

## Development of strategies to improve quality and safety and reduce cost of production in organic and “low input” livestock production systems

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**Key words:** organic husbandry, animal health, meat quality, animal nutrition, probiotics

### Abstract

*The demand for organic livestock products is still increasing. To support this growth and to help remove potential obstacles the fourth Subproject of QLIF addresses several themes related to livestock farming. In this overview paper the main results to date are presented. It briefly discusses progress made on preventative treatments against pig and poultry parasites, as well as the reduction of rodent burdens on farm. The activities on probiotics and nutraceuticals experiments are listed, as are studies undertaken to improve the meat quality of pigs through different protein sources and diet composition. Finally, work is being presented aiming to reduce the incidence of mastitis, and the reduction of faecal shedding of pathogens in cattle. The overview concludes that much work has been done, but that the main task of increasing competitiveness of the organic and low-input livestock sector through the implementation of our knowledge, still lies ahead of us.*

### Introduction

There is an increasing demand for organic and “low input” food from livestock production systems (Verbeke and Viaene, 2000; Andersen et al, 2005). The major reasons for this are consumer perceptions about health, animal welfare and environmental benefits. It is perceived, for example, that organic farming is associated with

- healthy livestock without the excessive use of veterinary medicines,
- behavioural freedom (space allowance) for the animals,
- more ‘natural’ (outdoor) rearing systems,
- species specific diets which meet the needs of the animals,
- the absence of GM-based feeds.

Organic farming can meet these expectations, but there are at least two important concerns that need to be addressed if the current development is to be continued. First of all, consumer may be reluctant to purchase organic products of animals’ origin due to high premium prices for meat from poultry, pork and beef production systems in

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particular. Secondly, there are a number of concerns raised by scientists with complaints about the lack of resources and specific management skills that are required to handle the demanding organic livestock production (Vaarst et al, 2006). Correspondingly, deficits in the management may increase health risks for livestock when kept in relatively 'open' organic husbandry systems (Spooler, in press). In addition to the reduced animal welfare, this could lead to human health risks if zoonotic pathogens are implicated. These concerns will need to be addressed as they both affect consumer demand for organic livestock products.

The QualityLowInputFood project, QLIF, addresses these issues in its fourth Sub-project on organic livestock production systems. Six main themes are dealt with in SP4, one per Work Package.

#### **WP4.1 Development of improved preventive management strategies for endo- and ectoparasites and bacterial zoonoses of pigs and poultry.**

Organic production standards for pigs and poultry require outdoor access. As a result, animals are exposed to a wider range of potential endo- and ectoparasites infection sources and challenges than animals kept under conventional indoor conditions. Preventing contact with these vectors are a first line of defence against parasites and disease.

In a two year study by Meerburg *et al* (2005) rodents and insectivores (n=282) were trapped on ten organic farms by using live-traps. *Salmonella* and *Campylobacter* infections were encountered in house mice and Norway rats, but not in other species. Further more, *Toxoplasma gondii* antibodies could be detected in 6.4% of the blood samples taken from 235 wild small mammals. Rodent control therefore appears to be of significant importance, and during the autumn of 2005 a study was set up 20 organic pig farms whereby two different rodent control methods were compared. Ten farms used conventional rodenticides and ten farms used live traps. Both treatments did not differ significantly, indicating that the use of live-traps may be a good alternative for rodent control on organic farms.

*At present the effects of rodent control on T. gondii seroprevalence (on farms with a know T. gondii presence) are investigated, and appear to give promising results.*

To investigate the effect of outdoor run management on poultry parasites, Maurer (2005) compared three different types of outdoor runs with increasing grass cover in small flocks of laying hens. In year 1, hens with helminth field infections had been used to contaminate the runs. In years 2 and 3, parasite naive young layers were put on the contaminated runs. The runs were managed according to different three regimes: "overused" old poultry run, "ideal" new run and an "extensive" run with structures and natural or artificial shelters, not mown. *Ascaridia galli* and *Heterakis gallinarum* were present on all farms and in all flocks. Tapeworms and *Capillaria spp.* occurred in a substantial proportion of the hens. The prevalences of Ascarids as well as the average faecal egg counts FECs were lowest in the "extensive" runs, whereas FECs of the "overused" and "ideal" runs were on a comparable level.

*Work on indoor litter management to reduce worm burden is ongoing.*

For pigs a different strategy was applied. Vermeer *et al.* (2006) aimed to reduce the infection pressure in the outside dunging area by directing pig dunging behaviour in such a way that infected faeces would be concentrated (localised) in the pen, rather than spread out over the whole area available. Eight groups of 14 pigs each were

allocated to one of 4 treatments in 4 batches lasting about 4 months. The treatments were designed to provide increasingly strong stimuli in the outdoor run to direct dunging behaviour towards the part of the run which was furthest from the outside pen wall, and easiest to clean manually. The study showed that dunging behaviour can be directed (pigs will use a designated 'toilet area'), but no difference in *Ascaris suum* infection was found between the four treatments applied.

*Work is now concentrating on the frequency of cleaning required to minimise the infection burden of these localised dunging areas.*

The second preventative strategy against pig endoparasites is to use carbohydrate sources with high contents of fructooligosaccharides (FOS) by Meijer, Thamsborg and co-workers. FOS are expected to significantly reduce female worm fecundity and worm numbers of both *Oesophagostomum* and *Trichuris* in pigs without affecting pig growth or production costs. The trials so far showed an effect on the egg excretion and worm burdens of *Oesophagostomum* only, with dried chicory roots being more effective against the parasite than Jerusalem artichokes.

*Currently work is underway to follow the egg excretion patterns of sows during and after a short feeding period to evaluate if environmental contamination can be reduced.*

#### **WP4.2 Development of alternative treatment strategies versus endo- and ectoparasites of pigs and poultry**

In its second year, the project has made a start with the investigation of alternative solutions to conventional anthelmintic drugs. In several experiments carried out by Maurer and co-workers, either laying hens naturally infected with *A. galli* and *H. gallinarum* or pullets with artificial *A. galli* infections were fed with promising anthelmintic plant products, identified in a literature survey. To date, none yielded a significant reduction in faecal egg count or reductions of *A. galli* burdens.

Control of the poultry red mite *Dermanyssus gallinae* is a challenge for organic as well as conventional egg producers. In organic poultry production, control should be attempted by mechanically acting substances (e.g. oils or diatomaceous earth), before acaricides are applied. In experiments by Maurer and Perler (2006), diatomaceous earth (DE) without acaricides was at least as effective as DE supplemented with pyrethrum or essential oils and a liquid formulation of silica *in vitro*. On farm, DE was effective during a limited period only, whereas the liquid formulation had a very good residual effect over several weeks.

*Tests with higher concentrations and different application schemes of the respective products are ongoing.*

#### **WP4.3 Develop strategies to augment non-immune system based defence mechanisms against gastrointestinal diseases in the pig**

The use of antibiotic growth promoters is not permitted in organic and most "low input" conventional pig and poultry production systems (EC Regulation 1804/1999). A range of studies has shown that probiotic treatments based on Lactic Acid Bacteria (LAB e.g. *Lactobacillus*, *Pediococcus* and *Bifidobacterium* spp.) can reduce the risk of gastrointestinal infections and diarrhoea caused by enteric bacterial pathogens.

The addition of certain compounds (e.g. oligosaccharides, lactose containing whey) was shown to increase the competitiveness and population density of LAB in the intestine after weaning, by providing selective nutrient sources for LAB. Such "nutraceuticals" are thought to improve the establishment of probiotic inocula when added in combination to the feed of newly weaned pigs. The most active probiotic strains had been identified in an earlier work by Biavati and co-workers, and recent work has concentrated on the effect of possible combinations of pro- and nutraceuticals on the population densities of LAB in the intestine. It appears that the use of a fibre supplementation in the pig's diet did not interact with the probiotic dose. However, the presence of FOS can stimulate bifidobacteria in the caecum, but it does not give additional growth stimulus when it is supplemented with the increasing dose of supplemented bifidobacteria.

In a subsequent trial, Biavati *et al* investigated if a strain of *Bifidobacterium animalis* would have beneficial effects for piglets challenged with *Salmonella enterica* serovar *typhimurium*. They found that by using the probiotic inocula the number of bifidobacteria in the caecum content significantly increased. There was, however, no significant effect of the probiotic on the *Salmonella* population, even though growth performance in the probiotic group was positive when compared to the control.

*Bifidobacterium* spp. with high resistance to low pH conditions are expected to survive better during transit in the acidic environment of the stomach. Although their susceptibility to acidified nitrite or thiocyanate solutions has not been determined, it is likely that the presence of nitrite or thiocyanate in the stomach acid will reduce the viability of *Bifidobacterium* cells during transit. Carlini *et al.* tested the susceptibility of strains of *Bifidobacterium* spp. from various origins for sensitivity to eight pH-values and combinations with 6 concentrations of nitrite and thiocyanate. From this, a ranking was determined of best surviving strains, and the strains with the best resistance profiles were subjected to various compositions of cultural medium (different sources of nitrogen and carbon) and cultural conditions (temperature, inoculum percentage, incubation time, pH of neutralization, etc.) to establish optimal growth conditions for each strain. Again, a ranking was determined.

*A total of 24 kg of one of the most promising probiotic cultures was shipped to another project partner (BOKU) to support feed trials on growing-finishing pigs.*

Apart from probiotics, diets containing significant amounts of nitrate and/or isothiocyanate (e.g. green plant materials, Brassicas and/or Cassava) have recently been shown to increase the antimicrobial activity of the stomach acid. This may increase the resistance of monogastric animals to pathogens like *Salmonella enteritidis*, *Escherichia coli*, *Salmonella typhimurium*, and *Yersinia enterocolitica*, whereas acid alone has only a bacteriostatic effect. An in vivo study was conducted by Biavati *et al.* (2007), in order to assess the effects of dietary nitrate on the microbiota and on the health of the gut (particularly in stomach and small intestine). Preliminary results showed no effect on the population densities of microbial groups either from the challenge or from the nitrate intake. However, increasing the time from challenge decreased either the counts of LAB in the stomach and jejunum or of Clostridia in the stomach.

#### **WP4.4 Development of nutritional strategies to improve production efficiency, sensory quality and food safety in organic pork production systems**

The availability of protein feeds and sources of essential amino acids are the main limiting factor in organic pig production. This is due to restrictions concerning bought-in feedstuffs, and to the ban on GM-crop based feed, on synthetic amino acids, and on the use of chemically extracted soybean meal. As a result, organic pork production is dependent on a relatively high product price to compensate for the lower production efficiency compared to conventional production. Two principal strategies have been chosen to address this problem.

The first strategy aims to develop a quality oriented production system with an emphasis on sensory quality in order to justify the higher prices.

Trials by Sundrum *et al* in the first two years of QLIF indicate that a feeding regime only based on cereals and home-grown grain legumes without further supplementation with high quality protein resulted in a reduction in pig performance compared to the control group but in an increase in the intramuscular fat content (IMF). The results indicate that it is possible to increase the IMF content by the use of specific feeding regimes, thereby playing a major role in relation to eating quality features. With respect to other possible factors they found that except for a positive relationship between birth weight and growth rate, no effect of the birth weight was found on performance nor on carcass traits and meat composition.

These results were the basis for an on-farm study by Abel *et al* (2007) in which a total number of 12 farms were involved, six in Germany and six in Austria. Two dietary treatments (a control and an experimental diet) were used simultaneously in the fattening period. The Control group were fed a diet representing the traditional feeding regime of the respective farm and based on cereals, grain legumes and by-products. The Experimental groups were fed a diet formulated to obtain a high IMF content in the pork. It contained a high portion (> 40 %) of grain legumes (lupines and faba beans) in Germany, and in Austria the rations contain 36 % of a mixture of peas and faba beans. Data analyses have not been completed yet, but preliminary results suggest that variation is higher between farms than between treatments within each farm.

*Future work is aiming to find answers in relation to the suitability of feed rations to increase the IMF content of pork under practical farm conditions.*

The second strategy identified protein crops which can provide additional sources of suitable protein and essential amino acids to improve the production efficiency and reduce production costs.

In an extensive literature review special attention was given to new genotypes (created using classical plant breeding) of candidate protein crops with reduced contents of ANFs, and to processing techniques that could be used under organic farming rules (Van der Peet-Schwering *et al.*, 2006). Further more, fourteen samples of protein rich crops (8 x faba beans, 5 x lupins and 1 x quinoa) were analysed for ANF's, mycotoxins, lectins and phytoestrogen activity. Samples were from protein crops raised in the Netherlands, the UK, Belgium and Switzerland. This study shows that with the genetic improvement in some alternative protein crops, the occurrence of ANFs in new cultivars has been reduced, also under organic farming conditions. With organic farming conditions, yields are lower than with conventional farming, but still

high enough to achieve a cost price of home-grown protein feeds that can compete with imports of for example oil seed meals, albeit at relative low margins per ha.

*Continued plant breeding will be able to create further improved cultivars with higher yields, less susceptibility to plant diseases, especially soil borne plant pathogens that will be easier to combine with other crops in crop rotations.*

A dose-response study was also performed to investigate the optimal inclusion levels of field beans, white lupins and quinoa. A soy based control diet served as negative control. Van der Peet-Schwering *et al* (2006) conclude that an inclusion level of up to 20% tannin-free field beans can be recommended in diets for weanling piglets. For alkaloid-low lupins the recommended inclusion level is up to 10%. However, it is questionable if quinoa is a 'protein crop' because the protein content in quinoa is much lower than in other protein crops.

*More knowledge on the digestibility of protein, amino acids and energy in organically grown protein crops is highly required.*

#### **WP4.5 Development of efficient farm and/or farmer group specific mastitis prevention plans**

Mastitis is a chronic disease of dairy cows, which can also be a factor affecting milk quality, especially somatic cell count and shelf life of milk. Many candidate strategies to improve udder health are not widely implemented in organic dairy farms. An important reason is the lack of scientific based knowledge on management measures and on the efficacy of non-antibiotic therapies.

In a study by Klocke *et al* (2006) comparing the effectiveness of a teat sealant, a homeopathic remedy and no treatment (control), it was found that treating all healthy cows with SCC values below 200 per ml lead to best results after homeopathy (76%) and only to 50% protection rate in the teat sealant group compared to 44% in untreated cows. Teat sealants helped to reduce environmental infections, and are perhaps useful when applied to sub-clinically infected quarters. By sealing the teats and avoiding super- or re-infections during dry period, an "undisturbed self-cure" may occur. This results in the following recommendations to dairy farmers:

Usage of teat sealants in problem herds (environmental mastitis) in healthy quarters

Usage of herd homeopathic remedies in infected cows in non-problem herds

No treatment at all in healthy cows of non-problem herds

In case of sub-clinical mastitis targeted strategic antibiosis discussable.

In the most recent QLIF work by Klocke *et al* (2007) the effects of homeopathic treatment on sub-clinical mastitis during lactation were investigated. There was no significant effect by the remedies at all. The cow somatic cell count over three months after treatment showed no significant difference in the five groups. The authors conclude that further work is needed to investigate if other factors like age, microbial agents or individualized protocols are responsible for the lack of success when using homeopathic remedies.

A second line of investigation is followed by Wagenaar and co-workers. They hypothesise that cows and their calves can be considered more 'robust' or less 'disease susceptible' if they have a more natural suckling period. They argue that early

weaning of calves can have a profound effect on disease incidence in later life, as well as on stress of the mother. In their study, Wagenaar and Langhout (2007) compared three calf rearing methods: bucket feeding of milk replacer, bucket feeding of tank milk and suckling at their mother. Their initial aim was to determine whether the technical results of suckling systems in calf rearing were satisfactory. Calves reared in a suckling system reached significantly higher live-weights at weaning (90 days). Although growth performance between weaning and the age of 1 year did not differ significantly, live-weight at 365 days did still differ significantly. Compared to both bucket fed rearing groups, suckling did not have a significant effect on Somatic Cell Count (SCC) of the mother cows. During the period of observation suckling systems did not result in increased problems with animal health.

*In 2007 the evaluation of the milk production performance of the calves raised in the three rearing methods will be completed.*

#### **WP4.6 Development of bovine feeding regimes which improve production efficiency, microbiological safety and/or sensory quality of milk**

*Escherichia coli* O157 is an enteric pathogen which rarely causes disease in cattle, but can cause life-threatening gastro-intestinal infections in humans. Several recent studies have shown that the dairy feeding regime significantly affects the risk of pathogen shedding in the faeces of dairy cows. Recent studies from the USA indicated that calves fed a diet high in Bermuda grass hay (*Cynodon dactylon*) had on average 10-fold fewer *E. coli* O157 than those fed a pre-dominantly grain diet. Factors other than the proportion of grain in the diet may also affect *E. coli* shedding. Blakewell *et al* (2007) have studied eight Hereford x Friesian steers prepared with rumen and duodenal cannulae, offered increasing proportions (increase of 33% each period) of red clover to grass over four periods with grass silage fed throughout. They were compared to 4 steers as an experimental control. Feeding red clover appeared to reduce pathogen loading but this was confounded by variation in the pathogen populations in the feed.

*In their ongoing work they will aim to elucidate the different effects of red clover and feed pathogen load on the gut and faecal pathogen populations. Furthermore, Davies et al are currently analysing data of trial on the effects of increasing proportions of red clover in the diet of dairy cows on the nutritional and organoleptic qualities of the milk they produce.*

#### **Conclusion**

Although many new insights on livestock production have been generated during the first three years of the QLIF project, some of the main questions still remain to be answered. Questions related to the socio-economic consequences and the perceived health risks and benefits of new management, housing and feeding techniques have yet to be explored in collaboration with others within and outside the QLIF project. Answering them will further increase the competitiveness of the organic livestock sector. However, at this point in time, with new data and analyses results coming in faster than ever, it looks like the project is on track to deliver significant additional knowledge to the organic and low input livestock farming community.

## Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

The results presented in this paper are based on the joint effort of the following research teams: IGER (UK; D. Davies), BOKU (A; W. Zollitsch), BU (I; B. Biavati), PRO (I; N. Carlini), DARCOF (DK; S. Thamsborg and H. Mejer), LBI (NL; J.P. Wagenaar), FIBL (CH; V. Maurer, P. Klocke), UNIK (D; A. Sundrum) and RIAH (Wageningen-UR; NL; H. Spoolder, A. Kijlstra, H. Vermeer, C. van der Peet-Schwering, A. Jongbloed). The credit for what has been achieved should be shared by all those mentioned above, whilst any mistakes or inaccuracies in this overview paper are the sole responsibility of the authors.

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## References

- Abel, S., R. Weissensteiner, C. Marien, W. Zollitsch, A. Sundrum, 2007. Effects of a feeding strategy to increase intramuscular fat content of pork under the conditions of organic farming. Proceedings of the 3<sup>rd</sup> QLIF Congress, Hohenheim, Germany, March 20-23, 2007.
- Andersen, H. J., N. Oksbjerg, M. Therkildsen (2005). Potential quality control tools in the production of fresh pork, beef and lamb demanded by the European society. *Livest. Prod. Sci.* 94, 105-124.
- Biavati, B., M. Modesto, I. Stefanini, M.R. D'Aimmo, M. Mazzoni, P. Trevisi, C. Tittarelli, P. Bosi, G.P. Strozzi, S. Allesina, F. Deidda, M. Barba, P. Lorenzini, 2007. Dietary Nitrate: Effects on the health of weaning pigs and antimicrobial activity on seven Probiotic *Bifidobacterium* spp. strains. Proceedings of the 3<sup>rd</sup> QLIF Congress, Hohenheim, Germany, March 20-23, 2007.
- Bakewell, E.L., R. Sanderson and, D R Davies 2007. Effects of inclusion of red clover silage on the carriage of gut pathogens in steers. Proceedings of the 3<sup>rd</sup> QLIF Congress, Hohenheim, Germany, March 20-23, 2007.
- Klocke, P., S. Ivemeyer, M. Walkenhorst, A. Maeschli, F. Heil, 2006. Handling the dry-off problem in organic dairy herds by teat sealing or homeopathy compared to therapy omission. In: Proceedings of the Organic Joint Congress, Odense (DK), May 30th to 31st. p 492-493.
- Klocke, P., S. Ivemeyer, F. Heil, M. Walkenhorst, C. Notz, 2007. Treatment of bovine sub-clinical mastitis with homeopathic remedies. Proceedings of the 3<sup>rd</sup> QLIF Congress, Hohenheim, Germany, March 20-23, 2007.
- Maurer, V., 2005. Strategies for parasite control in organic layer flocks. Abstracts of the first annual congress of the EU project QualityLowInputFood, Newcastle upon Tyne, 6-9. January 2005. p.112.
- Maurer, V., E. Perler, 2006. Control of the poultry red mite *Dermanyssus gallinae*. Organic Congress 2006, May 30.-31. 2006, Odense, DK, 504-505.
- Meerburg, B.G., W.F. Jacobs-Reitsma, J.A. Wagenaar, A. Kijlstra. 2006. Occurrence of *Salmonella* and *Campylobacter* in wild rodents and insectivores on organic farms. *Applied and Environmental Microbiology* 72, 960-962.

- Spoolder, H.A.M. In Press. Animal welfare in organic farming systems. *Journal of the Science of Food and Agriculture*.
- Sundrum, A. 2006. Implications of genotype and amino acid supply on pork quality. In: *Proceedings of the Organic Joint Congress, Odense (DK), May 30th to 31<sup>st</sup> 2006*.
- Van der Peet-Schwering, C.M.C., M.M. van Krimpen, P. Kemme, G.P. Binnendijk, J.T.M. van Diepen, A.W. Jongbloed, C. Henniphof-Schoonhoven, 2006. Alternative protein crops in diets of organically housed weanling pigs 2006. *PraktijkRapport Varkens 47*. Divisie Veehouderij, Wageningen UR. NL pp. 22.
- Vaarst, M., S. Padel, G. Arsenos, A. Sundrum, A. Kuzniar, M. Walkenhorst, L. Grova, B. Henriksen (2006): Challenges for animal health and welfare in the implementation of the EU legislation on organic livestock production: analysis of questionnaire survey among SAFO participants. In: Rymer, C., M. Vaarst, S. Padel (eds.) *Future perspectives for animal health on organic farms: main findings, conclusions and recommendations from the SAFO network*. 5th SAFO-Workshop, Odense, Denmark, p. 43-74.
- Verbeke, W. A., J. Viaene (2000). Ethical challenges for livestock production: meeting consumer concerns about meat safety and animal welfare. *J. Agric. Environ. Ethics* 12, 141-151.
- Vermeer, H.M., F.H.M. Borgsteede, H. Altena, 2006. The use of outdoor runs with rooting areas and drinkers by organic pigs. Paper presented at Joint Organic Congress, Odense, Denmark, May 30-31, 2006.. <http://orgprints.org/7467/>.
- Wagenaar, J.P.T.M., J. Langhout, 2007. Suckling systems in calf rearing in organic dairy farming in the Netherlands. *Proceedings of the 3<sup>rd</sup> QLIF Congress, Hohenheim, Germany, March 20-23, 2007*.