

QLIF subproject 2: Effects of production methods



Photo: ICROFS

Determining the effect of organic and low-input production methods on food quality and safety

The objectives of QLIF subproject 2 were to: (i) identify the effect of production systems (organic, low-input and conventional) on food quality and safety parameters; (ii) identify agronomic parameters responsible for differences in food quality and safety; (iii) carry out a pilot study into the effect of consumption of organic crops on hormonal balances and immune status in a model experimental animal system.

The results showed that organic food production methods resulted in: (a) higher levels of nutritionally desirable compounds (e.g., vitamins/antioxidants and poly-unsaturated fatty acids such as omega-3 and CLA); (b) lower levels of nutritionally undesirable compounds such as heavy metals, mycotoxins, pesticide residues and glyco-alkaloids in a range of crops and/or milk; (c) a lower risk of faecal *Salmonella* shedding in pigs. These nutritional benefits were linked to specific agronomic practices that are prescribed by organic farming standards. Pilot studies showed that these composition differences may translate into measurable health benefits in a model experimental system with rats. Further elaboration on the complex interaction between production methods and health benefits will have to be addressed in future studies.

Food from organic farming systems tends to have more nutritionally desirable compounds due to the organic fertiliser and feeding regimes

Effects of production systems

Organic farming systems prohibit the use of chemosynthetic mineral fertilisers, pesticides, growth regulators, hormones and most food additives. Standards also restrict the use of veterinary medicines and impose longer withdrawal periods of products from medicine-treated animals. As a result, there are much lower levels of agrochemicals in organic compared to conventional foods. However, higher risks of contamination from mycotoxins, heavy metals and enteric pathogens have frequently been ascribed to organic production methods, although there are virtually no scientifically sound studies to support these claims.

In contrast, in the 1990s and early 2000s there were a range of studies reporting that foods from organic crop and livestock production systems had higher concentrations of nutritionally desirable compounds such as vitamins, antioxidants and certain poly-unsaturated fatty acids. Yet, there were also some studies reporting no significant differences in composition between organic and conventional foods and/or a few studies reporting higher levels of certain desirable compounds in conventional foods. Most of these studies were based on either systems comparisons of foods produced in organic and conventionally managed fields or studies in which organic and conventional foods were purchased in different retail outlets and compared.

While these studies provided an estimate of the differences in food quality a consumer is faced with, they were scientifically unsatisfactory, because they did not allow the reasons for differences in food quality to be linked to agronomic factors that differ between organic and conventional production. These factors include: (a) fertilisation, crop protection regimes, rotation design and/or variety choice in crop production and (b) feeding regimes, health management, husbandry methods and/or breed/ genotype choice in livestock production.

The aim of QLIF subproject 2 was to: (i) identify the effect of organic, low-input and conventional production systems on food quality and safety parameters; (ii) identify agronomic parameters responsible for differences in food quality and safety; and



Photo: Organic Denmark

(iii) carry out a pilot study into the effect of consumption of organic crops on hormonal balances and immune status in a model experimental animal system.

Nutritionally desirable compounds in crops

Factorial field trials were established to identify the effect of fertilisation and crop protection regimes and rotational design on the nutritional composition of crops. Significantly higher levels of antioxidants, vitamins and/or other nutritionally desirable phytochemicals (e.g., glucosinolates in cabbage) were detected in a range of organic field vegetable and glasshouse crops (cabbage, lettuce, potato, tomato) when compared to conventionally grown crops.

In most crops, the increase in phytochemical content was linked to the fertilisation regimes (non-use of mineral fertilisers) used in organic production systems. Fertilisation regimes also affected gene expression, protein profiles and concentrations of resistance compounds, indicating that the impact of using organic matter rather than mineral fertiliser on crops has been underestimated.

For some crops (e.g., lettuce) significantly increased vitamin levels in organic crops were also linked to the crop protection regimes applied in organic systems (non-use of herbicides, pesticides and fungicides).

These data clearly indicate that the non-use of chemosynthetic mineral fertilisers, and in some cases pesticides, can improve the nutritional composition in a range of crops.

In contrast, insect-proof netting, used to protect organic cabbages against insect attack, caused a reduced concentration of certain antioxidants, compared to crops protected by pesticides. Clearly this is an area where organic farming practice needs to develop insect control strategies to improve the nutritional quality of crops.

Nutritionally undesirable crop compounds

In the factorial field trials, significantly higher levels of certain heavy metals (especially cadmium and nickel) were found in conventionally managed field vegetables, potato and wheat crops. In conventional potatoes, glycoalkaloid levels were also found to be higher. A meta-analysis of literature data showed that *Fusarium* mycotoxin levels were 2-3 times lower in cereal grains from organic production systems compared to conventional. According to the available literature, the lower levels in organic grain are due to a range of agronomic factors including the use of diverse rotations, non-use of high rates of chemosynthetic mineral N-fertilisers, certain fungicides and growth regulators that were all linked to higher *Fusarium* mycotoxin risk. As expected, levels of pesticide and growth regulator residues were only found in crops under conventional crop protection regimes.

These studies provide evidence that organic foods contain lower levels of many of the nutritionally undesirable compounds that are of concern to consumers. They also show that it is a myth that the risk of mycotoxin contamination increases when chemosynthetic pesticides are omitted from crop production.

Nutritionally desirable compounds in milk

A large scale, dairy-farm survey was carried out to investigate the effect of organic and conventional production methods on milk

quality. In all four study countries (Sweden, Denmark, UK and Italy) composition differed between milk from organic and conventional dairy herds. A range of nutritionally desirable vitamins/antioxidants such as Vitamin E, β -carotene, lutein and poly-unsaturated fatty acids (e.g., omega-3 fatty acids) were found at higher levels (up to 70%) in organic compared to conventional milk samples from the same country. However, there were also differences in milk composition between countries and between the summer outdoor grazing and the winter indoor periods when cows are fed a conserved forage-based diet.

Importantly, differences in milk composition were smaller during the winter indoor period. The long periods of outdoor grazing and high level of forage prescribed for dairy cow diets under organic production standards were identified as the main reasons for the higher levels of nutritionally desirable fatty acids and vitamins/antioxidants. Results from the farm survey were recently confirmed by a comparison of organic and conventional milk based on samples from major UK retail chains.

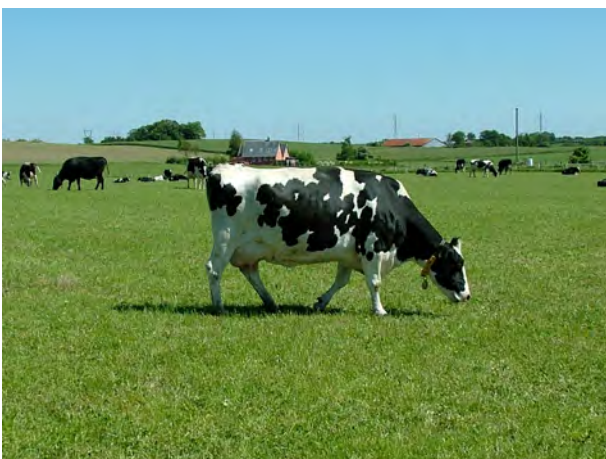
Reduced risk of pathogen transfer from pigs

A study in Denmark compared the levels of faecal *Salmonella* shedding in contrasting pig production systems. Data showed that the proportion of pigs with detectable levels of *Salmonella* in their faeces was 2-3 times higher in pigs from intensive indoor systems compared to both organic and conventional outdoor rearing systems. This demonstrated that outdoor rearing systems not only provide a more natural, welfare-friendly environment for pigs, but also reduce the risk of enteric pathogen transfer into the human food chain.

Impact of organic food consumption

In a pilot study, rats were reared on diets made from crops grown in the factorial field trials (see above). Differences in fertilisation and to a lesser extent crop protection had a significant effect on hormonal balances and immune status of the animals. Also, close correlations were detected between the concentration of specific hormones and the dietary intake of phytochemicals found in higher concentrations in rat feeds made from organic compared to conventional crops. These studies are thought to represent an important first step towards gaining an understanding of how the way we produce food can impact on their composition and ultimately animal and human health.

Photo: ICROFS



QLIF subproject 2: Quantifying the effect of organic and low input production methods on food quality and safety and human health

Subproject coordinator

Carlo Leifert, School of Agriculture Food and Rural Development, Newcastle Univ, UK

Email: c.leifert@ncl.ac.uk

Address: Nafferton Ecological Farming Group, Nafferton Farm, Stocksfield, NE43 7XD, UK

Subproject participants

Peter Shotton, Lorna Lueck, Julia Cooper, Mick Eyre, Gillian Butler, Steve Wilcockson, Robert Shiel, Andrew Carmichael, Chris Seal, Carlo Leifert, Newcastle Univ (UK), Tina Slots, Jacob H Nielsen, Marianne Bonde, Jan T Sørensen, ICROFS, Univ of Aarhus (DK), Jana Halslova, Vera Shulzova, Institute of Chemical Technology (CZ), Ismail Cakmak, Sabanci Univ (TR), Andrea Borsari, Angela Canever, GRAN (IT), Ewa Rembialska, Anna Baranska, Kristina Swarlo-Sonta, Evelina Hallmann, Katja Wisniewska, Johanna Groadzka-Ostrowska, Warsaw Agricultural Univ (PL) Richard N Bennett, Eduardo Rosa, Univ de Tras-os-Montes e Alto Douro (PT)

Selected publications

Lehesranta SJ, Koistinen KM, Massat N, Davies HV, Shepherd LVT, McNicol JW, Cakmak I, Cooper J, Lueck L, Kärenlampi SO, Leifert C (2007) Effects of agricultural production systems and their components on protein profiles of potato tubers. *Proteomics* 7, 597-604

Butler G, Collomb M, Rehberger B, Sanderson R, Eyre M, Leifert C (2008). CLA isomer concentrations in milk from high and low input management dairy systems. *Journal of Sci of Agriculture and Food* 89, 697-705

Butler G, Nielsen JH, Slots T, Seal C, Eyre MD, Sanderson R, Leifert C (2008) Fatty acid and fat soluble antioxidant concentrations in milk from high and low input conventional and organic systems; seasonal variation. *Journal of Sci of Agriculture and Food* 88, 1431-1441

Leifert C, Ball K, Cooper JM (2008) Control of enteric pathogens in ready-to-eat vegetable crops in organic and "low input" production systems: a HACCP based approach. *Journal of Applied Microbiol* 105, 931-950

About QLIF

The Integrated Project QualityLowInputFood aims to improve quality, ensure safety and reduce costs along the organic and low-input food supply chains through research, dissemination and training activities. The project focuses on increasing value to both consumers and producers using a fork-to-farm approach. The project is funded by the European Union and runs from March 2004 to March 2009. The research involves thirty-one research institutions, companies and universities throughout Europe and beyond.

QLIF comprises seven subprojects on:

- 1) Consumer expectations and attitudes
- 2) Effects of production methods
- 3) Crop production systems
- 4) Livestock production systems
- 5) Processing strategies
- 6) Transport, trading and retailing
- 7) Horizontal activities



Project co-ordinator

Prof. Carlo Leifert, University of Newcastle (UNE), UK

Academic co-ordinator

Dr Urs Niggli, Research Institute of Organic Agriculture (FiBL)

Information on partners and subprojects is found at the project website www.qlif.org. The website also holds the library for project newsletters and serves as entry to Organic Eprints, where more than 100 publications from the QLIF project are available: http://orgprints.org/view/projects/eu_qlif.html