

Which aspects of health are likely to be affected by our choice of food quality, such as organic food, and how can we investigate this question?

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In response to the greatly increased market share of organic food, there is an increasing interest in investigating whether there is any actual difference in the effects of organic and conventional food on health. Previous studies have not been able to provide definitive proof for differences between these two food production systems in terms of impact on human health. However, this conclusion mainly reflects that the designs of these studies were neither adequate to provide such a proof, nor targeted to those aspects where differences are most likely.

There are ample examples that the methods used for production of food do make a difference for food composition or other aspects of its quality, and that some of these differences are large enough to make a real difference for the consumer in terms of health, as summarised in the table below. Some of these differences may in fact cause (yet unproven) general differences in food quality between organic and conventional products. However, many of the production methods that benefit food quality are not necessarily restricted to either organic or conventional systems. Understanding the links between production methods and food quality therefore allows improvement of the products of any system, whether organic or conventional. Many of these benefits are linked with what is presently common practice in organic farming, but which is not prescribed by the regulations, and for these the main challenge can be to conserve existing quality benefits during further development of the productivity of organic methods.

Some of the effects on composition can be explained from scientific knowledge of relevant ecological factors (ecology is used here as the name of the scientific discipline, studying interactions among organisms and other factors in ecosystems). For example, increasing the nutrient availability to a plant, will make the plant allocate resources to increase the growth rate, including more carotenes with a role in photosynthesis, but less for resistance to diseases, resulting in a lower concentration of resistance-related secondary metabolites and vitamin C, thus higher incidence of fungal diseases producing mycotoxins. While this has mostly been studied in natural ecosystems affected by pollution, is there every reason to believe that agricultural plants react in the same way to changes in fertilisation

Table 1. Overview of effects on health of food constituents for which the content is known to be affected by production system. All are under investigation in QLIF (IP QualityLowInputFood).

Food component	Relative content in organic/ low input food	Effect of highest content on health	Impact on health in developed countries	Impact on health in developing countries	Indirect effects on health, or explanatory notes	Favours organic or conventional food
Vitamin C and E in plants	Higher by 10–50 %	Positive if deficient, otherwise none	Many studies show no effect	Substantial benefits among the poorest	Attracts consumers to healthy food	Organic, unless the cost is correspondingly higher
Nitrate in vegetables	Lower by 10–50 %	Probably beneficial, no consensus	No controlled data	No controlled data	-	Conventional, if there is any difference
Pesticides in vegetables and cereals	Lower by more than 90 %	Most known effects are negative	Estimated at near 0, no consensus	Estimated as substantial	Deters consumers from healthy food Exposure risk for workers	Organic, depends on degree of regulation of conventional
Phenolic antioxidants	Higher by 20–50 %	Possibly beneficial, no consensus	No controlled data	No controlled data	Attracts consumers to healthy food	Organic, if there is any difference
Carotenes in plants	In most cases lower by 10–50 %	Positive if deficient, otherwise none	Many studies show no effect	Substantial benefits among the poorest	Note: Higher content in organic plants than in plants from nutrient depleted soils	Conventional > organic > subsistence farmed
Non-nutrient secondary metabolites in plants, mainly vegetables	Average values more constant and higher by 10–50 %	Probably beneficial at intermediate levels, harmful if very high, no consensus	Many non-communicable diseases, so even a small benefit will be important	Very difficult to estimate if benefits outweigh anti-nutritional effects	Perceived risk of toxicity can deter consumers from healthy food. Very important for food security (e.g. cassava)	Organic in developed countries, insufficient data in developing countries
Minerals in plants	Tend to be higher, on very variable background	Positive if deficient, otherwise none	Many studies show no or very little effect	Substantial benefits among the poorest, in particular from crop rotations	Note: Improved Zn/phytate ratio in cereals on tropical soils.	Organic in developing countries, insufficient data in developed countries
Mycotoxins in food	Values more constant and most often lower	Negative if threshold is exceeded	Estimated at near 0, no consensus	Estimated as substantial	Perceived risk deters consumers from healthy food.	Organic, if there is any difference
Pathogens in animal products	Differences likely, but magnitudes not known, except lower for BSE	Negative if threshold is exceeded	Many cases, so even a small difference will be important	Very many casualties, so even a small difference will be important	Pathogens from organic animals are less resistant to antibiotics, so patients are easier to treat. Perceived risks may deter consumers	Organic, for those (few) pathogens where data are available – new data could go either way
Antibiotics in animal products	Lower by more than 90 %	Most known effects are negative	Estimated as very small, no consensus	Estimated as substantial	Exposure risk for workers	Organic, depends on how well conventional is regulated
Vitamins etc. in animal products	Tend to be higher, very variable	Positive if deficient, otherwise none	Provides only small proportion of RDI	No relevant data	-	No difference, or organic marginally better
Additives in processed food	Lower by approx. 90 %	Negative if limits are exceeded, may hide low quality	Estimated as small, no consensus	Increased risk of non-permitted substances	Perceived risks may deter consumers from un-healthy food	Organic, depends on how well conventional is regulated

intensity. Similarly, changing from grass to maize-based diets affect the microbial communities in the animal intestines and thus the composition of milk, eggs and meat as well as the risk of pathogens.

However, until recently there has been little effort in studying the importance for health of such minor compositional changes in the mainstream scientific community. As long as two diets contained adequate amounts of essential nutrients and were not toxic, it was believed that they would have the same effect on health, since it was defined that “food is not medicine”. Only now that various studies show how some foods such as the “Mediterranean diet” affects health differently from other nutritionally adequate diets, has the interest in non-nutrient effects of food on health taken off. But there is still a long way before we can predict the effect on health from a compositional analysis, so comparisons of impact on health are extremely important, both to determine the magnitude of effects and to obtain indications of which aspects of health to investigate further.

Note that there is very little overlap between the type of benefits expected from the composition data in Table 1 and the directly recorded benefits in Table 2.

This highlights how little we know about the impact of food on health, and the need for more and in particular better research. In particular, it indicates the important discoveries that are likely to be made within the next 10 years or so!

Table 2. Overview of different effects on health of foods produced in different production systems. A rat feeding study will be carried out in QLIF.

Food compared with conventional (first author)	Relative benefit of organic/ low input food	Modifiers or confounding factors	Suggested mechanisms	Consequences for impact on health in developed countries	Consequences for impact on health in developing countries	Need for further research – suggested experiments
Biodynamic carrots, wheat and beetroot (Velimirov)	Preferred by rats, replicated over 4 years	The same two farms compared. Access to other food.	Nutrient sensing, conditioned taste aversion	Increase intake of healthy food	Increased intake of healthy food	Test if rats like the organic or dislike the conventional. Find "active ingredient".
Nuns changing to biodynamic diet (Huber)	Self-reported better well-being and physical ability, blood pressure reduced	Not blinded, less protein and carbohydrate in biodynamic diet	Sub-toxic effects of additives and pesticide residues, benefits of natural substances	Decrease risks of depression and related syndromes if confirmed	Not clear if applicable	Conduct as double-blind study with appropriate replications. Find "active ingredients"
Organic tomato puree (Caris-Veyrat)	No differences found in uptake of antioxidants	Larger variation in habitual diet than between intervention foods	Not applicable	Not applicable	Not applicable	Conduct better controlled experiments. Use foods where measured differences are larger
Entirely organic diet for 22 days in cross-over design (Grinder-Petersen)	Content and uptake of flavonoids increased by 10-60%, impact on protein oxidation marker	Not the same varieties	Higher content of health-promoting compounds	More "concentrated" vegetables can help to alleviate too low intake	Not clear if applicable	Use same varieties. Include tests/questions for well-being, physical and intellectual performance
Biodynamic or organic feed to rats (Velimirov, Jegstrup etc.)	Small or no increases in fertility of animals (litter size or survival)	Large variation, very difficult to design to be relevant for humans	Nutrient content, sub-toxic effects of pesticide residues	None, since fertility is rarely limited by the same factors as in multiparous animals	May be applicable if confirmed in more relevant studies	Use marker for health impact that is clearly relevant for humans
Diet made from organic vegetables fed to rats (Lauridsen)	More regular sleep pattern, higher IgA levels, less fat deposition, better uptake of vitamin E	Not typical production systems. Experiment was not replicated	Sub-toxic effects of pesticide residues, benefits of natural substances	Decrease risks of obesity, depression, immune dysfunction and related syndromes if confirmed	May be applicable if confirmed in more relevant studies	Conduct more replications. Test different types of diets. Find "active ingredients"
Biodynamic diet, in children attending anthroposophic schools (Alfvén)	Reduced incidence of rhinoconjunctivitis symptoms and atopic sensitisation	Not all food biodynamic, confounded by vaccinations, smoking, social class. Not blinded	Multifactorial, including more fermented vegetables	Decreased incidence of allergies if food is the major factor	May be applicable if confirmed in more relevant studies	Test relevant factors in controlled studies as appropriate, including animal studies