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Implementation of True Cost of Food Accounting in selected Swiss Agricultural Value Chains: The Case of Potatoes

Production and Consumption in Switzerland and abroad

Potato (*Solanum Tuberosum*) found its way to Switzerland in the course of the 16th century as a root crop from Peru that produces higher yields than traditional cereals. As a relatively cold-resistant crop, it was perfectly adjusted to the little ice age that Europe was confronted with at that time. In addition, its nutritional content protected people from diseases related to nutrient deficiencies that especially affected the poor. Potato eventually became the most important food crop in Switzerland and helped to feed a growing population that moved from agriculture to industry in the 19th century. But growing adoption rates also led to monocultural practices and the spread of pests and diseases that caused harvest failure and emigration. Switzerland also became an innovative producer of instant potato-based products and snacks, such as stocki (instant mashed potato), chips and potato-based convenience foods. At the same time ware potato remains an important ingredient of many national dishes such as Raclette and Rösti.

Over the past two decades, the share of domestic potato producers has roughly halved. Nevertheless, thanks to continuous productivity increases the remaining 4000 potato-growing Swiss farms are able to cover between 75% and 85% of the domestic demand on a surface of a bit less than 11'000 hectares amounting to an annual harvest in the range of 400'000 tons. However, since the cultivation of the tubers is highly dependent on the weather conditions significant fluctuations may occur.

Around 75 percent of the production is designed for domestic human consumption in processed or unprocessed form. The remaining production consists of seed potatoes. 25% of the potato harvested is declassified because it does not conform with the strict retail standards. Declassified potato may be used as animal feed, biofuel or manure.

The Social Dimension: A relevant crop for less affluent Swiss families

Average consumption of potato per capita in Switzerland amounted to 47 kilograms compared to an average consumption of over 100 kg/capita in Eastern European countries. Yet, household consumption per capita varies widely in Switzerland. Less affluent households with children tend to consume double the amount per capita compared to more affluent single households with no children. The former also tend to benefit from a recent increase in discount offers for larger package sizes due to more competition in the Swiss

Potato: A crop that matters

<https://www.kartoffel.ch/>

Potato is the most important non-grain crop in the world and the third most important food crop after rice and wheat. Its adaptability, production capacity, nutritional value, and role as an essential component of varied cropping systems explains its crucial role in ensuring food security, combating malnutrition and improving household incomes, especially in times of crisis. At the same time, potato has also become a popular dish for health-conscious consumers in affluent countries for it is a crucial component of a vegan and gluten free diet. It is rich in vitamins, minerals and fiber, but relatively low in calories.

Yet, potato cultivation in Europe is also strongly affected by climate change. Consequently, plant breeding plays an important role in reducing the environmental footprint through more resistant varieties.

Food waste as well as water and energy consumption in the preparation and the processing of potato products is a challenge but also an opportunity. Advances in technology have made the use of potato waste products more economically viable.



retail market. It indicates that potato is still an important food security crop, even in affluent countries like Switzerland.

An attractive dish for people pursuing a health-conscious vegan life style

Potato is also marketed as an attractive life style food product that is vegan, gluten-free and mostly locally produced. This may also explain the increase of market share of certified organic potato from 10.6% in 2019 to 13.7% in 2023. Certified organic potato is able to fetch a substantially higher price than conventionally-grown potato in retail stores (CHF 3.33 per kg compared to CHF 1,82 per kg). One would therefore expect the market share to increase even to higher levels. However, yields of organically produced potato are substantially lower and more affected by extreme weather conditions. This may explain why average gross margin for organic potatoes may have actually decreased in recent years.

The Health Dimension: Two Tales

Potatoes are plant-based food that has steadily grown in importance in public efforts to promote a healthy and climate friendly, meat-free diet.

This vegetatively propagated root crop combines the favorable traits of starchy foods with the valuable nutrients of vegetables. As such, potato is an exceptional source of low-calorie energy, protein, and micronutrients like iron and zinc. A single unpeeled medium-sized potato of around 150 grams provides nearly half the daily adult requirement (100 mg) of vitamin C. It is also a good source of vitamins, such as Vitamin A, B1, B2, B3, B5 and B6, minerals such as iron, potassium, phosphorus, magnesium, calcium and numerous potentially healthy metabolites. Hence, potato is considered to be an essential crop in the global combat micronutrient deficiency, a major global public health problem affecting an estimated 2 billion people especially in low-income regions in Asia and Africa.

Moreover, potato proteins contain many functional and bioactive properties, including antioxidant, anti-inflammatory, and antimicrobial effects that contribute to improved human health and extended life expectancy. Despite their lower protein content compared to legumes or soybeans, potato proteins are rich in essential amino acids and have a very high digestible indispensable amino acid score (DIAAS).

In return, the share of processed potato consumed in the form of chips, French fries and many types of convenience food has increased due to the trend towards urbanization and lifestyles based on ready-made meals. Highly processed potato products have been related to increased risks of obesity mainly because of their high glycemic index¹. Even though there is no convincing evidence to suggest a direct link between intake of potato and risks of obesity, type II diabetes (T2D), or cardiovascular disease (CVD), overconsumption of these high-energy products combined with reduced physical activity may contribute to an elevated health risk. Innovative technologies such as ultrasound processing, pulsed electric field processing, microwave and radiofrequency processing have improved potato processing efficiency and product quality while preserving the nutritional and sensory properties of potato products.

¹ The glycemic index is a scale that ranks a carbohydrate-containing food or drink by how much it raises blood sugar levels after it is eaten or drunk.

The need for more resistant commercial potato varieties

In 2017, the Swiss Federal Council approved the action plan for risk reduction and sustainable use of plant protection products (PPP). It aims to reduce the risks of PPP for surface and ground water as well as natural habitats by 2027 by 50% compared to the average for the years 2012-2015. According to the interim report of the action plan published on May 2024, risk exposure has been significantly improved thanks to the adoption of more sustainable agricultural practices and an overall reduction of the use of PPP, except for the use of copper as a natural fungicide, most used in organic farming. However, it will be more difficult to further reduce the use of PPP without affecting crop yields significantly. Therefore, there will be an increasing need for more resistant varieties, especially in potato cultivation. The potato industry has signed a target agreement with the federal government. Robust varieties that are expected to reduce the use of pesticides and fungicides are to be adopted on 25% of potato-growing areas by 2028 and 80% by 2040 respectively. There are a few more robust varieties bred by means of conventional breeding. But, according to Swisspatat, it takes 12 to 15 years for a newly bred potato variety to reach the market. Moreover, undesirable characteristics are almost always transferred when crossing resistance from wild potato, while certain preferred traits in the potato value chain get lost. In addition, pathogens tend to mutate quickly and thus break resistance in varieties. Genome editing may address these challenges effectively. For example, it was shown under experimental conditions that potatoes of the 'Desirée' variety could be made significantly more resistant to Phytophthora infestation by switching off two genes, without affecting other preferred traits of this commercially successful potato variety.

Thermal processing of potato leads to a reaction that forms acrylamide, a recognized neurotoxin, which is widely considered to be a public health concern. Even though carcinogenic effects have been observed in animal trials, they could not be confirmed for humans.

There are however numerous ways of reducing acrylamide in processed potato by decreasing the acrylamide precursors or hindering the corresponding reaction pathways. In addition, the potato industry has responded to the problem by storing potatoes at less low temperatures (resulting in a lower share of reducing sugars) or by using varieties that are less susceptible to the formation of acrylamide.

Environmental challenges in potato farming

Climate Change has caused an increase in annual average temperatures and stronger variations in terms of precipitation during crop cultivation periods. Due to their shallow root system, potatoes are relatively sensitive to water deficits in the soil, especially during critical stages of growth. High temperatures also cause detrimental effects on potato growth, yield, and tuber quality. In addition to these abiotic stress factors, biotic ones such as pest and disease infestation also tend to increase in a warmer and more humid climate during spring and autumn.

Pests and Pathogens in Swiss potato cultivation

In addition to the usual potato pests such as the potato beetle and aphids, wireworms and the larvae of click beetles have been observed more frequently in recent hot and dry climate conditions. This explains why the use of pesticides continues to be strongly fluctuating in potato cultivation. The most important threat to potato yields is however a fungus: *Phytophthora* (*P.*) *infestans*. It causes bacterial blight, one of the most devastating plant diseases since the large scale adoption of potato in Europe in the 19th century. Climate change in Europe has led to more favorable weather conditions for *P. infestans*. Once it takes root, it may destroy the entire canopy of a potato crop within 10–15 days, resulting in total yield losses, unless there are numerous fungicide treatments in conventional agriculture. In organic agriculture, *P. infestans* is treated with copper as a natural fungicide, which also has a negative impact on soil health. There may be preventive measures such as the use of healthy seed potatoes, the removal of volunteer potatoes from the previous year and the adoption of more sustainable agricultural management practices. Yet, there is a strong need for more pathogen-resistant varieties with wide market acceptance to significantly reduce the use of copper and synthetic fungicides

Environmental Challenges in the Potato Value Chain

Food waste across the value chain and how it is reused

According to the Swiss Federal Office of the Environment around 46% of the potatoes grown in Switzerland end up as waste somewhere in the value chain. 70% of it occurs in the course of harvesting, trading and processing of potato. Potatoes are declassified when the shape, look or quality does not conform with required standards. A big share of declassified potatoes is then still used to produce half-finished and pre-packaged Röstli or Stockli (Instant mashed potato).

Swisspatat Perspective

Interview with Christian Bucher,
Managing Director of Swisspatat, the industry organization for Swiss potatoes, representing producers, trade and processing. The Interview was carried out on September 2, 2024.

Question: Where do you see the major challenges of Swiss potato farming?

CB: Potato farmers face an increase in biotic and abiotic stress factors due to weather conditions that are either too dry or too wet for potato cultivation. At the same time, there is a growing regulatory pressure to reduce the use of plant protection products (PPP). But Swiss potato farmers must cope with the impact of climate change and one of the alternatives to pesticides and fungicides are more resistant varieties. In a recent research project we were able to show that the use of PPP can be reduced by up to 75% with more robust varieties. In a target agreement with the Swiss Federal Office of Agriculture we aim to substantially increase the area grown with resistant varieties. However adoption rates are still low because potatoes must have many other traits that make them commercially attractive. Some of them may get lost in the breeding process. Moreover, there is a need for multiple resistance, which is currently not available.

Question: Do you see a potential of new breeding techniques in overcoming the low rate of adoption?

CB: Swisspatat is open to the use of new breeding techniques, including CRISPR-Cas9, if it helps to render potato farming to become more competitive and environmentally friendly. We would welcome a constructive public debate in Switzerland on the subject.

Biotechnological processes may have a great potential to further re-use declassified potato. For example, extraction and bioconversion processes make it possible to use significant amounts of valuable components in potato starch and peel as ingredients in health products as well as in instant and convenience food. In addition, fermentation of processed potatoes can be used in a variety of ways as substitute of petrochemical products, including as adsorbents, bio-composites, and biodegradable packaging materials. Even though the share of recycled waste potatoes that end up in value-added products is increasing, there are still significant business constraints in Switzerland such as regulatory barriers, high investment costs and the lack of willingness of customers to pay for products that contribute to the circular economy, according to a study by EBP Schweiz on behalf of the the Swiss Federal Office of the Environment.

Upstream Challenges

Potato is one of the crops in Switzerland that requires intensive care to deal with the growing biotic and abiotic stress factors due to climate change. The year 2024 was challenging because heavy rains provided a fertile ground pest and disease infestation and nutrient deficiency. Many farmers were able to reduce the risk of crop failure thanks to far-sighted agro-ecological practices (e.g. holistic nutrient supply throughout the entire crop rotation) but also more investment in agricultural inputs designed to protect the crop and supply the soil with sufficient nutrients. The problem for farmers is that these increasing labor and capital costs are not completely taking into account in the target price for 100kg of potatoes since they are based on mere overall output estimations.

Potato plants are grown as identical clones from tissue culture under laboratory conditions. The result are tiny seedlings or microtubers, the “basic material”. Pre-basic seed potatoes are then grown in the field by certified farmers under highly controlled conditions. The main purpose is to produce seed potatoes that are free of pest and disease infestation. Swiss farmers would have to produce around 25000 Mt of seed potatoes to cover the demand from domestic potato growers. However, more difficult weather conditions have led to a lower domestic supply and a higher dependence of imports (9000 Mt in 2024). Since neighboring countries face equal challenges, it has become challenging to produce seed potatoes in Europe.

Downstream Challenges

Between 50% and 60% of fresh potatoes in Switzerland that are designed for domestic human consumption are processed to create products such as frozen French fries, chips, dehydrated potato products (including flour, dried potatoes, granules, flakes, and meal), canned potatoes, and chilled-peeled potatoes. Processing techniques apply heat, such as boiling, baking and frying to break down the starch into more easily digestible forms. Overall, demand for these convenience food products is growing. The main environmental challenge of potato processing is the large energy consumption. It entails multiple energy-intensive water-demanding processing steps such as washing, (steam) peeling, water-propelled cutting and blanching. Industrial blanching accounts for the largest share of energy and produces a significant amount of waste water. It is a heat treatment

Swisspatat Perspective (continued)

Question: Potato is considered to be an important crop to ensure food security and enjoys a good image with health conscious consumers due to its nutrient rich content. At the same time, many of the highly processed products, such as chips, french fries are associated with unhealthy consumption and life styles. How do you deal with mixed health record?

CB: Potatoes are a healthy, versatile food that is suitable for almost all diets. However, depending on how they are prepared, the nutritional and physiological benefits of potatoes may be reduced. The increasing share of processed potato products primarily reflects society's need for easy-to-prepare food. Such products are not necessarily unhealthy if prepared properly. In addition to the nutritional benefits, potatoes have another advantage: they can be produced with a relatively low carbon footprint.

Question: How popular is organic potato production?

CB: The share of certified organic producers in Switzerland has not increased beyond 12% of the surface. This is due to the fact that production costs are substantially higher while the willingness of consumers to pay for the premium price for organic continues to be relatively low. Moreover, wet years like 2024 show how difficult organic potato production is because the use of PPP is more restricted and only a few robust varieties are available. More resistant varieties could make organic production easier.



where the washed, peeled and cut potato products are immersed in hot water or exposed to steam for a certain period. The resulting waste water is highly loaded with both organic matter and dissolved ions leached from the potatoes, making the water challenging to treat. However, a combination of increasingly stringent water management regulations, technologies with lower energy consumption, and closed loops for processing water in the potato business industry has helped improve the environmental footprint of potato processing companies that have adopted the new technologies to save and recycle water in more energy efficient ways.

Processed potato products in all forms are sold in small packaged items in the retail industry, which generates a lot of waste. Some of the packaging may be inevitable for food safety reasons and helps to directly or indirectly to reduce food waste, but there is often a lot of superfluous packaging that is not necessary. Moreover, the type of package material matters when determining its environmental impact. Regulatory pressure has already induced some companies to improve packaging management systems, reduce plastic packaging and prevent food waste by taking eco-design approaches and using environmentally friendly packaging and materials. As for bags for ware potatoes, Cardboard and paper has become a de-facto standard in Switzerland.

Swiss regulatory environment

The role of direct payments

The federal government ensures that potato production in Switzerland remains relatively attractive with direct payments and a contribution to overhead costs per farm – even though there is hardly any specific support for potato production. A requirement for obtaining the direct payments is the proof of ecological performance called ÖLN (ökologischer Leistungsnachweis). It is primary about compliance with required measures to promote sustainable agriculture. However, it remains unclear to what extent compliance with these regulations actually makes the respective farm more sustainable.

Import protection

The federal government protects the relatively high price level of Swiss potato through border protection. Imports are mostly within the tariff quota of 23,750 tons, which is divided into four sub-tariff quotas (seed, processing and table potatoes, as well as potato products). In the event of a good harvest, swisspatat has the possibility to declassify part of the production for fresh feeding and pay contributions to the producers – covered by the association itself. If weather conditions prevent the production of sufficient potatoes in terms of quantity and quality, swisspatat can submit an application to the Swiss Federal Office of Agriculture for a temporary increase in the partial tariff quotas.

In view of the fact that the average income from pure arable farming is lower despite import protection and direct payments, there are a relatively large number of mixed farms that also include livestock. Otherwise, farmers without livestock have the option to generate additional income through off-farm employment opportunities.

Swisspatat Perspective (continued)

Question: Potato farmers benefit in Switzerland from import protection and direct payments. Would Swiss potato farming be economically viable without this support?

CB: Import protection is definitely very important. It ensures a relative price stability and a decent farm income from sales. Without this instrument and without direct payments, Swiss potato production would not be competitive due to high production costs. Disadvantages of these instruments include, for example, the high amount of bureaucracy and the low level of land mobility. The latter means that smaller and less competitive farms are not willing to lease their land to other, more competitive farms.

Question: Currently farmers need to declare what kind of inputs they use to ensure environmental sustainability (ÖLN)? Would concrete output-based scores a more effective way to improve farm sustainability performance?

CB: Output-based scores would indeed lead to less paperwork, but they may also have a negative impact for some negative farmers. Swisspatat has taken a first step towards output-oriented targets by adopting a target agreement with the federal government regarding robust varieties.

Where do you see the opportunities and challenges of introducing a 'True Cost of Food' approach in the potato industry?

We have not yet discussed this concept widely within our association. But the pressure to reduce the carbon footprint, increase of biodiversity, etc. is increasing for the farmers. The true costs of food could help to provide an understanding of the actual (production) costs and increasing the willingness of consumers to share in these costs.

Labels for Swiss produce and sustainability

Since 2005, potatoes have been awarded the guarantee mark Suisse Garantie. Suisse Garantie distinguishes Switzerland as the country of origin and processing, sets clear requirements for production and processing, and ensures a seamless, independent control and certification system. In addition, the Swiss Federal Office of Agriculture supports farms that comply with additional environmental standards such as IP-Suisse and organic production Bio-Suisse.

Assessing the True Cost of Food of Potato Production Systems

At first glance, the external health, social and environmental costs of potato production in Switzerland may be comparatively low compared to potato produced abroad or livestock production in Switzerland. The Swiss federal government therefore promotes plant-based crops such as potato in its 'Klimastrategie Landwirtschaft und Ernährung 2050' (climate strategy for food and agriculture). But assessing the concrete environmental footprint of a potato farm is not easy because the large majority of farms who grow potato are mixed farms that also include livestock management. Generally, mixed farm systems may indeed be more sustainable because of crop-rotation and integrated crop-livestock systems that limit external nutrients by using farm-based manure and by feeding declassified potato to animals. It is also not clear, whether the external environmental costs generated by farms that specialize on the sale of certified organic potato are indeed lower compared to farms that follow IP Suisse standards. An assessment of the development of the application of fungicides and insecticides over the past decade portrayed in the Agrarbericht 2025 shows that the use of fungicides has been reduced in potato farming despite the problem with P. Infestations. However, the use of copper as a natural fungicide, which is also permitted in organic agriculture has increased. Insecticide applications in potato cultivation have been strongly fluctuating over the same period of time in response to more challenging weather conditions. More pest- and fungus resistant varieties that meet market requirements may therefore matter more to reduce external environmental costs than the promotion of organic farming.

Energy and water consumption as well as the waste production in the downstream part of the value chain generate external costs that are more relevant compared to upstream challenges in the value chain such as the growing dependence on imported seed potato and imported input products. Actors involved in the downstream part of the potato value chain are however committed to reduce their footprint through numerous innovations in technology and management.

Assessing external health cost of potato

Potato is an important and nutritious food crop and increasing its productivity and affordability would definitely be a significant contribution to food security and the global fight against malnutrition. This could be considered a positive external benefit. However, the trend in potato consumption is shifting from the consumption of healthy ware potato to less healthy processed potato due to the trend toward convenience food.

Swisspatat Perspective (continued)

Question: Is it possible to capture the environmental and social footprint of potato producers considering that potato is always part of a mixed farming system?

CB: That is indeed a challenge. Though there is a trend toward specialization, crop rotation systems combined with livestock management are still the rule and they also make sense from an environmental point of view. It is challenging to capture each crop and livestock footprint separately. Output-oriented scores capturing the overall footprint of a farm in terms of energy and water use, emissions, organic waste re-use, soil health and biodiversity may be a more accurate and less bureaucratic way to capture the footprint of the whole farm system. Nevertheless, as an industry we also depend on having specific data just for potatoes, so that we have the appropriate basis for decision-making.

Question: Swiss Agricultural Policy 2050 envisions to enhance the share of plant-based food in Swiss agriculture. Will that make it more attractive in future for farmers to grow potato despite the fact that it is a fungible commodity with low margins?

CB: The focus on enhancing the share of plant-based food is a positive signal for the potato industry. Today, the demand for Swiss potatoes is greater than the supply. The low supply is related to the growing costs of cultivating potato, especially due to many climate change-related risks that need to be kept under control. Another issue is the use of plant protection which is getting more and more difficult and costly. If Swiss Agricultural Policy 2050 can create better conditions in these areas, potato production can grow again in the future.

Processed potato products such as French fries and chips are considered to be a risk for health life styles and criticized foits high glycemic index and the acrylamid content. Companies have invested however in reducing the unhealthy content and the elimination of acrylamide.

Overall, a product-based assessment of the True Cost of Potato production and processing seems to be impossible without taking the respective context into consideration.

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Consumption, Production and Historical Importance of Potato in Switzerland and abroad

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Ecological Challenges of Potato Production in Switzerland

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economic and environmental challenges in the potato value chain

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