A more sustainable Swiss food system

Scientists working on NRP 69 have developed various proposals for producing meat, milk and vegetables in an environmentally friendlier way. Some of these proposals can also have direct positive effects on human health.

The project “Sustainable agri-food systems”[a] found that the agri-food system is responsible for about one third of all environmental impacts in Switzerland. Given that this sector accounts for just seven per cent of the national gross added value, this means that the sector disproportionately contributes to the environmental burden. Coordination between agricultural production, the processing industry, wholesaling, retailing and the consumption of food is needed to make the food system more sustainable.

In this chapter, “sustainability” refers mainly to the environmental impact of the food system, but in some instances also to its social and economic dimensions.

a. Birgit Kopainsky et al., Environmental-economic models for evaluating the sustainability of the Swiss agri-food system. NRP 69

Environmental performance of dairy farms in Swiss mountain regions

In the “Sustainable milk production” project[b], researchers assessed the environmental performance of dairy farms in mountain regions. Based on their work, they recommend always taking into account both the local and the global dimension when determining the environmental performance of farms, but distinguishing clearly between the two.

The research group identified factors that could potentially simultaneously improve both the global and local environmental performance as well as the economic performance of dairy farms in mountain regions. These factors are organic farming, better educated farm managers and, to a lesser extent, low-intensity use of cattle concentrate feed, larger farm size as well as full-time farming.

b. Pierrick Jan et al., ECON'ENTAL - Learning from the best: a benchmarking approach to the improvement of the economic and environmental sustainability of Swiss dairy farms. NRP 69

Measures to reduce emissions in dairy housing

Dairy farming accounts for a significant share of agricultural greenhouse gas and ammonia emissions. Ammonia not only harms sensitive ecosystems, it can also contribute to the formation of particulate matter that can harm human health[18].

For these reasons, one of the targets in the *Umweltziele Landwirtschaft*[18] is a 40% reduction in ammonia emissions compared to 2005 in Switzerland. Researchers working on the “Cow emissions”[c] project investigated the efficacy of various measures to reduce ammonia emissions. They found out that structural measures, which address the soiled floors, the main source of ammonia, are very promising.

c. Sabine Schrade et al., Sustainable milk production systems: ammonia and greenhouse gas emissions and abatement strategies. NRP 69

The first structural measure investigated was a floor with a 3% slope, so that the cows' urine could drain rapidly from the floor surface to a central gutter. An automatic manure scraper ran 12 times a day to enable unhindered drainage. First results showed 20% lower ammonia emissions in the system with the sloped floor compared to the reference system without slope.

The second structural measure which resulted in a significant reduction in ammonia emission were the "feeding stalls". The cows stood on a raised feeding area with partitions. Since there was hardly any faeces and urine on the platform, the heavily soiled area was reduced. The aisle behind the feeding stalls was frequently cleaned using a manure scraper without disturbing the cows while they were feeding.

In addition to the reduction of ammonia, both measures also led to cleaner and drier floor surfaces, which improved claw health and housing hygiene.

Both measures have been incorporated into the new "Ordinance on Structural Improvements in Agriculture"[19]. The Ordinance provides financial support for farmers who implement these measures to convert or build cattle housings.

Protecting the environment and the health of pigs

Like dairy farming, meat production also has an impact on the environment. Over the past 30 years, average meat consumption in Switzerland has fallen from 60 to 50 kilogrammes a year[20]. Pork is still the most popular meat in the country, as the 2017 figure of 22 kilogrammes testifies. Researchers of the "Healthy pigs" project[d] developed a model for pork production that not only reduces ammonia and greenhouse gas emissions, but simultaneously improves the animals' health and well-being.

To reduce greenhouse gas and ammonia emissions, this research group explored the pigs' protein efficiency. The more efficiently the animals can metabolise proteins, the less of it ends up in slurry as a source of nitrogen and ammonia.

The researchers also conducted a study of 112 pig farms to investigate when and where infections were most frequent and antibiotic use had to be increased in response.

According to the researchers, the following factors are essential for low-antibiotic pig rearing: good trough hygiene, appropriate amounts of special feed for young animals and avoiding that animals of different ages share the same sty. Reducing antibiotic use in pig farming contributes, among other things, to preventing the further spread of antibiotic resistance in bacteria that are pathogenic for humans and animals.

d. Peter Spring at al., Healthy Pork from Sustainable Production Systems - developing basic knowledge and skills of implementation. NRP 69

Limiting metal pollution in soil

e. Wolfgang Wilcke et al., Stable metal isotopes as tools to assess enrichment and sources of trace metals in soils and crops to improve sustainability of agricultural systems. NRP 69

Two NRP 69 projects addressed the environmental impact of arable farming. The "Metal exposure"[e] project investigated levels of cadmium, copper, uranium and zinc in Switzerland's arable land and grassland.

The results show that agricultural practices during the last fifty years have caused an accumulation of these metals in the soil. This is worrying for two reasons. Not only can elevated metal concentrations affect soil fertility, the metals also enter the human food chain because plants absorb them.

Over a one-year period, the research team took various soil samples from three different cornfields to which mineral fertilisers had been applied and three pastures that had been manured so that they could measure metal inflow and outflow in them.

The researchers found that the four metals had accumulated in the upper soil layers of all the fields they investigated. The primary source of the cadmium and uranium was mineral phosphate fertiliser. To limit metal pollution in the soil, the researchers recommend introducing a new uranium guidance value for mineral fertilisers and carefully checking this value and the guidance value for cadmium.

In addition, the accumulation of both metals could be avoided by increasing the use of recycled fertilisers from sewage sludge ash, provided that they are derived from heavy metal depletion processes.

Manure is the primary source of zinc and copper in the soil. Both trace metals are contained in the feed as additives, are excreted by the animals and end up in the manure.

To reduce the input of copper and zinc in the future, the researchers recommend that the guidelines relating to the addition of copper and zinc to animal feed be strictly applied and that liquid manure distribution be optimised across farmed areas. Furthermore, the adoption of grain varieties that absorb very little cadmium but transport zinc efficiently into the grain should be encouraged.

Change crop rotation to avoid fungal infection

f. Susanne Vogelgsang et al., Are healthy cereals safe cereals? - Ensuring the resistance of small grain cereals to Fusarium diseases. NRP 69

The "Safe cereals" project[f] compared different grain varieties in terms of their resistance to Fusarium infections. The main issue addressed by the project was how to reduce Fusarium infection in cereals. Because these fungi release dangerous toxins – known as mycotoxins – they pose a health risk if they contaminate cereals.

In growth chambers and field experiments, the researchers established that barley was more susceptible to Fusarium infection at 15°C than at cooler (10°C) or warmer (20°C) temperatures. Barley proved to be less resistant than oats at all stages of its growth.

Their results confirm that modifying crop rotation is the most effective way of preventing mycotoxin contamination. Barley should not be sown in fields where maize was the previous crop, while oats should follow large-grained cereals.

Two thirds of the Swiss environmental footprint occurs abroad

g. Birgit Kopainsky et al., Environmental-economic models for evaluating the sustainability of the Swiss agri-food system. NRP 69

The “Sustainable agri-food systems” project[g] simulated possible trends in the Swiss food system as part of NRP 69. The researchers applied two environmental-economic models. One of them shows that the agri-food system in Switzerland accounts for 17% of greenhouse gas emissions.

Most of the greenhouse gases are attributable to meat and milk production. Moreover, agriculture has a heavy environmental impact because it involves considerable amounts of land and water. In contrast, the environmental impact of the food processing industry, and trade and distribution are relatively low, even though these sectors generate the most added value.

The research team also showed that around two thirds of the environmental footprint of Swiss food consumption occurs abroad because of the amount of food, feedstuffs and raw materials that Switzerland imports. The fact that the majority of environmental impacts occur abroad refers to the aggregated environmental impacts according to the ecological scarcity method, greenhouse gas emissions and biodiversity damage potential.

Strengthening partnerships between producers and consumers

h. Marion Fresia et al., Alternative agro-food networks: innovative integration of sustainable eating habits and food production? NRP 69

Researchers from the “Organic food baskets” project[h] argue that efforts to make food supplies in Switzerland more sustainable should involve integrated strategies that target producers and consumers. They propose a standard integrated strategy.

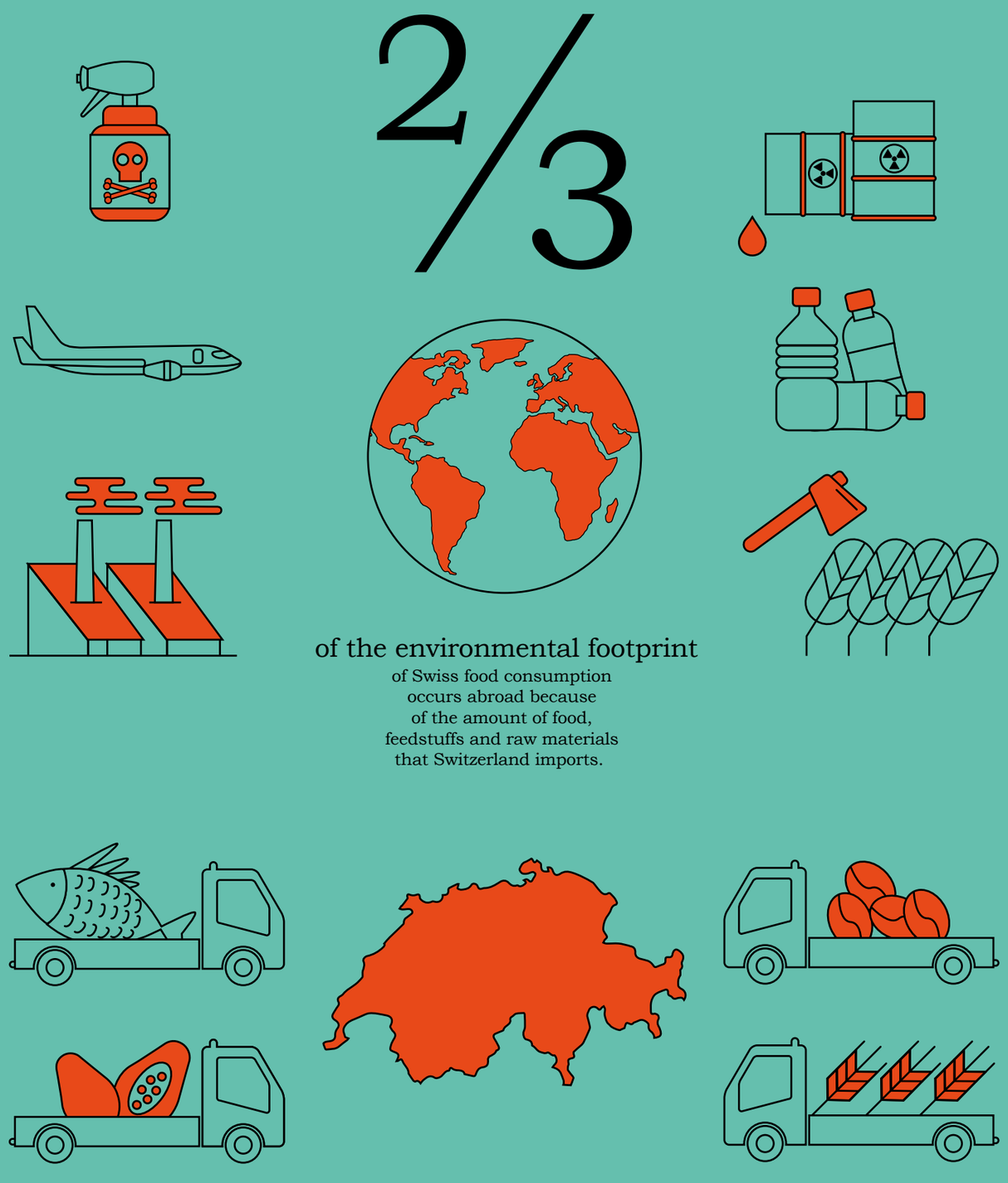
The project shows that encouraging people to eat locally sourced, seasonal food not only supports domestic producers, but also helps promote a healthy and sustainable diet. Over the last thirty years, there has been a growing interest in regional food networks in Switzerland. Such networks offer regional products by subscription, creating a direct partnership between farmers and consumers that allows them to share the risks if, for example, harvests are low due to bad weather.

The research group working on the “Organic food baskets” project carried out case studies on three different schemes in French-speaking Switzerland. They found that local contract farming (LCF) is evolving from a niche phenomenon into more rigorously structured systems.

But the systems seem to be having trouble gaining the acceptance of broad sections of the public. 80% of the members of the food networks had a high education level and belonged to the middle or upper classes.

In all three case studies, the subscription system brought producers greater autonomy because food baskets give them a more secure basis for planning. Moreover, many farmers reported that their work was more highly valued as a result of their partnership with consumers. Simultaneously, local contract farming encourages healthy and sustainable eating habits.

The researchers therefore recommend promoting LCF schemes, for example by increasing the number of partnerships between local producers and public and semi-state-controlled institutions such as crèches, schools, retirement and care homes.



Reducing food losses and waste: a source of leverage to make the food system more efficient and sustainable

Worldwide, around one third of all the food produced for human consumption ends up uneaten[10]. The figure for Switzerland is similar, according to the Federal Office for the Environment (FOEN)[11]. This translates into 2.6 million tonnes a year, with two thirds avoidable. On average, every inhabitant wastes 190 kilogrammes of edible food per year.

An estimated 37% of food losses occur in the industry; the catering trade accounts for 11% and the retail trade for a further 4%. Nine per cent of food losses occur in agriculture. But the biggest part of food waste – 39%, almost 900,000 tonnes a year – occurs in consumers' households[11].

According to the Food and Agriculture Organization[10], food waste refers to the discarding or alternative (non-food) use of food that is safe and nutritious for human consumption. According to the same source, food losses can be defined as the decrease in food, either in quantity or quality. These are agricultural or fish products intended for human consumption, which are ultimately not eaten, or which have suffered a perceived decline in quality – in terms of their nutritional, economic value or food safety. They occur throughout the food supply chain. Knowing that two thirds of the environmental footprint of Swiss food consumption occurs abroad[i], the impact of food production in Switzerland is obviously limited. Thus, systematically reducing losses and waste could help make the Swiss food system more sustainable in a relatively short time. The government currently relies on voluntary measures and employs a variety of communication activities to raise public awareness of the issue of food losses[11].

i. Birgit Kopainsky et al., Environmental-economic models for evaluating the sustainability of the Swiss agri-food system. NRP 69

However, the Swiss government ratified the Sustainable Development Goals (SDGs)[21]. Goal 12.3 calls for edible food waste to be halved at the retail and consumer levels, and to reduce food losses in agriculture, trade, and the processing industry by 2030. Therefore, the FOEN is developing a strategy to monitor and reduce food waste[11].

As part of this strategy, the FOEN published a report summarising amounts of food waste and environmental impacts in Switzerland, in collaboration with ETH Zurich[11]. The objective of this report is to identify hotspots of environmental relevance, deduce effective measures for food waste prevention, create a scientific basis for an awareness-building campaign and identify major research gaps.

One of the problems in conducting this type of analysis is how to measure losses and waste. At European Union level, in May 2019, the European Commission decided to introduce a common methodology to measure food losses and waste in the EU[22].

Food waste

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1/3

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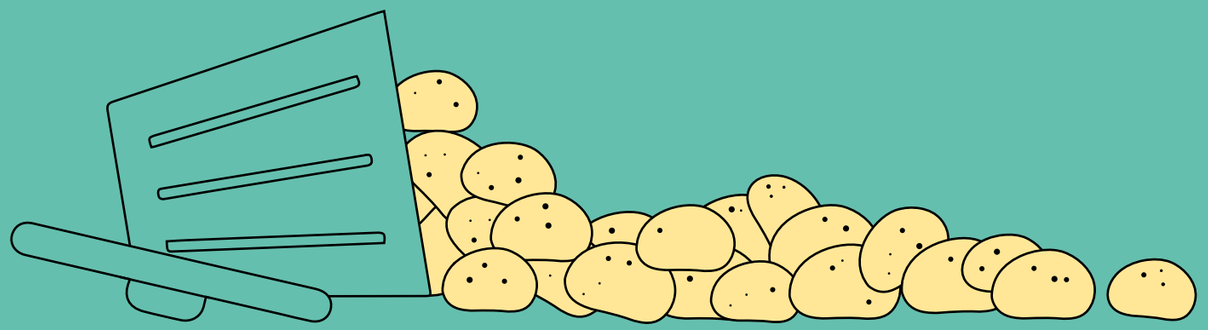
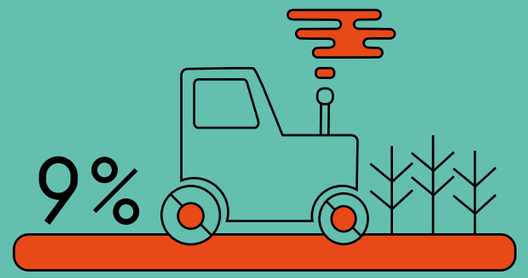
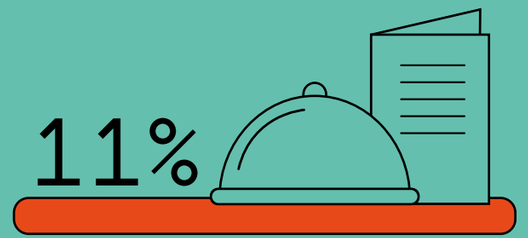




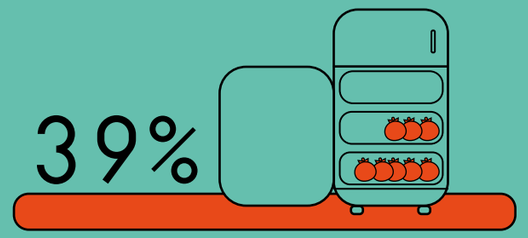
Agriculture

Food industry



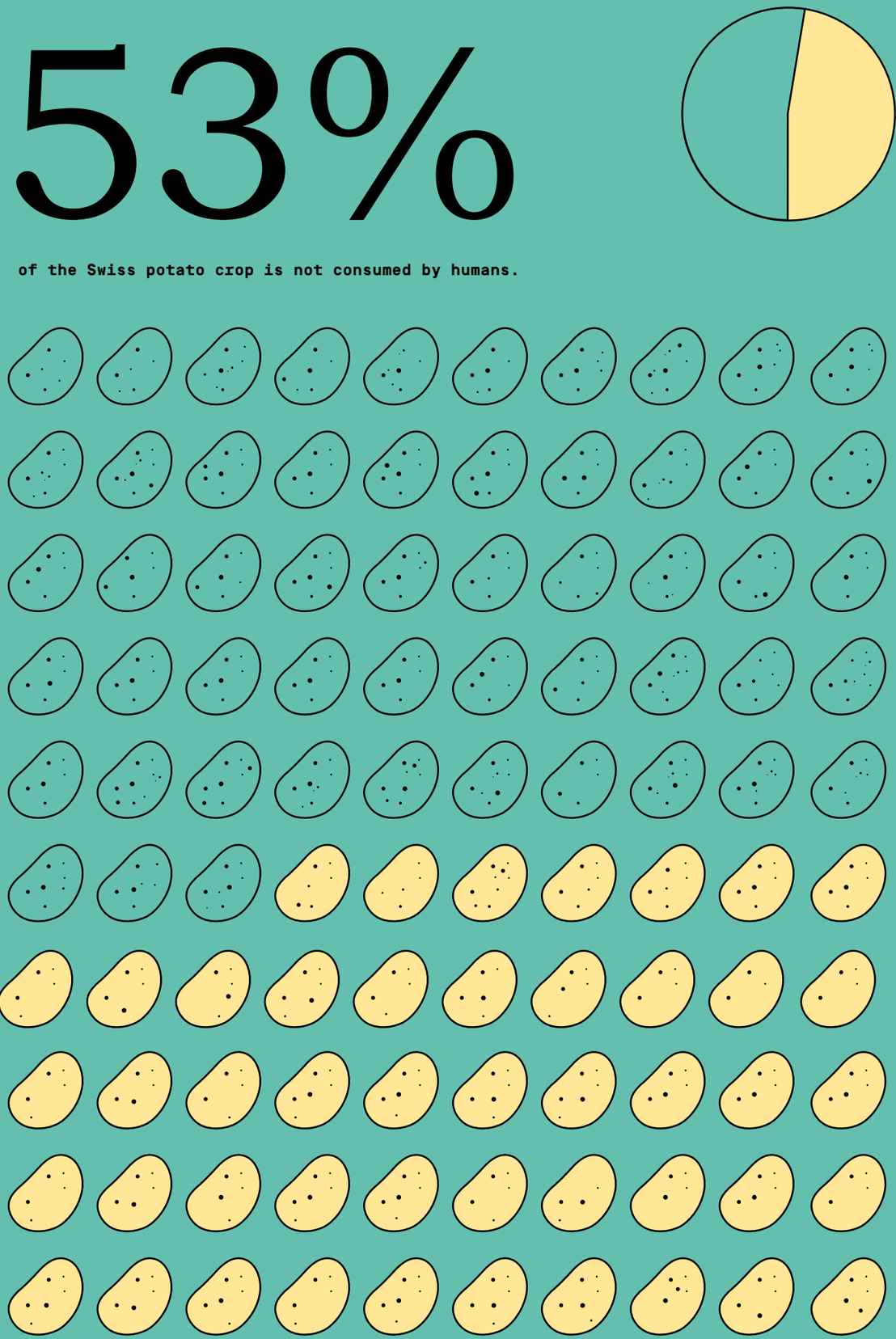
Catering

Retail trade



Consumer

Food waste occurs all along the value chain.



A study on potato losses

The general issue of food losses and waste and the scale of the problem is known (see context “Reducing food losses and waste” on page 43). However, it will only be possible to efficiently reduce food losses and waste if we have detailed information at each stage of the food value chain. At present, there are few comprehensive surveys of individual foodstuffs.

In NRP 69, one such initiative was carried out along the value chain for Swiss potatoes: the “Food losses” project[j] showed that no less than 53% of the potato crop is not consumed by humans. Almost half of the losses occur at farm-level. Having detailed insight into the potato value chain enabled the researchers to propose measures to reduce food losses and waste.

The project suggests that the cosmetic standards for potatoes be reduced, and that potatoes that do not meet the standards for food processing be used as fodder. Additionally, the team suggests that smaller, lightproof packaging could help consumers buy the right amount of potatoes to cover their needs.

These propositions are tailored to the potatoes value chain and cannot be easily transferred to other foods. The researchers recommend analysing the food value chain of other products, e.g. different types of vegetables, in a similar way. This will identify the extent and causes of waste at each stage of the value chain and provide a basis from which effective measures to reduce food losses and waste could be developed.

j. Gabriele Mack et al., POM-Q: Strategies for reducing food losses in potato-product supply chains: Implications of different quality standards. NRP 69

Innovations in date-marking and food preservation

The “Nano-preservation”[k] project provides a nanotechnology-based alternative to best-before dates of certain foodstuffs. The research group developed smart labels for packaging that react, e.g., to pH change in the food. Thus, for food that turns acid during spoilage, its deterioration is indicated by a change in colour or fluorescence of the labels. This technology is not ready yet for the market; further research on other indicator systems, on the consumers’ acceptance and on the production costs of such packaging is needed.

Another project called “Preservative bacteria”[l] investigated the possibility of using lactic acid bacteria as a possible way of preserving food for longer. The researchers developed a process for selecting the bacterial cultures with the best preservative properties.

Using such cultures in production processes could increase food shelf-lives and food safety by reducing contaminations. This could be the case for Staphylococci bacteria contaminations. Staphylococci release substances in the food that are toxic for humans. Other examples are contaminations with Listeria or Salmonella, two widespread pathogens. The food industry is making increasing use of lactic acid bacteria strains, which have very diverse properties and can be used for many different purposes.

k. Cornelia Palivan et al., Protein polymer nanoreactors to preserve food quality. NRP 69

l. Leo Meile et al., Genomic Approach to Identify Interactions between Microbes during Food Fermentation and Biopreservation. NRP 69

However, there is no overarching coordination in the management of the data on strains that have been scientifically investigated and classified as potentially useful. The team recommends exploiting the food-preserving potential of bacteria more effectively. This includes the sharing of information on known strains: data should be collected on a central platform for public and private partners and made freely and directly accessible.

In the “Staphylococci” project[m], researchers investigated the risk factors for bacterial food poisoning induced by Staphylococci. They investigated the impact of four stress factors on the formation of various staphylococcal toxins. They analysed the effect of high levels of salt, sugar, pickling salt and lactic acid (low pH), since these factors occur frequently during food processing and storage.

It emerged that the bacteria released less dangerous toxins, so called enterotoxins, in an environment that contained a high salt or sugar level. But the team also noted that each bacterial strain reacted differently to the stress factors tested.

To better address the health risks posed by Staphylococci, the researchers recommend developing new detection strategies, focussing on the quantification of enterotoxins present in the food instead of on counting the number of bacteria. The development of such detection systems is likely to increase food safety for consumers and help to reduce food losses.

m. Roger Stephan et al., Minimizing the risk of staphylococcal food poisoning while reducing food waste: evaluation of enterotoxin B expression under stress relevant to food production and preservation. NRP 69

The future of nutrition research

Two research groups participated in the European Joint Programming Initiative “A Healthy Diet for a Healthy Life” (JPI-HDHL) and paved the way for more efficient nutrition research.

It is generally accepted that dietary intake has an influence on health, but exactly how this happens differs from person to person: genetic predisposition, personal metabolism and environmental factors all play a role. There are still no precise methods available for measuring the health impact of dietary intake. New biomarkers can be used to observe the relationship between dietary intake and health more effectively and predict it more reliably for specific population groups. The aim of the research project “Mirdiet”[n] was to find new genetic biomarkers in the human body that provide indicators of the impact of dietary intake on health. The focus was on specific RNA molecules, or microRNAs. These non-coding ribonucleic acids circulate in the blood and play a role in the regulation of gene expression. Using volunteer test subjects, the study analysed the effects of changes in diet on various microRNAs. Overall, the technical difficulties associated with measuring microRNAs in the bloodstream had a limiting effect on the results obtained. The scientists recommend continuing to search for biomarkers for food intake, despite the complexity of the methods used to quantify them. Technical

n. François Pralong et al., Circulating microRNAs as markers of dietary intake. NRP 69

progress could help overcome these obstacles by making it easier to measure the microRNAs circulating in the bloodstream, since these still have plenty of potential in nutritional research and the promotion of a healthy diet.

It is common practice today for nutritional scientists conducting investigations on food consumption to depend on data from questionnaires. A new method holds out promise of more accurate results: dietary metabolomes (the complete set of substances found in the blood and urine after the consumption of food) have been used to analyse the effects of food on people’s health, but only a few types of food are currently covered by validated biomarkers. The international research consortium “FOODBALL”[o] proposed to (i) set up the technological tools necessary for the characterisation of these biomarkers, in particular nutritional metabolomics and databases allowing the quantification and identification of these biomarkers, and (ii) conduct human nutritional studies in order to identify biomarkers specific to a series of foodstuffs covering the different food groups.

For example, researchers from Agroscope and the University of Lausanne who participated in FOODBALL were able to identify biomarkers in the human metabolism that provide evidence of the consumption of milk, cheese and soy drinks. Among the molecules produced after ingestion of dairy products are lactose-derived molecules whose appearance in the blood and urine of participants is indicative of their ability to digest lactose. These results highlight the potential of the research conducted by the FOODBALL consortium to develop the field of personalised nutrition. In addition, the researchers identified metabolites derived from the amino acids tryptophan and phenylalanine as markers of the ingestion of fermented foods. These results have paved the way, through an observational human study, thus conducted in real conditions, to new work aimed at characterising the impact of fermented foods on health.

o. Guy Vergères et al., The Food Biomarkers Alliance – FOODBALL. NRP 69