Analysis Of Black Holes In Our Knowledge Concerning Animal Health In The Organic Food Production Chain

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Summary

Chapter 1: General legislation

Organic production is regulated throughout the EU via the EU-regulation (EEC) nr. 2092/91, whereby the animal food production chain came into effect in the year 2000. Within the EU all member states should at least comply to these rules. A number of countries including the Netherlands have included a number of additional rules. In the Netherlands the inspection of compliance to these rules has been assigned by the ministry of agriculture to a separate organisation named SKAL. SKAL is also the organisation that informs farmers and processors within the food chain with respect to legislation and takes care of certification. Certified producers are allowed to use the so-called EKO quality symbol. The EKO prefix (EKO-pigs; EKO-milk) is legally protected and can only be used after written permission from the SKAL organisation.
The main aim of the SKAL organisation is to certify the consumer that a product that claims to be organic truly originates from a certified organic production process.

Chapter 2: Disease and animal welfare in organic livestock

Immunological Defence in Animals held under Organic Conditions

Whether animals held under organic conditions have a better immune response towards prevailing pathogens as compared to conventionally reared animals is generally assumed but has not yet been formally proven. Many aspects of organic farming may affect the immune response of the animals in a positive or negative manner. Important aspects such as the genetic background, nutrition, environmental exposure weaning age and stress may all affect the immune response and preferably each factor should be analysed separately.

Disease and animal welfare in organic livestock

The amount of knowledge on disease and animal welfare in organic livestock, which has been presented through the peer-reviewed literature, is not very large at this moment. Most of the data have appeared in conference proceedings and are often limited to on farm experience and do not compare conventional with organic animal husbandry.
Typical aspects of organic farming that may affect animal health and welfare include 1) outdoor rearing 2) limited use of curative and preventive allopathic medicines 3) organic feed 4) incorporation of biological cycles within the farm. Most aspects will be dealt with in the following sections. One factor that will not be dealt with in depth is the fact that the principle of biological cycles which includes the use of organic manure within a farm may carry the risk of creating a reservoir of infectious pathogens.

Poultry

Animal welfare is an important desired feature of organic livestock production but despite this, several studies have indicated severe health problems e.g. in organic poultry production in Denmark. Apart from health problems the risk of zoonotic disease affecting food safety is an issue often mentioned in the literature. There is

listed the current literature on disease incidence in organic poultry, and wherever possible indicate which factors are due to the “organic” management of the animals.
In laying hens feather pecking is one of the main problems, together with worm infections and salmonellosis. In broilers infections with campylobacter may be a problem.

Swine

Organic swine production is of major benefit to the welfare of pigs due to the fact that larger living areas are given, the date at which piglets are weaned is lengthened to seven weeks and animals have access to an outdoor area. This latter change in housing may predispose animals to various infectious micro-organisms, normally not present anymore indoors due to high hygienic measures that can be taken. Especially parasitic infections are thought to be increased in organic swine production systems. This in combination with the rules that preventive therapy is not allowed and in view of the fact that homeopathic and “natural” therapies should first be considered, may affect the health of the animals and therefore have a negative impact on animal welfare. The authors summarise current data published in the peer-reviewed literature in combination with personal experience.
In pigs loss of piglets before weaning is one of the major problems. Worminfections may also be a problem because of the white spots in the liver leading to loss of income. Other problems are not different from conventional pig farming and include respiratory and gastro-intestinal infections, locomotion problems and fertility problems.

Organic Dairy Production

Herd health problems on organic dairy farms are similar to those seen on conventional farms. Main problems in descending order are: mastitis, fertility disorders, and hoof diseases whereas metabolic disorders such as acetonaemia and milk fever are less frequent.

Chapter 3. Use of phytotherapeuticals in organic animal production

Introduction

Organic farming has its own concepts of health and animal welfare. Health management is associated with methods including humane, preventive, self-regulation and holistic aspects. In therapeutical control of disease the use of natural feed additives and homeopathic and phytotherapeutic approaches are favoured. The use of regular synthetic veterinary medicines is restricted.
Herbal medicine is probably the oldest form of medicine, with a rich history behind it. Even today some of the conventional drugs are plant derived. Mostly the active ingredient is isolated or synthesised. Holistic doctors believe that prescription of a whole plant has the advantage of synergistic actions of all constituents and safety. Phytomedicines, or herbal medicinal products, are medicinal products containing as active ingredients only plants, parts of plants or plant materials, or combinations thereof, whether in the crude or processed state (ESCOP,1).

Legal aspects
Human phytotherapeuticals, when not registered as regular medicine, are regulated by the Warenwet and the Warenwetbesluit kruidenpreparaten. This Warenwet besluit kruidenprepraten includes a list of toxic plants that may not be used.
In human phytotherapeuticals there is a requirement for well established medicinal use, with recognised efficacy and an acceptable level of safety as demonstrated by detailed references (bibliographical) (EMEA, 3).
Veterinary phytotherapeuticals claiming preventive, curative or healing action are subjected to the Diergeneesmiddelenwet and may not be used unless registered by the Bureau Registratie Diergeneesmiddelen (BRD).
As compared to human phytotherapeuticals requirements for veterinary use are much higher, due to safety aspects regarding the possibility of harmful residues in products for human consumption.
Preventive use
Preventive use of phytotherapeuticals can be used in two manners: 1) aimed at increasing the health and natural resistance of the animal in general or 2) to reduce the effects of a specific disease.
Botanical dewormers may cause side effects in animals since the most powerful natural dewormers are often potential poisons. In a recent review it is stated that although largely recommended, phytotherapy and homeopathy do not have any demonstrated efficacy in managing helminths in ruminants. The use of antimicrobal growth promoters is restricted in the EU, leading to a search for alternatives.
Curative use
Lans describes ethnoveterinary use of 20 medicinal plants
to treat ruminants. Indications were endoparasites, injuries and pregnancy related conditions.
Chinese herbs have been used to control preweaning diarrhoea in piglets as well as acupuncture with favourable results. The herbal mix was effective in reducing the incidence of infection in one-day-old piglets, but also in curing pigs with preweaning diarrhoea.
Aloe secundiflora extract against *Salmonella Gallinarum* reduced in treated chicken mortality and reduced severity of clinical signs.
Efficacy
Few controlled clinical studies on effectiveness of herbal medicines in production animals are published in regular literature. For evaluation of human phytotherapeuticals animal studies are conducted to establish efficacy and safety. These data may also be used for use as veterinary medicine, but species differences in susceptibility, metabolism and possible toxicity of phytotherapeuticals should be taken into account
Conclusion
Although recommended for organic farming, there is little clinical evidence of effectiveness of herbal medicine published in open literature. The reason is the lack of good controlled studies, whereas potential products are available. Another reason is that the results of clinical test are presented in national reports and on symposia which are not covered by the literature search systems.

The use as veterinary medicine is restricted to registered products and the costs and requirements are in many cases too high for many herbal products. More or less the same is true for the use as feed additive, although some products are ready for registration. Without registration no medical claims can be made and the use of phytotherapeuticals is not really an alternative for registered veterinary medicines. Effort must be put on standardisation of products and registration of phytotherapeuticals with proven efficacy.

Discussion

Use of phytotherapeuticals may be a useful tool in disease management in organic farming. But National and European legislation make it very difficult to use these type of medicines because very few are registered as veterinary medicine or as feed additive. This means that the medical claims must be hidden and application is limited to additional feed or natural health additives without a medical claim. But there are developments in research and there are companies ready to enter the registration for their products as feed additives.

Another problem is the standardisation of the products. In biological material the levels of biological active substances depend on the plant species, part of the plant used, the stage of development of the plant, but also on the weather, soil and growth conditions etc. This makes it very difficult to define the ingredients of a plant or a botanical extract, which is required for registration. In human phytotherapy there are requirements for production (GMP), quality, purity and levels of marker components (22). Moreover the requirements on efficacy and safety are simple to fulfil and ready applicable for herbal remedies.

Another drawback in the use of phytotherapeuticals is the lack of good clinical trials, most claims are based on traditional use, anecdotal evidence or extrapolation of human data. When there is good research it is often not published in open literature, but presented and symposia or in national reports.

The European Pharmacopoeia gives strict requirements for herbal products concerning identification, purity, quality and safety.

Recommendations

To make it possible to use phytotherapeuticals in organic farming there is a need for good clinical studies and registration as feed additive or veterinary medicine. Effort must be put on standardization of products and registration of phytotherapeuticals with proven efficacy.

For food grade ingredients there should be a discussion concerning requirements necessary for registration. This because as compared with human phytotherapeuticals, which are freely sold without registration as a medicine, the requirements for veterinary phytotherapeuticals are much higher.

Chapter 4. Prevention of disease: garlic, vaccination and pest control

Garlic has been claimed to have a beneficial effect on human health and therefore would possibly be a suitable candidate to increase the health of animals in organic production. However a further literature search on the use of garlic in animal health only led to a very limited number of publications.

Garlic juice can be used for topical application (spraying on laying hens) to decrease the number of northern fowl mites on skin and feathers. These mites are

external parasites and can lower the egg production and cause anaemia and even death. Garlic has also been shown to decrease cholesterol levels in chickens without altering growth of the chickens and feed efficiency. An attempt to use garlic as chemoprophylaxis of cryptosporidiosis in chickens failed.
The oral administration of garlic may have side effects concerning adverse taste of eggs and meat.

In organic production the use of vaccines is allowed to some extent and GMO-based vaccines are also considered for treatment of diseases. The latter only for diseases with no available alternatives.
A new approach to produce and deliver vaccines, which could be particularly interesting for organic production systems with its specific demands, is the production of vaccines in plants. These plant-based vaccines could be developed further to allow oral administration and hereby circumvent some of the drawbacks associated with the current adjuvants used. An edible vaccine would be entirely plant based and would not contain any additional components of animal origin avoiding problems such as zoonotic diseases, prions etc. An edible plant vaccine is a GMO product and although considered an interesting approach will not meet the current regulations of organic farming.

Insects are known transmitters of disease. The control of insects in organic production systems is however limited by the fact that no chemical substances can be used. Alternative measures are needed. Ecological approaches that have been tried to control flies are for example the use of their natural enemies, the use of pheromones or the introduction of insect viruses as bio-pesticides.
Rodenticides are allowed for pest control of rats and mice but the presence of dead bodies that can be eaten by pigs or poultry may still lead to transmission of infectious disease.

Chapter 5. Quality of organically-produced feeds

Introduction

It is obvious that a lot of factors in production systems have an impact on the health of the animals involved. One major factor is of course the feeds administered to the animals. Depending on the production system (organic or conventional) differences in sorts of feeds and possibly also in feed quality might occur which could result in differences in the health status of the animals. The literature study performed, focussed on answering the question whether or not this is the case. Fir this, firstly differences in feed between organic and conventional production have been assessed and secondly aspects related to feeds which could affect the health of the animals have been identified.

Conclusion

The major differences in the quality of feeds between organic and conventional production systems seem to originate from differences in production of plants (such as limited use of crop protection products) and the lack of certain additives in the feeds. The types of feeds administered do not differ significantly and in this respect there are mostly quantitative differences observed (more raw feeds).

Because of this it is also hard to estimate whether or not the differences in feeds will affect the health of the organically produced animals and this is reflected in the limited amount of data available about this topic. Differences in animal health due to differences in feeds could in addition also occur due to other more chain-related factors such as the harvesting, storage and further processing of products.
One major topic seems to be feeds (en foods) contamination with toxins produced by fungi, the so-called mycotoxins and therefore this subject has been evaluated further.

CHAPTER 1: GENERAL LEGISLATION

Pressure from society has resulted in a movement towards a system of animal food production that incorporates a better treatment and welfare of the animals, takes care of our resources and environment and at the same time results in products that do not contain unwanted residues. This has resulted in an organic food chain in the EU that is firmly regulated by a number of rules.
The rules that have been set out have been developed as a compromise of the various goals that were set out towards the organic food producing chain. At present it is not clear what the consequences of these rules are for the health of the animals confined to such a system. It is the purpose of this review to identify the possible consequences of the EU regulated organic livestock production on the health of the animals reared under these circumstances. We have limited this overview to organic pig, poultry and dairy production.

Organic production is regulated throughout the EU via the EU-regulation (EEC) nr. 2092/91, whereby the animal food production chain came into effect in the year 2000. Within the EU all member states should at least comply to these rules. A number of countries including the Netherlands have included a number of additional rules. In the Netherlands the inspection of compliance to these rules has been assigned by the ministry of agriculture to a separate organisation named SKAL. SKAL is also the organisation that informs farmers and processors within the food chain with respect to legislation and takes care of certification. Certified producers are allowed to use the so-called EKO quality symbol. The EKO prefix (EKO-pigs; EKO-milk) is legally protected and can only be used after written permission from the SKAL organisation.
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Legislation concerning Animal Health (see appendix A disease prevention)

Disease prevention in organic live stock production is based on the assumption that feeding, housing and care of the animals is such that the animals have an optimal natural defence to combat disease. As mentioned later in this review there is little scientific evidence to date to support this assumption.

In case disease does occur the EU regulations state the following:

" Phytotherapeutic (e.g. plant extracts (excluding antibiotics), essences, etc.), homeopathic products (e.g. plant, animal or mineral substances) and trace elements and products listed in Part C, section 3 of Annex II, shall be used in preference to chemically synthesised allopathic veterinary medicinal products or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended; (b) If the use of the above products should not prove, or is unlikely to be, effective in combating illness or injury, and treatment is essential to avoid suffering or distress to the animal, chemically synthesised allopathic veterinary medicinal products or antibiotics may be used under the responsibility of a veterinarian;"

Interpreting these rules, many farmers will use phytotherapeutic or homeopathic treatments as a first line of treatment and only use allopathic veterinary medicines if the alternative treatments are not effective. Correct interpretation of the EU rules shows that these so called “alternative” treatments should only be used if their effect has been proven for the species and for the disease the animal is suffering from. As yet insufficient scientifically sound data is available to date indicating the therapeutic effects of the agents listed in the directives of the EU regulations (Hammarberg, 2001). Furthermore it is not clear whether for instance homeopathic drugs that are currently used by organic farmers comply with EU regulations stating that these drugs should be registered (EU regulation 1992/74). If “alternative” treatments are not effective a producer is allowed to use allopathic veterinary medicinal products.

It is not yet clear whether a vaccine is considered as an allopathic product. Preventive use of chemically synthesized pharmaceuticals and antibiotics is not allowed. The use of hormones, coccidiostatics and other growth or production stimulants are not allowed. Only a limited amount of allopathic treatments or treatment courses are allowed per animal per year, with the exception of compulsory treatments implied by law, vaccinations and anti-parasitic treatments. The withdrawal period after the use of an allopathic treatment has to be doubled, but in some countries longer waiting times have been implied.

CHAPTER 2: DISEASE AND ANIMAL WELFARE IN ORGANIC LIVESTOCK

Immunological Defence in Animals held under Organic Conditions

Introduction

Whether animals held under organic conditions have a better immune response towards prevailing pathogens as compared to conventionally reared animals is generally assumed but has not yet been formally proven. Many aspects of organic farming may affect the immune response of the animals in a positive or negative manner. Important aspects such as the genetic background, nutrition, environmental exposure weaning age and stress may all affect the immune response and preferably each factor should be analysed separately.

Breeding

Disease prevention in organic livestock production is preferably based on the principle that appropriate breeds or strains of animals should be selected. A number of breeding strategies for improved disease resistance in organic livestock production have been recently reviewed by Magnusson (2001). These include 1) recording disease incidence in the progeny and select those parents that produce the progeny with the lowest incidences of disease 2) use breeders possessing certain major histocompatibility complex antigens known to be associated with resistance to certain infections 3) identification of a set or combination of immune parameters crucial for resistance to infections and using parameters with high heredity in breeding programmes. Feasibility of the approaches mentioned above is hampered by the small size of organic livestock in most countries. Genetic control of parasitic disease is an option that has been shown to be operational in sheep (Windon 1996) and poultry (Gauli 2002). Selection for certain immune response traits relevant to organic farming has not yet been approached but should be feasible since examples from "regular" farming are available (Edfors-Lilja 1998).

Feeding

Investigations concerning the effect of organic foods on immunological defence in organic livestock has not been reported in literature. It is well known that nutrition has effects on the immune status of animals and man. Almost all nutrients in the diet play a crucial role in maintaining an "optimal" immune response, such that deficient and excessive intakes can have negative consequences on immune status and susceptibility to a variety of pathogens (Field et al, 2002). In humans it is well known that iron and vitamin A deficiencies and protein-energy malnutrition have an important influence on the immune status of an individual. A number of selected nutrients such as glutamine, arginine, fatty acids, vitamin E and C, zinc and selenium have also been shown to affect the immune response. Although it is well known that intestinal nematode parasites have deleterious effects on host nutritional status, only recently was it shown that malnutrition may also act as a predisposing factor to intestinal nematode infection (Koski et al, 2001). As mentioned later in this review, organic feed used in organic livestock production may be deficient in some of the above mentioned nutrients. Unravelling of nutrients essential in the immune response against a variety of pathogens encountered in organic livestock production is badly needed.

Outdoor versus indoor

As yet only one group has analysed the effect of outdoors versus indoor housing on the immune status of regular pigs. Kleinbeck et al (1999) showed that pigs reared outdoors had similar serum IgG concentrations in their blood. Of interest was the observation that outdoors reared pigs had lower white blood cell counts and lower Natural Killer cell responses than piglets kept indoors. Pigs raised outdoors had higher neutrophil levels but lower lymphocyte levels than those raised indoors. The authors concluded that under the experimental conditions outdoor pigs showed sign of stress-induced immunosuppression. It is unlikely that the experimental conditions used in these experiments equal those expected in organic pig production and extrapolation of these data to the effect of organic production systems on the immune status of animals is not valid. It is clear that outdoor rearing of livestock will increase the chance that animals come into contact with a broad range of environmental pathogens. Whether this results in an infection depends on both the nutritional and immune status of the animal. In the section below we will review the available literature on the incidence of infectious disease in organic livestock.

Stress

Housing conditions and access to straw beddings suggest that animals reared under organic conditions should be less stressed than animals kept conventionally. Stress has been long known to have an effect on the immune response of both humans an animals (Khansari 1990), but to date the effect of potentially lowered stress conditions in organic animal farming on the immune response of the animals has not yet been dissected.

Disease and animal welfare in organic livestock

Introduction

The amount of knowledge on disease and animal welfare in organic livestock that has been presented through the peer reviewed is not very large at this moment. Most of the data have appeared in conference proceedings and are often limited to on farm experience and do not compare conventional with organic animal husbandry.

Typical aspects of organic farming that may affect animal health and welfare include 1) outdoor rearing 2) limited use of curative and preventive allopathic medicines 3) organic feed 4) incorporation of biological cycles within the farm. Most aspects will be dealt with in the following sections. One factor that will not be dealt with in depth is the fact that the principle of biological cycles which includes the use of organic manure within a farm may carry the risk of creating a reservoir of infectious pathogens.

Poultry

Animal welfare is an important desired feature of organic livestock production but despite this, several studies have indicated severe health problems e.g. in organic poultry production in Denmark (see review Thamsborg et al 2001). Apart from health problems the risk of zoonotic disease affecting food safety is an issue often mentioned in the literature. In the sections below we will list the current literature on disease incidence in organic poultry, and wherever possible indicate which factors are due to the "organic" management of the animals.

Bacterial infections

In a recent review Engvall (2001) mentioned that close to 100 percent of organically farmed flocks in Sweden may be infected with *Campylobacter* as compared to only 10 percent of conventionally reared flocks. These findings were confirmed in a recent Danish study (Heuer et al 2001). Organic broiler flocks thus pose a serious threat for contamination of the processing lines at slaughter. Recent studies have shown that approximately 80% of cases of pasteurellosis (*Pasteurella multocida)* in Danish poultry were observed in flocks that had access to outdoor areas (Christensen et al 1998). *P. multocida* infections may occur as a superinfection in chickens infected with *A. galli* (Dahl et al 2002).
No publications were found in a PubMed search concerning prevalence of *Salmonella* in organic poultry systems as compared to conventional systems. Unpublished observations from The Netherlands (Hulst-van Arkel, 2002 unpublished observations) in organic broilers showed that the incidence of salmonella infections was lower compared to "regular" broilers. One explanation is that organic broilers are slaughtered at a later time point (81 days) and that the chickens may have mounted an effective immune response against salmonella resulting in clearance of the bacterium. In The Netherlands many organic laying hen farms vaccinate the chickens against *Salmonella (*personal communication Dr. Thea Fiks-van Niekerk (PV)).

Parasitic diseases

Outdoor production of poultry poses a higher risk to parasitic infection, which in combination with the rules of organic farming whereby preventive antiparasitic control is not allowed, may result in higher parasitic infections of the animals. Nutritional imbalance due to an insufficient protein balance in organic poultry feed may also lead to higher susceptibility to parasite infection. Only few of the above raised hypotheses have formally been addressed in the peer reviewed literature.

Permin et al (1999) performed a cross sectional prevalence study of gastrointestinal helminths in Danish poultry production systems on 16 farms during 1994 and 1995. In free-range/organic systems the following helminths were detected: *Ascaridia galli* (63.8%), *Heterakis gallinarum* (72.5%), *Capillaria obsignata* (53.6%), *Capillaria anatis* (31.9%) and *Capillaria caudinflata* (1.5%). In deep-litter systems: *A. galli* (41.9%), *H. gallinarum* (19.4%) and *C. obsignata* (51.6%). In battery cages: *A. galli* (5%) and *Raillietina cesticillus* or *Choanotaenia infundibulum* (3.3%). In broiler/parent system: *C. obsignata* (1.6%). In backyard systems: *A. galli* (37.5%), *H. gallinarum* (68.8%), *C. obsignata* (50.0%), *C. anatis* (56.3%) and *C. caudinflata* (6.3%). The authors conclude that there is a higher risk of helminth infections in free-range and backyard systems but prevalence may also be high in deep litter systems. These parasite infections can lead to reductions in growth rate, weight loss and decreased integrity of the intestinal mucosa, predisposing animals to secondary infections. Of interest is the observation that *A. galli* can function as a vector for *salmonella* (Chadfield et al 2001).

Thamsborg et al (2001) have suggested a number of measures to control parasites which include: biological control of helminths by using certain strains of fungi (larvae trapping fungi, egg destroying fungi; *Duddingtonia flagrans*), high rotation, decreased stocking rates or alternate grazing with other species. Further research is needed to validate these concepts. Various groups (Gauli et al (2002; Permin et al 2002) have recently shown that resistance to some of these parasites (*A. galli*) is genetically determined and these authors suggest selection of poultry strains based on parasite resistance.

The prevalence of external parasites such as mites in organic poultry systems is expected to be higher compared to conventional systems (Permin and Nansen, 1996). A Swedish study showed that *D. gallinae* was the only mite present in poultry systems, with high prevalence in deep litter (33%) and backyard (67%) flocks, compared to only 4% in battery systems (Hoglund et al, 1995). No published data are available concerning external mites in organic poultry systems.

Veterinary medicine, alternative therapies and vaccinations

Vaccination of young “conventionally derived” pullets is a strategy to prevent infection in chickens that are later transferred to an “organic” system. These include standard vaccinations against Marek’s disease, avian encephalitis and infectious bronchitis (Berg 2001). In Sweden, organic egg producers buy their pullets from a conventional farm when the animals are 16 weeks old. After a transition period of 6 weeks the eggs are sold as organic”. Coccidiosis for instance can be prevented by vaccination of these young pullets which are later used for organic egg production. Vaccination of pullets for coccidiosis used for an organic broiler system is formally not permitted because these animals should already be born as “organic” (Waldenstedt, 1999 unpublished). The use of GMO-based vaccines is a matter of discussion, whereby the EU rules allow these vaccines when no other alternatives are available.

No published data are available concerning differences in the use of therapeutic drugs between conventional and organic poultry systems. As in other organic animal husbandry systems it has been argued whether the increased withdrawal periods and the risk of losing the "organic" status of a treated animal may not lead to an under-treatment of sick animals thereby leading to needless suffering.

Feeding

The fact that synthetic amino acids or vitamins are not allowed in organic poultry feed can result in a nutritional imbalance leading to increased disease susceptibility and behavioural problems such as cannibalism and feather picking (Berg 2001, Damme, 2000).

Housing systems and poultry health

Poultry kept in loose housing systems may express unwanted behaviour such as feather picking and cannibalism. A questionnaire sent out to Swedish organic egg producers showed that almost half of the farmers reported cannibalism or feather picking (Berg 2001). These problems are not specific to "organic" management but are also observed in conventional systems with loose housing. Factors involved in this type of behaviour include genetic aspects, housing environment, feed composition and the presence of external parasites (Savory, 1995; Berg, 2001). In Denmark the Animal Ethics Council has previously (1996) concluded that the current situation is unacceptable. Organic egg producers have noted that severe outbreaks of cannibalism could be handled by changing from a brown hybrid to a white hybrid (Berg 2001).
Keutgen et al (1999) studied gross pathologic and histologic changes in animals from free range stocks, deep litter stocks, and from caging systems. Pododermatitis, deformation of the keel bone and amputated beaks occurred primarily in free range hens. Deep litter hens also suffered from pododermatitis, keel bone deformation and amputated beaks in addition to pecking wounds. Caged hens showed severe fatty liver syndromes, injuries of the claws and inflammation of the feather follicles. Injuries and fractures due to handling and transport were almost exclusively found in caged hens, indicating that loose-housed poultry have an improved bone strength (Berg, 2001).

Animal welfare in organic poultry systems

Other subjects affecting animal welfare on organic poultry systems include the shelter of the animals from predators, such as foxes and birds of prey. The incidence of mortality from predators is of course highly dependent on local circumstances including predator density and the use of preventive measures such as fences and artificial and/or natural shelters. Protection from foxes may be achieved by keeping poultry indoors between afternoon and morning dusk (R. Kwakkel; 2002, personal communication).

Swine

Organic swine production is of major benefit to the welfare of pigs due to the fact that larger living areas are given, the date at which piglets are weaned is lengthened to seven weeks and animals have access to an outdoor area. This latter change in housing may predispose animals to various infectious micro-organisms, normally not present anymore indoors due to high hygienic measures that can be taken. Especially parasitic infections are thought to be increased in organic swine production systems. This in combination with the rules that preventive therapy is not allowed and in view of the fact that homeopathic and "natural" therapies should first be considered, may affect the health of the animals and therefore have a negative impact on animal welfare. In the sections below we will summarise current data published in the peer reviewed literature in combination with personal experience.

Respiratory problems

The obligatory use of straw bedding in swine household management may lead to higher dust and bioareosol levels in stables. Endotoxin levels may increase from 40 ng endotoxin/mg dust to a level of 80 ng endotoxin/mg dust when straw bedding is used in a stable. At the same time the absolute amount of dust also increases dramatically when straw beddings are used, leading to very high respirabel endotoxin levels (Stockhofe and Aarnink, 2002 unpublished observations). Strategies to decrease the amount of dust during straw chopping include the use of lignosulfate (Breum et al, 1999), but it is the question whether this treatment complies to the rules of organic farming. The pig lung is extremely sensitive to endotoxin (Olson et al, 1995) and levels of endotoxin in bioaerosols in livestock buildings using chopped straw, may well lead to pulmonary problems. A small study of Feenstra (2000), who evaluated pulmonary health on four organic pig farms, showed that lung health was generally good with the exception of one herd with acute pleuropneumoniae of multifactorial origin. Serological screening showed positive results for *Mycoplasma hyopneumoniae* in all four herds. *Actinobaccilus pleuropneumoniae*, serotype 6 and serotype 12 were observed in two and three herds, respectively, whereas serotypes 2,5, and 7 were not detected. Antibodies *to Porcine reproductive and respiratory syndrome virus* (PRRSV) were found in three herds. Data obtained at slaughter from Austria indicate that pulmonary health in organic pigs was better than that observed in regular pigs (Baumgartner et al 2001). In the Netherlands pneumonia was detected in 19.2 % of "organic" slaughter pigs as compared to 4.5% in regular pigs (unpublished data Biovar study group; 2001, J. Kampshof).

Gastrointestinal problems

Small scale Danish studies have shown that neonatal diarrhoea was uncommon in organic pig production, possibly due to routine vaccination with *Clostridium perfringens, C enteritis* (Feenstra 2000). Austrian studies, however revealed diarrhoea in 30 % of finishing pigs (Baumgartner, unpublished 2001).

Claw and skin problems

Vaarst et al (2000) noted that physical injuries causing lameness, skin trauma's and sunburn were prominent findings in sows in an on farm study performed whereby four organic herds were studied in Denmark. Damages to the outdoor area due to driving resulted in deep tracks, causing injuries to the animals when walking. Skin traumas were considered an important cause of death in piglets (Vaarst et al, Darcoff report 2/2000 pp77-78). Analysis of claw and skin problems at slaughter in The Netherlands did not reveal differences between regular and organic pigs (unpublished results; Biovar study group; 2001, J. Kampshof).

Piglet mortality

High piglet mortality has been mentioned in organic swineherds although exact figures were not published (Vaarst et al Darcoff report 2/2000 pp77-78). Detailed analysis of the causes of pig mortality in one herd revealed that trauma due to crushing was the major cause (65%) of death (Feenstra Darcoff report 2/2000 pp 107-112). Data from the Dutch Biovar group for the year 2001 showed a markedly higher mortality of piglets until weaning in organic (mean 21 % range 14-39 %) compared to conventional (mean 12.7 %) systems (unpublished data, 2001, J. Kamphof and M. Steverink). Piglet mortality after weaning was 4.9 % (range 0.6-11.2 %) in organic compared to 2.2 % in conventional farms.

Other health aspects in organic pigs

Although the seven week lactation period has been considered by some as a threat to sow welfare a comparative study whereby piglets were weaned at 5 or 7 weeks did not show significant differences in sow welfare (Andersen et al Darcoff report 2/2000 pp 119-124).

Amino Acid imbalance

It has been hypothesised that organic foodstuffs are insufficient to meet the protein requirements in growing pigs, leading to amino acid imbalance, growth retardation, susceptibility to disease and increased pollution due to excretion of excess amino acids (Jongbloed 1992). Since synthetic amino acids are not allowed under the organic rules a search has started for plant foods with high protein levels. Sundrum et al (2000) performed experiments in growing pigs using alternative sources of protein such as peas, lupines and faba beans. Three organic barley/wheat-based diets were compared with an isocaloric conventional diet supplemented with synthetic amino acids. Protein sources in the organic diets were either 1) faba beans, supplemented with potato protein to the same amino acid level as the control diet, 2) peas and lupines, or 3) faba beans and lupines. Diets 2) and 3) were not supplemented leading to a lower level of limited amino acids. The organic diets with potato protein showed the same performance as the conventional diet supplemented with synthetic amino acids, although crude protein levels differed markedly. Pigs fed an organic diet in the absence of amino acid supplementation showed a decreased performance (growth, food intake) as pigs fed a conventional diet or an organic diet supplemented with amino acids. The latter treatment resulted in an increase in intramuscular fat content, which is considered a negative eating quality characteristic. These findings are in agreement with earlier studies showing that amino acid-deficient diets can produce substantial increases in intramuscular fat levels (Cismero et al 1996). Digestibility of protein from legumes may be enhanced by removal of anti-nutritional factors also leading to a better nitrogen utilisation (Jongbloed 1992).

Phosphor uptake

Pigs need phosphor for general metabolism and formation of the skeleton. One third of the phosphor in plant feed diets is available as anorganic phosphate whereas the other two thirds is present in an organic form bound to phytic acid (Kemme et al 1997). This latter phosphor can be released via the enzyme phytase, present in wheat or barley. Heating of the diets however leads to destruction of the plant phytase enzyme and conventional diets thus contain supplemented bacterial phytase. This latter supplementation is not allowed in organic farming. As yet it is not known whether phytase levels in organic feed are sufficient to allow optimal utilisation of organic phosphor thereby also leading to a lower environmental pollution.

Parasites

Borgsteede and Jongbloed (2001) reviewed the literature concerning the risks of outdoor rearing of pigs on the occurrence of parasitic disease. These authors have pointed to an increased incidence of *Ascaris suum* infection in pigs reared outdoors as evidenced by a strong increase of livers displaying so called "white spots". No evidence is available concerning a possible increase in the incidence *Sarcoptes scabei* infections. The incidence of *Toxoplasma gondii* in pigs reared outdoors is significantly increased as compared to conventionally reared pigs where no infected pigs could be detected (Kijlstra et al 2002, unpublished observations). Data concerning parasitic infections found in "older" days when pigs were kept outside such as *Hyostrongylus rubidus, Strongyloides ransomi, Oesophagostomum* and *Trichuris suis* have not yet been reported as reemerging infections in organic swine systems. Some of these infections are quite common in wild living swine (*Sus scrofa L.*) and it has been hypothesised that swine farms bordering areas may contract infections via transfer from these areas. Carstensen et al (2002) recently investigated parasitic infections in nine organic swine herds in Danmark. They measured faecal excretion and pasture contamination by parasite eggs or larvae between March to October 1999. The following results were obtained: *Ascaris suum* (28% of weaners, 33% of fatteners, 4% of sows), *Trichuris suis* (4% of weaners, 13% of fatteners, <1% of sows) and *Oesophagostomum* spp. (5% of weaners, 14% of fatteners, 20% of sows). No infections with *Hyostrongylus rubidus*, *Metastrongylus* spp. or *Strongyloides ransomi* were detected. None of the pigs showed clinical signs of scabies or lice. Analysis of soil samples revealed very few *Trichuris* eggs, whereas *Ascaris* eggs were observed in 14% of the soil samples from sow pastures and in 35% fof the slaughter pig pastures. The first infective eggs were recorded in July and the largest number in August. Infective *Oesophagostomum* larvae were found in the grass samples in increasing numbers from May to October. Exceptionally high parasite infection levels in a few herds could be ascribed to herd management procedures.

Important management procedures to prevent parasitic infection as suggested by Carstensen et al include the following:

1) begin organic pig production with helminth-free sows, i.e. animals originating from intensive indoor herds and pre-treated with anthelmintics.
2) keep the accumulation and transmission of helminth eggs/larvae at a minimum by using a low stocking rate
3) pasture rotation should be strictly maintained, and permanent pastures as well as stables with low hygiene should be avoided.
4) If clinical infections do occur the pigs should be treated with anthelmintics and moved to clean areas.

Research is needed into the prevention of parasitic infections of organic pigs, including desinfection strategies, genetic predisposition and novel plant derived antihelminthics (Waller et al 2001).

Organic Dairy Production

Herd health problems on organic dairy farms are similar to those seen on conventional farms. Main problems in descending order are: mastitis, fertility disorders, and hoof diseases whereas metabolic disorders such as acetonaemia and milk fever are less frequent (Krutzinna et al 1995).

Mastitis

No difference in the incidence of mastitis or somatic cell counts were reported in a Danish study whereby 27 organic and 57 conventional herds were compared (Vaarst & Bennedsgaard 2001). A Norwegian study showed that the incidence of mastitis was lower in organic (n=31) versus conventional (n=93) herds (Hardeng & Edge, 2001). No differences were noted in the milk somatic cell counts between organic and conventional herds. In this latter study, ketosis and milk fever were also less common in organic versus conventional herds. Various explanations were suggested by the authors including different attitude and disease management resulting in lower disease reporting in organic dairy farming, higher skill and performance of organic farmers or an inherent positive property of organic husbandry towards animal health (see also Sundrum, 2001).

Parasites

Since the prophylactic use of antihelminthics is not allowed in organic dairy production it has been hypothesised that management of parasite infection may be a problem. A Swedish study indeed reported a high incidence of lung worms (*Dictyocaulus viviparous*) in organic calves (Hoglund et al, 2001). Grazing management incorporating varying grass pasture species, specialty forage crops, rotations may offer a challenge towards a system whereby parasites can be controlled without the use of antihelminthics (Niezen et al 1996).

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CHAPTER 3: USE OF PHYTOTHERAPEUTICALS IN ORGANIC ANIMAL PRODUCTION

Introduction

As mentioned earlier in this report, organic farming has its own concepts of health and animal welfare. Health management is associated with methods including humane, preventive, self-regulation and holistic aspects. In therapeutical control of disease the use of natural feed additives and homeopathic and phytotherapeutic approaches are favoured. The use of regular synthetic veterinary medicines is restricted.

Herbal medicine is probably the oldest form of medicine, with a rich history behind it. Even today some of the conventional drugs are plant derived. Mostly the active ingredient is isolated or synthesized. Holistic doctors believe that prescription of a whole plant has the advantage of synergistic actions of all constituents and safety (11).

Phytomedicines, or herbal medicinal products, are medicinal products containing as active ingredients only plants, parts of plants or plant materials, or combinations thereof, whether in the crude or processed state (ESCOP,1).

In biological agriculture several approaches in health care are possible (2):

- The no-chemical approach: synthetical products are replaced by natural products
- Agro-ecological approach: goal is to improve the whole environment to a healthy balanced state. Prevention, management, feed, housekeeping, breeding and selection are directed at optimal functioning of the animal in its environment.
- The integrity approach: the holistic approach with respect for the animals being and needs.

Methods of use for phytotherapeuticals are:

- Preventive
- Curative
- Supportive

The use of veterinary phytotherapeuticals can be based on three sources:

- Traditional veterinary use (few data available)
- Transition of human phytotherapeuticals to veterinary use
- Ethnoveterinary use of botanical medicines
- New research with clinical studies

Legal Aspects

Human phytotherapeuticals, when not registered as regular medicine, are regulated by the Warenwet and the Warenwetbesluit kruidenpreparaten. This

Warenwet besluit kruidenprepraten includes a list of toxic plants that may not be used.

In human phytotherapeuticals there is a requirement for well established medicinal use, with recognised efficacy and an acceptable level of safety as demonstrated by detailed references (bibliographical) (EMEA, 3).
In human phytotherapeuticals there are 3 classes of products, depending on the efficacy of the product.
Levels of evidence 1:

- documented national experience or traditional use
- the plant material of the product used is identical as documented
- category of proof level C

Efficacy category II:

- hypothesis generating study
- hypothesis supporting study
- category of proof level B
- the plant material of the product used is identical as used for the experimental studies

Efficacy category III:

- hypothesis generating study
- hypothesis supporting study
- category of proof level A
- the plant material of the product used is identical as used for the experimental studies

The definitions of the studies

- hypothesis generating study: literature, at least one clinical study, well documented in vitro study
- hypothesis supporting study: when clinical efficacy is proven, equivalency of the product has to be documented. Or documentation of efficacy via an own clinical study. Or efficacy in vitro. Clinical test proving the expected results in practice.

Grading of recommendation
A: requires at least one randomised (double blind) controlled trial as part of the body of literature of overall good and consistency addressing the specific recommendations
B; requires the availability of well conducted clinical studies, but no randomised clinical trials on the topic of recommendation
C: Requires evidence from expert committee reports or opinions and /or clinical experience of respected authorities. Indicates absence of directly applicable studies of good quality.

Veterinary phytotherapeuticals claiming preventive, curative or healing action are subjected to the Diergeneesmiddelenwet and may not be used unless registered by the Bureau Registratie Diergeneesmiddelen (BRD) (4). This means there has to be a registration dossier.

This dossier requires detailed qualitative and quantitative information on the constituents of the product, results of clinical tests, residue analysis, metabolism and kinetics have to be documented.
The exact constituents of a phytotherapeutical are not always known and standardization is only possible on marker ingredients and not on the whole extract. More over in plant material the levels of bioactive compounds vary depending on growth stage, development, soil, weather, etc.
Since the market for phytotherapeuticals is relative small, the costs for registration are often far too high and the demands not always suitable for herbal products.

As compared to human phytotherapeuticals requirements for veterinary use are much higher, due to safety aspects regarding the possibility of harmful residues in products for human consumption.
When ingredients are used which have a history of safety, and that can be a constituent of regular human food or animal feed, the need for those veterinary requirements is not without discussion.
In order to make the use of veterinary phytotherapeuticals a real alternative, in food/feed grade products there should be a possibility to adapt the requirements to the requirements for human phytotherapeuticals.
However, the FDA states on the use of herbs and botanicals intended for use in animal diets, that herbs and other botanicals that have history of use in humans which can be used to establish reasonable safety levels for humans, these data cannot be extended to use in animals. This is due to the fact that each animal species requires different nutrients, absorbs and metabolises nutrients differently and can exhibit different toxic reactions to food and its components (5).

At present pharmacologically active veterinary phytotherapeuticals are sold as additional feed without a medical claim, but mostly not as feed additives.
Feed additives can be divided into four categories
Supplements: This category includes vitamins and provitamins, amino acids, trace elements and NPN (non-protein nitrogen).
Auxiliary substances: From the point of view of nutritional physiology, they are not essential. They are added to improve the quality and utilisation of the feed ingredients and thus increase the level of animal production. Included here are anti-oxidants, enzymes, probiotics, flavours, emulsifiers and pelleting agents, colourants including pigments, preservatives, free-flowing agents and acidifiers.
Digestive enhancers: Substances that improve growth and feed conversion efficiency and decrease nutrient excretion. Substances that improve gut health.
Disease-preventing agents: These substances are added to the feed to protect the animals against diseases caused by internal parasites. Among these substances are coccidiostats for poultry.
Registration of feed additives: All substances added to feedstuffs to improve their characteristics or to enhance animal production are covered in the annexes of the listed EEC-Directives (Council Directive 70/524/EEC).

A substance is allowed for selling to the market as a feed additive, after being thoroughly investigated by independent committees on national as well as EEC-level.
During the 1st European Symposium on bioactive secondary plant products in veterinary medicine, Vienna 2002 (29) the use of feed additives was an issue. It appeared that there were companies that had products ready for registration as feed additive for improving gut health (30).

This means that pharmacological active veterinary phytotherapeuticals have to be registered as feed additive or as medicated feeding stuffs prescription.
Most phytotherapeuticals are sold as complementary feed without a medical claim.

Preventive Use

Preventive use of phytotherapeuticals can be used in two manners: 1) aimed at increasing the health and natural resistance of the animal in general or 2) to reduce the effects of a specific disease.

Parasitic infection cattle

Concerning worm infections, the ideal is not to strive at any costs for an animal without worms, but to develop resistance or immunity preventing or limiting the establishment or development of worm infections and to reach a level of tolerance in which the animal maintains good productivity despite infection (6).
Susceptibility of the animals depends on genetic resistance, age and management. Prevention of infection is done by herd-, pasture- and soil management. Nematicide plants that can be grown on the pasture are mustard and tagetes species.
Botanical dewormers may cause side effects in animals since the most powerful natural dewormers are often potential poisons. Mentioned are: garlic for *Ascaris, enterobius* and lungworm especially preventive because garlic prevents the eggs of certain worms from developing into larvae (7). (the effects of garlic are mentioned extensively later in this report). In case of dairy animals it is preferable to feed them garlic during or immediately after milking so that the milk does not pick up the taste.
Other botanical dewormers mentioned are: wormwood (*artemisia absinthium*), common mugwort (*artemisia vulgaris*), wild ginger (*asarum canadense*), goosefoot (*chenopodium ambrosioides*), common juniper (*juniperis communis*) works against liver flukes, white or black mustard, curcubits form pumpkin seeds, fern (*dryopteris filix-mas)* for tapeworms, Lupine, hazelnut (*corylus)* is effective agains *ascaris,* carrot seeds *(daucus carota)* are dewormers and a mixture of anise, cumin and juniper seeds is effective against *Dictyocaulus* lungworms in calves (6).
In an recent review (26) it is stated that although largely recommended, phytotherapy and homeopathy do not have any demonstrated efficacy in managing helminths in ruminants.

Pigs

Pine needles can be used prophylactic for ascaris infections in pigs (6).

Poultry

Tobacco and its derivates have been used as dewormers particularly for fowl (6), in other farm animals this is too toxic. Pyrethrum (*chrysanthemum cinerarifolium*) is commonly used as an insecticide in agriculture but is also effective against *ascaris* in chicken.
Topical application of garlic has shown to reduce northern fowl mite infestation in laying hens (16). But garlic extract was not very effective in chemoprophylaxis or therapy of cryptosporidiosis in chickens (17).

Antibiotics

The use of antimicrobal growth promoters is restricted in the EU, leading to a search for alternatives.
Etheric oils are present in a wide range of plants and are used as perfume, anti-oxidant, aromatizer and as preservative. Some extracts are used as altenative medicines (8). Oil from *Origanum vulgaris* is marketed as Ropadiar®, working against Salmonella typhimurium, Escherichia Coli, Staphylococcus Aureus and Campylobacter jejuni (9).The product was mixed in feed at a 500 ppm dose. This supplementation led to increased food intake, increase growth, improved feed conversion and reduced diarrhea (10).
Several herbal feed supplements are marketed for better production but often ingredients are not mentioned (Aromex, phytogener Futtermittel zusatz basierend auf hochwertigen ätherischen und pflanzlichen Ölen sowie Kräutern und Gewürzen, Digestarom, fijngemalen kruiden en specerijen).
Another herbal antibiotic is Enteroguard which contains both garlic and cinnamon and what is used for weaned piglets, resulting in increased growth, reduced numbers of diarrhoea and improved food conversion (27).

Anxiolytica in Pigs

In pigs the effects on lavender straw on travel sickness and stress was compared with wheat straw. Addition of lavender straw appeared to decrease incidence and severity of travel sickness, but not overall levels of stress as measured by concentrations of salivary cortisol (21).

Anxiolytica in Poultry

Kenyatta (15) investigated the effect of intraperitoneal injections with *Piper methysticum* (Kava Kava) extract with vehicle, chlordiazepoxide and separate kavalactones. It was concluded that both chlordiazepoxide and Kava- extract attenuated separation induced distress voicalizations and stress induced analgesia, with dihydrokavain as mediator for the anxiolytic effects.

Curative Use

Cattle

Lans (12) describes ethnoveterinary use of 20 medicinal plants in Trinidad and Tobago to treat ruminants, main plants used were *Azadirachta indica* and *curcuma longa*. Indications were endoparasites, injuries and pregnancy related conditions. Increasing immune function by herbal medicines is investigated by Hu et al. (13), who tested 24 medicinal herbs in vitro on their effects on phagocytosis. Some herbs increase phagocytosis more than 40 % as compared to control (phosphate buffered saline).
Abaineh (22) investigated the effects of the herb *Persicaria senegalense* on bovine subclinical mastitis, using both in vitro and in vivo trials. When feeding 1.5 kg of cooked leaf a day for 5 days did not give any significant cure rate, in a second trial 0.77 kg of leaf powder was fed, resulting in an apparent cure rate of 92,8.% (52.8 % actual as there was a spontaneous cure rate in the negative control group). The positive control group was treated with an intramammary antibiotic preparation and showed a 80 % cure rate (40 % actual). Hu (23) used subcutaneous injections of ginseng on cows with subclinical Staphylococcus aureus mastitis. This led to an decrease in the number of infected quarters in treated cows, probably due to immune stimulating effects of ginseng (increases phagocytosis, higher monocyte and lymphocyte count).

Pigs

Chinese herbs have been used to control preweaning diarrhoea in piglets as well as acupuncture (17) with favourable results. The herbal mix was effective in reducing the incidence of infection in one day old piglets, but also in curing pigs with preweaning diarrhoea (18).

Poultry

A good clinical study has been conducted with *Aloe secundiflora* extract against *Salmonella Gallinarum* in experimentally infected chicken in Tanzania (19). Three groups of chickens were used; G1 (pretreated and infected), G2 (infected and untreated) and G3 (infected and treated). The extract reduced the mortality rate in pretreated chicks and even more in the infected and treated group. The experiment was replicated with chickens infected with Newcastle disease (20), in which Aloe treated chicken showed reduced mortality and reduced severity of clinical signs.

Supportive Use

Phytomedicines can also be used to increase the overall health status (23). Even milk production can be stimulated using ixbut (*Euphorbia lancifolia*) with cattle fodder (25).

Efficacy

Few controlled clinical studies on effectiveness of herbal medicines in production animals are published in regular literature. For evaluation of human phytotherapeuticals animal studies are conducted to establish efficacy and safety. These data may also be used for use as veterinary medicine, but species differences in susceptibility, metabolism and possible toxicity of phytotherapeuticals should be taken into account (11).
Miller et all (14) used rats and guinea pigs for investigating the effect of Sangre de grado (dragons blood, red tree sap from *Croton dracanoides*, *C. palanostigma*, or *C. Lecheleri*) on gastric ulcers and diarrhoea. Sangre de grado facilitated the healing of experimental gastric ulcer, reducing myeloperoxidase activity, ulcer size and bacterial content of the ulcer. Although these results are promising, without clinical trials, there is no evidence that this product can be used for gastric ulcers in pigs.
Egelund Olsen (28) investigated the efficacy of commercial feed products for piglets including Cylacin, Euroacid, Greenacid and Enteroguard and found only slightly better production in Greenacid (organic acids) fed pigs.

Discussion

Use of phytotherapeuticals may be a useful tool in disease management in organic farming. Both National and European legislation make it very difficult to use this type of medicines because very few are registered as veterinary medicine or as feed additive. This means that the medical claims must be hidden and application is limited to additional feed or natural health additives without a medical claim. But there are developments in research and there are companies ready to enter the registration for their products as feed additives.
Another problem is the standardization of the products. In biological material the levels of biological active substances depend on the plant species, part of the plant used, the stage of development of the plant, but also on the weather, soil and growth conditions etc. This makes it very difficult to define the ingredients of a plant or a botanical extract, which is required for registration. In human phytotherapy there are requirements for production (GMP), quality, purity and levels of marker components (22). Moreover the requirements on efficacy and safety are simple to fulfil and ready applicable for herbal remedies.
Another drawback in the use of phytotherapeuticals is the lack of good clinical trials, most claims are based on traditional use, anecdotal evidence or extrapolation of human data. When there is good research it is often not published in open literature, but presented at symposia or in national reports.
De Leeuw (23) reports standard treatments for organic pigs using natural health additives such as different feed ingredients, probiotics, prebiotics, organic acids, herbs, organic trace elements, omega fatty acids, homeopathic products, Bach remedies and aroma therapy. He aims at improving the animals resistance and immune function using natural products, and recommends the use of natural products to counter disease episodes. Concerning phytotherapy he states that the products have to meet the following requirements:

- composition depending on the growth season

- only products from organic crop production and using natural processing methods
- control on toxic substances
- only use herbs which have a broad therapeutic scope.

The European Pharmacopoeia gives strict requirements for herbal products concerning identification, purity, quality and safety (24).

Conclusions

Although recommended for organic farming, there is little clinical evidence of effectiveness of herbal medicine published in open literature. The reason is the lack of good controlled studies, whereas potential products are available. Another reason is that the results of clinical test are presented in national reports and on symposia that are not covered by the literature search systems.
The use as veterinary medicine is restricted to registered products and the costs and requirements are in many cases too high for many herbal products. More or less the same is true for the use as feed additive, although some products are ready for registration.
Without registration no medical claims can be made and the use of phytotherapeuticals is not really an alternative for registered veterinary medicines. Effort must be put on standardization of products and registration of phytotherapeuticals with proven efficacy.

Recommendations

To make it possible to use phytotherapeuticals in organic farming there is a need for good clinical studies and registration as feed additive or veterinary medicine. Effort must be put on standardization of products and registration of phytotherapeuticals with proven efficacy.
For food grade ingredients there should be a discussion concerning requirements necessary for registration. This because as compared with human phytotherapeuticals which are freely sold without registration as a medicine, the requirements for veterinary phytotherapeuticals are much higher.

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CHAPTER 4: PREVENTION OF DISEASE; GARLIC, VACCINES AND PEST CONTROL

Introduction

As mentioned earlier, disease prevention in organic live stock production is based on the assumption that feeding, housing and care of the animals is such that the animals have an optimal natural defence to combat disease. In the section below we will mention a number of additional aspects in the care of the animals that may promote their health and thereby prevent the occurrence of disease.

Prevention of disease by using Garlic

A well-known example of a health beneficial plant frequently used today is garlic. Garlic has many described beneficial effects on the health of humans. Because of the large amount of information available on the health-promoting effects of garlic this literature research was restricted to the antiviral effects of garlic. This still resulted in a lot of different publications, in which the antiviral effect was described. These articles were presented in, generally recognised, 'lower-standard' journals as shown in table 1. Furthermore, table 1 shows that testing of the antiviral effect of garlic was mostly performed *in vitro* and the described effect was found against a wide variety of human viruses.
As to the antiviral activity of garlic, it has been described that garlic was used successfully as a prophylactic against poliovirus (Huss, R., 1938, Mayerhofer, E., 1934). The more traditional antiviral uses for garlic include treatment of chicken pox, measles, the common cold and influenza (Fenwick, G.R. et al., 1985).

Table 1: Literature on the antiviral activity of garlic.

Antiviral effect theme	Subject	Reference
Epidemic	Polio virus	Mayerhofer *et al.* (1934). Arch. Kinderheilkd. 102, 106-16.
Epidemic	Polio virus	Huss *et al.* (1938). Wien.Med.Wochenschr. 88, 697-8.
Antiviral effect	Influenza virus A	Yakovlev *et al.* (1950). Bull. Biol. Med. 29, 384-7.
Antiviral effect	Influenza virus B	Schiefer *et al.* (1953). Chem. Abst. 47, 814.
Antiviral effect	Influenza B, herpes simplex type 1	Frolov *et al.* (1970). Microbiol. J. 32, 628-33.
In mice	Influenza virus	Nagai *et al.* (1973). J. Jpn. Assoc. Infect. Dis. 47, 321-5.
In mice	Influenza virus	Nagai *et al.* (1973). J. Jpn. Assoc. Infect. Dis. 47, 111-5.
In chicken	Ricketsia	Kumar *et al.* (1981). Indian J. Anim. Res. 15, 93-7.
Antiviral effect	Other herbs	Esanu (1981). Virologie 32, 57-77.
In mice	Influenza	Esanu *et al.* (1983). Rev. Roum. Med. Virol. 34, 11-17
Treatment plant	Rotavirus	Pang *et al.* (1984). J. Trad. Cin. Med. 4, 301-6.
Treatment plant	Rotavirus	Chen *et al.* (1984). J. Trad. Cin. Med. 4, 279-300.
Antiviral effect	Other herbs	Esanu (1984). Virologie 35, 281-93.
Epidemic	Influenza virus	Hanley *et al.* (1985). J. Plant Foods 6, 211-38.
in vivo and *in vitro*	Influenza B, herpes simplex type 1	Tsai *et al.* (1985). Planta Med. 51, 460-1.
in patient	Viral pneumonia	Lu *et al.* (1988). Experim. Hematol. 16, 484.
in vitro	Several viruses	Hughes *et al.* (1989). Planta Med. 55, 114.
Plant	Rotavirus and other viruses	Husson *et al.* (1991). Ann. Pharm. Fr. 49, 40-8.
in vivo and *in vitro*	Influenza B, herpes simplex type 1	Cai *et al.* (1991). Cardiol. Pract. 9, 11.
In patient	Viral pneumonia	Guo *et* al. (1991). Chem. Abst. 114, 600.
Antiviral effect	AIDS	Holzhey *at el.* (1992). Chem. Abst. 116, 109.
in vitro	HIV	Tatarintsev *et al.* (1992) J. Russ. Acad. Med. Sci. 11, 6-10.

in vitro	Several viruses	Weber *et al.* (1992). Planta Med. 58, 417-23.
in vitro	Human cytomegalovirus	Guo *et al.* (1993). Chin. Med. J. 106, 93-6.
in vitro	Human cytomegalovirus	Meng *et al.* (1993). Virologica Sinica 8, 147-50.
in vitro	HIV	Shoji *et al.* (1993). Bioch. Biophys. Res. Commun. 194, 610-21.
in vitro	Rotavirus	Rees *et al.* (1993). World J. Microbiol. Biotech. 9, 303-7.
In patient	Viral pneumonia	Lu *et al.* (1994). Bone marrow transpl 13, 703-4.
Antiviral effect	Other herbs	Craig *et al.* (1999). American journal of clinical nutrition 70, S491-^
Epidemic	Common cold	Josling *et al.* (2001). Advances in therapy 18, 189-93.
Immunological effect	General	Kang *et al.* (2001). Nutrition Research 21, 617-26.

Tsai et al. (Tsai, Y. et al., 1985) found that a commercial garlic extract had in vitro antiviral activity against herpes simplex virus type 1 (HSV-1) and influenza B virus, both envelop-surrounded viruses.
Studies using mice indicated that the aqueous ethanolic extracts of garlic administered orally 15 days before experimental infection with influenza virus AO/PR 8 strain were protective, while administration of the same extract at the time of virus infection had no effect (Nagai, K., 1973). Besides these specific antiviral effects, broader effects on the immune system have been described. Garlic intake in humans has for example been reported to enhance neutral killer cell activity (Kandil, O. et al., 1988) and a number of human immune fractions were found to be enhanced in vitro by aqueous garlic extract and its fractions (Burger, R.A. et al., 1993).
Briefly, the antiviral properties of garlic have been suggested to occur due to direct antiviral effect, to immune modulation or to some combination of these events. The mechanism of the antiviral action of garlic thus remains to be solved and active compounds remain to be identified.

The suggested active compounds of garlic

Most compounds in the plant are necessary for normal metabolism and are called primary metabolites. The content of these compounds is similar among nearly all plants. The bulk of the dry weight is composed of fructose-containing carbohydrates, followed by sulphur compounds, proteins and free amino acids (Koch, H.P. et al., 1996).

Table 2: The medicinal spectra of garlic.

Pharmacologic activity	Probable components contributing to activity
Anticoagulation	Ajoene
Antihypertensive	Selenium, germanium
Antimicrobial:	
-Antiparasitic	Allicin-alliin
-Antibiotic	Allicin-alliin
-Antimycotic	Allicin-alliin, ajoene
-Antiviral	Allicin-ajoene
Hypolipemic	Diallyl disulfide
Detoxification of heavy metals	Selenium, allyl mercaptan, germanium
Antitumor	Selenium, germanium
Vitamins	Thiamine, vitamins A and C
Antioxidant	Selenium, germanium
Anti-aging	Selenium, diallyl disulfide
Immune modulation:	
-Natural killer-cell activity and other cell-mediated immunity	Germanium, selenium, zinc*
-Humoral immunity	Germanium, allicin
-Complement activity	Magnesium, calcium

* Zinc is essential for the synthesis of the thymus gland hormone, thymosin

Compounds unique to a plant or genus, secondary metabolites, serve to provide among others resistance to a variety of diseases or pests. Garlic has an unusually high content of sulphur compounds of ~3.3 mg/g fresh weight compared to other food plants (~0.9 mg/g fresh weight). This has raised the suspicion that sulphur compounds might play a key role in the health effects of garlic. This idea is sustained by the fact that sulphur containing drugs e.g. penicillin and sulfonamide antibiotics are long recognised as containing pharmacological activity. Indeed effects of garlic have been substantiated *in vitro* and found to be due to diallyl thiosulfinates (allicin), methyl allyl thiosulfinates and allyl methyl thiosulfinates (Fenwick, G.R. et al., 1985, Koch, H.P. et al., 1996) (see table 2). Moreover, the antibacterial, antifungal, antiprotozoal and antiviral effects were almost inactivated by elimination of such sulphur compounds from crushed garlic.
The compound that is suggested to produce much of the activity of garlic is allicin, which is released when intact cells of a clove are cut or crushed. Allicin inhibits a wide variety of bacteria, molds, yeasts and viruses in vitro (Ankri, S. et al., 1999, Burger, R.A. et al., 1993, Este, J.A. et al., 1998, Harris, J.C. et al., 2001, Walder, R. et al., 1997). Thiosulfinates are very effective antibacterial and antifungal agents and may have the functions to offer the plant protection against bulb decay by fungi. Though positive effects have been demonstrated and active components have been identified *in vitro*, *in vivo* data on antiviral components are either lacking or inconclusive.

Other potentially active compounds of garlic; the plant viruses?

The compounds in garlic have been studied extensively, but as indicated before, the compound responsible for the observed antiviral effect is still a point of discussion. Strikingly, garlic contains a lot of plant viruses, which have been overlooked in the search for antiviral components of garlic. These viruses could potentially be responsible for the antiviral effects observed because of their relation to human viruses. The viruses present in garlic belong to different genera of different families, e.g. potyviruses belonging to the *Potyviridae*, several carlaviruses and allexiviruses of the *Closteroviridae* and a Fijivirus of the family Reoviridae (Salomon, R., 2002).

Conclusion

As illustrated by the literature above garlic has many described beneficial effects on human health and therefore would possibly be a suitable candidate to increase the health of animals in organic production. However a further literature search on the use of garlic in animal health only led to a very limited number of publications. The described methods used with garlic are mentioned here. For example garlic juice can be used for topical application (spraying on laying hens) to decrease the number of northern fowl mites on skin and feathers. These mites are external parasites and can lower the egg production and cause anaemia and even death. Also garlic has been shown to decrease cholesterol levels in chickens without altering growth of the chickens and feed efficiency. An attempt to use garlic as chemoprophylaxis of cryptosporidiosis in chickens failed.

The oral administration of garlic has some side effects, which are unwanted, such as adverse taste effects on meat, milk and eggs.

Examples of literature:

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Vaccination

Disease prevention by vaccination is an integral part of animal health management. Routinely used vaccines in chickens are for example vaccines against Intermediate Infectious Bursal Disease Virus, Newcastle Disease Virus and Marek’s Disease Virus (Sharma 1999). New vaccines, based on recombinant technology, are considered for commercial use and also new adjuvants are explored for their potential to enhance vaccine efficacy. This because existing animal vaccines have been shown to produce adverse effects. In fact Glickman (1999) states that all licensed animal vaccines are probably effective, but also produce some adverse effects.

Vaccine delivery systems are mostly based on injection of the vaccine into the target organism. However also other delivery systems exist and new ways to administer vaccines are being explored. For chickens, the vaccine delivery systems consist of in ovo injection, aerosol, spray, drinking water, eye drop and wing web injection (Sharma 1999).

In organic production the use of vaccines is allowed to some extend and GMO-based vaccines are also considered for treatment of diseases. The latter only for diseases with no alternatives available.

A new approach to produce and deliver vaccines, which could be particularly interesting for organic production systems with its specific demands, is the production of vaccines in plants. These plant-based vaccines could be developed further to allow oral administration and hereby circumvent some of the drawbacks associated with the current adjuvants used. An edible vaccine would be entirely plant based and would not contain any additional components of animal origin avoiding problems such as zoonotic diseases, prions etc.
Because of the fact that edible vaccines could be potentially be interesting to use in organic production systems a literature study was performed on such vaccines. A state of the art on the progress and developments in plant-based vaccines and more particularly edible vaccines is presented below.

Examples of Literature:

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Sharma JM. (1999). Introduction to poultry vaccines and immunity. Adv Vet Med; 41:481-94.

Sharma JM, Zhang Y, Jensen D, Rautenschlein S, Yeh HY. (2002). Field trial in commercial broilers with a multivalent in ovo vaccine comprising a mixture of live viral vaccines against Marek's disease, infectious bursal disease, Newcastle disease, and fowl pox. Avian Dis Jul-Sep; 46(3):613-22.

Plant-based edible vaccines

The literature search on edible vaccines revealed a great number of publications that deal with the subject of plant based vaccines. From these publications it is clear that already a lot of different types of target proteins have been successfully produced in plants. Small peptides and large proteins have been produced. Amongst them are proteins of biopharmaceutical interest and proteins from bacteria and viruses pathogenic to humans and animals. Examples of these are: single chain Fv epitopes, rotavirus, Norwalkvirus, respiratory syncytical virus, p24 of HIV, enterotoxins and the animal swine transmissible gasteroenteritis virus and Foot and Mouth Disease virus.
The proteins produced have been tested for their capacity to elicit immune responses in both animals and humans. From the tested proteins it is clear that the "proof-of concept" of production of active heterologous proteins in plants has been established. Both systemic and mucosal responses have been obtained in animals and humans and also significant levels of protection against challenges with the corresponding bacterial or viral pathogens have been observed. Also plant-derived antigens have been shown to be functionally similar to conventional vaccines. Optimism about the use of such proteins to increase the health of both humans and animals therefore is prevalent and many advantages of plants above other traditional systems for the production of vaccines are indicated. The advantages mentioned in the different articles are: faithful expression of highly immunogenic proteins, safe and economical method, heat stable products, easy to administer, cheap to produce, store and transport, easy to scale up for mass production, lack of contamination with animal pathogens, relative ease of genetic

manipulation and the presence of eukaryotic protein machinery, large quantities of protein/peptides produced, painless approach.
A drawback of the production of proteins in plants mentioned in the past is the sometimes low expression levels of the genes, which reduces the possibility of practical applications. However already new developments show promising results for an enhanced expression.
Antigens from infectious bacterial or viral diseases have been introduced into plants using Agrobacterium tumefaciens-mediated stable transformation methods or using recombinant plant viruses. The first method generates transgenic plants whereas the latter method is based on transient infection of plants.
As to the use of recombinant plantvirus as vector, e.g. CPMV, it was shown that plants can produce massive amounts of chimaeric virus particles which protect the target animal after a single injection against disease.
Both methods (transgenic plants and plant virus vectors) have been used increasingly to produce a wide range of biomedical reagents and seem promising methods for the future.

Conclusions

The collected data show that the concept of an edible vaccine is valid and that food plants can function as vaccines for simultaneous protection against infectious virus and bacterial diseases. The delivery of oral vaccines to a wide range of herbivore species seems feasible and the fact that proteins of important agricultural viruses such as Foot and Mouth Disease Virus can already be produced in plants and be functional in this respect is very promising. Still, transition from a model system into a practical reality has some way to go. Issues like oral tolerance, genetically modified organism safety, and effective vaccine doses need to be further studied. Also the stability and immunogenicity of orally delivered antigens can vary, which necessitates further studies on protein engineering.

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Prevention of diseases by controlling the transmitting insects and rodents

Insects are known transmitters of disease and therefore control of insects in all production systems is of major importance. The control of insects in organic production systems is however limited by the fact that no chemical substances can be used. Alternative measures are needed. One insect, the housefly, *Musca domestica* has been suggested regularly to play a role in the spread of pathogens such as bacteria and viruses and also protozoan and metazoan parasites. The housefly has been suggested to play a role in the spread of pathogens such as for example Aeromonas caviae (implicated in diarrhoeal disease of livestock), Aujeszky's virus (causal agent of pseudorabies), Campylobacter jejuni (avian campylobacteriosis) and Corynebacterium pseudotuberculosis (mastitis in cows). Ecological approaches that have been tried to control flies are for example the use of their natural enemies such as the parasitic wasp *Muscidifurax zaraptor* and bedding of calf hutches with sawdust instead of straw. Also the successful use of pheromones has been described both in laboratory settings as in field trials. In the latter case toxic targets are impregnated with pheromones in order to attract flies and eventually kill them. As the toxic targets used are not in contact with the animals or their food the use of such combinations of cages with pheromones seems an elegant approach for the control of the flies in organic production. The control of pest insects with pheromones is already widely used in organic crop protection programs and could be implemented in other organic production systems.

Another method that could be developed further for the control of insects is the use of insect viruses as bio-pesticides. This approach is also used in crop protection, though so far only for one insect virus (a baculovirus) a product has been developed (SpodX) for which permission of use is available.
In literature some other non-chemical methods to control flies are described which have major drawbacks. The use of electrocuting insect traps is mentioned, however studies show that killing of flies in these traps releases bacteria and viruses from the flies and therefore could theoretically increase the spread of infectious disease agents by flies. This example shows that any method used to control insects should be evaluated thoroughly before introduction into organic production systems.

Rodents have also been implicated in disease transmission and strict rodent control has been implemented in conventional animal production systems. Due to the fact that organic held poultry and pigs have outdoor access also means that keeping rodents out of the housing systems is more difficult as compared to conventional farming. Although rodenticides are allowed according to the EEC/2092/91 regulations, many organic farmers may be reluctant to use chemicals for rodent control and prefer biological control by employing farm cats or by stimulating the presence of prey birds in the vicinity of the farm.
Farm cats may transmit toxoplasma to pigs and their use on organic pig farms should not be encouraged. The use of poisons (based on anticoagulants such as brodifacoum, difenacoum, bromadiolon or difethialon) to kill rodents should not lead to the presence of dead rodents in the outdoor area or barns accessible to the animals. Both pigs and poultry are known to eat rodents possibly leading to transmission of various infectious micro-organisms. Furthermore some of these rodenticides may pose a serious risk to non target mammals and birds. Live rodent trapping techniques should preferably be used to counter disease transmission. Furthermore isolated feed storage, frequent removal of food spillover and vegetation control around the barns may help in rodent control.

Literature

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CHAPTER 5: QUALITY OF ORGANICALLY-PRODUCED FEEDS

Introduction

It is obvious that a lot of factors in production systems have an impact on the health of the animals involved. One major factor is of course the feeds administered to the animals. Depending on the production system (organic or conventional) differences in sorts of feeds and possibly also in feed quality might occur which could result in differences in the health status of the animals. The literature study performed, focussed on answering the question whether or not this is the case. For this, firstly differences in feed between organic and conventional production have been assessed and secondly aspects related to feeds that could affect the health of the animals have been identified.

Differences in feeds between organic and conventional production systems.

To get insight in the different types of feeds used in organic and conventional production systems information was obtained from different sources on the Internet. This because the information in scientific articles was too limited and fragmented.
"Stichting Voedingscentrum Nederland" gives a very nice overview of the subject "biologische landbouw" and all aspects involved such as regulations, fertilisation methods and crop protection products allowed etc. See www.voedingscentrum.nl.

From the information assessed it is clear that a major difference between organic and conventional production of feeds is that in organic production systems only limited crop protection and other products are allowed. In judging whether or not a certain product is allowed the natural character of the product is essential. The product should be derived from for example plants (or plantextract) or certain bacteria (e.g. *Bacillus Thuringiensis*) or obtained form natural sources. Examples of products used are soaps, spiritus, CO2, beer, milk, sugar solutions, algae-extracts, natural oils, micro-organisms, nicotine extract, garlic, salt etc.
These products are used for different purposes; as insecticides, fungicides, ascaricides or to enhance the growth of plants or increase the soil quality.
A remark should be made that the natural source of the products is no guarantee for non-toxicity for humans.

Besides non-chemical crop protection products organic producers use animal manure and other products to increase the growth of plants. The manure should be derived from their own production facilities or from other organic producers.

Another requirement of the feeds in organic production systems is that they should not be generated using gene-technology. The latter requirement and obtaining suitable manure are in the practical situation difficult to fulfil for an organic farmer and also difficult to control for the authorities.

Lists of animal feeds and other used products suitable for organic farming exist, including feeds of animal, plant and other origins and additives. For cattle the types of feeding of the animals does not differ between organic and conventional systems. Feeding of organic cattle should however be derived from organic production systems. Also the percentage of mixed feeds and raw feeds differ for organic cattle. For example 60% of the feeds should be raw feeds for organic cows. For organic cows also no synthetic additives, antibiotics etc. are allowed. Rules for pigs and chickens are similar.
As to nutritional quality of organic foods for humans there seems to be no difference in nutritional quality between an organic diet or a conventional diet, though the perception of consumers is that organically-produced crops and animal products are of higher nutritional quality. No evidence is available that can support or refute such perception in the scientific literature. Very few compositional differences have been reported, although there are reasonably consistent findings for higher nitrate and lower vitamin C contents of conventionally produced vegetables, particularly leafy vegetables (Williams, 2002).

In conclusion the major differences in the quality of feeds between organic and conventional production systems seem to originate from differences in production of plants (such as limited use of crop protection products) and the lack of certain additives in the feeds. The types of feeds administered do not differ significantly and in this respect there are mostly quantitative differences observed (more raw feeds).
Because of this it is also hard to estimate whether or not the differences in feeds will affect the health of the organically produced animals and this is reflected in the limited amount of data available about this topic. Differences in animal health due to differences in feeds could in addition also occur due to other more chain-related factors such as the harvesting, storage and further processing of products.

A further literature search was performed to gather more information on potential risks for animal health associated with the production of crops. In the literature found, serious concern has been expressed about a few topics in this respect. One major topic seems to be feeds (and foods) contamination with toxins produced by fungi, the so-called mycotoxins and therefore this subject has been evaluated further.

Mycotoxins

What are mycotoxins?

Mycotoxins are toxic secondary metabolites of fungi. Aflatoxins, ochratoxins, trichothecenes, zearelenone, fumonisins, tremorgenic toxins, and ergot alkaloids are the mycotoxins of greatest agro-economic importance, which are contaminants of agricultural commodities, foods and feeds. Mycotoxins are produced by several fungi, particularly by many species of *Aspergillus, Fusarium, Penicillium, Claviceps* and *Alternaria that* occur as plant pathogens, soil borne fungi, airborne fungi and aeroallergens. They are also very heterogenic. Approximately 400 of these fungal metabolites are considered to be toxic. Some fungi are capable of producing more than one mycotoxin and some mycotoxins are produced by more than one fungal species. Often more than one mycotoxin is found on a contaminated substrate. Fungi that produce these toxins do so both prior to harvest and during storage. They are distributed worldwide and may be recovered from a wide range of substrates. Their presence in food and feeds, as the result of fungal diseases in crops, can present a danger to animal and human health. Estimates are that at least 20% of the food crops grown in the EU and used for food and feeds contain measurable amounts of mycotoxins. Bulk products used for feed with high risk of mycotoxin contamination are for example grains (maize, wheat etc.). Whether or not mycotoxins are more problematic in organic production systems than in conventional systems is not clear from the literature.

What effects do they have?

Mycotoxins have adverse effects on humans, animals, and crops that can result in illnesses, mortality and economic losses. Diseases caused by mycotoxins are collectively referred to as mycotoxicosis. Disease is usually initiated after ingestion of feeds containing toxic doses of mycotoxins. Very small amounts of mycotoxins can already produce allergies, diseases, rashes on skin, nephrotoxicity and other disorders and more importantly long-term chronic effects.

Signs and symptoms vary and depend on the animal, the organ system involved, and on the dose and type of mycotoxins ingested. The symptoms can range from acute death, immunosuppression to skin lesions or to signs of hepatotoxicity, nephrotoxicity, neurotoxicity, or genotoxicity. Most of the toxic effects of mycotoxins are limited to specific organs, but several mycotoxins affect many organs. Induction of cancer by some mycotoxins is a major concern as a chronic effect of these toxins.

A well-known example of mycotoxins killing animals is aflatoxin, which killed 100.000 turkeys in 1960.

In addition to concerns over adverse effects of mycotoxins on animals consuming mycotoxin-contaminated feeds, there is also a public health concern over the potential for human beings to consume animal-derived food products such as meat, milk, or eggs, containing residues of those mycotoxins or their metabolites. However animals usually suffer more due to lower grain quality. In animals, next to acute intoxication, losses in productivity, reduced weight gain and immunosuppression are considered as most important feature of mycotoxicoses

The economic impact of mycotoxins include loss of human and animal life, increased health care and veterinary care costs, reduced livestock production, disposal of contaminated foods and feeds, and investment in research and applications to reduce severity of the mycotoxin problem. Although efforts have continued internationally to set guidelines to control mycotoxins, practical measures have not been adequately implemented.

What factors influence them?

Factors influencing the presence of mycotoxins in foods or feeds include environmental conditions related to storage. Other extrinsic factors such as climate or intrinsic factors such as fungal strain specificity, strain variation, and instability of toxigenic properties are important but more difficult to control. Production of mycotoxins is dependent upon the type of producing fungus and environmental conditions such as the substrate, water activity (moisture and relative humidity), duration of exposure to stress conditions and microbial, insect or other animal interactions.

The toxicity of the mycotoxins varies considerably with the toxin, the animal species exposed to it, and the extent of exposure, age and nutritional status. In some articles it is suggested that when growth conditions are suitable it is likely that all fungi are capable of producing mycotoxins.

Can we detect mycotoxins?

Suitable assays are required to implement control and regulatory strategies and to develop appropriate feeding regimens for infested feeds. Many different types of assays have already been used, most of which are however not reproducible or accurate. However, the immunoassays, particularly enzyme-linked immunosorbent assays (ELISAs), can be especially useful. Among these, assays that detect the water-soluble extracellular secretions of fungi, the exoantigens, are generally able to detect fungi at the genus or species level, whereas the heat-stable polysaccharides tend to be specific for one or more genus of fungi. Several species and genus (genera)-specific ELISAs have been developed using monoclonal or polyclonal antibodies against exoantigens and heat-stable polysaccharides from a wide range of fungi, including Aspergillus, Penicillium, and Fusarium species. Other assays have been developed that non-specifically detect fungi in food or feed, some using antibodies against a mixture of antigens from different fungi. These assays are highly sensitive, are easy to perform, and provide an index of the amount of fungi present in the sample. Further refinement of such assays could facilitate their widespread use by food and feed processors, regulatory agencies, taxonomists, and research scientists.

How to prevent mycotoxins?

It is nearly impossible to eliminate mycotoxins from the foods and feed in spite of the regulatory efforts at the national and international levels to remove the contaminated commodities. This is because mycotoxins are highly stable compounds, the producing fungi are ubiquitous, and food contamination can occur both before and after harvest. Mycotoxins and their effects on health are also difficult to study, because of the great number of toxins present. Nevertheless, good farm management practices and adequate storage facilities minimise the toxin contamination problems.

Thorough diagnostic evaluation of animals, appropriate testing of feeds and forages, and rational consideration of differential diagnoses help to put

mycotoxins in the proper perspective as a production-related management problem.
The most applied method for protecting animals against mycotoxicosis is the utilisation of adsorbents mixed with the feed which are supposed to bind the mycotoxins efficiently in the gastro-intestinal tract. Aluminosilicates are the preferred adsorbents, followed by activated charcoal and special polymers. The efficiency of mycotoxin binders, however, differs considerably depending mainly on the chemical structure of both the adsorbent and the toxin.
Another simple and effective approach to the chemoprevention of aflatoxicosis has been to diminish or block exposure to aflatoxins via the inclusion of HSCAS clay in the diet. HSCAS clay acts as an aflatoxin enterosorbent that tightly and selectively binds these poisons in the gastrointestinal tract of animals, decreasing their bioavailability and associated toxicities.
From the literature it is however not clear whether the methods mentioned can also be used in organic production systems.

Conclusion

From the available data it seems clear that mycotoxin contamination of feed should be controlled. Additional, systematic epidemiological data for exposure are needed for establishing toxicological parameters for mycotoxins and the safe dose for animals and humans. Multiple approaches will be needed to minimise the economic impact of the toxins on the entire agriculture industry and their harmfulness to human and animal health.
Current research is designed to develop natural bio-control competitive fungi and to enhance host resistance against fungal growth or toxin production. These efforts could prevent toxin formation entirely and reduce the risk of human and animal exposure to contaminated foods and feed.
Whether or not mycotoxins are more problematic in organic production systems then in conventional systems is not clear from the literature. A survey of Fusarium toxins in cereal-based consumption foods for humans showed the opposite; organic products containing lower amounts of toxin then conventional products. As to organic feeds no such data have been found and this stresses the fact that more research is needed in this particular area of research.

Examples of literature:

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Bhatnagar D, Yu J, Ehrlich KC. (2002).Toxins of filamentous fungi. Chem Immunol 81:167-206

Moreno-Lopez J. (2002) Contaminants in feed for food-producing animals. Pol J Vet Sci 5(2): 123-5

Hussein HS, Brasel JM. (2001). Toxicity, metabolism, and impact of mycotoxins on humans and animals. Toxicology Oct 15; 167(2):101-34.

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Hollinger K, Ekperigin HE. (1999). Mycotoxicosis in food producing animals. Vet Clin North Am Food Anim Pract Mar; 15(1):133-65, x.

Other components of feeds

Besides the above-described mycotoxins other components could be expected to be present in feeds according to the literature.
Several micro-organisms are described to be present in feeds and could be sources of infections for farm animals that could also result in human illnesses. These include Salmonella enterica, Bacillus anthracis, Toxoplasma gondii, Trichinella spiralis, prions, Listeria monocytogenes, EHEC, Campylobacter, Clostridium botulinum, Hog Cholera virus, Foot and Mouth Disease virus, etc.
Several pathogenic bacteria (pathogenic to humans) have been shown to be present on fresh food such as vegetables and fruits and have already caused health incidents. Such pathogens can be either present on the outside of the plant (epiphytes) or on the inside of the plant (endophytes, Hallmann, Quadt-Hallman et al., 1997). These micro-organisms appear to colonize plants via various routes during growth of the plants; via propagative material, growth substrate, water and biotic factors such as insects and cultural practices. Though the incidence of pathogenic bacteria in/on plants has not been investigated thoroughly it is clear that they form a realistic threat to human health.
As animals in organic production systems are fed with fresh products, theoretically they could also be exposed to these risks and therefore research on the incidence of pathogens in animal feeding is needed.
Seeds and plant propagative material are naturally contaminated with bacteria, further contamination can occur during harvesting, storage and processing of the fresh products. Also, the use of organic waste products for enhancement of soil

fertility is a major risk for introduction of pathogens into the production chains. A wide variety of pathogenic and non-pathogenic viruses, bacteria and parasites may be found in the manures used.

Besides negative effects on health some components e.g. endophytes have been shown to improve quality and storability of the fresh produce. Positive effects of components of plants (such as plant viruses, bacteria and fungi) almost have had no attention and limited data are therefore available.

Examples of literature:

Ackers, M.I. Mahon, B.E. et al. (1998). An outbreak of Escherichia coli O157:H7 infections associated with leaf lettuce consumption" J. of infectious disease 177, 1588-1593.

Beuchat, L.R. and J.H. Ryu (1997). "produce handling and processing practices" Emerg. Infect.Dis. 3(4), 459-65.

Hallmann, J.A., Quadt-Hallmann et al. (1997). "Bacterial endophytes in agricultural crops". Canadian J. Microbiology 43: 895-914".

Viswanathan, P. and P. Kaur (2001) "prevelance and growth of pathogens on salad vegetables, fruits and sprouts" Int. J. Hyg. Environ Health. 203 (3), 205-13.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

Although a large body of research on health aspects can be found via the web or in conference proceedings, only few papers reach the peer reviewed literature. This aspect makes it difficult to judge the quality of available data that relate to health aspects associated with organic livestock production.

Many data deal with “on farm case type studies” which often do not lead to a direct relation between certain management procedures and incidence of certain health aspects.

The principle that organic held animals are in better condition concerning their health as compared to conventionally held animals has not yet been proven. Well-controlled studies are needed to show the effects of organically held animals on innate and adaptive immune responses and disease susceptibility.

The conditions in organic livestock production lead to novel challenges concerning social interactions, physical requirements, climatic conditions and infectious burden which requires certain breeds of animals that differ considerably from the conventionally held animals. More research is needed to identify these breeds whereby breeding selection criteria specific to organic conditions and principles should be used.

A number of health problems such as infestation with parasites is an important problem that has been noted in organic livestock (poultry and pig) production and more research is needed to both prevent and treat these infections. Although largely recommended, phytotherapy and homeopathy do not have any demonstrated efficacy in managing helminths. A multidisciplinary approach is needed to address these questions. Investigations should be concerned with aspects such as rotation, stocking density, disinfections strategies, genetic predisposition and novel (plant derived or biological) antihelminthics.

A major drawback in the use of phytotherapeuticals is the lack of good clinical trials, most claims are based on traditional use, anecdotal evidence or extrapolation of human data. Another problem is the consistency/standardisation of the product; variations exist in the levels of “active” ingredients between lots.

Extensive studies have shown that garlic has a beneficial effect on human health and therefore would possibly be a suitable candidate to increase the health of animals in organic production. Further research is needed to substantiate this claim.

Although mastitis is not seen more often in organic dairy production compared to conventional farms, it is still frequently encountered and both basic and applied research concerning prevention and cure without the traditional use of antibiotics is needed.

More knowledge is needed concerning effects of alternative treatments in organic livestock production. As long as alternative treatments have not formally been proven to be effective, allopathic treatments should be preferred. Studies are needed concerning the welfare aspects of disease and insufficient or postponed treatment in organic animal production systems.

It is generally accepted that feather picking and cannibalism is a major problem in organic poultry and more research is needed to counter this unwanted behaviour of the animals. The following aspects including genetic influences, housing environment, feed composition and the presence of external parasites may be involved.

Vaccination has been one of the largest success factors in the prevention of disease in production animals. Most vaccines used nowadays are genetically engineered and should thus carry the GMO label. GMO based vaccines produced by incorporating genetic material from bacteria or viruses into plants is an attractive approach but does not comply with the principles of organic farming. Investigations concerning various vaccination strategies with or without GMO approaches should be evaluated to prevent various infectious diseases in organic livestock production systems.

Organic livestock production leads to an increase or re-emergence of certain zoonotic diseases (*Campylobacter, toxoplasma*). This is a serious drawback concerning claims that organic products are healthier as compared to conventional products and research into the prevalence of certain zoonotic infections, risk factors, farm management, post slaughter decontamination and consumer perception/education is badly needed.

Several micro-organisms are described to be present in feeds and could be sources of infections of farm animals. Such pathogens can be either present on the outside of the plant (epiphytes) or on the inside of the plant (endophytes). The incidence of pathogenic bacteria in/on plants used for organic animal feed is not clear and therefore research on the incidence of these pathogens is needed.

Biological cycles such as the utilisation of manure from organic farms may potentially lead to the creation of infectious reservoirs. Research is needed to provide evidence for this hypothesis and strategies should be devised to prevent this problem.

Little is known about the role of pests in the occurrence of disease in organic livestock production. Research is needed into the efficacy of alternative pest control strategies since current pest control methods are not in agreement with organic production principles (use of anticoagulants for rodent control).

The obligatory use of straw bedding in swine household management leads to higher dust and bioareosol (endotoxin) levels in stables. This may affect susceptibility to lung disease (farmer and animal) and investigations concerning measures to reduce dust and bioaerosol levels are needed. Current literature on this subject is not concordant and true differences may exist between management systems from different countries.

Piglet mortality is an important problem in organic production systems and research concerning genetic and housing aspects is currently performed but not yet reported in the peer-reviewed literature.

Amino acid imbalance and research into novel feed sources with high protein content is needed. More knowledge is known concerning possible anti-nutritive factors in these feeds and the effects of these new nutrients on gut health of the animals.

Amino acid imbalance may lead to higher excretion of excess amino acids into the environment. On farm research should be performed to substantiate whether these claims also apply to organic production systems.

It has been suggested that organic feeds for animals in organic production systems may contain higher mycotoxin levels thereby adversely affecting their health status. As yet no conclusive data concerning this issue has been published and research into this area is needed to prove or reject this myth.

As yet it is not known whether phytase levels in organic feed for pigs are sufficient to allow optimal utilisation of organic phosphor thereby also leading to a lower environmental pollution; further investigations are needed in this area.

APPENDIX A (EEC) nr. 2092/91 5. Disease prevention and veterinary treatment

5.1. Disease prevention in organic livestock production shall be based on the following principles:
(a) the selection of appropriate breeds or strains of animals as detailed in Section 3;
(b) the application of animal husbandry practices appropriate to the requirements of each species, encouraging strong resistance to disease and the prevention of infections;
(c) the use of high quality feed, together, with regular exercise and access to pasturage, having the effect of encouraging the natural immunological defence of the animal;
(d) ensuring an appropriate density of livestock, thus avoiding overstocking and any resulting animal health problems.

5.2. The principles set out above, should limit animal-health problems so that they can be controlled mainly by prevention.

5.3. If, despite all of the above preventive measures, an animal becomes sick or injured, it must be treated immediately, if necessary in isolation, and in suitable housing.

5.4. The use of veterinary medicinal products in organic farming shall comply with the following principles:
(a) Phytotherapeutic (e.g. plant extracts (excluding antibiotics), essences, etc.), homeopathic products (e.g. plant, animal or mineral substances) and trace elements and products listed in Part C, section 3 of Annex II, shall be used in preference to chemically synthesised allopathic veterinary medicinal products or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended;
(b) If the use of the above products should not prove, or is unlikely to be, effective in combating illness or injury, and treatment is essential to avoid suffering or distress to the animal, chemically synthesised allopathic veterinary medicinal products or antibiotics may be used under the responsibility of a veterinarian;
(c) The use of chemically synthesised allopathic veterinary medicinal products or antibiotics for preventive treatments is prohibited;

5.5. In addition to the above principles, the following rules shall apply:
(a) the use of substances to promote growth or production, (including antibiotics, coccidiostatics and other artificial aids for growth promotion purposes) and the use of hormones or similar substances to control reproduction (e.g. induction or synchronisation of oestrus), or for other purposes, is prohibited. Nevertheless, hormones may be administered to an individual animal, as a form of therapeutic veterinary treatment;
(b) veterinary treatments to animals, or treatments to buildings, equipment and facilities, which are compulsory under national or Community legislation shall be authorised, including the use of immunological veterinary medicinal products when a disease has been recognised as present in a specific area in which the production unit is located.

5.6. Whenever veterinary medicinal products are to be used the type of product must be recorded clearly, (including an indication of the active pharmacological substances involved) together with details of the diagnosis; the posology; the method of administration; the duration of the treatment, and the legal withdrawal period. This information is to be declared to the inspection authority or body before the livestock or livestock products are marketed as organically produced. Livestock treated must be clearly identified, individually in the case of large animals; individually or by batch, in the case of poultry and small animals.

5.7. The withdrawal period between the last administration of an allopathic veterinary medicinal product to an animal under normal conditions of use, and the production of organically produced foodstuffs from such animals, is to be twice the legal withdrawal period or, in a case in which this period is not specified, 48 hours.

5.8. With the exception of vaccinations, treatments for parasites and any compulsory eradication schemes established by Member States, where an animal or group of animals receive more than two or a maximum of three courses of treatments with chemically-synthesised allopathic veterinary medicinal products or antibiotics within one year (or more than one course of treatment if their productive lifecycle is less than one year) the livestock concerned, or produce derived from them, may not be sold as being products produced in accordance with this Regulation, and the livestock must undergo the conversion periods laid down in Section 2 of this Annex, subject to the agreement of the inspection authority or body.

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