DOSSIER

Sustainability and quality of organic food

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Sustainability and quality are linked

Is quality one aspect of sustainability or is quality an all-encompassing term? This dossier provides a contemporary, holistic concept for the assessment of food quality and highlights the differences between organic and conventional food based on selected aspects of sustainability and various examples.

The expectations regarding organic food are high: organic food should be pesticide-free, tasty and healthy, and be processed in an environmentally friendly and socially responsible way. Animal welfare and site- and species-specific husbandry, as well as the prohibition of synthetic pesticides, mineral fertilisers, genetic engineering and synthetic ingredients in organic farming should be reflected in the quality of organic food.

These expectations make it clear that the quality of food cannot be reduced to just the individual characteristics of the product, but must include the entire process from the field to the plate. Therefore, in today's understanding of the term, food quality includes not only regional added value, quality assurance, fair trade and sustainability, but also energy consumption and production and processing techniques. Quality and sustainability are closely intertwined.

The figure below shows how the aspects of sustainability and quality overlap. Health acts as a link between society, economy and ecology – the traditional pillars of sustainability.

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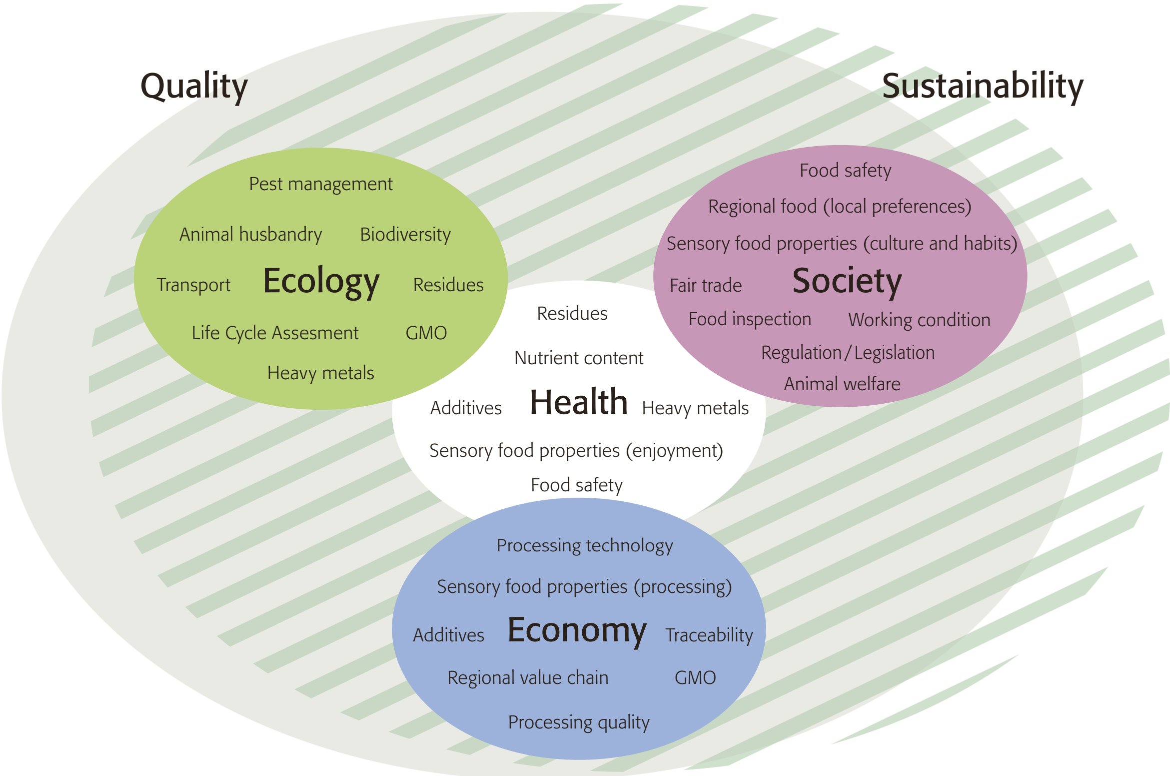
Quality considered as a result of sustainable production and life



The concept of sustainability includes not only environmental, but also social and economic criteria. To assess the quality of food, the aspect of health is added. Health is also fundamentally anchored in the Principles of Organic Agriculture, laid down by IFOAM (see box on page 3). The combination of these criteria allows a complex and in-depth evaluation of food.

Is organic food better?

The production of organic food is, in many ways, fundamentally different from the production of conventional food. With its principles, the organic movement is trying to satisfy all aspects of sustainability (see Principles of IFOAM, International Federation of Organic Agriculture Movements). This suggests that we should look for a sustainable diet based on regional, seasonal, eco-friendly and socially-sound food (in terms of production, processing and trading); our wellbeing is affected not only by our eating habits, but also by the way our food is produced.

In nutrition and health research, the evaluation of food is often based on the content levels of selected, positively-rated substances. Is organic food distinguished by higher levels of these substances? At least for some of these positively-rated substances, organic food seems to show higher levels than conventional food (see pages 4 and 5). Whether individual differences such as the higher content of phytochemicals and omega-3 fatty acids significantly improve human health is still debated.

Large-scale studies in France and Germany show that consumers of sustainable organic food are healthier[1, 2]. Does this make organic food generally healthier than conventional food, or do organic consumers simply live a healthier lifestyle? Presumably, organic food contributes to a healthy lifestyle, which respects society and nature.

The principles of organic agriculture

The principles defined by the International Federation of Organic Agriculture Movements, IFOAM [3] form the basis for the production of organic food.

IFOAM principles

Principle of Health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

Principle of Ecology

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

Principle of Fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

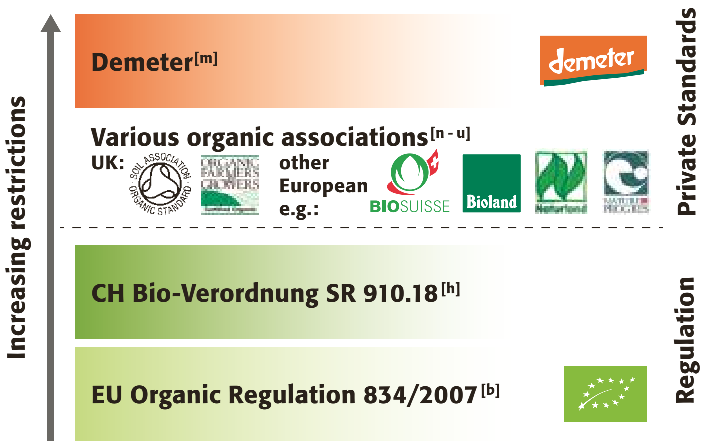
Principle of Care

Organic Agriculture is to be managed in a precautionary and responsible manner to protect the health and wellbeing of current and future generations and the environment.

Public and private regulations and standards

Current organic legislation builds on European and national regulations. Before these came into force in 1991 [a], with a complete revision in 2007, several private standards already existed in various countries, such as those of the Demeter co-operative formed in Germany in 1928 (leading to Demeter International [m]), followed by the Soil Association [n] and Organic Farmers & Growers (OF&G)[o] in the UK, Bioland [p] and Naturland [q] in Germany, Nature & Progrès and Biocohérence in France [r, s], Bio Austria [t] in Austria and Bio Suisse [u] in Switzerland. Global standards were prepared by IFOAM [l].
Since the adoption of the Regulation that protects the term "organic" for food in Europe in 1991, it has formed the legal basis for all organic products. Private standards may impose further conditions on top of those in the Regulation. Sometimes this results in significant differences in the requirements for the production and processing of food under the EU Regulation and under various national private standards.

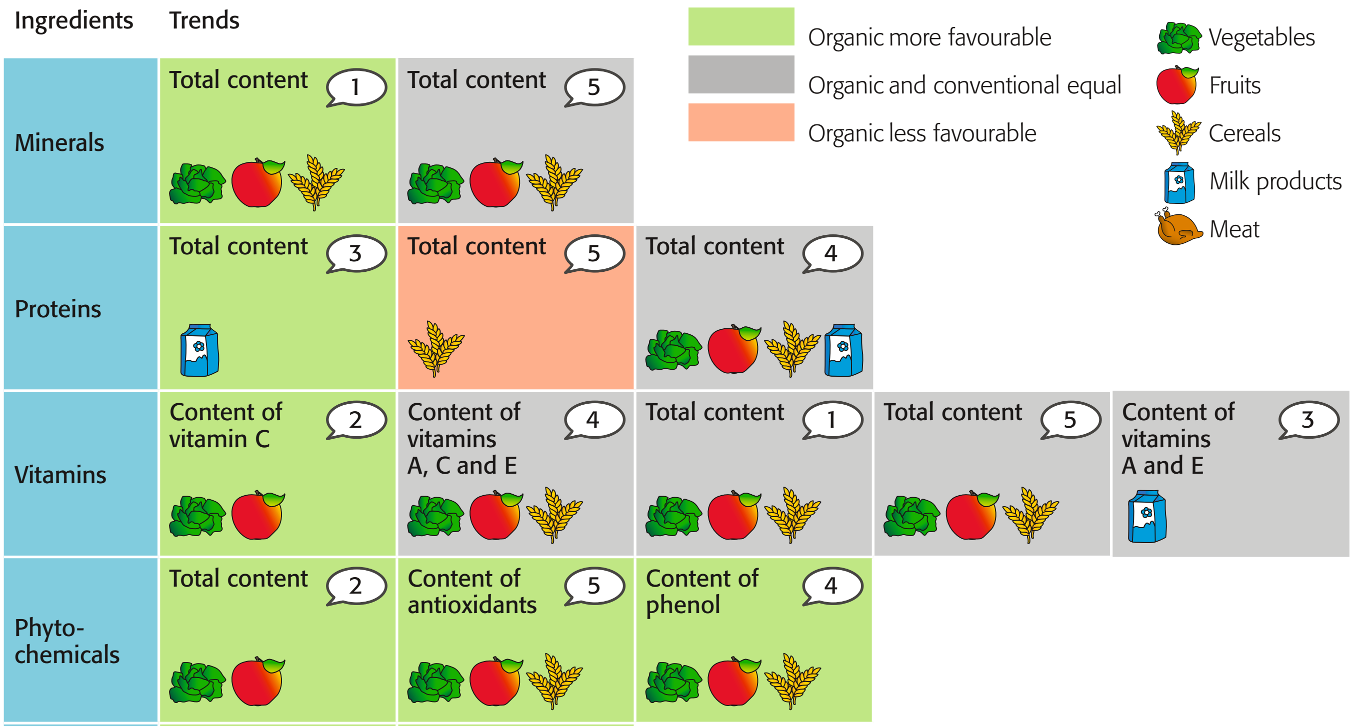
Organic legislation, ordered by the stringency of regulations/ restrictions

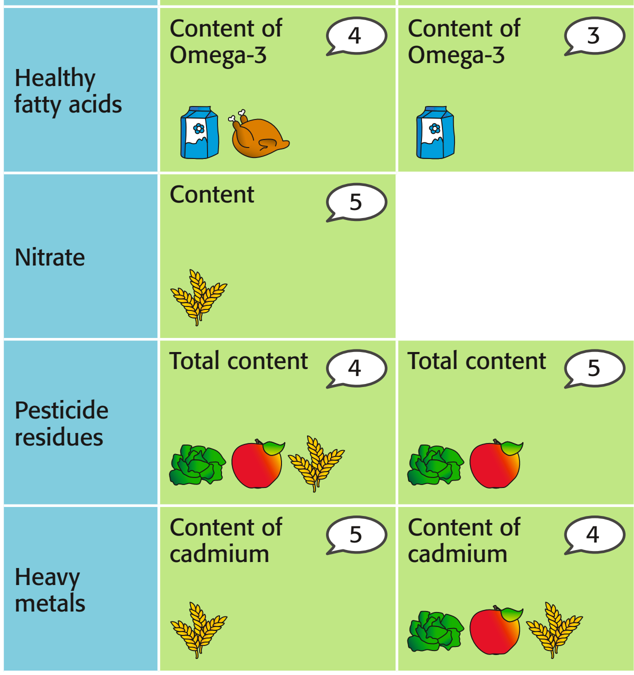


What does the science say?

Scientific studies on the quality of food are mainly based on the comparison of the content levels of individual substances. This approach makes the assessment of food easier for scientists and is accepted by the majority of experts. However, this approach cannot meet the requirements of a holistic assessment. In addition to individual studies focusing on selected foods and ingredients, meta-analyses, which summarise and combine the results of individual studies and draw overall conclusions, are also published in international scientific journals. This double page shows results from the most recent meta-analyses.

Trends from the comparison of organic and conventional food (literature studies since 2011)





The most recent meta-analyses come to the same conclusion: that organic food differs in many ways from conventional food, and usually comes off better. From a scientific perspective, however, it is difficult to base a conclusive assessment on individual criteria, as too many other factors are usually involved. For example, it cannot be generalised that the protein content of organic food is higher than that of conventional food; because, although it is higher in organic milk, in organic cereals it is often lower than in conventional ones. In addition, original studies usually only investigate varying selections of different vitamins, minerals and plant metabolites, which makes it difficult to generalise a statement for all of these components.

The situation is different for value-reducing substances such as nitrate, pesticides or heavy metal contents, where organic food generally performs better.

1

Hunter (2011) [4]

This study analysed the differences in the levels of vitamins and minerals in organic and conventionally produced foods of plant origin.

2

Brandt (2011) [5]

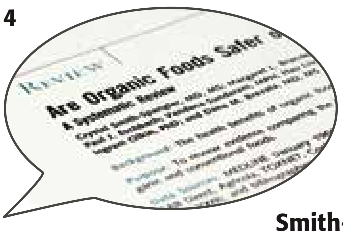
The study examined the effect of various organic and non-organic farming practices on the content of health-related phytochemicals in fruits and vegetables.

3

Palupi (2012) [6]

The authors determined the nutritional quality of organic and non-organic milk products based on various individual studies of specific vitamins, fatty acids and proteins.

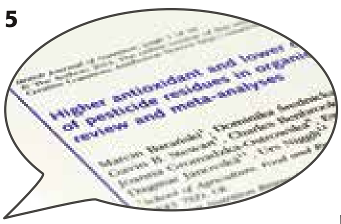
4



Smith-Spangler (2012) [7]

The authors evaluated over 200 individual studies to assess whether organic food is healthier than non-organic.

5



Baranski (2014) [8]

This meta-analysis assessed the results of 343 individual studies for significant differences in the content of key substances in organic and non-organic fruits, vegetables and cereals.

The increasing refinement of laboratory analysis methods allows a more sophisticated analysis of food.

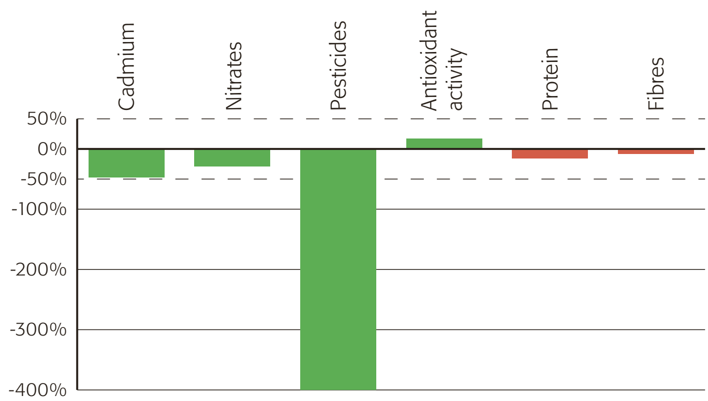
Newest conclusions based on the Baranski study [8]

The evaluation of well over 300 comparative studies in 2014 [8] revealed an increase of up to 69 % in the content of certain antioxidants like polyphenols in organic crops. Antioxidants could have a positive impact on health [9].

Clear differences are also found in the contamination levels from the environment. Organically grown crops contain four times less pesticide residue, and significantly lower levels of the toxic heavy metal cadmium.

The drawback is that because of the lower nitrogen supply of organic wheat, it has a lower protein content than conventional wheat and thus a lower content of gluten, which is important for industrial bread making (more on pages 8 and 9). Organic grains contain less dietary fibre, which contributes to good digestion. In general, however, the organically produced cereals, fruits and vegetables studied in this meta-analysis showed better results than conventional ones.

Difference between organic and conventional food with regard to selected contents and pesticides [8]



The picture shows six selected differences between organic and conventional cereals, fruits and vegetables from the Baranski study. The green bars represent positive results from the viewpoint of organic farming, the red bars the negative results. The antioxidant activity summarises the effect of all antioxidants together.

Fruit and vegetables

Fruit and vegetables are important for a healthy diet. They provide many essential vitamins and minerals, fibre and valuable plant metabolites. The production of most fruits and vegetables requires much care. Frequent use of crop protection products in conventional farming carries the risk of residues being left on the produce. Organic fruit and vegetables should not be treated with chemically synthesised pesticides and fertilisers and they are therefore significantly lower in various residues. The problem of unwanted residues is described in the following section, using fruit and vegetables as an example.

Significantly lower pesticide residues in organic fresh products

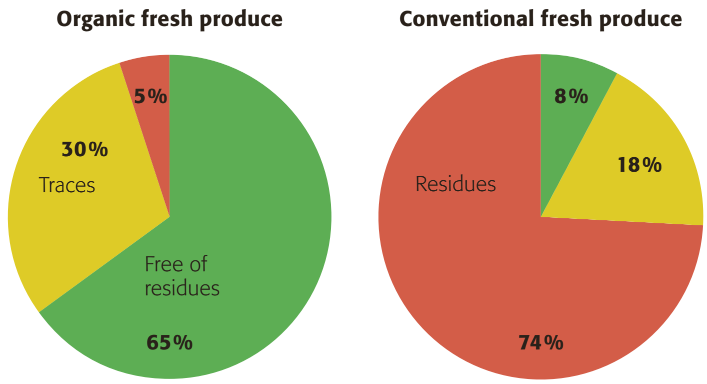
Some vegetables are very susceptible to pests and diseases. An infestation can reduce the yield, result in lower quality (e.g. scab on apples) and reduce the shelf life of the product. Today, a visible disease or pest infestation on food will not be tolerated by most consumers, resulting in intensive pesticide use for many fruit and vegetable crops in conventional farming systems. Currently, largely similar requirements for external quality apply to conventional and organic food, which places high demands on organic farmers and growers.

In organic farming, pests and diseases are managed primarily through preventative measures. Thus, for example, strips with flowering plants are sown alongside cabbage fields (see Picture below). These flowers attract beneficial insects, which in turn parasitise pests. One example is the control of cabbage whitefly with braconid wasps. Direct plant protection measures should only be used in cases where the preventative measures aren't sufficient to meet the high requirements for external food quality.

Due to the intensive use of pesticides, conventional fruits and vegetables are often contaminated with pesticide residues. However, with today's sensitive analytical methods, traces of pesticides can also be detected in organic food.

According to recently published comparative studies, organic food contains significantly lower amounts of pesticide residues than conventional food (see figure on the left). If residues are found in organic food, these are – in contrast to the case for conventional food – usually at trace levels below 0.01 mg / kg. For a period of 10 years, the Organic Monitoring Agency of the German region Baden-Württemberg has found 180-times lower pesticide contamination in organic fruits and vegetables than in comparable conventional food [11].

Pesticide residues on organic and conventional fruits and vegetables



In 2013, a survey of 253 organic and 1803 conventional samples of fruits and vegetables in the German region of Baden-Württemberg [10] revealed large differences in the levels of pesticide residues. While only a small percentage of organic produce showed more than 0.01 mg pesticides per kg of crop, three-quarters of conventionally produced fruit and vegetables were significantly contaminated.

The sowing of wildflower strips along vegetable fields promotes the development of beneficial insects. Beneficial insects help reduce the pest pressure in organic crops, but are negatively affected by pesticides in conventional fields.

A large-scale study in Europe has confirmed that residues are significantly less likely to be found in organic fresh produce, and then only in smaller quantities than in conventional products [12].

How can synthetic pesticides get into organic food?
On rare occasions, residues of synthetic pesticides are found in organic food. These can occur through deliberate, unauthorised use of synthetic pesticides during cultivation or storage of food. In such cases, pesticide residues on crops and food products are usually significantly higher than 0.01 mg / kg.

Residues at trace levels are generally not the result of intentional applications, but are the consequence of drift of spray from neighbouring conventionally farmed fields; or carryover in storage, processing or packing plants (among other possible causes). Such impurities are not in the interest of organic farmers and farmer organisations, and they do their best to avoid such contamination.

Drift of pesticide spray poses a major challenge for organic farmers, especially in growing areas with small field sizes.

How does the law deal with contaminated organic products?
The organic regulation prohibits only the use of synthetic-chemical pesticides. It does not specifically address residues which enter the organic food chain unintentionally. It is therefore down to the national governments, food-control agencies and organic control bodies to analyse and withdraw contaminated food from the market.

Some organisations, including the European Organic Certifiers Council (EOCC), as well as the German Umbrella Association of Natural Food and Products (BNN) and the Swiss Bio Suisse have developed an evaluation framework for the implementation of a process-orientated quality assurance system for organic farming. The aim of this quality assurance system is not primarily to evaluate whether a product should be withdrawn from the market, but to establish the causes of contamination and to prevent future cases of residue contamination. The primary questions are whether the pesticide has been used intentionally; whether contamination was caused by improper handling; or whether the contamination was inevitable and occurred through no one's fault in particular. The implementation of this process-orientated approach has revealed and eliminated several residue cases in the past.

The example of preservatives on organic lemons
The use of preservatives for organic fruits is not allowed. How is it possible then, that traces of synthetic-chemical preservatives are sometimes found on organic citrus fruits?

The peel of conventional citrus fruits is often treated with preservatives to increase storage and shelf life. Treated peel can pose significant health risks and should therefore not be consumed.

The most common cause of contamination of organic fruit is the transfer of preservatives from different machine parts (e. g. brushes) during packing. If organic fruits are run through the same packing plant straight after conventional batches, without thorough cleaning of the installation and changing the brushes, the organic fruits can get contaminated.

Since this contamination route is known, it can be avoided by optimising the processes in packaging and processing plants. For this reason, the number of contamination cases has declined significantly in recent years.

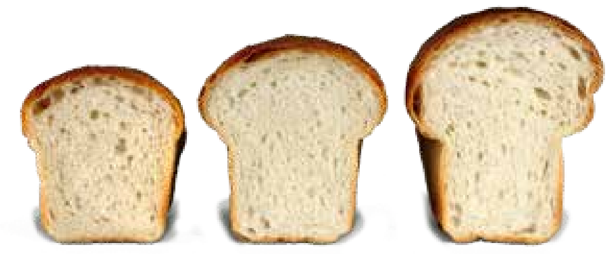
To avoid contamination, strict procedures must be followed if the same processing or packaging equipment is used for organic and for conventional food.

Field crops

Cereals, oilseed rape and potatoes – like most other field crops – are mainly grown in large areas. Along with maize, primarily grown for animal feed, they shape our cultural landscape in lower altitudes across Europe. The general prohibition on the use of synthetic pesticides and mineral fertilisers often poses high demands on cultivation techniques in organic arable systems. Also ensuring a GMO-free organic production is increasingly proving to be a very difficult task, and can generally not be 100 % guaranteed.

Lower protein content in wheat

In our latitudes, organic production approaches have a reputation for providing poor baking quality wheat. Protein quality and protein content of grain are important factors for the baking quality and volume of wheat bread [13]. The gluten-protein is important for the dough structure and thus also for the structure of bread.



Bread made from flour with 20%, 30% and 40% wet gluten content. The higher the wet gluten content, the better the dough rises during baking.

High quality, strong fluctuations
The study of more than 500 organic wheat samples from 2010-2013 shows that the gluten content of Swiss organic wheat is indeed very high, but is subject to large annual fluctuations. These changes are, to a certain extent attributed to the variety and choice of location, but primarily to the weather conditions. The latter have a decisive influence on the mineralization of slurry and manure, on the availability of nitrogen and thus to the development of gluten in the wheat grain. The enhancement of soil fertility improves the natural availability of nitrogen and can mitigate the influence of the weather. But even with the best organic practice, farmers can only partly affect the development of gluten. Therefore, a certain loss in quality of organic wheat needs to be taken into account.

Compensation for lower protein content with a modified dough production technique
If, for example, sourdough is used instead of yeast for the production of bread, and if the baking technique is adapted to the gluten content, high quality bread can be produced using Central European organic wheat. Imported organic wheat, which has a higher gluten content, can be mixed-in for the industrial production of organic yeast bread. Furthermore, isolated gluten can be added to the dough; however, this is quite expensive.

No genetic engineering in organic agriculture

The use of genetically modified organisms (GMOs) is banned in organic farming worldwide. Breeding techniques that isolate genes from bacteria, viruses, plants, animals and humans; which are then transferred to plants or animals and controlled and patented, are incompatible with the basic principles of organic farming [3].

The nitrogen fertilisation method has a direct influence on the gluten content of wheat and thus on its baking properties.

So far, the DNA (deoxyribonucleic acid) of maize, soybean, oilseed rape and cotton varieties (and to a lesser extent also sugar beet, alfalfa and papaya) in particular, has been modified for industrial cultivation [14]. The resulting GM varieties are resistant to herbicides and/or produce a lethal effect on insects that feed on the plants. These crops are grown primarily in North and South America, and are traded internationally.

Today, many producers who have grown herbicide-tolerant crops for several years need to use higher amounts of herbicides to control weeds [15]. In fields of GM maize or cotton, which should be protected against pests thanks to the GMOs, formerly unimportant pests multiply at significant rates. Some cases of pests resistant to the GMOs have already appeared in Africa and India [16].

The seed trade is controlled by a small number of multinational companies. They use special sales contracts to prevent these expensive seeds from being grown, bred and propagated by farmers or used for research.

That agriculture is also successful without these new breeding technologies is shown by a recent article in the prestigious journal Nature: Drought tolerant, conventional maize produced using traditional breeding techniques generates a higher income for African farmers than the cultivation of GM crops [17].

Between control and co-existence

Avoiding GMO contamination in growing and processing is a Herculean task and cannot always be fully achieved. In organic farming, there is a risk that insects and wind carry the pollen of genetically modified crops into organic crops of the same family. This is especially difficult for the breeding and propagation of organic seed. Studies show that contaminated seed is a relevant source of GMO traces in organic food [18].

If GM crops are cultivated in a region where organic farming is also present, extensive and costly control measures are necessary. Organic farmers are advised to keep a safe distance from GM crops, and to inform and organise

To avoid GMO contamination, organic products must be strictly separated from GMO products, from field to fork. If GMO residues are detected in organic food, the added value of organic production is destroyed.

themselves accordingly. This increases the costs of organic production [19]. GMO contamination of organic food cannot be completely prevented since bees are known to fly several miles, local wind conditions are often very different and contamination during harvest, transport or processing can occur. The coexistence of GMO and organic farming is not possible in small-scale agriculture and structured landscapes.

Exclusion of genetic engineering in processing

According to the EU Regulation on organic agriculture, the ban on GMOs applies not only to crops, but also to animals and microorganisms, as well as food additives, feed, fertilisers and pesticides.

In order to avoid GMO contamination, organic food processing uses lecithin (a widely used emulsifier) derived from sunflower seeds instead of soy lecithin. Also preserving acids produced by GMOs, such as citric acid, cannot be used in organic food processing. The same applies for cultures of microorganisms for the production of yogurt, cheese and sausages.

The example of the corn borer: targeted solution versus system approach

In contrast to the GMO strategy, organic farming uses a variety of measures for plant protection.

Animal products

Organic farming places great emphasis on the species- and site-specific production of animal products. The goal is the optimal, not maximal, performance of the animals. The prudent way in which organic farmers keep animals, care for and feed them is also reflected in a noticeably better quality of animal products.

Controversial food products

Today, food of animal origin dominates the human diet in developed countries, and increasingly also in emerging markets. This trend is ecologically questionable, since it requires millions of tonnes of cereals and soybeans to be used as animal feed, in order to improve the performance of dairy cows and as complete feed for pigs and poultry. Currently, a third of the cereals produced worldwide are used as animal feed [20]. The feeding of cereals and grain legumes to livestock is thus in direct competition with human consumption. Valuable food for humans is "devalued", because the production of one calorie of food of animal origin requires a lot more energy in comparison to the production of one calorie of food of plant origin. Should we therefore stop consuming animal products, and stop keeping animals on agricultural land which is unsuitable for arable or horticultural production?

Food of animal origin is an excellent source of protein and contains important vitamins and trace elements as well. The essential vitamin B12 is found exclusively in animal derived food products, and must be taken as a supplement by vegans. A vegan or vegetarian lifestyle raises a number of questions; for example, how can we produce fertiliser for crops, or with regard to animals that are bred for the production of milk or eggs, should these be fed until their natural death?

High animal welfare

Animal welfare has a high priority in organic agriculture. Livestock held on organic farms should be able to perform natural behaviours without restriction. The animals need, among other requirements, enough space, different functional areas in the barn, daily access to pasture and must be housed in groups of a reasonable size [c, i]. In contrast to conventional agriculture, where poultry houses with up to 20,000 chickens are allowed, the EU regulation for organic agriculture only allows a maximum of 3,000 laying hens per house. Some organisations may have even stricter regulations; such as for example, the private standards of the Soil Association or the OF&G Partnership Programme, which only allow 2,000 laying hens per poultry house.

Organic farms focus on optimal not maximum performance, and animals are given time to grow and develop naturally. Preventative use of antibiotics or the use of growth hormones are therefore prohibited. If an animal is ill, effective natural healing methods are preferred. The treatment of sick animals with antibiotics is permitted under prescription from a veterinarian, to avoid suffering or permanent injury of the animal; but withdrawal periods for organic animal products are twice as long as for conventional ones to avoid residues in food.

Better food quality through good stockmanship

A good relationship between farmers and their livestock is valuable in many ways: if the relationship is good, contact between humans and livestock causes less stress for all involved parties. A stress-free relationship can be achieved by regular positive contact with the animals. This includes friendly, quiet words and, above all, friendly touches like stroking, petting or using the TTouch® method developed by Linda Tellington. Loud, excited words and painful contacts are counterproductive.

Good stockmanship can have a lasting positive impact on the welfare of livestock, their health, their relationship with people and the quality of their products.

The relationship between humans and animals affects the behaviour of the animals and also the quality of animal products derived from them. If young cattle are accustomed to a positive human-animal relationship, they are more trusting towards new people and show fewer stress responses [21]. Blood tests taken in the slaughterhouse show lower cortisol levels, and the meat is more tender than that of animals not accustomed to positive human-animal relationships. Studies with dairy cows showed that more udder infections (mastitis) occurred in herds with a poor human-animal relationship [22, 23]. This is reflected, among other factors, in increased cell counts in the milk. The average cell count was higher when the farmer aggressively drove the animals into the milking parlour; and significantly lower where levels of stockmanship were high.

The dual-purpose chicken – a more ethical compromise?

The breeding of chickens has so far focused on two types: the laying hen with high egg-laying performance, and broilers with very fast body and muscle growth. The male chicks of laying hens grow much too slowly for poultry meat production and are therefore killed immediately after birth. Millions of male chicks are killed annually in the UK. This unnecessary and unnatural killing is unethical and contrary to the principles of organic farming.

Two alternatives are currently being explored: (1) dual-purpose chicken breeds, which are as highly rated for their fattening performance as for their egg production, and (2) the fattening of the brothers of laying hens. However, neither of the approaches can so far compete with common practice in terms of economics. The fattening of the cocks of dual-purpose chickens requires 50 % more time than the fattenig of broilers, and their hens lay nearly 20 % fewer eggs per year as the high performance laying breeds do [25]. If the brothers of the high performance laying hens are fattened, they grow even more slowly than the dual-purpose chickens, as they are unable to efficiently transform feed into meat. Additionally, due to their small size, they usually do not fit into the automated slaughterhouse processors and need to be slaughtered manually [26,27]. These alternatives are currently being developed by some organic farmers and by research institutes, so that they can be more widely adopted by organic producers in the future.

After one month, the broiler substantially outperforms the young laying hen with regard to body weight. Both breeds have been bred for extreme performance in one specialised area (meat production or egg production).

Aiming for sustainable feeding strategies

In organic animal husbandry much attention is also paid to the feeding of livestock. The basis for a healthy animal is a species-appropriate diet. The feed is required to be produced mainly on the farm where the animals live. For ruminants, a maximum of 40 % of concentrates (cereals and grain legumes) can be fed. In order to improve the sustainability of modern animal production, organic farming aims to further reduce the use of concentrates in ruminant feed and to promote the domestic production of grain legumes to feed organic pigs and poultry.

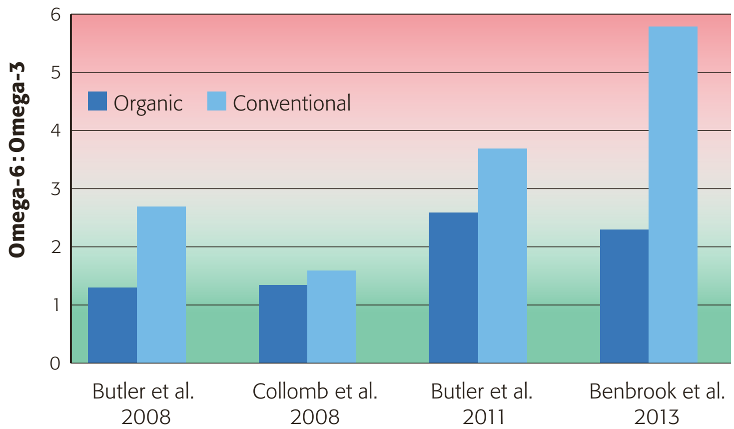
No animal products have been allowed as livestock feed in the EU since the BSE (bovine spongiform encephalopathy) scandal. For omnivorous pigs and poultry however, animal proteins would be useful. Therefore, a study by FiBL analysed the production of protein feed from insect larvae. This could replace some of the imported soybeans in the future. However, so far insects have not been approved as an organic animal feed.

Better fat composition in milk

Dairy products are an important source of protein in many regions of the world; they are also an important source of calcium, fat-soluble vitamins A, D, E and K, and the water-soluble vitamin B2. Milk fat contains a high proportion of saturated fatty acids [28]. Furthermore, it contains mono-unsaturated fatty acids and a low proportion of polyunsaturated fatty acids such as omega-3 and omega-6.

The ratio of omega-6 to omega-3 fatty acids is critical for human nutrition [29, 30]. The consumption of milk (or milk products) with a ratio below 2 can reduce the risk of type II diabetes and coronary heart disease [31]. The ratio of the main representatives of the omega-3 and omega-6 family (alpha-linoleic acid and linoleic acid) improves with an increased proportion of grass and hay in the feed ration and decreased proportion of concentrates (cereals, grain legumes). Due to the higher proportion of grass and hay in the ration of organic dairy cows, the fat composition of organic milk is usually nutritionally favourable compared with the milk of high-yielding cows fed with high proportions of concentrate feed.

Fatty acid composition of organic and conventional milk



The ratio of omega-6 to omega-3 fatty acids is lower in organic milk and thus is more favourable to human health compared with conventionally produced milk [32-35].

Convenience food

Convenience food is defined as ready to eat or semi-ready to eat dishes that can be prepared easily and quickly. The high demand for such products has led to the availability of a wide range of organic convenience foods today. But is this compatible with organic principles?

Convenience products require little effort to prepare and can also provide a tasty menu for people who cannot or do not want to cook. Typical examples are frozen pizzas, sandwiches or sausages and other snacks. Unfortunately not many convenience foods meet the requirements of a healthy diet, as recommended by the World Health Organisation (WHO), the British National Health Service (NHS) or the British Nutrition Foundation (BNF), because they usually contain relatively high levels of salt, sugar and fat. Due to the high amounts of fat and sugar, convenience foods contain too much energy in relation to their satiation effect and therefore contribute to the growing problem of obesity.

In recent years, more and more organic ready meals have entered the market. Today, in many European countries virtually everything that is available in non-organic form is also available in organic quality.

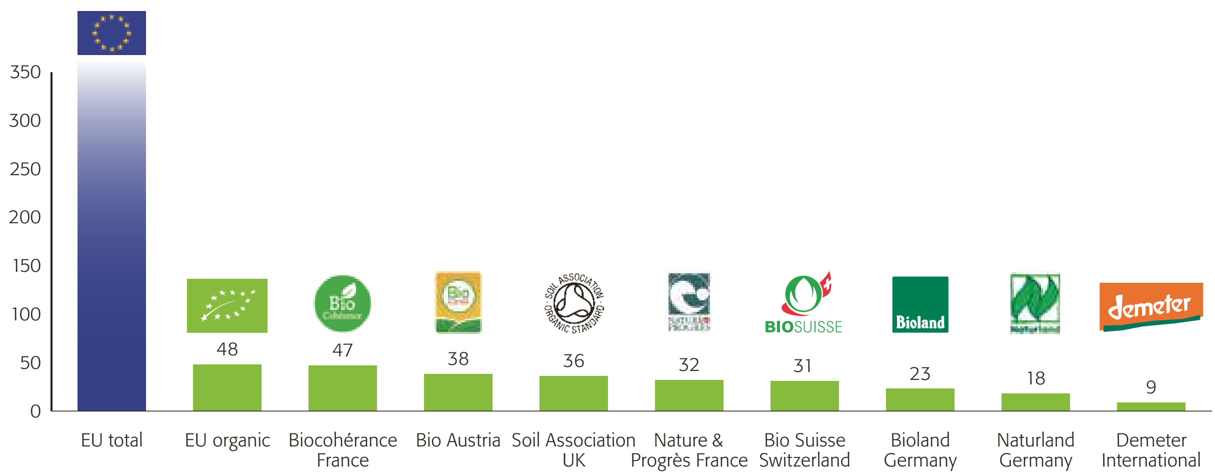
Fewer additives in organic processed foods

Another disadvantage of ready meals is the high proportion of preservatives and other food additives that they contain. Additives are used, for example, for colouring, preservation or sensory effects (e.g. flavour, sweetness, etc.). There are more than 320 additives approved for the processing of conventional food in Europe.[d] All these substances must be guaranteed to not be harmful to human health. Nevertheless, in many cases their use is unnecessary and unnatural.

In contrast to convenience food, fresh products, unseasoned frozen food or canned food require no additives for conservation. The freezing or heating process respectively provides adequate protection against deterioration.

Organic products need to be authentic. Therefore only essential additives are allowed in the processing of organic food. In total 48 food additives are permitted for organic processing in Europe, but many organic associations have further restricted the choice of permitted additives. Demeter is the most restrictive: it only allows 9 additives. How the authorisation of food additives affects processed food is shown on the opposite page.

Number of permitted food additives for the processing of conventional and organic products in Europe (January 2015)



The EU Organic Regulation and organic private standards strongly limit the number of authorised additives for the production of organic food.

The example of dried apricots

Why are conventional dried apricots orange while organic apricots have a dark brown to black colour? In the EU, conventional apricots may be treated with up to 2000 mg per kg sulphite (E220). This prevents the change of colour, but also protects the dried fruit against fungi and bacteria [36]. In principle, adding sulphite should not be necessary, because dried fruits can be stored for long periods even without preservatives [37]. Therefore, the addition of sulphite to organic dried apricots is not allowed.

As consumers, we are used to the different colours of different types of dried fruit: orange apricots, bright yellow raisins or white apples. However, the introduction of organic dried fruit has started a new trend. Today, sulphite is often also not added to some conventional dried fruit. This is because, although the use of sulphite as a food additive is safe as regards human health [38, 39], its addition to food is unnatural.

At first glance, dried apricots of a brown colour do not appear very appetising, but they taste just as good as apricots treated with sulphite.

The example of cured meat products

The production of cured meats differs between organic and conventional products. There is a lower limit for the amount of curing agents such as nitrite (E249–E252) in organic meats: 80 mg nitrite per kg of meat compared with 150 to 180 mg / kg in conventional meat products. The addition of phosphates (E338–E341, E450–E452) is not permitted in organic meat products.

Nitrite is added as a curing agent for several reasons: it prevents the growth of pathogenic bacteria, is responsible for the maintenance of the red colour and the typical taste of sausages, and acts as an antioxidant, increasing the shelf life by slowing down fat oxidation. The disadvantage of nitrite is the development of unhealthy N-nitrosamines during digestion, which are said to have a carcinogenic effect [40]. For this reason, less nitrite, if any, is used in organic sausages and meat products. Demeter prohibits the use of curing agents entirely. The protection against pathogenic bacteria and the long shelf life of the product can be guaranteed by alternative means.

Phosphate on the other hand is a processing aid which improves hydration during certain processing steps (e. g. crushing with added ice-water) and thus optimises the consistency of sausages [41]. Phosphates are naturally present in many foods. Added phosphates, however, are absorbed much more easily in the body [42]. Excessive phosphate intake, as is prevalent in today's western diet, can lead to kidney or vascular disease. A high intake of phosphate can have serious health consequences, especially for people with kidney problems.

The absence of nitrite and phosphate results in an equally flavourful sausage, but with a slightly different colour. Left: conventional sausage with high levels of phosphate and nitrite; Middle: organic sausage without phosphate and with little nitrite; Right: Demeter sausage without phosphate or nitrite.

Processing

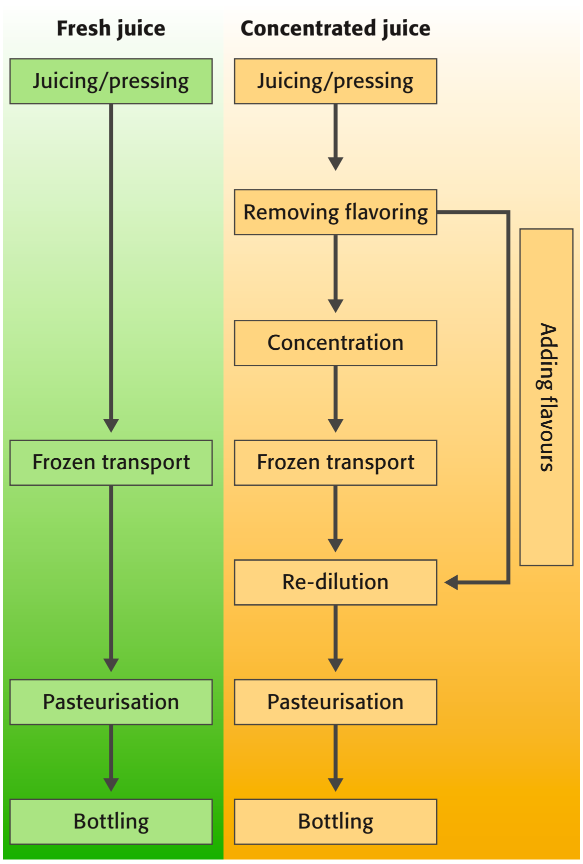
Many food products undergo more or less lengthy processing procedures. In order to preserve the original character of the products and their quality as much as possible, organic farming attempts to reduce the number and extent of the interventions to a practical minimum. The following examples show how the principle of careful processing is implemented in practice.

Production of organic orange juice

A large share of the orange juice consumed in Europe comes from the region of São Paulo in Brazil[43]. Conventional oranges are processed to concentrate on site and then shipped to Europe in refrigerated freighters. Before the final step of packaging in Europe, this orange juice undergoes several processing steps.

The EU organic regulation does not explicitly prohibit the production of concentrates and their re-dilution. Many organic certifiers, however, including Demeter, Bio Suisse and Naturland, do not allow this procedure. According to them, it is contrary to the principle of "as careful and gentle processing as possible". These associations, with few exceptions, only allow the production of fresh juice (pasteurised). In the UK, both the Soil Association and OF&G only allow juice made from concentrate if labelled accordingly.

Processing of fresh juice (not from concentrate) and concentrated juice



The production of organic juice avoids any unnecessary processing steps to obtain a food that is processed "as gently as possible". Conventional juice from concentrate, however, is separated into various components and then reconstituted before packaging

No differences in taste and energy use

The German consumer magazine *Stiftung Warentest* found no difference in flavour between a juice made from concentrate and fresh juice. Also, no differences in taste were found between organic and conventional orange juice [44]. This is probably because all of these juices are pasteurised and, due to the heating process, none of the juices taste like fresh orange juice anymore.

According to a recent study, the environmental impact of orange juice lies between 0.4 and 1.1 kg CO_2-eq per litre [45, 46]. It was found that it does not make a difference whether the juice is fresh (not from concentrate) or derived from concentrate. However, organic cultivation of the oranges reduced the environmental impact of organic orange juice. Organic orange farming can be more resource efficient, thus the carbon dioxide emissions can be reduced by more than half[45].

How ecologically sustainable can oranges from Central or South America be? The consumption of locally produced fruit juices, such as apple or grape juice, is always more sustainable than consumption of juices from tropical and subtropical climates.

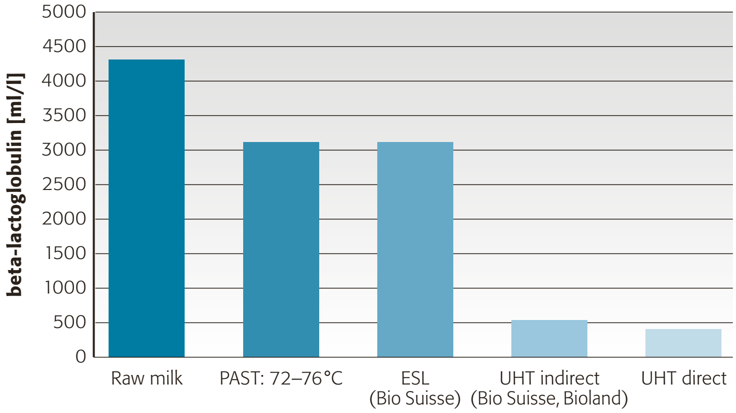
Preservation of milk

Milk bought in the store is always heat treated and usually homogenised. Pathogenic germs are killed at about 73 °C during pasteurisation. During homogenisation, the fat particles in the milk are uniformly crushed, to refine the milk and prevent creaming [47].

Neither pasteurisation nor homogenisation has been proven to have a negative impact on the most important nutrients of milk [48, 49, 50]. In addition to pasteurised milk of different fat contents, the refrigerated section of shops also offers some milk with a longer shelf life (ESL, Extended Shelf Life). The longer shelf life is reached by high-temperature pasteurisation at just below 135 °C or through microfiltration or double-bactofugation before pasteurisation. Microfiltration (filtration) and double-bactofugation (centrifugation) are methods to extract living germs and spores from the milk. UHT milk (Ultra High Temperature, above 135 °C) has the longest shelf life; it can be kept for several months at room temperature. However, the slight "cooked" taste and the loss of various vitamins during storage [47, 50, 51] reduce the quality of this milk.

The value of beta-lactoglobulin is often used as an indicator of the impact of the heat treatment on the quality of milk (see figure on the right). The closer the value of treated milk is to that of untreated milk, the gentler was the preservation process [51].

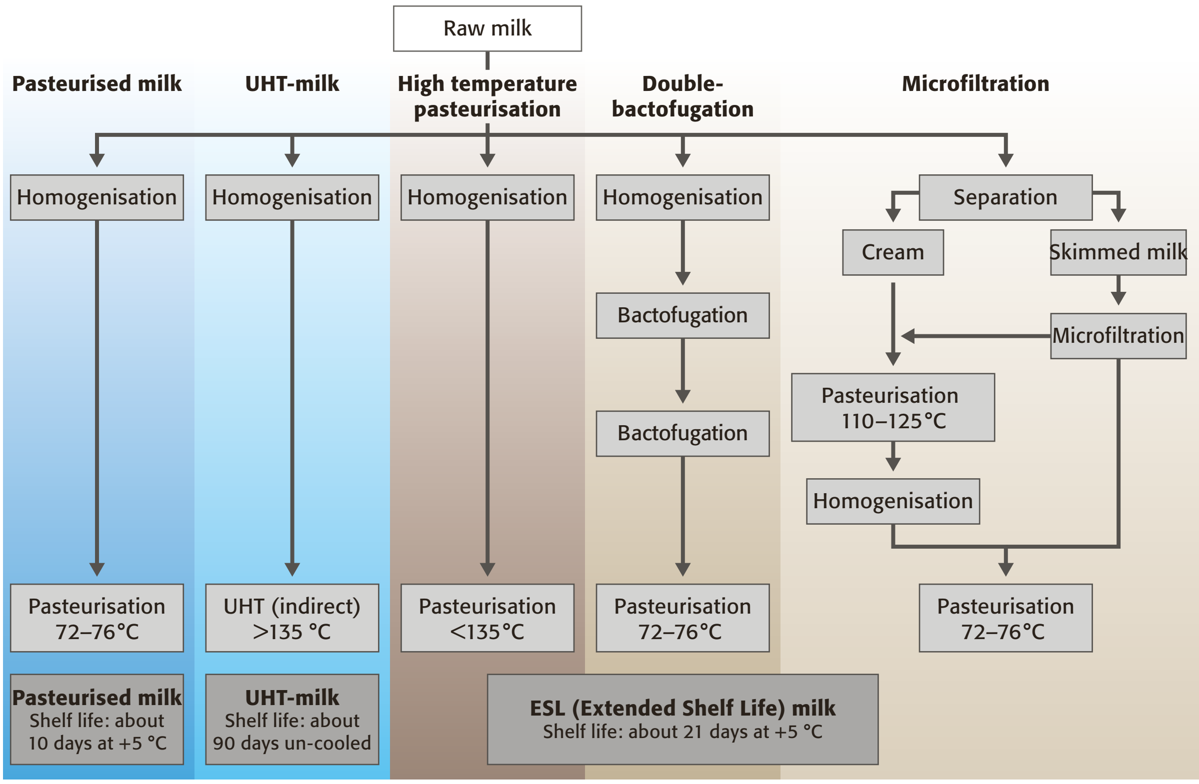
The effect of heat treatments on the quality of milk



A high beta-lactoglobulin value is an indicator of the careful processing of milk. Some organic standards specify minimum values for ESL (Extended Shelf Life) and UHT milk.

Bio Suisse prohibits high temperature pasteurisation for its products, but allows the indirect UHT method and the production of Extended Shelf Life milk by double-bactofugation and microfiltration. Some organic associations (e.g. Bio Suisse and Bioland) defined minimum beta-lactoglobulin values for specific milk treatments (see figure above). Most organic farming associations and control bodies, such as the Soil Association or Naturland, allow all of the methods of milk preservation described above. Demeter standards allow pasteurisation up to 80 °C, but prohibit homogenisation, as it is not in line with their principles and definition of natural milk.

Methods of preserving milk



The EU and UK regulations allow various techniques for the preservation of milk. However, some organic labels only allow certain methods for the preservation of drinking milk: Demeter only allows the pasteurisation without homogenisation; Bio Suisse prohibits high temperature pasteurisation and limits the heating of cream during microfiltration to 90 °C (January 2015).

Ecological sustainability

Organic farming practices are expected to be ecologically sustainable not only in production, but throughout the entire value chain. Therefore, the environmental sustainability of the organic value chain has been studied more intensively in recent years. Life-cycle assessments (LCAs) are a good tool to quantify the environmental impact of a food product along the entire value chain and identify weak points – a requirement for the ecological optimisation of food production.

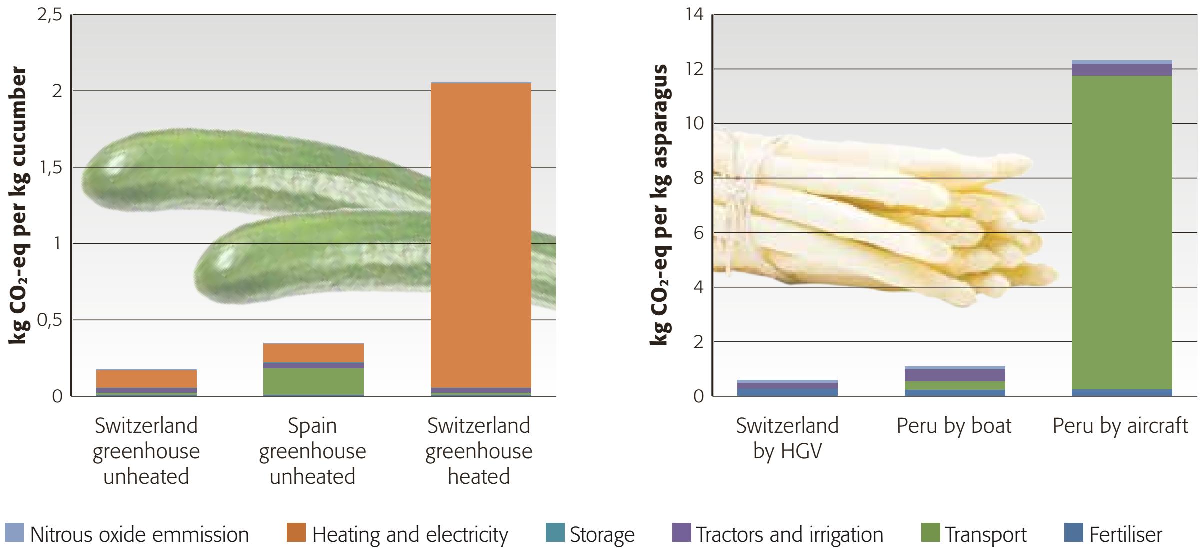
Mainly a question of energy use

Approximately one third of the negative environmental impact that the Swiss population causes through consumption is caused by the demand for food [52]. The majority of the environmental impact of food consumption is caused by agricultural production. Processing and transport, as well as food preparation, play a minor role. An exception to this is, for example, French fries, where preparation is responsible for almost half of the environmental impact [53]. As LCAs highlight, the question of ecological sustainability is highly dependent on the use of energy.

LCA results for food products can be surprising and are often not in accordance with common expectation or opinion. The principle that regionally and seasonally produced food is good for the environment still has its validity. However, LCAs of the production, processing and transport of organic food can contribute to a more detailed analysis of processes [54, 55].

Fruits and vegetables that are transported over long distances do not necessarily have a worse effect on the climate than locally produced food [54]. Of importance is not only the distance over which they are transported, but also the type of transport used. If asparagus and papaya are flown to Europe from overseas, transport dominates the negative climate effect. For greenhouse vegetables, heating using fossil energy can make up most of the negative climate effects [55, 56]. In this case, for example, cucumbers from Southern Europe, grown in unheated greenhouses, have a lower carbon footprint, despite longer transport distances, than those that were produced in Central Europe, out of season and in a heated greenhouse. Also, the energy required for storage in a controlled atmosphere can be important for the carbon footprint. However, new studies show that locally grown apples still outperform imported apples from New Zealand, even when they are stored for months [55, 57].

Life Cycle Assessment (LCA) of cucumbers and white asparagus from different origins and forms of production [55]



The most ecologically sustainable food results from seasonal and local production. Seasonality can be more ecologically sustainable than regionality. For example, cucumbers from an unheated greenhouse in Spain are more ecologically sound than local cucumbers from a heated greenhouse. However, as soon as air transport is required, the LCA results of a food product worsen significantly, as shown by the example of asparagus.

Under reduced tillage, the soil can store more carbon dioxide than it releases and thus contributes to climate change mitigation. The climate effect is further influenced positively by the fact that shallow soil cultivation uses less fuel; or negatively, through a potentially higher need for weed control and therefore increased machinery use.

Gaps remain in product-related LCA comparisons

LCAs are also used to compare organic and conventional food. The evaluation and comparison of production systems is highly relevant for the assessment of environmental sustainability. Product-related life cycle assessments are a useful tool for the evaluation of many environmental impacts. The environmental impact of organic and conventional food can vary significantly from case to case, but overall, LCAs of organic food tend to indicate a lower environmental impact relative to the production area [58]. If, however, the environmental impact is related to the amount of product that is produced, the picture may change. This is the case for the climate effect of dairy and beef production. Reasons for this could be an unfavourable balance between input and output per area, or methodological difficulties.

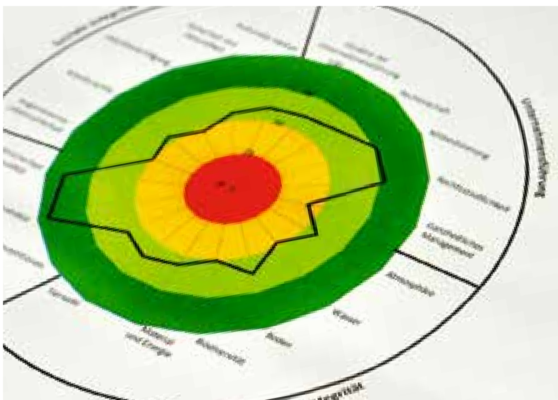
The incomplete consideration of environmental effects makes a final conclusion with regard to the environmental sustainability of food production difficult. So far, biodiversity, soil quality and higher carbon storage in soils under organic farming [59] (reducing the effect on global warming), have generally not been included in LCAs.

In addition to the increasing eco-efficiency of agricultural production, which is indicated in product-related LCAs, changing the nature of the food consumed is the second most important factor that can help to improve the environmental sustainability of our diet. A diet that involves a needs-based calorie intake and a moderate amount of animal derived food products contributes to environmental sustainability (see page 10).

Sustainability assessments of businesses

If social or economic aspects, rather than product-related qualities, are taken into account the sustainability of individual producers, companies or entire food value chains can be assessed through a holistic approach.

A variety of methods exist for the sustainability assessment of agricultural production and food processing businesses; they are often based on global approaches such as the SAFA guidelines (Sustainability Assessment of Food and Agriculture Systems) of the FAO (Food and Agriculture Organisation of the United Nations). These guidelines define four dimensions of sustainability: ecological integrity, economic resilience, social wellbeing and good governance, which in turn are divided into 21 topics and 58 subtopics. Specific targets are formulated for each of these subtopics on the basis of the possibility of assessing the sustainability performance of businesses. These internationally recognised guidelines provide an overall framework and a common language for standardised, transparent and comparable sustainability assessments in the agriculture and food sector [60].



Outcome of the sustainability assessment of a farm. The analysis of strengths and weaknesses provides evidence for the ecological improvement of the company.

Authenticity

Buyers and consumers of organic food need to have confidence that it originates from organic production and processing. Both the organic regulation and the private standards of organic farming ensure this in their principles.

Some organic control bodies, in their efforts to preserve the credibility of the food products that they certify, use, in addition to the information required by the certification process, further analysis to ensure quality and origin.

Traceability to the origin

The traceability of food is important for quality assurance and is regulated by law in the EU [e]. Companies trading in food must be able to declare:

a) where the raw material was obtained; and

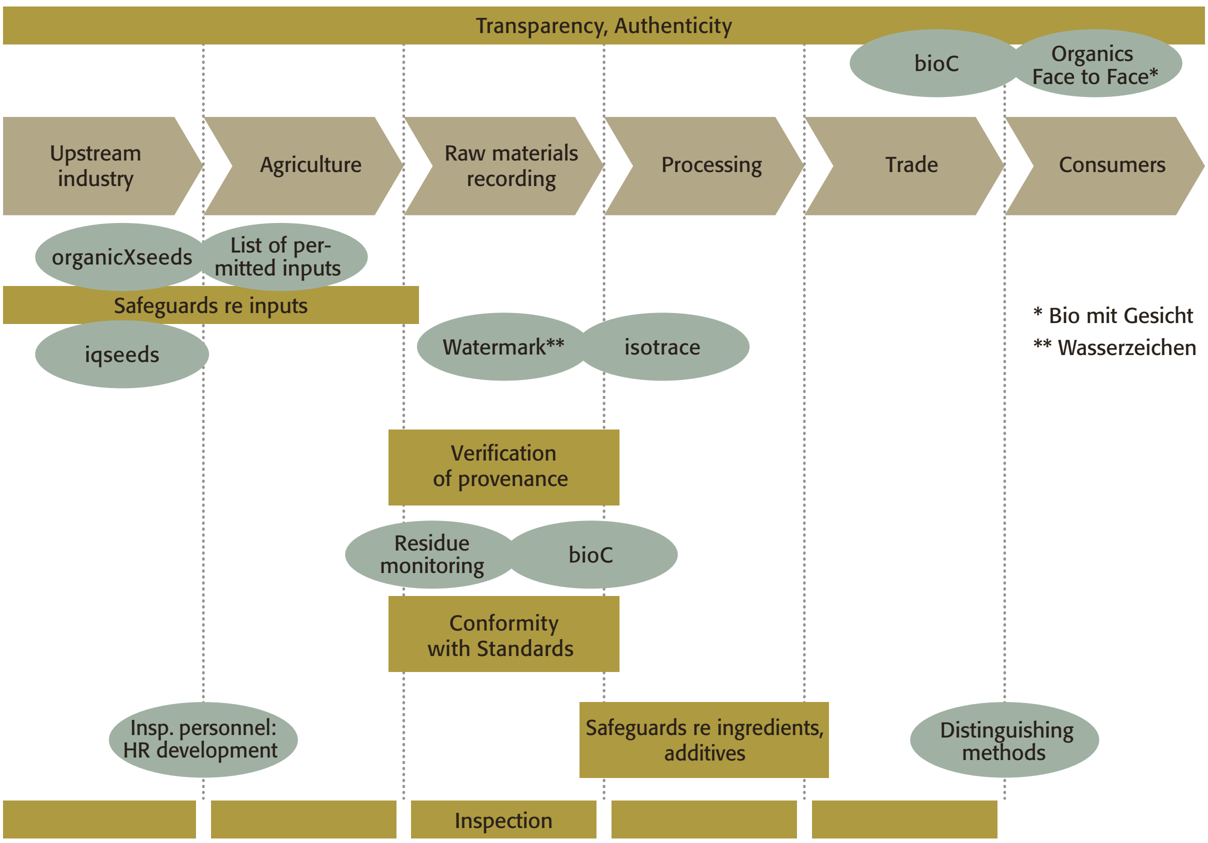
b) to which companies in the supply chain the food was delivered.

Trade in animal products and sprouted seeds is subject to additional rules.

Food traceability should enable the specific retention and recall of products, identify causes and sources of quality shortcomings or contaminations, and allow the in-house monitoring and optimisation of the production of food [61, 62]. The guarantee of traceability should protect consumers from animal diseases, chemicals, pathogens and other risks which may arise from food [61]. The major food scandals in recent years, such as EHEC (*E.coli* O157:H7), dioxin and BSE have highlighted the importance of full traceability in today's globalised market.

Organic food is checked, both quantitatively and qualitatively for its origin. In cases of discrepancies and uncertainties, control authorities are obliged to undertake so-called "cross-checks", informing each other about quantity flows and adjustments. This is how information gaps can be closed and fraud cases can be revealed.

Instruments for improved traceability of organic food along the value chain



Organic label organisations, control bodies and marketing organisations are committed to maintaining the best possible quality along the entire value chain of organic food, from the use of organic seed (e.g. OrganicXseeds, iqseeds), to the use of approved fertilisers and plant protection products, residue testing, proof of origin (e.g. water mark, isotrace) and the control (e.g. bioC) of products at retail level.

High food security due to statutory double checks

Controls are needed to ensure a high level of food safety. Therefore, double quality assurance was defined by law [f, j]. In addition to the regular official controls of food companies, these controls are primarily responsible for the quality and safety of their products. They are required by law to produce their products in accordance with good manufacturing practice (GMP) and good hygienic practices (GHP) and maintain a functioning internal control system (e.g. Hazard analysis and critical control points (HACCP).

Annual and comprehensive controls across the food value chain

The organic regulations require, in addition to food-regulatory monitoring, an annual, comprehensive inspection of all agricultural, processing, trade and storage operators that deal with organic food. The approved control bodies assess whether the applicable regulations and laws are well known and their requirements are correctly implemented on site.

Measures designed to prevent contamination or mixing of organic food with conventional products are intensively examined at all stages of the value chain. Each organisation and company needs to be able to demonstrate and document how the organic products and units are distinguished and kept separated from the conventional ones. Also the training needs of persons responsible for organic food products are addressed.

On the farm, apart from the evaluation of business records, compliance with the requirements in the field, barns, storage and on-farm processing facilities is examined. Separation from neighbouring conventional farms is assessed.

For processing plants, the focus of the inspection is on the flow of goods. Based on original documents, it is checked whether the amount of purchased organic raw material is sufficient for the quantities of goods that were produced. This also includes an assessment of product availability on certain days. The procedure additionally covers an evaluation of recipes and labelling.

Only the cooperative collaboration of all actors involved in the value chain can ensure the integrity of organic food.

The control of processing plants covers, among other things, an assessment of precautions that are taken to prevent contamination of organic products. The company must be able to demonstrate how it implements the measures in practice.

Refined analysis technique for the guarantee of origin

In recent years, the development of instruments to guarantee the origin of organic food and the analysis of unwanted or prohibited substances has increased [63]. The instruments measure either specific individual substances or deliver complex data from processing of various measurements. These include near-infrared spectroscopy [64], the metabolomic method for the measurement of many substances [65, 66, 67] and isotope analysis [68], which provides a characteristic fingerprint for each biological sample. The methods have been tested on a variety of agricultural foods. Currently, it is being investigated whether the methods can also be used to determine whether processed food originating from different regions was produced organically [69].

A well-studied example of an analytical method is the measurement of isotope patterns, the ratio of varying versions of the same atom in products. In many cases, organic and conventional foods have different isotope patterns, and this could be used as an additional control instrument in the future.

Organic meat, milk and even cheese contain less heavy carbon; because the animals usually eat less concentrated feed such as maize, and grass or hay contain less heavy carbon than maize. On the other hand, organic fruits, vegetables and cereals contain more heavy nitrogen, because organic fertilisers generally contain more heavy nitrogen than synthetic fertilisers do. This partially also applies to animal derived food products [68-80].

Seeing food as a whole

In the wholesome approach to organic farming and food processing, the holistic view and perspective on food has a high priority. Therefore, in addition to analytical methods for measuring the concentration of individual substances, complementary methods and sensory tests are also used to assess the quality of organic food. [81-84]

Complementary methods

Complementary analysis methods largely assess whole food products, meaning food which is, as much as possible, not chemically or physically disassembled [85-88]. The results are multidimensional and their evaluation is therefore complex [89-91]. A number of these methods have been documented as standardised and validated laboratory methods [86, 89, 90, 92]. Which quality aspects of food can be accurately detected with these methods is still the subject of scientific research [93].

Bio-crystallisation

The best studied holistic method so far is bio-crystallisation. The food is first prepared in a water-based, liquid form, and then crystallised with the addition of copper chloride salt [94, 95], producing two-dimensional patterns/images (see pictures below). The principle behind this method is scientifically explained by the process of self-organisation. The resulting crystal patterns are evaluated by eye or via computer-based programs [91, 96, 97, 98]. The method has been standardised in several European countries for a range of plant-based foods and milk [96, 99, 100] and is successfully used for the evaluation of manufacturing processes and for the classification of biological samples [100, 101].

Fluorescence-stimulation spectroscopy

After stimulation by light of one or different colours, food samples show measurable, ultra-weak photon emissions of different strengths [89]. Using the method of fluorescence-stimulation spectroscopy, conclusions about the origin and treatment of agricultural products and foodstuffs can be drawn [101].

Bio-crystallisation of milk

The bio-crystallisation method creates images under similar conditions, which thus can be compared. Left: the crystallisation picture of UHT-processed, homogenised milk from conventional production; right: the crystallisation image of pasteurised, biodynamic milk.

Authenticity verification and assessment of processing technologies

So far, most publications on holistic methods have dealt with the question of authenticity of organic food [89, 90, 92, 96, 100, 102, 103, 104]. In this case, these approaches seem to offer promising solutions complementing analytical methods. A number of complementary methods were able to successfully distinguish between wheat samples from organic and non-organic production in the DOK trial – a long-term field experiment initiated in 1978, comparing organic and non-organic production systems in Switzerland [101, 103, 104].

Holistic assessment methods can also be used for the assessment of technologies that are used in the processing of organic food, and provide valuable insights into the practice [100, 105, 106].

Sensory analysis

Sensory properties are the most important reason for buying food, whether organic or not [107]. Food products need to look good, have the right consistency, smell good and taste good.

Different sensory preferences

Sensory preferences can vary considerably between people, regions or countries [107, 108]. For example, the Swiss prefer sweet and slightly mealy apples, whereas the Germans prefer crisp apples and Italians choose mostly sour, slightly grassy-tasting apples. There are also different preferences for products like yogurt (where UK consumers prefer thicker texture), salami, oil, tomato sauce or biscuits.

Natural taste instead of artificial flavour

From a sensory perspective, organic food often differs slightly from conventional food. Fruits and vegetables are

Scientifically supported tastings provide important information for assessing sensory criteria of food, such as appearance, smell, taste and texture.

often a little smaller and less perfect in form. The sensory difference for processed products is mostly due to the fact that no artificial flavourings and colourings are added to the organic products. Such additives can significantly change the sensory properties of conventional food by giving it a stronger colour or a more intense flavour.

Often higher demands are placed on the sensory properties of organic food than of conventional food. An Italian study showed that the organic label can make a product which is rated good with regard to its sensory properties appear even better; a poorly-rated product however, is perceived to be even worse if it carries an organic label [109]. This was explained by the expectation and disappointment effect that occurs when the high expectations of consumers regarding the quality of organic products are not met.

FQH – a network for Quality Research

FQH
Food Quality & Health

The Food Quality and Health Association (FQH) is an international network of research institutions and companies which are studying the effects of production systems and processing on food quality.

The FQH network promotes and coordinates research on food and health, and provides its members with the most up-to-date knowledge available in this area. The members include research-focused institutions as well as a network of supporting companies and organisations.

The aim of FQH is to develop new perspectives for the understanding of and dealing with food and health. The work focuses on holistic methods, careful processing of food and sustainability of food. FQH organised the first two international conferences on quality of organic food in Prague (2011) and Warsaw (2013).

www.fqhresearch.org

Fair trade and social responsibility

In the eyes of consumers, organic food should not only meet high environmental, but also high social responsibility standards. However, the EU organic regulations address only the ecological component of organic food production. Therefore, it is up to the private standards to address social responsibility and to emphasise fair trade.

Fairness in the organic trade

Organic farming associations and control bodies are generally aiming for a fair relationship between producers and trading partners on a national and international level. There are some differences in the detailed standards of the individual organisations.

The Soil Association in the UK, as well as the German Bioland association, for example, are committed to the respect of human rights and social justice. So far, this aspect is formulated relatively openly and can be interpreted in different ways. Other associations are more specific in their guidelines. Bio Suisse in Switzerland has a written code of conduct for responsible business practice for the import of certified products. The Code requires transparency of trading relationships for example, and the promotion of small-scale farmers and structures. The Soil Association and Naturland in Germany refer in their guidelines to international conventions, such as the guidelines of the International Labour Organisation (ILO) and the UN Conventions for Human Rights and Children's Rights. In addition, Naturland requires a regular working relationship with a written contract of employment, minimum wages, social benefits and regular working hours.

Fairtrade strengthens the position of small scale farmers and plantation workers in developing countries, supporting them in their social and economic development.

In addition, the Soil Association, with "Soil Association Ethical Trade" and Naturland with "Naturland fair" have developed their own additional labels with strict requirements.

Soil Association Ethical Trade

The Soil Association Ethical Trade label requires social responsibility at all levels. For the employment of staff, national legal standards or ILO guidelines have to be applied, always satisfying the requirements of the stricter regulation. Trade relations need to be trustworthy, transparent, fair, long-term, regulated and defined by a contract. In addition, employers and mangers are required to contribute to the social and cultural life of the region.

Naturland Fair

To qualify for the Naturland Fair label, the social standards of the regular Naturland guidelines must be met as a baseline. In addition, the Naturland Fair standard requires a long-term and reliable cooperation with trading partners, as well as fair prices. Smallholders should be encouraged and supported. In one aspect Naturland Fair stands out as a particularly good example: under the fulfilment of certain conditions, producers are to receive pre-financing, which can reach up to 60 % of the supply batch.

The success story of Fairtrade

Fairtrade is a success story that began in The Netherlands in 1988, where the first Max Havelaar Foundation was established in response to the recurring coffee crises [110]. The aim of the Max Havelaar Foundation was to support coffee farmers, who were living on the poverty line, and to ensure a minimum standard of living through fair prices.

In the early 1990s fairtrade foundations were established in other European countries as well, either under the name "Max Havelaar" or "transfair"[110]. In 1997, the national foundations merged and founded "Fairtrade International", with global standards and certifications.

Today, the main revenue from fairtrade products comes, no longer from the coffee trade, but from bananas and cut flowers. In Switzerland, the market share of Max Havelaar bananas reached 54 % in 2012[111]. The import of fairtrade products to Europe continues to rise steadily. Growth in Europe in 2013 was between 10 % (Ireland, France) and 16 % in the UK, and 91 and 114 % in the Baltic states of Latvia and Estonia [112].

From label for fairtrade coffee to important market partner for small-scale farmers in the South: The development of fairtrade can be demonstrated by the product label of the Max Havelaar Foundation. Bottom right: the current logo design (in use since 2012).

Fairtrade and organic – a logical partnership

Fairtrade and organic are approaching sustainability from different angles and have rarely affected each other in the past [113]. Organic farming has its origins in ecology and slowly evolved into a social and economic sustainability label. Fairtrade, on the other hand, started out with social and economic justice objectives, and later adopted some ecological requirements into its policies. Today, the combination of organic and fairtrade labels is considered a guarantee of social, economic and environmental sustainability of products, especially of those originating in the global South. Many products are now certified to both organic and fairtrade standards.

Gradually transferring social responsibility to the South

The cultivation of cotton has so far caused the world's highest pesticide consumption of all agricultural crops and is therefore responsible for major health problems and serious environmental damage. Cotton can also be grown successfully and sustainably using organic methods, as was demonstrated in research carried out by FiBL. Cultivation of organic cotton is at least as profitable as conventional cultivation or the use of GM cotton seed.

FiBL have worked with around 16,000 organic farmers in West Africa since 2011, with the common goal of achieving a better life and predictable income for producers in the globalised market for organic cotton. The project attempts to show that the implementation of ecological principles, improved social organisation in cooperatives, sustainable production and food security are possible.

An essential part of the success of the project is a purchase guarantee from the industry before sowing. The organic and fairtrade premiums, which together account for about 30–45 % of the basic price, contribute to sustainable profitability. Currently, organic farmers in Mali receive 0.75 euro for 1 kg of raw cotton, of which 0.25 euro is a premium.

Particularly in the case of cotton production it becomes obvious that quality and sustainability go together, and that sustainable production is only enabled through fair organic production. However, monitoring of social responsibility still relies too much on non-profit organisations. In the long term, the costs should be transferred to public institutions in producing countries. However, there is still a long way to go to reach this goal.

Organic farming is an instrument for farmers in the South to make their production more sustainable and secure a market of their products in the long term.

Packaging

Packaging is primarily used to protect food. For the packaging of organic food, the same principles apply as for production and processing: the impact on the environment should be minimised and the food quality should not be impaired. Therefore, packaging should not transfer any pollutants into food.

Packaging is primarily used to protect food. For the packaging of organic food, the same principles apply as for production and processing: the impact on the environment should be minimised and the food quality should not be impaired. Therefore, packaging should not transfer any pollutants into food.

Food packaging fulfils several functions [114]. One of the most important is protection from external influences. This allows us to store the food and increases its shelf life. Packaging is also used as an advertising medium and a source of product information. Furthermore, packages often have a portion size function in order to simplify handling of the food.

But packaging not only has advantages. Often it is manufactured from non-renewable raw materials. These valuable resources are often only partially recycled after their first use. Another problem is the migration of contaminants from the packaging into food. The pollutants are consumed with the food and can endanger human health.

The requirements for packaging materials are regulated in EU law [g, k]. Packaging may only release those substances into food which:

1) pose no risk to human health;
2) do not cause any unacceptable change in the composition of the food;
3) do not cause any deterioration in the organoleptic characteristics of the food.

Higher requirements for label owners

Some organic organisations such as the Soil Association ("Reduce, Re-use, Recycle"), Bio Suisse and Bioland have set additional requirements for packaging. For ecological reasons, unnecessary and extensive packaging is prohibited. They generally require licensees to use those packaging systems which cause the least environmental impact and, if possible, provide a resource-saving multiple use of materials. Chlorine-containing materials such as PVC may not be used. Metal composite packaging and aluminium foil are only permitted in justified cases.

Pollutants from packaging

Recycled paper and cardboard contain many contaminants that can migrate into food. For example, mineral components of ink or phthalates from adhesives can have carcinogenic or oestrogenic effects. In contrast to the EU, in Switzerland wastepaper cannot be used as a base material for packaging that is in direct contact with foodstuffs; and in the UK, the Soil Association only allows process chlorine free (PCF) recycled paper in food packaging [o].

The direct contact of recycled PET (polyethylene terephthalate) with food is permitted in the UK because it is one of the most inert polymers and undergoes a "super-clean process" to remove any risk of contamination [o]. It has been suggested in various studies that oestrogenic substances migrate from PET packaging into drinks [115, 116], but this suspicion was refuted by several studies [117, 118]. Therefore, PET bottles can be produced with up to 100 % recycled PET. According to a study, this makes them as environmentally friendly as returnable and recyclable glass bottles [119, 120].

Examples of contaminant migration from packaging into food	
Phthalates migrate into food from twist-off lids [121].	Bisphenol A migrates from aluminium cans into beverages [122].
	

Endocrine substances from screw caps and protective coating of cans

Endocrine substances can get into our food through different routes. Some substances, such as phthalates, can migrate directly from packaging into food, while others reach the food chain more indirectly [124]. The indirect routes include mainly residues from pesticide applications, by-products of incineration plants or drugs that are absorbed by fish through waste water.

Since all of these substances are fat-soluble, they can be mostly found in fatty animal foods such as milk, meat or fish. Organic food is just as contaminated with these substances as conventional food. Protective caps and lids without plasticisers are available; however, the conversion of packaging systems is complicated and expensive.

Potato crisp packaging with nanoscale aluminium coating. Nanotechnology reduces the amount of aluminium needed significantly, while material properties remain the same.

No or limited use of nanoparticles in organic food and packaging

Nanoparticles and nanomaterials are artificially produced particles, 1–100 nanometres in size (nanoscale), which have special properties due to their small size [125]. These special properties are used not only for medicine, information technology or cosmetics, but also in food processing and packaging.

The level of knowledge with regard to nanoparticles is developing progressively. It is clear that nanoparticles are taken up by humans mainly through the lungs, but also through the skin or the digestive tract and that they can endanger health. The EU intends to introduce labelling requirements for the applications of nanoparticles in food and cosmetics in the future.

Since nanoparticles are produced synthetically, they are not approved for direct application in organic food. The packaging of organic products is not specifically regulated by the EU. However, EU food law applies to all packaging materials and requires that they do not compromise health if used in the intended or expected way. Only packaging materials that are approved by food law may be used. Since the toxicological evaluation of various nanoparticles is still far from complete, it must be decided on a case by case basis whether their use can be approved in the food industry [126].

There are currently three nanoscale food-contact materials explicitly permitted in the EU: silica, black carbon and titanium nitride (for PET). They can be used in packaging for example to prevent gas exchange or to protect the food from UV radiation.

So far, the Soil Association has prohibited the use of synthetically engineered nanoparticles under a certain size as an ingredient. Demeter, Bio Suisse, Bioland, Naturland and Bio Austria prohibit any use of nanotechnology in the production, processing and packaging of organic food or feed. This includes all applications through which synthetic nanoparticles could possibly enter into food or feed (e.g. via migration).

Recycled cardboard releases mineral oil component (MOSH and MOAH) [123].

Recycled cardboard releases benzophenone (a mineral oil component) [123].

Literature

The full list of literature can be downloaded at www.shop.fibl.org › 1404.

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Legal framework

EU-Regulations

a. Regulation (EEC) No 2092/91 (out of force)
b. Council Regulation (EC) Nr. 834/2007
c. Commission Regulation (EC) Nr. 889/2008
d. Regulation (EC) Nr. 1333/2008 (Food additives)
e. Regulation (EC) Nr. 178/2002 (Food and feed safety)
f. Regulation (EC) Nr. 882/2004 (Control, animal health, animal protection)
g. Regulation (EC) Nr. 1935/2004 (food contact materials)

Swiss Regulations

h. Verordnung über die biologische Landwirtschaft und die Kennzeichnung biologisch produzierter Erzeugnisse und Lebensmittel SR 910.18 (Bio-Verordnung)
i. Verordnung des WBF über die biologische Landwirtschaft SR 910.181
j. Lebensmittel- und Gebrauchsgegenständeverordnung SR 817.02 (LGV)
k. Verordnung des EDI über Bedarfsgegenstände SR 817.023.21

Private Standards

l. IFOAM Basic Standards: www.ifoam.bio › Organic Info Hub › IFOAM Standard
m. Demeter Standards: www.demeter.net › Certification › Standards
n. Soil Association Standards: www.soilassociation.org › What is organic? › Organic Standards
o. Organic Farmers & Growers (OF&G) www.organicfarmers.org.uk › Downloads › Standards and Certification Manual
p. Bioland Standards: www.bioland.de › Über uns › Richtlinien
q. Naturland Standards: www.naturland.de › Richtlinien
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u. Bio Suisse Standards: www.bio-suisse.ch › Verarbeiter & Händler › Richtlinien & Merkblätter

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Organic food is produced:

- by protecting and enhancing natural soil fertility,
- using natural fertilisers and biological nitrogen fixation of clovers and other legumes,
- closing nutrient cycles through use of manures and crop residues,
- controlling pests and diseases through husbandry methods rather than pesticides,
- promoting high biodiversity and beneficial insects,
- with mechanical weed control without herbicides,
- keeping animals free-range with regular access to pasture for foraging,
- rearing animals without the routine use of antibiotics and growth promoters,
- with much reduced risk of water pollution,
- without genetically modified organisms.

Processed organic food, compared with processed conventional food, contains:

- fewer additives
- no artificial sweeteners, stabilisers, or preservatives
- no addition of glutamate as a flavour enhancer
- no colouring
- no artificial flavours
- no hydrogenated fats
- no, or only traces of pesticides

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