

Improving the quality and safety of organic and low input foods and maximizing the benefits to consumers and producers

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Abstract

'Improving quality and safety and reduction of cost in the European organic and 'low input' supply chains' (QLIF) is an Integrated Project under the 6th Framework Programme of the European Commission which started in March 2004 and will end in February 2009. After three years of research by 31 QLIF partners, the scientific data on the benefits of the system approach used in organic and 'low input' agriculture has expanded considerably. At the same time the project has developed an array of technological innovations that are applicable to a wide range of food production systems and novel approaches for whole food chain management. During the 3rd QLIF Congress held at the University of Hohenheim, Germany, in March 2007, these results were discussed in nine synthesis papers and in 37 in-depth papers.³

Introduction

QLIF initially had 31 partners and included a further five partners via open calls after the project had started. The total budget is € 18 million of which the Commission contributes € 12.4 million. The duration of the project is five years.

The QLIF project aims to improve quality, ensure safety and reduce costs along the organic and 'low input' food supply chains through research, dissemination and training activities. It focuses on increasing value to both consumers and producers and on supporting the development of realistic business plans for all components of the food chain, using a farm to fork approach.

The main target is to facilitate measurable improvements in food quality and safety, but some potential impacts on human and animal health are also being explored (see figure 1).

The project has four main objectives:

- To identify consumer expectations, perceptions and actual buying behaviours in relation to organic and low input foods in order to enable such farming systems to be developed 'in tune' with consumer expectations, using a range of consumer survey and test marketing methodologies (7% of project effort).
- To quantify the impact of current organic and 'low input' management practices on the nutritional, sensory, microbiological and toxicological quality/safety of foods, using multi-factorial field trials and food analytical & nutritional experiments/surveys (30% of effort).
- To develop novel strategies/technologies which improve quality, ensure safety and reduce production cost throughout the organic and 'low input' food supply chains. This is achieved by a combination of laboratory and field research, including 'farmer participatory' approaches and facilitated through the involvement of ten industry partners (six small and medium-sized enterprises) representing primary production, processing, marketing, services and quality assurance businesses (55% of effort).
- To identify socio-economic, environmental and sustainability impacts of project innovations, efficiently disseminate project results and provide training opportunities to user and stakeholder groups as well as junior scientists (8% of effort).

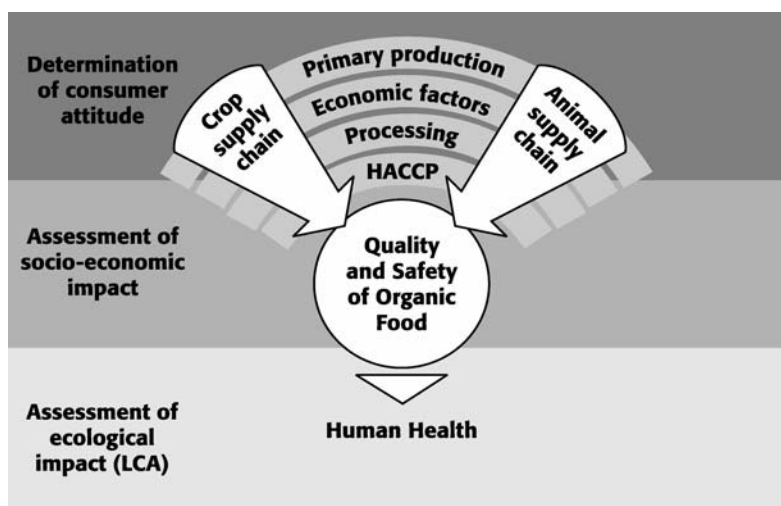


Figure 1: The food chain and the system approach of the QLIF project.

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³ A full list of all papers of the QLIF project presented at this congress is provided at the end of these proceedings.

The project pursues a whole food chain approach where findings and in many cases concrete deliverables are taken up from one investigation (= work package) to the other. The project also seeks to involve scientists in interdisciplinary research work and to enable them to understand 'in depth' methodological approaches and results from other disciplines. QLIF focuses on both organic production systems and on 'low input' crop and livestock systems which are characterized by reduced use of fertilizers, crop protectants, veterinary medicine, growth promoters/regulators and food additives and animal welfare focused livestock husbandry systems (e.g. 'free range' systems). While addressing many research questions and technological bottlenecks relevant to organic food, it is recognized that not all requirements of organic farming can be met within the scope of this project.

Consumer perceptions and buying attitudes (subproject 1)

The available local and national consumer studies were critically re-evaluated in order to gain a clearer picture of the expectations of European consumers and their buying attitudes. It was found that organic markets are segmented into a smaller group of regular buyers and a large group of consumers who occasionally buy organic food. Whilst the first group is relatively stable, further growth of consumption is thought to depend on increasing the numbers and 'dedication' of occasional consumers. Focus groups and in-depth interviews showed that for the occasional consumers, organic and 'low input' alternatives ('free range', 'local' and even 'integrated production') are market substitutes. Therefore, more information on factors affecting product loyalty and the drivers behind consumer decision making (e.g. why 'low input' or organic products are chosen) are needed and will be provided in years four and five of the QLIF project. Methods used will include ethnographic observation, cross-European household panels and choice experiments.

For a more detailed description of the work carried out under subproject 1 see Zanoli *et al.*, 2007.

Nutritional quality and safety of organic and low input food and effects on livestock and human health (subproject 2)

Intuitively, consumers expect organic food (and also 'low input' alternatives/substitutes) to have a higher nutritional value, to be healthier, or simply to be safer or less risky. The effects of organic and 'low input' production methods on food quality and safety and finally on livestock and human health are therefore scrutinized in experiments under subproject 2. Wheat, potato, cabbage, onion and lettuce were chosen as model crops, complemented by some work on feed crops and dairy production as the main livestock model. It was shown that high input (conventional) crops have higher levels of protein and vitamin E (wheat), carotenoids (potato, cabbage, lettuce) and alkaloids (potato) whereas organically grown crops tend to have more phytic acid (wheat), volatile metabolites (potato), phenolic compounds (potato, cabbage), glucosinolates and vitamin C (cabbage). Not well designed 'low input' methods in wheat production, which omitted either pesticides or mineral fertilizers, resulted in the highest levels of undesirable compounds (e.g. mycotoxin loads). However, work in the first three years also showed that the relative impact of adopting organic and low input production methods on food quality and safety may change over time (e.g. because of long-term effects on soil characteristics and/or changes in plant and animal varieties/breeds used).

An extensive milk quality survey of different dairy production systems in Denmark, Sweden, the United Kingdom and Italy demonstrated that milk from organic and low input, grazing-based dairy systems has significantly higher levels of the nutritionally desirable unsaturated fatty acids (the omega-3 fatty acids, vaccenic acid and conjugated linolenic acid) compared to milk from conventional production methods. Similar results were obtained with fat soluble antioxidants like α -tocopherol, β -carotene, lutein and zeaxanthine where organic and other grazing-based production systems were better than conventional ones.

In order to assess potential risks of organic and outdoor livestock management, the pathogen shedding of pigs was studied. Results indicate that, compared to pigs reared indoors, pigs reared in organic and other outdoor systems are more likely to come into contact with *Salmonella* and to develop immunity, resulting in pathogen shedding being reduced both on the farm and at slaughter.

Still not very conclusive are the results of two work packages which investigate the effects of organic, low input and conventional feeds on animal health status. One study showed no significant effect of chloro-choline chloride (CCC) on pig reproductive health. According to the second study organic wheat and vegetables seem to improve the immunological status of rats, but many interactions between the sex and the age of the animals occurred.

For a more detailed description of work under subproject 2 see Leifert *et al.*, 2007.

How can different crop strategies improve the quality and safety of food? (subproject 3)

The potential of organic and 'low input' methods for high quality, high safety and economically viable crops is far from fully exploited. Consequently, crop strategies are being scrutinized, namely interactions between soil fertility and plant health, nutrient release characteristics and nutrient uptake in organically managed soils, organic manuring and food safety as well as pest and disease control. In organic systems (and to a lesser extent in 'low input' systems), soil fertility management and its effect on plant health and eventually on yield, quality and food-borne pathogens are major issues to be addressed by research. The long-term use of organic matter based fertility inputs was shown to significantly increase the efficiency of organic production (input/output ratio) and also to suppress both seed-borne and foliar diseases.

In order to analyse the wide range of interactions responsible for such effects and to enable farmers to make the best use of them, long-term field experiments are crucial. Several work packages of both subproject 2 and 3 use long-term experiments in various parts of Europe, to facilitate the development of improved nutrient models and precision farming systems. As a main result it can be concluded that the potential of manure and compost based systems for improving crop yields and crop quality is still high. Wheat as a model crop showed the potential of fertility management improvements in order to increase both yields and quality. Field trials in the UK in 2005 demonstrated how improved fertility management increased yields of winter wheat by 6 to 33% (depending on the cultivar) and in summer wheat by (-4) up to 14%. Novel wheat varieties selected especially for 'low input' conditions produced protein contents between 11 and 12%, while the reference cultivar remained at 9.2%.

On the other hand, soil fertility is only one factor affecting disease suppression, as many interactions with other agronomic factors and soil properties occur. These will be analysed in the second half of QLIF.

The use of manure in organic farming systems – while having significant benefits for soil structural stability, biological activity and overall fertility – has also been criticized because it may increase the risk of transfer of enteric pathogens into the food

chain. These aspects were addressed by several field experiments. Enteric pathogens were found in lettuce at extremely low levels and independently of whether organic manure or mineral fertilizers were used. The most efficient way to reduce pathogen loads was shown to be the composting of manure.

Crop protection in organic and 'low input' systems has remained a bottleneck and affects both the cost of these production systems and the quality (and safety) of food products. The integrated use of preventative protection strategies (rotation design, fertility management, environmental diversification) are the basis of weed, pest and disease control in low input crop production. Such strategies minimize the need for crop protection products. In the QLIF project wheat, tomato, onion and apples were chosen as model crops to develop (a) a wide range of novel preventative crop protection techniques and approaches and (b) integrate preventative techniques with crop protection methods based on more benign forms of intervention (companion plants, biological control agents, elicitors and plant extract based products). Results so far are extremely promising and substantial progress can be expected when transferred into practice.

For a more detailed description of work under subproject 3 see Tamm *et al.*, 2007.

How can different livestock strategies improve the quality and safety of food? (subproject 4)

The livestock work packages of the QLIF project focus on the development of improved strategies for (a) the control of endo- and ectoparasites as well as bacterial zoonoses in pigs and poultry, (b) maintaining udder health and reducing enteric pathogen shedding in dairy cows and (c) improving feeding regimes for poultry and pig production systems and (d) health status of pigs. In these trials, both product quality and food safety are addressed.

The experiments with different layouts of hen runs showed that the prevalence of endoparasites (e.g. *Heterakis* and *Ascaridia*) is strongly influenced by the size of the run and the density of hens. Unfortunately, what has been defined so far as an 'ideal' run is not good enough, as only a very low hen density could reduce the average faecal egg counts.

Bioactive compounds in fodder plants, such as inulin (in dried chicory roots) appear to be very effective against nodular worm of pigs but not against roundworms. In contrast, no reduction of endoparasites could be observed in poultry fed with anthelmintic plant products. Positive results were obtained by diatomaceous earth (86% silica, 5% sodium, 3% magnesium and 2% iron) on poultry ectoparasites, an effect which was equal to natural acaricides.

In co-operation with farmer groups, mastitis prevention strategies were developed on dairy farms. As the knowledge of the farmers on preventive management measures and on non-antibiotic therapies is generally low, the co-operation between farmers and veterinarians led to a considerable improvement of udder health status. Some farmers were able to reduce the use of antibiotics to zero and in parallel to improve milk quality, including somatic cell count. In addition, a novel teat sealant was successfully tested and recommendations were made for sealants, homeopathic treatments and targeted antibiotic use. A successful case study comparing three calf rearing methods showed that suckling methods did not have a negative effect on milk quality (somatic cell counts). This is important evidence as mother cows and calves are more robust and less disease susceptible if they are allowed a longer and more natural suckling period.

Feeding experiments with pigs showed that supplementation of feed with synthetic amino acids can be replaced by use of home-grown grain legumes. Although the pig performance suffered, the intramuscular fat content (IMF) increased, resulting in a better meat quality and economic performance was therefore not affected negatively. In an on-farm study in Germany and Austria, experimental groups of pigs were fed during the fattening period with high proportions of grain legumes (36 and 40% respectively) in order to verify the on-station results. The grain legumes consisted of lupines, faba beans and peas. Although results are impressive so far, more knowledge on the digestibility of protein, amino acids and energy in organically grown protein crops is urgently needed.

Feed supplementation with probiotic bacteria (Lactic Acids Bacteria, LAB) can significantly decrease the risk of gastrointestinal infections and diarrhoea caused by enteric bacterial pathogens. In the QLIF project, we investigated the synergistic effect of adding oligosaccharides and lactose containing whey. These 'nutraceuticals' were tested after weaning and for piglets challenged with *Salmonella*. Although some effects on growth performance were significant, initial culture based tests indicate that *Salmonella* populations were not reduced. In a next stage, the probiotics will be tested on growing-finishing pigs and more sensitive molecular tests are being employed to test the impact of treatments on microbial diversity and *Salmonella* populations in the upper intestine of pigs.

For a more detailed description of the work carried out under subproject 4 see Spooler *et al.*, 2007.

Improving food quality and safety by 'low input' food processing methods (subproject 5)

The processing of food also affects food quality and safety. In a Delphi study European experts welcome the development of clear principles and criteria for the evaluation of additives and processing methods. 'Careful processing', 'minimal use of additives' and 'authenticity of food' seem best to describe principles for a future regulation of processing. In order to implement such principles, a code of practice is needed. It will provide clear guidance for operators on company level. Nonetheless, reconciling the three main trends (authenticity of food, added value with regard to health and ethical issues, and convenience) in consumer wishes with respect to food will remain a challenge, in particular for the organic food industry. Two main topics of processing are addressed in the project by experimental work: The first is the treatment of ready-to-eat lettuce where the conventional treatment with chlorine is replaced by careful and natural disinfection methods (e.g. ozone). This was shown to be successful but has so far only been done on a laboratory scale. In the last phase of the project, these small scale procedures have to be tested on industry scale. A second experimental study was carried out on fermentation processes of dairy products enhancing CLA content (e.g. butter).

Improving food quality and safety by HACCP and reducing costs of the organic food chain (subproject 6)

HACCP protocols and manuals for six commodities (wheat, field vegetables, apples, milk, eggs, pork meat) are being developed within the QLIF project. These HACCP based quality assurance systems address both (a) minimizing food safety and quality hazards and (b) ensuring maximum desirable quality characteristics demanded by the market. The focus on ensuring 'added value' quality characteristics (in particular nutritional composition) is a major difference to conventional HACCP systems, but essential for consumer confidence in organic standards. In some cases, organic production and processing standards are quite complex and demanding, and open to error. Such complex situations (e.g. with different conversion periods in animal and crop

production and different rules for annual and perennial crops) are best addressed by the establishment of a detailed customized HACCP system (see Knight and Stanley, 2007).

The goal to analyse the economic performance of different food chains on a European scale was ambitious. Case studies have been performed with wheat, tomatoes, apples, milk, pork and eggs. In a first round of semi-structured interviews with enterprise managers (SWOT analysis) economic problems of the food chains were analysed. Weak points of European organic food supply chains were high logistic and transport cost, high input costs and low expenditure on research and product development. As the organic food market is a niche (1% of the total EU market), there is on the individual company level no benefit from economies of scale. A key strategy for companies in order to reduce costs would therefore be improved co-operation (see Stolze *et al.*, 2007).

Assessment of the ecological impact of novel strategies and technologies in organic food systems and outreach of the QLIF project (subproject 7)

Organic farming reduces many of the environmental and ecological problems caused by intensive conventional farming such as pollution, loss of biodiversity, soil erosion etc. However, there are also critical points in the way that organic farming is practised. As a result it is important that new strategies and novel technologies that allow environmental impacts to be reduced further are introduced into organic and low input farming systems, through projects such as QLIF or other national and international research activities. In a first approach, subproject 7 addresses nitrate leaching depending on changes and optimization of crop rotations. Additional simulations will also be done with other factors (e.g. energy use) to provide an overall ecological and environment impact assessment of innovations developed under QLIF. The goal of these investigations is to improve the overall sustainability of organic production strategies on both crop and livestock level (see Thorup-Kristensen, 2007).

Dissemination of results gained through basic and applied research activities is a crucial effort of the QLIF project. In addition to many well known tools for outreach such as peer reviewed papers, publication in farmers' journals and magazines, all QLIF project outputs are made available at the Organic Eprints online archive at <http://www.orgprints.org/>, the most frequently visited Internet site for organic stakeholders. QLIF results have also recently been published in a '*Handbook of organic food quality and safety*' for producers, processors and scientists (Cooper *et al.* 2007).

Outreach activities include farmer workshops and visits to field trials, and QLIF training programmes for Master and PhD students as well as for junior scientists in cutting-edge organic food and farming research. These international training and exchange courses offer 'state of the art' knowledge on interdisciplinary and trans-disciplinary research approaches used in agricultural, landscape and environmental science and build a bridge for young scientists to poly-factorial and multi-level problems in practical science (see van der Burgt and Wagenaar, 2007).

Closing remark

The first three years of the QLIF project have clearly demonstrated the significant advantages of using a large 'integrated project' approach for the development of an industry (low input and organic farming, processing and retailing) that relies on the integration of both (a) a wide range of production system components and (b) multidisciplinary teams from across Europe to achieve its food quality, safety and production efficiency targets. QLIF has clearly already contributed significantly to achieving its specific research & development and wider integration objectives. It has also identified a range of issues (most importantly to select and breed crop varieties and animal breeds that are better adapted to organic and low input systems) that need to be addressed in future integrated research & development programmes.

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References

- J Cooper, J., U Niggli, U. & C Leifert, C. (2007). Handbook of organic food quality and safety. Woodhead Publishing Ltd. London.
- Knight, C., Stanley, R. (2007) HACCP based quality assurance systems for organic food production systems. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Kretzschmar, U., Ploeger, A., Schmid, O. (2007) Development of a framework for the design of minimum processing strategies which guarantee food quality and safety - Principles, concepts and recommendations for the future. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Leifert, C., Rembialkowska, E., Nielson, J.H., Cooper, J.M., Butler, G., Lueck, L. (2007) Quantifying the effect of organic and 'low input' production methods on food quality and safety and human health. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Spoolder, H.A.M., Maurer, V. and Sundrum, A. (2007) Development of strategies to improve quality and safety and reduce cost of production in organic and 'low input' livestock production systems. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Stolze, M., Bahrdt, K., Bteich, M.R., Lampkin, N., Naspetti, S., Nicholas, P., Paladini, M.E., Zanoli, R. (2007) Strategies to improve quality and safety and reduce costs along the food supply chain. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Tamm, L., Köpke, U., Cohen, Y. & Leifert, C. (2007) Development of strategies to improve quality and safety and reduce cost of production in organic and 'low input' crop production systems. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Thorup-Kristensen, K. (2007) Effect of crop management practices on the sustainability and environmental impact of organic and low input food production systems. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- van der Burgt, G.J.H.M. and Wagenaar, J.P. (2007) International training and exchange – a useful instrument in knowledge and attitude dissemination. In: Niggli, U. *et al.* (Eds) (2007): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland
- Zanoli, R., François, M., Midmore, P., O'Doherty-Jensen, K., Ritson, C. (2007) Determining consumer expectations, attitudes and buying behaviour towards 'low input' and organic foods. In: Niggli, U. *et al.* (Eds): *Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF)*. FiBL, Frick, Switzerland