Nutritional insights on future food

Future of Food – Mitä syöt tulevaisuudessa?
ChemBio Finland, 27-28.3.2019

Marjukka Kolehmainen
Professori
Kansanterveystieteen ja kliinisen ravitsemustieteen yksikko
Lääketieteen laitos
Itä-Suomen yliopisto
Content:

• Definitions
• Sustainable diet – what is it?
• Basis of the nutritional evaluation – nutrition recommendations:
  • Examples for evaluating the nutritional adequacy:
    – Springman et al 2018: scenarios on healthy and sustainable diets
    – Willet et al 2019: EAT commission – nutritionally adequate, healthy and sustainable diet
• Do we know enough? Importance of the evidence
• Conclusions
Definitions in the context
Sustainable development goals 2030 – SDGs
United Nations General Assembly

Number of indicators in each Sustainable Development Goal highly relevant to nutrition.

*Source*: Global Nutrition Report (IFPRI 2016)

Marjukka Kolehmainen: Nutritional insights of future foods
Estimates of how the different control variables for seven planetary boundaries have changed from 1950 to present. The green shaded polygon represents the safe operating space. 
Source: Steffen et al. 2015
Definitions for evaluating the nutritional balance of the foods/diets

- **Nutritional adequacy**: a result of the consumption of sufficient amount of all essential nutrients and energy to meet individual requirements – prerequisite for normal growth, development and maintenance of health
- **Essential nutrient**: a nutrient which human physiology is not able to produce and therefore needs to be taken from the diet
- **Requirement**: amount of nutrient that is needed to maintain health and wellbeing, and prevent the disease development
- **Recommended intake**: mean need + 2SDs at the population level, intake that is estimated to maintain health and wellbeing for almost everybody (97.5%)
- **E%**: percentages of energy intake
Sustainable diets

- Food production
- Distribution and aggregation
- Food processing
- Marketing
- Markets and purchasing
- Resource and waste recovery

UEF // University of Eastern Finland

Marjukka Kolehmainen: Nutritional insights of future foods
Core dimensions of sustainable and healthy diets

- Sustainable diets are:
  - protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy while optimizing natural and human resources

- Sustainable diets need also to be:
  - culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy while optimizing natural and human resources.

→Burlingame and Dernini 2012
Sustainable dietary patterns – how to measure?

• Various assessment methods
  – mostly focus on greenhouse gas emissions

• Nutritional quality is usually only partially analyzed

• Proposed nutritional indicators:
  – Vegetable/animal protein ratios, energy adequacy, energy density, nutrient density, fruit and vegetable consumption, dietary diversity, food biodiversity composition and consumption, percentage of local/seasonal foods and seasonality, percentage of eco-friendly food production and/or consumption, physical activity/inactivity prevalence, adherence to a Mediterranean dietary pattern, diet-related morbidity/mortality statistics, and nutritional anthropometry

→ Challenge: how to secure availability all the measures
Continue…

• “Nutritional footprint” (Lukas et al. 2016) combining nutritional and environmental dimensions – information on energy, salt, fiber, and saturated fat content together with land use, carbon, material, and water – into a single figure and tested the indicator on different types of meals.
  – individual foods or meals with color codes that indicate low, medium, and high levels of each dimension
• “Sustainable nutrient rich foods index” (Van Dooren et al. 2017) assesses energy density, saturated fat, sodium, added sugars, plant proteins, essential fatty acids, and dietary fiber.
  – correlates with greenhouse gas emissions and can be used in ranking individual products or base components in the “traffic light” labelling system.
  – recommended “green” products: vegetables, fruit, legumes, nuts, mushrooms, and vegetable oils
  – intermediate “yellow” products: fish, eggs, milk, lean meats, bread, and potatoes
  – “red” foods that should be limited: red and processed meats, cheese, butter, and full-fat dairy.
Nutritional evaluation → nutritional insight for sustainable diets
Energy nutrients and their relevance with health maintenance

- Finnish nutrition recommendations give reference values for energy intake:
  - General aim is to reduce energy intake at the population level
- Amount of fat and quality of fat
  - Food groups: plant based fats
  - Risk of chronic diseases: obesity, CVD, T2DM, cancer
- Carbohydrate and their quality
  - Core of the plant based diet
  - Dietary fibre from several sources
- Protein and their quality
  - Very complicated issue to be studied in humans
  - Quality especially important for vulnerable population groups, such as infants, children, pregnant women and elderly
Examples

Springman et al 2018: scenarious on healthy and sustainable diets

Willet et al 2019: EAT commision – nutritionally adequate, healthy and sustainable diet
Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail

Marco Springmann, Keith Wiebe, Daniel Mason-D’Croz, Timothy B Sulzer, Mike Rayner, Peter Scarborough

Panel: Dietary-change strategies for sustainable diets

Reduction of animal-source foods following environmental objectives
Replacement of 25–100% of animal-source foods with plant-based ones at constant total calorie intake (ani-25, ani-50, ani-75, and ani-100); plant-based replacements consist of 75% legumes and 25% fruits and vegetables

Improving calorie intake and weight levels following food-security objectives
Improvement of 25–100% in energy imbalances (kcal-25, kcal-50, kcal-75, and kcal-100) with simultaneous reductions in underweight, overweight, and obesity

Using balanced diet patterns following public health objectives
Nutritionally balanced diet patterns in line with available evidence on healthy eating:
- Flexitarian: no processed meat, small amounts of red meat (one serving per week), moderate amounts of other animal-source foods (poultry, fish, and dairy), and generous amounts of plant-based foods (fruits, vegetables, legumes, and nuts)
- Pescatarian: replaces meat with two-thirds fish and seafood and a third fruits and vegetables
- Vegetarian: replaces meat with two-thirds legumes and a third fruits and vegetables
- Vegan: replaces all animal-source foods with two-thirds legumes and a third fruits and vegetables

• 150 individual countries:
  • Divided into high income, upper middle income, lower middle income, low income.
  • Finland in high income countries
• Including:
  • Full nutritional analysis
  • Comparative risk analysis with nine dietary and weight-related risk factors
  • Environmental analysis on: greenhouse gas, emissions, cropland use, freshwater use, nitrogen application, and phosphorus application
Nutrient supply by diet scenario in 2010/baseline

Replacing animal-source foods (ani-groups):
- Lower protein and fat content, improved fat quality
- High-income and middle-income countries
  - Protein intake remained adequate
  - Micronutrient intake improved
  - Baseline low levels of vitamin A, folate, iron, potassium, and fibre increased
  - Calcium, pantothenate (B5), and vitamin B12 decreased
- Low-income countries:
  - Protein intake decreased to lower than recommended
  - Replacing the small intake of animal source foods was not sufficient to increase vitamin A, potassium, calcium and riboflavin to recommended level

Improving energy balance (kcal-groups):
- High-income and middle-income countries
  - Total energy intake was reduced to achieve recommended
  - No improvement in micronutrient intake
- Low-income countries:
  - Increased to achieve recommendations
  - Improved micronutrient intake due to increased energy intake
  - Vitamin A, folate, calcium, potassium, and riboflavin remained below recommended values

Balanced dietary patterns (flexitarian, pescatarian, vegetarian, and vegan):
- Combined the nutritional impacts of improving energy balance with food-based dietary guidelines for all regions
- Most of the nutrients that are at low levels in the baseline diets (vitamin A, folate, iron, potassium, and fibre), increased to recommended values in all four patterns
- Riboflavin, calcium, and vitamin B12 intakes lower than recommended in vegetarian and vegan scenarios
Premature mortality and environmental impact

Scenarios in 2030:
- Replacing animal sources resulted in 4-12% reduction in total mortality
  - 2-3 times higher reductions in high- and middle income countries
- Improvement of energy balance reduced mortality 2-10%
  - Non-cvd counted for 60% followed by T2DM, cancer, coronary heart disease and stroke
- Balanced dietary patterns reduced mortality 19-22%
  - Due to reduction in overweight, underweight and changes in diet composition
  - Coronary heart disease, non-CVD, cancer, stroke, T2DM
Premature death in relation to environmental consequences

- All different scenarios (12 altogether) were different in their environmental impacts
- All animal source foods have been replaced
  - Greenhouse gas reductions most marked
  - Increase of fresh water use
  - Regional differences in other impacts
- Improved energy balance
  - Moderate to low environmental impacts at the level of 100% energy balance
- Balanced dietary patterns resulted in most overall improvements in the environmental impact
- Scenarios show alignment between health and environmental impact – **regional and income produced large differences in the calculations!**
  - Baseline situation is important factor!

UEF // University of Eastern Finland
**Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems**


- Healthy reference diet proposed is based on the vast scientific literature on the health effects of suggested sources of foods
- Composed with:
  - Plenty of vegetables, fruits (berries), whole grains, legumes, nuts, unsaturated oils
  - Low to moderate amounts of seafood and poultry
  - No or low amounts of red meat, processed meat, added sugar, refined grains, starchy vegetables
- "Global adoption of healthy reference dietary pattern would provide major health benefits, including a large reduction in total mortality."
- Adoption of the framework:
  - Provide healthy diet for 10 billion people by 2050 at the mean energy intake level of 2500 kcal (over 2-years of age)
  - Remain in the safe operating space regarding the environmental impact

---

**Macronutrient intake (possible range) per day**

| Whole grains* | 312 (total gains) 0–60% of energy | 811 |
| Tubers or starchy vegetables | 50 (0–100) | 39 |
| Vegetables | 360 (200–600) | 0 |
| All vegetables | 100 | 23 |
| Dark green vegetables | 100 | 20 |
| Red and orange vegetables | 100 | 25 |
| Other vegetables | 700 (100–200) | 126 |
| Whole milk or dairy equivalents (eg. cheese) | 250 (0–500) | 353 |
| Protein sources | 7 (0–14) | 15 |
| Beef and lamb | 7 (0–14) | 15 |
| Pork | 7 (0–14) | 57 |
| Chicken and other poultry | 13 (0–25) | 19 |
| Fish | 28 (0–100) | 40 |
| Legumes | 50 (0–100) | 972 |
| Soy foods | 25 (0–50) | 312 |
| Fouguts | 25 (0–75) | 142 |
| Tree nuts | 25 | 149 |
| Added fats | 6.8 (0–6.8) | 60 |
| Palm oil | 40 (20–60) | 354 |
| Unsaturated oils | 0 | 0 |
| Dairy fats (include in milk) | 5 (0–5) | 36 |
| Added sugars | 31 (0–31) | 120 |

---

Marjukka Kolehmainen: Nutritional insights of future foods
Transitions needed to meet the reference diet in Finland:

Red and processed meat consumption in men and women in Finland.

Vegetable, fruits and berries consumption for men and women in Finland.

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Macronutrient intake grams per day (possible range)</th>
<th>Caloric intake kcal per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole grains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice, wheat, corn and other</td>
<td>232</td>
<td>811</td>
</tr>
<tr>
<td>Tubers or starchy vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes and cassava</td>
<td>50 (0-100)</td>
<td>39</td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vegetables</td>
<td>300 (200-600)</td>
<td>78</td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All fruits</td>
<td>200 (100-300)</td>
<td>126</td>
</tr>
<tr>
<td>Dairy foods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole milk or equivalents</td>
<td>250 (0-500)</td>
<td>153</td>
</tr>
<tr>
<td>Protein sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef, lamb and pork</td>
<td>14 (0-28)</td>
<td>30</td>
</tr>
<tr>
<td>Chicken and other poultry</td>
<td>28 (0-58)</td>
<td>62</td>
</tr>
<tr>
<td>Eggs</td>
<td>13 (0-25)</td>
<td>19</td>
</tr>
<tr>
<td>Fish</td>
<td>28 (0-100)</td>
<td>40</td>
</tr>
<tr>
<td>Legumes</td>
<td>75 (0-100)</td>
<td>284</td>
</tr>
<tr>
<td>Nuts</td>
<td>50 (0-75)</td>
<td>291</td>
</tr>
<tr>
<td>Added fats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsaturated oils</td>
<td>40 (20-80)</td>
<td>354</td>
</tr>
<tr>
<td>Saturated oils</td>
<td>11.8 (0-11.6)</td>
<td>96</td>
</tr>
<tr>
<td>Added sugars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All sugars</td>
<td>31 (0-31)</td>
<td>120</td>
</tr>
</tbody>
</table>
Transitions needed to meet the reference diet in Finland

• Food level changes:
  – Increase in the consumption of vegetable, fruits, berries, whole grain, nuts, legumes
  – Decrease in the consumption of fish, eggs, poultry, dairy, sucrose
  – Dramatic decrease in the consumption of red and processed meat, especially in men
  – Improvement in the quality of dietary fat

• Nutrient level changes:
  – Fat quality:
    • decrease in saturated fat, n3-fatty acid intakes
    • increase in polyunsaturated fat, linoleic acid intakes
  – Increase in dietary fibre – quality of carbohydrates would improve
  – Increase in folate, iron, magnesium, potassium, zinc, vitamin C and B intake
  – Decrease in calcium, vitamin B12 intake
  – Decrease in vitamin D intake

• What is realistic until 2050?
• What is needed for transition?
Gap between current intake and planetary diet:

Globally

North America

Sub-Saharan Africa

UEF // University of Eastern Finland

Marjukka Kolehmainen: Nutritional insights of future foods
Do we know enough?
Importance of the evidence
Example: protein bioavailability of alternate sources

- Protein quality is related to its amino acid composition and amount of the essential amino acids in the source
  - Dairy, egg and meat are regarded as the best protein source for human consumption based on their amino acid composition
  - Mixed plant sources in the same food (mix of legumes and cereals) close to the ‘optimal’
  - Important is to include varied sources of proteins in the diet → providing the essential amino acids from different sources

- Alternate protein sources are many times plant based sources
  - Plant based protein are many times located within plant cell structures
  - Antinutrients/bioactives may affect both digestibility and bioavailability
  - How to increase the bioavailability?

- Preparation/processing conditions
  - Increases convenience and safety, extend shelf life and improve taste
  - May increase the bioavailability
  - May interfere to the protein bioavailability

- Mixed sources of good quality protein are needed for some population groups to secure:
  - Growth and development
  - Maintenance of cognitive and physical performance

- Food safety? From microbiological aspects to global foods safety aspects such as sufficient nutrition to populations?
**TABLE 1** Key characteristics of an ideal method to determine the bioavailability of amino acids (protein quality) in human foods

- Preferably a direct measurement in humans; if this is not possible, need sufficient cross-species predictions from animals
- Directly applicable to all human life stages, genetics, environment, and nutritional status, etc.
- Applicable to a wide range of human foods by taking into consideration the effects of food processing and cooking on protein quality
- Applicable to all individual amino acids; give priority to indispensable amino acids
- Applicable to mixed human diets and supplementation
- Capable of wide implementation to establish a global database on amino acid availability based on local foods and diets and food processing/cooking methods
  - Reasonable cost
  - Minimally invasive
  - Validated in animals
- Potentially recognizable by regulatory authorities, at least by CODEX

---

1. CODEX Alimentarius Commission.
Why to prove the health effects?

• Whose interests is to seek information on what?
  – Health professionals, health care systems, policy makers
  – Researchers, research institutes: collaboration among the experts in health effects and consequences, technology, environmental impact…
  – Industry
  – Education
  – Economics
  – Society
  – Other interests?
Study question will be different in differing interest groups

• To assess safety
• To analyse nutritional value
• To study mechanisms of action
• To understand the health consequences
• To study the technological process on bioavailability
• To study the possibilities of side chains and waste use
• To evaluate the public health consequences
• ……
Conclusions

• This is not a black and white discussion!

• Nutritional and environmental consequences differ depending on the current (baseline) dietary pattern

• Examples presented here and elsewhere in the literature are good basis for next actions and discussions

• We need research on health effects of alternate sources of foods

• We need collaboration and discussion among stakeholders
Thank you