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Plant based premium food innovation horizon for the Swiss Food System in a Global Context

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1. Introduction

The 2030 Agenda of the UN with its 17 sustainability development goals got out of step in 2020 due to the COVID-19 pandemic, and some Sustainable Development Goals (SDGs) currently seem out of reach. A "recalibration" of the SDGs is in lively (UN) discussion. From different sides, in particular, increased prioritization and investments in public services, social protection and especially in the food and health systems are called for, which reflects the global impact of the pandemic. Both the disease and the fear of disease have triggered substantial global economic and social impacts, along with restrictions on international travel imposed by most countries, the quarantining of millions of people, dramatic declines in the tourism and hospitality industries, and disruption of supply chains for food, medicines, and manufactured products. COVID-19 is compelling policy makers to make urgent decisions to ensure food supply chains continue to function, but the fundamental task is to address these immediate disruptions while also investing in the long-term goal of a resilient, sustainable and productive global food system.[1]

Food systems' complexity requires a holistic and coordinated approach to understand the impact of innovative building block implementation and derive overarching optimization rules for added value generation. Most food security and nutrition challenges are complex problems whose solutions are contested and which transcend disciplinary, divisional, and institutional frontiers. In our increasingly globalized food systems, challenges result from interactions across different scales and levels. They require integrated actions taken by all stakeholders at local, national, regional, and global levels, by both public and private actors, and across multiple boundaries. Considering direct and indirect dependencies of reactions across an entire multidimensional food value chain (= food value network or food system) is of utmost relevance taking agriculture, food processing, transport, retail, consumer, health, trade, policy, environment and infrastructure as major building blocks into account. A synergetic merging of these rather than a destructive clashing has to be the ultimate goal.

A rising star food domain since few years is the "plant-based foods" for which consumer demand is increasing at a significant rate. In 2019, the total retail market for plant-based foods in the US was worth nearly $4.5 bn, and dollar sales have grown by 31% over the past two years. Plant-based protein, and derived vegetarian alternatives, make up a significant portion of this market. Meanwhile 44% of US consumers have been identified as flexitarians, in Switzerland about 25% are counted as such. To some extent the role of plant-based protein may have also been expedited as a result of the corona pandemic, as consumers across the world became increasingly aware of their personal health and immunity, as well as how and where their food is sourced. For a growing number of consumers, rise of plant-based alternatives is attributed to an increased focus on ethical (e.g. animal welfare) and sustainable consumption. For others, like most of the flexitarians, taste and texture still rule.

Against this background, it gets obvious that the plant protein space is a growing source of product and

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1 UN Sustainable Development Goals: *https://www.un.org/sustainable-development/*

technology innovations entering the global food system and thus significantly impacting on many of the food system building blocks from the agricultural primary production of protein-rich plant species *via* their processing and transformation into food products to their consumption and digestion, the latter including the more plant-food-specific adaptation of the human microbiome.

Such overarching impact gives rise to the development of new business cases and in the context of the corona pandemic, chances for the introduction of new strategies fostering resilience and improved self-supply demand. This can reach dimensions of regional, national and global strategic interests, which shall be addressed in further detail below.

2. Global food system perspective

The global food system has to be considered in the context of globalization and superimposed population growth, urbanization, growing wealth, changing consumption patterns as well as climate change, pollution and depletion of natural resources. During the past three decades, developments in food systems have yielded many positive results, especially in developing countries. These results include the expansion of off-farm employment opportunities as food industries have developed, and the widening of food choices beyond local staples, thus satisfying consumers' preferences in terms of sensorial and nutritional quality.[2]

However, the associated rapid structural transformations have also resulted in increasing and significant challenges, with potentially wide-reaching consequences for the state of food security and nutrition. These include (*i*) the many high-calorie and low nutritional value food items that are widely available and consumed, (*ii*) limited access of small-scale producers and agri-enterprises to viable markets, (*iii*) high levels of food loss and waste, (*iv*) increased incidences of food safety, (*v*) animal and human health issues as well as (*vi*) an increased energy-intensity and ecological footprint associated with the industrialization of food supply chains.

From a global perspective, it can be summed up that food is the single strongest lever with coupled optimization potential for human health and environmental sustainability on Earth. However, food is currently threatening both people and planet. An immense challenge facing humanity is to provide a growing world population with healthy diets from sustainable food systems. While global food production of calories has generally kept pace with population growth, more than 820 million people were lacking sufficient food before the Covid-19 pandemic appeared, and many more consume either low-quality diets or too much food. As a result of the pandemic impact, according to estimates of the UN's World Food Program (WFP), by December 2020, additional 271.8 million people in countries where the WFP operates are acutely food insecure or directly at risk of becoming so due to the aggravating effect of the COVID-19 crisis.[3]

While unhealthy diets pose a big risk to morbidity and mortality, the global food production threatens climate stability and ecosystem resilience and constitutes the single largest driver of environmental degradation and violation of planetary boundaries. Accordingly, a radical transformation of the global food system is urgently required. Without action, the world risks failing to meet the UN Sustainable Development Goals (SDGs), and the coming generation will inherit a planet that has been severely degraded with its population increasingly suffering from malnutrition and preventable disease.

According to the 2019 study report of the EAT Lancet Commission there is substantial scientific evidence that links diets to human health and environmental sustainability. Yet the absence of globally agreed scientific targets for healthy diets and sustainable food production has hindered large-scale and coordinated efforts to transform the global food system.[4] The commission's analysis suggests that staying within a safe operating space for the development of future food systems requires a combination of substantial shifts toward mostly plant-based dietary patterns, dramatic reductions in food losses and waste, and major improvements in food production practices.

2.1. Key factor plant proteins

Key factor component in a plant-based future dietary pattern with significant impact on possible environmental sustainability improvement is the plant proteins which compared to their animal-originated counterparts show factor 2–75 lower carbon or water footprints with pulses being best in class.[5]

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2 FAO-Sustainable Food Systems, Concept and framework. *http://www.fao.org/3/ca2079en/CA2079EN.pdf*

3 World Food Programme. Covid19 Level 3 emergency; External Situation report. *https://docs.wfp.org/api/documents/bb06a3493e85496587739785abfe5b28/download/?_ga=2.58019433.2144455157.1613691655 1437313209.1613691655&_gac=1.215447781.1613692638.Cj0KCQiAvbiBBhD-ARIsAGM48bz-PQwmkQ4Ty9S3q3CM70CAEe9PHcmtZeJ-ItlPnrPwm9zoH54Ts9SEaAv-CPEALw_wcB*

4 Willett, W., Rockström, J., Loken, B., *et al.* (2019). Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems. *Lancet*; 393: 447–492.

5 Carbon and water footprints of diet choices. Animal Charity Evaluators: *https://animalcharityevaluators.org/research/dietary-impacts/carbon-and-water-footprints-of-diet-choices/#conclusion*

A long-term predicted (2050) global undersupply of proteins for a growing world population coupled with an increasing questioning of the sustainability of food of animal origin, which has been registered at least in industrialized nations, have significantly stimulated research and development activities on new protein sources and their technological processing in recent years. In the current discussion on alternatives to farmed animal-based proteins, main attention is paid to proteins from legumes (e.g. peas, lentils, beans, lupins), oilseeds, grains and nuts/kernels, in addition to the most explored soy proteins that have dominated industrial food-product applications so far. Pea and field-bean proteins are prominently on the rise in consideration due to their high protein content and suitable amino-acid profiles. Prerequisite is the technological mastery of (*a*) conditioning processes to eliminate anti-nutritional components and (*b*) efficient protein extraction. There is still a need for technological development in order to increase efficiency, even though suitable protein isolates and concentrates are already available at mostly empirically optimized yields. Their use in the production of plant-protein-based meat analogues and vegetable-derived milk-type beverages and cheese has become the base of outstandingly increasing food categories since mainly the "millennials" have started the "flexitarian movement".

2.2. *Pulses as "bifunctional" protein source*

With the "bifunctional" attribute we denote that legumes/pulses could on one side play an important role in delivering valuable proteins in high concentration besides other nutritionally relevant fiber and minerals and on the other side provide multiple services in line with sustainability principles. Concerning the latter, legumes/pulses contribute to reduce the emission of greenhouse gases (GHG), as they release 5–7 times less GHG per unit area compared with other crops, allow the sequestration of carbon in soils (SOC) with averaged values from 7.21 to 23.6 g C kg^{-1} Dry Matter, and induce a saving of fossil energy inputs in the system thanks to the reduction of nitrogen-based fertilizers, corresponding to 277 kg ha^{-1} of CO_2 per year.[6] Legumes/pulses could also be competitive crops and, due to their environmental and socioeconomic benefits, could be introduced in modern cropping systems to increase crop diversity and reduce the use of external inputs. They also perform well in conservation systems, intercropping systems, which are very important in developing countries as well as in low-input and low-yield farming systems. Legumes fix the atmospheric nitrogen, release high-quality organic matter in the soil and facilitate soil nutrients' circulation and water retention. Based on these multiple functions, legume crops have high potential for conservation agriculture, being functional either as growing crop or as crop residue.[7]

From the nutritional perspective, besides valuable protein, pulses provide fibre, as well as a significant source of vitamins and minerals, such as iron, zinc, folate, and magnesium, and consuming about 80 grams of beans or peas per day can enhance diet quality by increasing intakes of these nutrients. In addition, the phytochemicals, saponins, and tannins found in pulses possess antioxidant and anti-carcinogenic effects, indicating that pulses may have significant anti-cancer effects. Pulse consumption also improves serum lipid profiles and positively affects several other cardiovascular disease risk factors, such as blood pressure, platelet activity, and inflammation. Pulses are high in fibre and have a low glycemic index, making them particularly beneficial to people with diabetes by assisting in maintaining healthy blood glucose and insulin levels. Emerging research examining the effect of pulse components on HIV and consumption patterns with aging populations indicates that pulses may have further positive effects on health. In conclusion, from a nutritional perspective, including pulses in the diet is a healthy way to meet dietary recommendations and is associated with reduced risk of several chronic diseases.[8]

2.3. *Alternative protein sources*

For completeness, it should also be mentioned that besides crops/pulses as plant protein sources there are further alternatives from algae but also from insects which have come into focus during the past five years. Algae are a promising source of protein, containing up to 70% protein in dry matter, essential amino acids and high amounts of micronutrients. The blue alga *Arthrospira* (= cyanobacterium also known as *Spirulina*) and the green alga *Chlorella vulgaris* are considered to be the "algae superfoods" with advantageous amino acid profiles compared to typical plant proteins such as those from legumes. Technologically, there is still a clear need for development of processing methodologies for an economically viable extraction of the high-quality algae proteins.

For insect protein production an environmental impact assessment based on industrial production approaches has not yet been carried out. In the meantime, companies have reached industrial production

6 Stagnari, F., Maggio, A., Galieni, A., et al. (2017). Multiple benefits of legumes for agriculture sustainability: an overview; *Chem. Biol. Technol. Agric.* 4, 2. https://doi.org/10.1186/s40538-016-0085-1

7 Charles, R., *et al.* (2008). Which grain legumes for cropping in Switzerland; July 2008; *Agrarforschung* 40(1), 17–23.

8 Mudryj, A.N., Yu, N., Aukema, H.M. (2014). Nutritional and health benefits of pulses. *Appl Physiol Nutr Metab* 39(11), 1197–204. doi: 10.1139/apnm-2013-0557 Epub 2014 Jun 13. PMID: 25061763.

standards, based on which relevant life cycle assessments can be made. The first of these come to the conclusion that insect proteins are competitive for the production of animal feed. Further increases in efficiency are foreseeable in the future, provided that previously unused biomass waste streams are used. The life cycle analyzes (LCA) carried out also provide information on improved environmental compatibility when organic waste is transformed into insect biomass compared to treatments using composting and anaerobic degradation.

3. A Swiss national perspective

The Swiss food system and the related Swiss food industry have implemented the UN SDGs in their objectives on a broad application level. Since the SDGs were published in 2015, Switzerland has made visible progress in most of the areas addressed by the SDGs.[9] To what extent the effects of the COVID-19 pandemic will result in restrictions or weight shifts with regard to the SDGs, remains to be seen. On the other hand, new priorities could be derived from this, *e.g.*, in connection with SDGs 3 (health and well-being) and 12 (responsible consumption and production) in such a way that nutrition-based disease prophylaxis, *e.g.*, with additional emphasis on immunologically relevant aspects, is given more importance, and relevant business cases are derived. Corresponding skills are available in Swiss industry and should be increasingly activated.

According to the Federal Agriculture Office, Switzerland's gross self-sufficiency rate in 2018 was 58%.[10] The degree of self-sufficiency is defined as the ratio of domestic production to total domestic consumption. With imported animal feed taken into account, the net level of self-sufficiency was 51% that year. A closer look addressed at the data reveals major differences across products. The country has been able to produce almost 100% of its animal foodstuffs for years, yet has managed only about 40% self-sufficiency in plant-based food.[11] Self-sufficiency in animal products is also relative. When imported feed is factored into the calculation, the rate drops below 80%. The degree of self-sufficiency merely indicates a theoretical relationship between domestic production and total domestic consumption – it does not reflect reality. The reality is that Switzerland imports more than it exports. In fact, its food imports per capita are among the highest in the world, due to in large part to its rather high population density and the relatively small area available for cultivation.[12] In fact, the food and beverage imports with a value of 10784 million CHF in 2019 were 19% higher than the exports. In the 2020 pandemic year, this difference increased to remarkable 28%.[13]

Accordingly, due to coupled self-supply, public health, environmental sustainability and economic reasons, there is strong motivation for the Swiss Food System to increase its plant-based food production and reduce farmed animal production. To make things move, a concerted development action of the Swiss Food System players is required. Switzerland has the resources and skills to make this happen.

3.1. Switzerland as innovation pilot plant

Switzerland is predestined to be developed into a "Food, Nutrition & Health Innovation Pilot Plant" which, from a scientific and technological perspective, allows innovative solutions to regional and global issues in the areas of food, nutrition and health to be developed, tested and implemented. Coordinated cooperation between industrial and university-based research and development centers throughout Switzerland is therefore envisaged. Special additional benefit through innovation is to be achieved through the targeted development interaction between high-tech areas (e.g. IoT/digitization, robotics, additive manufacturing, in-line sensors and process optimization, artificial intelligence and biotechnology) with new and established food technology process and product solutions. The entire food system from sustainable agricultural production to disease prevention through sustainably processed, personalized, healthy nutrition is imperative for consideration in order to establish a holistic approach required for gaining comprehensive system knowledge.

Before entering into a concretized recommendation for a "Swiss Food System Future" (SFSF) development approach addressing the plant protein space prominently, the specific qualification of Switzerland as Research, Development and Implementation (RDI) platform shall now be emphasized.

3.1.1. Switzerland's RDI potential

Switzerland's specific RDI qualification in the Food System is based on seven pillars (A-G) briefly described in the following:

9 UN-Sustainable Development Knowledge Platform: Sustainable development in Switzer-land and the 2030 Agenda. *https://sustainabledevelopment.un.org/memberstates/switzerland*

10 Rossi, Alessandro (2020). BLW Agrarbericht 2020. *https://www.agrarbericht.ch/de/markt/marktentwicklungen/selbstversorgungsgrad?_sm_au_=iVV3D4RWLqqkP6ZD*

11 Rossi, A., *Ibid.*, and SWI-Swiss Info CH. Does Switzerland produce half of all the food it needs? *https://www.swissinfo.ch/eng/fact-check_does-switzerland-produce-half-of-all-the-food-it-needs-/44380058*

12 SWI-Swiss Info CH, *see fn. 10.*

13 / Pfammatter, M. (2021). Statistische Informationen, EZV (28.1.2021); Swiss Federal Department of Finance FDF; Federal Customs Administration FCA; Press release. Date: 28 January 2021; *https://www.ezv.admin.ch/ezv/en/home/topics/swiss-foreign-trade-statistics.html*

A. Education and Training system

In the Global Competitiveness Report of the World Economic Forum (WEF), the Swiss education system has been ranked first in a world-wide comparison for years. In a number of world university rankings ETH and EPFL are among the top universities (after few from USA and UK). – In addition, Switzerland has a particularly efficient dual training system that offers the opportunity to enter a vocational training system at the secondary level, which is much more balanced than in other industrialized nations, if such training exists at all, and produces highly qualified technicians and engineers.

B. Innovation profile

Switzerland has been number 1 in the World Innovation Index for seven years in a row (score 67.7 in 2017) according to the Global Innovation Index. In terms of the annual (here 2016) number of patent applications per inhabitant, Switzerland ranks third globally after Japan and Korea. Switzerland also ranks first in terms of "high-tech and medium-high-tech output" worldwide.[14]

C. R&D funding

With the Swiss National Science Foundation (SNSF) and Innosuisse, the Swiss funding system has efficient and coordinated funding bodies for fundamentals (SNSF) and application research (Innosuisse) with a total annual budget of about 1.25 billion CHF (2019).[15] In addition, the Swiss universities receive approx. 4.9 billion CHF from the federal government and cantons as budget funds. The private sector based in Switzerland invests around 15.5 billion CHF in R&D per year (approximate numbers from 2019).[16] In January 2021, Innosuisse announced a "Flagship Program" which may well suit for the installation of a "Swiss Food System Future" (SFSF) Research, Development and Implementation (RDI) program with a 2030 perspective. The same holds for a possibly soon to be launched National Research Program (NRP) concerning the Food System from SNSF.

D. Swiss industrial landscape in the food sector

Switzerland is a main location of major global players along the food value chain from primary food production to the production of functional foods (*e.g.*, Syngenta, Bühler, Nestlé, Givaudan, DSM AG). Complemented by the retailers Migros and Coop, which focus on Switzerland, as well as large processors in agriculture and the dairy products sector (*e.g.* Fenaco, Emmi, Hochdorf Swiss Nutrition) and a large number of SMEs, a closed, high-performance industrial food system component is unique in Switzerland.

E. Swiss food consumer

The Swiss food consumer is the world leader (after Bermuda) in terms of per capita spending on living and grocery shopping (grocery index: 122.56, mid 2016); both in Retail as well as in the restaurant/gastronomy area.[17]

F. Politics and society

The Swiss economy is one of the most liberal and most competitive in the world. Low capital costs, a stable currency, strong purchasing power, moderate taxation, a federal structure and political stability guarantee a high level of security for investments in Switzerland. Switzerland is also a very safe country and offers an extremely high quality of life. In important areas such as income, health care, climate and geography as well as political stability, security, personal freedom as well as family and community life, Switzerland achieves top marks both in cities and in rural regions. For years, the Swiss cities of Zurich, Bern and Geneva have been among the top 10 worldwide in the city rankings compiled by the global consulting company Mercer.[18]

G. Organisational structure in the Swiss Food System

Based on a number of coupled initiatives to create a strategic agenda for the Swiss Food System (e.g. *via* the "Food Technology" topic platform of the Swiss Academy of Technical Sciences, SATW), targeted building blocks have emerged in this regard. These relate in particular to (1) the Swiss Food and Nutrition Valley (SFNV), (2) the ETH/EPFL "Future Food" initiative and (3) the Swiss Food Research (SFR) Innovation Booster, which is supported by Innosuisse. Further integration of these and additional industrial company members across the Swiss Food System joining can form a powerful base for targeted RDI programs (e.g. NRP, Flagship) supported by the Swiss funding bodies addressed under C.

14 Cornell University, INSEAD, and WIPO (2017): The Global Innovation Index 2017: Innovation Feeding the World, Ithaca, Fontainebleau, and Geneva; ISSN 2263-3693; ISBN 979-10-95870-04-3; Printed and bound in Geneva, Switzerland, by the World Intellectual Property Organization (WIPO), and in New Delhi, India, by the Confederation of Indian Industry (CII).

15 *https://www.swisscore.org/swiss-knowledge/research* and *https://www.innosuisse.ch/inno/en/home/about-us/newsroom/foerdergeschaeft-2019.html*

16 *https://www.bfs.admin.ch/bfs/en/home/statistics/education-science/surveys/fe-priv.assetdetail.14776473.html*

17 *https://www.numbeo.com/cost-of-living/rankings_by_country.jsp*

18 *https://www.s-ge.com/en/article/news/zurich-geneva-and-basel-among-top-10-cities-highest-quality-living-worldwide*

3.2. *Recommended Swiss healthy and sustainable food system approach CHFood2030 with plant protein focus*

"Swiss Plant Protein Food (CHFood-PP)" is classified as a possible concrete main RDI subject area for a national CHFood2030 program of the ETH domain, universities, applied universities, research stations, industry and consumer associations.

Entering this area with (*i*) the primary production of protein-rich agricultural plants providing good yields in Switzerland, including the Alpine region and which can be advantageously integrated in crop rotation with benefits for environmental sustainability (e.g. legumes), followed by (*ii*) sustainable up-stream processing to obtain functional protein and micronutrient-rich dietary fiber fractions, (*iii*) processing of nutritious, high sensory quality food products as well as biocompatible packaging materials using side stream fractions from (*ii*) by means of sustainable processes, up to (*iv*) the creation of new product lines for sensory and nutritionally customized/personalized consumer convenience products including (*v*) quantification of the health support impact spectrum, taking, *e.g.*, into account microbiome, gut-brain axis and epigenetic influence potential, would complete the backbone building blocks for an innovative food system development program approach to be addressed.

Using the before-mentioned (section 3.1.1.) advantageous Suisse ecosystem potential, significant synergistic innovation support can be expected to be achieved through coupling the described food system backbone building blocks (*i*)-(*v*) with potentially interaction-relevant, innovative industrial technology areas established in Switzerland. Such are (*a*) Robotics & Additive Manufacturing, (*b*) Industry 4.0 / digitization, (*c*) Sustainable Circular Economy, (*d*) Artificial Intelligence and (*e*) Cybersecurity.

Since these areas are industrially and academically represented by operational thematic platforms of the Swiss Academy of Technical Sciences (SATW), there is great chance to use these to facilitate efficient implementation of related Swiss industry into a suggested CHFood-PP2030 development program to be established.

3.2.1. *Existing Swiss building blocks*

We now turn to describe the five building blocks mentioned above in more detail.

(i) Primary production of plant protein sources. Grain legumes are currently underrepresented in European agriculture and produced on only 1.5% of the arable land in Europe compared with 14.5% on a worldwide basis. Growing more and specific plant protein in Switzerland is what a new longer-term CHFood-PP2030 national RDI food system scenario should aim for.

Within the framework of a European project called GL-Pro (European extension network for the development of grain legume production in the EU), from 2003–2005 the Swiss FiBL (Research Institute of Organic Agriculture, Lausanne) was part of a crop demonstration network for grain legumes set up for evaluating the potential of these crops to enhance their development. In Switzerland, crops grown by farmers were observed to evaluate their specificities, assets and weaknesses. These results were compared with European network ones. Accordingly, field pea shows highest and most stable yields. Spring faba bean and white lupin are interesting alternatives. Pea is the best-adapted wintering grain legume. The cultivation of winter faba bean is also possible.[19]

Within a joint study of FiBL and ETH Zürich in 2014 positive interactions between species, growing mixtures of cover crops demonstrated improving the ecosystem services provided by cover crop cultivation. The characterization and the quantification of species interactions allowed identifying the key mechanisms affecting mixture performance. Without N fertilization, complementary resource use had a major role in mixture biomass production. The highest performance was observed in the mixtures containing pea.[20] – Accordingly, field pea grown sole or in mixture with other crops may be prioritized.

(ii) Upstream-processing of protein containing plant material. Dry up-stream processing of pulses including peas connects a series of steps being: (*i*) cleaning, (*ii*) grading, (*iii*) dehulling, (*iv*) (optical) sorting, (*v*) fine grinding and (*vi*) air classification. As typical products resulting from this treatment there are protein rich flours. With Bühler AG, there is a prominent industrial global player of Swiss origin who is highly skilled

19 Charles, R., *et al.*, *see fn. 6.*

20 Büchi, L., Gebhard, C., Liebisch, F., Sinaj, S., Ramseier, H., Charles, R. (2015). Accumulation of biologically fixed nitrogen by legumes cultivated as cover crops in Switzerland. *Plant Soil* 393:163–175; *DOI 10.1007/s11104-015-2476-7* – Wendling, M., Büchi, L., Amossé, C., Jeangros, B., Walter, A., Charles, R. (2017); Specific interactions leading to transgressive overyielding in cover crop mixtures. *Agriculture, Ecosystems and Environment* 241, 88–99. – Watson, C.A., Reckling, M., Preissel, S., Bachinger, J., Bergkvist, G., Kuhlman, T., Lindstrom, K., Nemecek, T., Topp, C., Vanhatalo, A., Zander, P., Murphy-Bokern, D., Stoddard, F. (2017). Grain Legume Production and Use in European Agricultural. *Systems Advances in Agronomy*, 144, 235–303. *DOI: 10.1016/bs.agron.2017.03.003* – Ferjani, A., Mann, S., Zimmermann, A. (2018). An evaluation of Swiss agriculture's contribution to food security with decision support system for food security strategy; *British Food Journal*; ISSN: 0007–070X; Publication date: 3 September 2018.

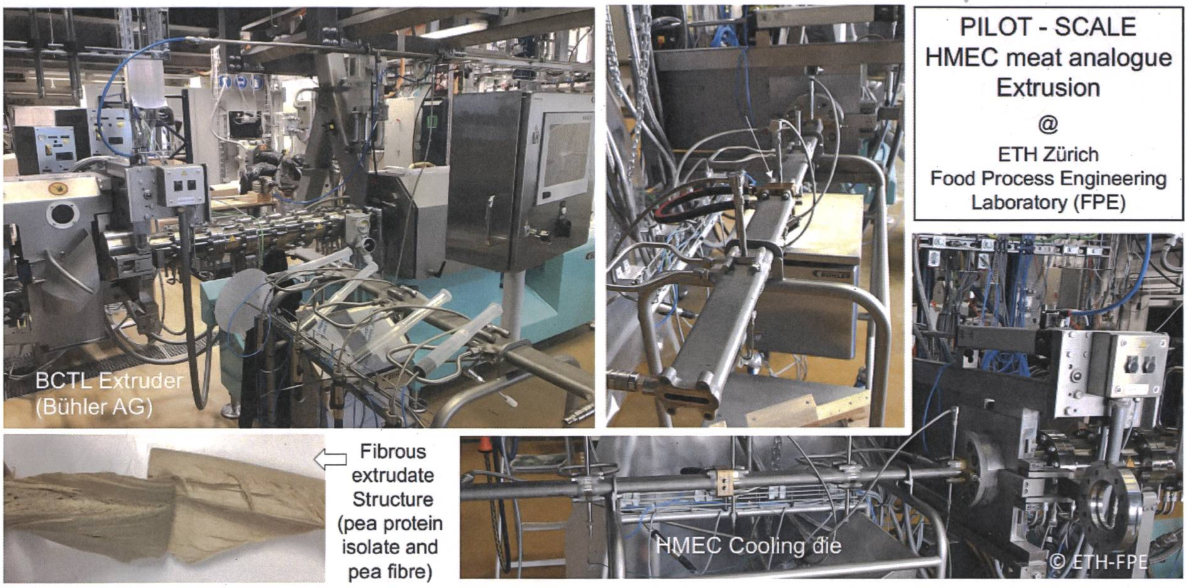

Figure 1. Pilot Plant setup for High Moisture Extrusion Cooking of plant protein-based meat analogues at ETH Zürich / Food process Engineering Laboratory (FPE/IFNH/D-HEST)

in development and optimization of the before-mentioned processing steps and with related industrial production scale equipment manufacturing capabilities.[21] Dry fractionation by air classification is so far limited to about 60%wt. protein content in the protein enriched (fine) powder fraction.[22] This is so far not sufficient for specific applications, most prominently represented by extruded plant protein-based meat analogues, which require higher protein concentration for the desirable fibrillar meat-like product structure generation. However, there is potential for dry fractionation improvement which could be tackled e.g. by ETH and Bühler.

For higher protein concentration (ca. ≥ 90%) two-step wet fractionation processing is typically applied: In order to prepare protein concentrates/isolates from pulse seeds or oilseed cake, the most widely used process is the two-steps process patented in 1955 by Anson and Pader.[23] After an alkaline solubilization of the proteins, the insoluble material (starch, fibers) is removed by centrifugation. Adding hydrochloric acid to the supernatant, the protein is precipitated iso-electrically (pH 4.0–5.0), separated by centrifugation and neutralized. The co-product contains the other soluble components, mainly sugars, soluble fibers, fat and ashes. Other versions of 2-steps processes (Extraction/ Isolation) are described elsewhere.[24] ETH (FPE-Lab) has developed hyperbaric steam extraction technology with expected potential for increasing wet fractionation efficiency at reduced water and energy consumption, thus improving processing sustainability of the so far in this respect not fully satisfying wet fractionation technology.[25]

For large industrial scale wet fractionation of pulse proteins, one might evaluate to what extent the highly subsidized Swiss sugar industry could be re-oriented. If pulse (field pea, faba bean) cultivation in Switzerland would increase, a stepwise replacement of sugar beet cultivation could be synchronized with a factory transformation from sugar to protein extraction. Even though the extraction technology for sugar and pulse protein are not identical, there are similarities concerning energy/steam supply, centrifugation processing and material logistics.[26]

(iii) Processing of plant protein-based food products. Most prominent candidates of plant protein-based food products are meat analogues processed by High Moisture Extrusion Cooking (HMEC) with authentic meat-like fibrillar structure.[27] Such analogues demonstrated a rapid market growth in the past two years

21 /Bühler AG (undated). Peas-processing - the protein of the future. *https://www.buhlergroup.com/content/buhlergroup/global/en/industries/Pulses/dry-peas.html*

22 Schutyser, M.A.I.,van der Goot, A.J. (2011). The potential of dry fractionation processes for sustainable plant protein production. *Trends in Food Science & Technology* 22, 154e164. *Doi:10.1016/j.tifs.2010.11.006*

23 Anson, M.L., Pader, M. (1957). Extraction of soy protein; US-Patent 2,785,155.

24 Plant protein extraction: state of the art; *http://www.improve-innov.com/plant-protein-extraction-state-of-the-art/*

25 Friedman, T., Lustenberger, C., Windhab, E.J. (2004). Filtration experiments with compressible filter cakes in centrifugal fields with superimposed static pressure; *https://www.sciencedirect.com/journal/international-journal-of-mineral-processing/vol/73/issue/2* Pages 261–267.

26 BMA: *https://www.bma-worldwide.com/extraction-plants-for-sugar-beet-factories.html* and: Soy protein isolate processing: *http://www.fao.org/3/t0532e/t0532e07.htm*

27 Osen, R., Toelstede, S., Eisner, P., Schweiggert-Weisz, U. (2015). Effect of high moisture extrusion cooking on protein–protein interactions of pea (Pisum sativum L.) protein isolates. *International Journal of Food Science and Technology* 50, 1390–1396.

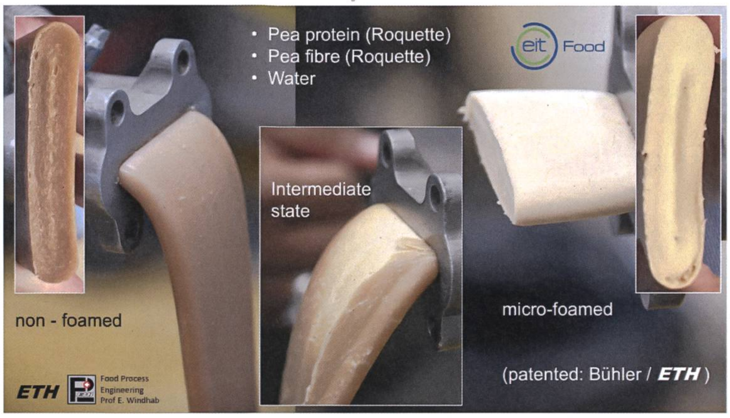

Figure 2. HMEC-AEREX extrusion of novel micro-foamed plant protein-based meat analogue structure with adjusted "tenderness" and "fibrousness" (Bühler / ETH-FPE patent application)

and are consequently in the focus of an increasing number of food producers, from Swiss global players like Nestlé to Swiss startups. One of the most successful Swiss startups in this product segment is Planted Foods AG,[28] a 2019 founded spin-off from the ETH Food Process Engineering Laboratory which already delivers its products in Switzerland successfully *via* the retailers Coop and Migros. For such meat analogues, ETH, in collaboration with the Swiss company Bühler has succeeded in developing, scaling and implementing a novel process which, through micro-foaming, allows for the meat analogues to adjust their "degree of tenderness" from chicken to beef types without losing the fibrillar structure.[29] Further Swiss company partners involved in a related EU: EIT Food project have thus been able to work out a technological lead position, which is to be used as a key strategic component for the CHFood-PP2030 RDI program suggested. Figure 1 demonstrates a Bühler BCTL extruder in the ETH-FPE pilot plant and Figure 2 shows novel, patented "tenderness-tailored" meat analogues from pea protein and pea fiber mixtures.

Besides the before-addressed meat analogues, there is ongoing R&D work on other pea protein-based food product systems in the plant-milk and cheese domains.

(iv) Storage, distribution and retail. So far HMEC processed meat analogue products are vacuum-packaged and cold stored. However, there are most relevant sustainability-optimized concepts for ambient storage under development.

(v) Kitchen processing and meal preparation. Presently most of the HMEC processed meat analogue products have entered the market in sliced and marinated formats. The upcoming next product generation with adjusted tenderness will probably also take meat-like "grown" steak/schnitzel pieces into account. In addition, extended processing concepts are on the way to be implemented which promise the setting of juiciness. This will be the base for near-future concepts addressing sensory and nutritional customization/personalization.

(vi) Consumers' preferences, acceptance and nutritional needs (PAN). The processing concepts under development introduced in *(v)* have good chance to enable meeting specific preferences, acceptance and nutritional needs of consumer target groups (*e.g.*, elderly, pregnant women, gluten intolerant) and also fulfil further sensory quality expectations of the growing flexitarian population group. In this respect there is also advanced consumer science related knowledge available based on consumer surveys by the ETH consumer behavior lab.[30]

(vii) Derived health and sustainability benefits. Pulses are a low fat source of protein with high levels of protein and fiber. Pulses also contain important vitamins and minerals like iron, potassium and folate. There is extensive knowledge in Swiss research groups concerning plant protein and fiber analysis (e.g. ETH Zürich, Food Biochemistry, Food Biotechnology and Food and Soft Materials labs).

4. Conclusions

A food systems approach is a way of thinking and acting that considers the food system in its totality. It is not confined to one single sector, sub-system (*e.g.*, value chain, market) or discipline, and thus broadens the framing and analysis of a particular issue as the result of a web of interlinked activities and feedbacks. In the context of global food system challenges including the estimated post-Covid situation, boundary conditions and building blocks for the creation of a strategic agenda of the Swiss Food System have been introduced. From this a preferred concept has been derived for the generation of a "Swiss Plant Protein Food" (CHFood-PP2030) Research, Development and Implementation domain, suggested as a first main thematic building block of a national CHFood2030 program involving the ETH domain, universities, universities of applied sciences, research stations, industry and consumer associations, and for which support by SNF (NRP) and Innosuisse (Flagship) should be taken into account. ■

28 Planted Foods AG; *https://en.eatplanted.com*
29 E. J. Windhab, E. Stirnemann, B. Mitra, M. Weinberger (2020). Bühler/ETH Patent Application PCT/EP2020/073444.
30 Michel, F., Hartmann, C. Siegrist, M. (2021). Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. *Food Quality and Preference* 87, 104063.

Fostering nutrition research in Switzerland

Fabian Wahl*

Most of us don't organize our daily lives to optimize our long-term health; yet we do prepare or make decisions about the food we eat every day!

1. Challenges and chances for nutrition research

Nutrition research is currently experiencing a revolution mainly driven by spectacular developments in analytical sciences in biology and bioinformatics.. Nutrition is characterised by the complexity of the interactions taking place between foods and the human organism. Indeed, foods are composed of thousands of nutrients which interact with the human organism. Each of these nutrients undergo a complex and subtle array of processes including their digestion, absorption, distribution, metabolism and excretion. Scientists now have access to powerful and sensitive analytical technologies that allow them to measure and analyse, not yet fully understand, these interactions. As a consequence of these technological possibilities, scientists realize more and more that they can no longer consider human subjects participating in their studies as anonymous members of a group of subjects and that each of these persons react individually to the ingestion of foods. This observation opens the door to personalized nutrition, what resonates in media and raises big hope at the consumer side. Nutrition research is therefore about to come of age and loose its image of a pseudo-science, falsely attributed by media and the public, exactly because of the complexity of the interactions taking place between foods and the organism.

Yet, the double burden of malnutrition (undernutrition and overnutrition) is gaining momentum worldwide so that the questions of both access to sufficient calories and nutritional quality of these calories are not globally resolved. To date dietary risk factors account for 22% of deaths worldwide and 15% of deaths in Western Europe (Christopher et al, 2019). The risk of suboptimal diets is higher than any other global risk including tobacco smoking. Solving these issues requires that a sufficient number of reliable biomarkers be available in order to more accurately assess food intake and nutrient metabolism in intervention studies as well as the behaviour of consumers in observation studies.

Also, our planet is under the strong ecological pressure induced by human activities, and the agricultural production is one important element of this ecological pressure. Key questions have emerged during the last decade in particular the ecological impact of foods of animal origin. This pressure towards changing dietary patterns is further strengthened by ethical issues related to animal welfare.

Nutrition research is therefore globally faced with important challenges that need solutions. Governments and health authorities have recognized these issues and developed nutrition strategies for the coming decades that are, not surprisingly, very similar across the globe (see next section). In order for Swiss nutrition research to contribute efficiently to this global effort, and to be at the research forefront both internationally at the academic level and nationally on applied sciences, researchers working in this field in Switzerland need to come together to raise their competences and research delivery to the level that will be expected from them by the consumers, authorities, and economic actors in the near future. The Swiss nutrition researchers propose to reach this goal within a decade by creating a National Centre of Competence in Research (NCCR) "Healthy Nutrition".

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Fabian Wahl, Dr. rer. nat., ist Mitglied der Geschäftsleitung Agroscope und verantwortet den Strategischen Forschungsbereich « Mikrobielle Systeme von Lebensmitteln ». Nach dem Studium in Chemie an der Universität in Freiburg (D) promovierte Fabian Wahl ebenfalls in Freiburg, in organischer und analytischer Chemie bei Prof. Dr. Horst Prinzbach. Seine Doktorarbeit trägt den Titel « Die Pagodan-Route zu Dodecahedranen – ein verbesserter Zugang zum C20H20-Grundgerüst und totale Funktionalisierungen » (H. Prinzbach *et al.*, Nature, 2000, 407, 60–64.). Vor Agroscope arbeitete Fabian Wahl bei der Merck Group, einem in den Bereichen Healthcare, Life Science und Performance Materials international führenden Wissenschafts- und Technologieunternehmen. Als Head of New Business im Bereich Strategy &Transformation der Merck KGaA war er mitverantwortlich für die Entwicklung und Implementierung einer neuen Konzernstrategie aufbauend auf den zentralen Pfeilern Digitalisierung und Innovation. Zuvor arbeitete Fabian Wahl seit 1993 bei Sigma-Aldrich, die 2015 von Merck übernommen wurde. Bei diesem weltweit führenden Hersteller und Händler von chemischen, biochemischen und pharmazeutischen Forschungsmaterialien war er zuletzt Global Director Corporate Development. In dieser Funktion leitete er ein globales Expertenteam (Schweiz, USA, UK und Indien) und war für das analytische Portfolio zuständig. Forschungsprojekte u.a. in den Bereichen Analytik, Synthese, IoT, Blockchain spiegeln sich in zahlreichen Publikationen und Patenten wider.

2. International and national nutrition policies

The United Nations Decade of Action on Nutrition 2016–2025 aims at undertaking 10 years of implementation of policies, programmes and investments to eliminate malnutrition in all its forms with a program centred on six impacts (UN, 2016)

1. Sustainable, resilient food systems for healthy diets;
2. Aligned health systems providing universal coverage of essential nutrition actions;
3. Social protection and nutrition education;
4. Trade and investment for improved nutrition;
5. Safe and supportive environments for nutrition at all ages;
6. Strengthened governance and accountability for nutrition.

In the US, the strategic plan 2020–2030 for nutrition research developed by the National Institute of Health (NIH) is organized around a unifying vision of precision nutrition research including four strategic goals:

1. Spur discovery and innovation through foundational Research – What do we eat and how does it affect us?
2. Investigate the role of dietary patterns and behaviours for optimal health – What and when should we eat?
3. Define the role of nutrition across the lifespan – How does what we eat promote health across our lifespan?
4. Reduce the burden of disease in clinical settings – How can we improve the use of food as medicine?

The World Health Organisation (WHO) has developed a set of global targets to reduce the burden of non-communicable diseases (NCDs), which include a 25% relative reduction in the risk of premature mortality from NCDs, as well as a 30% relative reduction in mean population intake of salt or sodium, and a zero increase in levels of diabetes and obesity (WHO, 2013).

For Europe, the WHO has published the European Food and Nutrition Action Plan 2015–2020. The mission of this Action Plan is to achieve universal access to affordable, balanced, healthy food, with equity and gender equality in nutrition for all citizens of the WHO European Region through intersectoral policies. The following objectives of the Action Plan were set for Europe by WHO:

1. Create healthy food and drink environments;
2. Promote the gains of a healthy diet throughout life, especially for the most vulnerable groups;
3. Reinforce health systems to promote healthy diets;
4. Support surveillance, monitoring, evaluation and research; Strengthen governance, alliances and networks to ensure a health-in-all-policies approach.

However, Member States of the European Region are overall not fully on-track to achieve the global NCD targets related to nutrition. Therefore, if countries are to shift this trend, more ambitious and comprehensive nutrition policies should be implemented at a faster pace. Moreover, expanded and more robust surveillance, monitoring and evaluation systems should be prioritized in order to understand progress and to guide timely and effective policies (Breda *et al.*, 2020).

In Switzerland the vision of the Swiss Nutrition Policy 2017–2024 "Eating well and staying healthy" is that everyone living in Switzerland is able to choose a balanced and varied diet, possesses the skills to do so and has the necessary environment to autonomously maintain a healthy lifestyle irrespective of origin, socio-economic status and age". The Swiss Nutrition policy defines four action areas

1. nformation and education
2. Framework conditions
3. Coordination and cooperation
4. Monitoring and research.

3. The satellite 2019 meeting on nutrition research in Switzerland

Translating this vision requests concretizing actions. The 16th edition of NuGOweek, the annual conference of the international nutrigenomics organisation NuGO, organized in Bern between 9th and 12th September 2019 and entitled "From Foodomics to Nutrigenomics: Translating food composition data into healthy Diets" was the occasion to address the future of nutrition research in Switzerland.

A meeting entitled "Filling in the Gaps in Swiss Nutritional Research – the Stakeholders' Perspective" took place in Berne on 12 September 2019 with the participation of 71 experts from around 45 different institutions. Stakeholders from the spheres of nutritional research, agriculture, the food and nutrition industry, nutritional counselling and public health were represented. The satellite meeting aimed to promote innovative nutritional research in Switzerland. A report primarily directed at participants in the satellite meeting, as well as decision-makers in the sphere of Swiss nutritional research is available (Mühlemann, 2019). Although this lays no claim to completeness, its findings can be considered representative of the Swiss nutritional research landscape.

The satellite meeting showed that the different stakeholder groups have numerous interests in common. Despite the high relevance of thematic gaps in Swiss nutritional research, the experts unanimously agreed that their top priority should be looking into setting up a Swiss Centre of Excellence for Nutritional

Research. This conclusion resulted in the following recommendations:

1. The creation and regular updating of a National Nutrition Research Strategy as an orientation aid for all nutrition research professionals;
2. Creating a "nutrition science quality initiative" to improve the quality of Swiss nutritional research;
3. Promoting collaborative research at national and international level;
4. Promoting exchange or networking between nutritional researchers at national and international level; promoting dialogue between research and practice, and raising the profile of Swiss research;
5. Bundling the financing for nutritional research in Switzerland, and increasing transparency in this domain;
6. Improving the quality of information and boosting confidence in nutritional research, thereby increasing credibility.

A number of structural weaknesses in the Swiss nutritional research landscape were identified back in a 2010 expert survey. Various measures suggested at the time were also mentioned at the satellite meeting, including promoting interdisciplinary nutritional research and strengthening the topic of nutrition at policy level.

Many of the weaknesses and gaps discussed (e.g. the lack of reproducibility of scientific findings) are not the exclusive problem of nutritional research, but affect all life-science fields. However, owing to the complexity of nutritional science (ingredient interactions, the complex effects of the ingredients in the human body, various factors influencing eating behaviour, etc.), the weaknesses and gaps in nutritional research were more prominently highlighted. The report of the satellite meeting concluded that time has come to speak with one voice, *inter alia* in order to strengthen confidence in nutritional research. The will of the different stakeholder groups to shape the future of nutritional research in Switzerland together was also palpable. The satellite meeting finally called for concrete action.

4. The NCCR Healthy Nutrition initiative

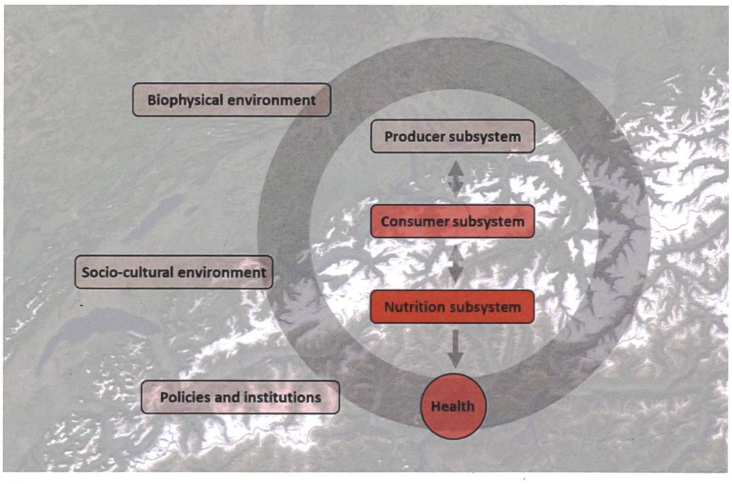
As a follow up of the 2019 satellite meeting, a series of meetings took place in 2020 with a wide range of stakeholders from the food and nutrition landscape. During these meetings, a decision was taken to bundle Swiss nutrition researchers towards the joint submission of a National Centre of Competence in Research at the occasion of the next call by the Swiss National Science Foundation (SNF).

Although a date for the next call for NCCR proposals has not been communicated yet, the authors prepare for a call in 2024–2025. To this end, a Task Force "Swiss Research Network – Healthy Nutrition (SRN-HN)" composed of two representatives from ten research institutes involved in nutrition research has started its activities in October 2020. The following institutes are represented in the Task Force: Agroscope, Berner Fachhochschule BFH, École polytechnique fédérale de Lausanne EPFL, Fernfachhochschule Schweiz, Haute école spécialisée de Suisse occidental HES-SO, Swiss Vitamine Institute, Université de Lausanne, Universität Zürich UZH, ETH Zürich, Zürcher Hochschule für Angewandte Wissenschaften ZHAW. The Task Force has set an agenda with the aim of framing the main lines of the NCCR Healthy Nutrition until the middle of 2021.

A key question was the scope of the nutrition research that should be conducted in the broader context of food and nutrition systems. In that regard, the Task Force confirmed the outcome of the 2019 satellite meeting as well as of the stakeholder meetings 2020 to focus the research frame of the NCCR on the "nutrition subsystem", including in particular the impact of nutrition on health and consumer sciences. The NCCR Healthy Nutrition will however leave room to important components of the nutrition system including food sciences (producer subsystem), public health (policies and institutions), and sustainability (socio-cultural environment; biophysical environment) (see Figure).

The first decision of the Task Force was to define the title of the NCCR. The Task Force proposed the title "Healthy Nutrition" to highlight the preventive nature of nutrition to support human health. The Task Force then defined a series of research question that should be addressed by the research projects to be advanced by the NCCR Healthy Nutrition.

1. How does nutrition impact on human health?
2. How can Swiss consumers be encouraged to eat healthy diets?



3. How can precision nutrition foster health?
4. How can technologies contribute to healthy nutrition?
5. How can food innovation be driven by health?

These research questions set the frame for defining the main research projects that will be addressed by the NCCR Healthy Nutrition. The Task Force is currently defining these research questions. The NCCR Healthy Nutrition aims at bundling forces in the nutritional landscape to build a strong Swiss nutrition research, which reaches excellence in the international scene as well as impacts on the health of Swiss citizen. The NCCR Healthy Nutrition will therefore federate Swiss research institutes in academic institutions (universities, ETHZ/EPFL), applied research institutions (Agroscope, universities of applied sciences) as well as non-profit organizations (Swiss Vitamin Institute...). It will also closely collaborate with professional societies in the food and nutrition sector. As the research conducted by the NCCR Healthy Nutrition must translate into solutions that impact on consumer food choice and health, the NCCR will create a scientific board with members of stakeholders in the nutrition sector. As food production and transformation is key to consumer health and dietary choice, the food sector will also be represented in the scientific board.

As mentioned at the beginning of this article, metabolic diseases, with its main physiological and clinical manifestations – dyslipidemia, insulin resistance, hypertension, type 2 diabetes and cardiovascular diseases – impose a heavy burden on society, also in Switzerland. As nutrients are key in shaping human metabolism, nutrition provides a key entry point for scientists to develop and encourage the implementation by the consumers of dietary solutions that will mitigate metabolic diseases. The NCCR initiative Healthy Nutrition will therefore centre its research program on the topic of metabolic health. To this end, the network of scientists contributing to the NCCR initiative will propose a translational research that will evaluate the impact of nutrition, be it nutrients, foods and dietary patterns of plant and animal origin, across a wide range of scientific disciplines including food sciences, mechanistic molecular research on cells, animal models and human subjects, nutritional intervention and observational studies in human cohorts, in particular with the establishment of a Swiss nutrition cohort, consumer sciences and public health nutrition. The concept developed by the initiative NCCR Healthy Nutrition is still in a dynamic phase and, thus, evolving.

The Task Force NCCR Healthy Nutrition is currently building the research network around the program metabolic health, and the first granting initiatives to gradually establish this network will be started at the national level in fall 2021. If successful, Switzerland will have a strong competitive research community in the field of nutritional research that will be able to respond to the important nutritional challenges awaiting the Swiss society in the next decades. ■

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