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Nutrition challenges ahead

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Abstract

The breakout session 'Nutrition challenges ahead' was held at the EFSA 2nd Scientific Conference 'Shaping the Future of Food Safety, Together' (Milan, Italy, 14–16 October 2015) to address the main problems in the area of nutrition to be faced in the 21st Century, both at a global and individual level. The nutrition challenges ahead are diverse and depend on agricultural, socioeconomic and individual factors. At a global level, food security, food sustainability and decreasing the impact of food production on climate change are of paramount importance. Decreasing the prevalence of obesity and related disorders, which may coexist with selected micronutrient deficiencies, is a major challenge for wealthy countries; for developing countries and rural food systems, fighting protein–energy malnutrition and micronutrient deficiencies is a priority. Diets based on a wide variety of nutrient-rich local plant foods (e.g. fruits, vegetables, whole grain cereals, vegetable oils, nuts) that contain moderate amounts of animal protein (preferably in the form of fish) and are low in saturated and *trans*-fatty acids, added sugars and sodium, are healthy, nutritious, sustainable and climate friendly. Creating an environment where such diets are also economically advantageous and convenient may be a part of a global solution to these nutritional challenges. Individuals, however, are unique regarding their genetic background, gut microbiota and health status. In addition, nutrition may already play a role in the development (and prevention) of disease very early in life. Thus, additional health benefits could be achieved by tailoring nutritional strategies to particular population subgroups or even individuals on the basis of current and future knowledge about the relationship between nutrients, genes, the microbiome and health. New technologies and food innovation may help in finding novel foods fit for purpose.

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Table of contents

| | |
|--|---|
| Abstract..... | 1 |
| 1. Scientific background and aim..... | 4 |
| 2. Summary of presentations | 4 |
| 2.1. Nutrition in the 21st Century | 4 |
| 2.2. Food for me..... | 4 |
| 2.2.1. Metabolic programming: implications for feeding infants and children..... | 5 |
| 2.2.2. Personalised nutrition for the gut microbiome: feed it, change it, swap it? | 5 |
| 2.3. Food for us..... | 6 |
| 2.3.1. Novel foods | 6 |
| 2.3.2. 'Under-used' food sources of key nutrients | 6 |
| 2.3.3. Agricultural biodiversity for healthier diets from sustainable food systems..... | 7 |
| 3. Panel discussion | 7 |
| 4. Conclusions..... | 8 |
| References..... | 8 |
| Abbreviations..... | 9 |

1. Scientific background and aim

Rapid developments in science and technology have fostered our understanding of the link between nutrition and health. Genome sequencing has contributed to greater knowledge about the relationship between genetics, nutrition and health, and thus about personalised nutrition. Such developments may help to prevent non-communicable diseases and conditions, such as obesity, diabetes and cardiovascular diseases (CVD) later in life. At a global level, the sustainable provision of nutritious food to the growing population of the planet is a striking challenge. A significant section of the human population is suffering from nutrition-related problems, including undernutrition and obesity. Finding solutions to this double burden are of paramount importance, given the multifactorial nature of malnutrition in all its forms and its evidence-based association with adverse health outcomes. The session focused on developments and challenges in nutrition in the 21st Century and options for addressing the growing need for food and key nutrients. It was introduced and chaired by Professor Androniki Naska and by Dr Junshi Chen.

2. Summary of presentations

2.1. Nutrition in the 21st Century

The session started with a keynote speech on the big nutrition-related challenges which developed countries will need to face in the 21st Century. Professor Tom Sanders identified three main challenges for Europe: (i) the ageing population; (ii) the increasing prevalence of obesity in the young; and (iii) climate change.

The ageing process entails loss of physical competence (e.g. poor dentition, visual loss, loss of taste, dementia, loss of mobility and dexterity), social isolation, and increased risk of disease and medication use, which either alone or in combination may adversely affect the nutritional status of older people. Diet-related health risks among elders include cardiovascular disease, cancer, diabetes, anaemia, osteoporosis, sarcopenia, dementia and blindness. As far as CVD is concerned, the problem is particularly serious in eastern European countries. Risk factors for CVD (e.g. obesity and diabetes) have also increased steadily in England and other western European countries in the last 10–15 years, although death rates due to coronary heart disease (CHD) have been falling, mostly due to medical progress in the treatment of events and secondary prevention (Bajekal et al., 2012).

The prevalence of obesity and related metabolic diseases among adult Europeans is high, although the problem is becoming worse among children, particularly in southern and southern-east Europe, where the prevalence of childhood obesity is as high as 20–25% in some countries (Wijnhoven et al., 2014). The comorbidities associated with obesity include pulmonary diseases, acute pancreatitis, gout, gall bladder disease, gynaecological abnormalities, some types of cancer, osteoarthritis and non-alcoholic fatty liver disease, among others. In addition, obesity is a risk factor for the development of type 2 diabetes and CVD, including CHD and stroke. The number of hospital admissions primary or secondary related to obesity has increased exponentially in England between 2002 and 2012, primarily among subjects aged 25–64 years.

Research and the development of new technologies may play a role in the solution to these problems. These include the introduction of novel foods, understanding of the interactions between diet and genetics (personalised nutrition), epigenetics and nutritional programming, and information technology. However, simple dietary modifications may have a bigger impact at a population level. Current advice focuses on favourable dietary patterns (e.g. Mediterranean, Japanese and vegetarian diets), which have not changed much in the last 20 years and share common traits, such as low consumption of foods high in sodium (salt), saturated fats, *trans* fats and added sugars; low consumption of refined grains and red meat; and high consumption of fruits, vegetables, whole grains and seafood. It is equally important to balance energy intake (e.g. through the reduction in portion sizes) with physical activity to manage body weight. These dietary patterns can also contribute to climate change. The carbon dioxide emissions linked to vegan diets may be as twice as low than those associated to meat-based diets.

2.2. Food for me

This section addressed aspects related to personalised nutrition, such as the interaction between diet and the genetic background early in life and the role of the unique gut microbiota of each individual in the development of chronic diseases.

2.2.1. Metabolic programming: implications for feeding infants and children

Professor Mary Fewtrell explained that the concept of programming, understood as a stimulus at a critical period that leads to a permanent change in structure or function, has been known for centuries. Human beings are exposed to numerous programming stimuli, both endogenous (e.g. hormones) and exogenous (e.g. temperature, light, drugs, contaminants, nutrients), although there may be a critical window in which exposure to such stimuli may induce permanent changes. Both under- and overnutrition may programme later outcomes, which may differ by gender. Metabolic (e.g. blood pressure, blood cholesterol, glucose tolerance, obesity) and non-metabolic (e.g. behaviour and learning, longevity) outcomes have been programmed through nutrition in animal models.

The evidence available on the relationship between mother's and infant nutrition and health outcomes later in life comes mostly from observational studies, which alone are unable to prove causality. In addition, cohort attrition and loss of follow-up in long-term studies lead to selection bias and loss of power. Randomised controlled trials, however, are not always feasible in infants due to ethical reasons.

The available evidence suggests that exclusive breastfeeding is associated with lower blood pressure and blood cholesterol during puberty and adulthood, which could have a major impact on the incidence of, and mortality from, CVD at a population level. This association could be mediated by specific factors in breast milk and/or by slowing down early growth. The growth acceleration hypothesis suggests a long-term increase in CVD risk resulting from faster growth in the early post-natal period. Faster weight gain in breastfed infants and higher protein intakes through formulae feeding have also been associated with higher fat mass in childhood. Epidemiological studies suggest that 20% of the risk of being overweight might be explained by a high weight gain between birth and 4 months of age (Wells, 2014).

The practical implications of these observations, however, may depend on the context in which infants grow. Avoiding fast weight gain and reducing the protein content of infant formula seems to be wise advice for at term infants in food-secure countries. Preterm infants, however, are exquisitely sensitive to the effects of early nutrition on the brain, and high nutrient intakes may improve cognitive function later in life by modifying brain structure and function, in addition to improving survival and bone health. In addition, faster infant weight gain and linear growth in low income countries is associated with large gains in human capital, but not with increased CVD risk (Jain and Singhal, 2012).

Some questions remain open. Is the critical window the same for all outcomes? Does the critical window for metabolic effects extend to the weaning period? Do all protein sources have the same effects? What is the effect of specific nutrients in programming? How do genotypes, appetite traits, epigenetic and environmental factors contribute? On the basis of current evidence, sensible advice for term infants includes exclusive breastfeeding for at least 4 months, avoiding rapid early weight gain also during complementary feeding, and decreasing the protein content of formulas, whereas promoting both growth and good nutrition is essential for optimal brain outcomes in preterm infants, who should consume human milk with nutrient fortification if required to achieve optimal growth and/or preterm formula designed for such purpose (Fewtrell, 2011).

2.2.2. Personalised nutrition for the gut microbiome: feed it, change it, swap it?

Dr Kieran Michael Tuohy introduced the gut microbiota as an essential organ in humans that interacts with diet, drugs, the immune system, the gut and its annexes, and which may influence systemic metabolism and the adipose tissue, as well as brain development and function. It is composed of about 1,000 species of bacteria, the majority of which cannot be cultivated, and it is unique for each individual.

Several beneficial health effects associated with calorie-restricted, traditional, and sustainable diets (e.g. Mediterranean and Japanese diets) can be explained by the bacterial metabolism of key dietary components (e.g. plant polyphenols, dietary fibre). The same applies to the adverse health effects associated with diets with a high environmental impact, such as those rich in red meat. For example, bacterial metabolism of phosphatidylcholine and L-carnitine in red meat leads to by-products (e.g. trimethylamine *N*-oxide (TMAO)) which are strongly associated with an increased risk of CVD (Wang et al., 2011; Koeth et al., 2013), whereas the addition of inulin (a dietary fibre) to the diet blunts the production of such by-products. Another indication that the gut microbiota may be heavily involved in the development of metabolic diseases is the fact that differences in the gut microflora between lean and obese subjects are attenuated when the latter undergo an energy-restricted, weight-loss diet (Ley et al., 2006; Zhang et al., 2015).

How can an individual's microbiota be changed to a more favourable one in terms of health? The first option is to **feed it**, providing substrates, such as dietary fibre and plant polyphenols, which increase the relative abundance of *Bifidobacterium* and other 'fibre degraders' and decrease the abundance of microorganisms involved in TMAO and choline metabolism. The second option is to **change it** by providing microorganisms with the diet with a clear mechanism of action by which they could improve the metabolic profile of the host, or through surgery in obese subjects (e.g. gastric bypass, vertical banded gastroplasty). The third option is to **swap it** with a more favourable gut microflora through faecal transplant. This technique has not only been used in animal studies to show that the microbiota profile has a clear impact on body weight, fatness and the metabolic profile, but also to treat recalcitrant *Clostridium difficile* infections in humans.

2.3. Food for us

This section faced the challenge of feeding an exponentially growing planet population in a sustainable way.

2.3.1. Novel foods

Dipl-Ing Klaus Riediger provided an overview of the legal framework governing the authorisation of novel foods (NFs) in the European Union (EU). NFs are defined in European legislation as foods or food ingredients with no significant history of consumption within the EU before the 15 May 1997. NFs include foods and food ingredients: (i) with a new or intentionally modified primary molecular structure; (ii) consisting of, or isolated from, microorganisms, fungi or algae; (iii) consisting of, or isolated from, plants or consisting of, or isolated, from animals, except for foods and food ingredients obtained by traditional propagating or breeding practices and having a history of safe food use; (iv) obtained through a new production process giving rise to significant changes in the composition or structure of the foods or food ingredients that affect their nutritional value, metabolism or level of undesirable substances. In the new EU Regulation, cloned animals, nanotechnologies and traditional foods from third countries derived from primary production (e.g. plants, animals) and a history of safe food use in that country are explicitly mentioned.¹ GMOs fall under a different legal framework.

NF authorisations have been granted for a wide variety of foods and ingredients, including sugar replacers (e.g. D-tagatose), underused protein sources (e.g. rapeseed protein), fatty acids with known health benefits (e.g. long-chain omega-3 fatty acids usually present in fatty fish) obtained from unusual sources (e.g. algal oils and chia seeds), or common foods (e.g. milk) treated with new technologies (ultraviolet-C) which may improve their nutritional value (e.g. increased vitamin D content). In the future, exotic animals, including insects, may be proposed as new sources of protein for consumption in Europe.

2.3.2. 'Under-used' food sources of key nutrients

D. Nanna Roos discussed the different prevalence of diet-related health risks by type of food system around the world. She highlighted the limited supply of animal protein sources in populations vulnerable to micronutrient deficiencies and undernutrition, such as developing countries with rural food systems (IFPRI, 2015). While exploring new, underused sources of animal protein, mammals and birds were considered to have little potential; some potential was attributed to fish species and other seafood that can be mass-produced and contribute significantly to key nutrients; insects, for which few mass-production systems have been investigated and developed so far, had the largest potential (van Huis et al., 2015).

The nutritional composition of insects varies between species and morphological stage but, in general, insects can supply protein, fat and key micronutrients of high quality. The contribution of wild sources (captured) to animal and human diets is expected to be limited, whereas a number (< 20) of selected species could be domesticated and suitable for mass production. The safety of farmed insects for food and feed has been recently evaluated (EFSA Scientific Committee, 2015; Finke et al., 2015). It was found that the biological and chemical hazards would depend on what the insects are fed on (substrate). When currently allowed feed materials are used, the chances of microbiological hazards are equal (or lower) to other sources of animal protein and should not pose an additional risk, whereas

¹ Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods, amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001. OJ L 327, 11.12.2015, pp. 1-22.

the use of other substrates, such as organic wastes (food waste and manures), must be specifically evaluated.

Insects can contribute to human diets as sources of high-quality nutrients in food systems with insufficient supply of foods of animal origin, as well as introduce taste and gastronomic diversity and, at a global level, may reduce the climate and resource burden of diets compared to other animal foods.

2.3.3. Agricultural biodiversity for healthier diets from sustainable food systems

Dr Gina Kennedy set the scene by enumerating the main challenges to be faced in the nutrition area in the 21st Century. First, the nutritional trilemma: the coexistence of obesity, micronutrient deficiencies and undernutrition (IFPRI, 2014; FAO, IFAD and WFP, 2014). Second, the shrinking biodiversity: among the 250,000 plant species identified worldwide, three (rice, maize and wheat) provide > 50% of the world's calories from plants and, together with soy, expand through > 50% of the global agricultural area, whereas 12 crops and five animal species provide > 75% of the world's food (FAO, 1997). Third, the sustainability of food production: climate change, land degradation, demographic changes and food quality should be considered carefully (IPCC, 2014).

Agricultural and tree biodiversity can be part of the solution. On the one hand, increasing the variety of plants harvested fights pests and plant diseases mitigates climate risk in several ways and boosts ecosystems. On the other hand, it improves nutrition contributing to diet diversity and to the valorisation of nutrient-rich local foods, provides livelihood opportunities to small local agricultural communities, and can reduce food loss. Biodiversity stewardship and sustainable use, however, requires that governments create an enabling environment by facilitating harvesting and trading of local foods, and by fostering consumption through appropriate agriculture policies and consumer awareness campaigns.

3. Panel discussion

Several questions were raised by the audience present at the conference and through the social media. Although some questions were of technical nature, such as requests for clarification on the scope and regulatory framework of NFs in the EU, others referred to the wider issue of whether future dietary recommendations should differ depending on the type of country and food system in place, on the characteristics of a population and subgroups thereof, or even on the genetic background of single individuals.

Some apparent contradictions among the messages given in different presentations were highlighted by the audience. It was questioned, for example, why there was a need for new and sustainable sources of high-quality animal protein (e.g. insects) that could potentially introduce new risks in the food chain, when high protein intakes and rapid growth in infants had been associated with increased incidence of chronic diet-related diseases later in life. It was also perceived that a call for 'more nutritious' foods could foster food fortification in some countries, and that this practice could provide consumers with an *alibi* not to follow nutrition recommendations for high intakes of fruits and vegetables.

Other comments were of more general nature. For example, the use of health claims on foods with no nutrient profiles in place was criticised because this could result in the promotion of unhealthy foods through health messages. There were also questions on whether the addition of flavourings to food could lead to a divorce between taste and nutrient content, and thus mislead consumers about the nutritional value of foods, as well as on whether the food industry should do more to prevent obesity, as the pharma industry has tried to do.

The discussion on the questions and comments raised turned around the need to consider, first of all, the context (e.g. type of food system, population subgroup, environmental factors and disease risk) in which nutritional considerations are made. Populations with a high prevalence of protein–energy malnutrition and/or specific nutrient deficiencies may benefit from new sources of animal protein, from carefully selected foods naturally rich in one or more nutrients, and also from fortified and nutritionally complete ready-to-eat foods. Conversely, populations with a high prevalence of obesity and related metabolic diseases may benefit the most from reducing portion sizes and energy-dense foods, and from avoiding 'empty calories' (e.g. in sugar-containing beverages and alcohol). Drugs for the treatment of obesity have indeed been developed, although those with proven efficacy were withdrawn due to unacceptable adverse effects. The role of personalised nutrition in facing this dual global burden of disease at a population level was found to be limited at present as a result of

being both research and resource intensive. Personalised nutrition, however, was acknowledged as a concrete plan for the future.

4. Conclusions

The nutrition challenges ahead are diverse and depend on agricultural, socioeconomic, and individual factors. At a global level, food security, food sustainability and decreasing the impact of food production on climate change are of paramount importance. Decreasing the prevalence of obesity and related disorders, which may coexist with selected micronutrient deficiencies, is a major challenge for wealthy countries; for developing countries and rural food systems, fighting protein–energy malnutrition and micronutrient deficiencies is a priority. Diets based on a wide variety of nutrient-rich local plant foods (e.g. fruits, vegetables, whole grain cereals, vegetable oils, nuts) that contain moderate amounts of animal protein (preferably from fish) and are low in saturated and *trans*-fatty acids, added sugars and sodium, are healthy, nutritious, sustainable and climate friendly. Creating an environment where such diets are also economically advantageous and convenient may be part of a global solution to these nutritional challenges. Individuals, however, are unique regarding their genetic background, gut microbiota and health status. In addition, nutrition may already play a role in the development (and prevention) of disease very early in life. Thus, additional health benefits could be achieved by tailoring nutritional strategies to particular population subgroups or even individuals on the basis of current and future knowledge about the relationship between nutrients, genes, the microbiome and health. New technologies and food innovation may help in finding novel foods fit for purpose.

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Abbreviations

| | |
|------|------------------------|
| CHD | coronary heart disease |
| CVD | cardiovascular disease |
| NF | novel food |
| TMAO | trimethylamine N-oxide |