i.e. producers’) brands, and because they also create loyalty to a particular supermarket chain rather than to a national brand. For manufacturers, their emergence means greater investment in strengthening the position of their own brand or producing private label products for major retailers following their stipulations, without any recognition among consumers. Sometimes branded manufacturers produce private-label products to make use of excess capacity at their own production plants.

The big food retailers put cost and quality pressures on food manufacturers and producers. Issues of concern are imbalances in the negotiating power between large retail groups and food suppliers that may lead to abusive exercise of market power (and, for example, unfair business practices such as charging manufacturers fees for display, retroactive changing of contracts, etc.). These result in increased competition and the exclusion of many small producers, whereas large multinational food manufacturers of must-stock products remain less affected (retailers may in fact have a weak bargaining position in relation to suppliers of must-stock items). Recently, the multi-stakeholder High Level Forum for a Better Functioning Food Supply Chain tackled business-to-business contractual practices and developed a set of good practice principles on vertical relationships in the food supply chain.

3.1.2 Impact on consumers and diets

From the consumer perspective, the rise of supermarkets means lower prices, wider selection of products (including year-round supply of seasonal and exotic products) and greater product safety. It also results in a general upgrading of the supply chains in terms of efficiency, innovation, product quality and consumer orientation. The positive dietary implications include making a more diverse diet available and accessible to more people. However, the greater availability and variety of food products at lower prices offered by big retailers may lead to both convenience and confusion, and to excessive caloric intakes, especially by less affluent consumers.

On the other hand, the growing consolidation trend raises concerns about the secure supply of nourishing food, particularly for disadvantaged groups. A decline in the number of stores can lead to inequalities in access to food, especially affecting those for whom the proximity of shops is of greatest importance (the elderly, disabled, socially isolated, living in sparsely populated areas, those who cannot afford a car, etc.). A WHO report on food and health in Europe mentions the business practice of some large retail chains adjusting their prices and range of food according to store location and depending on the level of competition within local shopping areas. This may result in restricted access to healthier (e.g. low-fat or low-sugar) versions of foods at a reasonable price in low-income neighbourhoods.

To attract customers and increase sales, supermarket operators use marketing practices such as introducing larger portion sizes for a minimal price, buy-one-get-one-free promotions, price discounts, fidelity schemes like the distribution of coupons and loyalty cards, and even store layouts are designed specifically to promote greater purchasing (e.g. optimised length of aisles, placing items that are often bought on impulse near the entrance, music, aromas, etc.). Customers may consume more of the products they purchase on promotion, and may be enticed to consume more than they intend. Frequently, promotional strategies are targeting the most responsive audiences, especially children (e.g. certain items are placed at the children’s eye level near the checkout).

Supermarket operators determine the range of foods made available, shelf space allocation, pricing of different types of foods, style of promotion, etc. These factors can significantly affect customers’ purchasing decisions. The focus frequently given to ‘value-added’ processed food categories is of particular concern because this may encourage the consumption of energy-dense, nutrient-poor, highly processed foods (see also Chapter 4). The cost of packaged, processed foods can be cut more easily due to their ease of handling and stocking and the efficiency of dealing with large suppliers. Nevertheless, there is also a tendency for some supermarkets to include a specialist retail offer suited to specific consumer segments, including minimally processed products which are healthy, sustainable, fresh, organic, etc.

167 European Commission DG Enterprise and Industry (2011) The impact of private labels on the competitiveness of the European food supply chain
168 European Competition Network Subgroup Food (2012) ECN activities in the food sector. Report on competition law enforcement and market monitoring activities by European competition authorities in the food sector
169 High Level Forum for a Better Functioning Food Supply Chain (2011) Vertical relationships in the Food Supply Chain: Principles of Good Practice
170 FAO (2007) Report of the panel of eminent experts on ethics in food and agriculture
172 WHO Regional Office for Europe (2008) WHO European action plan for food and nutrition policy 2007-2012
It is debatable whether supermarkets’ activities respond to consumer preferences or whether they shape and create consumer demand. Generally, they encourage consumers to buy and thus to consume more179.

3.1.3 Globalisation

The supply chains for food products are extending beyond national borders as a result of trade liberalisation, which has facilitated cross-border mergers and foreign direct investments. Drivers of food retail globalisation include saturation of local markets, search for suppliers offering the best price, and the growing sophistication of consumers178. The European retail grocery industry is expanding and entering different geographical markets. In addition to current global players, there is the possibility of a new generation of globally competitive companies emerging from developing markets180. Initially, the large multinational companies operated as if the entire world were a single entity, selling the same things in the same way everywhere179. However, the strategy that has proved more successful while entering new markets is the customisation of market models and product offers in order to meet local needs and preferences179.

In Europe, global sourcing of food products means that foods are less seasonal and diets may be more diverse as most products are available all year round. Consumers are encouraged to try new foods such as exotic fruits and vegetables that have not featured before in their diets174. On the other hand, this trend has driven a decline in traditional domestic foods and the standardisation of diets across the globe175. It also raises concerns associated with imports from countries where food safety systems are less developed. The globalisation of the food market and the spread of supermarkets are contributing to a dietary transition towards energy-dense diets composed predominantly of highly processed foodstuffs155.

Counter-trends

Growing interest in the idea of buying local is one of the trends opposing the globalisation of the agri-food system. Nine out of ten people surveyed by Eurobarometer in 2011 agree that buying local products is beneficial and that the EU should help to promote their availability180. Currently, just 20 % of European food production is sold locally because of the focus on large-scale, industrialised food production181. Advocates of buying locally produced food mention economic, social and environmental benefits, such as supporting traditional agrarian structures, restoring the bond between the people who produce food and the people who eat it, and the reduction in ‘food miles’181, 182.

This focus on local food reflects the more general tendency to think critically about the food system. There is a wide range of global counter-movements, such as the Slow Food movement183, questioning the standardisation of food taste and culture, supporting environmental sustainability, or addressing issues around the social justice and power of the food industry multinationals. More customers are willing to pay higher prices for food that is fair trade or organic (see also Section 3.4).

3.2 The food-service sector

Out-of-home consumption accounts for a significant and growing proportion of European food intake184. Food and beverage consumer services generated almost one-quarter of the turnover of the total food, beverages and tobacco retailing in the EU-27 in 2008156. The food-service sector in the EU-27 is fragmented – in 2008, it comprised almost 1.5 million enterprises, typically micro or small in size (almost 70 %)156. Restaurants and mobile food services have dominated the sector, accounting for more than half (55.1 %) of all the enterprises in 2009, while beverage-serving activities accounted for 40.6 % of the remaining enterprises, and the share of the event catering and other food-services subsector was below 5 %156. Food-service sales account for approximately one-third of consumer expenditure on food186. Nevertheless, the food-service industry has been severely affected by the financial and economic crisis which resulted in a 5.4 % reduction in the volume of EU-27 household expenditure on catering services between 2008 and 2009 compared to a 2.4 % reduction in total food and beverages expenditure156.

According to 2008 data, the highest numbers of food-service enterprises were located in Spain and Italy (18.4 % and 17.1 % respectively)156. These were typically small family-run enterprises, while in Northern Europe it has become relatively common to find a number of food and beverage chains (especially in Latvia, Lithuania, Finland and the UK)156. This trend correlates with the growth of major fast-food chains that successfully tapped into the increasing demand for swift, convenient meal solutions at affordable prices154. In the UK, 50.4 % of all meals eaten out of home were purchased at quick-service restaurants in 2011 (up from 47.3 % in 2009)187.

179 Coca-Stafaniak et al. (2010) Int J Retail Dist Manag 38(9):677-697
155 Committee of the Regions (2011) EU CoR Press Release COR/11/3
186 Slow Food International webpage (accessed in June 2012)
187 Wallop, H (2012) The Telegraph, Fast food becomes the UK’s meal of choice
An increase in eating out has significant dietary implications. These depend on the service providers’ decisions about the available menu choices, which are made according to criteria such as cost, preparation time, ease of cooking, storage needs and shelf-life. Food can be produced on-site using traditional methods or assembled from standard ingredients including frozen or chilled products.

Generally speaking, food consumed away from the home is associated with a higher total energy intake. Out-of-home foods are usually richer in fat, including saturated fat, and lower in fibre, micronutrients and overall nutritional value compared to food eaten at home. Greater attention has also been paid to the nutritional quality of food served in public institutions (health and social services, childcare services, schools, workplaces, etc., including vending machines) as they are one of the most important sources of eating out of home in terms of energy intake, especially for schoolchildren.

In this context, it is necessary to mention the strong marketing power of fast-food chains which is linked to the promotion of energy-dense and nutrient-poor foods and unhealthy eating habits (excessive portion sizes) among children. Furthermore, the growing importance of the food-service sector and its ability to absorb higher and higher consumer expenditure inspires growing competition between food service and food retailing. Supermarkets respond to this challenge by introducing more ready-to-eat or ready-to-heat foods, thus also supporting the change in consumption patterns towards more processed food.

### 3.3 Relevance of information and communication technologies

Use of information and communication technologies (ICT) has been one of the main drivers of change within society and businesses for more than a decade. Innovation in ICT is seen as a way to maintain or increase market shares.

**Rise of online grocery retailing**

Electronic commerce continues to grow in the EU, but still lags behind the Asia-Pacific region and currently accounts for only 3.4% of retail sales (food and non-food), with a very uneven distribution among Member States and a North-South divide. Online grocery retailing is a relatively undeveloped sector with 7% of sales online in 2008 (1.5% of total grocery spend in 2011). However, online purchasing is expected to be the fastest growing channel in grocery retailing in the next few years (22.1% growth for online in 2011 compared to 2.5% growth for total grocery).

### Mobile and wireless technologies

Mobile and wireless technologies are emerging as the most dominant consumer technology platform and it is forecast that by 2013 more than 2 billion mobile users globally will have made a purchase via their handset.

At present in the EU, m-commerce (electronic commerce conducted from a mobile phone, tablet, etc.) is still less-well developed and its growth is slower than in the US and Japan. Nevertheless, the percentage of EU consumers who visited an online retailer site from their mobile phone increased from 10% in 2008 to 28% in 2010 (compared to 41% in the Asia-Pacific region).

Simultaneously, retailers are extending supply-chain technology capabilities. Developments such as 2D/matrix/QR (Quick Response) or barcodes, magnetic stripes on credit or loyalty cards, and RFID (radio-frequency identification) tags and readers have not only enhanced supply-chain efficiency (real-time visibility into inventory and buying trends) but have also created new levels of communication between retailers and consumers, enabling a more personalised service.

The dissemination of smart phones has been also increasingly supplying customers with personal barcode and RFID readers, too. These lend themselves to providing information in a rapid and easy-to-use format whilst shopping, thus becoming the focus of advertising strategy as well as providing easy access to more detailed information, for instance, for consumers suffering from food allergies. They are used for enhanced online shopping – for example, in Korea, virtual grocery stores are being set up in the form of billboards with photographs of products and QR codes to scan with the smart phone. The mobile technology is also changing the nature of checking out, billing and charging consumers (instant/self-checkout, personalised marketing: coupons and discounts offered based on the purchasing list and loyalty programmes).

Through mobile technologies, retailers can reach consumers anywhere at any time. At the same time, online and mobile technologies create a virtual extension of the storefront where customers can expect and demand services 24 hours a day.

Adoption of consumer technologies will define new service models that move beyond selling individual products to deliver an improved customer experience.
Use of social media/multi-channels
Adoption of ICT is also of growing relevance to retailers and their suppliers in the context of multi-channel retailing (retailing that combines several types of sales channels, such as physical stores, internet, mobile, catalogues, call centres, social networking and digital displays, to reach more and different consumers).

Consumers increasingly identify and use many different channels and sources of information to optimise the different elements of their grocery shopping (e.g. comparison between offer and price)\(^{179}\). A key element is the spread of social media by which consumers get discounts, look for collective buying opportunities (e.g. Groupon) and, above all, influence the buying behaviour of other consumers (reviews, evaluation, recommendation sites, etc.). To successfully adopt multi-channel strategies, retailers (and also food-producing companies) will increasingly develop these new tools to reach consumer groups and impact their behaviour by interacting with selected social communities and managing communication on the sites\(^{177,191}\).

Data analytics and personalisation
The multitude of channels through which retailers are interacting with consumers and the spread of ICT amplify the amount of consumer data that can be collected. These include analysis of transactions (products purchased, financial records), tracking the physical location of consumers, visits to websites, social media posts, surveys, etc. The increased need to leverage the huge amounts of information about consumers and their shopping behaviour will stimulate further development of customer data analytics solutions and advanced prediction tools\(^{177,179}\). These tools are used to analyse consumers’ behaviour patterns and build consumer profiles to get valuable insights about their expectations and responses to various marketing strategies (promotions, brands, channels, messages, etc.). This information is used to develop personalised marketing campaigns, services and customer experiences, for pricing and promotional decisions, and for fostering customer loyalty. Nevertheless, the industry methods for assessing consumer behaviour may also be used by public health researchers and authorities to build strategies promoting healthy dietary patterns\(^{179}\).

3.4 Other trends shaping marketing strategies
The general trend shaping the food industry is to provide unique products that meet consumer needs. The debate continues as to whether consumer demand influences retailer behaviour or retailers influence consumer preferences through their product selection and marketing. Nevertheless, a number of trends most likely to affect the food industry in the coming years can be identified.

Increased importance of health and well-being
Consumers are paying greater attention to aligning their food choices with a healthy lifestyle, a trend (and consumer segment) that is expected to grow significantly\(^{163,177,192}\). There have also been calls by governments and civil society aimed at retailers and food caterers to play a greater role in addressing obesity. At the same time, consumers want convenience and to maintain a certain food-related quality of life (i.e. eating habits, food choice, meal patterns, etc.).

Meeting these seemingly contradictory demands is a substantial challenge. To attract health-conscious consumers, retailers have been developing nutrition-related activities, such as reformulating and developing healthy lines of own-brand products, introducing front-of-pack nutrition labels, promoting fruits and vegetables, and implementing nutrition-education initiatives (e.g. sponsoring sports events). Fast-food companies have started to declare the nutritional composition of their products, have initiated changes in cooking practices in an attempt to lower fat, salt and sugar levels, have introduced healthier options (e.g. salads with low-fat dressing, no sugar-sweetened beverages) and some portion sizes have been reduced\(^{170,195}\). Nevertheless, many of these initiatives have been criticised for their lack of efficiency\(^{173}\).

Growing concern about sustainability
Another trend that will require a response from the sector is an increase in consumer awareness regarding sustainability. A major environmental concern is food waste, resulting from logistical and technical malfunctioning in the retail industry (overstocking, marketing strategies, quality standards), and from issues including portion size, packaging, storage, (lack of) awareness, individual preferences, planning, and socio-economic factors in the food service\(^{196}\). The retail and wholesale sector is responsible for 5 % and the food-service sector for 14 % of EU-27 food waste.

Particular attention is also increasingly being paid to societal issues covering human rights, fair working conditions of food producers, animal welfare, and global food security. These are often extended to topics such as nutrition and healthy lifestyles (responsible marketing, targeting children, etc.). More and more consumers in Europe are willing to opt for fair trade and ‘green’ products\(^{192}\). Sustainability issues are also likely to significantly influence the retail sector (new approaches to energy consumption, packaging, transport, logistics, certification, quality control, pricing strategies, etc.) as they are increasingly being seen as a way of keeping ahead of the competition\(^{195}\).

References
\(^{161}\) Rutsaert et al. (2013) Trends in Food Sci & Technol 30 (1): 84-91
\(^{162}\) Vidéria et al. (2012) Background paper on Sustainable Food Consumption and Growth. RESPONDER project
\(^{163}\) European Modern Restaurant Association (2008) Our commitments to the EU Platform
Drive for transparency

Food safety concerns, growing consumer awareness (health, sustainability), and interest in how their food is produced and transported, and what it contains, have been driving the demand for food transparency, which is yet another trend facing the retail sector.161

A key element of ensuring food safety and providing information on food products is food traceability. Traceability systems enable rapid and precise food recalls, involving the ability to identify, at any specified stage in the food chain (from production to distribution) where the food came from and where it went (the so-called OUOD: ‘one-up, one-down’ system). This is crucial for building consumer trust in the safety of the food supply chain. Given the multiplicity of ingredients used to produce foods and their global sourcing, the technologies in current use will have to be improved or replaced to simplify data collection and standardisation and to satisfy an increase in requirements regarding the speed of traceability systems (emerging ‘critical tracking events’ system)198.

Information about food products provided through labelling and advertising has played a major part in marketing strategies, offering consumers the possibility to differentiate between products. In the EU, labelling rules are put in place to enable consumers to obtain comprehensive information (ingredients, quantity, durability, allergen content, origin, etc.) and to protect them against claims that could be misleading (see also Chapters 4.6 and 6). Nevertheless, possible confusion among consumers resulting from the proliferation of voluntary labelling schemes and lack of convergence between them has become a concern. In addition to the tendency to demand and deliver more and more information about foodstuffs, there is also a need for reduction of complexity and simplification of labels.197

New business models

Along with advances in ICT solutions and the increasing adoption of multi-channel strategies, the physical store is becoming one piece in a larger, more connected and interactive customer experience (including activities such as crowdsourcing, competitions, games). Store visits will become increasingly personalised (personalised promotions, recipe inspirations and advice, etc.), enhanced by tools such as dynamic displays, in-store bars, product tasting and trials, all to attract and retain customer interest.177, 198

To target various needs and preferences, and to remain competitive, retailers must also continue to diversify their business. In search for more lucrative niches, they are launching specific advertising campaigns or new product lines and providing completely new services. Increasingly, retailers are seeking a competitive advantage in responding to demographic changes such as population ageing or smaller households (e.g. single parents). The current business model might need to be adapted to better serve the needs of an older population, including, for example, providing shuttle transport, improved home delivery services, easier-to-read labels, changes to outlet design (e.g. wider aisles), or developing specific products.179

4. Food processing and packaging

Processing and packaging food involves the various transformations primary agricultural products (cereals, vegetables, fruits and animals) undergo before they reach the retail market for sale through various distribution channels. All of these activities significantly alter the characteristics of the raw material, making it more palatable and familiar to consumers, and ‘adding value’ in an economic sense.199

4.1 Goals, means and consequences of processing

Nearly all food undergoes processing. Historically, the most important reason to process foods was to preserve them against spoiling and to ensure the provision of safe and edible food. Food-treatment techniques have been further developed to preserve and modify the organoleptic and nutritional properties of foodstuffs, to provide greater variety in food supply, and to maintain or raise nutrient levels. Finally, developments in processing technology facilitate delivery of easy, everyday nutrition solutions such as ready-to-eat and semi-prepared foods. From an industry perspective, the main purpose of food processing is to provide safe and high-quality food according to consumer demands, and to add value.

Food-processing technologies

Primarily, processes to preserve foods include microbial stabilisation (destruction of pathogens and inactivation of their natural toxins and enzymes), as well as chemical (against oxidation, Maillard reaction), biochemical (against enzymatic degradation) and physical (against phase separation, loss of consistency, drying, etc.) stabilisation. These are most frequently achieved by using techniques such as pasteurisation, sterilisation, refrigeration, freezing, fermentation, drying, adding salt or sugar (or other preservatives) and packaging.

161 Welt et al. (2012) Food Traceability. ILFoSIT Scientific Information Bulletin (SIB)
162 High Level Forum for a Better Functioning Food Supply Chain (2011) Report on Food Labelling Practices
166 van Boekel et al. (2010) Mol Nutr Food Res 54(9):1215-1247
Raw materials are converted into foods via a variety of additional transformation processes, such as extrusion, hydrogenation of fats, emulsification, extraction, etc., which often significantly alter their appearance, properties and content. Next, food technology is used to extract components or ingredients (starches, flours, oils, fats, sugars, etc.) from raw materials by phase or molecular separation processes (filters, membranes, centrifugation, crystallisation, distillation). Finally, manufactured foods are made from various ingredients, such as products in which some components have been replaced by others (e.g. soya protein substituting milk protein), or ready-made meals. Foods made from combinations of other processed foods and processed food ingredients are called highly processed foods as opposed to minimally processed foods that have not been substantially changed from their raw, unprocessed form.

**Nutritional implications of food processing**

The principal beneficial aspect of food processing is food safety and the prolongation of storage life. Next, an important beneficial effect is the enhanced digestibility of food and bioavailability of nutrients (e.g. denaturation of proteins or gelatinisation of starch facilitates hydrolysis by digestive enzymes). Processing technologies may promote the formation of desired compounds (flavours, antioxidants, colouring agents) including health-promoting compounds such as vitamins and bioactive peptides produced during fermentation. The development of industrial processing technologies has enabled the global sourcing of foods, thereby contributing to more diversity and less seasonality in diets. Last but not least, processing enhances the sensory quality of food and enhances quality of life by offering convenience in the preparation of meals.

While food processing offers both industry and consumers many benefits, certain aspects raise nutritional concerns. Processing may negatively impact on the nutritional value of foods due to the loss of some essential nutrients, such as certain minerals or vitamins (e.g. refined grains deprived of iron, losses in activity of heat-labile vitamin C, thiamine, riboflavin, folate during thermal processing). Processing may also adversely affect a product’s satiety properties (e.g. processed grains are more easily digested and therefore have lower satiety). Moreover, some methods of food and drink modification can trigger the formation of undesired compounds, such as carcinogenic heterocyclic amines, trans fatty acids (TFA) or polycyclic aromatic hydrocarbons (PAH) (e.g. when frying meat at high temperatures) or acrylamide (during the intense and prolonged industrial cooking of starch-based foods like crisps, French fries). Some substances used to preserve food or to enhance its taste, flavour and appearance can also adversely affect human health. Finally, processing practices may have undesired consequences for food quality, such as loss of texture, discoloration, or a negative effect on flavour. In addition to issues inherent to the technologies being used, food processing poses the risk of food contamination (biological, chemical) in processing plants. In the EU, food-production practices, as well as food additives and contaminants resulting from food manufacturing and processing, are regulated by legislation to minimise the risks to food safety.

Another category of prominent nutritional implications of food processing is related to the growth in consumption of highly (or ‘ultra’) processed foods and their relative importance within diets. Although highly processed foods are not detrimental to health as such, many foods in this category are energy-dense, high in added sugar, sodium, saturated fats or trans fats, grossly depleted of micronutrients, and contain little dietary fibre. The issue is the proportion of diets they occupy. Their frequent consumption unbalances diets, leading to nutritional deficiencies or chronic diseases. Highly processed products are formulated to be convenient (ready to eat or ready to heat) and tempting (appetising, visually attractive and impressively packaged). They are typically branded, very profitable and therefore heavily advertised and marketed (also in supersized packages and portions at discounted prices). All these factors may undermine the normal processes of appetite control, encourage unhealthy eating patterns and drive over-consumption (and obesity).

4.2 Packaging goals

Increased industrial processing of food, greater international trade in food products, extra distribution steps, more information on labels required by consumers and legislation, and less time available for preparing fresh foods (more convenience foods) have all contributed to an increase in packaging. Originally, food packaging was simply a container to hold food but over time its multifunctionality has grown.

The main function of packaging is protection from damage and preservation from external contamination. This involves slowing down deterioration, extending product lifetime (durability) and maintaining the quality and safety of packaged food. Packaging includes barriers to environmental influences such as oxygen, moisture, flavours, heat, light, pressure, enzymes, micro-organisms, insects, dirt and dust particles, etc. It ensures containment (that a product has not been intentionally spill or dispersed). Packaging is also used for convenience (to reduce cooking/preparation time), communicating information (labelling), marketing and branding (to increase the attractiveness of products), and serves the functionality of the supply chain and distribution.
Traditionally, the ideal packaging material had to be inert and able to prevent molecular transfer from or to packaging materials. Nowadays, the concept of active and intelligent packaging has emerged, which allows packages to interact with food and the environment and play a dynamic role in ensuring food quality. In the EU, food contact materials should be manufactured in compliance with regulations so that any potential transfer to foods does not raise safety concerns, change the composition of the food in an unacceptable way, or have adverse effects on product taste and odour.

4.3 Food industry in the EU

The food industry in the EU comprises around 288,000 companies, provides jobs for more than 4 million people, and is considered to be one of the main industrial sectors. The food-processing sector is quite fragmented, with numerous small- and medium-sized enterprises (ca. 99%) but, at the same time, is dominated by large companies (1% of companies provide 52% of the turnover and 37% of the jobs). One of the most important trends is globalisation, based on cheap transport and the search for the cheapest mass producers. Although globalisation facilitates the year-round supply of certain foods, at the same time it raises new food safety concerns (e.g. food-borne-disease epidemics, unpredictable nature of food fraud, different attitudes to food safety in different countries) and has put pressure on natural resources. Geographical shifts in food production and new emerging markets have also had an impact on the industry. The EU is a net exporter of food and drink products, but the industry’s export market share worldwide has been declining, in favour of emerging economies. A related important trend is structural change. Mass production and economies of scale are major elements of being competitive, particularly on a global scale. In addition, the consolidation trend within the food industry has been driven by a shift in control over the food economy towards food retailing and service. Small-scale companies try to remain competitive through more specialisation, serving local markets, and concentrating on regional preferences. Large companies compete on the global market and respond to the power of international food retailers by putting a new emphasis on branding and marketing.

The food industry is increasingly being challenged by changing consumer preferences (due to income developments, shifts in population structure, new lifestyles, more out-of-home and ready-meal consumption, more demand for meat, organic, local, fair trade products, etc.) and regulatory issues (food safety, animal welfare, environmental quality, etc.). As in retailing, the debate continues around the extent to which consumer needs influence industry and how much food-processing companies influence consumer choice. Other key trends shaping the food industry include a new focus on health and nutrition, sustainability issues and new technological developments.

4.4 Growing importance of health and nutrition

One of the key challenges facing the food industry is the need to react to the greater emphasis consumers, governments and international organisations are putting on health and the relationship between diet and disease. Food manufacturers are confronted with dietary concerns related to the consumption of highly processed foods (see Section 4.1) and marketing and advertising strategies that encourage unhealthy behaviours (see Chapter 2). On the other hand, this trend also offers an opportunity to capture the growing market in health-promoting food products. Health may become both a marketing tool and a commitment for companies. The emergence of functional foods and reformulated products and other health-related activities (e.g. sponsoring sports events) come in response to these challenges.

Reformulation

Recently, in the EU, many initiatives have been taken to reformulate foods, led by industry and governments (e.g. WHO European Action Plan for Food and Nutrition Policy and the EU Platform for Action on Diet, Physical Activity and Health). Reformulation activities include the reduction of certain nutrients (sodium (salt), saturated fats, industrially produced trans fats, sugars) in processed foods and/or their fortification with other nutrients (vitamins, minerals, etc.), and portion-size reduction. They aim to modify/reduce nutrient and energy intake in diets.

A number of issues affect product reformulations. Reformulation creates costs for industry. Technical challenges include the need for technologies to drastically reduce sugar, salt and fat without compromising sensory properties (taste, texture) and food safety (durability, artificial sweeteners). Reformulated products can face a lack of consumer enthusiasm (change in taste, reluctance to consume ‘artificial’ ingredients, perception of decline in quality, higher price). The potential for reformulation is also

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205 Robertson et al. (eds.) (2004) Food and health in Europe: a new basis for action. WHO Regional Publications European Series 96


209 European Commission EU Platform for Action on Diet, Physical Activity and Health (accessed in July 2012)

210 Webster, J. (2009) Reformulating food products for health - the way forward
influenced by regulatory issues, such as standards, defining criteria, recommendations and target values for food composition. Finally, although some of these modifications are positive, others may be harmful (e.g. replacing fat with higher sugar content and ‘light’ products with reduced but still too high energy density).

**Functional foods**

A functional food is a “food that beneficially affects one or more target functions in the body beyond adequate nutritional effects in a way that is relevant to either an improved state of health and well-being and/or reduction of risk of disease. It is consumed as part of a normal food pattern. It is not a pill, a capsule or any form of dietary supplement”211. Examples include food in which one or several components have been modified, replaced or enhanced. The list of promising **dietary active compounds** continues to grow (vitamins, carotenoids, fatty acids, syrbiotics (probiotics/prebiotics), minerals, trace elements, antioxidant enzymes, etc.) and thus the types and potential applications of functional foods are growing steadily (products for gastrointestinal health, immune function, mental health, physical performance, early development, etc.).

**Fortification** has been a common strategy in functional food development. Simple techniques, such as formulation and blending, have been used successfully in the control of deficiencies of, for example, vitamins A (fortification of margarine) and D (fortification of milk), and iodine (salt iodisation). The composition of foods may be also modified by breeding or biotechnology (vitamin A-enriched rice, vitamin E-enriched vegetable oils). Technologies are also emerging that aim to improve the nutritional properties of food by preventing the deterioration of physiologically active compounds (microencapsulation, edible films and coatings, vacuum impregnation), although they have yet to become widely used211, 212, 213.

The expansion of functional foods may be further driven by a greater knowledge of **nutrigenomics** (metabolomics, proteomics, bioinformatics, and the development of nutritional markers). This may enable the development of foods for targeted population groups (suffering from allergies, diabetes, cardiovascular disease, etc.) or even foods tailored to individual needs (**personalised nutrition**). Although dietary advice based on DNA is already commercially available (e.g. through numerous internet sites), dietary advice based on DNA is already commercially available (e.g. through numerous internet sites), translation of genetic knowledge into meaningful and reliable dietary recommendations is currently valid in only a few cases (e.g. phenylketonuria, galactosemia – see also Section 1.2.2).

Due to the lack of a commonly used definition and limited data, the EU market for functional food can only be estimated: it ranges from EUR 6 to 20 billion, representing 1–3 % of the total EU food market. However, available information indicates that the market is growing and is expected to do so for the foreseeable future214. Functional foods promise health benefits but while some of these **benefits** are well established, the health efficiency of some products remains unverified215. Moreover, they have the potential to mislead consumers as, for example, fortification of an unhealthy product with micronutrients does not make it healthy, although consumers are led to believe it does216.

### 4.5 Growing interest in sustainability

The transition towards healthier, and more environmentally friendly and socially fair food is increasingly driving the shift to a more sustainable food supply215.

**Increased adoption of Corporate Social Responsibility regimes**

Food products tend to become services more than industrial products, i.e. more focus is put on their non-physical characteristics. Interest in ethical and responsible food consumption is increasing (see Section 3.4). Governments, NGOs and the media together with internet-based social networks are pushing companies to account for the social consequences of their activities215. Retailers, who are becoming very influential in specifying the requirements of the foods they put on sale, are exerting pressure on food manufacturers to adopt sustainable manufacturing processes (see Section 3.1.1)216. Finally, companies are looking to make more use of strategic social positioning in the markets. Consequently, sustainable (‘green’) projects are increasingly not only part of corporate social responsibility (CSR) programmes, but also an integral element of strategy215.

**Environmental sustainability**

From an environmental and economic point of view, sustainable food production requires efficient use of resources and minimised waste generation. The food manufacturing industry produces 39 % of EU-27 food waste, resulting largely from logistical or **technical malfunctions** such as overproduction, misshapen products, and product and packaging damage217. Minimising waste at the manufacturing level includes strategies such as reuse, recycling and recovery (e.g. producing bioenergy from waste and finding uses for by-products)218.

Packaging can prevent more waste than it generates by providing protection for and minimising the damage of transported goods and thus

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218 FoodDrinkEurope (2012) Environmental sustainability vision towards 2030
minimising waste. For most products and environmental indicators, the share of packaging in the environmental impact of a product’s life cycle is less than 10% (one of the main exceptions being the packaging of beverages). The environmental impact of packaging is being addressed by using biobased materials, biodegradable materials, reusable packaging and recycling of packaging materials (see Section 4.8). However, currently is number of issues remain to be solved such as low practicability of recycling, confusions related to sorting plastics (e.g. some incorrectly sorted biodegradable packages may contaminate the recycling chain of non-biodegradable materials) or environmental impact of bioplastics over the lifecycle (use of resources, use of hazardous chemicals during production etc.).

Efforts to enhance resource efficiency cover sustainable sourcing (supporting sustainable agricultural practices to protect and promote natural resources and biodiversity), improving energy performance (process optimisation and control), cutting greenhouse gas emissions (using by-products and waste as a source of renewable energy, investments in low-carbon technologies), improving water management (improving wastewater quality, water recovery and reuse) and development of innovative packaging materials with improved environmental impact. Resource-efficient food production is challenged by a number of factors, e.g. minimisation of water use has not proved very effective due to the limited use of recycled water (negative consumer perception) and because it is very often cheaper to pay for fresh water than investing capital in water-purification plants.

Another topic of debate is transport. Across Europe, food travels increasingly longer distances with the growing number of distribution steps. An immediate and plausible solution for reducing the adverse environmental impacts of transport would be to shift from global sourcing to local production. However, the simple sustainability indicator based on total food kilometres (‘food miles’ concept) has proven to be inadequate because food imported into an area may be produced more sustainably than locally available food, even if the latter has a lower transport footprint. The adverse environmental impact of transport can be reduced through improved efficiencies in product sourcing, modal shifts, distribution networks, route planning and vehicle choice.

Social justice

In general, the main areas of ethical concern in food production are food and water security, food safety, nutritional technologies and specific production practices and conditions (animal welfare, environment, fair working conditions, new (bio- and nano-) technologies, etc.). The European market for fairly traded food products is growing – the most frequently sold products being coffee, bananas, orange juice, tea and chocolate. However, the overall market share only represents around 1%. It is worth noting that fair trade and working conditions are an issue not only for developing nations – European farmers also require fair payment for their produce. Companies can manage ethical workplace conditions by following international standards, such as the Social Accountability Standard 8000 (SA 8000) or the ISO standard for CSR (ISO 26000).

4.6 Informing the consumer

Ethically responsible food production (reformulation, fortification, shift to environmentally friendly or socially just production, etc.) involves investment in both cost and time. Once such an effort has been made, industry seeks to communicate this fact to consumers and to use it as a marketing tool. At the same time, consumers search for information about food they want to buy. To support informed choices, a label (presentation, promotional campaign) should be scientifically valid, understandable and not misleading.

In the EU, the scientific substantiation of nutrition and health claims has to be verified by the European Food Safety Authority (EFSA) and approved by the European Commission before they can be used in labelling and marketing. The recently performed authorisation process has revealed a number of issues related to insufficient levels of characterisation of products/substances (e.g. probiotic products) that claim to bring health benefits, and the lack of a solid scientific foundation for cause-and-effect relationships supporting such health claims. Furthermore, the latest revision of the rules on nutrition labelling has created intense debate between industry, governments, consumers and public health organisations over methods for setting up nutritional profiles, defining recommended daily values, the adequacy of GDAs (Guideline Daily Amounts) and colour coding (traffic light) system, consequences of nutrition declaration on a per-portion basis vs. per 100g/ml, and the need for ‘front-of-pack’ nutrition labelling (currently voluntary), etc. Nutrition labelling and health claims are high on stakeholders’ agendas because they effect consumer perception of the ‘healthiness’ of foods and thereby influence purchase decisions and nutritional behaviour.

Another issue concerns the communication of the environmental impact of a food product. The main difficulty is the lack of uniform environmental assessment methodologies for food and drink, which is related to the high diversity of food commodities and the range and complexity of environmental...
factors and impacts along the food chain. The existing indicators of food product sustainability include food miles, air freight, the product's carbon footprint, water footprint, etc. However, the validity and method of calculating some of these indicators remain under discussion. The global Ecolabel Index\(^{223}\) lists 147 labelling schemes for food. They differ in terms of scope, coverage of different phases of the life cycle, and their relation to agriculture, geographic coverage and certifying criteria. The multi-stakeholder initiative 'European Food Sustainable Consumption and Production (SCP) Round Table' establishes reliable and harmonised environmental assessment methods for food products (the ENVIFOOD Protocol, based on life-cycle assessments). It is also developing recommendations on tools for environmental communication, aiming at preventing the use of misleading claims ('green washing')\(^{222}\).

### 4.7 Emerging technological developments in food processing

New technologies, such as microwaving and steam-cooking, have changed the way domestic cooking is performed, including the availability and use of (semi-) finished processed foods in everyday cooking. Food-processing technologies are subject to many changes for several reasons, **safety and productivity** being among the main drivers. An overview of reasons for change is given in Table 4.1.

Traditionally, thermal processes have been used extensively in food technology. Other technologies have only started to emerge recently, among them being high-hydrostatic pressure, pulsed electric fields, cold plasma, and ultrasound applications. Along with **inactivating pathogens** and enhancing the **shelf-life** of the treated foods, several of these emerging techniques have the potential for **food-structure engineering** (novel textures). High-pressure treatment can gelatinise starch granules and proteins; the resulting structures have different properties in comparison to heat-induced gelatinisation and may be used to create products with novel biological and technological functionalities. An overview of emerging processing techniques is given in Table 4.2.

**Table 4.1: Drivers for innovation in food processing (based on \(^{221}\))**

<table>
<thead>
<tr>
<th>Push</th>
<th>Pull</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TECHNOLOGY</strong></td>
<td><strong>PRODUCT</strong></td>
</tr>
<tr>
<td>• High pressure</td>
<td>• Quality</td>
</tr>
<tr>
<td>• Pulsed electrical fields</td>
<td>• Safety</td>
</tr>
<tr>
<td>• Pulsed light</td>
<td>• Convenience</td>
</tr>
<tr>
<td>• Irradiation</td>
<td>• Freshness</td>
</tr>
<tr>
<td>• Ultrasound</td>
<td>• Extended shelf-life</td>
</tr>
<tr>
<td>• Cold plasma</td>
<td></td>
</tr>
<tr>
<td><strong>ECONOMY</strong></td>
<td><strong>CONSUMER</strong></td>
</tr>
<tr>
<td>• Cost reduction</td>
<td>• Healthy diet</td>
</tr>
<tr>
<td>• Increased productivity</td>
<td>• Well-being</td>
</tr>
<tr>
<td>• Process reliability</td>
<td>• Ethical production</td>
</tr>
<tr>
<td>• Sustainable production</td>
<td>• Eco-Friendliness</td>
</tr>
<tr>
<td>• Availability of raw materials</td>
<td>• Hedonism</td>
</tr>
<tr>
<td></td>
<td>• Price</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process</th>
<th>Advantage</th>
<th>Disadvantage</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pressure</td>
<td>No formation of undesired compounds</td>
<td>No formation of desired heat-induced flavour</td>
<td>Fruits, vegetables, cold cuts</td>
</tr>
<tr>
<td></td>
<td>Nutritional quality largely maintained</td>
<td>Not continuous</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retention of freshness</td>
<td>Expensive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical modification (novel textures)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulsed electric field</td>
<td>No formation of undesired compounds</td>
<td>Spores are not inactivated</td>
<td>Conductive foods</td>
</tr>
<tr>
<td></td>
<td>Gentle processing, retention of freshness</td>
<td>No formation of desired heat-induced flavour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cell disintegration</td>
<td>No inactivation of anti-nutrients and enzymes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvements of mass transfer processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical modification (novel textures)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultrasound</td>
<td>Facilitates heat and mass transfer</td>
<td>Limited microbial stabilisation</td>
<td>Used in combination with other techniques</td>
</tr>
<tr>
<td></td>
<td>Physical disruption</td>
<td>High cost</td>
<td></td>
</tr>
<tr>
<td>Pulsed light</td>
<td>No thermal damage</td>
<td>Only active at surfaces, or in transparent liquids</td>
<td>Packaging material</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Transparent liquids</td>
</tr>
</tbody>
</table>

\(^{223}\) Ecolabel Index (accessed in July 2012)
\(^{222}\) Knorr et al. (2011) Annu Rev Food Sci Technol 2:203-235
Nanotechnology has three main application areas in food technology (excluding packaging and distribution)\textsuperscript{225}.  
- **Quality control**: nano-based sensing systems have the potential to detect chemical as well as microbial contaminants in the supply chain with high specificity and sensitivity; other fields of application include electronic noses and tongues.  
- **Processing**: nanotechnology enables surface coatings to control the adhesion of macromolecules and microbes, thus reducing biofilm formation which can lead to food spoilage and contamination.  
- **Nanofiltration** technologies have the ability to separate and concentrate useful components from waste (e.g., recycling of water and recovery of valuable side-stream products).  
- **Functional foods**: nano-sized delivery systems with controlled and targeted release properties (e.g., liposomes, nano-emulsions, micelles, solid lipid nanoparticles, encapsulation) for food additives, nutrients and bioactives are expected to have a high potential to add functionality to food. Other application areas will include texture engineering to improve ‘mouth-feel’ by using nanostructured components made from natural or synthetic polymers, and nanostructured edible coatings to protect perishable food from oxidation, moisture uptake and microbial attack.

### 4.8 Emerging technological developments in food packaging

Safety, logistics, sustainability, marketing and ergonomics are the main factors influencing the development of packaging technology (Table 4.3). Changing lifestyles and growing demand for convenience are factors that continue to influence packaging design most significantly\textsuperscript{226, 227}. The resulting solutions cover packages that are easy to open and re-close, user-ready (microwave or oven-ready, containers enabling selective heating of certain foods in the same tray), easy to store, contain single-serving portions, are portable and easy to use ‘on-the-go’ (containers that are self-heating, based on the exothermic reaction of calcium oxide with water, or self-cooling thanks to zeolite technology)\textsuperscript{228, 229, 230}. Packaging is a critical factor in the consumer decision-making process, both at the point of sale\textsuperscript{226} and while shopping online\textsuperscript{221}. Therefore, it is becoming more and more customised to reach many target audiences\textsuperscript{222}. The development of high-speed packaging machinery, print-on-demand technology and printed electronics enables the production of a short series of packages containing, for example, scratch-off labels with tickets for sports events, programmable messaging labels, write-on labels, labels containing most popular names, etc. Technological advances, such as 2D barcodes, digital watermarks, image recognition, and radio-frequency identification tags (RFID) facilitate the equipment of packages with elements that are linked to electronic information and traceability systems\textsuperscript{233}. These enable better supply-chain efficiency and product traceability (automatic identification for inventories) and also extend the communication function of packages beyond printed messages to reach consumers’ smart phones. Examples of information that can be transferred in this way include shopping lists, recipes, recommendations of healthier choices, daily nutrient requirements, and detailed information on the foodstuff, such as the origin of each component or manufacturing process\textsuperscript{229} (see Sections 3.3 and 3.4).

<table>
<thead>
<tr>
<th>Safety</th>
<th>Preservation of package content and extension of shelf-life through packaging in modified atmosphere</th>
<th>Preservation of package, tamper indication</th>
<th>Safety of packaging components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics</td>
<td>Traceability, inventory control, supply-chain efficiency, handling</td>
<td>Disposal, reuse, recycle</td>
<td>E-business, home shopping</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Environmental impact, costs related to packaging life cycle</td>
<td>Needs of various categories of users (disabled, seniors, children)</td>
<td>Honest information</td>
</tr>
<tr>
<td>Marketing</td>
<td>Health awareness (demand for fresh produce without artificial additives; portion control)</td>
<td>Demand for convenience, demand for small/individual portions (smaller households)</td>
<td>Communication, branding, differentiation, product image and visibility</td>
</tr>
<tr>
<td>Ergonomics</td>
<td>Functionality, handling (e.g. easy grip)</td>
<td>Accessibility of packaging content (easy to open)</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{225} Robinson et al. (2009) Nanotechnology developments for the agrifood sector - report by the Observatory NANO.  
\textsuperscript{228} Brody, A. (2012) Food Technol 66 (7):72-74  
\textsuperscript{229} Brody et al. (2008) J Food Sci 73 (8):107-116  
\textsuperscript{230} Mahaiq et al. (2010) Trends in Food Sci Tech 21:117-128  
\textsuperscript{231} Packaging Europe News (2012) Packaging: a medium with considerable power (accessed in July 2012)  
\textsuperscript{233} Lindqvist et al. (2012) Packag Technol & Sci 25:1-6
The trend towards environmentally friendly packaging is driving the development of lightweight materials and bioplastics (biodegradable/compostable or biobased materials)\textsuperscript{234}. There is growing interest in innovative feedstocks and waste-conversion technologies to use recycled materials from organic waste, agricultural by-products, food or wood processing (e.g. technology to convert CO\textsubscript{2} emissions into polyactic acid)\textsuperscript{232,235}. Currently, the most significant tendency is to advance technologies to produce biobased conventional plastics (chemically identical to petrochemicals), such as plant-based polyethylene (e.g. made from sugar-cane ethanol) and polypropylene (e.g. produced by genetically modified bacteria)\textsuperscript{232,234}. In parallel, the research is ongoing into improving the functional properties (heat and tear resistance, permeability, clarity, durability, etc.) of biopolymers so that they can compete with conventional plastics\textsuperscript{232,234}.

The trend towards improving barrier properties continues to drive innovation in packaging materials. Packaging should protect the food from a variety of destructive or harmful substances and factors while, at the same time, preventing the loss of volatile flavours and aromas. No material is completely impermeable and in some applications high barriers are undesirable (e.g. fresh fruits require continual access to oxygen)\textsuperscript{236}. Ways to enhance packaging barrier properties include development of new polymers, polymer blending (barrier and standard), coating, lamination, metallisation, using complex multi-layer films, and nanomaterials\textsuperscript{236}.

Research is increasing into the application of nanotechnologies in packaging\textsuperscript{236,237}. Polymer nanocomposites, for example, improve barrier properties (gas, solvent permeability), mechanical and oxidation stability, temperature control, flexibility, flame resistance, etc.\textsuperscript{236,237}. In addition, some nanomaterials have positive effects on shelf-life (and thus on food quality and safety) owing to their antimicrobial properties and/or, particularly for fruit and vegetables, their ability to adsorb and decompose ethylene (e.g. commercially available materials with embedded silver nanoparticles)\textsuperscript{237}, Nanotechnology also offers the possibility to retain or encapsulate bioactive molecules and to release them slowly and steadily.

Advances in nanotechnologies contribute to the development of active packaging (designed to interact with the content and/or environment) and intelligent/smart packaging (capable of monitoring the condition of the content and/or environment)\textsuperscript{238}. Examples of active packaging include oxygen scavengers or antioxidants (e.g. to inhibit the degradation of ascorbic acid, oxidation of fat, growth of aerobic micro-organisms), moisture adsorbers, ethylene scavengers (to prolong the post-harvest life of fruits and vegetables), flavour and odour absorbers/releasers (quality improvement), antimicrobials (e.g. ethanol releasers)\textsuperscript{239}. Intelligent packaging solutions include time-temperature indicators (which change colour after exposure to temperature, and RFID tags), seal and leak indicators (colour-changing gas/moisture detectors), freshness and/or ripening indicators (colour-changing indicators of volatile metabolites (diacetyl, amines) produced during ageing of foods), and biosensors (enzyme, conductivity, bioluminescence sensors, immunosensors) to detect, for example, the presence of harmful organisms, toxins, chemicals or genetic modifications\textsuperscript{237,238}.

5. Relevant aspects of primary production

Primary production provides the raw material for the food chain and thus influences diets to a certain extent. It is determined by a variety of social, economic, physical and biological factors, as well as policy measures. European consumers expect a continuous and secure supply of safe, healthy and affordable food, plus an increasing awareness of environmental and animal welfare aspects in food production (see Section 2.4). To meet these expectations, strict European standards\textsuperscript{239,240} are in place to regulate agricultural management practices, with particular attention to product quality.

5.1 Food availability

Food availability is determined by the combination of: (i) food production, (ii) food distribution, and (iii) food exchange (food trade)\textsuperscript{241}. Current food-retail systems ensure that practically any type of food is made available to European consumers. Given the uninterrupted functioning of food distribution and exchange, food availability in the EU is mostly dependent on global and European primary production. Considering the expected increase in the global population in the coming decades, mainly in Asia and Africa, food production needs to increase by an estimated 60 % until 2050\textsuperscript{242}. EU agriculture, which accounts for 18 % of world food exports and about 40 % of total food production in the OECD\textsuperscript{243},

\textsuperscript{235} Hattersley V. (2011) Packaging Europe 6 (2):28-33
\textsuperscript{236} Duncan, T. V. (2011) J Colloid Interf Sci 363:1-24
\textsuperscript{237} Cushen et al. (2012) Trends in Food Sci Techn 24:30-46
\textsuperscript{238} Pereira de Abreu et al. (2012) Food Rev Int 28:146-187
\textsuperscript{239} Council Regulation (EC) No 73/2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers
\textsuperscript{241} ESF & COST (2009) Forward Look: European Food Systems in a Changing World
\textsuperscript{242} OECD & FAO (2012) Agricultural Outlook 2012-2021
will also have to increase its output. Several recent foresight studies have dealt with the issue of **global food security**. All stressed the urgent need to find a way to increase production globally, while reducing the environmental impact of primary production, also with a view to alternative uses of biomass, for example to replace fossil fuels, dealing with scarcities of essential production factors, as well as the adaptation to and mitigation of climate change.

In general, it can be assumed that EU citizens will not face future food insecurity, considering the overall comparatively high economic levels and the rather modest population growth in the Union. However, food insecurity elsewhere could also have repercussions for the EU food market, e.g. via disturbances in food trade and price increases. The latter might have a greater effect on economically weak population groups, potentially leading to the consumption of poor diets (see Sections 1.4 and 2.4). Food security is therefore one of the core objectives of the post-2013 EU common agricultural policy, fostering global market stabilisation, thus ensuring continuous and secure food supplies to EU consumers at a reasonable price.

**Environmentally sustainable agriculture**

Climate change will also influence EU agriculture. Current models predict that **Europe will be 1.5°C warmer** in the 2021-2050 period, compared to the 1960-1990 period, and the most pronounced changes will be seen in the Scandinavian and Mediterranean regions. One major effect of climate change is the desertification of soils. In Europe, extensive soil- and land-degradation processes are occurring, mainly in Southern Europe, which is the major fruit and vegetable producing region. This, coupled with drought periods of increased frequency and intensity and the predicted rise in temperature, may impact European fresh food produce and, as a result, reduce both its availability and accessibility. Climate change might also have implications for food safety.

EU primary production needs to become more **environmentally sustainable**. Studies show that human activities on a global scale, including food production, use more resources than our planet’s capacity to recover can tackle. Agriculture and food production are associated with a range of environmental externalities and contribute significantly to greenhouse gas emissions, fossil energy use, loss of biodiversity, soil erosion and water pollution, thereby raising concerns in terms of sustainability. One important driver towards a more sustainable primary production could be changing consumer demand (see Section 2.4). In this context, organic farming is experiencing growing demand (between 2000 and 2008, the cultivation area increased by an average annual growth of 6.7 % (EU-15) and 20 % (EU-12). Consumption in this sector is increasing with an average annual growth rate of up to 18.1 % in the four largest markets – France, Germany, Italy and the UK – although the overall environmental impact compared to conventional agriculture is still under discussion.

In the context of future food security, the Western-type diet, with its large share of animal-based products, also plays a role. Several studies suggest that sustainably feeding a world population of 9 billion in 2050 will be impossible without **significant changes** in animal production and consumption. Increased resource and energy efficiency of intensive production systems, shifting meat production patterns from ruminants to monogastric animals (e.g. pigs and poultry) or changing consumption patterns towards diets with less meat are possible approaches to reducing the environmental impact of animal livestock.

Livestock is a significant contributor to the serious environmental problems we face today. Animal livestock production is estimated to be responsible for 9 % to 18 % of the overall anthropogenic greenhouse gas emissions. Furthermore, animal production systems have a negative energy balance, and need intensive energy input while returning a disproportionately low output in calories. Around 33 % of global arable land (ca. 30 % of the Earth’s entire land surface) is devoted to producing feed for livestock, while 39.8 % of the EU’s total agricultural input costs are associated with animal production.

**5.2 Affordability of food**

Affordability of food refers to the purchasing power of households or communities relative to the price of food. As such, it is one of the main contributing factors to the access to food, and determines the amount and composition of food that the consumer can purchase. **Agricultural commodity prices** increased sharply in 2006-2008, and are expected to remain at relatively high levels in the mid-term future. Influencing factors include, among others, unfavourable weather conditions, increased demand, trade policies, and changes in oil and fertiliser prices.

244 UK Government Office for Science (2011) Foresight: Future of food and farming
245 INRA & CRAD (2009) Agrimonde foresight study
246 European Commission (2011) Sustainable food consumption and production in a resource-constrained world – The 3rd SCAR Foresight Exercise
248 European Environmental Agency (2012) Climate change models for Europe
250 FAO (2008) Climate change: Implications for Food Security
253 ETP (European Technology Platform) 2008 Food for Life – Implementation Action Plan
257 PBL Netherlands Environmental Assessment Agency (2011) The Protein Puzzle
260 European Commission, Joint Research Centre (2010) Evaluation of the livestock sector’s contribution to the EU greenhouse gas emissions (GGBLS) – final report
261 Kastner et al. (2012) PNAS 109 (18): 6868-6872
Price volatility has also increased, to its highest level in the period 1997-2008 since the 1960s for most agricultural products, and is likely to remain high262. The recent effects of drought in the US and Canada, as well as in Russia, Ukraine and Kazakhstan, on corn and wheat harvests and the resulting price increases are a case in point. Given that price fluctuations cannot be eliminated completely, policy mechanisms are needed to constrain their harmful impacts263, 264. A report by international organisations highlighted a number of weaknesses in relation to the provision of market information at the global level and the coordination of policy responses to food-price volatility. The primary recommendation of this report is to develop market-information-share mechanisms, price-monitoring instruments and appropriate early-warning systems to tackle food-price volatility265. The EU is introducing instruments for sharing market information and price monitoring266.

5.4 Emerging technologies and applications

Sustainable intensification through new technologies has the potential to increase food production yields while minimising the negative impacts of agricultural activities. Biotechnology (e.g. marker-assisted selection (MAS), genetic modification, cloning, synthetic biology) might be used in the future to support plant and animal breeding processes towards improved efficiency, but also towards the development of products with an enhanced nutrient profile or other health-promoting characteristics267, 271.

Another approach to decrease the environmental impact of meat production is to grow animal muscle tissue in vitro, rather than rearing whole animals272, 273. This technology is called ‘cultured-meat’ (or in vitro meat) production and is currently being researched. In addition, cultured meat could have a lower risk of animal-borne diseases and epidemic zoonoses, and potentially facilitate the manipulation of nutritional, textural and taste profiles, such as the quantity and quality of fat, with possible positive health effects.

The concept of ‘vertical farming’ brings together traditional indoor farming with cutting-edge technologies to meet the increasing food demand without additional land use. This approach includes the use of a vertical, multi-storey greenhouse equipped with hydroponic plant cultivation, using recycled, nutrient-rich urban wastewater. It could offer the sustainable production of a safe and varied food supply (year-round crop production), including local production of fresh products for urban consumers, and could offer solutions to the restoration of ecosystems that have been sacrificed in horizontal farming. Related technology is currently under development, since a major limitation of the concept (artificial light demand) is still unsolved274.

5.3 Quality of agricultural products

Since its reform in 2003, and as subsidies have been decoupled from production activities, the direct effect of the EU common agricultural policy on production levels has decreased progressively. In the past, agricultural subsidies were key production incentives worldwide –this trend may have shaped European diets to a certain extent. Over the second half of the 20th century, technological developments and policy changes resulted in a substantial increase in agricultural production. Subsidies were primarily designed to support farmers’ competitiveness and have never been designed to affect people’s diet. Yet, food price, availability and quality affect food choices.

Therefore, one could ask the question whether past agricultural policies have contributed to the current obesity trend in Western Countries267; in other words, has the promotion of basic cereals (corn) and soybeans contributed to the growth of, for example, processed food and meat production? Together with other factors related to consumption patterns, affluence and life style, such trends in production could have contributed to higher animal protein diets or to the growing consumption of energy-dense, sugar-rich, more salty and fatty food.

There is a wide range of risk factors related to agricultural production can have a significant impact on food safety. In agricultural production, there are several possible chemical and biological hazards, including residues of synthetic agrochemicals, environmental pollutants, nitrates, animal-feed contaminants, veterinary drugs or animal disease patterns, natural plant toxins, biological pesticides, pathogenic microbes with increased antibiotic resistance, and fungal mycotoxins which can all cause chronic or acute diseases268. Strict European food standards269, 270, 271, 272 are in place to ensure the highest quality and hygiene of agricultural food products. However, changes in environmental conditions, e.g. through climate change, or agricultural practices (as in the case of bovine spongiform encephalopathy, BSE) and new technologies can lead to new risks. For this reason, the EFSA has initiated the development of procedures to monitor, collect and analyse information and data for the identification of emerging risks in the field of food and feed safety269.

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262 European Commission (2011) Agricultural Market Briefs, 1, 1-11
266 European Commission (2012) Short-term outlook for arable crop, meat and dairy markets
6. Food and health policy measures

Food safety, as the precondition for a healthy diet, is targeted by a comprehensive regulatory framework at the EU level to protect consumer safety and interests. A ‘farm-to-fork’ approach is being followed, including feed production, primary production, food processing, storage, transport, and retail sale, enabling comprehensive and effective regulation and control of the food chain.

Health-related aspects of foods and diets other than food safety are largely addressed at national level in the EU, following the Member States’ responsibility for public health. In its White Paper – A strategy for Europe on nutrition, overweight and obesity related health issues, the European Commission set out to increase coherence and consistency of Community policies and to coordinate and support Member States in their efforts to promote a healthy and balanced diet. Initiatives envisaged in the Commission strategy include regulatory approaches, for example, on labelling and health claims, as well as a partnership approach between relevant stakeholders (e.g. Member States, private actors) on an international, European and local level with continued support to existing networks (such as the EU Platform for Action on Diet, Physical Activity and Health), and the creation of new networks such as the High Level Group on Nutrition and Physical Activity. Cooperation with the WHO also takes place, against the background of the WHO European Action Plan for Food and Nutrition Policy 2007-2012, to facilitate data collection and monitoring the implementation of these strategic documents.

Indeed, the presence of food and health is increasing on the agendas of policy-makers and regulators worldwide, and there is a rise in the number of initiatives to promote healthier nutrition of European citizens. Capacci et al. classify the initiatives into four broad categories: interventions supporting more informed choice; interventions changing the market environment; interventions not explicitly targeted at healthy eating; and generic interventions. Overall, 129 initiatives were identified and, as far as possible, evaluated. Most initiatives are related to supporting an informed choice, including public information campaigns and school education programmes. Initiatives targeting the market environment mainly focus on the regulation of school meals and promotion of private-sector actions. For actions other than information campaigns, a geographical focus on Scandinavian countries, the UK, and France was detected. According to Capacci et al., current evidence suggests that nutrition labelling policies and regulation of advertising to children generate positive behavioural responses. Product reformulations have not yet been evaluated but are considered to be potentially effective. Furthermore, a recent OECD analysis concluded that health education and promotion, regulation and fiscal measures and counselling in primary care are cost-effective measures for tackling obesity, with a combination of measures having the potential to increase impact via synergistic effects. However, overall, more empirical evidence is needed to fully evaluate the efficiency of policy measures.

Some selected measures are detailed below:

Informed choice

**Food labels**

Consumer information on food labels is subject to EU regulation. The aim is to provide consumers with the necessary and accurate information on the products they buy. So-called health claims play a specific role in increasing the consumer attention towards food products with a particular health benefit, on the one hand to providing information, being a strong marketing tool on the other. The health claims regulation provides the framework for harmonised rules for nutrition (such as “low fat” or “high in fibre”) and health claims (suggesting a health benefit). For the latter, this involves an evaluation by the EFSA of the scientific evidence for proposed food-health or food-compound-health effects and their legal approval according to the regulation, as well as a risk-benefit assessment of foods where necessary. The European Commission recently approved a list of 222 health claims which have been evaluated by the EFSA based on scientific evidence supporting these claims.

There are various approaches in Europe and beyond which aim to guide the consumer towards more healthy choices between or within food categories linked to their nutrient composition. These are based either on national initiatives, such as the keyhole symbol in Nordic countries, or on private initiatives, such as the choices programme in Europe or NuVal® in the US, or on participating retail sectors, such as the traffic-light system in the UK. No such system has been agreed for the EU in the recently adopted Regulation on the provision of food information to consumers. This aims

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278 Capacci et al. (2012) Nutr Rev 70:188-200
279 OECD (2010) Obesity and the Economics of Prevention: Fit not Fat
281 European Commission, Joint Research Centre (2012) How can science support policy makers in addressing the nutritional challenges of Europe? Workshop report EUR 25165 EN
283 EFSA Journal 2010; 8(7):1673
284 European Commission press release 16 May 2012 IP/12/479
285 Nordic Council of Ministers – About the Keyhole (accessed in July 2012)
286 Choisir Programme website (accessed in July 2012)
287 NuVal website (accessed in July 2012)
288 National Health System UK – Food Labels website (accessed in July 2012)
289 Regulation (EC) No 1169/2011 on the provision of food information to consumers
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to further harmonise labelling and calls for mandatory nutritional information on energy, fat, saturated fat, carbohydrates, sugars, protein, and salt (per 100g or ml). It also improves the legibility of labels and adds requirements for the labelling of vegetable fat/oil origin, or the highlighted labelling of allergens, for example.

Various scientific initiatives recommend more consumer guidance using front-of-pack signposting systems290,291,292,293, following the revelation that the average attention paid to nutrition labels when consumers are shopping lasts between 25 and 100 milliseconds, which does not allow for a conscious processing of information. The wider introduction of such systems may also be facilitated through the WHO-initiated process to harmonise nutrient profiling294 (classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health).

Caloric information in menus

In the US, the provision of caloric information is required from major chain restaurants with 20 or more outlets nationwide, taking full effect in 2012, and complementing and superseding initiatives at the state and municipal level. A recent study found that restaurants that currently make caloric information less readily available have menus with a higher fat, salt and energy content295.

Advertising control

The European Parliament recently called for a check as to whether stricter rules are needed for advertising aimed at children and young people, in particular regarding food296. In addition, in his report the UN Special Rapporteur on the right to food recommends taking stricter actions to limit/abolish the advertising of foods with known detrimental health effects297. Currently in the EU, the Audiovisual Media Services Directive obliges relevant media service providers298 to replace the taxed products might not necessarily seem difficult to predict, and substitutes chosen to replace the taxed products might not necessarily present a healthier food choice305.

In the EU, food taxes are not subject to European Union legislation. However, national initiatives need to comply with the functioning of the EU’s internal market. Some Member States already have taxes in place: Denmark has taxation on chocolate and confectionary and soft drinks. The tax on saturated fat introduced in October 2011 was abolished about one year later due to implementation costs. In September 2011, Hungary introduced a health food tax targeting packaged products with high sugar, salt or caffeine levels. France recently introduced a soft drink tax, with effect from January 2012304. However, these measures are too recent to be able to evaluate their impact on diets.

Apart from possible health effects, food taxes could create revenues which, in turn, could be used to support public health initiatives. However, since taxes also affect the economically more vulnerable societal groups, it is recommended to combine them with price reductions/subsidies for healthier alternatives305. Substitution effects must also be taken into consideration when developing fiscal measures. Consumer reaction to price changes still seems difficult to predict, and substitutes chosen to replace the taxed products might not necessarily present a healthier food choice305.

Fiscal measures

Purchase decisions in the area of food are sensitive to product price (e.g. the price elasticity is between 0.27 and 0.81 (absolute values) for foods and non-alcoholic beverages in the US, out-of-home food, soft drinks, juice and meats are most responsive to price changes (0.7-0.8, i.e. a 10 % price increase would lead to a reduction of 8 %-10 % in demand299). Against this background, fiscal measures to direct food consumption towards a more healthy choice have gained more and more attention in recent months. Also, the WHO recommended the use of fiscal measures to influence food prices towards promoting healthier diets300, 301. This recommendation was recently taken up by the UN Special Rapporteur on the right to food297. There is some evidence that increasing the price of selected foods could be an effective approach to reducing consumption. However, these price increases need to be sufficiently large to have any real effect302, 303.

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Making the healthy option available
Apart from promoting the consumption of fruits and milk via the School Fruit Scheme\textsuperscript{307} and the School Milk Scheme\textsuperscript{308}, initiatives targeting reformulation are ongoing to reduce salt, sugar and fat consumption via the EU Salt Reduction Framework\textsuperscript{309}, as is a new framework for a holistic approach to all nutrients as well as portion sizes and frequency of consumption. As regards the latter, the European Commission is currently working towards a common framework for the reduction of saturated fat within the holistic approach\textsuperscript{310}. For removing trans fats in diets, a variety of successful initiatives exist in different countries worldwide (e.g. voluntary or mandatory reformulation of food products as well as nutrition recommendations, awareness campaigns and labelling). A common prerequisite for success seems to be the collaboration between governments, industry, public health sectors and academia, while the media play an important role in increasing consumer awareness. Adaptation of measures to the local environment is also considered necessary. For example, in Denmark, since 1994, a combination of high media and consumer awareness, agreement with relevant industries, followed by legislation in force since 2003 has resulted in nearly zero intake of trans fats, at the individual as well as population level\textsuperscript{311}.

\textsuperscript{307} European Commission, School Fruit Scheme
\textsuperscript{308} European Commission, The European School Milk Programme
\textsuperscript{309} European Commission DG Health and Consumers (2012) Implementation of the EU Salt Reduction Framework (Results of Member States survey)
\textsuperscript{310} European Commission (2012) High Level Group on Nutrition and Physical Activity, Flash Reports of meetings on 2 February 2012 and 14 June 2012
\textsuperscript{311} L’Abbé et al. (2009) Eur J Clin Nutr 63:50-67
Tomorrow’s healthy society

Research priorities for foods and diets

ANNEX II

BRIEF OVERVIEW OF RELEVANT DRIVERS FOR FUTURE FOOD PRODUCTION AND CONSUMPTION

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I. Introduction

The scope of the present document is to give a brief literature overview of relevant drivers potentially impacting future food production and consumption as well as consumer behaviour.

This review is mainly focused on the European Union (EU); however, where relevant, global trends are presented. In some cases, aspects of the described drivers have already been covered adequately by the background document (Annex I). In these cases, this review will only present additional elements that complement the background document.

This review does not aim to provide an exhaustive description of each of the drivers; rather, it aims to give a food-, diet- and (where applicable) health-related snapshot of the current situation and a glimpse of future developments, which will allow for a better understanding of the four scenarios.

II. Review

1. Climate change and natural resources

Climate change has the capacity to influence, either directly or indirectly, food and freshwater availability and access, and health. Apart from its direct impact on food and health, climate change effects could also result in significant economic damage, leading to a permanent loss of over 14 % on average of global consumption per capita. The magnitude and rate of climate change depends on the rate of increase of greenhouse gas concentrations, the extent of the effect greenhouse gases can have on temperatures, precipitation and sea level, and on natural influences on climate (volcanic activity, sun intensity, ocean circulation patterns).

According to the Organisation for Economic Co-operation and Development (OECD), in 2050 the world economy will be four times larger and will consume about 80 % more energy than today. About 85 % of that energy would come from fossil fuels, while only 10 % would come from renewable sources (including biofuels) and about 5 % from nuclear power. The major energy users would be the emerging economies of Brazil, Russia, India, Indonesia, China and South Africa (BRIICS).

Agricultural land use in BRIICS and OECD countries is expected to peak before 2030 and then decline, due to population growth slowdown and improvements in crop yield, while in the rest of the world a further increase is foreseen in the use of agricultural land. The size of mature forests is projected to decrease by 13 %, due to increased agriculture, commercial forestry and human encroachment. This reduction will also lead to a 10 % decrease in biodiversity by 2050. The biodiversity of water habitats is also under threat.

Freshwater availability will be reduced across many regions; 2.3 billion more people are expected to be living in areas of water stress by 2050; and groundwater depletion could well become the main problem in urban and agricultural water supply.

Although air pollution is also expected to be a threat to ecosystems and human health (premature deaths due to exposure to particulate matter are expected to double by 2050), knowledge is still limited on the possible future impacts of air pollution.

1.1 Past and future trends

Global warming is a certainty: the earth’s atmosphere has become successively warmer in the last three decades, compared to any preceding decade since 1850, and it is considered likely that the period 1983-2012 was the warmest since 600 AD. The total temperature rise between the 1850-1900 average and the 2003-2012 average is 0.78 °C. This warming is also reflected in an increase in ocean (upper 75 metres) temperature by 0.09-0.13 °C per decade in the period 1971-2010. Ice sheets have been losing mass in Greenland and the Antarctic, while glaciers have continued to shrink around the globe. Arctic ice and northern hemisphere spring snow cover have also continued to decrease. The rate of sea-level rise has been higher in the last 50 years than the mean rate during the previous 2000 years; in the period 1971-
2010, mean sea level rose by 0.19 metres, mainly due to glacier mass loss and ocean thermal expansion.

The continually increasing emissions of greenhouse gases are expected to cause further global warming and, subsequently, changes in the specific components of the climate system. Compared to the period 1986-2005, the global mean surface temperature is likely to increase by 0.3-0.7 °C in the period 2016-2035. In the periods 2046-2065 and 2086-2100, the average mean increase could range between 1.0-2.0 °C and 1.0-3.7 °C, respectively⁴ (Figs. 1.1, 1.2). In general, more hot temperature extremes are expected, in parallel with fewer cold extremes, as well as a greater contrast in precipitation between wet and dry regions and seasons. The Arctic region is expected to warm more rapidly than the global mean, and the mean warming over land surface is predicted to be larger than over the oceans. Finally, arctic sea-ice covers, spring snow cover in the northern hemisphere, as well as global glacier volume are all expected to decrease, while global sea levels are expected to continue to rise during the 21st century⁵.

The 2009 Copenhagen Agreement⁶ established that, to combat climate change and its effects, the increase in global temperature should be held below 2 °C, compared to the pre-industrial (before 1850) global mean temperature, and that to achieve this deep cuts in global emissions are required. This was further recognised and confirmed in the Cancun Agreement⁷, which also introduced a set of agreements that represent key steps forward in implementing plans to reduce greenhouse gas emissions, including the development and transfer of clean technology, the scaling up of funds to enable developing countries to take greater and effective action, encouraging the participation of all countries and creating networks and assisting vulnerable people in particular to adapt to climate change effects⁸. According to an OECD¹ report, by 2050, and in the absence of additional policy interventions, an increase of 50 % is expected in greenhouse gas emissions, due to a 70 % increase of CO₂ emissions from energy use. Under these conditions, compared to pre-industrial years, the increase in global surface temperature is likely to exceed 2 °C by 2050; in 2009, it was already 0.7-0.9 °C higher. Even if the Cancun Agreements

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④ Copenhagen Accord (2009) - U.N. Framework convention on climate change
⑥ Cancun Agreement (2011) - U.N. Framework convention on climate change
⑦ United Nations - The Cancun Agreements website (accessed in November 2013)
were to be fully implemented, they would not be sufficient to prevent a global average temperature increase above the 2 °C threshold by 2050, unless very rapid and costly emission reduction measures were realised after 2020 (Figs. 1.1, 1.2). In almost all future scenarios, global warming will certainly exceed 1.5 °C by 2100 (compared to 2010)\(^9\), which is a more than 2 °C increase from pre-industrial temperatures\(^9,10\), ranging from 1.5 °C to 8.6 °C, depending on future greenhouse gas emissions and on different climate models. The likelihood of experiencing a warming of 4 °C by 2100 is around 20 %, even if current mitigation commitments and pledges are fully implemented. If these mitigation goals are not met, a warming of 4 °C could occur as early as 2060\(^10\).

### 1.2 Climate change in Europe

The average temperature of EU land area in the decade 2002-2012 was 1.3 °C higher than pre-industrial levels\(^11\), being the warmest decade on record. In the period 2021-2050, a 1.0-2.5 °C temperature increase (compared to 1961-1990) is predicted for Europe, while for the period 2071-2100 the increase could range between 2.5 °C and 4.0 °C. Under all scenarios examined by the European Environmental Agency (EEA), the EU target of limiting global average temperature increase to less than 2 °C, compared to the pre-industrial period, will be exceeded\(^11\).

Overall, in the 21\(^{st}\) century the largest temperature increases are projected to occur over eastern and northern Europe in winter and over southern Europe during summer, during which heatwaves are expected to become more frequent and to last longer. Widespread reduction in snow cover in Europe, as well as a 22-66 % decline in the volume of European glaciers is also predicted by 2100\(^11\). Average surface-water pH is projected to decline further, to 7.7-7.8 by 2100, which is a 100-150 % increase in acidity relative to present conditions, with possible consequences for ocean organisms, including marine ecosystems and fisheries. Global and European sea-level rise in the 21\(^{st}\) century is more likely to be less than 1 metre than more than 1 metre.

### 1.3 Global climate change - future impact

A 2 °C warming (compared to pre-industrial levels) is expected to have significant impact on food production and freshwater availability\(^10\). Food availability in particular may be threatened either directly by a short-term lack in supply, threatening geographical areas that are already vulnerable to hunger and under-nutrition, or indirectly by affecting food access and utilisation due to collateral effects on household incomes\(^12\).

The predicted 2 °C rise in temperature would alter rainfall patterns, increase glacier melting and mean sea level, worsen the intensity of extreme weather phenomena (heatwaves, droughts, storms, floods), and result in significant loss in biodiversity. A 4 °C increase could lead to a sea-level rise of 0.5-1.0 m by 2060, as well as an increase in the intensity and frequency of high temperature extremes\(^10\). Heatwaves and droughts could also affect freshwater availability, which could be a serious issue in 2050, since a 55 % increase in global demand for water is expected due to manufacturing, domestic and electricity needs. In addition, in 2050, nearly half of the global population is expected to live under conditions of water scarcity\(^13\).

### 1.4 Climate change - future impact in Europe

The main climate change effects in Europe are expected to be: a) increases in heatwaves and droughts in Southern Europe and the Mediterranean basin; b) melting of ice and snow in its numerous mountains; c) sea-level rises, intense rainfall and floods threatening coastal regions, river deltas and flood plains; and d) increasing temperatures and melting ice in the Arctic and far Northern European regions\(^11\). According to a study of the physical and economic impacts of climate change in Europe, if the climate conditions of 2080 were to be applied today, the EU would lose between 0.2-1.0 % of household welfare, based on the effects of river flooding and rising sea levels in coastal areas on agriculture and tourism. Regions such as Southern Europe, the British Isles and Central-North Europe will be more affected by climate change due to higher temperatures, while Northern Europe may experience positive effects on agriculture and may even enjoy net economic benefits\(^14\).

Climate change effects on plant life and, as a consequence on agriculture, will be of particular importance. It is predicted that, by 2100, European plant species will shift several hundred kilometres to the north, while forests will contract in the south. In the agricultural sector, the length of the growing season is expected to increase further enabling a northward expansion of warm-season crops, while the expected shortening of crop-growth phases could be particularly detrimental to the yield of cereals and oilseed crops, due to the shortening of the grain-filling phase\(^14\). As a result, climate change is projected to improve the suitability for growing crops in Northern Europe and to reduce crop productivity in large parts of Southern Europe. Most models predict an increase in precipitation...
in Northern Europe during winter and a decrease in Southern Europe during summer, as well as a decline in river flows in Southern and Eastern Europe (particularly in summer) and an increase in the rest of Europe (particularly in winter)\(^{13}\).

Another effect of climate change is the desertification of soils. In Europe, extensive soil- and land-degradation processes are already occurring, mainly in Southern Europe. Coupled with drought periods of increased frequency and intensity and the predicted temperature rise, this is likely to impact European fruit and vegetable production and, as a result, reduce both their availability and accessibility\(^{12}\). Rain-fed agriculture might also be affected in Southern Europe, resulting in the development of more irrigation infrastructure to cope with water scarcity\(^{12}\).

Although the effects of climate change on wild fish distributions are difficult to pinpoint, due to high fishing rates, future climate change is likely to increase fishing-catch rates in the Arctic region and to decrease (or not increase) catch rates in all other European seas. Although aquaculture has the means to adapt to climate change, specific aspects such as the optimal location for growing, the appropriate choice of species, and the efficiency of the production could all be affected\(^{11}\).

Human health effects are also to be expected and, depending on the geographical area, climate-change effects on existing health risks could be either positive or negative. In addition, health risks may emerge that are new to specific regions. In general, potential health benefits from favourable outcomes, for example, milder winters and a reduction in cold-related mortality, are not expected to outweigh the impact of negative outcomes, such as heatwaves and floods. Specifically, it is predicted that cold-related mortality will decline, also allowing for better socio-economic and housing conditions in those areas currently affected by low temperatures during winter. In contrast, the length, frequency and intensity of heatwaves are expected to lead to an increase in mortality, especially among vulnerable population groups. In addition, the higher temperatures are expected to increase the risk of food-borne diseases, such as salmonellosis, and coupled with intense floods, could also increase the risk of campylobacteriosis, and cryptosporidiosis as well as norovirus and non-cholera Vibrio infections\(^{11}\).

2. Agricultural commodity and food prices

In the present foresight study, agricultural commodity price is one of the two major drivers behind the scenarios. Agricultural commodity prices have an impact on consumer food prices and thus on food choice and diets. In the following chapter, past, current and future trends for agricultural commodity prices and the main factors driving commodity price rises and affecting price volatility are summarised, and the relationships and price transmission from commodity to consumer (retail prices) are presented.

2.1 Past trends and current situation

Between 1960 and the early 2000s, the Food and Agriculture Organization (FAO) food price index\(^{16}\) showed a substantial fall in global food commodity prices. From 2003 to 2006, a slow increase was followed by a rapid increase up to mid-2008, before a decline in the second half of that year (Fig. 2.1). Once again, food price indices have risen rapidly since the second half of 2010. During July 2010 to February 2011, the FAO food price index rose by approximately 40 %, higher than the peak recorded during the 2008 food price increase, while the price index of cereals alone rose by 70 % in the course of 12 months, from June 2010 to June 2011\(^{17}\). In addition, there is a worrying increase in price volatility, as attested by the increase in the standard deviation of agricultural commodity prices, which was more than twice as high in the last five years compared to the previous 15-year period (29.3 compared to 13.5)\(^{22}\).

In the short term, higher food prices directly raise poverty in developing countries; the 2008 food price increase was estimated to push 105 million people into poverty in low-income countries, while the 2010 price surge resulted in 44 million people driven into poverty in low- and middle-income countries\(^{15}\). The 2008 price surge was the fifth since the 1973 oil crisis. Even though food prices are expected to rise in the foreseeable future, there is no clear pattern in their timing and duration\(^{20}\).

Between 2005 and 2012, the EU food price index\(^{22}\) increased by an average of 3.6 %, ranging from 1.6 % in milk, cheese and eggs to 4.0 % in meat. From November 2011-December 2012, agricultural commodity prices in the EU rose for maize, soft

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14 FAO consumer food price index is a measure of the monthly (and annual) change of specific food commodity prices: cereals, vegetable oil, dairy, meat and sugar
15 Barilla Center for Food & Nutrition (2011) - Food prices and market volatility: the variables involved
16 FAO Food Price Index (accessed in March 2014)
19 EU consumer food price index is a measure of the monthly (and annual) change of specific food commodity prices: bread and cereals, meat, milk, cheese and eggs, fats and oils and sugar
20 Barilla Center for Food & Nutrition (2011) - Food prices and market volatility: the variables involved
21 European Commission Joint Research Centre - European Soil Portal website (accessed in December 2013)
wheat, barley, butter and beef, ranging from 1.3 % to 3.4 %, while a fall in prices was observed for durum wheat, pork and poultry (-1.1 %, -3.4 % and -0.5 %, respectively). The average increase in consumer (retail) food prices in the EU was 3.6 %, between December 2011 and December 2012, ranging from 1.6 % for milk and eggs, 1.7 % in fish/seafood, and 2.2 % in bread and cereals to 4 %, 6 % and 8.3 % in meat, fruits and vegetables, respectively22.

2.2 A summary of factors affecting food commodity prices

Various factors have influenced the increase of prices which began in 2003 (Figs. 2.2, 2.3). In general, the reasons lie on the supply side of the food chain20. Thus, weather extremes, such as droughts that affect world crop production and trade, can greatly affect food prices. It has been estimated that, barring other factors, the effects of rising temperatures and changes in rainfall since the 1980s account for a ~19 % increase in cereal prices17.

Energy costs also directly influence operating costs in the agricultural sector, ranging from cultivation to transport, including machinery, fertilisers, heating etc. Other factors include policies that promote biofuel use, which increase demand for maize and vegetable oils for non-food uses, as well as the depreciation of the United States (US) dollar. Slower growth in cereal yields over the last 30 years due to low investment, and trade policies, such as export bans or massive purchases in response to supply emergencies (droughts, crop failures), and stock market effects are also factors affecting food prices17, 20, 23, 24.

On the demand side of the food chain, the growing world population and its continuous urbanisation, economic growth in developing countries with large populations, as well as the observed shift towards a Western-style diet (rich in meat and dairy protein and fats) lead to greater demand for resources such as grazing land, water, petrol and fertilisers, further driving up the agricultural cost of food. For example, the Westernisation of dietary habits in certain developing countries with very large populations, such as China and India, has increased the demand for meat, and hence animal feed and farmland to be used for grazing, indirectly affecting food prices17.

It is clear that commodity food prices depend on multiple variables and it seems that, due to the complexity of the factors involved and often relationships between the variables which are not precisely quantifiable, it is currently not possible to distinguish between the factors that have either major or minor impacts17.

2.3 Consumer (retail) food prices and price transmission

Wide price variations exist between EU Member States in various food and beverage groups. In 2012, the prices for food and non-alcoholic beverages in Denmark were 143 % of the EU average, while in Poland they were 61 % of the EU average. Denmark, along with Austria, were the most expensive EU countries for meat, fish, bread and cereals, while Cyprus was the most expensive country for milk, cheese and eggs. On the other hand, the lowest prices for the above-mentioned food categories were observed in Poland, except for bread and cereals, which were cheapest in Bulgaria25. As regards oils and fats, the most expensive EU country is Denmark,
whereas fruits, vegetables and potatoes are the most expensive in Sweden. The lowest prices for this category can be found in Poland. When comparing the price dispersion within the EU between 2003 and 2012, the conclusion is that food prices have converged for each of the main group of the above-mentioned food categories.

The share of household consumption expenditure for food and non-alcoholic drinks can be seen in Fig. 2.4. In 2013, EU households spent on average 12.6% of their expenditure on food and drinks, slightly less than 2010 (at 13%). In 2010, after “housing, water and energy”, expenditure on food and drinks is ranked second, along with transport in the consumption expenditure of EU households²⁶. The highest proportions of household budget dedicated to food and beverages were in Romania, Lithuania, Bulgaria and Estonia, while the lowest proportions were observed in Germany, Austria, Ireland, the UK and Luxembourg.

According to a US report²⁷, the “farm value” of commodity raw materials used in food production (including what is necessary for their production in terms of agricultural expenses, energy, etc.) accounts for 19% of total consumer food price (in 2007), down from 37% in 1973. The remaining share of final retail price was due to the so-called marketing bill, which includes the cost of labour, packaging, energy requirements, transportation, advertising, interest, business taxes, and profits; all of the above are not attributed to basic agricultural commodity prices.

²⁶ Food and Drink Europe (2011) - Data & Trends of the European Food and Drink Industry
²⁷ Informa economics (2007) - Analysis of Potential Causes of Consumer Food Price Inflation
²⁸ Schnepf, R. (2013) Congressional Research Service - Consumers and Food Price Inflation
The agricultural commodity price peak in the second half of 2007 generated a rapid increase in producer and consumer food prices (Fig. 2.5)\(^{29}\). The situation differed across the various EU Member States (MS); among those MS who are more recent EU members, such as Bulgaria, Latvia and Lithuania, consumer prices increased by more than 15%, while in older MS, such as Austria, Denmark and Ireland, consumer prices rose by approximately 6%. These differences could be explained by the generally higher levels of wage and price inflation in the former, and because the share of agricultural commodities price in the final retail food price is higher. Therefore, consumer food prices were more sensitive in those countries, while the share of household consumption was typically higher in the countries joining the EU after 2007 (Fig. 2.4).

The state of the food industry in the different MS also plays a major role in the degree to which increases in agricultural commodity prices are transmitted to consumer food prices. For example, more-developed food industries tend to be less affected by raised commodity prices, and in less-developed food industries, the input share of the agricultural sector and the food process itself tends to be higher.

This may not always be the case, however, as demonstrated by the food price increase in the UK in the period 2005-2011 – an old MS with a developed food industry. Food price indices from 2011 show an increase in food prices ranging from 3% (Ireland) to 20% (Denmark) for most EU MS (baseline = 2005), including the southern European ones that were hit harder by the recent financial crisis. The highest increases were observed in Poland (25.8%), Slovenia (28.6%), UK (34.3%), Estonia (42.3%) and Hungary (53.1%)\(^{30}\).

The transmission of prices from the food production sector to consumers could also be buffered by a reduction of profit margins in the retail sector. In most of the euro-zone countries, from mid-2007, consumer food prices started to rise much slower than producer food prices, whereas the opposite was true in the five-year period before the food price peaks. Again, in most of the new MS the increase in consumer food prices from July 2007–July 2008 exceeded the producer price increase. The status of market competition may also play a role; the more competitive the food market, the lower the final price levels are likely to be, as firms are compelled to lower their costs or profit margins and bring prices down. Finally, there are some indications that the consolidation of the EU retail sector can have a beneficial effect, leading to improved efficiency and lower prices\(^{29}\). The above details indicate that factors that lie upstream from agricultural production can affect the consumer food prices and explain the differences seen in various MS during the agricultural price peaks of 2007 and 2008\(^{29}\).

In general, fluctuations in agricultural commodity prices tend to be transmitted to producer prices at rates that vary across both product groups and EU MS\(^{31}\). Low transmission rates indicate that changes in agricultural commodity prices tend to be absorbed during pass-through to the food production sector, via a reduction in profit margins. Food markets in developed countries offer many alternatives for a single product, and therefore consumers can respond to changes in food prices by shifting their purchases among different food products. However, this may affect the quality of their diets, via the so-called ‘substitution effect’, whereby the alternative product is low cost but also of lower dietary quality\(^{31}\). In addition, in developed countries, the average share of household budget spent on food is relatively low,


\(^{30}\) TRANSFOP EU funded project (2012) – Food Inflation and the Cumulative Effects of Commodity Price Shocks

\(^{31}\) García-Germán et al. (2013) Working Paper No. 2 ULYSSES FP7 Project
so the impact of increased food prices could be limited, although more vulnerable EU households may still feel the pressure.

As food expenditure rises, other household expenditures might have to be lowered in response, such as health or education. This can have serious consequences for the quality of life among lower socio-economic status households and could increase their vulnerability. In 2011, 24.2% of people were at risk of poverty and social exclusion in the EU, and on average approximately 10% of the population could not afford a meal including meat, chicken, fish (or vegetarian equivalent) every second day; the highest rates were observed in Bulgaria (85.5% of the population). Over the period 2004-2008, a growing disparity in price was observed between nutrient-dense and energy-rich foods, implying that food prices may inhibit consumers’ adherence to healthy dietary habits. In the UK, from 2007-2012, consumer food prices rose by 32%, which is twice the EU average price increase. Compared with the years prior to the crisis (2005-2007), in 2010-2012 British households reduced real expenditure on food purchases by 8.5% and spent 5.2% less per calorie; the reduction was highest in families with young children, where the largest decrease in nutritional quality occurred. On average, all households moved away from calories obtained from fruit and vegetables (the worst effect seen in single-parent households with young children); instead, processed sweet and savoury foods were used as substitutes.

2.4 Future projections

The general consensus is that food commodity prices are likely to remain high and volatile although some believe that volatility levels could drop to historical levels over the coming years. According to various projections, price levels will remain moderately high in the decade 2010-2020. World prices for rice, wheat, maize and oilseeds in the five-year period 2015-2020 will rise by 40%, 27% and 48%, respectively, compared to the five-year period from 1998-2003. Inflation-adjusted prices will remain flat compared to the previous decade, which saw several years of record high prices. For the period 2013-2022, average real prices for most agricultural commodities will remain above the 2005-2012 average.

Long-term projections (2050) foresee modest increases in food commodity market prices, according to an FAO baseline scenario. Taking into account a base 100% price index in 1990, cereal prices will to 94% at 2020, return to the 1990 status in 2030 (99%), increase towards 2040 (107%) and further increase to 113% in 2050. Livestock product prices follow a continuous increase, from 110% in 2030 to 119% in 2050. In general, and taking into account other scenario models, by 2030 prices will tend to revert to pre-surge levels (1990), but by 2050, cereal prices in the baseline would be higher than in 1990, but much lower than those during the period of price surges. Prices would not revert to a path of decline.

Food commodity prices are expected to rise in the future, due to the factors mentioned in Section 2.2, including the continued growth of both the emerging economies and world population, which will exert...
upward pressure on demand. The anticipated increased use of biofuels will also drive high prices in food. In addition, agricultural production costs are tightly tied to oil prices – the expected increase in the latter will contribute to higher agricultural production costs and higher food prices. Another factor that will drive the increase of food prices is natural resource constraints in farmland and water availability, linked in particular to climate change. Apart from being higher, over the longer term prices are also expected to become more volatile. This is due to increasing demand in developing countries as well as the greater frequency of extreme weather events, leading to frequent production disruption accompanied by higher price volatility. Poor countries that have to import most of their food are expected to fare worst.

The link between food prices and oil prices via biofuels has made the issue of volatility more complex: an increase in oil prices would lead to greater demand for biofuels, which would raise food prices. Historically, oil prices have been quite volatile and particularly affected by geopolitical developments in the less stable parts of the world; their linkage to food prices would add to the volatility of the latter.

3. The macroeconomy

In recent decades, globalisation has introduced interdependencies among global economies. In addition, the world economy has grown substantially; a significant part of this may be due to the growth seen in the so-called BRIC (Brazil, Russia, India and China) countries, although the US, the EU and Japan are still the major economic powers globally. BRIC economies are continuing to grow, with increased internal demand that was only slowed temporarily by the 2008 financial crisis. However, the crisis did accelerate the trend of shifting power from the mature, developed economies of the US, EU and Japan to the emerging economies of the BRIC countries.

China had the highest GDP (4.300 billion euro, 9 % of global GDP) among the BRIC bloc, followed by Brazil (1.600 billion, 3 %), India (1.300 billion, 3 %) and Russia (1.100 billion, 2 %), while at the same time the EU had a GDP of 12.300 billion (27 % of global). As regards GDP per capita in the BRIC countries, Russia had the highest (61 % of EU-27 average), followed by Brazil (33 %), China (22 %) and India (10 %).

In comparison, the EU-27 average GDP is almost twice as high as the BRIC average, while the GDP per capita is three times higher. Finally, the EU-27 was the dominant power in world trade (17 % of global), followed by the US (14 %) and China (12 %).

3.1 Global future projections

It is predicted that the average global GDP will nearly quadruple by 2050. The international system of power, established after the Second World War, is expected to change significantly by 2025, due to the rise of emerging powers, an increasingly globalised economy, and the transfer of economic power and relative wealth from the West to the East. In general, it is assumed that BRIC countries will match the G7 share of global GDP in the period 2040-2050 and surpass it by 2050. The OECD countries’ global GDP share is expected to decline from the current 54 % (2010) to less than 32 % in 2050, while the BRIC countries’ share will increase to over 40 %.

By 2030, Asia might be well on its way to becoming the world’s powerhouse, while the US would probably still be “first among equals”, because of the multifaceted nature of its power. For the first time in history, most of the world’s citizens would be middle class and not poor.

In the coming decades, average GDP growth rates are expected to slow down in China and India. Nevertheless, according to a 2013 report, in terms of purchasing power parity (PPP), China is expected to overtake the US by 2017, while India could become the third power by 2050. In addition, by 2050, the Brazilian economy could be larger than that of Japan, the Russian economy could overtake the German one and become the largest in Europe; Mexican and Indonesian economies could be larger than the French and UK economies together; and the Turkish economy could be larger than the Italian economy. However, such projections are prone to change, depending on regional or global developments. For example, the trend in shifting economic power to emerging economies has been further accelerated by the global financial crisis.

Other emerging economies, beyond BRIC or the E7, have the potential to grow significantly, including countries such as Vietnam, Nigeria, Egypt, Pakistan, Thailand, Iran, Argentina, Saudi Arabia and South Africa. The foreseen shift of economic power to emerging countries will undoubtedly impact their lifestyles, consumption patterns and dietary preferences, which could lead to increased pressure on both resources and the environment (e.g. land, water, energy, minerals and biodiversity).

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41 FAO (2011) - The State of Food Insecurity in the World
43 Eurostat (2012) - Eurostat Pocketbooks (2012) - The European Union and the BRIC countries
44 Eurostat (2012) - Eurostat Release (802/2012) - The European Union and the BRIC countries
45 World Bank (2013) - The World in 2050 - The Brics and Beyond: Prospects, Challenges and Opportunities
46 The E7 comprises the seven major emerging economies: China, India, Brazil, Mexico, Russia, Indonesia and Turkey
47 OECD (2008) - Environmental Outlook to 2030 summary

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3.2 Urbanisation and its impact on future global economy

With few exceptions, OECD member countries will experience slower rates of urban growth from 2005-2030, compared to previous decades. However, even if urban growth is slowing, suburban growth continues to increase in some countries. Switzerland and the north of Italy are examples where small and dispersed urban centres are gradually integrating into large urban agglomerations. Notwithstanding the slow growth of urban centres, cities are still likely to absorb the total population growth between 2010 and 2050, when it is predicted that approximately 70% of the global population will live in urban areas. In the period 2010-2025, the GDP of the 600 largest world cities will account for nearly 65% of global growth. The move to urban settings is expected to raise the incomes of millions of people worldwide; in cities, by 2025, 1 billion of people will enter the “consuming class”, earning high enough incomes to become significant consumers of goods and services. Around 60% of them will live in 440 cities in emerging markets, generating almost half of global GDP growth between 2010 and 2025. According to these projections, by 2025, cities would need to expand their commercial and residential floor space by 85% – an area the size of Austria – and would need 80 billion cubic metres of water supply per year and over 2.5 times greater port infrastructure to meet rising demand for shipping.

3.3 European projections

In the long term, the average annual GDP growth rate is projected to remain stable, with an average potential growth of 1.5% up to 2020, a rebound to 1.6% from 2021-2030, slowing down to 1.3% from 2031-2060. The emerging multi-polar world, already expected for 2025, will change the global economic and political landscape, with a probable decline in the EU’s economic and political influence. However, the EU is expected to remain a major importer of goods and services, providing the possibility to exert influence on production standards outside its geographical boundaries. 

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47 McKinsey & Company (2012) - Urban world: Cities and the rise of the consuming class
50 Netherlands Environmental Assessment Agency (2009)- Getting into the Right Lane for 2050
### 3.4 Inequalities

Prior to the onset of the economic crisis, household incomes in OECD countries rose by an average of 1.7 % per year. However, the household incomes of the richest 10 OECD countries grew faster than those of the poorest 10. In 2011, the average OECD country household income of the richest 10 % of the population was about nine times higher than the income of the poorest 10 %. However, figures differ considerably from country to country: the ratio was lower than 9:1 in Nordic or continental EU countries (e.g. 6:1 in Germany, Denmark and Sweden), but reached 10:1 in Italy, Japan and the UK, 14:1 in the US, and 27:1 in Mexico and Chile. The sustained period of strong economic growth in BRIC countries has resulted in higher living standards and incomes for millions of people, although the uneven distribution has increased inequalities. Brazil has managed to reduce inequality somewhat, but the gap between rich and poor still stands at a ratio of 50:1.

Not surprisingly, the most important factor driving inequalities concerns differences in salaries, since salaries represent about 75 % of total household income. Data from the US suggest that the share of net household income for the top 1 % of the population doubled over the period 1979-2007, from 8 % to 17 %, while the share of net household income of the bottom 20 % of the population fell from 7 % to 5 %.

According to the OECD, globalisation and free trade have had little effect on wages and employment inequalities; the earning gap between high-tech skilled workers and low-skilled workers is growing in an age where technological progress demands high labour skills. Although regulatory reforms have managed to create employment for many people, these have been in the low-paid category and, as a result, inequalities are widening. Similarly, atypical employment (part-time, casual, fixed-term, teleworking, short assignments, etc.) has increased whereas collective trade union contracts have decreased, giving rise to unequal working conditions. Changing family structures have made household incomes more diverse (e.g. single parents), thereby contributing to inequality. Tax and benefit systems have become less redistributive in the last 20 years, and cash transfers and income taxes are currently reducing inequality among 25 % of the working population.

Salary inequalities leading to household budget inequalities can be a source of social tension, creating a vicious circle covering crucial aspects of life. In the context of generic financial crisis and instability, where state healthcare budgets may need to be constrained (see Section 8.4), household budget inequalities can also give rise to inequalities in access to healthcare. Unequal household budgets may also mean differences in the accessibility of healthy dietary components (see Section 2.3), fuelling inequalities in diets. In turn, low-quality diets further contribute to health inequalities.

### 4. Demographics

This driver refers to the structure and characteristics of the population, and includes topics such as population growth, fertility rates, ageing, life expectancy, household structure, and migration. The impact of demographic characteristics on the future of food and health is significant and is reflected in both the scenario descriptions and narratives of the foresight study. For example, an increased proportion of older people are expected to require a larger share of the healthcare budget as well as specialised foods to meet their specific needs, while smaller households may change dietary habits and the need for cooking skills. Immigration also has the potential to diversify the demands of European consumers as regards, for example, the demand for ethnic foods or exotic products, as well as specialised health treatment.

#### 4.1 Population growth and fertility rates

According to the 2012 revision, the United Nations (UN) estimates the world population to be 7.2 billion in mid-2013, and forecasts that it will increase by 1 billion people until 2025, reaching 8.1 billion. Further increases of up to 9.6 billion and 10.9 billion are foreseen for 2050 and 2100, respectively. These projections are based on a medium-variant scenario which assumes a drop in fertility rates in countries where large families are still prevalent, as well as a slight rise in fertility rates in countries that currently average fewer than two children per woman. The effects of different scenario variants on future global population can be seen in Fig. 4.1. Almost all of the population growth is expected to occur in developing countries.

The highest total fertility rates are observed in South-Saharan and Central Africa, ranging from four to eight children per woman. However, total fertility rates ranging from four to six children per woman are expected to decline to an average of 2.85 by 2045-2050, and even lower (2.1) in 2100. It should be noted that China recently eased the decades-long one-child policy – introduced to curb population growth that might have resulted in consuming too many resources and suffocating

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52 United Nations (2013) - World Population Prospects, The 2012 Revision (Highlights and Advance Tables)  
growth with potentially significant long-term impacts on global demographics.

The population of the EU reached 502 million in 2010, and is expected to increase slightly to 526 million in 2040 before falling back to 517 million by 2060. For the EU as a whole, the total fertility rate is predicted to rise from 1.59 children per woman in 2010 to 1.64 by 2030 and up to 1.71 by 2060. Approximately half of the EU-27 MS will experience a fall in total population until 2060 (BG, CZ, DE, EE, EL, LV, LT, HU, MT, PL, PT, RO and SK), while an increase is projected for the rest (BE, DK, IE, ES, FR, IT, CY, LU, NL, AT, SI, FI, SE and UK). The strongest population growth is predicted in Ireland (+46%), Luxembourg (+45%), Cyprus (+41%), the United Kingdom (+27%), Belgium (+24%) and Sweden (+23%), and the sharpest decline in Bulgaria (-27%), Latvia (-26%), Lithuania (-20%), Romania and Germany (both -19%). In 2060, the UK is expected to be the most populous MS (79 million), followed by France (74 million), Germany (66 million) and Italy (65 million). In contrast, in 2010, Germany was the EU MS with the largest population (82 million), followed by France (65 million), the UK (62 million) and Italy (60 million). It should be noted that in all EU MS the fertility rates are expected to remain below the natural replacement rate of 2.1 children per woman in the period up to 2060.

4.2 Ageing and life expectancy

The EU population is ageing, and it is assumed that the number of people aged 65 and over will rise from 17% to 30% in 2060 – i.e. almost doubling in the next 50 years (to over 150 million in 2060) – with those aged 80 and over nearly tripling (from 23.7 million in 2010 to 62.4 million in 2060), thus becoming as numerous as those in the 0-14 years age group (12% and 14%, respectively). This can have serious repercussions, for example, for pension systems, public healthcare, workforce composition, etc. The 14-64 years age group will decline to 56% of the total population, compared to 65% in 2010. On the other hand, the proportion of young people (0-14 years) is projected to remain fairly constant (around 14%). This will result in demographic old-age dependency of 52.5% by 2060, up from current 26%.

Life expectancy is forecast to increase from 76.7 years for males and 82.5 years for females in 2010 to 84.6 and 89.1 years, respectively, in 2060, implying a possible convergence of life expectancy in the future. In 2010, life expectancy for males was lowest in Bulgaria, Estonia, Latvia, Hungary and Romania, ranging from 67 to 71 years old, while for females the lowest life expectancies (below 80 years) were in Bulgaria, Latvia, Lithuania, Hungary, Romania and Slovakia. In general, it is assumed that, in 2010, countries with lower life expectancies will experience proportionally greater gains than countries with higher life expectancies.

4.3 Migration

From an historical perspective, immigration towards Europe is a rather new phenomenon, since most European countries have traditionally been a source of immigrants rather than a destination. European countries first became an immigrant destination in the 1950s: in Germany, post-war labour recruitment was needed for reconstruction, attracting immigrants from Southern Europe, or in countries with a colonial past, which attracted immigrants from overseas ex-colonial territories in Africa and Asia (UK, France and the Netherlands). In the early 1990s, Southern European countries (Italy, Spain and Greece) became

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Footnotes:

53 United Nations 2013
55 New York Times Article (15/11/2013) - China to Ease Longtime Policy of 1-Child Limit
destinations for immigrants from (at the time) non-EU Central and Eastern European countries as well as from Asia and Africa; currently, Central and Eastern European countries are both sources of and destinations for immigrants. Before the economic crisis, the EU had a net migration of 1.5 million people, with 55% originating from outside the EU and 44% moving from one EU country to another. At the moment, the EU-27 hosts about 20 million non-EU nationals, and about 5 million non-EU nationals have received European Union citizenship since 2001. The movement of EU citizens between MS accounts for 2.5% of the Union’s total population, while immigrants coming from countries outside the EU account for 4.0% of the EU population. Figures for 2008 indicate Morocco, China, India, Albania and Ukraine as the main countries of origin, but any political and environmental crisis could easily change that picture.

For the EU, annual net migrant inflows are projected to increase from approximately 1 million in 2010 to 1.3 million in 2020 and thereafter decline to 0.95 million people by 2060. It is predicted that, until 2060, net immigration will be concentrated in a few destination countries: Italy (15.9 million), Spain (11.2 million) and the United Kingdom (8.6 million). By 2060, 33% of the EU-27 population is expected to comprise people with at least one foreign-born parent.

A study by the Oxford University in the UK explored the drivers that could have a significant impact on the future of migration in Europe. The most uncertain and important drivers identified include economic growth in the EU, the economic fragmentation of EU into sub-regional blocs, as well as labour market regulations. While it is unlikely that the EU and the euro zone will entirely fragment by 2035, its future cohesion, the status of the less-prosperous MS and the future of EU expansion remain highly uncertain. EU economic cohesion is also very important for immigration; high EU economic cohesion may mean expansion of the Union and new sources of labour migration; on the other hand, a weak economic cohesion may result in divergence in growth within the EU, fuelling intra-regional migration.

### 4.4 Household structure

The EU consumer is mainly a city dweller, as 75% live in urban environments – a figure which is predicted to rise to 80% by 2020. According to Eurostat data, in 2013, each household in the EU-28 comprised 2.3 people on average. In the US, the average household size fell from 3.3 in 1960 to 2.6 in 2000. Similar trends are evident from OECD data: in OECD countries, average household size fell from 2.8 in the mid-1980s to 2.6 in the mid-2000s.

In the US, single-person households rose from 13% (of total households) in 1960 to 26% in 2000, while in the EU, 12% of the population lived in single-person households, and over 4% were single parents in 2008. Eurostat reports the single adult (below 65 years old) households at 17.6% of all households in 2007, ranging from 6% in Portugal to 30% in Denmark, and generally being lower in Southern Europe, higher in Eastern Europe, even higher in the North-West, and highest in the Nordic countries. A similar pattern is seen in the share of couple-only (no children) households, where at least one adult is less than 65 years old (14%).

The percentage of childless women in the 33-37 years age group is 27%, being lowest in Lithuania (7%) and Eastern Europe and highest in Italy and Spain (over 33%). Today, there are no children in over half of the households in almost all OECD member countries. On the other hand, the largest families are found in Ireland, where 21% have three or more children, followed by Belgium and the Netherlands. The smallest percentage of large families is found in Spain, Portugal, Greece and Italy (under 7%). The number of children born outside marriage has tripled in OECD countries, from 11% in 1980 to nearly 33% in 2007. Almost 10% of all children now live in reconstituted households (adults in any form of partnership who have children from previous relationships), and nearly 15% in single-parent households, while one in 15 children live with their grandparents.

Similarly, between 1950 and 2000, the number of single-parent households rose from 1.5 million to 9.5 million, reflecting declining marriage rates across Europe, but with marked differences across geographical areas. In 2008, in Sweden, unmarried couples living together represented 20% of the total, while children born to unmarried parents made up 50% of the total number of births. Between 1970 and 2009, marriage rates fell from over 8/1000 people in 1970 to 5/1000 in 2009, while the average divorce rate doubled to 2.4/1000 people. In Southern Europe, the percentage of unmarried couples living together ranged from 1-5% of couples, while children born to unmarried parents were below 10% (of the total number of births) in Italy and Greece. Almost all OECD member countries for which projections...
Household size depends on changes in population age, fertility rates, and the rate of household formation and dissolution. Although few projections exist, all of the three factors mentioned above point towards smaller household sizes, assuming that the average future household size will not exceed 1.9 members per family. Such trends are seen in the forecasts for specific OECD countries: in the UK, single-person households are expected to increase by 2026 for all age groups, while it is forecast that average household size will fall from 2.11 in 2004 to 2.09 in 2029. Similarly, in Australia, a decrease is expected from 2.6 people per household in 2001 to 2.2-2.3 in 2026, while in Japan a fall from 2.56 in 2001 to 2.09 in 2029. Similarly, in Australia, a decrease is expected from 2.6 people per household in 2004 to 2.27 in 2030 is expected.

'Statistics Netherlands' has envisaged three different future household scenarios for the EU-15 in 2025: individualisation, family, and a baseline scenario which is an average of the two. All scenarios predict for 2025 an increase in people living in non-private, institutional households ranging from 6 to 7.5 million. The individualisation scenario (in which long-term trends of individualisation, secularisation and emancipation continue) predicts a decline in the number of private households (non-institutionalised), in the number of couples, and in the number of children living with their parents, and an increase in single-person households, up to 20 % of the total in 2025. The average number of people per household for 2025 was foreseen at 2.1. In the family scenario (in which trends in individualisation, secularisation and emancipation slow down), the proportion of people living alone also increases, although here numbers of private (non-institutionalised) households are expected to rise. Average household structure falls slightly to 2.4 (from 2.5 in 1995). When compared to the baseline scenario, the number of people per household drops to 2.2.

Currently, all projections for future household structures for developed countries foresee a drop in the average number of persons per household and an increase in the percentage of single parents. As a result, changing household structures might lead to different eating habits and lifestyles.

4.5 Individualisation in Western societies

Over the last few decades, Western societies have become more individualistic. This, it is claimed, has created a difficult environment to live in – based on the lack of communitarianism, moral bonds and welfare – where we have less interaction with our social peers, due to changes in working conditions, family structure, city life, television, computers etc., leading to a decline in the "social capital". In advanced economies, and once living standards rise above the poverty level, it is claimed that income becomes irrelevant to well-being and happiness; rather, it is social relationships and good family life that are the main sources of well-being. In addition, it has been claimed that rising inequalities come from the long allegiance to "individualism", especially in countries like the US. However, the opposite has also been proposed: a study measuring the quality of life in 43 nations in the early 1990s reported that the more individualised the nation, the more citizens enjoy their life, and that the benefits of individualisation are greater than the costs.

5. Food consumption

5.1 Trends and projections for food consumption

Globally, between 1969-1971 and 1999-2001, the daily energy consumption per person increased by about 300 kcal, from 2411 to 2725, reaching 2771 kcal in the 2003-2005 period. However, there are still areas (such as sub-Saharan Africa) where the per-capita energy consumption has declined. Before the 2008 food price spikes, approximately 850 million people worldwide were undernourished. The 2008 food price spikes increased this number to more than a billion, reverting to 925 million in 2010.

In the period 1963-2003, developing countries increased the available calorie consumption from meat (by 119 %), sugar (127 %) and vegetable oils (199 %), while in the developed world only vegetable oil consumption increased significantly (105 %). China displayed a complete change in diets between 1963 and 2003, massively increasing calorie consumption from vegetable oil (683 %), meat (349 %) and sugar (305 %). In the 1960s, in Europe and Oceania, animal fats were consumed at higher level than vegetable oils. However, in recent decades, a decline has been observed in animal fat and an increase in vegetable oil consumption, trends which are also expected to continue in the same fashion in...
the future. Sugar consumption rose in the developed countries in general as well as modestly in Europe (especially the eastern part), while it declined in North America and Oceania. The FAO has calculated that by 2050 the global average daily consumption could rise to more than 3100 kcal per person, which is approximately an 11% increase from 2003, which means that agricultural production would need to increase by 60% from 2005-2007 to 2050. In developed countries, daily consumption could increase slightly to reach around 3500 kcal per person, while in developing countries daily consumption could increase from 2600 to approximately 3000 kcal per person (Fig. 5.1). In parallel, the number of people living in countries with an average consumption of below 2500 kcal may decrease tenfold, from 2.3 billion to 240 million.

The ‘Agrimonde’ foresight study has also explored future food availability (in terms of calorie availability per capita per day), under two scenarios: Agrimonde GO and Agrimonde 1. The first scenario uses projections of current trends in food consumption and involves investments in research and infrastructure, with intense economic growth, low trade barriers, rapid diffusion of new technologies and a steep rise in energy demands. The Agrimonde GO mindset is to provide employment and food for a growing world population. It foresees a mean global availability of around 3600 kcal/cap/day by 2050, ranging from approximately 4100 kcal (of which ~2400 kcal come from plant sources) per capita per day for OECD countries to 2970 kcal (of which ~2700 kcal come from plant sources) per capita per day in sub-Saharan Africa. On a global level, 75% of calorie availability per capita per day comes from plant sources. It is interesting to note the different share of calorie availability from plant sources between OECD and sub-Saharan African countries – i.e. approximately 59% and 91%, respectively. Overall, the Agrimonde GO scenario foresees a general increase in calorie availability (e.g. up to 30% in Asia), driven by growing income, global convergence and the urbanisation of eating habits, as well as a greater share of animal proteins in diets and obesity rates. As a result, the future double challenge of the health and environmental sustainability of diets is of the utmost importance in Agrimonde GO.

The Agrimonde 1 scenario, on the other hand, involves sustainable food systems, protected ecosystems, regulated global trade, and fewer inequalities in access to food. In this scenario, the average global food availability is foreseen at 3000 kcal/cap/day, which includes approximately 500 kcal/cap/day of animal protein (~17%) and 2500 from plant products (~83%). Due to the nature of this scenario (i.e. regulated trade and fewer inequalities) there are no large differences in calorie availability between the world regions. Compared to the baseline (year 2000), for OECD countries this implies a reduction of 25% of calorie availability per capita per day. The 3000 kcal per capita per day availability foreseen for Agrimonde 1 could have a positive impact not only on alleviating pressure on natural resources for food production, but also on public health, by reducing malnutrition in developing countries while, at the same time, limiting overconsumption (and nutrition-related NCDs) in developed countries.

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**Fig. 5.1:** Global and regional daily average food consumption (in kcal) per capita; 2005-2007 and 2050 outlook (Source: FAO 2012, page 4)
5.2 Trends and projections for main dietary constituents

Cereals still remain the most important food source in the world, contributing 50% of calories. Current global projections foresee a decline in consumption (in terms of calories) from cereals to around 46% in 2050. In developing countries, such as parts of Africa and Asia, the contribution of cereals to energy intake can be as high as 70%, while in developed countries it can be as low as 30%. Wheat consumption will continue to be of major importance in developing countries, together with maize, the consumption of which is set to rise modestly up to 2050.

The consumption of roots and tubers (including cassava and potatoes) has fallen moderately worldwide, particularly in China and sub-Saharan Africa. Generally speaking, potato consumption is falling in developed countries but rising in developing countries. Fruit and vegetable production has been increasing worldwide, although inadequate consumption remains an issue.

In recent decades, other livestock products have shown variable consumption trends. For example, egg consumption has doubled globally, mainly due to increased consumption in developing countries. Further variation also exists in the developing world, where the greater consumption of eggs is due to changes in dietary habits in Brazil and China, but not in areas like India or Africa. Similar variations exist in the developed world: for example, egg consumption has risen modestly in Europe, especially in the eastern part, while it has declined modestly in North America and Oceania. Milk consumption has risen in developing countries, while in the US, for example, it has declined sharply, in parallel with a rise in the consumption of carbonated beverages and juices.

Projections for 2050 suggest that the current trends will continue, i.e. egg consumption will rise and milk consumption will decline (in developed countries). No changes are foreseen in butter and cheese consumption globally.

Fish catches are increasing globally while fish stocks continue to be depleted. In the period 1963-2003, there was little increase in the consumption of marine fish but, at the same time, more freshwater fish and seafood were eaten. Highest increases were seen in Oceania and China, where freshwater fish consumption increased 10-fold over the same period. Global projections for 2050 foresee a modest increase in marine fish consumption, as well as a higher rise in seafood consumption that will surpass all other fish categories.

Future projections foresee that higher consumption of specific food groups is expected for vegetable oils (33%), meat (26%), and milk and dairy products (excluding butter) (19%) (Fig. 5.2).
6. Employment and working patterns

Working patterns, unemployment, and the balance between private and working life are important elements in the four different scenarios of this foresight study on diets and health, and vary according to the conditions in each society, from high employment rates, well-being at work, and a clear distinction between working and private life to increased demand for mobility and flexibility, hectic working schedules, and a blurring of personal and professional life. This chapter aims to examine the current and future trends in employment, the composition of labour sectors, and the private and working life balance.

6.1 Employment and workforce in the EU

In 2012, the EU employment rate among working age people (15-64 years) dropped slightly to 64.2 %, with 11 MS registering higher employment rates than the average, and ten MS with employment rates below 60 % of the EU-27 average. The highest rates (72.5–75.0 %) were observed in the Netherlands, Sweden, Germany, Denmark and Austria, while the lowest rates were recorded in Greece, Spain, Italy and Hungary (51.3-57.2 %). In 2012, the EU workforce comprised approximately 241 million people, an increase of 0.4 % compared to 2011. Of those, 216 million were employed. While youth unemployment remains a major issue in the EU, the employment rate for those aged 60-64 years increased from 23 % in 2000 to 31 % in 2010. In the same period, the employment rate for people aged 55-59 years rose from 50 % to 61 %, reflecting the trend in active ageing in the EU. In 2012, employment rates for the 55-64 years age category increased to 49 %, ranging from 33 % in Slovenia to 73 % in Sweden.

The service sector employed 70.1 % of the working people in the EU-27; 39.6 % were involved in market-oriented services, such as trade, transportation, accommodation and food services, information, financial activities and real-estate, while 30.5 % were employed in non-market services, such as public administration, education, human health, arts, entertainment and recreation. Almost 25 % of employed people worked in industry, while only 5 % were employed in agriculture. The skill level and qualification of those employed also varied across the EU, with skilled non-manual workers accounting for 57.8 % in Luxembourg, while skilled manual workers accounted for 49.5 % in Romania and 36.9 % in Poland. Employees accounted for approximately 83.3 % of total EU employment in 2012, of whom 15.2 % were self-employed. Foreign citizens accounted for 7 % of employed personnel, with the highest percentages observed in Luxembourg (49.9 %) and Cyprus (22.7 %). The majority of foreign citizens were nationals of another EU MS.

6.2 Current unemployment

In September 2013, the average (seasonally adjusted) unemployment rate was 12.2 % in the euro-zone area and 11 % in the EU. Both figures had increased compared to September 2012 (11.6 % and 10.6 %, respectively). The total number of unemployed EU citizens was almost 27 million, almost 20 million of whom were in the euro zone. The lowest unemployment rates were recorded in Austria, Germany and Luxembourg (49 %, 52 % and 59 %, respectively), whilst the highest rates were observed in Greece and Spain (27.6 % and 26.6 %, respectively). In comparison, the unemployment rate in the US was 7.2 % in August 2013. In September 2013, ca. 5.6 million young people (under 25 years) were unemployed in the EU, registering a slight fall in the Union but a slight rise in the euro zone. Youth unemployment rates for the EU reached 23.5 %, ranging from 7.7 % in Germany and 8.7 % in Austria to 52.8 % in Croatia, 56.5 % in Spain and 57.3 % in Greece.

6.3 Employment projections

Demographic change can have many impacts on future European labour, the most significant being the changing composition of the workforce (with respect to age, gender and nationality), as well as effects on health, safety and lifelong learning. For the period 2018-2050, the ageing effect is expected to lead to a decline in total employment in Europe, which could translate into shortages in the labour market. Older workers (over 55 years) provided 10 % of the global workforce in 1990, and 14 % in 2010. By 2050, this proportion could reach 22 %, increasing to 40 % by 2060.

The overall participation rate (employed people plus those actively looking for employment) in the EU is expected to increase from 75.6 % in 2010 to 78.8 % in 2060, although the increase in the rate of participation in the 15-64 years age group is expected to be smaller and to occur mainly before 2020. The biggest increase in participation rate is expected among workers in the 55-64 years age group (ca. 22 % increase for women and ca. 11 % increase for men), leading to a narrowing of the gender gap in participation rates by 2060. Unemployment, on the other hand, is predicted to fall in the EU-27 from 9.7 % in 2010 to 6.5 % in 2060. A similar trend is expected for the euro zone (falling from 10.1 % in 2010 to 6.7 % in 2060). In parallel, employment is expected to rise from 68.5 % in 2010 to 71.5 % in 2020 and 74 % in 2060 (EU-27), with similar trends also foreseen for the euro zone.
In the period 2007-2012, the working-age population and the number of employed persons increased, since demographic developments are still supportive of growth. According to projections, in the period 2013-2021, the decline of the working-age population is countered by rising employment rates, while in the period 2021-2060 the ageing effect becomes more pronounced, and, in the absence of interventions, the working-age population and the number of people employed are expected to decline (Fig 6.1)\textsuperscript{49}.

However, OECD projections yield somewhat different messages. According to OECD pre-crisis projections, the total labour force for the OECD area will remain roughly the same, or decline slightly by 2050. Without policy interventions, the participation rate in the OECD area might fall from 60 % to less than 53 % in 2050, with the drop more pronounced in the EU\textsuperscript{82} (Fig. 6.2). Substantial falls in labour participation rates are expected in countries such as Austria, Italy, Eastern European countries, Japan, Korea and, to a lesser extent, Germany, due to weak population growth, rapid ageing, and the low participation of workers aged 50 years or more.

### 6.4 Careers in the future

Over the next few decades, jobs in advanced economies are unlikely to resemble either jobs of the past, or those recently lost due to the recession\textsuperscript{83}. Technology and demography have changed working conditions. As a result, the notion of full-time, exclusive...
employment (full-time employment by a single employer), permanent jobs, where people are paid according to the time they accumulate at work and are evaluated by their hierarchical superiors, may be a characteristic of the 20th century, but not necessarily one of the 21st century workplace84. In the EU, for example, part-time work patterns were high in some countries (e.g. the Netherlands, 49.2 % of employed people) but low in others (Bulgaria and Slovakia, 2.2 % and 4.0 %, respectively)85. In the medium to long term, the expected rising share of part-time employment will result in a slight reduction in the total number of working hours, especially from 2020 onwards.

The concept of full-time exclusive employment has already been challenged, either by financial constraints or by adopting crowd-sourcing techniques and part-time schemes, using digital online platforms. Teleworking and video- or web-conferences are increasingly used in private and governmental settings, while outsourcing complete projects or parts of them results in non-standard hierarchies84.

In 2011, and notwithstanding the economic crisis, 26 % of employers in Europe reported difficulties in filling jobs due to the lack of qualified candidates with the required skills, while 66 % of European managers said that finding candidates with the right skills was a key challenge for the near future86. In the US, during 2000-2009, nearly all newly created jobs involved occupations characterised by complex interactions rather than simple two-way transactions, direct services or production, which is in line with a trend towards jobs that require more education and skills. Most of these interaction jobs were in ‘non-tradable’ sectors, not affected by global competition, such as in healthcare and education, and therefore their nature has changed less dramatically. In contrast, globalisation and technology had a significant impact in transactions and production-related work84.

By 2020, it is foreseen that the US may lack 1.5 million workers with college or graduate degrees but may have an excess of 6 million workers who have not completed high school. Similarly, France could lack 2.2 million baccalaureate holders while, at the same time, having a surplus of 2.3 million workers without a degree. Geographical mismatches could also come into play in the future – i.e. high job offer and high job demand do not coexist geographically, as is already the case in North/South Europe. Finally, growing income polarisation, coupled with changing household structures and lower household income, is another factor to be considered in future85.

In 2050, the labour market could be divided into two major dimensions: highly mobile, globally connected and specialised workers, on the one hand, and people working in the service and high automation sectors, relatively disconnected globally, with lower mobility options and opportunities, on the other. In the latter, efficiency, productivity, high quality and customer relations will become another form of specialisation. In future, highly specialised markets will require solutions for highly complex tasks, thus more collaboration between various areas of expertise will be needed86.

According to the US Bureau of Labour Statistics86, in the period 2008-2018, employment in healthcare-support occupations is expected to grow most rapidly (35 %), followed by personal care and services professions (27 %), as well as healthcare practitioners and technical occupations (26 %). As regards specific professions, registered nurses, home health aides and personal care aides are expected to add the most employment, reflecting ageing population needs as well as an individualised society. In total, around one-third of the fastest growing occupations will be related to healthcare86.

Of course, apart from already-known occupations that are expected to be in demand in the future, completely new functions may also be created as the result of technological and scientific developments. Table 6.1 presents some novel jobs that may be in demand in the future.

### 6.5 Work-leisure balance

The work-leisure balance is considered to be one of the major indicators of well-being. Too little work means that the individual may not earn enough to afford their desired standards of living, while working too much can have a negative impact on an individual’s health, personal and family life87.

According to a recent literature review on work-leisure balance, an increase in economic growth (expressed as GDP) does not necessarily result in an increased feeling of well-being, since people tend to evaluate their income in relation to changing life standards88. Balancing work and leisure is a common challenge for the average working person in the 21st century. In the 1960s and 1970s, a common belief was that technology would shift the balance towards leisure, by cutting down on hours of work89. However, advances in information and communication technologies and digitalisation of the social and working environments have resulted in much easier access to work material, not only from home, but from virtually anywhere. A common example is checking emails from home or while travelling, or working late at night having access to office servers, etc. In effect, digitalisation has enabled increased availability outside normal working hours, as well as the expectations of being available, expanding the boundaries from work well into what is considered private life89.

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83 European Commission Digital Agenda For Europe/Futurium website - Julie Kronstrøm Carton interview (accessed in February 2014)
85 OECD (2011) – Compendium of OECD well-being indicators
87 The Conversation website article (30/07/2012) - ‘Tool or time thief? Technology and the work-life balance (accessed in February 2014)
However, the opposite can also be true. A study revealed that the internet was being used for personal purposes during work time to a greater extent than for work-related purposes during non-work time, and found that internet used for work purposes outside of traditional working hours could assist work-leisure balance\(^9\). Finally, the notion of increased balance between work and leisure is not necessarily the only model of managing the relationship between working and private time. The ‘work-leisure balance’ that is sought after in the Western world will be in competition with the ‘work hard - get rich’ model that is emerging in Asia\(^9\).

In the end, technology is a tool and the shift in work-leisure balance might ultimately depend on the use made of it. Some companies have recognised that there are advantages, in terms of productivity and creativity, in ‘switching-off’ completely from work when not working, as in the case of a well-known European car manufacturer which only allows the receipt of work emails 30 minutes before and after the normal working period; outside normal working hours, email accounts are deactivated\(^9\).

One of the greatest impacts of work-life imbalances relates to the time available for caring for and staying with children. In some cases, parents and companies employ schemes, such as part-time employment, continued wage payments during maternity leave, flexible working hours, childcare facilities and similar family-friendly practices. However, most of those are observed in the public sector or large private entities and are most commonly associated with highly educated and highly skilled employees. Often, less-skilled employees do not have access to similar opportunities, and smaller firms find the cost of family-friendly practices too high\(^9\). In parallel, governments are reluctant to intervene and impose family-friendly practices due to the fear of increasing labour costs along with the belief that this issue should be handled at employer-employee level. However, some countries, such as the Netherlands and the UK\(^9\), have begun to regulate flexible workplace practices.

The OECD reports\(^9\) that the best country for work-leisure balance is Denmark, followed by the Netherlands, Norway and Belgium, with Japan, Mexico and Turkey being the worst. In Denmark, people devote 69 % of their day to personal care (sleeping, eating) and leisure (socialising with friends, family, games, computer, television), which amounts to 16.1 hours. In addition, less than 2 % of employees work very long hours. In comparison, the OECD average is 14.9 hours, accounting for

<table>
<thead>
<tr>
<th>Job</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Productivity councillor</td>
<td>Helps people put emphasis on productivity and cost efficiency in their personal and professional lives</td>
</tr>
<tr>
<td>Personal digital curator</td>
<td>A specialist who recommends and maintains your unique suit of apps, software and hardware for your personal and business life</td>
</tr>
<tr>
<td>Microbial balancer</td>
<td>A trained expert who assesses the microflora of an environment or individual and provides recommendations for improving the ecosystem or personal diets and health</td>
</tr>
<tr>
<td>Corporate disorganiser</td>
<td>An expert who shuffles hierarchies in companies to create newness, start-up culture and organised chaos</td>
</tr>
<tr>
<td>Alternative currency speculator</td>
<td>Investment opportunities in virtual currencies such as Bitcoin</td>
</tr>
<tr>
<td>Urban shepherd</td>
<td>A micro-farmer specialised in plant care in small-scale urban gardens</td>
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<tr>
<td>3D handyman</td>
<td>A local 3D printing specialist, a ‘do-it-all’ repairman to fulfill everyday micro-manufacturing needs</td>
</tr>
<tr>
<td>Personal life logger</td>
<td>A need for experts to organise, catalogue and make sense of the volumes of personal information available</td>
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<tr>
<td>Digital detox therapist</td>
<td>A specialist in separating technology-obsessed individuals from their devices</td>
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<tr>
<td>Crowd-funding specialist</td>
<td>An expert of the ‘kick-starter’ system who understands how to promote and acquire funds for a project</td>
</tr>
<tr>
<td>Personal diet-trainer</td>
<td>A health trainer who not only recommends and looks after diets but also analyses personal and fitness data to create optimal life choices in food and health</td>
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<tr>
<td>Privacy consultant</td>
<td>This specialist reveals vulnerabilities in an individual’s personal, physical, and most importantly, virtual habits</td>
</tr>
<tr>
<td>Remote staging</td>
<td>Hired career advisors and trainers who prepare and school people in the use of remote interviews, holo-conferences, including acronyms, ‘webtiquette’ and conversational skills</td>
</tr>
<tr>
<td>Internet meme agent</td>
<td>An agent who, instead of talents or celebrities, represents and maximises intellectual property in internet crazes</td>
</tr>
<tr>
<td>Drone driver</td>
<td>Expanding out of the military and into social life, be it taxis or bulldozers, remote drone operators with urban experience will be highly sought after</td>
</tr>
</tbody>
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\(^9\) Adapted (2013) from Innovation Excellence website (accessed in November 2013) and sparks & honey website (accessed in November 2013)

\(^9\) Wajcman et al. (2010) \(/ Social 46:257-275\)

\(^9\) IMD World Competitiveness Yearbook (2014) - The Competitiveness Roadmap 2014-2050


\(^9\) OECD website on Work-Life Balance (accessed in November 2013)
62 % of the day. The share of employees in OECD countries working more than 50 hours per week is 12 % for men and 5 % for women; Turkey (46 %) Mexico (29 %) and Israel (20 %) display the highest shares of employees working more than 50 hours/week compared to the total. 

In the absence of policy interventions to reduce working hours, the global trend towards a US-style model of more work (more working hours, blurring of boundaries between work and private life) will continue. In the US, this trend is due to the growing participation of married women in employment, growing inequalities in income, new technologies and the desire for increased profits; similar factors apply in the UK.

Apart from the increasing number of working hours and the blurring of work and private life, the type of leisure activity is also important. For many, leisure is used for relaxing and recuperating from the stress of work, potentially resulting in a passive leisure lifestyle. On the other hand, active leisure, such as trying and mastering novel challenges (new hobbies or leisure activities), is rendered difficult by our social system and environment. However, it is this active leisure that is most important for health and well-being, as participation in both physical and nonphysical leisure activities has been shown to reduce depression and anxiety, and to promote positive moods, self-esteem and social interactions.

7. Non-communicable diseases and obesity

Non-communicable diseases (NCDs) are responsible for about 63 % of all deaths worldwide (ca. 36 million out of 56 million deaths in 2008), with cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases playing the major role. They represent a burden for the affected individuals but also put substantial economic strain on the healthcare system.

7.1 Current NCD trends

Among NCDs, cardiovascular diseases were responsible for most deaths in 2010 (17.3 million), followed by cancers (7.6 million), respiratory diseases (4.2 million) and diabetes (1.3 million). Major NCD risk factors (tobacco use, physical inactivity, alcohol abuse and unhealthy diets) are lifestyle-related and thus can be influenced. Even in Africa, NCDs are rising rapidly (with the double burden of hunger and obesity considered to contribute to this development), and are expected to exceed communicable, maternal, perinatal and nutritional diseases by 2030 as the leading cause of death. Susceptibility to NCDs increases with age, so the ageing population is expected to experience an increase in the burden of mortality due to NCDs.

The global prevalence of diabetes rose worldwide from an average of 8.3 % in men (range: 6.5-10.4 %) in 1980 to 9.8 % (range: 8.6-11.2 %) in 2008. Similarly, in women, diabetes prevalence increased from 7.5 % (8.1-10.5 %) to 9.2 % (8.0-10.5 %) in the same period. In 2013, 382 million people had diabetes; this number is expected to increase by almost 55 % to 592 million in 2035. Most people with diabetes are aged between 40 and 59 years, and 80 % of diabetics live in low- and middle-income countries.

High blood pressure, a major risk factor for coronary heart disease and stroke, is estimated to have caused 7.5 million deaths annually (2004), which was about 13 % of the total deaths. The prevalence of high blood pressure is slightly lower in high-income countries (35 %) compared to 40 % in all other income groups.

In 2008, 2.4 million new cases of cancers were diagnosed in the EU, while 1 million deaths were related to cancer in 2006. The most common cancer types for women were breast cancer, for men prostate cancer, followed by colon and rectum cancers, as well as lung cancer, amounting to more than 50 % of total cancer incidence in 2006. In general, cancer rates tend to be low in Southern and Western Europe, with some exceptions (Belgium, France, Luxembourg), and higher in Central and Eastern European countries (e.g. Slovakia and the Czech Republic). Projections show that by 2020, without any policy intervention on risks factors, there would be about 3.4 million new cases of cancer each year in Europe, a 20 % increase from 2002, and that much of this rise in the total cancer burden will occur among men and women aged 65 or over.

It has been estimated that approximately 30-35 % of cancer deaths in the US are linked to dietary factors. According to the diet and cancer report by the World Cancer Research Fund and the American Institute for Cancer Research, 70 % of endometrium cancer cases and almost half of stomach and colorectal cancer cases (47 % and 45 % of cases, respectively) could be prevented by the appropriate diet and body-fat levels, as well as...
physical activity. To a lesser extent, this also applies to pancreas (39 % of cases), breast (38 %), kidney (24 %), gall bladder (21 %), liver (15 %) and prostate cancer (11 %).

Apart from NCDs linked to lifestyle and diets, dementia is also a public health concern in both the developed and developing worlds, driven by increasing life expectancy. Approximately 36 million of people suffered from dementia in 2010, a number which is expected to double every 20 years, reaching 66 million by 2030 and 115 million by 2050. In addition, approximately 60 % of those afflicted currently live in low- to middle-income countries, where awareness is low and social and healthcare-protection mechanisms are limited. Since the bulk of the expected population increase will occur in those countries, so will the increased prevalence of dementia. In 2050, 71 % of dementia-affected people are expected to be living in low- to middle-income countries106.

7.2 Obesity
(addendum to background document107)

Obesity is considered by the WHO as one of the greatest public health challenges for the 21st century. Worldwide, obesity prevalence has doubled since 1980; in 2008, an alarming 1.46 billion adults were overweight, and one-third of those were obese108. The body mass index (BMI) has increased worldwide by 0.4 kg/m² per decade from 1980 to 2008.

Obesity is a major contributor to the burden of NCDs and loss of quality-adjusted life years (QALYs). The burden of disease caused from obesity may be equal to, or even greater than that caused by smoking, due to the marked increase in the proportion of obese people.

Childhood obesity is a particularly challenging public health issue, because overweight and obese children are likely to stay obese into adulthood and develop NCDs such as diabetes and cardiovascular diseases.

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107 This section complements Section 1.1.2 of the background document (Annex I)
at a young age. In 2010, more than 40 million children under the age of five were overweight. The vast majority of those (35 million) are living in developing countries.

According to country estimates for 2008, over 50% of men and women in the WHO European Region were overweight, while 23% of women and 20% of men were obese. In the EU (Figs. 7.1 and 7.2), overweight affects 30-70% and obesity affects 10-30% of adults. For both women and men, the lowest obesity rates were observed in Romania (8.0% and 7.6%, respectively), Italy (9.3% and 11.3%, respectively) and Bulgaria (11.3% and 11.6%, respectively). The highest shares of obese men were recorded in Malta (24.7%), the UK (22.1%) and Hungary (21.4%), while for women, highest rates were observed in the UK (23.9%), Malta (21.1%) and Estonia (20.5%). Obesity increases with age, and a clear pattern is emerging among all MS: the older the age group, the higher the share of overweight and obese individuals. In contrast, the share of overweight and obese people falls with increasing levels of education.

According to global forecasts, by 2015, the number of overweight and obese people will rise to 2.3 billion, of whom 700 million will be obese. Currently, 35.7% of adults and 16.9% of children (aged 2-19) are obese in the US. By 2020, 77.6% of men and women highest rates were observed in the UK (23.9%), Malta (21.1%) and Estonia (20.5%). Obesity increases with age, and a clear pattern is emerging among all MS: the older the age group, the higher the share of overweight and obese individuals. In contrast, the share of overweight and obese people falls with increasing levels of education.

According to the UK obesity study, projected that by 2015, 36% of males and 28% of females would be obese. By 2025, 47% of men and 36% of women would be obese, and by 2050 this would increase to 60% and 50% respectively, with less than 10% of men and 15% of women having a healthy body weight.

8. Healthcare expenditure

Public spending on pensions, healthcare, and long-term care is considered a "daunting challenge" for EU policy-makers especially when trying to reduce health expenditure without reducing the quality of healthcare services. This chapter looks at healthcare expenditure in the EU, both currently and in the pre-crisis period, and presents how healthcare coverage can change where state funding is strained.

8.1 Health expenditure snapshot in 1998-2009

Health spending in OECD countries has risen more than GDP, resulting in an increasing share of GDP being spent on healthcare, amounting to 9.6% in OECD countries in 2009 and 8.3% in the EU in 2008 (up from 7.3% in 1998). On average, annual total health expenditure in Europe was around EUR 2200 per capita (both state and private insurance schemes), with the highest expenditure in Norway (about EUR 4300) and the lowest in Romania (around EUR 690). Most Northern and Western European countries spent between EUR 2500-3500, which is between 10-60% more than the EU average, while those spending less than the EU average were mainly Central and Eastern European countries.

Across all EU MS, per capita spending on health grew by 4.6% in the period 1998-2008. Highest increases were observed in countries which had low expenditures, while countries with high expenditures saw moderate increases. Slovakia and Ireland experienced an average annual growth in real health expenditure per capita by 8.5% and 7.8%, respectively, while on the other hand, Switzerland, Germany and Norway experienced an increase of 1.9%, 1.8% and 0.8%, respectively. In general, there was a positive association between GDP and health expenditure per capita across European countries. However, situations arose where countries with similar GDP per capita devoted different funds to healthcare, for example in Spain and France, where Spanish spending on health was less than 80% of the French expenditure.

8.2 Health expenditure by function

Health spending also varies by function, and is influenced by factors such as hospital-bed availability, numbers of doctors, and access to new technologies. Across European countries, curative and rehabilitative care accounted for approximately 60% of all health expenditure in 2008.

The amount of curative and rehabilitative healthcare allocated to in-patient or out-patient spending.

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110 WHO Obesity and Overweight Fact sheet No. 311 Updated March 2013, accessed in February 2014
111 Eurostat - Overweight and obesity - BMI statistics website (accessed in February 2014)
112 Berlin Institute Overweight website (accessed in February 2014)
113 Robert Wood Johnson Foundation (2013) - F as in Fat: How Obesity Threatens America’s Future
117 OECD (2011) - Health at a Glance 2011: OECD Indicators
Public budget expenses on pharmaceuticals were the lowest in Bulgaria (20 %), while countries like Germany, Luxembourg and Greece passed on only a small portion of the expenditure to the patient (approximately 80 % being covered by their health-care systems). On average, pharmaceutical spending accounted for 1.7 % of GDP across the EU, ranging from below 1 % (e.g. Luxembourg, Norway) to more than 2 % (e.g. Greece, Hungary, Portugal)\textsuperscript{118}.

### 8.4 Health expenditure after the crisis

In 2011, health expenditure fell from 9.6 % to 9.3 % (of GDP) across all OECD countries\textsuperscript{119}. The economic crisis affecting Europe has also hit the public health-care sector, especially in Southern Europe. In 2010 and 2011, the annual increase in public spending on health was minimal, around 0.5 % (compared to 5 % annually from 2000 to 2009)\textsuperscript{119}. Health spending fell sharply in 2010, and stagnated in 2011, due to the effects of the economic crisis, particularly in those EU countries most affected by it. For example, in Greece, overall health spending fell by 11 % in 2010 and 2011, mainly due to deep cuts in government spending, following annual growth rates of 5 % from 2000 to 2009. Other crisis-stricken countries, such as Portugal and Italy, delayed cuts in 2010 but reduced public spending in 2011. In Portugal, public spending decreased by 8 % in 2011\textsuperscript{119}. Health spending has also slowed in Canada and the US.

These reductions in public expenditure on health have usually been made across the board, with a reduction in pharmaceutical spending, increased co-payment for the citizens, reduced prices and ranges in cover, as well as promoting the use of generic drugs. Portugal, Greece and Spain cut expenses on pharmaceutical prescriptions by 20 %, 13 % and 8 %, respectively, and in Spain the market share of generic drugs doubled between 2006 and 2011\textsuperscript{119}. Some countries have also opted to cut funding for prevention measures, although prevention does not usually account for a large part of health expenditure.

Public spending on hospitals has also been reduced, by lowering wages for doctors and hospital personnel, reducing staff and beds, increasing co-payment, and merging health structures, etc. As a result, for the first time since 2009, the percentage of GDP devoted to health spending has been reduced in many OECD countries.

A 2010 OECD report outlines priorities and strategies to be employed in the health system in times of reduced funding capability\textsuperscript{121}. In order to reduce health-care costs, bonus insurance schemes for a healthy lifestyle or significant reductions in insurance coverage could provide a way forward\textsuperscript{120}. So far, EU countries have opted for the latter: reductions in healthcare coverage, in the percentage

\textsuperscript{118} OECD (2013) - Health at a Glance 2013: OECD Indicators

\textsuperscript{119} The Federation of German Industries (BDI) & Z Punkt (2012) Germany 2030

\textsuperscript{120} The Federation of German Industries (BDI) & Z Punkt (2012) Germany 2030 – Future perspectives for value creation
of state coverage for pharmaceuticals, as well as reimbursements only for generic drugs are just some of the examples. In Germany, the health spending per capita increased by only 1.8 % per year in the decade 1999-2009, one of the lowest percentages in the EU, due to cost-containment policies such as those mentioned above. Growth in pharmaceutical spending is an area that has seen intervention by state policies, via a mix of price and volume controls directed at doctors and pharmacies, as well as policies such as lower drug prices (Ireland, Greece and Sweden) or state reimbursement of generic drugs only (which are cheaper than the original brands). Such measures can result in substantial savings in spending, such as those seen in Germany and the Netherlands.

8.5 Healthcare expenditure projections

Long-term projections of spending on public healthcare are challenging, since they involve many uncertainties, including future spending and the complex situations surrounding national healthcare systems. Nevertheless, according to the 2012 Ageing Report, the reference scenario projected an increase in health-care spending from 7.1 % of GDP to 8.3 % for the EU-27, with the lowest increases forecast for Belgium and Cyprus (0.4 % percentage points) and the highest for Malta (2.9 %).

In particular, long-term care costs in the EU could be affected and could almost double from 1.8 % of GDP in 2010 to 3.4 % in 2060, ranging from a rise of less than 0.5 % in Bulgaria, Estonia, Cyprus, Latvia, Portugal and Slovakia to more than 2.5 % in Belgium, the Netherlands, Finland and Sweden. Higher rises in public health expenditure are projected in the “risk scenario”, where the average EU public spending on healthcare is expected to rise to 8.9 % of GDP by 2060, 1.7 % higher than the 2010 expenditure and 0.6 % more than the reference scenario. On average, long-term care costs in the risk scenario for the EU are expected to increase by 1.7 %.

OECD projections suggest that as a result of the drivers that exert upward pressure on health spending, such as rising incomes, technological changes and demographic factors, health expenditure will continue to rise and become a major concern for most governments. Health expenditure and long-term care could increase by 50 % or even 100 % between 2005 and 2050 across OECD countries. Even with the adoption of cost-containment policies, public health-care spending could still increase by approximately 50 % over the same period.

However, the recent economic crisis has shown that wild-card events like this could severely affect health-care spending and change decade-old trends. Current projections for OECD countries in 2060 place long-term care and public health expenditure at 9.5 % of GDP (8 % public healthcare and 1.5 % long-term care), under cost-containment scenarios, and assuming policy interventions will be made to rein in expenditure growth. In a cost-pressure scenario, which assumes no policy interventions, total spending could reach up to 14 % of GDP. Increases in health-care expenditure will be mainly driven by the combined effects of technology, relative prices and exogenous factors (institutions and policies).

9. Digitalisation and technology in food and health

We currently live in a highly digitalised world, accessible mainly by personal, mobile devices which, apart from being used in everyday transactions, also function as portals for virtual social life. Digitalisation and technological advances are already finding their way into health and food applications and are expected to have an even greater impact in the future. Therefore, this part of the review focuses on both the current status and future trends of digitalisation, with a special focus on digitalisation in healthcare and food.

The digital world is evolving at an astonishing speed, producing massive amounts of data, the volume of which is expected to grow even more with ever-more powerful computing. Data might increasingly be stored in a cloud-computing format rather than traditional storage devices (e.g. hard disks) and could become accessible from an expanding range of personal mobile devices. In future, free access to information will affect many aspects of private, social and political life. However, digitalisation can be a double-edged sword, offering extended freedom of information but also providing for extensive control.

Technological innovation in food and health through information and communication technologies (ICT), nanotechnology, biotechnology and synthetic biology has the potential to influence processes and products throughout the food and health sector, as well as consumer behaviour. Tight regulation in technological developments may benefit the careful...
assessment and safety of use but, on the other hand, it may slow down innovation, and there is a risk that technological developments will not be able to tackle future challenges. In contrast, the lower regulation of new technologies leaves room for innovation and the rapid development of novel techniques, with the risk of a lack of long-term assessment of their effects, which could potentially create issues in the provision of safe food and health services. In either case, consumer acceptance of new technologies is key.

9.1 Digitalisation: general trends and future impacts

The use of internet for personal and social communication has already substituted traditional forms of communication: 54% of US internet users have posted original photos or videos they have produced themselves, while 47% have shared photos or videos found while browsing online. Digitalisation has become an integral part of everyday life in the developed world, being involved in communications, financial transactions, business and governmental infrastructure, online shopping, etc. Although a wealth of information is readily available, there is no guarantee that such information is always of good quality.

The control of information provision through the internet, in both a political and commercial sense, is already of crucial importance and will continue to be so in the future. The importance of internet control was highlighted by the 2012 World Conference on International Telecommunications, organised by the International Telecommunication Union (a UN agency), to update a global treaty on technical standards for communications. The last such meeting was in 1988, when the internet was in its infancy, and communications were still of an analogue nature. Debate during the 2012 conference centred on who should control internet, and to what extent, and on how much control a state should exercise over its own internet, dividing the participant nations in those that broadly support internet freedom (e.g. US and EU) and those that advocated tighter controls, including monitoring, filtering and censoring content (e.g. emerging powers such as China and Russia).

However, various groups, such as Google, the Internet Society, the International Trade Union Confederation and Greenpeace have already warned that such discussions by governments – even on a global scale – on internet communication standards, could set a bad precedent, introducing practices and opening up ways of controlling the internet.

In 2011, approximately 30% of the global population had access to internet, 60% of whom were users from the developed world (Europe, US, South Korea and Japan). In total, Asia accounted for 42% of internet users in 2010. It is likely that towards 2030 there will be a shift of influence towards Asia, as a bigger share of its increasing population gains access to the internet. Following current trends, by 2020 most people would be connecting to the internet via mobile devices, which are expected to evolve into a small personal computer device with telecommunication capabilities. In fact, mobile device internet access is the only internet access available to the majority of people in the developing world, and is expected to remain so in 2030.

The emergence of internet users in countries such as China may result in new regional digital platforms and services that would challenge the current integrated state of the internet, and could result in fragmented or closed communities in future. Therefore, the digital world of the future may not be similar to the current, globalised state. The influx of new users from emerging nations may have other impacts in the global digital arena and could change the way the internet works. These new users are expected to be more innovative, more likely to produce and change rather than merely consume content, compared to users in the developed nations. Even so, it is unlikely that the technological supremacy and innovation of US companies will be challenged in the near future.

Over the last decade, computer prices have fallen by 90% – a trend which is expected to continue in the future. On the other hand, between 2000 and 2011, the number of global internet users rose by 480%. Following a similar exponential growth rate, 99% of the global population could have internet access by 2030, assuming that internet access is seen as a public good and is prioritised by governmental policies. As a result, it is expected that in the future the digital divide between developed and developing world will be reduced significantly, while not disappearing completely. Current electronic gadgets could be sold for very low prices, unimaginable today.

In addition, the development of tools such as cloud computing would give small businesses and individuals in the developing world the chance to use the same tools as their competitors in the developed world, since no special or physical infrastructure is required. However, this enhanced availability of information in the developing world would not guarantee increased knowledge for the public, and the management of knowledge could be a further issue: a new divide may develop between companies, governments and regions that control strategic knowledge (in the political and commercial sense) and those that do not.

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130 NY times online article (27/11/2012) – Integrity of Internet is Crux of Global Conference (accessed in February 2014)
131 The Economist online article (6/4/2013) – To each their own: China’s model for controlling the internet is being adopted elsewhere (accessed in January 2014)
132 The Guardian online article (22/08/2012) – The fight for control of the internet has become critical (accessed in January 2014)
133 Foreign Policy article (15/08/2011) – The FP survey: The Internet (accessed in February 2014)
134 Wall Street Pit online article (13/052009) – Computer Prices have Fallen by 90% over the Last Ten Years: is that Evidence of Monopoly Power?
The digital world offers huge opportunities for virtually unlimited access to information, potential empowerment of the individual, as well as peer-to-peer connections and knowledge exchange. Access to information would not be concentrated in the hands of a few and information could be spread easily and widely, challenging established channels. New informational tools enable citizens or small groups to double-check facts, using digital platforms to report in a rapid and wide manner on issues that might normally be hidden from the public (or inaccessible). This can give even small individual groups considerable power, and can support revolutions against totalitarian and oppressive regimes, potentially facilitating a move to more democratic forms of government. In future, controlling the digital world will be difficult, even for organised entities such as governments or corporations. Countries which limit/control internet access have already experienced how difficult this task can be.

Unlimited access to data and extensive digitalisation of private and social life can be a double-edged sword. Governments, corporations and organised interest groups could also exploit digitalisation to exert greater control over citizens’ lifestyles and diets, violating their privacy. Digital surveillance, either of browsing habits for marketing purposes or of digital communications for political or military purposes, is already happening and will continue to do so in the future, possibly including new forms of digital propaganda, outright censorship, and banning internet access, etc. Cyber-attacks are also likely to increase in the future, as more and more critical aspects of life and work are conducted online. Cyber-crime by organised criminal groups, and cyber-attacks by activists or anarchists are likely to threaten business, individuals and governments as they rely increasingly on digital systems. Similarly, cyber-warfare could be used by states or other groups to gain strategic or even tactical battlefield advantage. In fact, digital platforms are perfectly suited for individuals or smaller and less powerful groups to challenge opponents with conventional/ traditional power.

9.2 The changing face of healthcare

Three major technological trends that are currently evolving have the potential to impact the future of healthcare: size and scale of digital technologies and available information, the personalisation of all kinds of services for individual needs, and social networking creating interlinked communities of consumers. In general, the concept of healthcare is moving towards personalised preventative health maintenance and away from cure. However, to achieve this by 2050, various scientific and information technology developments are needed (e.g. better knowledge of effects of nutrition on health, ability to combine data from multiple settings to construct health profiles), as well as mindset and policy and institutional changes (responsibility of health shifted in part from physician to empowered individuals, required legal and structural framework).

Currently, a proliferation of patient-focused health applications intended for use by the patient alone can be seen. By 2050, the individual/ patient could become increasingly able to self-monitor his/her health status – via advanced medical devices – while acquiring the ability to understand and interpret basic data and patterns and receive early warnings. Peers with similar health interests, as well as health collaborators and advisors (health coaches, wellness instructors, etc.) could also assist in data interpretation and basic preventive measures. Finally, as a third layer, traditional public health-care systems and health professionals could provide specialised health-care services in diagnosis and treatment. All of the above would take place in an environment where various omics technologies (e.g. genomics, metabolomics) generate data on personalised health informatics platforms. An expanded concept of personalised preventive health and healthcare would include desirable health outcomes going beyond prevention, treatment and cure towards enhancement and longevity.

The above technological trends (size and scale, personalisation, and social networking) can already be seen in health technologies. Gaming consoles are being used for fitness, tele-health is offering patients remote access to specialised professionals, resulting in faster, cheaper as well as multiple medical advice, and health-care networks help practitioners deliver services better or stay informed on developments within their profession. Currently, 60 % of US physicians use their smart phones to access health content online, and 44 % use tablet computers (so-called mobile or mHealth).

Apart from better access to medical records, digitalisation also enables teleworking for certain functions within the medical profession, and helps reduce staff and space resources in the healthcare system. Last, but not least, digitalisation offers immense opportunities for the remote and real-time monitoring of patients. Worldwide, 2.8 million patients are already using monitoring devices to measure and send alerts on issues such as sleep apnea, blood pressure or adherence to medication. Remote monitoring may not only provide faster intervention in healthcare, but may also help offset a shortage of doctors where this remains a major issue.

Mobile devices are being turned into decision-making diagnostic tools; for example, specific products deliver foetal heartbeat and maternal contraction-pattern data in real time to a professional’s mobile device, whereas other applications enable instant access to radiology diagnostic images and reports.

132 Medical Economics online article (10/02/2013) - 5 tech trends that will affect the way you practice medicine in 2013
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A US study of more than 6500 people reported that, in 2005, for 62% of participants, general practitioners were the most highly trusted source of information, followed by the internet (24%), television (20%), family and friends (19%), magazines (16%), newspapers (13%) and radio (10%). When asked how they would prefer to access specific health information, 50% said they would want to go to their physicians. However, when asked where they actually went for this specific information, 49% checked online sources first, whereas only 10% went straight to their doctor140. The potential of ICT applications in health has been recognised by the US Food and Drug Administration (FDA), which recently called for the implementation of balanced and transparent approaches in the development of health IT solutions while, at the same time, ensuring appropriate protection for the patient141.

In an age where doctors will no longer be the sole holders of medical information, the role of the basic, primary, family doctor might change to that of a ‘medical curator’, directing patients to appropriate applications and online sources of information. Patients going for medical visits having already gathered information on their potential diagnosis from online healthcare sources138, 140. The numbers of health applications designed to be used by the patient alone are rising, including those to increase efficiency (reminders, web-based cognitive behavioural therapy), improve quality, and provide more accessible care for difficult issues (alcohol abuse and eating disorders). However, there has not been any solid evaluation of the emerging apps138.

Access to medical information will be less and less limited to practitioners, since an increasing number of patients can access their personal health records via websites or mobile phone applications. The nature of electronic records for doctors is also changing. A survey from the US Centers for Disease

142 Medical Daily online article (19/03/2013) - College Student Joe Landolina Creates Healing Gel (accessed in December 2013)
143 University of Texas, Anderson, M.D. Cancer Center news (15/05/2010) - 3-D Cell Culture: Making Cells Feel Right at Home
144 Fox News online article (24/01/2013) Artificial gel mimics living cells (accessed in December 2013)
145 Nature website news (09/12/2012) - Brain cells made from urine (accessed in December 2013)
146 CBS News article (17/10/2012) Underwear uses electric shock to prevent bed sores (accessed in December 2013)
147 Nextgov Newsletter website (10/12/2012) - Pentagon, NIH fund pollen-based vaccine delivery research (accessed in December 2013)
148 BBC News article (05/11/2012) - Heartbeat ‘could power pacemaker’ (accessed in December 2013)
149 Mercier et al. (2012) Nat. Biotech. 30:1240-1243
150 New Scientist article (25/07/2013) - Sensor knows when you’re lying through your teeth (accessed in December 2013)
151 New Scientist article (24/07/2013) - Feather-light sensors are as comfy as a second skin (accessed in December 2013)
152 Imperial College news (17/07/2013) - “Intelligent knife” tells surgeon if tissue is cancerous (accessed in December 2013)
Control and Prevention showed that, in 2011, 54 % of doctors had adopted an electronic health-record system, 85 % of whom reported being somewhat or very satisfied, and 75 % reported that this change had resulted in enhanced patient care\textsuperscript{165}.

However, accelerating the adoption and implementation of fully digitalised health services will require more public-private partnerships (e.g. between state health-care institutions, academic experts, private health-care services and insurers, and private providers of health IT systems), as well as a robust evidence base regarding their implementation. Solid cost-benefit calculations on information technology implementation in health-care seem to be lacking. A current indicator for cost efficiency is the fact that institutions that both pay for and deliver health-care services have adopted health IT at a greater rate than organisations that only deliver healthcare\textsuperscript{159}.

Various advances are foreseen in the field of medicine\textsuperscript{160, 161} based either on projections of current scientific achievements and developing technologies\textsuperscript{162} or on the insight of futurists\textsuperscript{163}.

It is beyond the scope of this review to discuss and evaluate specific future technologies in medicine, although some of them are presented in Table 9.1 to enable a vision of future healthcare.

### 9.3 Digitalisation in the food sector

Even though consumer preferences are, to a large extent, still defined by geographical and cultural characteristics, the recent digital revolution is connecting billions of people around the globe, overcoming cultural and geographical boundaries and empowering choices in how, where, when and at what price to get their food\textsuperscript{164}. Mobile devices have made this even easier: smart phones are used for accessing the internet, transferring money, and researching and purchasing consumer goods. In the US, digital shopping is now commonplace, with 25 % of smart phone owners having used the device to shop during the 2010 holiday season\textsuperscript{164}. However, it is not only about shopping, since many consumers are using digital platforms to evaluate products bought physically and online, as well as to evaluate retail services. In the retail sector in particular, digital technologies have become a vital tool, evidenced by an increasing number of consumer shops online. In addition, there are significant opportunities for food manufacturers to exploit the rise of digitalisation in emerging markets, to better understand consumer preferences, and thus to target demands accordingly\textsuperscript{165}.

As mobile technologies evolve, more and more consumers are expected to use their mobile devices for every kind of shopping interaction: locating products inside the store, adding products to their digital basket while walking up and down the aisles, mobile payments, loyalty programmes and price comparisons. In future, retail services might adopt their marketing strategies and concentrate on offer specialisation, including brand-offer alerts, personalised shopping lists, mobile checkouts, and product ratings and reviews\textsuperscript{166}. Further, digital technologies could also provide opportunities for consumers with specific needs, such as food allergies, to use mobile scanning to quickly identify any items not suitable for their diets. Short-term predictions foresee a continual annual rise of 12 % for e-commerce in the retail of food and consumables for the period 2012-2017\textsuperscript{167}. In addition, while robotically handled foods (with the option to choose fresh produce oneself), selected via mobile devices and home delivered might be a thing of the future, virtual food supermarkets, with “augmented reality” retail models, where only some products are displayed physically and all shopping transactions are done via mobile phone applications, along with home delivery, are already a reality in some countries\textsuperscript{158}.

Technological innovation for food in the home environment has also sparked interest and has led to appliances\textsuperscript{166, 170} such as automated kitchens that suggest and cook your meals, can recycle food components and water, retractable and self-cleaning kitchens, portable kitchens, automated coffee machines guided by user movements on a touchscreen, multimedia kitchens serving as computers, hi-fi and radio to improve the cooking experience, and ‘lifematic’ ovens with a movable base for convenient loading. These are just some of the food-related home-appliance technologies which, although rare and still considered odd today, give a glimpse of what we can (or cannot) expect in the future.

\textsuperscript{159} US Centers for Disease Control and Prevention (2012) NCHS Data Brief No.98 – Physician Adoption of Electronic Health Record Systems: United States, 2011

\textsuperscript{160} See also Section 1.5 of the background document (Annex I)

\textsuperscript{161} The New Atlantis online article (No.1 Spring 2003) The Future of Medical Technology (accessed in November 2013)

\textsuperscript{162} Listverse.com website online article (22/03/2013) - 10 Medical Technologies That Could Shape The Future (accessed in November 2013)

\textsuperscript{163} RossDawson.com website online article - Six radical visions for the future of health (accessed in November 2013)

\textsuperscript{164} Strategy& online article (2013) - New Food Retail Industry Outlook is Personal, Digital and Virtual (accessed in December 2013)

\textsuperscript{165} Food Navigator article (22/06/2011) - Digital technologies driving food industry growth (accessed in December 2013)

\textsuperscript{166} Sowka, H (2013) The future of food retailing

\textsuperscript{167} Retail Feedback Group article (16/09/2013) - Future Food Retailing Possibilities (accessed in December 2013)

\textsuperscript{168} House Automator website – Futuristic Kitchen (accessed in November 2013)

\textsuperscript{169} Trend Hunter website article (20/06/2013): The 2D smart kitchen handles all of your cooking needs (accessed in November 2013)
10. Primary production: trends and future challenges

10.1 Main characteristics of EU primary production

A large proportion of EU citizens still live and work in rural areas: around 24 % live in predominantly rural regions while 36 % live in intermediate regions (regions where the rural share of the population is between 20-50 %). More than half of EU land area is made up by rural regions, while about a third comprises intermediate regions; approximately 40 % of the EU land area is currently being farmed.

Structure of the sector: In 2007, there were 13.7 million agricultural holdings in the EU, of which 7.3 million where commercial and around 6.4 million were small holdings. Almost 60 % of all commercial agricultural holdings where located in Italy, Poland, Spain and Romania. The average EU farm size of all types of holdings was 12.6 hectares. The average size of commercial holdings in particular was 22.0 hectares, varying widely between EU MS, ranging from less than 10 hectares in Italy, Greece, Cyprus and Malta to more than 100 hectares in Slovakia and the Czech Republic.

Land use, holdings size and labour: The majority (60.5 %) of the agricultural area being utilised in the EU is devoted to arable land, rising to 90 % in Denmark and Finland. The largest share of arable land can be found in France (18 %), followed by Germany, Spain, Poland (11 %) and Romania (8 %). The largest permanent pasture land share was in Ireland (75 %) as well as the UK and Slovenia (60 %). UK, Spain and France were the countries with the largest areas in pasture land, accounting for 18 %, 15 % and 14 % of the EU total, respectively. In 2007, across the EU, 16.4 million people worked on a regular basis in commercial agricultural holdings, the majority of whom (89 %) were farm holders or their family members. Half of the farm labour force worked in crop farming, 36 % worked in livestock farming, and 13 % worked in combined crop and livestock farming. Organic farming has a rather small share in the EU, with close to 200 000 holdings classified as organic in 2009. In 2010, intermediate consumption within agriculture was about 60 % of the gross agricultural output, with items associated with livestock production taking a 40 % share, mainly feedstock.

Livestock: In 2010, livestock production in the EU numbered 152 million pigs (largest shares in Germany (about 18 %) and Spain (around 17 %)), 88 million cattle (about 22 % in France), and more than 87 million sheep (about 24 % in UK and about 21 % in Spain). In 2009, 148.5 million tonnes of milk were produced in the EU, 90.5 % of which was collected, the rest being consumed on farms (lowest in Romania, 21.3 % of milk collected, followed by 55.9 % in Bulgaria). Almost 70 % of total EU milk production took place in Germany, France, the UK, Poland, the Netherlands, and Italy.

Agricultural products: Cereal production in the EU reached 296 million tonnes in 2009, the largest share coming from France (23.6 %); other major producers were Germany (16.8 %) and Poland (10 %). The production volume was relatively stable over the medium term (2000-2009). The main cereals were wheat (46.7 %), barley (20.9 %) and grain maize (19.5 %). Germany, France and the UK were the main wheat and barley producers, while grain maize was largely produced in France, Romania, Hungary and Germany. One-third of the EU potato production of 62.5 million tonnes was produced by Germany and Poland; France and Germany produced more than half of the EU sugar-beet harvest in 2009 (about 114 million tonnes).

Fruit and vegetable production tended to be concentrated in a few EU MS. In 2009, tomatoes were largely produced in Italy and Spain, carrots in the UK and Italy. Orange production took place mainly in Spain and Italy, whereas more than 50 % of EU apple production occurred in Poland, Italy and France. Pears, with an overall much lower production volume than apples, were mainly produced in Italy, Spain, the Netherlands, Portugal and Belgium.

Fisheries: The largest fish catches were made in the Netherlands and Spain (about 882 000 and 704 000 tonnes, respectively), while Denmark, France, Ireland, Italy and Germany all reported landings of over 200 000 tonnes. For comparison, the total fish catches of these seven MS were only slightly higher than the combined fish landings of Norway and Iceland. Aquaculture has continued to grow in recent years: the main species being produced are mussels, trout, salmon and oysters. In 2008, Norway, the largest European producer, together with Spain, France, Italy and the UK, provided 78 % of the production from 34 European countries.

171 This chapter complements Chapter 5 of the background document (Annex I)
172 Eurostat Pocketbooks (2011) - Food from farm to fork statistics
173 European Environmental Agency, Aquaculture production (CSI 033) - Assessment published Sep 2011 (accessed in February 2014)
enough food to potentially feed everyone; feeding the world in an environmentally sustainable way, protecting biodiversity; and reducing the contribution of the agri-food chain to climate change.174.

The major limiting factor for global food production is the cropland area needed for food and feed cultivation; the amount of land required depends mainly on population numbers, average food consumption, and yield per unit of land175. In general, potential savings on the cropland area for food production, due to yield increases, are counteracted by a combination of population growth and dietary change. However, crop yield gains have been based mainly on practices such as the increased use of fertilisers, pesticides and energy, and irrigation infrastructure, with significant environmental impacts.

In addition, as socio-economic status improves, population growth falls but diets become richer in animal protein. Animal products alone represent almost 50% of the increase in cropland requirements since the 1960s175. Much of future meat production will stem mainly from feeding cattle with grains, instead of grazing them on pasture176; in a ‘business as usual’ (no dietary changes) scenario, grain production for feed purposes is forecast to grow by 77% by 2030176. Taking into account the fact that the world population is predicted to stabilise at approximately 9 billion in 2050 (see Chapter 4.1), the shift towards diets rich in animal protein may become the major factor driving increased land requirements in future for growing food and feed175.

10.3 Projections on natural resources needed for food production

In the coming decades, land resources are likely to remain an important concern in food production. Moreover, it is evident that it will be necessary to produce more food either by using more land or by improving yields. Currently, around 11% of the world’s land surface is used to grow crops. Significant areas of unused land with agricultural potential could be exploited in parts of Eastern Europe and in the former Soviet Union, but most of the potentially usable land is located in sub-Saharan Africa and South America. However, much of this has low productivity potential, and its conversion to agricultural land would result in significant negative impacts on climate change and biodiversity177. The projections for increases in future arable land vary; FAO projections estimate an increase of almost 5% (70 million hectares, an increase of 120 million hectares in developing countries, and a decrease of 50 million hectares in developed countries), while others178 foresee an increase ranging from 6% to more than 30% (average range 10-20%).

The above emphasises the need for novel approaches in food production so as to increase yield without impacting the environment179. According to the FAO, 90% of the growth in crop production (80% in developing countries) will be due to higher yields and increased cropping intensity, (with the rest resulting from increased land use)177. As with future land use, projections for future yield growth vary widely. FAO projections179 foresee that crop yields will continue to grow, albeit at a slower rate, with an annual growth of 0.8% (2005-2007 to 2050); cereal yield in particular would slow down to 0.7% annually, reaching approximately 3.94 tonnes/ha in 2050 (2.94 tonnes/ha in 2005-2007). However, there is room for improvement in certain geographical areas. In Africa, for example, cereal yields have grown slowly, and are approximately one-third (1.2 tonnes/ha) of developing world average yields177.

Irrigated agricultural land is expected to expand by 17%, mainly in developing countries; the freshwater needed for irrigation is expected to increase by 11% by 2050180. Total agricultural water demand could increase by as much as 30% by 2050, while global total water demand could almost double (by 2050), due to agricultural, industrial and domestic demands174. Globally, there is more than enough freshwater available, but it is unevenly distributed. The problem is often more severe in countries that also suffer from arable land scarcity, i.e. in the Middle East, North Africa and South Asia180. In Europe, freshwater is mainly used for agriculture (42%), industry (23%), as well as urban use and energy production (both 18%). However, these rates vary according to geographical areas. In Southern European countries, like Greece, Italy and Spain, water is mainly used for irrigation, while in Scandinavian countries, like Finland and Sweden, freshwater is mainly used in industry (cellulose and paper production). Future projections for Europe foresee no increase in the use of freshwater for irrigation, particularly in Southern Europe; in fact, it may even decrease under environmental pressures or due to urban demand177.

The scarcity of nitrogen and phosphorous – two other natural resources – could impact food production in the future. Nitrogen is required for plant growth; its under-supply can be a constraint in crop yields in developing regions while, on the other hand, in high-intensity agricultural areas an excess of nitrogen fertiliser can cause eutrophication and environmental pollution. The current trends in agricultural projection could lead to a more than twofold increase in the global consumption of

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175 Kushnir et al. (2012) PNAS 109:6868-6872
176 Overseas Development Institute (2014) Future diets - Implications for agriculture and food prices
177 European Commission (2011) Standing Committee on Agricultural Research - Sustainable food consumption and production in a resource-constrained world (3rd SCAR Foresight Exercise)
180 FAO (2009) - The Resource Outlook to 2050. By how much do land, water and crop yields need to increase by 2050?
nitrogen fertilisers. Phosphorous is also an essential plant nutrient, and a major non-renewable and non-replaceable input for agricultural food production, having a significant effect on grain yields. Global demand for phosphorous is growing – at current rates of use, current global reserves could last almost until the end of the 21st century. Scarcity of phosphorous could have a major impact on food prices, food security and the widening of inequalities between countries.
Tomorrow’s healthy society
Research priorities for foods and diets

ANNEX III

SCHEMATIC SCENARIO OVERVIEWS
ANNEX III

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Schematic overview of the HEALTHY NEW WORLD scenario

- Strong community spirit
- Low agricultural commodity price

Demographics
- Ageing population, low fertility rates
- Active & independent elderly
- Pension age raised
- Low inequalities
- Limited immigration

Food Policies
- State-funded healthcare
- Provision of care
- Focus on prevention/healthy lifestyles

Health Policies
- Strong governance on food quality & safety
- Authoritative nutrition guidelines
- Strong regulation of food sector
- Fiscal measures

Education
- Health consciousness & nutrition literacy
- Public awareness campaigns
- Nutrition in school curricula

Private Food Sector
- Online shopping
- Traditional supermarkets
- Concentration due to high regulation
- Niche markets for SMEs and co-operatives

Technology
- Generally accepted
- Careful assessment and regulation
- Modern technologies support cooking
- Apps for health monitoring and behaviour tracking
- Combining health & nutrition with taste & convenience
- Apps provide info on nutrition, specific diets, labelling, references
Schematic overview of the **HEAL THE NEW WORLD** scenario

- **Strong community spirit**
- **High agricultural commodity price**

### Demographics
- Ageing population, low fertility rates
- Extended family model
- Pension age raised
- Social cohesion
- Limited immigration

### Health Policies
- Basic state-funded healthcare, co-payment necessary
- Transition period from treatment focus to prevention focus
- Limited support for vulnerable groups

### Food Policies
- Strong governance on environmental sustainability
- Compulsory environmental labels
- Taxes on foods with high environmental footprint
- Focus on EU/regional/local products

### Education
- Environmental & health effects of diets in school curricula
- Focus on cooking skills

### Work
- Long hours
- Seniors also active
- Teleworking common
- Mobility & flexibility required

### Technology
- Aim to increase cost-efficient production
- Acceptance after careful evaluation
- Government enforces framework
- Apps for healthcare, food
- GMOs, alternative & novel foods, nanotechnology
- Ready-to-use cooking ingredients

### Private Food Sector
- Concentration of food chain
- Online shopping
- Less physical shopping
- Direct purchase from local producers

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**Food Choice**

- Mainly European/regional/local products
- Fair trade & animal welfare
- Fresh foods & home-grown produce
- Reduced red meat and dairy consumption

**Diets**

- Fresh foods & home-grown produce
- Reduced red meat and dairy consumption

**Health**

- Reduction in diet-related diseases
- Degenerative diseases emerging
- Older generations carry burdens

**Eating habits**

- Communal eating at home, school & work
- Eating together brings economic & environmental benefits
- Self/family-prepared meals

**Planning ahead**

- Planning ahead
- Low food waste

**Sustainability**

- Conscious & socially responsible
- Price & quality

**Demographics**

- Ageing population, low fertility rates
- Extended family model
- Pension age raised
- Social cohesion
- Limited immigration

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Schematic overview of the EAT TO LIVE scenario

- Individualistic society
- High agricultural commodity price

Demographics
- Ageing population, low fertility rates
- Social inequalities & tensions
- Poverty an issue
- Crime increasing
- Limited immigration

Health Policies
- Basic state-funded healthcare, co-payment necessary
- Private healthcare available (for those who can afford it)
- Long waiting lists in public health system
- Policies limited to provision of information
- Prevention in form of self medication/nutraceuticals

Food Policies
- Focus on market functioning
- Minimal regulation

Education
- Information from government, websites, industry, social circle
- Misconceptions, confusion & misinformation common
- Health & nutrition not taught at schools
- Poor cooking skills

Private Food Sector
- Concentration including primary production
- Multinationals mass produce limited variety of fortified foods
- Online shopping common
- Discount chains strong online
- Real shops reserved for special, high-end products
- Emergence of informal, non-regulated p2p businesses
- Vulnerable food system, compromised food safety

Food Choice
- Focus on ‘healthy eating’, perceived as eating enhanced foods & nutraceuticals

Health
- Socio-economic status important
- Inequalities
- Diet-related diseases still prevalent
- Malnutrition

Convenience & safety

Less choice & variety due to uniform & mass-produced food

Taste

Diets
- Low-cost, mass-produced foods
- Low-cost alternative protein sources
- Processed & ready-to-eat foods

Price

Automated preparation & cooking (for those who can afford it)

Eating at home to save money

Restaurants a luxury

Less food waste

Eating habits

Out of home in fast foods, cantinas & street vendors

Eating at work or while travelling

Lack of time, cooking knowledge

Work
- Labour market insecurity
- More years & longer hours
- High flexibility & mobility required
- People often need two jobs

Technology
- High acceptance
- Aimed at cost-efficient food production
- Focus on longer shelf-life and packaging
- Low cost & common diet/health-monitoring sensors
- Reliable, science-based supportive apps expensive
Schematic overview of the **ME, MYSELF AND I** scenario

- Individualistic society
- Low agricultural commodity price

### Demographics
- Ageing population, low fertility rates
- Flexible pension age
- Limited immigration

### Health Policies
- Basic state-funded healthcare
- Additional coverage self-paid
- Focus on treatment & self-management

### Food Policies
- Focus on food safety
- Reliance on market mechanisms

### Education
- Diet guidelines depending on app/device provider
- Health/nutrition not taught in schools

### Private Food Sector
- Diversity, both multinationals and SMEs
- Pharma & cosmetics industry expand in food sector
- High share of food-services sector
- Shopping online or in physical shops
- Variety, customised products

### Food Choice
- Food choice often automated by devices according to health-sensor data
- Fashion & hedonics

### Work
- High flexibility required
- Blur between leisure and work
- Adaptation of working life according to needs
- Teleworking

### Technology
- High acceptance
- Guarantees individualised lifestyles
- Personalised medicine and diets
- Considerable progress & innovation
- High penetration in all aspects of life

### Eating habits
- Eating together uncommon/not a social value
- Individualised eating schedules
- No cooking skills
- No efforts to reduce food waste
- Various devices align diet to health

### Health
- Improved general health status (due to progress in medicine)
- Obesity and diabetes still prevalent

### Diets
- Nutraceuticals & supplements common
- High variety, from local to exotic
- Novel foods
- Junk foods
- Fashion foods
- Highly processed
- Personalised foods & diets

### Means to individual identity
-Fair trade, animal welfare are niche markets
- Origin of food irrelevant

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**JRC Foresight Study - Tomorrow’s Healthy Society**
Tomorrow’s healthy society
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ANNEX IV

NARRATIVES
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The future ‘Healthy new world’ family is represented by François, 48 years old, and his wife, with their two children, Pierre and Estelle, 7 and 15 years old, respectively. The grandmother in the family, Margherita (84), is living in a community which takes care of the elderly.
Estelle

An entry in her personal diary,
Wednesday 15/05/2050, 22:33

This morning, as always, I woke up to the sound of my Weecon alarm. I let my eyes get accustomed to the morning light and then brought the I-scan sensor of the Weecon right in front of my eye to unlock the device. I checked the other side of the room and my brother Pierre was doing the same thing on his Weecon. He only has the simple version but calls it ‘SuperWee’ of course. It’s not actually called Weecon, its real name is We-connected multifunctional personal device, but even dad calls it Weecon. Anyway, no new notifications or status updates from last night, although a holo-image of my friend Josephine is already blinking and waving on the screen. I haven’t actually talked to Josephine face-to-face in quite some time, so I sent her a wee-pointment to meet later today. Apparently Pierre had finished chatting with his new pal Thomas in his Weecon because he was already up and nagging about breakfast... “Come on Estelle, let’s get some breakfast, I bet it is ready by now!”

Mum and dad prepared the breakfast as always, checking the smart fridge to make sure that we each get what is necessary for our age. We have breakfast together every day before leaving for school, which is kind of nice. After breakfast we hopped on our bicycles and rode to school, where we started the day with exercises and meditation. Pierre then joined his class while I went to log into my study terminal and join my group. Each of these classes is not made up of children of the same age, the way it happened when grandmother went to school (imagine that!), but of children that have the same intellectual needs. After studying, I joined my cooking group and prepared our lunch. We often do this in school, because apart from lessons in diets and nutrition we have practical classes supervised by real cooks three times a week. As usual we prepared a plate with various cooked and raw vegetables, but today the recipe included a small piece of meat! Yummy...Then, of course, we had fruit for dessert, no surprises there...

In the afternoon, right after the daily sports practice and before heading for the showers I met some of my schoolmates and we jumped over the fence of the school next to the sport fields. As agreed last week, each of us brought a few sweets and candies that we got from our grandparents. Some kids didn’t manage to get them but we shared what we had. Our parents and teachers would have a fit if they saw us stuffed with candies and sweets! We are only allowed a few of them each week. Plus, they are really expensive with all the government taxes on fat and sugar and we can’t afford them with our own pocket money (apart from the fact that our parents would immediately find out if we bought them online), but hey, what are grandparents for anyway!

Back at home Pierre went to play virtual games on his Weecon, while I hooked up with my friends for a bit of MM0Ving (massive multiplayer online virtual gaming, as the teachers call it). At dinner time we ate with mum and dad and granny, who unexpectedly came to visit, taking time to enjoy dinner and discuss our days. Mum and dad have to work a lot, but their flexi-schedule allows them to have quite a bit of time to relax at home and chat with us.
The day after tomorrow is grandmother’s visit day, which is actually quite cool. Yes, we saw her tonight as well but mum and dad were here. On visit day, we ride by ourselves to the community home where she is staying, and she might have some more sweets for us. Then we swim in the super-nice swimming pool there. Can you believe their swimming pool is actually better than the one at school. Anyway, grandmother Margherita will probably have another of her stories to tell us tomorrow. I wonder if she makes them up the day before or if they actually happened in the past. Like the time she told us about the water-wars, which happened before we were born. According to granny, not all countries always had enough water, because some countries kept it all for themselves. We haven’t done history of the 2020s in school yet (next year maybe), so I’ll have to check on my Weacon to see if it really happened. I keep forgetting though... Anyway, time to check with my friends online before going to bed...

François

Linking up with his uncle who lives on another city via holo-conference and describing his day

Today started as usual with a joint breakfast with the wife and kids, enjoying a wholemeal baguette, fresh fruit and vegetables, cheese, cereal and fruit jam. As we know, breakfast is the most important meal of the day so we always take great care to make sure it gives us a healthy and energetic start. I know I am going to need that for work...I don’t know who invented the smart fridge all those years ago but the guy deserves an award – I don’t know what we would do without it!

I caught the electric bus to work and had a look at the morning newspapers. Call me old-fashioned but I still like to buy the paper version, although it does mean I have to make a 10-minute detour every morning to buy it while walking to the bus stop. I read today that...hmm...apparently a group of senior citizens are organising junk-food events for kids. Honestly, sometimes, I don’t know who is worse, the children or the grandparents. I hope my mother Margherita doesn’t take part in these things. Pierre and Estelle would love to eat more sweets, and I know Margherita likes to spoil them. Anyway, I made a note on my PD (personal device) to have a chat with my mum next time I visit her.

Did you know I now work in the central offices of the FTAA (Food Technology Assessment Agency)? I have a customised and flexible working week, although sometimes I have to put in long hours, and so I am happy that both my kids and my mum are well taken care of by state services – in school and in the old people’s home – and that their food is of high nutritional quality. Talking about food, today we ate with colleagues at the canteen, as usual. It was “easy Friday”, so apart from our usual assortment of vegetable dishes we had some meat choices, too. Small portions and fat free of course. After lunch I checked my personal device to see when I last had meat, and to have a look at my health and diet monitors in general. Today, I ignored the “most appropriate dish for today” notification...

Before returning home after work I decided to go to the supermarket to buy some food. I like to visit the few remaining old-style supermarkets as I don’t get the same feeling when choosing food using the online system. This means I had to take an agency bicycle to go to the supermarket before returning home, since the electric bus doesn’t go near the store. While cycling home I was thinking how our world is and what we can do to make sure our kids grow up in a better place. The climate change indicators don’t look so good... and on top of that we have our own senior citizens smuggling sweets to our kids. Bah! So, what about you, uncle?
Margherita

Explaining to her friends how she ended up in the black market

Tonight I am particularly happy because I visited my son and grandchildren! Not all of us in the ‘community’ (old people’s home, officially) live as close to their family as I do. This thought immediately brightened up my day this morning, especially after the nightmare I had last night. I dreamed that I was young again and some children were bullying me because I was obese. I still am, of course, but in the community we all are. Same age, same problems, mainly due to being obese most of our lives. Back when I was just a young girl not so many kids were obese, at least not as many as later on, at the start of the new century. Fortunately my health monitors informed the nurse on duty about my stress levels and she arrived this morning to cheer me up, and of course to give me the medication I take for my diabetes.

As usual, breakfast was served in the garden and comprised a healthy and varied buffet prepared by the accredited chefs in the community, who also explained the breakfast ingredients and their impact on our health. These days, the information on food and its impact on health is quite easy to understand, even for us old people. My reading glasses can give me this kind of information immediately, as well as monitoring my health. I have a bit of a problem following all these little letters and numbers on my lenses while I am trying to eat though.

After breakfast I relaxed in the sun chair, enjoying the community garden while reading an Agatha Christie novel using my special glasses. I don’t read real books anymore although I quite miss them. Later I met with friends and went for a dip in our pool on the roof of the community main building, and then we relaxed in the spa area on the top floor. And after all that hard work, we were served lunch by the poolside. The healthy food we ate was quite nice of course but I must admit that the desserts and sweets we get are not enough! My glasses keep telling me to eat more vegetables, but I don’t really want any more. What I want is more sweets in my daily menu! I just ended up taking more sweets than I am allowed, they were so delicious. The chefs are to blame, really. I hope nobody noticed, because I promised the kids that I would have some for them, too, next time they come to visit alone. I hide the sweets in the cupboard in my room. My friend in the next room is a retired electronic engineer and he has installed a little script that can fool the sensors about what we have in the cupboards! Take that, healthcare system!

After lunch today I went back to the garden to rest, I get tired easily these days. Doctors tell me also that it's because of my weight, but what do they know? Later on I visited my family and had dinner with them. I picked up a community car, which is always convenient (and free of charge!) and drove to François’ home where I had a great time with the family. The dinner was tailored to my needs; François would not have it any other way of course. Then I played some trans-generational games with Pierre; just lately Estelle has become bored of these games. That’s teenagers for you!

On my way home my glasses warned me that my blood glucose levels were low. Hmmm, what a coincidence! I guess my implanted blood glucose balancer needs to be adjusted again, but what better excuse to turn off the navi-tracker in the car (I know how to do it, thanks to my flatmate) and sneak off to the black market for more sweets? And here I am. Come on, Joan dear, let’s see if we can find some full-fat, full-sugar chocolate tonight!
The future ‘Heal the world’ family comprises Ana and Helen, who have two children, Eric (5) and Sarah (10). Peter and Cristina (both 75) are Helen’s parents and live in the same house with the rest of the family. Søren (100), Peter’s father and the children’s great-grandfather also lives with them.
Hello, my name is Eric, I am five years old, and I am going to school! Today, Spiderman was in my holo-clock to wake me up! I chose it the night before because he’s my favourite hero! He said: “Good morning Eric, when you grow up you will be my assistant” and then he told me to get up and reminded me about Sarah’s birthday. Sarah is my sister; she is older than me and is nice sometimes.

My two mums gave me a lot of kisses and prepared my breakfast. All the family was there and we all sang a birthday song for Sarah. Great-grandpa Søren forgot the words again! The table was really full of colourful food for Sarah’s birthday; I want to have that many colourful fruits for my birthday as well. I told my granddad Peter and he said that he will see to it! Great! We also had more things to eat today than other days; I think we should have a birthday every day! I told granddad Peter and he smiled and gave me a kiss!

Sarah and I went to school on our bicycles, because my mums say it’s cheap, quick and also healthy for us. Today, my friend Tomen’s dad came with us. I think tomorrow it will be Karen’s mum, she is really funny! We also took our digital lunch boxes with us in our school packs. I saw the holo-display and inside there were grilled vegetables and grilled grasshoppers with fat-free chocolate sauce. I love them! My great-grandpa Søren says that this “fat-free junk” that they give us tastes like water. Water doesn’t taste like that; he is very old so maybe he forgot?

In the school canteen we ate a lot of fruit and other nice foods that are provided by the school. It’s called a “school fruit scheme” and the teacher told us that it is a very old programme, as old as him. The teachers told us that fruit and veggies are healthy and “sus-tain-a-ble”, which means they are good for the planet but also good for our tummies. My mums say they are also good for our pocket.

In the lunch break I played with my friends and then we had a nap. I wanted to play some more but the teacher said that taking a nap is obli-ga, obli-ga-to, - that we had to do it! Later we did our homework and I went home with Sarah and the other friends with the bicycles. My friends will come over later tonight because they are also invited to the party! It was my idea! Now I have to go because the grandparents are calling us to play some games in the communal garden. Bye!
Ana

Personal reflections during a five-minute break from work

I often sit and wonder how much things have changed in the last 16 years. I came from Spain and worked in Brussels, where I met Helen. We now live with our two children in northern Europe, together with Helen’s parents and grandfather. Discussions about family structure ended a long time ago, and today our family is just like any other, living together in an extended household of four generations, because the cost of living and care, especially for children and the elderly, are just way too high.

Today I woke up early again. Three elderly people in the house can make a lot of noise. Søren got up first; I guess he went to the black market again. Was he with us at breakfast? Yes, he was back already, because he complained about the alternative dairy products not being “the real thing”. What else did we eat, hmmm, nuts, apples, whole grain bread. The children are already off to school with the neighbourhood biking scheme, and Helen is off to work in the hospital. She is a doctor and needs to be physically present. I work as a remote taxi driver, doing my job in front of a holo-terminal at home. Once used in the military, remote piloting has become pretty much standard in the last 10 years. People still like to socialise and chat in the taxi, so I am what hairdressers used to be back at the beginning of the century – a sort of informal psychologist. I talk about the weather and politics a lot, of course, but I can’t complain, I am always up to date.

Right now it is 11:00 and I am having a five-minute break and relaxing... In a bit I will meet Mogens, our neighbour, and run for 30 minutes. Mogens isn’t the most athletic type out there, and he will probably lag behind as usual, but even he realises the need for daily physical activity. Later we will have lunch with the senior members of the family who are at home, and Mogens will join us. He is alone, so we share expenses and he comes every day to eat. He used to work as a cook in a nearby restaurant before they closed it down and he lost his job. He has some great ideas about cooking once in a while.

Anyway, after lunch I will have to sleep for half an hour, following government recommendations for a productive and healthy working life. I already have problems sleeping at night, worrying if we can make it to the end of the month, so I don’t think I will actually sleep, but it’s nice to just lie there a bit, I guess. At 14:30 I will have to start working again until the kids get home in the afternoon.

Today is Sarah’s birthday – I can’t believe she is ten already! We have invited some of her friends, and Eric’s as well, for a small party. I went ahead and bought some real Spanish oranges for the party. I probably shouldn’t have, since they are so expensive, because they are out of season right now. Kids love them, however, as do we. Fortunately the grandparents are taking care of the party organisation; there is no way me or Helen could have managed to spend any time on that. Helen will come home for dinner, hope she isn’t late today. People work so many hours nowadays; I guess I should be lucky that I work from home. Theoretically everybody should work 10 hours a day, but everybody knows that most people have to put in 2-3 extra hours or have two jobs. Which reminds me, before I go running I should start the in vitro meat machine. I remember when we bought it that we had to explain to Søren that it’s like the old domestic bread-making machines. Of course he was not happy with the taste at all. Can’t say he isn’t right, we had some real meat at Christmas and it was really something else.

I am also supposed to pick up the vegetables from our roof-top garden, but I won’t make it. I’ll ask Peter if he can do that. We have some more food we bought, the standardised industry stuff we eat every day. Maybe we can add it to our dinner, and perhaps Peter can prepare his special sauce to add a bit of taste and variety today since it is Sarah’s birthday. After the dinner party I will probably have to go through the budget with Helen. I can’t think what we would do if the grandparents weren’t giving us a hand with the kids and the house. We don’t want to spoil the mood after the party, but there are a lot of taxes to pay, food is expensive, and to make sure we make it to the end of the month we have to plan ahead. Even on our daughter’s birthday.
Let me introduce myself in this very first attempt to blog in our forum: I am Peter, 75, and live with my wife Cristina, also 75, in an extended communal ‘kangaroo’ housing complex, together with my daughter Helen, her companion Ana, and our grandchildren Eric and Sarah. My father Søren, who has managed to make it to 100, also lives with us, being active and providing us with all sorts of memories (every single day) from life in the 1960s and 70s. Cristina and I are still working, still not retired. She is a patent lawyer and works part-time downtown, while I am an artificial intelligence programmer for robotic med-assistants in hospitals.

Today was Sarah’s birthday, so we woke up early, a bit later than Søren who was already making his way down the back alleys to find his contact and buy a smoke. Old habits die hard even today now that smoking is practically banned, like many other items, due to ridiculously high taxes. Black markets are thriving, and since all monetary e-transactions are monitored, Søren and the other old coots now trade their memorabilia from the 1990s – like soccer cards or analogue calculators and wristwatches – for items like burgers or tobacco. I don’t know how many times I’ve told him that he doesn’t need to sneak down the stairs; we know where he is going, and that he makes more noise when he is trying to sneak … At least he managed to remember to scan himself today as he left the house, so his digital vital signs will pass via the house register to the local hospital. This is an extra service we are paying for, but in this way I always know how he is doing. He is also supposed to monitor his daily nutritional intake to optimise his health, but I won’t vouch for that – we didn’t buy the auto-tracker, and I have a suspicion that he is intentionally reporting false data!

Today, while preparing breakfast with Cristina for the rest of the family we watched a bit of the early edition of the holo-news on our old 3DTV. There was a special report on food prices, which have spiked again to unprecedented heights. Droughts are quite common nowadays, and the report said that the climate conditions in Europe are getting drier. Commodity prices have risen 50 % since last year. Luckily, the government is now holding one year of staple food categories in stocks to smooth price volatility, but it’s hard to stay ahead of the game. The coffee didn’t taste so good, it was produced somewhere in Southern Europe. Our favourite coffee from Kenya is very expensive and considered a luxury; it’s heavily taxed as it is environmentally unsustainable as well as not adhering to fair-trade criteria. At least some of these taxes go to support the poor.

Preparing food for the children at the birthday party might have seemed complex when I was younger, but nowadays it is quite a simple affair. Having the names of the children attending the party, we can access their health attributes and design snacks and food items to suit them all. Well, it’s not us, actually it is our automated cooker that will do all that, and provide list of alternatives, taking into account the preferences found on each child’s ‘My Face’ account. We had to order in some extra foods, which will arrive before the party and I will pick them up as I am at home.

Cristina has a very important patent case in court today, defending a new process for transforming insect bodies into “steak-type meat” (can’t call them insect steaks due to legislation), burgers and sausages. It has been going on for several years now, since the government reviews everything so carefully to ensure the protection of public interests. Unfortunately, some companies have already given up investing in new processes because of the delays and strict regulations involved and have moved their research to other parts of the world. On the other hand, public research has gained momentum, especially since there is the need to find efficient sources of food.

I guess I should go check up on my dad Søren again and make sure he makes it home for the party. He has been spending so much time in his ‘100+ Club’ recently. Yesterday I received a notification from the hospital that he needs to visit to check his muscle mass. His recent health data has raised some concerns, and he should increase his exercise and adapt his daily routine. I don’t even want to think how much his hospital check-up will cost. But look at me – it’s already time to prepare for the party and here I am still working on this blog. Well, more tomorrow, will let you know how the party went!

Have a nice evening fellow old-timers!

Peter, ’75er. Posted on 05/04/2050
This future family comprises Martina, her husband and her son Alexander (13). Maria (96) is Martina’s mother-in-law but does not live with the family.
So yesterday I tried hacking into the Nescuisine using that worm-ware that you sent me. I didn’t manage, but I got close. Next time I will do it, just you wait and see. I wanted to know what would turn up for breakfast this morning. I am bored of the usual fortified fruit salad and I wanted one of those foods I saw online. But my mum got upset when I told her, and she told me I shouldn’t eat that stuff. Man, I wish she could just pop some chill-pills and relax like your mum does.

Apart from not hacking into Nescuisine, yesterday was a really fab day. To start with, it was the f2f day, the face-to-face day, where I can really meet all my schoolmates. It’s about the only time we can relax and talk without any parental or teacher monitor drone hovering over us. You know, we spend most of our time with the nannies and we only see each other on-screen, like we are doing now. Thanks again for the secure-com software; really cool – my mum can’t register our holo-chats anymore!

Anyway, something even more exciting happened. You know how we are always allowed to play some old-style games like soccer towards the end of the f2f day, right? And how the school is in the corner of the fortified complex where we all live, yeah? Well, we were kicking this real ball in the school field, when Adam kicked the ball too high, sending it over the school wall. So instead of waiting for Freddie, our bodyguard, to go outside and pick it up, I climbed on the tree next to the wall and meant to climb down on the other side and get the ball. I knew it would set off all kinds of alarms, but I have a clean track record in school and I am allowed two penalty points per year, so I said I would do it. Betty was also watching, so… you get the point.

I never got the chance to actually do it of course. As soon as I popped my head over the wall, I heard shouts and angry cries. Did you know that the soundproofed field that isolates the school and the complex extends only as high as the perimeter wall? Anyway, I saw some strange children, they must have been our age, but they were dirty and quite angry. In the beginning I didn’t even realise they were actually kids like us! So, they were carrying some banners saying “Down with mega-corporations”. They looked a bit scary as well. Anyway, at that point Fred came and pulled me down before I could ask them what their problem was. What’s the problem with mega corps anyway? Why did they look so different? I want to ask my mum but she is always nervous and snaps back at me when I ask her things and never has time to just chat. Do you think your mum knows?
Martina

Thoughts while starting another work day

What time is it? 05:30... Half an hour more until the alarm goes off. I should get some sleep to face the tough day ahead... but I can’t. My worries are keeping me awake again. If it’s not about my job as a manager of the food distribution system at MultiFood downtown, it’s about the rising tension in the city outside the fortified living complex. Anyway, I might as well voice-order the preparation of the breakfast for me and Alexander... the Nescuisine voice terminal is right next to the bed. Today we will have some quite traditional items: probiotic yoghurt and some fruit and coffee.

A sharp beep in the sec-terminal – Jeeves, our house servant, is being cleared for entrance at the security point by the guards of the walled compound where our house is located.

Time to get up. I pass by my son’s room and give him a kiss, he is still asleep. I eat breakfast in a rush and leave our spacious apartment, taking the gravi-lift to the parking area and enter one of the self-driven smart vehicles there. I confirm my destination towards downtown, choosing the C alternative route to avoid the demonstrations in the main avenues and already fire up the telecom terminal for the appointment with our suppliers in Africa. There is social unrest down there, much more than here in Europe, so I want to know whether they can deliver our primary resources of coffee beans and exotic fruits or if I need to start looking for it in another part of the globe.

While I wait for them to convene, I read flash-news items on the vehicle’s multi-screen: one of our major competitors has announced a 20 % profit increase due to a novel waste-recovery system in their main food-processing plant. Oh, my boss will not be amused at all. Our profits have still to recover from the large outbreak of antibiotic-resistant listeria six months ago, which killed 160 people across the whole of the country. My boss will probably call a meeting with the crisis manager, and we will spend the whole morning and well into lunch discussing our strategies. Talking about lunch, I don’t have a clue what they will bring us. I never do.

Maria

Thinking to herself and recollecting the day – doing short-term memory exercises

I miss my husband, Hans, and my family and my old life at home. I wish I could live near my daughter and grandson, but my pension is small and I can’t afford an institution in my home country. No one can afford to cover part of my expenses either. Now I live in an institution for older people in another, remote country, which became a member of the EU some time ago, but prices are still much lower here than in the EU-38.
When I was younger, in my 50s, Hans kept telling me to lose weight and improve my diet, but I didn't take his advice. I was already obese and diabetic at that time, and now my institution care expenses are higher than normal because of that. As if this wasn't enough, the doctors here are telling me I have mild Alzheimer's disease and that I have begun to forget recent events and need to do memory exercises. Humph! I still remember the past quite well though.

The alarm rang, as usual, around 06:00 and the lights flashed. A few moments later the robot brought me my morning pills. I recollect the breakfasts of my past, with the taste of freshly baked bread and home-made marmalade. Now it's just nutrient-dense cookies and medication pills. The robot accompanied all of my dormitory mates to the bathroom. We always have to keep our bio-sensing monitors on as they track our heart rates, blood pressure as well as other biological parameters, and send any updates immediately to the robot so it can promptly intervene if we need help urgently. There are also some nurses and a doctor on duty, but we don't get to see them unless there are emergencies or we have a pre-set medical appointment.

In a few days my grandson Alexander will come to visit. Haven't seen him in over a year, I bet he is really grown up by now. How old is he now? Maybe we can connect later via the Smart See terminal? I am really proud of him and my daughter-in-law. She has a good job and Alexander is lucky to grow up in an environment where nothing is missing.

For lunch the food dispenser provided me with food and water. With very few exceptions, we eat an easy-to-chew cake with a high nutritional density – you should know that I still have good teeth however. I told the doctor that I can eat normal food, too, but he said that they can't afford to cater for personalised preferences, especially with the food prices these days. Every now and then we also get algae as a side dish. Easy to chew, and full of omega-3s which they say is good for our brains. I don't really believe them though. I still keep forgetting.

After lunch we watched the news on the terminal. The news is in English, and not all of the people here understand it. In this institution, you see, we come from all parts of Europe. There is the option to get a private terminal with news and programmes in your mother tongue, but it is an extra and most people can't afford it.

My mind drifts back to the time when I shared my meal with my two boys. They have also gone, like their dad, a few years ago. One died in a terrorist attack in the food megacorporation he was working for, and the other died from a deadly food-borne outbreak about five years ago. I keep going on…I can leave this world if I decide to, but I am not sure yet. My genetic profile and health status predict that, even with my obesity and diabetes, I could live up to 110 years, but I don't know if I really want that.
The future ‘Me, myself and I’ family comprises Daniel (48), his daughter Sophie (16) and his father Bruno (80).
Ok, Flint, are we on? Sure? OK, here goes... Hiya all, I’m Sophie, I turned 16 a month ago. I am attending high school now, although here in Europe we don’t really go to school every day. We physically go to school just twice a week and today I am sending this message from home, during a break from my courses. Yeah, we still have to follow remote schooling courses the rest of the working week. Flint, do a holo-projection of yourself in front of the recording bio-iris: World, meet Flint! He is my social cyborg, he keeps me company, connects me to the rest of the world and advises me on many issues, like when to study and when not, when to go for a walk and to hang out with my friends, when to eat and, of course, on the moosooost fashionable food to eat! Do you have social robots where you all come from? They are not so expensive anymore, are they?

Anyway, I wear some sensors attached to my clothes and Flint can read my body needs concerning food. My dad Daniel has installed my genetic profile as a software add-on on Flint, and now Flint has access to my genetic make-up, age and dietary profile! The perfect mix to suggest what food would fit yours truly! The best thing though is that Flint can also sense my mood via my clothes sensors! We have a wireless connection all the time so he can sense my emotions and add emotional food to my diet as required – to cheer me up or slow me down if I get too excited!

Hey, right now, Flint activated the auto-cooker to prepare my lunch. But tonight I am going to put Flint in hibernation mode as I am going to have an actual dinner with my friends. I mean, social ‘bots are cool but it’s nice to meet face to face once in a while... Tonight we are going to eat with my real friends at the FIESTA restaurant. I am sure you also have it in your countries; it’s the No. 1 chain for fast, delicious, and most important, fashionable food! So I checked earlier with Flint what’s on the menu today and he suggested the “positive mood dish for dinner”, which will be perfect for my mood tonight but also for my dress! Its stratiﬁed pasta and a light orange chocolate mousse with 100% artificial cherry aroma! Yum Yum.

Oookaaay, so I’ll be waiting for your comments and ratings on my registration video! I can’t wait to be part of the GGFFF community! See ya!
Today I read an article in the morning update of the hologram newspaper that made me wonder. The headline was "New restaurant serving food grown on Mars". I am thinking of how to get inspiration for my next designer food that has to be marketed quite soon when people are already serving food from Mars that was colonised just a few years ago. I have to stay ahead of the game and its getting tough lately. Maybe having dinner at this new restaurant could actually help… I’ll have to talk to my assistant cyborg for a reservation after I complete this note. Speaking of which, I still need to finish my breakfast, most importantly those wonderful, real, and actually yellow bananas that were flown in overnight from Ecuador. This has given me an idea. Today will be my yellow day! I will programme my holo-assistant accordingly and order yellow-based natural or anti-coloured food for the rest of the day. I feel some inspiration coming on!

I also have to do my medical check-up later today. I am getting a bit worried as I am getting older; I wonder how long it will take them to invent a real anti-ageing pill, not of course the fake ones that they sell in those subscription holo-sites. You don’t know who you can trust anymore on issues like health and food. I also have to check if my solar hover car is fully charged and if the autopilot has downloaded all the recent updates to take me to my health insurance agent appointment. He proposes a scheme which will cover every possible treatment I will ever need, plus some more treatments I never even knew existed. It costs quite a lot, but successful design food specialists, like me, earn enough.

Anyway, time to end this memo and get on with the day. I have to connect to my working team right now and propose them the idea I have just come up with. If someone can provide food grown on Mars, how about some water and soft drinks crafted in the vacuum of space???

Pleased to meet you. I am Bruno, 80 years old, and I live with my son and his family in a nice house in the country with a garden and a personal gym area. Yes, I am indeed retired officially but I have kept this part-time job, it helps me stay sharp and connected, even though it is a bit far away from home. Although with these hover-trains a 50km ride to the city is not really an issue anymore. Do you remember the good old days with petrol-powered cars and traffic jams on the highway?

I usually get up at 06:00 every morning and have my complete health Rap’O’Check. You know the usual things, urine, exhale tests, blood from the thumb, etc. You have them too? I see. Then my health device suggests the most fitting breakfast, taking into account my age and physical status (it gets the data from Rap’O’Check). For the last few months, milk and eggs have been locked; I am only allowed to choose from fruit and some supplements. I complete my early morning with a fast session in the gym before I take this hover-train to work in the city centre.
Most days I eat my dinner while travelling back home from work, usually supplements and fruit, packed by the auto-kitchen in the morning. Although, sometimes I bump into my friend Bob – have you met him? We usually decide to eat together at his place, so we allow access to each other’s device and our health apps communicate and find the best combination for both of us and suggest a shopping list. So when we get off the train together – we live near each other you see – we pick up our meals from the food-dispenser at the hover-train landing pad. We usually have the pleasure option enabled, with the “retro” style active as well, to spark those fond memories of when we were young and working as chefs. Yes, I was a chef, but I hardly cook now. We also let our families know when we are having dinner together, although they rarely manage to join us. We just end up talking about the good old times usually, before our devices tell us it’s time to go to bed. Anyway, I have to hop off now; the next hover-pad station is mine. Have a nice evening!
Tomorrow’s healthy society
Research priorities for foods and diets

ANNEX V

FP6 AND FP7 PROJECTS RELATED TO THE IDENTIFIED RESEARCH PRIORITIES

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Towards healthier eating: integrated policy-making

**Improve the evidence base for adoption of healthier dietary behaviour**

**Sixth Framework Programme (FP6)**

**EURECCA - EURopean micronutrient RECommendations Aligned**
The project targeted evidence-based methodologies and tools to help develop quality-assured and aligned micronutrient Dietary Reference Values (DRV) across Europe, with a special focus on vulnerable groups and consumer understanding.

**Develop a scientific framework for a systems approach to food and nutrition policies**

**Seventh Framework Programme (FP7)**

**CONNECT4ACTION - Strategies for improving communication between social and consumer scientists, food technology developers and consumers**
The project is focusing on communication and knowledge exchange between food technologists and consumer scientists in order to improve multidisciplinary dialogue and increase consumer acceptance of new food products.

**Provide a framework to design, monitor and evaluate policies**

**FP6**

**HELENA - Healthy Lifestyle in Europe by Nutrition in Adolescence**
The project developed harmonised and comparable European data about food intake among European male and female adolescents, taking advantage of computer-based dietary assessment tools.

**IDEFICS - Identification and prevention of Dietary- and lifestyle-induced health EffectS In Children and infantS**
The study explored the risks related to overweight and obesity in children, as well as the associated long-term consequences. IDEFICS also developed, implemented, provided and evaluated health-promotion programmes in kindergartens and schools.

**ISAFRUIT - Live a long and fruitful life**
The strategic objective of this project was to increase fruit consumption to improve Europeans’ health and well-being by taking a total-chain approach, identifying the bottlenecks and addressing them with consumer-driven preferences.

**FP7**

**CHANCE - Low cost technologies and traditional ingredients for the production of affordable, nutritionally correct foods improving health in population groups at risk of poverty**
The project aims to contribute to the better understanding of existing nutritional barriers to healthy nutrition among European sub-clusters with low purchasing power, limited education and the highest risk of diet-related diseases due to suboptimal nutrition. It is developing nutritional strategies and guidelines for the prevention of malnutrition in population groups at risk of poverty.

**CLYMBOL - Role of health-related claims and symbols in consumer behaviour**
The objectives of this project are to determine how health-related symbols and claims in their context are understood by consumers and how they affect purchasing and consumption.

**EATWELL - Interventions to Promote Healthy Eating Habits: Evaluation and Recommendations**
The project has assessed the efficacy of past policy initiatives, aiming to identify appropriate measures to improve dietary and health outcomes. It has developed procedures for assessing cost-effectiveness, cost-utility and cost-benefit analysis of policy initiatives, which take into account market interactions and agents’ adaptive behaviour.

**FLABEL - Food Labelling to Advance Better Education for Life**
The project team is developing and applying a framework incorporating information on the characteristics of food labels and how consumers read them. Based on their findings, nutrition labelling guidelines will be developed. The project
is assessing which labels are most appealing and informative to the public and how best to strike a balance between ‘simple’ and ‘complete’ nutritional information.

**FOODRISC - Food Risk Communication Perceptions and communication of food risks/benefits across Europe: development of effective communication strategies**

Researchers in the project have compared the use of traditional and social media, and evaluated the public’s information-seeking behaviour and perceptions of food risks and benefits. Based on their findings, an e-resource centre has been developed to help communicators to disseminate information on food risks and benefits.

**HABEAT - Determining factors and critical periods in food habit formation and breaking in early childhood: a multidisciplinary approach**

The project aims to understand how food habits are formed in infants and young children, including identifying the critical periods and the most-effective strategies for breaking habits.

**I.FAMILY - Determinants of eating behaviour in European children, adolescents and their parents**

This project will compare families who have developed and maintained a healthy diet with those whose diet has developed in an unfavourable direction, in order to study the impact of biological, behavioural, social and environmental factors on dietary behaviour over time. The focus will be on the family environment, socio-behavioural and genetic factors determining familial aggregation.

**PREVIEW - PREvention of diabetes through lifestyle Intervention and population studies in Europe and around the World**

The project’s primary goal is to identify the most efficient lifestyle pattern for the prevention of type-2 diabetes in a population of pre-diabetic overweight or obese individuals, including children, adolescents, adults and the elderly, by conducting a multi-centre, randomised clinical trial and using data form large population studies.

**TOYBOX - Multifactorial evidence-based approach using behavioural models in understanding and promoting fun, healthy food, play and policy for the prevention of obesity in early childhood**

The project is identifying key behaviours related to early childhood obesity and their determinants, and evaluating behavioural models and educational strategies.

**TRANSFOP - Transparency of Food Pricing**

This work addresses the key aspects of the food chain, including different characteristics of the food sector throughout the EU Member States, and ongoing developments in the food chain with regard to its vertical coordination, consolidation and how the regulatory environment affects the overall functioning of food supply chains across the EU.

**Food, nutrients and health: cross-interactions and emerging risks**

**Deepening the understanding of human nutrition: facing the complexities**

**FP6**

**FLAVO - Focus on flavonoids in food quality and health**

The project team carried out research on how different production and processing methods can influence the flavonoid content of food products, and what kind of products are most appropriate for enhanced flavonoid content.

**FLORA - Bioactive protection for healthy living**

This project aimed to systematically analyse the health-promoting effects of plant flavonoids and related phenolics, and to identify the mechanisms by which bioactive nutrients protect against disease at the cellular level.

**LYCOCARD - Increase your tomato intake!**

The project investigated the role of lycopene, the compound in tomato which reduces the risks of both cardiovascular disease and cancer. The LYCOCARD consortium analysed lycopene bio-availability, the oxidative catabolism of lycopene, the physiologically relevant isomers and metabolites, modulation of endothelial functions, and the effects of lycopene and its derivatives on cell signalling pathways.

**ZINCAGE - Keep taking the zinc tablets?**

The work involved studying the behaviour of zinc and its related physiology in the immune cells of elderly, testing whether faults can be corrected with supplements, and generating advice on who could really benefit from zinc supplements and diets with zinc.

**FP7**

**ATHENA - AnThocyanin and polyphenol bioactives for Health Enhancement through Nutritional Advancement**

The overall objective of the project is to provide a robust scientific foundation for improved dietary recommendations that include foods with high levels of anthocyanins and related polyphenols to promote health and to protect against chronic diseases.

**BACCHUS - Beneficial effects of dietary bioactive peptides and polyphenols on cardiovascular health in humans**

The project team is developing tools and resources that can be used to support claims of a cause-and-effect relationship between consumption of bioactive peptides and polyphenols, and beneficial physiological effects related to cardiovascular health in humans.
EFRAIM - Mechanisms of early protective exposures on allergy development
This project has investigated protective factors and mechanisms, such as the maturation of immune responses, gut colonisation, mucosal barrier function, and genetic and epigenetic factors influencing the development of allergies.

ETHERPATHS - Characterisation and modelling of dietary effects mediated by gut microbiota on lipid metabolism
The work aimed to develop systems-biology tools that can facilitate studies of dietary interventions aiming to modulate lipid homeostasis. The plan was to optimise all models in the context of studies of dietary interventions, to be integrated into a sophisticated software platform.

EURO DISH - Study on the need for food and health research infrastructures in Europe
By building on available projects and systematically mapping existing research institutions, the research aims to provide feasible recommendations on the need to integrate existing, and to develop new food and health research institutions that are relevant to innovation in mechanistic research and public health nutrition strategies.

FIBEBIOTICS - Dietary Fibres supporting Gut and Immune Function - From polysaccharide compound to health claim
The goal of this project is to support the development of functional food ingredients and products that are beneficial for the human gut and immune system. Therefore, the team is studying the molecular, cellular and whole-organism effects of specific non-digestible polysaccharides.

FLAVIOULA - Targeted delivery of dietary flavanols for optimal human cell function: Effect on cardiovascular health
The researchers aim to explain the cellular and sub-cellular effects of flavanols and their main human metabolites, and to investigate the key parameters of dietary flavanol absorption, clearance and efficacy towards surrogate markers of cardiovascular function in humans. The goal is to develop evidence-based dietary recommendations and innovative new products that are nutritionally responsible and able to optimise nutrient delivery.

FULL4HEALTH - Understanding food-gut-brain mechanisms across the lifespan in the regulation of hunger and satiety for health
Here, laboratories are collaborating to investigate the mechanisms of hunger, satiety and feeding behaviour, the effects of dietary components and food structure on these processes, and their possible exploitation in addressing obesity, chronic disease and under-nutrition.

FUNCFOOD - Impact of agents with potential use in functional foods on biomarkers for induction of age related diseases
EU and Indian research centres are collaborating to investigate the protective actions of various non-toxic agents in vitro as well as in rodent models with respect to the induction of DNA lesions, tumours and biomarkers for the development of diabetes, diabetic retinopathy and atherosclerosis.

LIPIDDIET - Therapeutic and preventive impact of nutritional lipids on neuronal and cognitive performance in ageing, Alzheimer's disease and vascular dementia
The project aims to develop a lipid-based diet that reduces the risk of Alzheimer's disease and related diseases and has a stabilising effect on cognitive performance in ageing.

MOODFOOD - Multi-country cCollaborative project on the rOle of Diet, Food-related behaviour, and Obesity in the prevention of Depression
The goal of the project consortium is to gain a better understanding of the psychological, lifestyle and environmental pathways underlying the links between food intake, nutrient status, food-related behaviour and anxiety/stress on the development of diet-related diseases, and how risk factors like stress in the workplace are encouraging disadvantageous behaviour.

NEUROFAST - The Integrated Neurobiology of Food Intake, Addiction and Stress
This project is analysing the determinants of food addiction and substance abuse, the effect of mood, anxiety and stress on the development of diet-related diseases, and how risk factors like stress in the workplace are encouraging disadvantageous behaviour.

NUDGE-IT - The Neurobiology of Decision-Making in Eating
The project is seeking a better understanding of decision-making in food choice, and is building predictive models with strong explanatory power to contribute to improving public health policy.

NUTRIMENTHE - Effect of diet on the mental performance of children
Researchers are studying the role, mechanisms, risks and benefits of specific nutrients and food components on children's mental performance from the foetal stage to childhood. They are also addressing key issues in child mental health where diet could play a role, for example, cognitive development, cognition and anxiety/stress.

NUTRITECH - Application of new technologies and methods in nutrition research - the example of phenotypic flexibility
The work involves using cutting-edge analytical technologies and methods to evaluate the diet-health relationship, and to assess the underlying and related biological and genetic cell mechanisms and the physiological adaptation processes when homeostasis is challenged.
ODIN - Food-based solutions for Optimal vitamin D Nutrition and Health through the life cycle (ODIN)
The study aims to establish a standardised analytical platform for 25-hydroxycholecalciferol (25OHD) and to describe the prevalence of vitamin D deficiency in Europe. The team will carry out RCTs in pregnant women, children, teenagers and ethnic immigrant groups to provide experimental data to specify vitamin D intake requirements.

PATHWAY-27 - Pivotal assessment of the effects of bioactives on health and wellbeing. From human genome to food industry – pathway
This project is addressing the role and mechanism of three bioactives with known/claimed effectiveness in reducing some risk factors of metabolic syndrome, and determining their impact on the physiologically-relevant end points of metabolic syndrome.

TORNADO - Molecular Targets Open for Regulation by the gut flora – New Avenues for improved Diet to Optimise European health
The project aims to determine the influence of diet on the gut flora, and the impact of gut flora on the immune system/other organ systems. It will deliver data that can be used to recommend biomarkers for evaluating the effects of diet or microbes.

Anticipation of emerging risks

FP6

BIOTRACER - Tracking microbes for improved food safety
The work developed recommendations for controlling the risks of food contamination with microbes, through the integration of novel genomic and metabolic data on contaminating micro-organisms.

ECHAIN - Developing a stakeholders’ guide on the vulnerability of food and feed chains to dangerous agents and substances
The objective of this project was to develop methodologies to optimise traceability and provide quantitative risk assessments of chain vulnerability.

GRACE - Verification of GMO risk assessment elements and review and communication of evidence collected on the biosafety of GMO
The project framework created quality reviewing processes for different fields of GMO impact assessment and addressed the need for a well-documented, transparent and sustainable representation of these reviewing processes.

HEALTHY-WATER - Spring of life
The study was designed to further scientists’ understanding of pathogens in drinking water by building on previous work on the microbiological surveillance of water supplies. The major focus was on the development and validation of molecular-detection technologies.

MONIQA - Monitoring and Quality Assurance in the Food Supply Chain
This network is promoting the harmonisation of analytical methods for monitoring food quality and safety in the food supply chain by coordinating and combining research activities, infrastructure and personnel.

PATHOGENCOMBAT - Fighting new pathogens in food chain
The researchers studied eight new and emerging pathogens and developed molecular-based methods to detect, predict and characterise these pathogens along the food chain and at the time of consumption.

TRACE - From fork back to farm
This project set out to develop generic and sector-specific traceability systems for the food industry, including molecular biology methods, genetic markers and microarray technology specifications relating to the origin of food.

FP7

AQUAVALENS - Protecting the health of Europeans by improving methods for the detection of pathogens in drinking water and water used in food preparation
The project aims to identify and characterise the genes of pathogens in drinking water and water used in food preparation, as well as to determine their virulence in humans. Based on this knowledge, new technologies are being developed that integrate sample preparation and detection into a single standardised platform.

COLLAB4SAFETY - Towards sustainable global food safety collaboration
The project team is setting up a global network on food safety for exchanging information on food safety related to research findings, capacity building and policies, and is facilitating the control and mitigation of existing and emerging food risks.

DREAM - Design and development of REAlistic food Models with well-characterised micro- and macro-structure and composition
The study aimed to improve knowledge on the relationship between food compositions, processing and end-product structures on the molecular to macroscopic scale. To validate this approach, the team investigated the impact of structural changes in the food matrices on nutrient and toxicant bioavailability and the microbial food-borne population.

FOODINTEGRITY - Ensuring the Integrity of the European food chain
The researchers will establish processes for harmonising and exploiting existing databases, a methodology to address stakeholder needs, and will develop a self-sustaining food-fraud early-warning system.
FOODRISC - Food Risk Communication. Perceptions and communication of food risks/benefits across Europe: development of effective communication strategies
The project identified the barriers in communicating to consumers across Europe and key socio-psychological and socio-demographic characteristics, including gender, that affect food risk/benefit perceptions and processes as well as consumer preferences regarding communication channels.

OBELIX - OBesogenic Endocrine disrupting chemicals: Linking prenatal exposure to the development of obesity later in life
The work involves assessing prenatal exposure to six major classes of endocrine disrupting chemicals (EDCs) found in food identified as potential inducers of obesity later in life, by using mother-child cohorts from various European regions.

PARASITE - Parasite risk assessment with integrated tools in EU fish production value chains
The project aims to provide new scientific evidence and technological developments to detect, monitor and mitigate impacts of zoonotic parasites occurring in fishery products.

STARTEC - Decision Support Tools to ensure safe, tasty and nutritious Advanced Ready-To-Eat foods for healthy and vulnerable Consumers
This project is developing tools based on scientific evidence and predictive and probabilistic models to enable food operators to estimate the quality and safety of their products (ready-to-eat foods). It is focusing on vulnerable consumers in situations where increased quality and safety levels are needed, e.g. patients in nursing homes, hospitals, and old and sick people living at home.

SYMBIOSIS-EU - Scientific sYnergisM of no-no-Bio-Info-cOgni Science for an integrated system to monitor meat quality and Safety during production, storage, and distribution in EU
The aim of the project was to identify and quantitatively evaluate practical and easy-to-use chemical, biochemical and molecular indices and to establish their applicability in monitoring the safety and quality of meat during inspections.

VITAL - Integrated Monitoring and Control of Foodborne Viruses in European Food Supply Chains
Researchers used standardised methods to detect viruses in and control contamination of the European food supply by pathogenic viruses throughout three food supply chains – salad vegetables, soft fruit, and pork – from farm to market.

Making individualised diets a reality
The projects mentioned below cover both research priorities in this thematic area: ‘Data needs: creation and management of necessary data for enabling individualised diets’, and ‘Analysing the feasibility and impacts of individualised, healthy diets’.

FP6

DIOGENES - Diet, Obesity and Genes
The project set out to demonstrate prototypes of innovative products or advice regimes to help susceptible individuals to avoid weight gain and regain, and to link with implementers to facilitate commercialisation in the market place.

LIPGENE - Diet, genomics and the metabolic syndrome: an integrated nutrition, agro-food, social and economic analysis
The work examined how variations in the composition of dietary fats interact with common human genetic variations and influence the development of metabolic syndrome. It assessed consumer attitudes, economic barriers and the usefulness of the newly developed agro-food technologies and the cost of dietary versus pharmaceutical approaches in managing metabolic syndrome.

NUGO - European NutriGenomics Organisation
The project links genomics, nutrition and health and provides a network to develop and integrate genomic technologies, facilitate the application of these technologies, and train a new generation of European scientists to use them.

FP7

BIOCLAIMS - BIomarkers of Robustness of Metabolic Homeostasis for Nutrigenomics-derived Health CLAIMS Made on Food
Researchers are developing new biomarkers predictive of a healthy metabolic phenotype during ageing, as well as characterising and evaluating them for practical application in human nutrition and comparing them to traditional biomarkers.

FOOD4ME - Personalised nutrition: An integrated analysis of opportunities and challenges
The goal of the project is to determine the application of personalised nutrition, by developing suitable business models, researching technological advances, and validating delivery methods for personalised nutrition advice. It will compile current scientific knowledge and consumer understanding of personalised nutrition to inform the EU institutions, the food industry, and other stakeholders.
NU-AGE - New dietary strategies addressing the specific needs of elderly population for healthy ageing in Europe
The project aims to counteract the physical/cognitive decline occurring in the elderly as a consequence of the progressive alteration of different organs/systems, using a one-year elderly-tailored whole diet intervention in healthy elderly study subjects. It is also assessing the effect of the newly designed food pyramid specifically for EU citizens aged 65 and over, using a large set of biomarkers related to nutrition and ageing.

Shaping and coping with the 2050 food system

Understanding the social role of food
No related FP6 or FP7 projects have been identified.

Towards a sustainable food system producing safe, affordable and healthy dietary components

FP6

HEALTHY STRUCTURING - Nutritional and structural design of natural foods for health and vitality
The project focused on preserving the qualities of fruit and vegetables throughout the entire production process for ready-to-eat meals. The team used real food products and analysed plant characteristics from the early stages of production until their arrival on the consumer's table, as well as their impact during consumption. Ways of preserving the nutritional qualities of the raw materials were also explored.

FP7

FOODMANUFUTURE - Conceptual Design of a Food Manufacturing Research Infrastructure to boost innovation in Food Industry
This project is investigating the main trends and challenges of the food and manufacturing sectors and defining four possible scenarios for the future of European food manufacturing.

FOODMETRES - Food Planning and Innovation for Sustainable Metropolitan Regions
The researchers are aiming to identify concepts and practical examples for food chain innovation in the context of small-scale urban, peri-urban and rural forms of agriculture and food production up to large-scale metropolitan production. They are also studying and comparing the technical, logistical, organisational and governance aspects of innovative food-chain system regimes and assessing their economic, environmental and social impacts.

FUSIONS - Food Use for Social Innovation by Optimising waste prevention Strategies
The overall aim of the project is to contribute to the harmonisation of food-waste monitoring, the feasibility of social innovative measures for optimised food use in the food chain, and the development of a common food waste policy across the EU.

GLAMUR - Global and Local food chain Assessment: a Multidimensional performance-based approach
The project goal is to integrate advancement in scientific knowledge concerning the impact of food chains with the application of knowledge to practice in order to increase the sustainability of food chains through public policies and private strategies.

SENSE - Harmonised ENvironmental Sustainability in the European food and drink chain
The objective is to deliver a harmonised system to assess the environmental impact of food and drink products and to validate the new system in the juice, meat, dairy and aquaculture chains.

SUSMILK - Re-design of the dairy industry for sustainable milk processing
The project aims to initialise a system change that will contribute to the sustainable processing of milk, quark and cheese and a redesign of the dairy industry via the products' existing infrastructures.

Supporting technologies to meet societal needs

FP6

NUTRA-SNACKS - ready-to-eat food for breakfast and sport activity with high content of nutraceutics preventing disease and promoting public health
The aim was to produce food with a high content of natural metabolites with the following recognised health activities: anticancer, antilipidemic, anti-cholesterol, antimicrobial, antibacterial, antifungal, antiviral, antihypertensive, anti-inflammatory and antioxidant activity, and the realization of bioreactor/sensors for innovative plant cell and in-vitro systems suitable for nutrient production.

FP7

CARODEL - Use of Microorganisms for Carotenoids Delivery: Next Generation of Probiotics for Cardiovascular Disease
The project aims to valorise the results of the previous FP7 COLORSPORE project, in which initial isolation and characterisation work was performed on Bacillus strains producing gastric-stable carotenoids.

HEALTHBREAD - HealthBread product innovation based on FP6 HealthGrain results and knowledge
Based on an SME and consumer-oriented approach, the project is developing whole grain and white
breads with further improved nutritional and product quality by applying scientific and technological knowledge acquired from the FP6 HEALTHGRAIN project to the production and marketing of commercially viable, healthier bread.

**NAMASTE - New Advances in the integrated Management of food processing waste in India and Europe: use of Sustainable Technologies for the Exploitation of by-products into new foods and feeds**

Researchers are developing industry-relevant approaches for the valorisation of citrus, mango, pomegranates, wheat and rice bran by-products and waste into healthy food ingredients, foods and feeds.

**NOSHAN - Sustainable Production of Functional and Safe Feed from Food Waste**

The project is investigating the process and technologies needed to stabilise food waste and convert it into suitable raw materials for bulk feed at low cost, low energy consumption and with maximum recovery.

**PEGASUS - Public Perception of Genetically modified Animals - Science, Utility and Society**

The work focuses on providing policy support for the development, implementation and commercialisation of GM animals, and derivative foods by integrating existing social, public perception, environmental and economic knowledge and conducting a foresight exercise.

**PERFORMANCE - Development of Personalised Food using Rapid Manufacturing for the Nutrition of elderly Consumers**

The project will develop and validate a holistic, personalised food supply chain for frail elderly people in nursing homes, ambient-assisted living facilities or at home (receiving nursing services). As a result, an overall concept will be made available enabling the automatic manufacturing and supply of personalised, specially textured food for frail elderly people.

**PLEASURE - Novel Processing approaches for the development of food products Low in Fat, Salt and Sugar**

The researchers aim to develop innovative processes and/or to implement novel technologies to allow for the development and production of food products with low fat (saturated and trans-fatty acids), salt and sugar content.

**PROTEINSECT - Enabling the exploitation of Insects as a Sustainable Source of Protein for Animal Feed and Human Nutrition**

The objective of the consortium is to facilitate the exploitation of insects as an alternative protein source for animal and human nutrition. It will set up pilot-scale production facilities in order to demonstrate the feasibility of using insect-derived proteins in animal feed.
Tomorrow’s healthy society
Research priorities for foods and diets

ANNEX VI

WORKSHOP PARTICIPANTS
## Participants in the three study workshops

(not all participants attended all three workshops)

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