VKM
Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

Comparison of organic and conventional food and food production

Part II: Animal health and welfare in Norway

Opinion of the Panel on Animal Health and Welfare and the Steering Committee of the Norwegian Scientific Committee for Food Safety

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Summary

The Norwegian Food Safety Authority (NFSA) requested an assessment of current knowledge regarding conventional and organic food production and a review of scientific literature that compare these two food production systems in order to provide support in their management of food safety. NFSA needed to clarify the extent to which existing research demonstrates whether there are differences with respect to human health and animal health and welfare between organic production systems and products and conventional production methods and products. Furthermore, if there are significant differences in the production systems, how would these differences impact public human health and animal health and welfare?

The assessment was divided between five different panels. The Panel on Animal Health and Animal Welfare, via an appointed project group, summarised and evaluated current knowledge based on comparisons between conventional and organic animal production and how the different production factors influence the animal health, animal welfare and feed for cattle, poultry, swine, sheep, goat and bees when organic production systems are used compared to conventional production systems.

The assessment is based on comprehensive literature searches using relevant keywords and combination of keywords. The conclusions given below are results of reviews of relevant scientific literature and of expert opinions of the panel.

The mean herd size in conventional Norwegian animal production is small compared to the major European agricultural countries, both due to government regulations on herd size (pigs and poultry) and milk quotas (cows and goats) and distribution of agricultural land. Further, the Norwegian animal welfare regulations for conventional animal production are strict compared to those of other countries in Europe, possibly with the exception of Sweden and Switzerland. Hence, the differences between animal welfare regulations in Norway for organic and conventional animal production are less than in most other countries.

It is also important to be aware that the authorities' regulation of the distribution and sales of medicine for use in animal production is very different between the Nordic countries and the rest of Europe and overseas countries. In Norway and other Nordic countries, only veterinarians are allowed to prescribe antibiotics for animal use. This is probably, together with freedom from several of the main serious infectious diseases in animal production, the reason why the use of antibiotics is considerably lower in Norway compared to the countries outside the Nordic countries.

Due to these aspects, the project group agreed on that this assessment should strictly be based on the differences between the Norwegian regulations for organic animal production and the Norwegian regulations for conventional animal production concerning animal health and animal welfare. The main differences in the regulations for organic and conventional farming related to animal health and welfare were found to be space allowance, access to pasture and outdoor areas, feeding practices, use of organic grown feed, use of concentrate, fertilizers (organic manure), double withdrawal time after use of medications and some restrictions on the frequency of use of medication for the same animal.

The Panel on Animal Health and Welfare reached the following conclusions regarding organic and conventional husbandry systems:

- The frequency of medication of animals are found to be lower in organic compared to conventional farming for many diseases, except for milk fever in dairy cattle. However,

looking at objective subclinical measures which are not imposed by farmers' attitude to call for veterinary assistance, like somatic cell count and metabolic parameters, and after adjusting for confounding factors, the conclusions are that there is no difference in objective disease occurrence between organic and conventional farming except for less clinical mastitis and more milk fever in organic herds.

- For dairy cattle, the difference between the two systems in proportional rate of antimicrobial resistant bacteria is small and insignificant. The presence of antimicrobial resistant bacteria in both production systems are very low in Norway, compared to other countries in Europe and overseas countries.

- For cattle, the increased access to pasture and outdoor areas, the use of group housing for milk feeding calves and the increased space allowance for growing cattle is positive for animal welfare in organic production. However, grouping of young calves, suckling for three days, as well as pasturing, could have some hygienic challenges due to more exposure for pathogens and parasites, but these challenges can be overcome with good management. The practise of suckling in three days makes a challenge to control that the calves get sufficient amount of colostrum.

- For sheep and goats, the differences in animal health and welfare are small. Both predators and prevention of parasites on pasture are huge challenges in both systems.

- For pigs, the access to outdoor area and provision of roughage is positive for animal health and welfare in organic production. On the other hand, prevention and control of parasites and pathogens from wildlife as well as predators may be a challenge for pigs with access to outdoor areas. These challenges can however be overcome by good management.

- For poultry, the increased space allowance in organic production, the use of slow growing breeds, the use of roughage and natural light is beneficial for both health and welfare. Access to outdoor areas is positive for animal welfare, but increases the risk of parasites and infectious diseases. There might also be an increased risk of death caused by predators. These challenges may to a great extent be overcome by good management.

- Differences of organic and conventional feed production concerning use of pesticides, fertilisers, chemically synthesized solvents, flavours and colours, and synthetic amino acids on animal health and welfare remains to be shown. The nutrient contents, bioactive secondary plant compounds as well as contaminants such as mycotoxins and pesticide residues, may differ between organically and conventionally produced plants for feed. The impact on animal health and welfare is sparsely documented.

- For honeybees, the ban in organic farming against feeding bee colonies with pollen supplements in periods with low pollen availability, as well as the ban (EU regulation) against caustic soda to disinfect equipment, causes welfare and health challenges compared to conventional honey production.

Norsk Sammendrag

Mattilsynet har bedt VKM om en vurdering av dagens kunnskap om konvensjonell og økologisk matproduksjon, samt en gjennomgang av vitenskapelig litteratur som sammenligner disse to produksjonssystemene, for å kunne gi Mattilsynet støtte i sin forvaltning av området. Mattilsynet trengte å avklare i hvilken grad eksisterende forskning viser om det er forskjeller med hensyn til menneskers helse og dyrs helse og velferd mellom økologiske produksjonssystemer og produkter og konvensjonelle produksjonsmetoder og produkter.

Videre ble VKM bedt om å vurdere hvordan eventuelle forskjeller i de to produksjonssystemene påvirker menneskers og dyrs helse.

Vurderingen ble delt mellom fem forskjellige faggrupper. Faggruppen for dyrehelse og dyrevelferd har, via en nedsatt arbeidsgruppe, oppsummert og evaluert dagens kunnskap basert på sammenligninger mellom konvensjonell og økologisk husdyrproduksjon. Faggruppen har også evaluert og oppsummert hvordan de to produksjonsformene påvirker dyrehelse, dyrevelferd og fôr til storfe, fjørfe, svin, sau, geit og honningproduserende bier.

Vurderingen er basert på omfattende litteratursøk ved hjelp av relevante søkeord og kombinasjoner av søkeord.
Den gjennomsnittlige besetningsstørrelsen i konvensjonell, norsk husdyrproduksjon er liten sammenlignet med store europeiske landbruksland, både på grunn av myndighetenes konsesjonsgrenser for besetningsstørrelse (svin og fjørfe), melkekvoter (storfe og geiter) og fordeling av jordbruksland.

Videre er det norske dyrevelferdsregelverket for konvensjonell husdyrproduksjon strengt i forhold til de andre landene i Europa, muligens med unntak av Sverige og Sveits. Derfor er forskjellene mellom dyrevelferdsregelverk i Norge for økologisk og konvensjonell husdyrproduksjon mindre enn i de fleste andre land.
Det er også viktig å være klar over at myndighetenes regulering av distribusjon og salg av veterinære legemidler for bruk i husdyrproduksjon er svært forskjellig mellom de nordiske landene og resten av Europa og oversjøiske land. I Norge og andre nordiske land, er det kun veterinærer som har lov til å foreskrive antibiotika for bruk på dyr. Dette er trolig, sammen med frihet fra flere av de viktigste alvorlige smittsomme sykdommene i husdyrproduksjonen, grunnen til at bruken av antibiotika er betraktelig lavere i Norge sammenlignet med land utenfor Norden.

På grunn av disse forholdene ble prosjektgruppen enig om at denne vurderingen burde baseres på forskjellene mellom det norske regelverket for økologisk husdyrproduksjon og det norske regelverket for konvensjonell husdyrproduksjon.

De viktigste forskjellene i regelverket for økologisk og konvensjonelt landbruk knyttet til dyrehelse og dyrevelferd er plasstilgang, tilgang til beite og uteområder, fôringspraksis, bruk av økologisk dyrket fôr, bruk av konsentrat, gjødsel (organisk gjødsel), dobbel tilbakeholdelsestid etter bruk av medisiner og restriksjoner i forhold til bruk av medikamenter til ett

og samme dyr.

Faggruppen for dyrehelse og dyrevelferd har kommet til følgende konklusjoner om økologiske og konvensjonelle systemer for dyrehold:

- Medisinbruken til produksjonsdyr, med unntak av melkefeber hos melkeku, er funnet å være lavere i økologisk landbruk sammenlignet med i konvensjonelt landbruk. Når man ser på objektive subkliniske helseparametere (som ikke er påvirket av bøndenes holdning til å ringe etter veterinær assistanse), som for eksempel celletall og metabolske parametere, er konklusjonen at det ikke er forskjeller i objektiv sykdomsforekomst mellom økologisk og konvensjonell melkeproduksjon (med unntak av lavere forekomst av klinisk mastitt og høyere forekomst av melkefeber i økologiske besetninger).

- Forskjellen mellom de to systemene når det gjelder forekomst av antibiotikaresistente bakterier er liten og ubetydelig. Tilstedeværelsen av antimikrobielle resistente bakterier i begge produksjonssystemer er svært lav i Norge sammenlignet med andre land i Europa og oversjøiske land.

- For storfe er økt tilgang til beite og uteområder, bruk av gruppebinger for melkefôrede kalver og økt plasstilgang for storfe i vekst positivt for dyrevelferd i økologisk produksjon. Gruppering av unge kalver som får die i tre dager, så vel som beiteforhold, kan medføre hygieniske utfordringer på grunn av mer eksponering for patogener og parasitter. Disse utfordringene kan imidlertid løses med godt stell. Praksisen med å la kalven suge moren i tre dager gir en stor utfordring i det å kontrollere at kalvene får tilstrekkelig mengde med råmelk.

- For sauer og geiter er forskjellen i dyrehelse og dyrevelferd mellom systemene liten. Både rovdyrangrep og parasitter på beite er store utfordringer i begge produksjonssystemer.

- For griser er tilgang til uteareal og grovfôr positivt for dyrehelse og dyrevelferd i økologisk produksjon. På den annen side er parasitter, overføring av patogener fra ville dyr, så vel som rovdyrangrep, en utfordring for griser som har tilgang til uteområder. Disse utfordringene kan imidlertid løses ved godt stell og riktig forvaltning av utearealene.

- For fjørfe er økt plass, bruk av saktevoksende raser i slaktekyllingproduksjonen, bruk av grovfôr og naturlig lys fordelaktig for dyrevelferd og dyrehelse i økologisk produksjon. Tilgang til utearealer er positivt for dyrevelferden, men øker risikoen for parasittangrep og utbrudd av smittsomme sykdommer. Det kan også være en økt risiko for predasjon. Disse utfordringene kan imidlertid i stor grad løses ved godt stell og riktig forvaltning av utearealene.

- Eventuell påvirkning på dyrs helse og velferd grunnet forskjeller i økologisk og konvensjonell fôrproduksjon når det gjelder bruk av plantevernmidler, gjødsel, kjemisk syntetiserte løsningsmidler, smaks- og fargestoffer, samt syntetiske aminosyrer, ikke klarlagt. Innholdet av næringsstoffer, bioaktive sekundære plantemetabolitter samt forurensninger som mykotoksiner og sprøyetmiddelrester kan være forskjellig i økologisk og konvensjonelt produsert plantefôr, men påvirkning på dyrehelse og dyrevelferd er i liten grad dokumentert.

- For honningproduserende bier vil forbudet i økologisk produksjon mot fôring med pollen som kosttilskudd i perioder med lav pollentilgjengelighet, samt EUs forbud mot kaustisk soda for å desinfisere produksjonsutstyr, forårsake velferdsutfordringer i forhold til konvensjonell honningproduksjon.

Keywords

Animal Health, Animal Welfare, Organic Farming, Conventional Farming, Organic Food, Conventional Food, Animal Feed, Biological Hazards, Microbiological Contaminants,

Contents

Background

The goal of the Norwegian government is that 15% of the agricultural production is organic in 2020 (St. Meld. 9, 2011-2012). However, knowledge on the impact of an increase in organic production in Norway is limited. If and how organic production practices may affect human health, animal health and welfare, plant health, the environment and sustainability is not clear.

In order to be able to give scientifically based information and advice on this issue to consumers and other target groups, the Norwegian Food Safety Authority (NFSA) requested a scientific evaluation of current research and other data on organic food and food production from The Norwegian Scientific Committee for Food (VKM). The scientific evaluation and the knowledge will also be used in connection with the NFSA's regulatory and international work on organic food production. The NFSA first prepared a draft request that was put out for public consultation. Remarks from the bodies that commented on the proposal clearly stated that there are limitations in the basic data for such an evaluation. NFSA therefore limited the scope and focus of the request somewhat. Sustainability aspects and environmental impact of organic and conventional agricultural practices are not addressed. In addition, organic aquaculture, which has only been practiced for a few years, is excluded from the request.

All foodstuffs on the market shall be safe and wholesome. Whereas all food produced and marketed shall comply with relevant legislation, food marketed as organic must in addition comply with regulations specific for organic production.

Organic food production is defined in Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products as "The use of the production method compliant with the rules established in this Regulation, at all stages of production, preparation and distribution". The regulation on organic food production is part of the EEA Agreement and covers inputs, crop production, livestock production, rules for processing, labeling, and inspection, and provides provisions for imports from third countries.

According to Council Regulation (EC) No 834/2007, organic production shall be based on the following principles (article 4):

(a) the appropriate design and management of biological processes based on ecological systems using natural resources which are internal to the system by methods that:

- i) use living organisms and mechanical production methods;
- ii) practice land-related crop cultivation and livestock production or practice aquaculture which complies with the principle of sustainable exploitation of fisheries;
- iii) exclude the use of GMOs and products produced from or by GMOs with the exception of veterinary medicinal products;
- iv) are based on risk assessment, and the use of precautionary and preventive measures, when appropriate;

(b) the restriction of the use of external inputs. Where external inputs are required or the appropriate management practices and methods referred to in paragraph (a) do not exist, these shall be limited to:

- i) inputs from organic production;
- ii) natural or naturally-derived substances;
- iii) low solubility mineral fertilisers;

(c) the strict limitation of the use of chemically synthesised inputs to exceptional cases these being:

i) where the appropriate management practices do not exist; and
ii) the external inputs referred to in paragraph (b) are not available on the market; or
iii) where the use of external inputs referred to in paragraph (b) contributes to unacceptable environmental impacts;

(d) the adaptation, where necessary, and within the framework of this Regulation, of the rules of organic production taking account of sanitary status, regional differences in climate and local conditions, stages of development and specific husbandry practices.

Terms of reference

The Norwegian Food Safety Authority (NFSA) requests the Norwegian Scientific Committee for Food Safety (VKM) to evaluate current scientific knowledge of organic production and organically produced food based on existing national and international research results and other documentation. The NFSA wants the evaluation to focus primarily on Norwegian production.

NFSA has found it appropriate to divide this comprehensive evaluation of organic production and organic food into five parts:

1. Plant health – plant production
2. Animal health – animal welfare and feed
3. Human health – nutrition and contaminants
4. Human health – hygiene and pathogens
5. Human health – pesticide residues

NFSA would like VKM to compare the effects of organic versus conventional production based on the evaluations that are done in the five areas above. If lack of data prevents such a comparison, this should also be reported.

Part II. Animal health – animal welfare and feed

NFSA requests VKM to evaluate the impact of different production factors on animal health, animal welfare and feed for cattle, poultry, swine, sheep, goat and bees when organic production systems are used compared to conventional production systems. For the evaluation of animal welfare the method described by EFSA Panel on Animal Health and Welfare (AHAW) would be recommended, Guidance on Risk Assessment for Animal Welfare, Scientific Opinion, Draft version, EFSA Journal 2011).

<u>NFSA requests VKM to identify and/or assess:</u>

- consequences on animal welfare and animal health of feed and feeding practices using an organic production system compared to a conventional production system
- differences in animal welfare and health for various species of livestock under an organic versus conventional production system
- differences in animal welfare and health for bees under organic versus conventional production systems.
  - May the prohibition of feeding with pollen replacement /protein have any negative consequences?

Introduction

The Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM) has at the request of the Norwegian Food Safety Authority (Mattilsynet, NFSA) compared organic and conventional food and food production in relation to possible impact on plant health, animal health and welfare and human health. The assessment is based on published peer reviewed scientific literature and assessment reports from international and national scientific bodies.

The following aspects of organic food production were not addressed in the assessment as they were not part of the request; sustainability aspects and environmental impacts of organic and conventional agricultural practices, and furthermore: aquaculture, because organic aquaculture has only been practiced for a few years.

At the request of the Norwegian Food Safety Authority the assessment was divided into five parts addressing:

I) Plant health and plant production (assessed by Panel on Plant Health)
II) Animal health and animal welfare (assessed by Panel on Animal Health and Welfare)
III) Humane health - nutrition and contaminants (Panel on Nutrition, Dietetic Products, Novel Food and Allergy)
IV) Human health – hygiene and pathogens (assessed by Panel on Biological Hazards)
V) Pesticide residues (assessed by Panel on Plant Protection Products)

The present report focuses solely on animal health, animal welfare and feed. VKM appointed a working group consisting of VKM members and external experts to prepare a draft opinion. The opinion was approved by VKMs Panel on Animal Health and Welfare. The Scientific Steering Committee of VKM approved the final opinion, i.e. this document.

Overview of organic animal production in Norway

The number of organic farms in Norway was 2303 in year 2002 and increased to 2590 in 2012 (Debio, 2013). The proportion of organic agricultural land is now 5.1 %.

The number of organic farms with cattle production in Norway in 2012 was 595, the number of farms with pig production was only 16. A total of 638 organic farms had sheep production and 38 had goat production. Poultry production was found on 94 organic farms.

Table 1. Numbers of farms and number of animal in organic production in Norway 2012 (Debio, 2013).

	Number of animals	Number of farms
Dairy cattle	9049	330
Beef cattle	3628	256
Young stock	16720	571
Breeding sows	269	12
Growing-finishing pigs	1279	14
Piglets (< 20 kg)	756	6
Ewes/lambs	43360	595
Year around outdoor ewes	4968	59
Dairy goats	429	8
Goats for meat production	388	38
Young stock	478	40
Laying hens (> 20 weeks)	151095	89
Chickens	112055	3
Broilers	28999	4
Turkeys	11500	1

Background

The mean herd size in conventional Norwegian animal production is quite small in comparison to other European countries, both due to government regulations on herd size (pigs and poultry) and milk quotas (cows and goats) and of course because of the distribution of agricultural land. Further, the Norwegian animal welfare regulations for conventional animal production must be regarded as relatively strict compared to other countries in Europe, possibly with the exception of Sweden and Switzerland. Hence, the difference between animal welfare regulations in Norway for organic and conventional animal production must be considered to be less than in most other countries.

In the Nordic countries, there are regulations of distribution of antibiotics and other medical drugs for production animals, where such drugs have to be sold from the pharmacies only (Grave et al., 1999). This means that veterinarians cannot sell antibiotics directly to the farmers with an additional provision. In many other countries veterinarians can sell drugs to the farmers and this is a fairly large part of their income. In some other countries farmers can also buy drug directly from the pharmaceutical companies or other drugstores, like feeding companies. Antimicrobial growth promoters (AGPs) were phased out in Denmark, Norway and Sweden in 1998 and this is a fairly large part of the use of antibiotics in some countries (Grave et al., 2006). This use of antibiotics also is reflected in the EU report from 2013 (European Medicines Agency, 2013) where the use of antibiotics measured in mg per PCU (mg active ingredient sold per population correction unit (mg/PCU), is lowest in Norway and Iceland, followed by Sweden. Se figure 1.

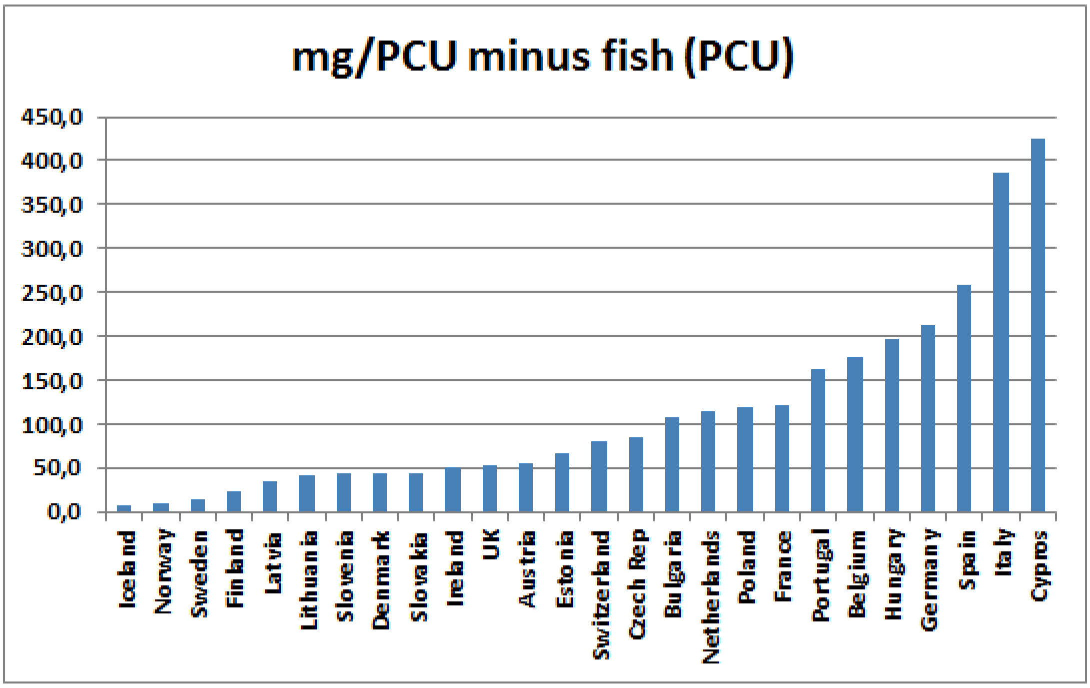

Figure 1. Mg antibiotics sold for production animals in European countries in 2011. PCU is an estimate of kg of different categories of livestock and slaughtered animals. In this graph the production of fish is withdrawn and the consumption for fish in other countries estimated as equal to the Norwegian consumption. (The fish production in Norway consists of 50.5 % of all fish in all countries, and the fish production is 68 % of the Norwegian production – in Italy (next to Norway) fish consists of only 4 % of the production) (source: European Medicines Agency, 2013).

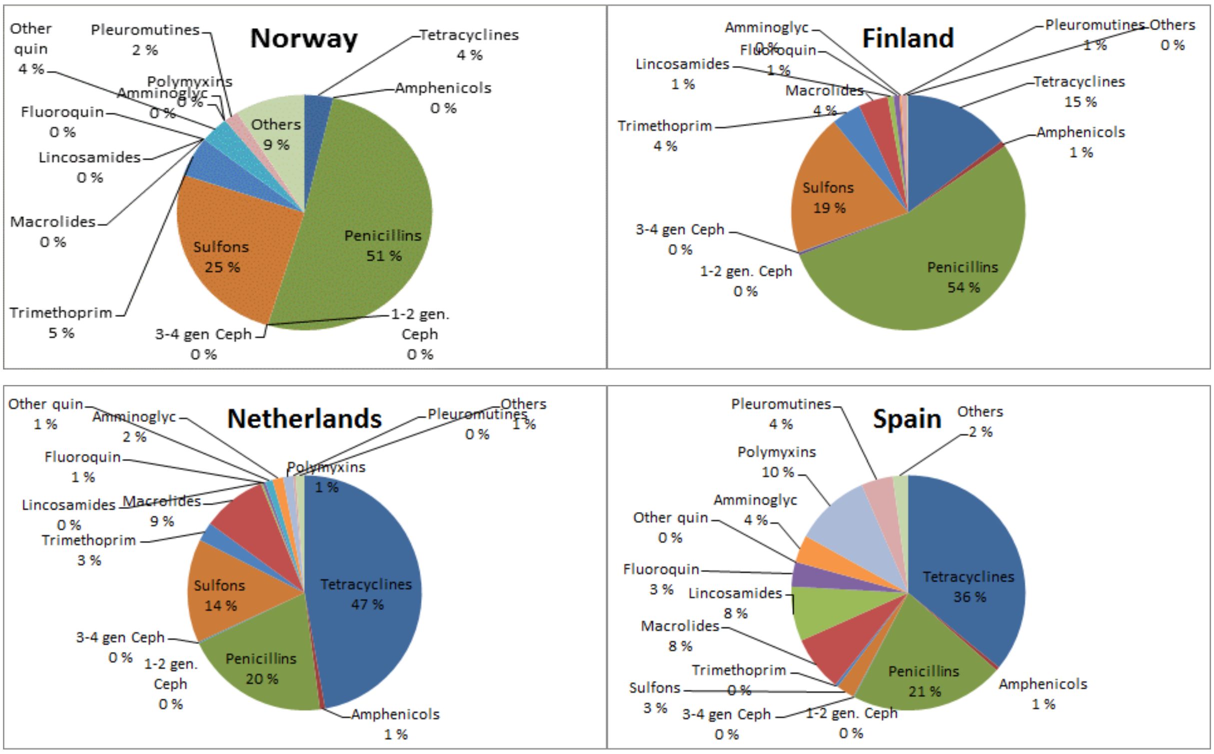

Figure 2. The distribution of different types of antibiotics sold for production animals in 2011 in Norway, Finland, The Netherlands, and Spain (source: European Medicines Agency, 2013).

According to the European Medicines Agency (2013) the distribution of different antibiotic are very diverse between different European countries and there is a huge differences in diversity of antibiotic used between Nordic countries and other European countries. An example of this is illustrated in figure 2.

The consequence of the sales of antibiotics and distribution of different types of antibiotics used for production animals in different European countries indicates that a comparison of disease treatments and the distribution of resistant bacteria between organic and conventional farming system between different countries is not a relevant comparison.

The ad hoc scientific group agreed on that this assessment should be based on the differences between the Norwegian regulations for organic animal production and the Norwegian regulations for conventional animal production concerning animal health and animal welfare. Spoolder (2007) has made a review on animal welfare in organic farming systems. It is interesting to notice that in most of the comparisons between organic and conventional production (see review on animam welfare in organic farming systems by Spoolder, 2007), the conventional production systems are quite unlike the conditions for animals in Norway.

There is one national regulation for organic production ("Forskrift om økologisk produksjon og merking av økologiske landbruksprodukter og næringsmidler, 2005"). In addition The Norwegian Food Safety Authority has prepared a national guide for organic production based on this regulation ("Veileder B, Utfyllende informasjon om økologisk landbruksproduksjon") in order to provide more detailed information. The national regulations are based on the European regulations for organic production, Council regulation No 834/2007 and Commission Regulation (EC) 889/2008.

The national regulations for conventional animal production for the different farm animal species can be found in:

Regulations on the keeping of chickens and turkeys (2001)

Regulations on the keeping of pigs (2003)

Regulations on the keeping of cattle (2004)

Regulations on the welfare of sheep and goats (2005)

Definitions of animal welfare

Most of the proposed scientific definitions of animal welfare are related to three main approaches: 1) "the biological functioning approach", 2) "the subjective experience approach" and 3) "the natural living approach". The biological functioning approach relates to the proper function of the animals' biological systems. Welfare depends on whether the animal can cope successfully with its environment and function normally from a biological perspective. Within this approach, welfare is reduced by disease, injury and malnutrition, whereas good welfare will be indicated by e.g. high levels of growth, production fitness and longevity (Duncan and Fraser, 1997; Fraser and Broom, 1990). Records of disease, production and physiological parameters as well as behavioural parameters indicating proper biological function may serve as indicators of animal welfare. The subjective experience approach relates to the animals' negative subjective experiences such as pain, fear, frustration, hunger, and positive subjective states such as contentment, pleasure, and comfort (e.g. Duncan 1993; Duncan and Fraser 1997; Spruijt et al., 2001; Boissy et al., 2007). It is impossible to measure subjective states in animals. However, behavioural, physiological and cognitive approaches can be used to indirectly assess animal welfare. The natural living approach implies that animal welfare depends on the animal being allowed to perform its "natural behaviour" and live a "natural life"; e.g. Rollin (1993): "Not only will welfare mean control of pain and suffering, it will also entail nurturing and fulfilment of the animals' natures, which I call telos". This approach means freedom to perform most types of natural behaviour in a natural environment.

A current understanding of animal welfare incorporates all three approaches mentioned above. In Norway, the proposition to the Parliament on the present Animal Welfare Act discusses animal welfare definitions (Ot.prp. no. 15 (2008-2009), ch. 2.1.1.4). The Ministry of Agriculture and Food states that it "agrees with the hearing statements that a definition of animal welfare can be *the individual's subjective experience of its mental and physical condition, as regards its attempt to cope with its environment*." This must therefore be regarded as the definition to be used when interpreting the Animal Welfare Act.

It has to be emphasized that animal welfare is understood somewhat differently in organic farming from what is common in conventional agriculture, and is to a great extent based on the natural living approach. According the International Foundation for Organic Agriculture (www.ifoam.org), good animal welfare means that the animals should have the possibility to perform natural behaviour, getting feed adjusted to their physiology and living in an environment as similar to the biotope which the animal is evolutionary adapted to as possible. One interpretation of this definition is that livestock should have access to an outdoor area. However, organic feed and natural life is not enough to guarantee a good quality of life. The overall goal in organic farming is to create sustainable agrosystems, but the relationship between a well-functioning system and individual welfare is not straight-forward (Lund, 2006). Natural behaviour may be defined as the behaviour performed by an animal in its species-specific biotope (www.agropub.no). Livestock buildings and management systems should be adapted to the production animals in accordance with up to date knowledge about their natural behaviour. The organic understanding of the animal welfare concept, and the philosophy underlying organic farming, bring about some practical consequences for livestock production and also some dilemmas. In organic farming allowing animals a natural life is considered a good in itself and a precondition for a good life. This means that even some negative experiences for the individual may be tolerated. To an extent, such experiences are perceived as a natural part of life that can never be completely deleted from an individual animal's spectrum of experiences. This does not mean that such experiences are not negative for the individual as they happen, but rather that they are viewed as an important part of the functional feedback system connecting individual behaviour and the surrounding world (Lund, 2006). This interpretation of the animal welfare concept can result in different interpretation of welfare status in animals. For example, a pig outdoors in bad weather with a subclinical parasite infection fulfil many criteria for having a natural life, but may not be considered as having good welfare within the biological functioning approach (Lund, 2006). Furthermore, access to outdoor area provide a «natural life» but there is a risk of exposing the animals to various viral, bacterial and parasitic infections some of which may influence the animals' own welfare in terms of biological function whereas other ones may also endanger the health of conventional livestock (Bestman et al., 2009).

Taken together, conclusions about welfare may in general be strongly influenced by definitions of welfare and underlying values that in turn decide which indicators to use as basis for conclusions. Thus, there are general major challenges when reviewing animal welfare consequences of conventional and organic farming. In this assessment the risk of suffering is interpreted in terms of the animal welfare concept. Animal welfare incorporates the animal’s quality of life. Various definitions have been proposed to define welfare and several are still used. In this current assessment, animal welfare is defined as *the individual’s subjective experience of its mental and physical condition as regards its attempt to cope with its environment.* In this definition, mental state incorporates emotional and cognitive states; physical state includes physical and physiological states which affect the mental state; and environment encompasses the animal’s social, physical and other biological environment. The welfare level is characterized by the balance between positive and negative experiences. Health, behaviour and physiologically related indicators are important.

Differences in regulations for organic and conventional animal production in Norway. Mapping the hazards.

The project group has identified the following differences/hazards between the regulations for organic and conventional animal production in Norway. In general, all animal production in Norway must follow the national regulations, and the regulations for organic production come in addition to this. Regarding minerals and conservation of feed, there are no differences in the legislation between organic and conventional animal production. These aspects have of this reason not been considered.

Table 2. Differences between the regulations for organic and conventional animal production in Norway.

Veterinary treatments

	Hazard	Organic Regulation	Conventional Regulation
1	**Treatment of sick animals**	According to Commission Regulation No 889/2008, Article 24: 1. Phytotherapeutic, homoepathic products, trace elements and products listed in Annex V, part 3 and in Annex VI, part 1.1. shall be used in preference to chemically-synthesized allo-pathic veterinary treatment or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended. 2. If the use of measures referred to in paragraph 1 and 2 is not effective in combating illness or injury, and if treatment is essential to avoid suffering or distress of the animal, chemically-synthesised allopathic veterinary medicinal products or antibiotics may be used under the responsibility of a veterinarian.	There is no such regulation for conventional animal production in Norway
2	**Withdrawal time**	According to Commission Regulation No 889/2008, Article 24: 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 as referred to in Article 11 of Directive 2001/82/EC or, in a case in which this period is not specified, 48 hours.	
3	**Disease prevention**	According to Commission Regulation No 889/2008, Article 23: 1. The use of chemically synthesised allopathic veterinary medicinal products or antibiotics for preventive treatment is prohibited, without prejudice to Article 24(3). 2. 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 or for other purposes (e.g. induction or synchronisation of oestrus), is prohibited.	
	Disease prevention	According to Commission Regulation No 889/2008, Article 23: The use of chemically synthesised allopathic veterinary medicinal products or antibiotics for preventive treatment is prohibited, without prejudice to Article 24(3).	

		According to Commission Regulation No 889/2008, Article 24 Phytotherpeutic homoepathic products, trace elements and products listed in Annex V, part 3 and in Annex VI, part 1.1 shall be used in preference to chemically-synthesized allopathic veterinary treatments or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended. If the use of measures referred to in paragraph 1 and 2 is not effective combatting illness or injury, and if treatment is essential to avoid suffering or distress of the animal, chemically-synthesized allopathic veterinary products or antibiotics may be used under the responsibility of a veterinarian. With the exception of vaccinations, treatments for parasites and compulsory eradiction schemes where an animal or group of animals receive more than three courses of treatments with chemically-synthesized allopathic veterinary medical products or antibiotics within 12 months, or more than one course of treatment if their lifecycle is less than one year, the livestock concerned, or the produce derived from them, may not be sold as organic products and the the livestock shall undergo the conversion periods laid down in Article 38.	
4	**Reproduction, mating/insemination and hormones**	According to Council regulation No 834/2007, article 14 c (i) reproduction shall use natural methods. Artificial insemination is however allowed; (ii) reproduction shall not be induced by treatment with hormones or similar substances, unless as a form of veterinary therapeutic treatment in case of an individual animal; (iii) other forms of artificial reproduction, such as cloning and embryo transfer, shall not be used	
5	**Medication more than three courses**	According to Commission Regulation No 889/2008, Article 24.4, state that with the exception of vaccinations, treatments for parasites and compulsory eradication schemes where an animal or group of animals receive more than three courses of treatments with chemically-synthesised allopathic veterinary medicinal products or antibiotics within 12 months, 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 organic products, and the livestock shall undergo the conversion period laid down in Article 38 (1).	No such rules

Cattle

	Hazard	Organic regulation	Conventional regulation
1	**Suckling and milk feeding periode**	According to Commission Regulation No 889/2008, Article 20, all young animals should be fed on maternal milk in preference to natural milk, for a minimum of three months in cattle. In addition the national regulation state (§ 13) that calves should be able to suckle for the first three days after birth and if the suckling period is less than one month, the calves should be fed milk with a teat bucket.	There is no demand for suckling after birth or teat feeding in conventional cattle production.
2	**Calves in single boxes**	According to Commission Regulation No 889/2008, Article 11, housing of calves in individual boxes shall be forbidden after the age of one week.	In conventional cattle production (§ 23, Regulations for keeping of cattle, 2004) calves can be kept in single boxes for the first 8 weeks after birth.
3	**Tethering**	According to article 39 of the Commission Regulation No 889/2008 gives some exceptional rules related to tethering: Where the conditions laid down in Article 22(2)(a) of Regulation (EC) No 834/2007 apply, competent authorities may authorize cattle in small holdings to be tethered if it is not possible to keep the cattle in groups appropriate to their behaviour requirements, provided they have access to pastures during the grazing period according to Article 14(2), and at least twice a week access to open air areas when grazing is not possible. According to national regulations (Forskrift om økologisk produksjon og merking av økologiske landbruksprodukter og næringsmidler, 2005), the exception for small herds to tether cattle will no longer apply, and the regulations will be the same as for conventional production.	According to § 7, Regulations for keeping of cattle, 2004, all cattle should be kept in loose housing systems from 1st January 2024. However, for cattle buildings built between 1st January 1995 to 22nd April 2004, this imposition takes effect from 1st January 2034.
4	**Access to pasture**	According to Commission Regulation No 889/2008, Article 14, 2, herbivores shall have access to pasturage for grazing whenever conditions allow. However, bulls over one year old shall have access to pasturage or an open air area.	According to § 10, Regulations for keeping of cattle, 2004 cattle shall be kept on pasture for a period of minimum eight weeks during the summer with the exception for uncastrated males of more than 6 months of age. For cattle in loose housing systems this imposition takes effect from 1st January 2014. For cattle that are tethered the pasture period is extended to 16 weeks. Cattle that cannot be kept on pasture, the alternative is an outdoor yard. Still, when building new buildings or when increasing the number of cattle in an existing building, adequate pasture areas should be provided.
5	**Access to outdoor area**	According to Council regulation No 834/2007, article 14 b, iii, the livestock shall have permanent access to open air areas, preferably pasture, whenever weather conditions and the state of the ground allow this unless restrictions	According to § 10, Regulations for keeping of cattle, 2004 cattle that are tethered should be offered the possibility for free movement and exercise also outside the pasture period.

		and obligations related to the protection of human and animal health are imposed on the basis of Community legislation. Further, according to Commission Regulation No 889/2008, Article 14, 3,: In cases where herbivores have access to pasturage during the grazing period and where the winter-housing system gives freedom of movement to the animals, the obligation to provide open air areas during the winter months may be waived. Further, according to Article 46, the final fattening phase of adult bovines may take place indoors, provided that this indoor period does not exceed one fifth of their lifetime and in any case for a maximum period of three months.	
6	**Space allowance**	According to Commission Regulation No 889/2008, Annex III, dairy cows should have a space allowance of 6.0 m2 per animal. For breeding or fattening cattle the space allowance should be 1.5 m^2 for animals < 100kg, 2.5 m^2 for animal < 200 kg, 4.0 m^2 for animals < 350 kg and for heavier animals 5.0 m^2 and with a minimum of 1 m^2/100 kg.	According to § 23, Regulations for keeping of cattle, 2004, the space allowance for calves should be 1.5 m^2 for calves < 150 kg, 1.8 m^2 for calves < 220 kg and 2.0 m^2 for calves > 220 kg. Space allowance for heavier animals are not specified, but recommendations state that cattle should have 3.0 m^2 for animals < 350 kg, 3,5 m^2 for animals < 450 kg and 4.5 m^2 for animals < 550 kg. Space allowance for cows is not specified, but in cubicle housing systems there are requirements for one cubicle per animal.
7	**Lying area and solid floor**	According to Commission Regulation No 889/2008, Article 11, "at least half of the indoor surface area as specified in Annex III shall be solid, that is, not slatted or of grid construction.	According to § 22, Regulations for keeping of cattle, 2004, cows should have access to a lying area with solid and soft bedding. Further, in all new buildings, all female cattle should have access to lying areas with solid flooring. Hence, there is no demand for solid floor lying areas for bulls.
8	**Roughage**	According to Commission Regulation No 889/2008, Article 20. At least 60 % of the dry matter in daily rations of herbivores shall consist of roughage, fresh or dried fodder, or silage. A reduction to 50 % for animals in dairy production for a maximum period of three months in early lactation is allowed.	No specific rules
9	**Feed-stuff**	According to Commission Regulation No 889/2008, Article 21, up to 30 % of the feed formula of rations on average may comprise in-conversion feedstuffs. When the in-conversion feedstuffs come from a unit of the holding itself, this percentage may be increased to 60 %.	No specific rules
10	**Fertilizers-mineral content in feed**	According to Council regulation No 834/2007 (12) plants should preferably be fed through the soil eco-system and not through soluble fertilizers added to the soil. Further, according to Article 12, e, mineral nitrogen fertilizers shall not be used.	
11	**Reproduction**	According to Council regulation No	

		834/2007, article 14 c, i, reproduction shall use natural methods. Artificial insemination is however allowed.	

Pigs

	Hazard	Organic regulation	Conventional regulation
1	**Suckling period**	According to Commission Regulation No 889/2008, Article 20, all young animals should be fed on maternal milk in preference to natural milk, for a minimum of 40 days piglets, which imply that minimum age of weaning is 40 days.	According to Regulation for keeping of pigs, 2003, § 9, the minimum age at weaning is set to 28 days. However, very few herds practice an age of weaning of less than 35days.
2	**Space allowance sows and piglets in the lactation period**	According to Commission Regulation No 889/2008, Annex III, farrowing sows should have an indoor area of minimum 7.5 m^2 and access to an outdoor area of minimum 2.5 $m^{2.}$	According to Regulation for keeping of pigs, 2003, § 25, the minimum space requirements for farrowing sows is 6.0 m^2. However, most farmers have installed farrowing pens that provide at least 7.0 m^2 per sow. There is no demand for an outdoor area.
3	**Space allowance for dry sows**	According to Commission Regulation No 889/2008, Annex III, dry sows should have a minimum indoor space allowance of 2.5 m^2 per sow, In addition, the dry sows should have access to an outdoor area of 1.9 m^2 per sow.	According to Regulation for keeping of pigs, 2003, § 25, the minimum space allowance is 2.25 m^2 per sow. There is no demand for access to an outdoor area.
4	**Space allowance for fattening pigs**	According to Commission Regulation No 889/2008, Annex III, the minimum indoor space allowance for fattening pigs in organic production should be 0.80 m^2 per animal for pigs < 50 kg, 1.10 m2 per animal for pigs < 85 kg and 1.30 m^2 per animal for pigs < 110 kg. In addition the fattening pigs should have access to an outdoor area.	According to Regulation for keeping of pigs, 2003, § 26, the minimum indoor space allowance for fattening pigs 0.50 m^2 per animal for pigs < 50 kg, 0.65 m^2 per animal for pigs < 85 kg and 1.00 m^2 per animal for pigs < 110 kg. There is no demand for access to an outdoor area.
5	**Roughage to pigs**	According to Commission Regulation No 889/2008, Article 20, roughage, fresh or dried fodder, or silage should be added to the daily ration for pigs and poultry.	According to Regulation for keeping of pigs, 2003, § 21, pigs should have continuous access to an ample amount of materials which they can explore and be occupied. Materials like straw, hay, sawdust, peat and earth can be used.
6	**Outdoor access**	According to Council regulation No 834/2007, article 14 b, iii, the livestock shall have permanent access to open air areas, preferably pasture, whenever weather conditions and the state of the ground allow this unless restrictions and obligations related to the protection of human and animal health are imposed on the basis of Community legislation.	No demand for outdoor access
7	**Synthetic amino-acids**	According to Council regulation No 834/2007, article 14 d, v, d synthetic amino-acids shall not be used.	

Sheep and goats

	Hazard	Organic regulation	Conventional regulation
1	**Space allowance indoors**	According to Commission Regulation No 889/2008, Annex III, sheep and goats should have a minimum indoor area (net area available to animals) of 1.5 m^2 per animal and minimum outdoor area (exercise area, excluding pasturage) of 2.5 m^2 per animal. For lambs and kids the corresponding numbers are 0.35 m^2 per animal and 0.5 m^2 per animal.	According to § 11, Regulations for the welfare of small ruminants, 2005, the space allowance should be adapted to the need of the animals, but there is no specific demand for minimum indoor area per animal.
2	**Solid lying floor**	According to Commission Regulation No 889/2008, Article 11, "at least half of the indoor surface area as specified in Annex III shall be solid, that is, not slatted or of grid construction. However according to § 10 in the Norwegian regulation for organic farming (2005), organic sheep farms in Norway do not have to follow this demand. However, small lambs and kids should have access to a lying area with solid flooring.	According to § 11, Regulations for the welfare of small ruminants, 2005, the animals should have access to a comfortable and dry lying space with no draught and all animals should be able to lie down simultaneously. However, small lambs and kids should have access to a lying area with solid flooring.
3	**Suckling period**	According to Commission Regulation No 889/2008, Article 20, all young animals should be fed on maternal milk in preference to natural milk, for a minimum of 45 days for sheep and goats.	According to § 20, Regulations for the welfare of small ruminants, 2005, lambs and kids should have an adequate amount of milk, and that newborn lambs and kids should be fed an adequate amount of colostrum as soon as possible.
4	**Access to pasture**	According to Council regulation No 834/2007, article 14 b, iii, the livestock shall have permanent access to open air areas, preferably pasture, whenever weather conditions and the state of the ground allow this unless restrictions and obligations related to the protection of human and animal health are imposed on the basis of Community legislation.	According to § 24, Regulations for the welfare of small ruminants, 2005, sheep and goats should be kept on pasture for at least 16 weeks.
5	**Access to outdoor area**	According to Commission Regulation No 889/2008, Article 14, 3,: In cases where herbivores have access to pasturage during the grazing period and where the winter-housing system gives freedom of movement to the animals, the obligation to provide open air areas during the winter months may be waived. According to Commission Regulation No 889/2008, Annex III, sheep and goats should have a minimum outdoor area (exercise area, excluding pasturage) of 2.5 m^2 per animal.	According to § 24, Regulations for the welfare of small ruminants, 2005, sheep and goats should, when it is possible, have access to outdoor areas outside the grazing season.
6	**Roughage**	According to Commission Regulation No 889/2008, Article 20. At least 60 % of the dry matter in daily rations of herbivores shall consist of roughage, fresh or dried fodder, or silage. A reduction to 50 % for animals in dairy production for a maximum period of three months in early lactation is allowed.	
	Synthetic amino-acids	According to Council regulation No 834/2007, article 14 d, v, d synthetic amino-acids shall not be used.	

		According to article 18.3 Any feed materials used or processed in organic production shall not have been processed with the aid of chemically synthesized solvents.	

Poultry

The majority of layers in conventional Norwegian egg production are kept in free range, indoor production systems (54 %, Animalia, 2013) and the number of herds adopting this system is increasing, but many conventional herds still use the furnished cages. EFSA (2005) has earlier reviewed welfare aspects of various systems to keep laying hens and summarized the welfare challenges in furnished cages. Hence, in the present report it was found to be most interesting and relevant to compare conventional free range production systems for layers with organic production systems.

	Hazard	Organic regulation	Conventional regulation
1	**Outdoor access**	According to Council regulation No 834/2007, article 14 b, iii, the livestock shall have permanent access to open air areas, preferably pasture, whenever weather conditions and the state of the ground allow this unless restrictions and obligations related to the protection of human and animal health are imposed on the basis of Community legislation. According to Commission Regulation No 889/2008, Annex III, the outdoor area for both layers and broilers (fattening poultry) should have minimum 4 m^2 per bird and for turkey 10 m2 per bird for at least one third of their lives.	No demand for outdoor access
2	**Space allowance for broilers (fattening poultry)**	According to Commission Regulation No 889/2008, Annex III, broilers (fattening poultry) should have an indoor space allowance of maximum 10 birds per m^2 and maximum 21 kg live weight per m^2. In addition the birds should have access to an outdoor area.	According to § 35a, Regulations for keeping of poultry and turkey, 2001, maximum animal density is 25 kg per m^2. However, if a poultry herd has agreed to participate in a national animal welfare program, the animal density can be increased to 36 kg per m^2.
3	**Slow-growing poultry strains**	According to Commission Regulation No 889/2008, Article 12 / 5, poultry shall either be reared until they reach a minimum age (81 days for chickens, 100 days for female turkeys and 140 days for male turkeys) or else shall come from strains from slow-growing poultry strains. In Norway all herds with organic chicken production uses slow-growing poultry strains. When use of non-organic one-day old chicken, there is a requirement for 70 days conversion period before slaughtering.	There is no specific demand for slow growing strains for conventional production.
4	**Space allowance in loose-housing systems for layers**	According to Commission Regulation No 889/2008, Annex III, laying hens should have an indoor space allowance of maximum 6 birds per m^2, minimum 18 cm perch per animal, maximum 7 birds per single nest or 120 cm^2 per bird in case of common nest. In addition the birds should have access to an outdoor area.	According to § 25, Regulations for keeping of poultry and turkey, 2001, there should be an indoor space allowance of maximum 9 birds per m^2, minimum 15 cm perch per animal and maximum 7 birds per single nest or 83 cm^2 per bird in case of common nest. There is no demand for access to an outdoor area for conventional loose-housing systems.
5	**Natural light**	According to Commission Regulation No 889/2008, Article 10, buildings for animal organic production shall permit light to enter. Further, in Commission Regulation No 889/2008, Article 12 /	There is no requirement for natural light in conventional poultry housing

		4 natural light may be supplemented by artificial means to provide a maximum of 16 hours light per day with a continuous nocturnal rest period without artificial light of at least eight hours.	
6	**Flock size**	According to Commission Regulation No 889/2008, Article 12, the maximum number in poultry house is 4800 chickens and 3000 laying hens.	For conventional poultry production regulations state that the maximum number of layers in one house is 7500 and maximum number of chickens produced one each farm is 120 000 per year.
7	**Cages**	According to Commission Regulation No 889/2008, Article 12, poultry shall not be kept in cages.	According to § 28, Regulations for keeping of poultry and turkey, 2001, layers can be kept in enriched cages.
	Perches	According to Commission Regulation No 889/2008, Annex III there should be 18 cm perch per animal.	According to § 25, Regulations for keeping of poultry and turkey, 2001, there should be 15 cm perch per animal.
	Nests	According to Commission Regulation No 889/2008, Annex III there should be 7 laying hens per nest or in case of common nest 120 cm^2 per bird	According to § 25, Regulations for keeping of poultry and turkey, 2001, there should be 7 laying hens per nest or in case of common nest 1 m^2 per 120 birds.
8	**Roughage**	According to Commission Regulation No 889/2008, Article 20, roughage, fresh or dried fodder, or silage should be added to the daily ration for pigs and poultry.	There is no demand for supplying roughage to poultry in conventional poultry production.

Honey bees

	Hazard	Organic regulation	Conventional regulation
1	**Ban on feeding substitutes for honey and pollen**	According to Commission Regulation No 889/2008, Article 19 / 2, in the case of bees, at the end of the production season, hives shall be left with sufficient reserves of honey and pollen to survive the winter. The feeding of bee colonies shall only be permitted where the survival of the hives is endangered due to climatic conditions. Feeding shall be with organic honey, organic sugar syrups, or organic sugar.	In conventional bee farming substitutes for honey and pollen is allowed.

Assessment

1 Animal health in organic and conventional cattle production

The literature search was done by using ScholarGoogle.com with the search word: organic and conventional, dairy, health, Norway, health OR dairy OR welfare. And additionally the exact wording “organic and conventional” should be included. The search was done in two parts; firstly the search included 1300 paper, and restricting to the period after 2009 included 562 papers (as of 29th of November 2013). Of these 60 was referred to after judging the title content and the summary. A new literature search with the same search word but restricted during the time for publication from 1991 till 2009 gave 722 additional papers. This was finally done 25th January 2014. After checking all these references 100 of these were judged from title and short description as relevant for further reading and after reading the summary 26 papers were referred to. Altogether, 86 relevant papers were identified by this search, and additionally papers found in the references during this search were also included.

This is almost the same at Simoneit et al., (2012) found. They found 569 papers. From these they reviewed 33 %. Of these, 42 papers had general topics and 211 described cattle. All these 569 papers were looked closer at and 36 were reviewed, judged as relevant and used in the assessment.

1.1 Trading live animals

As organic herds have to keep animals from organic herds only, the trading of live animals is therefore restricted. This could have some implication on the occurrence of infectious diseases, as many infectious diseases are transmitted from one farm to another by moving live animals. This is indicated by a study in Sweden by Bidokhti (2008). Around 700 serum samples, taken from 20 conventional and 20 organic dairy herds in south eastern Sweden on two sampling occasions with one year interval, were tested by ELISA for presence of antibodies to Bovine Corona Virus (BCV) and Bovine Respiratory Syncytial Virus (BRSV). On individual level, the seroprevalence at both occasions varied between 82-86 % to BCV and 79-82 % BRSV. Analyzing the data on herd level revealed that the conventional herds had a significantly higher mean seroprevalence to BCV and BRSV than the organic ($P< 0.001$). A significant association was found between age and seroprevalence ($P< 0.001$). Cows younger than 5 years old in conventional herds had significantly higher mean seroprevalence than the organic ($P< 0.001$). Only 30 % of the youngest cows in organic herds compared to 70 % in conventional herds were positive to both BCV and BRSV which increased up to 100 % in the oldest cows. The mean absorbance value in positive cows older than 5 years was significantly higher compared with those younger than 5 years ($P<0.001$). Higher mean titres of antibody in the oldest cows most likely make their enriched colostrum a valuable tool in herds with neonatal infection problems. This study suggests that organic management may be associated with a lower incidence of BCV and BRSV infections compared with conventional management.

1.1.1.1 *Conclusion*

As organic herds have to buy live animals from other organic herds or have these animals in a conversion period, this will restrict the trading of live animals or trading between certain herd groups. If buying from other herds, these animals need a conversion period, which could be a kind of quarantine. It is interesting to find that there is found less BRSV and BCV in organic herds in Sweden compared to conventional herds. BRSV and BCV are mainly spread from region to region by trading live animals.

1.2 Hazard identification and characterization

1.2.1 Milk feeding for calves

The regulation in organic farming state that the calves should be fed on natural milk for at least three month. This would then be whole milk from the original farm and organic cows. In conventional system there are no such rules and the option could be using different milk replacers. These milk replacers could have different content like soy protein or whey protein as protein source. Other sources are of course milk powder. The new born calf would have problems with digesting other proteins than milk proteins the first three weeks, so it is recommended to feed milk protein also in conventional farms at least for 3 weeks. It has been common to feed calves on sour milk which could be acidified by natural fermentation, using fermentation cultures or by using formic acid. From 2012 also natriumformeate is allowed in organic herds. It is also shown that sour milk has some benefits according to stabilizing the gut flora. Natural fermentation is recommended for organic farms, but acidification with formic acids is also allowed. It is more difficult to control the natural fermentation process than with formic acid. Thus natural fermentation could be more prone to bacterial growth which is not appropriate. It is a goal during such fermentation to reach a pH of 4.5.

Gulliksen et al., (2009a, b) revealed that 46 (37 %) out of 125 herds fed their calves with sour milk. There was no information on the practice of using milk replacers; however it is well-known that under a market situation or farm situation with less excess of milk there would be beneficial to feed calves with milk replacers. Milk replacers could also be given as sour milk. Gulliksen et al. (2009b) found that calves fed on sour milk had 3.5 times less respiratory diseases. There was no indication of an association to diarrhea (Gulliksen et al., 2009a). Later Gulliksen (2014) have found that calves fed on sour milk excreted less Cryptosporidium than calves fed on non-soured milk. This indicates that the feeding system with the different feeding components would have an effect on calves immunity, diarrhea, dehydration status and thus general health.

Cryptosporidium parvum-like oocytes were found in 96 % of the Swedish herds (Silverlås et al., 2009). Prevalence was 52 % in calves, 29 % in young stock and 5.6 % in cows. Three two-day-old calves shed oocytes. *Cryptosporidium andersoni* was found in seven animals from four different herds. Factors associated with prevalence of shedders among sampled animals in a herd were age at weaning, cleaning of single calf pens, placing of young stock, and system for moving young stock, and year of sampling. Factors associated with shedding in calves were age, placing of young stock, routines for moving young stock and time calf stays with the cow. The only significant factor in young stock was age. In cows, number of calves in the herd and type of farming (organic vs. conventional) affected shedding.

1.2.1.1 *Conclusion*

To our knowledge there is no literature comparing conventional and organic farming, concerning health in calves related to the length of milk feeding period. There are indications that the shedding of *Cryptosporidiae* oocytes is lower in herds using sour milk, however, use of fermented milk is allowed both in organic and conventional farms. The health thus depend more on the farm management than if the farm are organic or conventional.

1.2.2 Suckling period

The national Norwegian regulation say that the calf should suckle their mother for at least 3 days after birth, while there is no such rules in conventional farming. The EU regulation has no such rule. The benefit of suckling should be that the calf is fed naturally, as done in the nature. This will help the feed to reach correctly the abomasum and pass the undeveloped rumen by the functioning of correct rumen bypass function, which is stimulation by suckling. This is also the reason why feeding with teat bucket is recommended later. Suckling will also stimulate the mother as well as the calf with the hormonal reactions bound to suckling, like oxytocin release. There could also be a benefit for the calf that the newborn ingest bacterial flora which is common for the adult ruminants, and thus got easier access to micro flora which will settle down in the rumen and start up correct rumen fermentation there. On the other side there is also a larger possibility to ingest pathogenic microbes and parasites like *E.coli*, Coccidia, Cryptosporidium and well as different pathogenic viruses (Fecteau et al., 2002). Literature illustrate that calves living together with their mothers will be more prone to have diseases caused by these organism (Gulliksen et al., 2009b), especially in larger herds where the infections pressure will increase. The newborn calf is born without any immunity (Weaver et al., 2000), and thus has a need to ingest antibodies as fast as possible after birth (Liberg, 2000). The literature illustrate that calves having their feed only from suckling very often has too low immune status, due to too little access to good colostrum (Simensen et al., 2005). If the calves are suckling there is still a need to control that the calves get enough colostrum. The IgG concentration in blood should be above levels of 10 mg/ml the first day after birth. If not so, there is a sign of too little access to good colostrum. The deficit of colostrum (Failure of Passive Transfer, or FPT) of immunoglobulins will have detrimental effect on the young calves' health, with more diarrhea, respiratory diseases and umbilical disorders, as well as arthritis. These diseases will accordingly lead to more use of antibiotics or vaccines. Such calves with low immunity will also be animals with lots of excretion of pathogens, which will have impact on the infection pressure of other calves in the same pen.

In conventional herds Gulliksen et al. (2009b) revealed that 13 (10.5 %) out 125 herds practice suckling as a feeding regimen. The suckling period could last for one day or more days, which is not stated in that paper. The same paper revealed that 27 (21.6 %) of the farms separated the calf from the dam during the first 24 hours, while 10 (8.0 %) separated them later. This should indicate that approximately 10 % of conventional farmers had the same practice as organic farmers under Norwegian condition. Gulliksen et al. (2009b) found that calves being together with the dam more than 24 hours had 3.5 (1.3-9.2) times the odd ratio (OR) of having respiratory disease later. This could be a result of lack of control of good colostrum intake and thus failure of passive transfer of immunoglobulins or /and also a higher infection pressure from the dam to the calf during this common raising period. These negative risk factors could be controlled by a tight control of colostrum intake and quality despite suckling and a high hygienic standard in the maternity pen. Calves having had respiratory disease have higher mortality risk later during their live compared to calves not having respiratory disease (Gulliksen et al., 209c). This increase is at a level of OR = 5.0 (4.1-6.1) the first week of life, OR = 5.5 (4.5-6.7) from 8 days to 30 days in life; OR = 6.2 (5.1-7.6) from 30 to 180 days in life and finally OR = 7.5 (5.3-10.6) from 180 to 365 days of life. There is a lack of information on the exact use and practice of milk replacers and their effect on calves' health in Norway.

Michanek and Ventorp (1993) found that calves going together with their mother on individual loose pens showed the highest levels of plasma IgG, whereas those housed in the group pen together with other cows had the lowest values. On the farm where calves where in group pen, only 1 calf sucked exclusively its mother and 4 sucked only alien cow(s). Eleven of the calves born into the group housing suckled both their mothers and alien cows. The low average plasma IgG levels observed for the calves on this were attributed to their extensive sucking of non-mother cows.

Krohn (2001) found that long-term suckling without additional milking in early lactation can in some situations stimulate the subsequent milk production in cows to a greater extent than milking alone. No clear or significant differences can be found between restricted and free suckling systems. Most experiments show that suckling decreases the risk of mastitis in the suckling period and in some cases even for some time after the suckling has been terminated. Suckling and milking during the same period is not advantageous in production turns because of a very poor ejection of milk. Long-term suckling can increase the post-partum interval until first heat, in some cases until the end of the suckling period. However, as the cows appear to be more fertile, the net effect on reproduction is small. The suckled calves are usually healthy with a high daily gain. Short-term suckling have more advantages than disadvantages on production, health and behaviour of both the cow and the calf compared to an immediate separation after birth.

1.2.2.1 *Conclusion*

A study revealed that 10.5 % of Norwegian herds practice suckling as a feeding regimen. The suckling period could last for one day or more days. Many papers indicate that calf suckling their mothers have larges risk of getting 'Failure of Passive Transfer' (FPT), and thus less immunity in the newborn stage. Calves suckling their mother have a higher risk of indigested pathogens from contaminated teats. FPT will increase the risk of getting infectious diseases. Thus, it has to be concluded that this specific Norwegian rule of organic farming is a risk factor both for FPT, as well as indigestion of serious pathogens. This is shown to give higher risk both at respiratory diseases and death. This could be counteracted by securing that calves getting enough colostrum by manual feeding with good quality colostrum, as well as extremely good hygiene at the maternal cows. It is also important to avoid suckling of alien cows. On the other hand suckling could have some benefit for the udder health and reproductive organs of the mother.

1.2.3 Single boxes for calves

The regulation for organic farming state that calves should not stay in individual pens for more than one week, for conventional farms the regulation says 8 weeks. The benefit of having more calves together in groups is the socialization that calves learn to know each other and learn the social habits of the species. It is also shown in research that calves raised in group pens will eat more and thus have a potential faster growth rate (Cobb, 2012). The problem is that if one calf has an infectious disease there is a larger chance that the other calves in the same group get the same infectious agent. This is illustrated at least for respiratory diseases. The infectious pressure will increase. Calves within the same group will also have a tendency to suckle on each other, suckling on the udder, tails, mouths etc. This infection pressure will increase with larger groups and with larger age difference between the calves within the group. Especially if they use the same feeding automate etc. So both the grouping size and the age difference within the group and common feeding system will increase the probability of being infected with microbes, parasites or viruses.

Gulliksen et al. (2009a) revealed that 60 (48.0 %) of farmers had calves in single pens at least for 2 weeks. This means that up to 50 % of the conventional farmers have the same, or almost the same confinement as organic farmers. Gulliksen et al. (2009a) found that straw in single pens increased the OR of diarrhea by 2.9 (2.0-4.3) and removing manure in from the pen less frequent than once a week increased diarrhea with an OR = 4.1 (2.7-6.1). There was no association to the time of grouping calves neither for diarrhea, respiratory disease nor mortality. This could indicate that grouping by itself, as practiced in Norway is not very important, however the bedding material and removal of manure/bedding material from the single pens are essential to prevent diarrhea in calves.

1.2.3.1 *Conclusion*

All together 48.0 % of farmers had calves in single pens at least for 2 weeks. This means that up to 50 % of the conventional farmers have the same, or almost the same confinement as organic farmers. There is an increased risk of spreading infectious diseases within boxes where there are several calves; however the inter-calf socialization and feed intake could be improved. The increased risk of infectious diseases could be minimized by increasing hygienic practice and removing straw and manure at increasing frequency, as well as removing and isolate infected animal from the common pen as soon as they are diseased to avoid further spread of the infectious agents.

1.2.4 Tethering

Cattle in organic farming should not be tethered except for building built before 20th of August 2000. These animals should still have regular exercise. This exception is not applied after 1st of January 2011, except for smaller herds (less than 35 dairy cows). These cows should still be outside at least two times a week. The new regulation from 8th August 2013 state that all cattle (both organic and conventional) should not be tethered after 1st of January 2024, except for those building that are built between 31st December 1994 and 22nd April 2004. For the last building the tethering is forbidden from 1st January 2034 if the building has been in continuous use. The benefit of no tethering is that the cattle can move freely around, and express their natural behaviour. This could give less stress and better immunity as the social and physical expression is good. On the other hand cattle have their own ranking in the flock, and this ranking will have a social impact on both looser cows as well as high ranked cows. High ranked cows will have better access to resources like bedding, feed, water, automatic milking systems (AMS) etc., while low ranked cows would have likewise less access to these recources, especially if the available room area is small. This could lead to high ranked cows being fat due to good access to feed, and more stress and frustration for the low ranked cows, which could lead to less production and more diseases. Several studies have shown less mastitis, ketosis and reproduction disorders in free-stall herds (Ekesbo 1966; Bakken, 1981; Valde et al., 1997; Simensen at al. 2010). There has also been shown less production in free-stall herds with less than 35 cows, compared to tie-stalls within the same size. The opposite is found for larger herds (Simensen et al., 2010). This is an indication that small free-stall has some difficulties in this production system, which is an indication of the ranking system according to these housing system (Simensen at al. 2010). In free-stall there is also the problem that cows are constantly walking in their own manure either on slatted floor, concrete or rubber mats. If the scraping is not functioning well, there would be lots of manure on the claw, which again lead to more infectious claw disease. One study shows that tethered cows had 48 % remarks on claw and cows in free-stall 71.8 % lesions in claws (Sogstad et al. 2005). This means that claw health is a huge problem in free-stall herds.

As there is no real difference in the regulation on tethering between Norwegian organic and conventional farms, it is not a need for doing a large assessment on this item. Literature illustrate that free-stall have better performance on metabolic (ketosis) and reproduction than tie-stalls (Simensen at al., 2010). However, the milk production was lower in smaller free-stall herds (less than 35 cows) than compared with tie-stall. This indicates that there is a challenge with animal welfare in smaller free-stalls. Another challenge in free-stall is the close contact between animals and their own manure, which increases the risk of fecal-oral infections, as well as an increase of contact between animals direct or indirect, which will increase the probability of spread of infectious diseases. It is obvious that such a system will increase the risk of diseases where the faecal-oral infection rout is important. Free-stalls will also give closer contact between claws and manure, which is a huge challenge for infectious claw diseases. Sogstad et al., (2005) showed that free-stall had significantly more claw diseases compared to tie-stall, most for heel-horn erosion OR = 7.2 on hind feet, and for all other diseases an increase in OR from 1.2 for sole ulcers to 2.2 for white-line haemorrhages. Lameness and claw diseases is one of the most serious diseases in milk production world-wide, and the free-stall system have huge challenges on preventing claw diseases.

1.2.4.1 *Conclusion*

At present about 50 % of conventional cows are in free-stalls, from 2024 the majority will be in free-stalls, and from 2034 no cow should be tethered in Norway. From that year there would be no difference between organic and conventional farms. Tethering will decrease the natural habits for animals and improve reproduction and metabolic diseases. However, literature illustrate that cows moving freely in small free-stall have lots of risk factors which will have influence both in production and diseases (especially claw diseases). Many of these factors are probably linked to ranking order of animals where high ranked cow's role over low ranked cows, and thus limit the access of low ranked cows' to important resources. Thus the benefit of small free-stall as good for health (less than 35 cows) could be questioned. There will also be increased fecal-oral contacts, and claws will be exposed for manure and ammonia, and thus claw health in free-stalls is really a challenge.

1.2.5 Access to pasture or free air

Organic herds should have their cows out on pasture, defined as when the grass is from 5 to 10 cm long and are still growing. Tethered cows in organic herds should be outside for free air at least twice a week. In conventional herds the regulations says that tethered cows should be outside at least 8 weeks during a year, and from 1st of January 2014 this is also applied for free-stall herds. The benefit of pasture is that cows are moving around and pasturing as is natural for this species.

The difference between organic and conventional farmers would then be that organic farms would have longer time than 8 weeks on pasture. Pasturing is shown to be good for claw health as many of the claw lesions occurring in indoor season is corrected during summer pasturing (Hernandez-Mendo et al., 2007). Improved gait for cows on pasture was not because of increased lying times. Cows on pasture actually spent less time lying down than cows kept indoors (10.9 vs. 12.3 h/d), although this lying time was spread over a larger number of bouts (15.3 vs. 12.2 bouts). Cows housed on pasture also lost more weight and produced less milk relative to cows in free-stalls, likely because of reduced nutrient intake. These results indicate that a period on pasture can be used to help lame cattle recover probably because pasture provides a more comfortable surface upon which cows stand, helping them to recover from hoof and leg injuries.

Time at pasture was recorded and the effects on claw health (dermatitis, digital dermatitis, heel horn erosion, 5 sole hemorrhages and sole ulcers) were analyzed in two farms in Sweden (Kivling, 2013). The hygiene on the flank was better for grazing groups than non-grazing groups ($P \leq 0.05$). Differences in the prevalence for claw health remarks was found for: number of days at pasture, grazing zone, herd size, breed and type of flooring. The total prevalence of remarks in the autumn was higher for cows that had been grazed less than 138 days ($p \leq 0.05$) and for cows in zones with shorter prescribed pasture period ($p \leq 0.05$). Cows in herds with more than 200 cows had a lower prevalence of total remarks at autumn trimming ($p \leq 0.05$) compared to smaller herds. It was found that 80 % of the interviewed farmers believed that the pasture management worked satisfactory in their dairy herds.

Brenninkmeyer et al., (2012) found the mean farm prevalence of hock lesions, i.e. scabs, wounds, and swellings were 50 %, with a range from 0 to 100 %. The final model contained eight factors which were largely related to lying comfort and explained 75 % of the variance. The presence of a curb turned out to be the most influential beneficial factor. Additionally, there were fewer hock lesions when cows were housed with deep bedded cubicles compared to cubicles without deep bedding. Other factors in the regression model were softness and length of the lying surface and height of free space under cubicle partitions, the proportion of over-conditioned cows and a variable encoding three different combinations of region, husbandry system (organic and conventional) and breed. Kielland et al., (2009) also found an association between organic/conventional farming and hock lesions.

For dairy cattle, grazing reduces foot and leg problems common in confinement systems, but lowers milk production and exposes cows to parasites that can be difficult to treat without pharmaceuticals (Hafla et al., 2013).

However, there has also been shown that cows are prone to heat stress, especially high producing cows. These cows can experience heat stress at temperature already at 20 degree C (Kadzere et al. 2002). Thus, it is important to give them shadow and good access to water. Experience shows that cows do not like to go outside in a warm, sunny, humid day. They would then like to stay indoors, and walk out during the evening when the sun is set. There could also be problems with mosquitos, midge and other insects outside. A survey on isolation of mastitis pathogens in year 2000 from Norway revealed that the prevalence of positive finding especially for *S.aureus* and *S.uberis* was much higher during summer time than indoors season in the winter (Østerås et al. 2006). There is no information on the reason for this seasonal trend which is also reflected in higher SCC during summer time, especially in warm and humid summers. There is also well-known from the literature that *S.uberis* is somehow linked to grass or straw material (Lopez-Benavides et al., 2007). The interesting by this finding is that the mastitis problem is not reduced during summer, however increased – probably due to heat stress and /or better growth of microbes. One also recognizes that the mastitis pathogens are changing due to environmental situation. This means that grassing will have other problems than indoors mastitis problems. From this it could not be expected that mastitis is less of a problem in grassing animals, but that the bacterial flora are changed more on to *S.uberis* and probably *S.aureus* for some or another reason. We do not really know if this increase in SCC or mastitis is linked to indoor-kept animals or is specific to outdoors kept animals. More research is needed to reveal this.

Grazing can be a problem for parasite infestation. From Sweden, Höglund et al. (2010) compared antibodies for different well known parasites in organic and conventional herds. According to the Svanovir®*Ostertagia* ELISA, the mean optical density ratio (ODR) was significantly higher in the milk from organic compared to conventional herds, i.e. 0.82 (95 % CL = 0.78–0.86) versus 0.66 (0.61–0.71). However, no significant differences were observed in the samples collected at different time points from the same 16 herds ($F_{3,39}$ = 1.18, P = 0.32). Antibodies to the lungworm, *D. viviparus* infection, were diagnosed with an ELISA based on recombinant major sperm protein (MSP), and seropositivity was found in 21 (18 %) of the 113 organic herds and 11 (9 %) of the 113 conventional herds. The seroprevalence of *D. viviparus* was somewhat higher in the organic herds (Chi-square = 3.65, P = 0.056), but with the positive conventional herds were located in the vicinity of infected organic herds.

Lund and Algers, (2003) present a literature review. Only 22 peer-reviewed papers were found in the search, mainly dealing with dairy cattle health and parasitology. Ten were comparative studies. In addition, two overviews were found. None of the published articles found indications that health and welfare are worse in organic than in conventional livestock farming, with the exception of parasite-related diseases. A cautious conclusion based on this material is that except for parasite-related diseases, health and welfare in organic herds are the same as or better than in conventional herds.

Hovi et al. (2003) stated that there are, however, some well-identified areas, like parasite control and balanced ration formulation, where efforts are needed to find solutions that meet with organic standard requirements and guarantee high levels of health and welfare. It is suggested that, whilst organic standards offer a good framework for animal health and welfare management, there is a need to solve apparent conflicts between the organic farming objectives in regard to environment, public health, farmer income and animal health and welfare. The key challenges for the future of organic livestock production in Europe are related to the feasibility of implementing improved husbandry inputs and the development of evidence-based decision support systems for health and feeding management.

There is found more *Bacillus cereus* in milk from organic farms compared to conventional farm, probably due to more pasturing. *Bacillus cereus* is introduced to milk via grass and soil from the pass ways to and from pasture (Coorevits et al., 2010). This is most important for milk quality; however, there are also mastitis problems with *Bacillus cereus* infections.

1.2.5.1 *Conclusion*

As of 2014 all Norwegian cows should be out in free air for at least 8 weeks during the summer. The difference between organic and conventional farming will be that some few conventional farms could use an outside restricted area and not pasture for free air access. The length of the pasture time could also be longer in organic farming. The largest difference will then be the pasture length. The claw health is improved and the muscles and joints are recovered on pasture. Heat stress on warm days is well-known and heat stress is also linked to higher disease risks like increased somatic cell counts and mastitis. The risk of infestation of parasites also is at higher risk on pasture, one of the reasons for more parasites in organic farms. These risks could be counteracted by good management.

1.2.6 Feedstuff –concentrate and organic feed

It is a demand in organic farming that the roughage in mean percentage should be above 60 % of all the feed during the whole lactation period. During the three first month of lactation it should be above 50 %. There is no such rule for conventional farming. It is goal for organic farming not to have too much high yield, and the feeding strategy is part of this strategy. The benefit of having high roughage percentage in the feed is that it stimulates the rumen and gives stable rumen fermentation. If the cows are fed with high ration of concentrate there is a risk for Sub-Acute Ruminal Acidosis (SARA) (Kleen et al., 2003). This disease could also cause an increase in claw diseases, other metabolic diseases and change in the fat content in milk (milk fat depression). One problem with restriction of concentrate could be lack of energy and thus more ketosis, and reproductive disorders (De Vries and Verkamp, 2000).

In Norwegian conventional herds the mean concentrate percentage in ration is 43 %, and 35.6 % is below the maximum limit for organic herds. This means that altogether about 65 % of the conventional herds are exceeding the maximum limit for organic herds. High percentage of concentrate will increase the production and will also be a risk factor for SARA (Kleen et al., 2003). Andersen et al. (2011) found that cows starting their lactation with very high yield the first week of lactation had a significant increase in mastitis. This illustrates a link between yield in that part of lactation and mastitis. How one can regulate this yield is not really known, however, the concentrate in the late dry period of lactation and around calving could be one factor. High concentrate ration will also impact the gut flora, with more *E.coli*. There has been literature indicating that one way of reducing the contamination and risk of *E.coli* infestation in the gut before slaughter is to put the animals on a higher roughage ration, but different result are found (Callaway, et al., 2013).

More thermo tolerant bacteria like *Ureibacillus thermosphericus* and *Bacillus lichiniformis* has been found in milk from conventional farms compared to organic. This could be due to more feeding with heat treated concentrate as pellets or imported tropical waste products from foreign countries (Coorevits et al., 2010).

The feeding practice with more roughage in organic herds could be one of the reasons why there are less recorded diseases in organic compared to conventional herds. Since January 2008 the ration for organic herds has been required to be 100 % organic (Regulation No. 889/2008). This may not satisfy the high energy demands of early lactation cows. Blanco-Penedo et al., (2012) investigated this possible effects of 100 % organic feed on the energy balance in Swedish organic dairy herds as indicated by the following blood parameters: Beta-hydroxybutyrate (BHBA), non-esterified fatty acid (NEFA) and insulin, and the occurrence of clinical ketosis. Thirteen organic and 13 conventional herds were visited and blood samples from 81 cows around parturition (≥ 3 cows per herd) were used. The metabolic status of the same herds under the previous rules was available for comparison. The BHBA, NEFA and insulin levels were different before and after the change of legislation, but the effects were similar in organic and conventional cows. The incidence of clinical ketosis was not associated with herd type or the change of legislation. Thus, the change in legislation did not appear to have had any detrimental effects on the metabolic profiles of organic cows in early lactation and there was no evidence that organic cows were metabolically more challenged or had a severe negative energy balance. Sehested et al. (2003) compared three different levels of concentrate in organic dairy. The three concentrate levels, N, L and L+ (38, 0 and 19 % of dry matter (DM) intake, respectively) were investigated in a herd of 60 cows during 3 years. The production in group N was 6723 kg energy corrected milk (ECM) per cow year, based on an intake of 6226 kg DM of which 38 % was concentrates. In group L the omission of concentrates reduced intake to 4770 kg DM, and milk production to 5090 kg ECM per cow year. Milk protein content was reduced and milk free fatty acid content was increased, and the first calving interval was significantly increased, as compared to group N. The intake in group L+ was 5226 kg DM per cow year of which 19 % was concentrates. Milk production in group L+ was reduced by only 493 kg ECM per cow year as compared to group N, primarily due to a significantly improved feed conversion ratio (12 %). There were no indications of health problems associated with the reduced feeding levels.

Roesch et al. (2005) tested blood samples sampled at visit 2 to determine plasma concentrations of glucose, nonesterified fatty acids, *β*-hydroxybutyrate, albumin, urea, insulin-like growth factor-1 (IGF-I), and 3,5,3′-triiodothyronine. Metabolic and endocrine traits as well as milk yield, fertility, and feeding factors were compared among cows in the 2 production systems, organic and conventional. A univariable and stepwise multivariable logistic regression model was used to identify risk factors for poor milk yield. Energy-corrected milk yield medians and milk urea concentrations were less in organic (OP) than in conventional (IP) cows at visits 2 and 3. Organic farms provided less concentrates, and OP cows at all visits had lower body weight than IP cows. Plasma albumin and urea concentrations were lower in OP than IP cows. The following factors were positively associated with low milk yield (below median): Simmental breed, greater BCS, positive California mastitis test in hindquarters, and sampling during summer. Factors associated with an elevated (above median) milk yield were: Holstein breed, greater body weight and lactation number (age), weak udder suspension, greater blood albumin, milk fat and milk protein, more lactation persistency, longer calving intervals, routine teat dipping, and more outdoor access during winter. In conclusion, significant differences including milk yield were detected between Swiss OP and IP cows. Lower milk yields were due to a range of individual animal and farm-level factors such as breed, nutrition, management, and udder health.

Dairy cows transform grass to milk with help from ruminal microorganisms that can digest indigestible fiber in their feed (Herlitz, 2010). The digestive system of the cow is adapted to a diet consisting of forage and disorders like acidosis, laminitis and abomasal displacement can occur if the feed contains too much starch. To achieve the highest production possible the cow has to be given a high amount of concentrate or grain as the difference in milk yield is significant, approximately 1000 kg energy corrected milk per cow and year between conventional and organic cows that are fed a lower versus a higher share of forage. If the cow shall be able to eat the same amount of energy from forage as from grain or concentrate the eating- and rumination time gets longer and she might not be able to eat enough, which will result in a lower milk yield and will make it harder for the cow to recover from the negative energy balance that originate from the beginning of the lactation. Fat and protein content in milk also differs depending on if the cow is given a high or low share of forage.

It is an essential part of organic production, that the animals should not be pressed in their production. The production can be regulated by feeding. It is well known that animals in negative energy balance would be more susceptible for different diseases. Less occurrence or short length of the period of negative energy balance could be one of the reasons why there is less recorded diseases in organic farming compared to conventional farming. On the other hand if the feeding is not adequate, and the adjustment to yield is not correctly done this could lead to larger and longer energy deficit and more diseases. In the annual report from the Norwegian cattle health service the relation between disease incidence and milk yield per cow-year is illustrated (Table 3). Table 3 illustrate that diseases like ketosis and reproduction disturbances are associated with low yielding herds, however, milk fever and clinical mastitis, as well as reproductive treatments are more associated to high yielding herds. Bulk milk somatic cell count (BMSCC) is also associated with low yield.

Table 3. Number of treated cows for all registered diseases together with the most common diseases per cow-year (incidence rate), and bulk milk somatic cell count as well as fertility index classified into different milk yield groups. (Source: Annual report Norwegian Health Services, 2013).

Average herd milk yield (kg milk per cow-year)	*Number of herds*	*All diseases*	*Clinical mastitis*	*Cell count Bulk tank*	*Fertility index*	*Reproductive disorders*	*Ketosis*	*Milk fever*
< 5499	682	0,385	0,106	**137.900**	**50,3**	0,047	0,015	0,025
5500 – 5999	591	0,533	0,137	129.000	55,3	0,072	0,019	0,035
6000 – 6499	991	0,570	0,152	128.300	57,3	0,070	**0,022**	0,031
6500 – 6999	1 408	0,617	0,156	125.100	59,2	0,078	0,020	0,033
7000 – 7499	1 635	0,678	0,164	123.900	63,4	0,083	0,020	0,036
7500 – 7999	1 406	0,686	0,170	125.400	63,2	0,086	0,017	0,036
8000 – 8999	1 436	**0,750**	**0,177**	125.200	65,7	0,080	0,017	0,029
9000 -	336	0,688	0,156	130.700	68,9	**0,089**	0,012	**0,037**

The study of Bennedsgaard et al. (2010) from Denmark illustrates the difference in recorded disease treatments in 118 organic herds and 115 conventional herds (Table 4).

Table 4. Disease incidence of treated diseases cases in organic and conventional herds in Denmark in 2006 (according to Bennedsgaard et al., 2010).

Variable	Organic	Conventional
Average calving number	2.3	2.2
Milk production 305 days ECM	8085	9061
Culling rate/100 cow-years	35	39
Mortality rate/100 cow-years	3.7	3.9
Bulk milk somatic cell count in 1.000/ml	242	234
Mastitis treatments/100 cow-years	35	52
Dry cow therapy/100 cows	8	18
Locomotion disorders/100 cow-years	6.3	9.7
Reproductive treatments with antibiotics/100 cow-years	9.7	18.7
Other reproductive treatments/100 cow-years	1.2	2.3
Ketosis/100 cow-years	3.0	6.8
Milk fever/100 calvings	8.6	5.8

Table 5. Disease incidence of treated diseases cases in organic and conventional herds in Norway in 2013 (according to Norwegian Animal Recording System, 2014).

Variable	Organic	Conventional
Number of herds	284	7720
Mean number of cows	29.2	24.0
Average calving number	2.5	2.4
Milk production 305 days ECM	6656	7239
Culling rate/100 cow-years	41.6	44.7
Mortality rate/100 cow-years	1.1	1.2
Bulk milk somatic cell count in 1.000/ml	129	124

Mastitis treatments/100 cow-years	14.0	21.6
Dry cow therapy/100 cow-years	2.4	3.3
Locomotion disorders/100 cow-years	2.0	2.5
Reproductive treatments total/100 cow-years	3.6	9.5
Ketosis/100 cow-years	2.1	2.8
Milk fever/100 cow-years	5.5	4.2

Table 5 illustrates the same disease and production parameters in Norway as is illustrated from Denmark in Table 4. These two tables illustrate the same trend although the figures from Norway are generally lower than the Danish. The trend difference between organic and conventional is exactly the same. Organic herds have lower production, older cows and less clinical mastitis and reproductive treatments and higher milk fever incidence.

Fertility index and BMSCC is probably more objective measure of health than reproductive treatments and mastitis therapy, which is a kind of veterinary investment in the production system and not a measure of disease as such. Thus it could be expected that if the feeding adjustment is made correctly in organic herds it could be less diseases, but if it not adjusted correctly and low yield is due to too little or unbalanced feed intake there will be more diseases. Hardeng and Edge (2001) found less mastitis (OR = 0.38), ketosis (OR = 0.33) and milk fever (OR = 0.60) in their organic herds, compared to conventional herds. There were no differences in the interval to first AI, interval to last AI or calving interval between organic and conventional farming (Garmo et al., 2010). The cows were older in organic farming. Conventional cows yielded more, had higher SCC, and received more concentrates than organic cows. Higher level of concentrate fed to organic cows in recent years is probably an important factor for higher reproductive efficiency in organic cows than ten years ago as found by Reksen et al. (1999). Also in Sweden they found that the organic managed cows did not differ from convention managed cows in udder health or reproduction, with the exception of having longer calving interval for organic herds (Fall and Emanuelson, 2009). Fall et al. (2008) compared udder health in groups of organically and conventionally managed cows, using data from a longitudinal study in a Swedish dairy-research farm. Management of the groups was identical except for feed composition and the feeding regimen. Udder health was assessed by the geometric average somatic-cell count (SCC) within 150 days after calving, by the number of monthly SCC tests >200,000 cells/ml within 150 days after calving and by presence of lactations with veterinary-treated cases of clinical mastitis. The effect of animal group was analyzed by multivariable linear, Poisson and logistic-regression models, controlling for factors such as lactation number, breed, year, season and milk yield. The groups did not differ in any measure of udder health. They had power to rule out differences of at least 33,000 cells/ml in the geometric average somatic-cell count, an incidence rate ratio of 0.65 in the incidence of high-SCC milk-testing occasions, and an odds ratio of 0.43 in veterinary treated cases of mastitis. Conventionally managed dairy cows in 3rd lactation or more were found to have longer time from calving-to-first service than organically managed dairy cows. Beside that difference, the groups did not differ in any aspect of reproduction. Comparisons of number of veterinary treated cases of disease per lactation and the length of productive life revealed no significant differences or trends. With this unique study design, applied in a well-managed herd, they were not able to demonstrate any obvious differences in reproduction, general health or longevity between organically and conventionally managed dairy cows.

In a study from the United States risk factors for clinical mastitis, ketosis, and pneumonia in dairy cattle on organic and similarly sized conventional farms were examined at a total number of 292 farms (Richert et al., 2013a). Increased rate of clinical mastitis was associated with use of conventional management. Increased rate of ketosis was associated with feeding a greater amount of concentrates, and increased rate of pneumonia was associated with lack of grazing. At the same farms associations of risk factors with SCC in bulk tank milk were examined (Cicconi-Hogan et al., 2012). Overall, no difference in SCC was observed between the conventional and organic grazing systems. The amount of grain fed per cow per day was negatively associated with SCC. Interestingly, the same group of authors conclude in an article about management that: “Results suggested that management intensiveness was more closely associated with frequency of veterinary usage than was organic status; therefore, veterinarians should characterize farms by factors other than organic status when investigating which farms are most likely to use their services” (Richert et al., 2013b).

Reksen et al., (1999) did a comparative cohort study of reproductive performance in organic and conventional dairy husbandry was conducted using longitudinal data from the Norwegian National Board of Animal Production Recording from January 1, 1994 to December 31, 1996. The organically managed cohort comprised 998 lactation periods, and the conventionally managed cohort comprised 3016 lactation periods. Both groups were similar in herd size and geographical distribution. The following reproduction variables were studied: days open, calving interval, calving to first AI interval, calving to last AI interval, and AI per cow. No consistent difference in reproductive performance was found between the cohorts before adjustments were made for milk yield, breeding season, service, and parity. After inclusion of these independent variables in the repeated measures, mixed-model analyses, reproductive efficiency of organic managed dairy cows were impaired compared with those under conventional management. In organic dairy farming, breeding efficiency was difficult to maintain in cows bred during winter. Organic husbandry proved more efficient than did conventional husbandry in converting roughage into milk. Furthermore, the average multiparity percentage was higher in organically managed cows.

Another large study from Sweden with data included records from 2,902,718 lactations, collected in organic (n = 471) and conventional (n = 13 976) herds between 1998 and 2005 found that the replacement rate was slightly lower in organic herds and fewer Swedish Holsteins were used (Sundberg et al., 2009). The statistical analysis of cow performance in the first three lactations showed lower milk, fat and protein production in organic herds, but the increase in production from first to second lactation was larger when expressed in kg milk. Fertility was better for organically managed cows compared to conventionally managed cows, but the somatic cell count (SCC) was higher. However, at a given production level the fertility was slightly worse in organic herds while there was no difference in SCC. No interactions of importance were found between production system and breed for any trait. These results showed that organic and conventional dairy production differed regarding herd structure and cow performance. However, the differences in fertility and SCC found were to a high extent explained by the lower milk yield in organic production and no breed was found to perform better in either system.

Based on organic principles, livestock diets should be in a form that allows an animal to carry out its natural feeding behaviour and meet their digestive needs and should also provide for high-quality products rather than maximizing output (Marley et al., 2010) However, failure to maintain the correct energy-to-protein balance in the diet, resulting in the intake of excess protein, affects the fertility of the dairy cow. High-protein diets may also cause peri-parturient problems including retained placenta, metritis and ovarian cysts (Barton et al., 1996), an increase in the number of services/conception and impaired embryo survival (Chamberlain and Wilkinson, 1996).

Hansson et al. (2000) studied carcass quality, expressed as affection, pathological findings, slaughter-weight and evaluation, a picture of an animal's health and potential as high quality food is achieved. The study compares the carcass quality in Swedish certified organic meat production with that of conventional meat production slaughtered during 1997. The study involved about 570 000 cattle all reared conventionally and 4949 cattle reared according to organic standards. Pathological and additional findings are registered by meat inspectors from the Swedish National Food Administration at the post-mortem inspection. The total rate of registered abnormalities in cattle was systems around 28 % from organic and 27 % from conventionally reared herds. Carcass evaluation of cattle from organic herds gave higher classification in the EUROP system, whereas the fat content was lower than that of conventionally reared cattle.

In organic farming there is a limit of 30 % feedstuff from in-converted feed. If the feedstuff is from the same farm there is no limit in use (100 %). The organic feed can come from own farm or cooperating farms which is organic. The benefit of this rule is that the farmer will have a nice control of the content of the feed and where it is coming from. The difficulties could be that if the farmer’s field has a lack of some kind of minerals (Ca. Se, Co, Zn etc.) or excessive of minerals like potassium, this could lead to certain mineral deficits or a problem with setting up a correct Dietary Cation-Anion balance (DCAB) in the feed. This could lead to lack of certain minerals if that particular area or of an organic farm has a lack in the soil. Also in conventional farms most of the roughage will come from own farm, but there are no restrictions on this. The hypothesis could therefore be that organic farms have a higher risk of being deficient in certain vitamins or minerals. However, organic farms can also add minerals by using mineral and vitamin additives. This makes a need for diagnostic procedure to detect mineral deficiency and correct that. It would be easier for conventional farmers to find feedstuff which could balance out the deficits which exist on the specific farm; however these farms also have the challenge to detect possible mineral deficiency, however to a less extent. Most common mineral which is in deficit under Norwegian conditions are Se, Cu, Co and probably Zn. These minerals are supplemented in concentrate together with vitamin E and other vitamins. So, fewer rations with concentrate and more local feedstuff could increase the risk of certain deficits. There is a general lack of information on the status of minerals and vitamins in Norwegian soil and feedstuff, and the relation to disease. Most literature is on Se and vitamin E. This indicates there is a real deficit in Se, which is corrected by adding Se to concentrate. Lack of Se and antioxidant can be associated to more mastitis, reproduction problems as well as oxidation and rancidity of milk.

Ruminants that acquire the majority of their feed from forages, as hay or by grazing, may be more affected by variations in forage nutrient quality and availability than those on diets that contain higher proportions of supplemental feeds. Further, ruminants may selectively absorb or passively excrete mineral nutrients and nitrogen, altering the effect of dietary mineral content (Hafla et al., 2013).

1.2.6.1 *Conclusion*

Data from the Norwegian animal recording illustrates that 35.6 % of the Norwegian conventional herds are below the maximum limit of concentrate for organic farms. Less use of concentrate and more roughage in the feed will improve the rumen fermentation, less risk for developing Sub-Acute Ruminal Acidosis (SARA) and the diseases related to SARA. Less concentrate in the dry period and first part of lactation could also be related to a delayed peak and less increase in lactation yield. A very high yield early in lactation (first week) is shown to be a reason for mastitis later in lactation. However, less concentrate could also cause a larger and longer negative energy balance followed by metabolic diseases like ketosis as well as reproductive problems. All these problems could be avoided by good management strategy in feeding practices, and thus more balanced energy intake and output. Less use of concentrate in organic farming could be the reason why organic farms usually are associated with having less clinical mastitis. The occurrence of SARA in Norway is not really known, neither in conventional nor organic farms.

1.2.7 High amount of concentrate may reduce the mycotoxin tolerance of ruminants

Seeling and Dänicke (2005) indicated that sheep and beef cattle are normally less sensitive to DON than dairy cows, and that low-producing dairy cattle are more tolerant to DON than high milk producers. This may be due to greater stress, lower immunity and faster rumen turnover in high-producing animals. Furthermore, diets containing high levels of concentrate increase ruminal turnover and reduce ruminal pH, which inhibits DON biotransformation. Thus, ruminants on intensive concentrate feeding that results in chronical ruminal acidosis, or animals with other metabolic diseases, as well as animals that in other ways are forced to provide high production rates, may be more sensitive to adverse DON effects than ruminants in normal rumen-physiological balance.

Purified T-2 toxin was given orally to ewes (0.3 and 0.9 mg/day; 0.005, and 0.015 mg/kg bw per day, estimated to be 0.1 and 0.3 mg/kg total diet) for 21 days to test the effects upon ovarian function in comparison with control animals without T-2 exposure (Huszenicza et al., 2000). Half of the animals were given concentrate-rich feeding to increase the acid condition of the rumen. The T-2 exposed animals on concentrate-rich feeding showed retarded follicle maturation and ovulation. This observation was not generally replicated in ewes fed hay together with T-2 exposure, where only 1 of 5 animals at highest T-2 dose showed reduced reproductive function.

Another study by the same authors was performed on heifers with a single dosage level of T-2 toxin (9 mg/day; 0.025 mg/kg bw per day; estimated to be 1 mg/kg total diet) for 21 days, to test the effect upon ovarian function and compared with control animals without T-2 exposure (Huszenicza et al., 2000). All animals were given concentrate-rich feeding, which increased the acid condition of the rumen. The T-2 exposed heifers showed retarded ovulation and reduced plasma progesterone levels compared with controls.

EFSA (2011) stated that the effects observed in nutritionally challenged heifers and ewes indicate that rumen detoxification of T-2 toxin may not always be complete and thus effective at preventing the effects on ruminants.

1.2.8 Fertilizers - mineral content in feed

Bought organic fertilizers are allowed in organic farming. It is forbidden to use easy soluble nitrogen fertilizers. In organic farming the common industrial fertilizers could not be used. The most common fertilizer is the manure from own organic production. This means again that the organic farming system is dependent on the content of the manure. Very often such manure is high in potassium and this could lead to a high Dietary Cation Anion Balance (DCAB) in feed for dry cows. This is known as a risk factor for milk fever (Tucker et al., 1988) if fed in late dry period. There could also be lack of certain minerals as the supplementation of fertilizers is restricted.

Manure is usually high in potassium (K). K is the most important ion in DCAB. DCAB should be negative the last 14 days before calving to prevent milk fever (Goff and Horst, 1997). It could be a risk for having more milk fever in organic farming if the DCAB is not regulated in other ways. Milk fever is also associated with high milk yield. So, when the milk yield usually is lower in organic farming the yield will have a preventive effect. Fertilizer could also be enriched by minerals like Se, Zn, Cu, Co etc. which will help to avoid deficit in conventional farming, but not so then in organic farming. In organic farming meat bone based fertilizers could be used. Enriched fertilizers in Se are far less used in Norway compared to example Finland. It would be of interest to compare mineral status in organic versus conventional herds and the effect of this on animal health.

However, the standards allow the use of mineral and trace element additives without prior permission provided that justification, such as if forage, soil or blood analysis, can demonstrate a deficiency. This could be counteracted by measuring content of trace blood elements and thus supply accordingly (Marley et al., 2010). The risk of hypo-magnesaemia occurring during the spring period, when cows graze lush grass swards grown with high inputs of nitrogen and potash (K_2CO_3) fertilizer, is a problem in many conventionally managed herds. However, in organic systems where the primary N input for crop production is white clover, the incidence of hypomagnesaemia has been found to be lower (Weller and Bowling, 2000) and may be attributed to lower N inputs and the higher magnesium concentration of white clover compared with the levels found in grass. The same may be true for other minerals, trace elements and vitamins. However, there have been few studies into the effects of different pasture species on the mineral and trace element status of organic dairy cows and into the long-term sustainability of this approach to prevent deficiencies.

An excess of potassium (K+) in the soil solution, which is more likely in heavily manured soils (Hafla et al., 2013), can result in luxury uptake by forages in excess of plant requirements, and lead to an imbalance of high potassium, and therefore a relative deficiency of calcium and magnesium (Soder and Stout, 2003). High K+ concentrations in forages can result in metabolic issues in grazing ruminants due more to antagonisms with other elements such as calcium (Ca) and magnesium (Mg), than to simple deficiencies. Grass tetany (hypomagnesaemia) is characterized by low blood Mg and usually occurs in beef cows and ewes grazing lush grass pastures during periods of cool and cloudy weather (Ball et al., 2007). Grass tetany tends to occur when the dietary intake of total Mg is not particularly low, but instead when factors exist that increase the animal‘s Mg requirement (early lactation) or reduce the availability of Mg to the animal. Potassium inhibits the animals’ ability to absorb Mg resulting in a relative deficiency, and therefore the ratio of milliequivalents of K to (Ca+Mg) in forage has been used to predict the tetany hazard of forages (Church, 1988). Furthermore, milk fever (hypocalcaemia) is characterized by low levels of blood calcium and most commonly occurs in high producing dairy cows 12 to 24 h after calving when the sudden demand for Ca required by the onset of lactation tests the Ca homeostatic capabilities of the animal (Goff and Horst, 1997). Excessive K concentrations in the pre partum diet of high-producing dairy cows decreases Ca resorption from the bone resulting in an imbalance in Ca homeostasis and a possible deficiency regardless of dietary concentrations of Ca (Goff and Horst, 1997). Soder and Stout (2003) noted that the high K concentrations observed in orchard grass pastures fertilized with dairy manure slurry could predispose lactating dairy cows to milk fever. Hardeng and Edge (2001) examined the incidence of disease between 31 organic and 93 non-organic Norwegian dairy herds and unexpectedly found no differences between the production systems for cases of milk fever. The authors noted that for each kg increase in peak milk production, the risk of milk fever increased by 5 %; however, the mean maximum milk production for organic herds was 4.6 kg lower compared to non-organic herds. Therefore, they suggested that the lower milk production found in the organic herds resulted in reduced Ca depletion from milking compared to non-organic herds (Hardeng and Edge, 2001).

From a Swedish study Fall and Emanuelson (2011) using multivariable models could not demonstrate any differences in retinol, α-tocopherol, β-carotene or selenium concentrations between systems. Median concentrations of α-tocopherol were 0.80 µg/ml in organic and 0.88 µg/ml in conventional milk, while for β-carotene the median concentrations were 0.19 and 0.18 µg/ml, respectively; for retinol, the median concentration was 0.32 µg/ml in both groups; the median concentrations of selenium were 13.0 and 13.5 µg/kg, respectively, for organic and conventional systems.

From UK it is reported that organic milk was 42.1 % lower in iodine content than conventional milk (median iodine concentration 144.5 versus 249.5 ng/g; $P<0.001$), and this was across regions (Bath et al., 2011). This is also found in other European countries. There has been no such comparison in Norway. However, Haug et al., (2012) evaluated the iodine level in Norwegian milk, the iodine concentration was determined in 104 dairy tanker milk samples collected from 19 milk tours in different areas of Norway, throughout the year 2008. The iodine concentration in milk from indoor feeding was 122 µg L^{-1} and higher than in milk from the summer season, being 92 µg L^{-1}. The weighted average mean iodine concentration throughout the year was 114 µg L^{-1} milk. The results showed that the iodine concentration in milk from the winter season 2008 has been reduced to nearly the half during the last decade, from 232 µg I L^{-1} in milk collected in the winter season in 2000. The iodine concentration in milk from the summer season is at the same level as a decade ago. The reason for the reduction in iodine in milk produced during the winter season is not known. As organic farms have longer pasture period it is reasonable to believe that organic milk in mean will have less iodine than conventional.

Essential trace element concentrations in organic milk were significantly lower compared to conventional milk in north-western Spain (Rey-Crespo et al., 2013), this was especially evident for elements that are routinely supplemented at high concentrations in the conventional concentrate feed: Cu (41.0 and 68.9 µg/L in organic and conventional milk, respectively), Zn (3326 and 3933 µg/L), iodine (I) (78 and 265 µg/L) and Se (9.4 and 19.2 µg/L). Toxic metal concentrations in milk were in general very low and no statistically significant differences were observed between organic and conventional milk. In addition, the mineral content of organic milk showed a seasonal pattern, the significantly higher As (65 %) and Fe (13 %) concentrations found in the winter sampling possibly being related to a higher consumption of concentration feed and soil ingestion when grazing.

Vitamins and minerals are provided to dairy cows in a non-organic system by including them in the total mixed ration (TMR). By mixing vitamins and minerals in a formulated ration, the animals cannot choose to consume more or less of a specific ingredient and selective feeding is limited. The practices of organic dairy producers can include a similar vitamin and mineral supplement using allowed ingredients, but may be more varied in regard to delivering vitamins and minerals (Hafla et al., 2013). On the other hand restrictions on herbicide use and the greater biodiversity often found in organic pastures may result in greater concentrations of weeds in organic systems. Therefore, the mixed pastures often found in organic systems may help provide livestock with needed minerals through plant species biodiversity (Hafla et al., 2013).

Toledo et al. (2002) showed small or no differences in the investigated parameters between organic milk and the milk from the conventional farms or average values regarding gross composition of Swedish raw milk. The only significant differences found were in urea content and somatic cells, both of which were lower in organic milk. In addition, levels of selenium were lower in organic milk, which is of nutritional importance since dairy products are significant dietary sources of selenium in Scandinavian diets.

Forage micronutrient content is affected by soil content and plant uptake. The availability of the micronutrients iron, zinc, cobalt, manganese and copper is greater in acidic soils, while the availability of molybdenum and selenium is higher in alkaline soils. Iron is primarily used by ruminants to enable hemoglobin to carry oxygen in the blood for respiration; a deficiency can lead to anemia. Manganese, molybdenum, selenium and copper are needed for enzyme activity, and cobalt is a component of vitamin B-12. Zinc is required for enzyme activity, but is also needed to stabilize RNA and DNA, and for membrane function (Whitehead, 2000). Deficiencies of manganese are uncommon, but the primary symptom is lameness. Deficiency symptoms of zinc and copper are not specific, but include poor growth in young stock and increased susceptibility to disease. Copper deficiencies are relatively common, and reduced copper absorption can be caused by high dietary molybdenum, sulfur, or zinc. Cobalt deficiencies result in loss of appetite, and are common either where soils are naturally low in cobalt, or where high levels of iron or manganese reduce the availability of cobalt to plants. Excesses of iron or zinc can interact to reduce the absorbance of each other (Zollitz et al., 2004). Selenium is required for the enzyme glutathione peroxidase, and a deficiency of selenium can result in excessive lipid peroxidation, called white muscle disease, which can be fatal in young sheep and cattle. Excessive selenium can also be deadly: most ―locoweed plants are selenium accumulators, and their consumption can produce acute selenium toxicity, leading to rapid death; chronic consumption of selenium accumulator plants can lead to blindness or infertility (Whitehead, 2000).

Govasmark et al. (2005a) conclude that Zn, Fe and Mn did not limit plant growth, and that the herbage concentrations, except for Zn, were sufficient to meet the dietary needs of ruminants on organic dairy farms. They also found that plant growth was not limited by the supply of Cu, Mo or Co, but the herbage mineral nutrient concentration alone was not balanced to meet the dietary needs of ruminants. Supplements of mineral nutrient mixtures and/or concentrates fortified with Cu and Co are required to ensure sufficient supply for ruminants (Govasmark et al. (2005b).

Hoac et al. (2007) found the selenium content in whey and desalted milk produced using organic regimens was significantly lower than that in conventional samples. Moreover, the proportion of selenium in protein fractions of organic whey was significantly smaller than that in conventional whey, but the distributions of zinc and copper did not differ.

Blanco-Penedo et al. (2009) determined how trace metal concentrations in beef-cattle in North-West Spain vary between farms (including farms that have intensive, conventional and organic management practices) and to determine what the likely major causes of such variation are. Soil, feed (forage and concentrate) and animal tissue (liver and kidney; n = 165) samples were collected from three neighboring farms in each of three districts in Galicia (9 farms in total). Trace metal concentrations (Co, Cr, Cu, Fe, Mn, Mo, Ni, Se and Zn) of digested samples were determined by ICP-MS/OES. Farm husbandry practices that involved use of a high proportion of in-farm produced forage and low/no mineral supplementation, as typically practiced by organic farms, were associated with mineral deficiencies or physiological imbalances in calves. Strict management of the feed ration is needed to avoid sub-clinical or marginal deficiencies which are difficult to diagnose clinically, but can cause physiological stress and decreased production. The widely practiced mineral supplementation of concentrates on intensive and conventional systems guarantees that the physiological trace element requirements of calves are met, even when concentrates comprise a relatively low proportion of the diet.

1.2.8.1 *Conclusion*

Due to mainly use of organic manure from own farm there could be a higher risk of unbalanced mineral status in organic farming compared to conventional. This could specially be the case for high potassium level and unbalanced Dietary Cation Anion Balance (DCAB) causing higher risk of milk fever. Studies illustrate that other minerals could be a deficit in organic farming, but could also be adjusted by good management. Thus, there is not really a difference between the disease risk in organic compared to conventional as long as good management, diagnostics procedure and proper adjustments are put in place. However, it is a larger challenge to secure the mineral status in organic herds compared to conventional.

1.2.9 Medication and withdrawal time

Phytotherapeutic, homeopathic products, trace elements shall be used in preference to chemically-synthesized allopathic veterinary treatment or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended. This means that alternative medicine is preferred in organic farming. However, despite this only three known organic herds in Norway are using such products, others are using conventional therapy. It is also known that some very few conventional farms occasionally are using alternative therapy. There is very little scientific proof of effect of alternative therapy. One research on therapy of mastitis showed no better effect of homeopathic drugs than the self- cure rate in bovine mastitis (Hektoen et al. 2004). Significant reductions in mastitis signs were observed in all treatment groups. Homeopathic treatment was not statistically different from either placebo or antibiotic treatment at day 7 or at day 28. The antibiotic treatment was significantly better than placebo measured by the reduction in score ($P < 0.01$). Two-thirds of the cases both in the homeopathy and placebo groups responded clinically within 7 days. The outcome measured by frequencies of responders at day 28 was poor in all treatment groups. Evidence of efficacy of homeopathic treatment beyond placebo was not found in this study, but the design can be useful in subsequent larger trials on individualized homeopathic treatment. The self- cure rate and the dynamics of several diseases are underestimated, which means that therapeutic trials without control groups cannot really be conclusive. The risk of such medication is that diseased cows do not get right therapy and then turn into chronic cases, with less production, higher SCC for mastitis and could also be a risk for animal welfare. Chronic infected cows also have higher risk of having resistant bacteria as is shown from research that cows and herds with high SCC has higher risk of having penicillin resistant *S.aureus* than herds with low SCC and higher incidence of clinical mastitis (Østerås et al. 1999). On the other hand one could also say that many conventional herds trust the use of antibiotics for cure too much. This will then lead to an overuse of antibiotics and higher selection pressure for resistant bacteria.

With the exception of vaccinations, treatments for parasites and compulsory eradication schemes where an animal or group of animals receive more than three courses of treatments with chemically-synthesized allopathic veterinary medicinal products or antibiotics within 12 months, - 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 organic products, and the livestock shall undergo the conversion periods. This practice under a situation when a herd has many cows which need therapy is that they could be slaughtered sooner, or one would have less treatments than is optimal both from the animal welfare point of view, as well as for the therapy effect of the drug chosen. In another way it is always a benefit to get rid of chronic infected cases which are more frequent having resistant bacteria both in vitro and in vitro. In conventional farming system there is also more and more common to get rid of animals that do not respond properly to therapy. According to the Norwegian Cattle Health Service (2013) only 1.8 % of all cows treated for mastitis are treated for more than 3 times during a year. This is due mainly because there is too much workload with such animals. If this practice lead to more chronic infected cows there is a risk for development of shedders which can contaminate the environment with more pathogenic microbes, there could also be a risk for developing resistant strain of the microbes. Therapy with anthelmintic is still allowed in organic farming. A farming system which is more pasture based will also has larger challenges with parasites.

All withdrawal time for organic farming is extended with the double of the conventional farming. The benefit is that there would be no residues from the product, but the therapy would also be accordingly more expensive as the product has to be kept from the market. In addition also the value of the organic product to be discharged is higher as the payment for organic milk and meat is higher. This could be a driving force for lowering the treatment rate to a lower level than is acceptable from animal welfare and from the concept of optimal therapy. Theoretically this could also lead to more chronic cases and more resistant bacteria. There could also be more shedders of pathogens, which can infect other animals in the herd.

This will eventually also lead to higher limit level for contacting veterinary treatments, which will lead to less recorded treatments in the recording system as described by Valle et al., (2007) and Hardeng and Edge (2001). One way of treating clinical mastitis is also to dry off the quarter. This will not be detrimental to the milk quality and the animal can continue in the production. Garmo et al., (2010) found a higher proportion of cows with dried off teats in organic compared to conventional herd. The main reason for culling in Swedish cows in organic herds was poor udder health, whereas for cows in conventional herds it was low fertility. Furthermore, the shift in main culling reason from fertility, which was most common in first lactation regardless of production system, to udder health occurred at a lower age in organic production (Ahlman et al., 2011). There was no genetic difference. Both more dried off teats in Norway and relatively more culling due to udder health in organic herds in Sweden illustrate that the mastitis problem could be managed in different ways in organic and conventional herds in both the Nordic countries. The interesting in this is that penicillin resistant for *S.aureus* is found to be more linked to high SCC at both herd level and individual cow level, than to the treatment rate with antibiotics (Østerås et al., 1999). The reduced use of antibiotics in organic farms is hypothesized to lead to less resistant bacteria; however, there is very diverse information on this from the literature. Garmo at al. (2010) found there was few *S. aureus* isolates resistance to penicillin in both management systems. Penicillin resistance against Coagulase negative staphylococci isolated from subclinically infected quarters was 48.5 % in conventional herds and 46.5 % in organic herds. The antibiotic use in dairy production has been reduced by 70 % from 1994 to 2012, down to 17 cases per 100 cows in conventional herds in whole Norway (Norwegian Cattle Health Services, 2013). This is one of the lowest figures in the word together with Sweden (European Medicine Agency, 2013). At the same time the BSCC is at a very low level, only Switzerland has lower figures. Garmo et al. (2010) found slightly different mastitis flora in organic versus conventional herds. In subclinical mastitis organic herds had relatively more Coagulase negativ staphylococca, in clinical mastitis there were more mastitis without any growth, less *S.aureus* and *E.coli* and more *S.dysgalactiae*.

Sato et al., (2004) did an observational study to compare the antimicrobial susceptibility patterns of *Staphylococcus aureus* isolated from bulk tank milk in organic and conventional dairy farms in Wisconsin, United States, and southern Jutland, Denmark. Bulk tank milk samples and data regarding management and production were collected from 30 organic and 30 conventional dairy farms in Wisconsin and 20 organic and 20 conventional dairy farms in Denmark. Of the 118 bulk tank milk samples in Wisconsin, 71 samples (60 %) yielded at least one *S. aureus* isolate, and a total of 331 isolates were collected. Of the 40 bulk tank milk samples from Denmark, 27 samples (55 %) yielded at least one *S. aureus* isolate, and a total of 152 isolates were collected. Significant differences between organic and conventional dairies were detected only to ciprofloxacin in Wisconsin and avilamycin in Denmark. Significant differences ($P < 0.05$) between the two countries were detected in nine antimicrobials. Denmark had a higher probability of having reduced susceptibility to ciprofloxacin and streptomycin ($P = 0.015$ and 0.003, respectively). Wisconsin isolates had a higher probability of having reduced susceptibility to seven other antimicrobial agents (bacitracin, gentamicin, kanamycin, penicillin, sulphamethoxazole, tetracycline, and trimethoprim). We found small differences between organic and conventional farm types in each country and larger differences between the two national agricultural systems. This study thus illustrate that there are larger difference in antimicrobial susceptibility between countries than between organic and conventional farms within a country.

Bennedsgaard et al., (2006) found in Denmark overall prevalence of *Staphylococcus aureus* (SA) and SA penicillin restistance (SAr) among their cows was 29 % (95 % confidence interval: 24 %–34 %) and 4% (95% confidence interval: 2 %–5 %) respectively. The prevalence of penicillin resistance among SA infected cows was 12 % (95 % confidence interval: 6 %–19 %) when calculated from the first herd visits. No statistically significant differences were observed in the prevalence of SAr or the proportion of isolates resistant to penicillin between herd groups. For conventional herds the percentage of SA cows with SAr was 8 % and for organic herds since 1995 at 22 %, and for herds converted from one to few years ago the percentage was from 7 to 10 %. Milk production and the prevalence of mastitis treatment in the conventional group were significantly higher than in the old organic and the converting herds after one year of organic production; it was also significantly higher than in the larger group of 109 herds enrolled in the entire project. This indicates that there is not an obvious association between the higher increased use of antibiotics for mastitis and increased penicillin resistance for SA. The same as was found by Østerås et al. (1999).

A group of 80 dairy farms was used in a study in UK: 40 organic farms and 40 nonorganic farms (Haskell et al., 2009). The farms were recruited in pairs, and each organic-nonorganic pair was matched for herd size, housing type, genetic merit for milk production and geographical location. Somatic cell count data were extracted from national databases for a standard year (2004), and analyzed using stepwise logistic regression models. The organic status of the farm did not appear in the final model, indicating no major influence of organic status on SCC. There were, however, several effects of management on SCC, like dirty udders. The conclusion from this study is that the organic management with less use of traditional therapy did not influence the SCC.

The incidence rate of mastitis treatments was reduced considerably from 20 treatments per 100 cow years to 10 treatments per 100 cow years after the project period both in organic and conventional herds with the stable school concept (Bennedsgaard et al., 2010) in Denmark. Somatic cell count (SCC) and scores for acute and chronic intra-mammary infections did not change significantly during the study period, and milk production increased at the same rate as in the other herd groups. This illustrate that the incidence rate of mastitis treatments or the reduction of the incidence rate could be related to the herd SCC or the prevalence of blind quarters. As a result of this there could be an increase in herd SCC and blind quarters in organic herds as a result of reduced use of antibiotics.

Benedsgaard et al., (2003) compared these groups: herds converted to organic milk production before 1990 (old organic herds) compared to herds converted in 1995 and 1999use of antibiotics that are still conventional. They found that the old organic herds differed from the other three herd groups by having lower milk production per cow, lower somatic cell counts and fewer treatments for mastitis. Herds converted in 1995 and 1999 to 2000 were comparable to the conventional herds before conversion for all analyzed parameters. However, herd size was larger than both the older organic herds and the conventional herds after conversion. Production was ~2 kg energy corrected milk lower per cow per day than before conversion and compared to the conventional herds. In the herds converted in 1999–2000 little difference could be seen in relation to udder health after conversion when compared to conventional herds. The organic herds had fewer treatments for retained placenta and ketosis than the conventional herds. The shape of the lactation curves changed over the 11-year period with better persistency from day 60 to day 305 in all herd groups except for the old organic herds, which had the best persistency in 1990.

Also from US the mean somatic cell score did not differ between conventional (3.3 the homeopathy and placebo groups responded clinically within 7 days. The outcome measured by frequencies of responders at day 28 was poor in all treatment groups (Mullen et al., 2013). The proportion of cows with subclinical mastitis did not differ between conventional (20.8 %) and organic (23.3 %) herds in the same study, as well as there was no difference in bacteriological findings from subclinical cases.

Changes in udder health and antibiotic resistance of mastitis pathogens isolated from dairies upon conversion from conventional to organic management over a 3-year period were studied by Park et al., (2013). Coagulase-negative staphylococci (CNS) were the most prevalent mastitis pathogens isolated. CNS was significantly less resistant to β-lactam antibiotics (penicillin, ampicillin, chephalosporine and cloxacillin) when isolated from milk after the herd transitioned to organic management. There was no difference for other antibiotics or bacterial species like *Staphylococcus aureus* or S*treptococcus* spp. Cessation of the use of antimicrobial therapies in dairies in combination with organic management could lead to a reduction in the antimicrobial resistance of mastitis pathogens. However, at the same time the prevalence at parturition have increased both for CNS and Streptococcus spp., 68.9 % versus 47 % in organic and conventional farms respectively (Park et al., 2013). There was no difference at drying off.

A Swiss study (Roesch et al., 2006) compared organic dairy farms (OP; n=60) and conventional dairy farms (integrated production, IP; n=60), matched in size, location, and agricultural zone (altitude), were studied for possible differences in management, feeding, production, reproduction and udder health. OP and IP farms were similar in size (17.7 and 16.9 ha), milk quota (65900 and 70000 kg/year), cow number (14 and 15), cow age (5.3 and

5.2 years), housing of cows of the Simmental × Red Holstein or Holstein breeds (87 and 75 %; 45 and 60 %), but differed significantly with respect to loose housing systems (18 and 7 %), outside paddocks (98 and 75 %), energy-corrected 305-d milk yield (5695 and 6059 kg), milk protein content (31.8 and 32.7 g/kg), use of bucket milking systems (73 and 33 %), observance of regular (12-h) milking intervals (47 and 68 %), routine application of the California-Mastitis-Test (10 and 28 %), teat dipping after milking (25 and 43 %) and blanket dry cow treatments (0 and 45 %). Milk somatic cell counts on OP and IP farms (119,000 and 117,000/mL) and reproduction data were similar and there were no significant differences between OP and IP farms as concerns available feeds, planning and management of feeding. Alternative veterinary treatments were used more often on OP than IP farms (55 and 17 %). Main causes for cow replacements on OP and IP farms were fertility disorders (both 45 %), age (40 and 42 %), sale (30 and 37 %) and udder health (35 and 13 %). Between OP and IP Swiss dairy farms thus relatively few larger differences were found.

There could be a concern of animal welfare if the animal is suffering from pain, although the rules for organic farming state there should be taken extra care of animals so they are not suffering. If the limit for calling on traditional veterinary therapy is increased this will lead to lower recorded treatment rate in organic herds compared to conventional herds, despite the objective disease situation is the same. There is some indication in the literature that this is in fact the true (Valle et al., 2007). They concluded this: Earlier studies from Norway indicate that organic dairy farms enjoy better animal health than conventional dairy farms. However, these studies use veterinary treatment records and may not reflect the true health status since animal health may be handled differently, i.e. there might be different treatment schemes on organic versus in conventional farms. A study of animal health and health handling on both organic and conventional farms was performed based on information gathered from a mailed questionnaire merged with information from the Norwegian Cattle Health Services and the Norwegian Dairy Herd Recording System. Based on the original health records, there appeared to be many and large differences in herd health (veterinary) treatment parameters between the two production systems. However, after looking closer into the major disease problems of mastitis, ketosis, and milk fever and converting from treatment to estimated case load based on questionnaire information about the observed differences in health handling, all that remained was a lower level of acute mastitis in organic dairy herds relative to conventional. When controlling for production level — milk yield being lower in organic herds — no difference between the two groups remained. We conclude that, based on official health records, there is an apparent difference in animal health performance which is mainly related to an observed difference in health management. The remaining difference in acute mastitis which is not explained by disease handling appears, at least in part, to be associated with a lower intensity of milk production. The impact of these findings in relation to animal welfare as a central issue in organic farming needs further investigations. Finally, the study demonstrates the need for a critical assessment of routinely collected health-related data used in research, in order to make valid inferences regarding animal health performance. In addition to this there has been found higher bulk milk SCC in organic herd compared to conventional herds, but Hardeng and Edge, (2001) found that this was not related to higher SCC at cow level, but organic herds had older cows which were found to have higher SCC. Espetvedt at al. (2012) found that varying behavioural intention partly explain the differences in completeness of disease data in the Nordic countries: if farmers have different thresholds for contacting a veterinarian the registered incidence of clinical mastitis will be affected. Knowledge about the importance of attitudes and specific drivers may be useful in any communication about mastitis management in the Nordic countries. This would obviously be the same between organic and conventional farmers.

In a German study the time course of SCC and of bacteria count in bulk tank milk was not different between organic and conventional herds (Müller and Sauerwein, 2010). In organic herds, the portion of cows with individual SCC < 150,000 cells/mL in samples collected during the 3 months before and after the dry period was lower (P = 0.001) than in conventional herds. In addition, cows with individual SCC > 150,000 cells/mL during the 3 months preceding and following the dry period were more frequent than in conventional herds. Following up the SCC of cows with either SCC below or above 150,000 cells/mL, the portion of cows in conventional herds that passed from elevated SCC before the dry period to decreased SCC after the dry period was higher (P < 0.01) in conventional than in organic herds. For increasing SCC values above the 150,000 cell/mL threshold from drying-off to early lactation, there was a trend (P = 0.07) for higher portions of cows in organic herds. These results indicate that with the exception of synthetic antibiotics, all diagnostic measures and animal care at drying-off provide a means to improve mammary gland health regardless of the management system, and thus could be a result of lack of dry cow therapy in organic herds.

The conclusion (Fall, 2009) in his thesis concluded that under Swedish conditions, cows in organic and conventional dairy management differ only marginally considering mastitis, reproductive performance and metabolic profiles, implying that animal health in organic management is equally good as in conventional management in these specific fields.

A review from Wilhelm et al., (2009) has the objective to identify, evaluate, and summarize the findings of all primary research published in English or French, investigating prevalence of zoonotic or potentially zoonotic bacteria, bacterial resistance to antimicrobials, and somatic cell count (SCC) in organic dairy production, or comparing organic and conventional dairy production, using a systematic review methodology. Among 47 studies included in the review, 32 comparison studies were suitable for quality assessment. Fifteen studies were not assessed for quality, due to their descriptive nature or a low sample size ($n \leq 2$ farms). Overall, bacterial outcomes were reported in 17 studies, and prevalence of antimicrobial resistance (AMR) and multidrug resistance (MDR) of zoonotic or potentially zoonotic bacteria in 12 and 7 studies, respectively. *Campylobacter* spp., *Escherichia coli* including Shiga toxin–producing strains, *Salmonella* spp., *Staphylococcus aureus,* and SCC were investigated in 2, 7, 4, 6, and 15 studies, respectively. Contradictory findings were reported for differences in bacterial outcomes and SCC between dairy production types (organic vs. conventional). Lower prevalence of AMR on organic dairy farms was reported more consistently in studies conducted in the United States, as opposed to those conducted in Europe. These conflicting findings may result from geographic differences in organic production regulations governing antimicrobial usage, use of antimicrobials in conventional dairy production, and baseline prevalence, as well as laboratory methods, study designs, or methods of analysis employed. The majority (four of seven) of MDR investigations reported no significant differences in prevalence. Overall, only 9 of 32 studies met all five methodological soundness criteria. More well designed, executed, and reported primary research is needed at the farm and post-farm levels. This review highlights the difference in use of antibiotics in US and Europe as such. It is also a huge difference in the use of antibiotics from Nordic countries and other European countries. All this illustrate that findings from US or Europe is not really relevant for the Nordic countries according to antibiotic resistance. One example is the use of antibiotics in Canadian dairies published by Saini et al., (2012), where antimicrobial use was measured as antimicrobial drug use rate (ADUR), with the unit being number of animal defined-daily doses (ADD)/1,000 cow-days.

Antimicrobial drug use rates were determined at farm, region, and national level. Combined ADUR of all antimicrobial classes was 14.35 ADD/1,000 cow-days nationally. National level ADUR of the 6 most commonly used antimicrobial drug classes, cephalosporins, penicillins, penicillin combinations, tetracyclines, trimethoprim-sulfonamide combinations, and lincosamides were 3.05, 2.56, 2.20, 1.83, 0.87, and 0.84 ADD/1,000 cow-days, respectively. In Norway cephalosporins, tetracyclines and lincomycin is hardly used in dairy farms, and more than 95 % is penicillin-related (Norwegian Cattle Health Services, 2012).

Incidence rates for clinical mastitis tended to be lower in the observed organic herds in Canada (Levison, 2013). The overall mean incidence rate of clinical mastitis (IRCM) for participating conventional herds was 28.1 cases per 100 cow-years are risk and mean IRCM was 17.1 cases per 100 cow-years at risk for certified organic herds. Research often reports lower IRCM on organic farms when compared to conventional (Hamilton et al., 2002; Hamilton et al., 2006) which may represent a truly reduced incidence of clinical mastitis in organic production system systems or may be deceptively low due to lack of reporting by organic producers (Berry and Hillerton, 2002; Ruegg, 2009). Housing type and access to pasture did not impact overall IRCM suggesting the overall IRCM is consistent notwithstanding the environment in which cows are housed.

1.2.9.1 *Conclusion*

Research has shown that alternative therapy like homeopathic have no better effect than the self-cure rate. The research comparing antibiotic resistance for *S. aureus* in organic and conventional herds shows no difference, neither in Norway, Sweden nor Denmark.

Usually research reports show lower treatment rate in organic herds than in conventional herds for several diseases. One reason could be the doubling of withdrawal time making the treatment much more expensive. Lower treatment rate could be due to higher threshold for using veterinary treatments, and not less true disease. More studies report that there is no significant difference between organic or conventional herds in disease frequency after correcting for herd size, age, yield etc., except for clinical mastitis which seems to have a lower frequency in organic herds.

Some studies report more dry teats in organic compared to conventional herds. Drying off teats could be one way to avoid use of antibiotics for mild clinical mastitis. Double withdrawal time could also influence the strategy in drying off cows, as long-acting dry preparation for treating dry cows is difficult to use in organic farming. This could be the reason that the SCC is found to be higher before drying off and after drying off in a Swedish study where long-acting preparation at drying off is the only preparation in use.

1.2.10 Mating or artificial insemination

Mating is preferred before artificial insemination in organic farming. Artificial insemination has been a key factor to reduce and avoid sexual transmission of diseases the last decade. If natural mating is being more common there is also a risk that the old sexual transmitted diseases will occur again. Mating with one bull in a herd will also increase the probability to mate close relatives which means less genetic variation and a higher risk of congenital diseases.

Garmo et al. (2010) found that natural mating was performed in 16.0 % of the mating in organic farming while in conventional farming natural mating was performed in 3.3 % of the mating. This reflects the intention that natural mating should be preferred in organic farming. Days open in organic farming using natural mating was 74 days, while in conventional farming 105 days. In artificial insemination the same figures where 98 and 95 days respectively. This illustrate that in organic farming natural mating was performed as a routine, however, in conventional farms the figures indicate that natural mating was performed for problem cows or herds having problems with detecting estrus. Thus, these figures are not comparable. The potential problem with natural mating like inbreeding, and breeding with one bull with a potential bad genetics could not be revealed from these data. Neither could the potential risk for spreading infectious venereal diseases.

1.2.10.1 *Conclusion*

One study from Norway illustrate that more cows on organic farms had natural mating (16.0 %) compared to the frequency of natural mating in conventional farms (3.3 %). This could give a higher risk of inbreeding, less genetic variation within the herd, as well as higher risk of spreading venereal disease between cattle.

1.2.11 Reproductive therapy

Medical estrus regulation or estrus synchronization is not allowed in organic herds. But therapy for cystic ovaries or treatment on corpus luteum can be done on individual basis. From a breeding point of view this would be a long term sustainable system as cows which do not come in heat in a natural way will not be bred and will be excluded from further breeding. A systematic use of estrus synchronization will on the other side lead to that animals that are not bred normally will continue to have offspring with the same genes. Therefore this interferes with the natural selection process. From economic point of view to avoid systematic estrus synchronization could be an economic challenge. There is still a huge difference from the attitude to do synchronization in the Nordic countries compered to overseas attitude where synchronization is the main part of the breeding system (Galvão et al., 2013).

1.2.11.1 *Conclusion*

In Norway there is a tradition for not using estrus synchronization, as is very often a principal in many other countries. However, it is though being more and more frequent in the last year for some animals, but not for the whole herd. As therapy for cystic ovaries or treatment on corpus luteum can be done on individual basis also in organic farms, there is not really a large differences expected between organic and conventional herds.

1.3 Data gap and future research

There is a lot of research on the differences in organic and conventional herds on animal health in dairy cattle in Nordic herds.

However, there is a lack of data from Norwegian organic and conventional dairy production on trace mineral content in blood and the implication for that in cattle health. It seems also to be lack of data on the consequences of the grouping system and milk feeding system for calves and the effect on calf's health.

There is a need for more research on mineral balances, both macro- and micro-minerals in both organic and conventional herds and the effect on animal health and product quality.
There is also a need for more research to look at the reasons for development of resistant strain of udder pathogens. It is clear from this literature review that the believed strong connection between the use of antibiotics and resistance in common udder pathogens are not that simple. There is obvious a kind of connection between the animal immunity reaction and high SCC and developing of resistant strain in chronic infected cows.

There is a need for more knowledge of how to avoid parasite burden on pasture-based systems both in organic and conventional systems, as well as avoiding development of resistant parasites.

2 Differences in animal welfare between organic and conventional cattle production

2.1 Hazard identification and characterization

2.1.1 Suckling period

According to Commission Regulation No 889/2008, Article 20, all young animals should be fed on maternal milk in preference to natural milk, for a minimum of three months in cattle. However, here the national regulations for organic production differ quite heavily from the Commission Regulation. The national regulation state that calves should be able to suckle for the first three days after birth. If the suckling period is less than one month, the calves should be fed milk with a teat bucket. There is no demand for suckling after birth or teat feeding of calves in conventional cattle production at all. Unfortunately, the regulations are not followed on all farms with organic production. In a survey to farms with organic dairy production in Norway and Sweden (et al., 2012), 9 % answered that they did not allow the calf to suckle during the colostrum period and only 23 % allowed to calves to suckle beyond the first week. However, on many farms (< 75 %) the calves were suckling a foster cow.

Most dairy producers separate the cow and calf immediately after birth, both in Norway and other countries in Europe and North America. Producers suggest a number of reasons for separating the calves early (review by Flower and Weary, 2003):

1. Preventing from suckling may result in more milk for the producer
2. Artificial rearing allows for closer monitoring of food intake
3. Suckling inhibit cow's return to oestrus
4. Suckling will extend milking time
5. Early separation minimizes stress of separation

Lidfors (1996) investigated the behavioural effects on the cow of separation immediately and 4 days after birth, and concluded that later separation leads to increase in cow activity and vocalization and decrease in rumination. Correspondingly, Weary and Chua (2000) found higher call rates for cows when calves were removed after four days than at 6 h or one day, and Flower and Weary (2001) reported that cows separated from their calves at two weeks showed stronger vocal and behavioural responses than those separated after just one day.

Metz (1987) estimated that the milk production was the same when cows were kept with their calves for a short period (10 days) versus cows separated from calves immediately after birth. Flower and Weary (2001) found that milk production in the parlour was were lower when cow and calf were kept together for two weeks after birth, but milk yields recovered so that total milk yield over the lactation did not differ.

Calves separated at day 4 were lying less and performed more oral behaviours than calves separated immediately (Lidfors, 1996). Weary and Chua (2000) found that calves separated at 4 days after birth showed more movements in the pen, spent more time standing, spent more time with head out of the pen and called more. Also Flower and Weary (2001) found the same effects of late separation, but the authors also emphasize that calves separated late showed more intense social behaviour when introduced to an unfamiliar calf. An Also Krohn et al. (1999) report that calves that were allowed to stay with the mother and suckle for four days were less fearful of other calves, suggesting that maternal presence is important for learning social behaviour.

Newborn calves have no antibodies against neonatal infections and hence it is important that they suckle and consume colostrum as soon as possible after birth. However, allowing the cow and calf to stay together will unfortunately not secure that the calf actually consume colostrum. Both Edwards (1982), Lidfors (1996) and Wesselink et al. (1999) observed that more than 30 % of the calves failed to suckle within four, six and 24 h respectively.

Under natural conditions the calves form relationships with both their mothers and their peers. Studies show that isolation from conspecifics may lead to abnormal behaviours (e g. Jensen et al., 1998). Hence, the effects of early separation might be mitigated if calves were group-housed after separation.

Krohn and Madsen (1985) found that calves allowed to stay with the cow and suckle for 10 days had a much higher daily gain for the first 10 days, but at 88 days of age the live weight was the same. Several other studies reports that average daily gain was higher in calves allowed to suckle the dam for some time after birth (Metz, 1987; Lidfors, 1996, Flower and Weary, 2001), but no information is provided for how long time these differences were maintained.

The method of supplying the milk will definitely affect the behaviour of artificially reared calves. Loberg and Lidfors (2001) showed in a nice experimental set-up that both teat feeding vs. bucket feeding and a slow milk flow vs. fast milk flow reduced the amount of abnormal sucking. The positive effects of teat feeding on abnormal sucking are confirmed in several other studies (e.g. Szücs et al., 1977; Bøe, 1986).

2.1.1.1 *Conclusion*

The required length of the suckling period in organic production is only 3 days. It is in general positive for animal welfare that the calves can stay with their mother. However, when considering the fact that calves of high yielding have problems of finding the teats and thus get sufficient amounts of colostrum and that calves separated from the mother after three to four days showed strong vocal and behavioural responses, indicate that this procedure do not improve animal welfare and that the animal welfare in fact is better in conventional animal production.

2.1.2 Calves in single boxes

According to Commission Regulation No 889/2008, Article 11, housing of calves in individual boxes shall be forbidden after the age of one week. In conventional cattle production (§ 23, Regulations for keeping of cattle, 2004) calves can be kept in single boxes for the first 8 weeks after birth. However, on many conventional Norwegian dairy, the calves are kept in groups also during the milk feeding period. A survey among conventional dairy herds (Gulliksen et al., 2009) showed that more than 50 % of the herds kept the calves in groups from two weeks of age. The introduction of computer controlled milk feeding systems is probably the reason for the increase of group housing in the milk feeding period (Bøe and Havrevoll, 1993).

Housing of calves in outdoor single pens was introduced in USA in the late 1940ies (Davis et al. 1954) in order to reduce health problems, and especially respiratory problems. Another reason for introducing single pens for calves was to reduce cross-sucking. Some producers are also afraid that cross-sucking in calves might increase the problem of inter-sucking among cows (Keil et al. 2006).

When the health status of the calves is satisfactory, the daily gain do not seem to differ between calves reared in groups or calves housed in single pens (e.g. Bøe and Havrevoll, 1986; 1988). However, the housing systems will influence their behaviour and welfare. Several experiments have shown that the general activity is higher in calves reared in group pens than in single pens (Graf, 1978; Gjestang, 1983; Bøe, 1986). Calves in single pens spent more time with the head out of the pen (Bøe, 1988) and spent more time performing self-grooming (Bøe, 1986). Further, calves in groups spent more time sucking and licking others calves under the belly and their ears and mouth (Gjestang, 1983; Dybkjær et al., 1986; Bøe, 1988). But also calves in single boxes can suck on the mouth and ears of neighboring calves, unless totally isolated (Bøe, 1988). Still, it is important to notice the effect of the milk feeding system. By providing the milk through a rubber teat and at a low flow rate, cross-sucking can be reduced to very low level also in group pens (Loberg and Lidfors, 2001). Comparable results are reported by Jensen and Budde (2006). It is interesting to notice that the level of cross-sucking seem to be low when calves are kept in computer-controlled milk feeding systems (Bøe and Havrevoll, 1993; Jensen, 2004; Nielsen et al., 2008).

Jensen et al. (1997) showed using an open-field test at three months of age, that individually reared calves were more fearful when introduced to a novel social situation and when isolated in a novel arena. In a later experiment, the effects of open and closed single pens were investigated (Jensen et al., 1999). Calves isolated in closed single pens explored more during an open-field test and had a longer latency to enter an open-field arena that calves reared in open single pens. Calves kept in groups sniffed and mounted other calves more than calves housed in single pens. Arave et al., (1992) found no difference in daily gain in calves reared individually or in isolation, but calves reared in isolation spent more time standing and socialized less. Also Creel and Albright (1988) showed that isolated calves were standing more and tended to vocalize and investigate more. As yearling heifers isolated calves had a higher mean serum cortisol concentration than controls following short-term stressors.

Vieira et al. (2010) demonstrated that calves kept in pairs vs calves previously kept in single housing had a shorter latency to start feeding, visited the starter feeder more frequently, spent more time at the feeder and consumed more starter when moved to group pens after weaning.

2.1.2.1 *Conclusion*

If calves in conventional herds are kept in single pens up to 8 weeks of age, the welfare of the calves must be considered to be better in organic production than in conventional production.

2.1.3 Tethering

Article 39 of the Commission Regulation No 889/2008 gives some exceptional rules related to tethering: *Where the conditions laid down in Article 22(2)(a) of Regulation (EC) No 834/2007 apply, competent authorities may authorize cattle in small holdings to be tethered if it is not possible to keep the cattle in groups appropriate to their behaviour requirements, provided they have access to pastures during the grazing period according to Article 14(2), and at least twice a week access to open air areas when grazing is not possible.*

As the national regulations have been changed recently (autumn2013), there is no longer any differences in the regulations for organic or conventional dairy production concerning the question about tethering of cattle.

2.1.4 Access to pasture

According to Commission Regulation No 889/2008, Article 14, 2, herbivores shall have access to pasturage for grazing whenever conditions allow. However, bulls over one year old shall have access to pasturage or an open air area. For conventional cattle production the national regulation state that cattle shall be kept on pasture for a period of minimum eight weeks during the summer with the exception for uncastrated males of more than 6 months of age. For cattle in loose housing systems this imposition takes effect from 1st January 2014. However, for cattle that are tethered after 1st January 2024, the pasture period is extended to 16 weeks. For cattle that cannot be kept on pasture, the alternative is an outdoor yard.

In order to increase the use of pasturing, the Norwegian government in 2006 established a system with economic support for farms letting their animals out on pasture for 12 - 16 weeks yearly. According to the data from farms applying for this support, Hegrenes et al. (2012) calculated that around 80 % of the Norwegian dairy herds had their cows on pasture. However, this number will not comprise herds that use pasture, but for less than 12 - 16 weeks. Hence, 80 % of the herds might well be and underestimation of the proportion of dairy herds using pasture.

How advantages are pasture for animal welfare?

It is generally assumed that pasture provides cattle with better welfare compared to indoor housing systems (Burow et al., 2013). However, the breeding programs have resulted in dairy cows which have a high genetic potential for milk production and thus higher nutritional requirements. Unfortunately, these nutritional demands cannot always be achieved from grazing alone. However, Kristensen et al. (2007) found that the milk yield actually increased when time at pasture was increased from 4 to 9 hours per day, and the live weight gain was not significantly different between treatments.

In a preference experiment (Charlton et al., 2011), dairy cows chose to go indoors almost twice as often as to pasture (66.2 % vs. 33.8 %). As could be expected, weather conditions influenced the cows' preference. During rainfall cows spent more time indoors. Lactation number and lameness score did not affect the preference of the cows, but low yielding cows spent more time on pasture.

2.1.4.1 *Conclusion*

The main difference between organic and conventional dairy production for access to pasture is actually the duration of the period in which the cows have access. The difference in duration is also quite limited, and hence the difference in animal welfare between organic and conventional dairy production must be considered to be small.

2.1.5 Access to open air areas

In cases where herbivores have access to pasturage during the grazing period and where the winter-housing system gives freedom of movement to the animals, the obligation to provide open air areas during the winter months may be waived (Article 14, 3, Commission Regulation No 889/2008). Further, according to Article 46, the final fattening phase of adult bovines may take place indoors, provided that this indoor period does not exceed one fifth of their lifetime and in any case for a maximum period of three months. Hence, the difference in animal welfare between organic and conventional dairy production must be considered to be small.

2.1.6 Space allowance

According to Commission Regulation No 889/2008, Annex III, dairy cows should have a space allowance of 6.0 m^2 per animal. In the Regulations for keeping of cattle, 2004, the space allowance for dairy cows in conventional production is not specified directly. However, for cubicle (freestall) housing systems (in which the majority of group housed cows are kept) there are requirements for minimum one cubicle per animal. Næss and Bøe (2010) calculated the space allowance for 232 Norwegian dairy herds with cubicle housing and found that the mean total cow area was 8.4 m^2/cubicle, and consequently higher than the required minimum for organic production. Fregonesi and Leaver (2002) compared total space allowance of 10.6 and 7.7 m^2/cow in housing systems with cubicles and found that space allowance had no significant effect on milk production, live weight change, condition score, feed intake or total time spent lying or feeding, but agonistic interactions were higher at low space allowance.

The minimum space allowance for breeding or fattening cattle is apparently somewhat higher in organic than in conventional production (see table 6), but the differences is small for the calves. For new buildings in conventional production, where female cattle should have a lying area with solid flooring, the recommended space allowance for especially the heavier animals has to be increased.

Table 6. Minimum space allowance for fattening and replacement cattle according to regulations for organic and conventional production.

Organic production		Conventional production	
Live weight (kg)	Space (m^2)	Live weight (kg)	Space (m^2)
< 100	1.5	150	1.5
< 200	2.5	220	1.8
< 350	4.0	> 220	2.0
> 350 [b]	5.0	350 [a]	3.0
		450 [a]	3.5
		550 [a]	4.5

a According to official recommendations.

b Minimum of 1 m^2/100 kg

Jensen et al. (1997) found that a space allowance of 1.35 m^2/calf and 4.05 m^2/calf in group housing systems did not have any effect when the calves were tested in an open-field test at three and six months of age. However, Jensen et al. (1998) in a parallel study found that space allowance significantly affected the quantity of locomotor play in week 4 and 6. Jensen and Kyhn (2000) kept calves in groups of four at a space allowance of 4.0, 3.0, 2.2 and 1.5 m^2/calf and found that calves kept at 4.0 and 3.0 m^2/calf performed more locomotor play at 5 weeks of age, but in weeks 7 and 9 no effect was found.

Hickey et al. (2003) kept finishing steers (mean live weight 516 kg) at space allowance of 1.5, 2.0, 3.0 and 4.0 m^2/animal,(344, 258, 172 and 129 kg/m^2 correspondingly) and hence a quite high stocking density. Increasing space allowance above 2.0 m^2/animal increased daily gain, decreased feed conversion rate and total lying time, but had no effect on aggression, grooming and stereotypic behaviour. They conclude that a space allowance of less than 3.0 m^2/animal adversely affected animal welfare.

Gygax et al. (2007) studied finishing bulls of 360 – 500 kg at space allowances of 2.5, 3.0, 3.5 and 4.0 m^2/animal in slatted floor pens. The results showed that increasing the space had a significant positive effect on lying time, lying bouts, time spent lying on the belly with one fore or hind leg stretched, changing lying posture and cleanliness. The authors conclude that increasing the space allowance up to 4.0 m^2/animal was beneficial for animal welfare.

In an experiment with dairy heifers (400 kg live weight) in slatted floor pens with a total area of 5.4 m^2/animal, the size of a lying area with straw bedding was kept at 1.8, 2.7 and 3.6 m^2/animal (Nielsen et al. 1997). The results indicated that increasing the lying area from 1.**8** to 2.7 or 3.6 m^2/animal improved the welfare of the heifers. In a parallel experiment (Mogensen et al., 1997) the slatted area was kept constant and the straw bedded area was increased from 1.8 to 2.7 and further to 3.6 m^2/animal. Also in this experiment both welfare, health and performance was improved when increasing the straw bedded area above 1.8 m^2/animal.

Two review articles have focused on the effect of space allowance for growing cattle. Ingvartsen and Andersen (1993) conclude that reducing the space allowance from 4.7 to 1.5 m^2/animal has a significant effect on feed intake, daily gain and feed conversion ratio for bulls and steers weighing 250 – 500 kg. Wechsler (2011) conclude that housing finishing bulls and steers in pens with low space allowance adversely affect animal welfare and that minimum space allowance should be 3.0 m^2/animal for a bull or steer expected to reach 500 kg.

2.1.6.1 *Conclusion*

For dairy cows, the difference in space allowance between organic or conventional production seems to be negligible. For calves, the required space allowance is somewhat higher in organic compared to conventional production, but it is unclear if this limited difference will have any significant effect on animal welfare. For growing cattle > 300 kg live weight, the differences in required space allowance is considerably higher in organic than conventional production and data suggests that this will have a significant effect on animal welfare.

2.1.7 Solid lying floor

In organic production, at least half of the indoor surface area shall be solid (Commission Regulation No 889/2008, Article 11). According to the Norwegian regulations for keeping cattle, cows should have access to a lying area with solid and soft bedding. Further, in all new buildings, all female cattle should have access to lying areas with solid flooring. Hence, there is no demand for solid floor resting areas for bulls in conventional animal production and neither for heifers in existing buildings.

According to Swedish regulations (Statens jordbruksverks föreskrifter, 2010), calves, heifers and bulls can only be kept in slatted floor pens if the room is insulated and the slatted floor surface made of rubber. In Denmark, fully slatted floor pens are not recommended for replacement cattle or bulls because of negative impact on animal welfare (Indretning av stalde til kvæg, 2005).

Even though we have no recent data for the use of slatted floor pens for replacement heifers and bulls in Norwegian dairy herds, it is reason to believe that such housing systems are the most common system for these categories of cattle. Also in Sweden, slatted floor pens are the main housing system for replacement heifers (Pettersson et al., 2001).

Several studies have shown that dairy cows prefer soft bedding materials (e.g. Manninen et al., 2002) and that soft bedding in freestalls in fact can improve milk yield (Ruud et al., 2010). Fully fleeced sheep show no clear flooring preferences (Færevik et al. 2005). Sheared ewes, however, prefer softer floors with low thermal conductivity (deep litter straw and wooden solid floors or wooden slatted floors). The reduction in lying time was less dramatic when ewes had access to straw, indicating that that access to straw the first weeks after shearing may improve animal welfare (Færevik et al. 2005). There are however, few studies that have investigated the effect of solid/soft flooring in the resting area on welfare of heifers and bulls.

The cleanliness of the lying area is important. One alternative is a deep bedding system. Another alternative is a sloped floor system (8 – 10 % slope in order to keep the surface sufficiently clean), a straw-flow system or freestalls/cubicles.

In a Danish study (Hindhede et al., 1996) dairy heifers were housed in groups of six and at a space allowance of 3.0 m^2/heifer in either fully slatted floor pens or pens where half of the pens were slatted and the other half were bedded. Bedding had no effect on daily gain, but the prevalence of heel horn erosions was reduced and the claw length was increased with access to bedding. In another Danish study (Nielsen et al., 1997) dairy heifers were housed in slatted floor pens with different sized bedded lying areas (1.8, 2.7 and 3.6 m^2/heifer). Total space allowance was the same in all treatments. Synchronization of resting decreased and butting and forcing another heifer to stand up increased at the lowest space allowance (1.8 m^2/heifer). Mogensen et al. (1997) performed an experiment with dairy heifers where the slatted area at the feeding table were kept constant and the size of the bedded lying area was increased from 1.8 to 2.7 and up to 3.6 m^2/heifer. None of the heifers were lying in the slatted area and total lying time was not affected by the size of the lying area, but synchronization of lying was lower and variation in lying time and number of aggressive interaction was higher at the lowest lying space allowance (1.8 m^2/heifer). Also feed intake and daily gain was lower and heel horn erosions were higher at the lowest lying space allowance.

In a study in Northern Ireland (Lowe et al., 2001), finishing beef cattle were kept in either fully slatted floor pens, fully slatted floor pens covered with rubber and solid floor pens with straw bedding. There was no significant effect of treatment on production parameters but animals housed on slats or slats with rubber were significantly more dirty than those on straw bedding. Wierenga (1987) in a review concluded that accommodating fattening bulls in fully slatted floor pens had a negative effect on their welfare. In an experiment with freestalls for calves (Bøe et al., 2014), calves were very seldom observed to by lying outside the stalls.

2.1.7.1 *Conclusion*

Several experiments show that access to a lying area with solid flooring and/or bedding is positive for the welfare of calves, heifers and bulls. It is important that the cleanliness of the surface of the lying area is kept sufficiently clean.

3 Animal health in organic and conventional sheep/lamb production

The Norwegian sheep farming system is based on extensive use of natural open ranges pastures. Lambs are born during late winter or spring, and sheep and lambs graze on fenced farmland before being released on open forested or alpine ranges. The animals are gathered in September, and selected lambs are then slaughtered. After a period of autumn grazing on farmland, retained animals are again fed indoors. There are several local adaptations. In coastal areas the sheep can graze outdoors all year round, while owners without adequate land for spring grazing let the animals out on the open range pastures directly from their in-house feeding.

There are no health studies being conducted on organic versus conventional sheep production in Norway. The literature and knowledge about differences are based on trials conducted in other countries were management, breed, feeding and use of indoor area and pasture may differ considerably from Norwegian conditions. The National Animal Health Service works with prevention and control of diseases in Norway. Approximately 28 % of all the sheep farms (44 % of all the ewes) were registered in the Norwegian Sheep Recording System (Annual report, 2012) where all diseases and treatments are recorded. A special problem in Norway is losses on pasture caused by predators (wolverine, bear, wolf and fox) as well as by alveld, a hepatogenous photosensitivity disease of sheep, but there are no literature showing differences in organic versus conventional sheep farming when it comes to losses on pasture.

3.1 Hazard identification and characterization

3.1.1 Suckling period

The differences in the regulatory between organic and conventional sheep production when it comes to the suckling period are related to maternal milk versus natural milk and a specified minimum length of the suckling period. Ewe milk production herds have shorter suckling period than recommended in organic flocks in Norway. Since we only have a few flocks that produce ewe milk in Norway, the increased suckling period demanded in organic production is the same length as they use in conventional sheep production. Hence nearly all conventional sheep farmers use maternal milk as feeding source to the lambs and the length of the suckling period is the same in both farming types.

Most preweaning lamb deaths occur within the first week of life (Nowak & Poindron, 2006). In extensive systems, the majority of lamb deaths are attributed to two main causes: dystocia from prolonged or difficult birth, and the starvation-mismothering-exposure complex. Lamb deaths attributed to the starvation-mismothering-exposure complex have contributing factors such as adverse weather conditions, inadequate energy reserves, thermoregulatory problems, delayed lactogenesis, insufficient colostrum yield, aberrant maternal or lamb behaviour, competition with siblings or udder defects (Nowak & Poindron, 2006). There are no data on differences in starvation or inadequate energy reserves in organic versus conventional farming. Neonatal mortality rates, ranging from 6 to 13%, have been reported from different countries (Holmøy et al., 2012). Holmøy et al (2012) concluded that continuous monitoring of the ewes during the lambing season, active support to ensure sufficient colostrum intake of the lambs, feeding a combination of grass silage and hay compared with grass silage alone, and supplying roughage at least twice per day versus only once significantly increased lamb survival. Increased survival was also observed in flocks where the farmer had at least 15 years of experience in sheep farming and in flocks in which the Spæl breed predominated compared to the Norwegian White breed.

In Norway, most of the lambing is conducted indoor or in close relation to the barn in both farming types which gives the farmer the opportunity to reduce the dystocia problems by helping out or calling a veterinarian for help. Hence there should be no differences between the farming systems. This is also in accordance with Lindqvist (2002) who listed haemonchosis, diarrhoea, high lamb mortality and lean ewes as the most commonly registered health problems in Swedish organic sheep flocks, although the problems were not more extensive or different from conventional flocks.

3.1.1.1 *Conclusion*

The suckling period length and the use of maternal milk are the same in both farming type. There are very few published data on differences in organic versus conventional sheep production when it comes to use of maternal versus natural milk and neither of the publication saw any differences.

3.1.2 Space allowance

The differences between the regulatory when it comes to space allowance between organic and conventional sheep farming are the required indoor and outdoor area in organic farming. There is no specific demand for minimum indoor area per animal and there is no demand for access to an outdoor area in conventional farming. Hence it is likely to conclude that conventional sheep farming has smaller space allowance than organic farming.
Caroprese et al., (2009) looked at dairy ewes and space allowance. They concluded that ewes allowed access to the outdoor area had a higher protein content and lower somatic cell count in their milk, whereas reduced space allowance led to a reduction in milk yield and an increase in somatic cell count of milk. Their results indicate that both increased space allowance and availability of outdoor area can improve the welfare and production performance of the lactating ewe.

Since there is no demand for organic sheep to have access to outdoor area during the winter, both organic and conventional lamb and sheep are equally exposed to parasites during the outdoor period. The control of helminth diseases represents one of the major problems in sheep farming. In organic farming, the problem is further aggravated by a limit of only one conventional treatment per year and double withholding period, but preventive therapy is allowed with regards to parasite treatment. As one alternative to chemoprophylaxis, the application of an appropriate rational grazing management may contribute to an effective reduction in endoparasitic disease risk in sheep farming. Helminth infection is usually, but not always, more intense on organic farms than on comparable conventional farms and the diversity of infection (more species and in balanced proportions) was always higher in organic farms (Cabaret et al., 2002a; Cabaret et al., 2002b; Cabaret et al., 2009). It is possible to farm organic sheep efficiently, as shown from production figures (carcass quality seemed to be similar to that for conventional farms (Hansson et al., 2000) and economic returns

(Benoit and Laignel, 2002). Lindqvist (2002) studied the prevalence of nematode infections in organically raised sheep in Sweden. They also studied management practices to relate them to parasite infections. A high proportion of flocks were infected with nematodes. Clinical outbreaks in lambs were highly dependent on egg output from the ewes. Even though infections of ewes could be considered moderate, the authors point out the risk that the infections will cause the parasite population to build up, which would significantly affect lamb growth.

One indicator that there are differences in the farming types could be to look at carcass quality differences. By studying carcass quality, expressed as affection, pathological findings, slaughter-weight and evaluation, a picture of an animal's health and potential as high quality food is achieved. Hansson et al (2000) compared the carcass quality in Swedish certified organic meat production with that of conventional meat production slaughtered during 1997. The study involves 190,000 sheep reared conventionally and 4997 sheep reared according to organic standards. There were no differences in sheep, reared organically and conventionally.

3.1.2.1 *Conclusion*

The previewed literature did not address differences between health/diseases and access to indoor or outdoor area. The control of helminth diseases represents one of the major problems in sheep farming and implemented control regimen is a prerequisite to avoid problems in both farming types.

3.1.3 Solid lying floor

The use of solid floors is not common in conventional sheep farming. Norway is temporarily given exemption from the EU regulation which demands that at least half of the indoor surface area should be solid floor in organic sheep production. It is assumed that factors of the floor like thermal conductivity and softness will affect both animal preferences and also animal welfare. The thermal conductivity of the floor will influence the thermoregulatory behaviour of the animals, both under cold and warm climatic conditions. The cleanliness of the floor will probably also influence the preference for lying area. The absorption capacity of the flooring material will therefore be of some importance for the cleanliness of the lying area. Færevik et al. (2004) investigate sheep preferences for different types of pen flooring and concluded that sheared ewes preferred softer floors with low thermal conductivity (straw and wood). The unsheared ewes showed no clear flooring preferences. In a social group of animals, other factors than flooring material may influence the preference for lying area. In accordance with the findings of Marsden and Wood-Gush (1986), the ewes in the present study lay constantly next to a wall. Ewes lay in the middle of the lying area in pens with access to straw. Since Norway is given exemption from the EU regulation, there is probably no difference between the farming types. However, sheared ewes should have access to straw the first weeks after shearing may improve animal welfare.

3.1.4 Forage

The livestock shall be fed with organic feed, preferably produced at the farm or produced locally. At least 60 % of the feed for sheep shall come from the farm unit itself or in case this is not feasible, be produced in cooperation with other organic farms in the same region. There is no requirement for producing feed at own farm in conventional production. At least 60 % of the dry matter in the daily rations for sheep shall consist of roughage, fresh or dried fodder, or silage.

There are no specific requirements for the proportion of roughage for sheep in conventional production.

There are no previewed literatures exploring differences in organic versus conventional sheep production feeding/forage/roughage strategies and animal health which could be applied under Norwegian conditions. Organic livestock must be fed on organically produced feedstuffs and a smaller proportion of their daily ration could consist of concentrate. There is a low production of organic grain in Norway and organic farmers must import organic concentrate. Hence, one challenge could be to get enough organically produced feedstuffs at a reasonable cost. A self-sufficient rate of at least 50 % could lead to a deficiency of certain minerals if the concentration is low in the surrounding soil. Most common mineral which is in deficit under Norwegian conditions are Se, Cu, Co and Iodine. It is therefore very important to analyse the roughage and use minerals supplemented if needed. The same goes for conventional farms which are more or less self-sufficient in roughage in Norway.

3.1.4.1 *Conclusion*

The farmers usually lack information on the status of minerals and vitamins in his/hers soil and feedstuff. Fewer rations with concentrate and more local feedstuff could increase the risk of vitamin and mineral deficits. There is probably no difference, under Norwegian condition, between conventional and organic sheep farming when regards to vitamin and mineral deficits.

3.1.5 Medication

Under organic livestock management, preventative husbandry and management practices must be introduced to avoid and minimise pest and disease problems, and to minimise reliance on chemical treatments. Phytotherapeutic, homeopathic products and trace elements shall be used in preference to chemically-synthesized allopathic veterinary treatment or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended. This means that alternative medicine is preferred in organic farming given an effect of the medicine.

Mederos et al., (2012) conducted a review-meta-analysis of primary research investigating the effect of selected alternative treatments on gastrointestinal nematodes in sheep under field conditions. Their results indicated that from the studied alternative treatments, nutraceuticals and use of genetically resistant sheep might be more promising for control of gastrointestinal nematodes in sheep. There have been conducted three very small studies using homeopathic medicine in sheep farming (n=10 in each gruoup). Da Rocha et al (2006) and Chagas et al (2008) evaluated the efficacy of the homeopathic treatment, Fator Vermes, administered according to the manufacturer's recommendations, against gastrointestinal nematodes infections in sheep. Infective larvae of Haemonchus spp., Trichostrongylus spp., Cooperia spp., and Oesophagostomum spp. were identified in the fecal cultures. Both trials concluded that daily treatment with the Fator Vermes, did not benefits in either sheep health/productivity or in the prophylaxis of gastrointestinal nematode infections. Zacharias et al (2008) evaluated the effects of homeopathic treatment on control of Haemonchus contortus infection in sheep. A significant reduction in number of H.contortus larvae ($p<0.01$) was observed for animals in the homeopathic treatment group compared to the negative control group and daily weight gain in the homeopathic treatment group was superior to the control and to the antihelminthic groups, 31 and 6.5 %, respectively.

One in vitro trial has been conducted to evaluate the effect of two phytotherapeutic alternatives, plant extracts from Melia azedarach and Trichilia claussenii, for use to control gastrointestinal nematodes in small ruminants. T. claussenii showed greater anti-parasite potential in vitro than M. azedarach. However, studies on the isolated compounds, toxicity and administration forms to animals are also needed to validate low-cost alternative herbal remedies for use to control gastrointestinal nematodes by family farmers (Cala et al., 2012).

3.1.5.1 *Conclusion*

The use of phytotherapeutic, homeopathic products or trace elements treatments under Norwegian condition is probably low. When it comes to effect on parasites, the systematic review meta-analysis concluded that there is no evidence that alternative medicine is preferable.

3.2 Data gap and future research

Since organic and conventional sheep production is close to similar in Norway, there is no need to look at differences between these two farming types.

4 Animal health in organic and conventional goat production

4.1 Hazard identification and characterization

4.1.1 Milk feeding period for goat kids

The milk feeding period should be at least 45 days. The Norwegian goat production has recently been through a sanitation program for eradication of three main chronic infections, caprine arthritis encephalitis virus (CAEV), pseudotuberculosis and paratuberculosis. The main part of this program has been to remove the kid from the mother immediately after birth by snatching the kid directly from the birth canal and isolate them in an infectious free environment to avoid any possible infectious contact between mother, other adult goats, and kid. Thus, during this period there have been restrictions on feeding by goat colostrum and goat milk from these farms during this program. In the program the kids has been given cow colostrum and later on milk replacers. The important though is that under natural raising the milk for kid has to be restricted to be from their own mother only or from replacer to avoid spread of infectious diseases through the infected milk from other mothers. Feeding of goat milk from the bulk tank would be the worst case scenario. This was in fact the role before the sanitation program, and was in fact one of the main reason the spread of especially CAEV which spread from CAEV infected udders, and paratuberculosis which spread to the kid by indigestion of infected manure by suckling on contaminated teats. Except for the problems with spreading these diseases there is very little literature on the milk feeding period for goats.

4.1.1.1 *Conclusion*

After the sanitation program ("Friskere geiter – Healthy Goats") have ended, it is still important that kids get colostrum only from their own mother to avoid spreading any of these infectious diseases. Thereafter they might still get milk from their own mother, or milk replacer. In some countries they have developed routines for pasteurizing goat milk on the farm and give the kids, but this is so far not a practical choice in Norway. Artificial colostrum is also available in the market, but those products are used in a very small scale in Norway, though it is more frequently used in ex. in The Netherlands.

4.1.2 Suckling period

Serum immunoglobulin (Ig) levels were measured in 39 consecutively newborn goat kids on an intensively managed dairy goat farm in New England using a quantitative, spectrophotometric zinc sulfate turbidity assay (O'brien and Sherman, 1993). The health and performance of these kids was monitored through weaning at 6–7 weeks of age. By weaning time, 24 kids were healthy, four had required treatment, and 11 had died. The mean serum Ig concentration for all kids was 1170 mg/dl. Mean serum Ig level for healthy kids was 1439 mg/dl, for treated kids, 706 mg/dl, and for dead kids, 750 mg/dl. There was a statistically significant difference in mean serum Ig levels between the group that died and the group that remained healthy ($P<0.05$). No differences were observed in either death rates or mean serum Ig levels between male and female kids. Among kids that remained healthy through weaning, there was no identifiable correlation between initial serum Ig concentration and average daily weight gain. It was concluded that the failure of passive transfer (FPT) of maternal antibodies to kids via colostrum at birth, leads to increased morbidity and mortality from infectious disease in young goats. Results from this study suggest that in intensively managed dairy goat herds in New England (USA), failure of passive transfer in newborn kids can be defined by the presence of circulating serum Ig levels less than 1200 mg/dl.

4.1.2.1 *Conclusion*

Colostrum and the problem with 'Failure of Passive Transfer' (FPT) are as important for kids as for calves. Thus it is likewise important to secure that kids are getting enough colostrum also if they are suckling their mother. There is found no literature on the comparison between organic and conventional farming.

4.1.3 Access to pasture or free air

The goat production is mainly based on a long pasturing season also in conventional herds. However, organic goats should have access to outdoor area the whole year. There is not identified literature illustrating the effect of outdoor area the whole year for goats.

4.1.4 Roughage and feedstuff

There is not found any literature comparing organic and conventional production on the use of roughage for goat. However, there would be the same principles as for sheep and cattle. Large excess of fast fermented carbohydrates are a cause of diarrhea and Clostridium intoxication in small ruminants.

4.1.5 Fertilizers-mineral content in feed

There is not found any specific literature in goat production in relation to use of fertilizers comparing organic and conventional production. The same principles as for sheep and cattle have to be applied and assessed.

4.1.6 Medication and withdrawal time

There is very little relevant literature on use of medication comparing organic and conventional production from the Nordic countries.

Langoni et al., (2011) evaluated the efficacy of a homeopathic compound in the treatment and prevention of mastitis in goats, especially by analyzing its effect on somatic cell count and milk production before, during and after its administration. Forty dairy goats of "Pardo Alpina" breed were randomly divided in a double-blind experiment into two groups. The animals were weekly evaluated for somatic cell count (SCC) and milk production. Before the homeopathic treatment, the control group had 1.42 $x10^3$ cells/mL (log-transformed value) and 1.10 liters of daily mean production, compared to 1.31 $x10^3$ cells/mL and 0.9 liters of mean production by the experimental group. During the experiment, the control group had increased LogSCC values and decreased milk production (2.11 $x10^3$ cells/mL and 1.00 L, respectively); the same was noticed for the experimental group (1.97 $x10^3$ cells/mL and 0.80 L milk, respectively). Such facts suggest that there is interference of external factors on the increased milk cellularity in the different periods, not necessarily due to the homeopathic compound. In the present study, SCC and milk production were not affected by the homeopathic compound.

The most relevant differences between cattle and goat are the parasite problem at pasture. There is one paper from Brazil (Silva et al., 2011) were they analyzed the dynamics of gastrointestinal helminthiasis in Saanen goats maintained in organic and conventional milk production systems during pregnancy, parturition and lactation. In the conventional system, the animals were kept under continuous grazing and dewormed monthly. In the organic system, no anthelminthic were used, the animals were kept under rotational grazing and separated by age. The goats in the organic systemic had higher fecal egg counts ($p < 0.05$) than the goats in the conventional system during pregnancy and parturition, with no statistical difference ($p > 0.05$) during lactation. The peripartum period was a risk factor for the occurrence of clinical parasitism in animals with a greater predisposition in the herd, thereby increasing the infestation of pastures. In the conventional system, even with monthly deworming, the animals were moderately infected, thus demonstrating the possibility that helminthic resistance or high reinfection rates might develop. Although no anthelminthic were used in the animals raised in the organic system, they showed a moderate degree of infection, thus indicating that management might be present a viable option for sustained helminthic control. As parasitic medication is allowed in organic Norwegian goat production so this paper is not really relevant, but illustrate that parasite can be a problem in organic goat farming.

4.1.6.1 *Conclusion*

Use of medication has the same problems in goat at for sheep and cattle. Parasitic burden is however lower in goat industry. This means that good preventive management is more important in organic compared to conventional production.

4.1.7 Reproductive therapy

Medical intervention in reproduction is not very common in goats. Synchronization can be done and have been used to change the goat kidding period. Usually goats that do not get pregnant are usually slaughtered.

4.1.7.1 *Conclusion*

The comparison of organic and conventional production is not very relevant for reproductive therapy for goats.

4.2 Data gap and future research

There is very little if any relevant literature comparing Norwegian organic and conventional goat production. This means that there is in general a huge data gap in comparing organic and conventional goat production.

The differences would be on feeding practices and the percentage of concentrate in the feed as well as the mineral content in organic produced feed compared to conventional and the possible effect of this on goat health. Different grouping strategy and feeding of goat kids are also of interest not only in organic herds but also in conventional herds.

The parasite burden in goat production is rather high compared to other productions. So research on parasites and how to prevent infestation of parasites is being more important in the future.

5 Differences in animal welfare between organic and conventional sheep and goat production

There was only found one relevant international peer-reviewed publication comparing the welfare of small ruminants in organic versus conventional production (Napolitano et al. 2009). This study stated that no significant differences were observed between organic and conventional sheep farms in terms of resource-based parameters (Animal Needs Index scores), housing characteristics and animal-based parameters (integument alterations, animal dirtiness, hoof overgrowth, lameness and lesions). These results were not surprising, as most of the farms, both conventional and organic, based their farming systems on an extensive use of the land by grazing animals. Due to the low number of relevant articles, remaining literature searches were focusing on each of the hazards described below, irrespective of farming system.

5.1 Hazard identification and characterization

5.1.1 Indoor space for sheep and goats

Sheep and goats are commonly housed at 0.7-0.9 m^2 per head in conventional farms in Norway. This space allowance is very low compared to the conventional regulations and recommendations in other European countries. In Norwegian organic farming sheep and goat farms have to offer at least 1.5 m^2 indoor area per head.

The ability to display synchronized behaviour is important for gregarious animals, especially regarding foraging and resting. Behavioural studies have documented that reduction of the lying area from 1 m^2 to 0.5 m^2 per ewe reduces the total lying time and gives less synchronized lying behaviour (Bøe et al. 2006). Reduced lying space allowance also resulted in a large increase in the number of displacements, indicating increasing negative social interactions due to dominance with increasing density of animals. However, Dalholt (1985) found no difference in lying time or the number of lambs born when reducing the total area from 0.86 to 0.69 m^2 per ewe. Sevi et al. (1999) documented that dairy sheep kept at low densities (2 m^2 per head) had higher milk yield, higher content of milk protein and fat, and better udder health compared to sheep housed at higher densities (1,5 and 1 m^2 per head).

Loretz et al. (2004) documented that goats on deep litter flooring reduced their resting time with reduced area available (2 m^2; 1.5 m^2; 1 m^2 per head), whereas the activity level was unaffected. In a study on pregnant Norwegian dairy goats kept at 1, 2 or 3 m^2 per animal, Vas et al. (2013) found that higher frequency of agonistic behaviours was present even at 2.0 m^2 per animal, and they concluded that if this is regarded as a sign of social stress, recommendations regarding available space per goat should be adjusted. However, keeping goats even at 1 m^2 per animal did not have any impact on productivity or weight development, suggesting that goats easily habituate to sub-optimal environmental conditions. In a very similar Spanish study, (Averós et al. 2013), they observed less activity, as indicated by reduced movement and higher percentages of time at the feeder at 1 m^2 compared to 2 and 3 m^2 per ewe. Occurrences of both positive and negative interactions were higher at 1 m^2 per ewe, interpreted as higher chances for the goats to meet another individual at high density, rather than of increased social conflict.

Negative welfare impacts of minimum 1.5 m^2 indoor area per sheep or goat are not documented. Very low densities of animals in pens with expanded metal or slatted floors, might however result in dirtier animals, since a certain number of animals per square meter is needed to trample the manure and feed leftovers down through the floor.

5.1.1.1 *Conclusion*

Indoor space allowance of 1.5 m^2 per animals in organic sheep and goat production gives increased animal welfare compared to the most commonly used space allowance of 0.7-0.9 m^2 in conventional sheep and goat farming.

5.1.2 Outdoor space for sheep and goats

All Norwegian sheep and goats, both organic and conventional, graze outside during summer. It is only during the 6-8 month winter housing period that access to an outdoor area differs between the two management systems. Very few conventional sheep and goats have access to an outdoor area during winter. Access to an outdoor area may facilitate activity and behaviours that cannot be performed indoors. An interesting question as well, is how much of the time the animals prefer to spend outdoors?

Jørgensen and Bøe (2011) documented that fully fleeced ewes with access to an outdoor yard during winter time in Norway, spent 44 % of their total time per day and night outdoors when the yard was covered with a roof, whereas 36 % of the time was spent outdoors when the outdoor area was uncovered ($p<0.05$). Furthermore, they spent 45 % and 35 % ($p<0.01$) of their time in the outdoor yard when the feed was located outdoors and indoors, respectively. Weather factors did not affect the proportion of time sheep were observed in the outdoor yards. Synchrony of resting was higher in pens with roof-covered yards, whereas location of feed had no effect on this parameter. Great individual variation was observed; Six out of 20 ewes spent on average > 70 % of their total resting time indoors, while four ewes spent 50-55 % of their resting time in the outdoor yard regardless of weather, roof or feed location. Locating the feed outdoors increased the time spent in the yard standing and walking, but also the indoor resting time. This indicates that when all feeding activity is outdoors, the area indoors will emerge as a preferred and undisturbed resting area.

A behavioural investigation of dairy goats kept in slatted floor pens that were given access to an outdoor yard 8 hours a day showed that the goats spent nearly 50 % of the time outside. All the goats appeared to have a regular use of the enclosure and provision of branches were perceived as an attractive enrichment initially. Play behaviour was only observed in the outside enclosure, but also the number of aggressive interactions tended to increase outdoors

(Bøe et al. 2012). A follow-up study documented that an outdoor yard was less used when the air temperature dropped and when there was rain or snow, but the total lying time and time spent feeding were not affected. Irrespective of weather conditions, goats spent more time in outdoor yards covered with a roof than in open yards, but this effect was limited. Thus, a housing system with an inside resting area and an outside activity area provide adequate environmental protection for goats, even at low temperatures (Bøe and Ehrlenbruch 2013).

In general, a roof covering the outdoor yard may be beneficial in areas with large amounts of rain and snow in order to preserve surface properties and reduce runoff problems. Heavily trampled outdoor areas should be established on solid ground to prevent muddy areas and dirty animals. In organic livestock production it is a goal to use/recycle the manure as a fertilizer, thus the manure on outdoor areas should be collected (Grøva et al. 2007, Jørgensen and Bøe, 2011).

In an organic context, access to fresh air and daylight for sheep and goats corresponds more to the natural specie-specific way of living than indoor housing, and therefore regarded beneficial for sheep and goats. One may also assume that indoor winter housing of animals that use to spend the summer on pasture may have cognitive impacts to the animals, which are likely to affect their expectations. These hypothesis are however difficult to test and document scientifically. Environmental enrichment of the outside enclosure, preferably by some sort of roughage, may increase the attractiveness of the outdoor area, as shown by Jørgensen and Bøe (2011) and Bøe et al. (2012). In practice, access to an outdoor area is an easy and cheap way to increase the total space allowance for sheep and goats.

5.1.2.1 *Conclusion*

When given access to an outdoor yard sheep and goats will spend up to 50 % of their time outdoors. Playing behaviour in goats is only documented outdoors, not indoors. Thus, access to an outdoor area is positive for sheep and goat behaviour and welfare, presupposed that the outdoor area is managed according to best practice.

5.1.3 Space allowance for lambs and goat kids

The organic regulations require a space allowance of 0.35 m^2 per lamb and goat kid indoors and 0.5 m^2 per animal outdoors. This regulation is meant for indoor housing of young breeding animals and feedlot lambs after weaning. Housing of these groups of animals is however limited in number (approx. 25 % of female lambs and kids in the stock) and time (3 months). Lambs and kids are considered as “adults” at the turn of the year, and by 1st of January they should be housed according to space regulations for sheep and goats. Few studies relevant for Norwegian husbandry practices are conducted and most of the literature is old. No references regarding indoor housing of goat kids were found, nor publications documenting welfare effects of access to an outdoor area for lambs and kids.

Arehart et al. (1969) found no differences in growth rate between two month old feedlot lambs in pens varying between 0.37 m^2 and 0.93 m^2 area per head, whereas Gonyou et al. (1985) documented reduced growth of lambs in pens measuring 0.32 m^2 per lamb compared to 0.48 m^2 per lamb. Leme et al. (2013) found that the average weight gain tended to be higher for feedlot lambs in pens of two (2.4 m^2 per lamb) compared to lambs housed in pens of 10 (2.4 m^2 per lamb). They concluded that the number of animals per group influenced the behaviour of confined lambs, changing the pattern of food intake which could affect weight gain.

5.1.3.1 *Conclusion*

Due to little documentation in the literature, it is difficult to conclude whether the regulation of indoor and outdoor space allowance for lambs and goat kids in organic production is significant to animal welfare. It seems, however, that the organic regulation acclaiming a space allowance of 0.35 m^2 per lamb and kid indoors is a fairly high density compared to space allowances of young animals most often used in studies conducted abroad.

5.1.4 Solid lying floor

Expanded metal is the most commonly used flooring material in Norwegian sheep and goat farming. All organic goat farms have to offer at least 0.75 m^2 solid floor area per animal, or the animals must be housed in a deep litter system. The use of solid floors is not common in conventional goat farming. Norway is temporarily given exemption from the EU regulation which demands that at least half of the indoor surface area should be solid floor in organic sheep production. However, an evaluation of how solid floors affects sheep welfare is useful, since the exemption is only temporarily and documentations might be important in further communication within the issue. Total resting time and the extent of synchronized lying behaviour, as well as preference tests are indicators of the floor's lying comfort as perceived by the animal.

Research have documented that fully fleeced sheep show no clear flooring preferences (Bøe 1990, Færevik et al. 2005). Sheared ewes, however, prefer softer floors with low thermal conductivity (deep litter straw and wooden solid floors or wooden slatted floors). The reduction in lying time was less dramatic when ewes had access to straw, indicating that that access to straw the first weeks after shearing may improve animal welfare (Færevik et al. 2005). Hansen and Lind (2008) documented that fully fleeced 6 months old lambs preferred to lie on expanded metal floors (EMF) rather than on two-level wooden platforms. After shearing, no significant differences in preferred floor type were found. The authors did not recommend the two-level wooden platforms due to a low overall utilization of these. Jørgensen and Bøe (2009) found that significantly more sheep were observed resting in pens with front-and back (FB)-shaped resting platforms than in pens with U- or L-shaped platforms. An effective perimeter length with a minimum of 0.9 m per ewe was needed to enable all sheep to rest simultaneously on the resting platform. Increasing the slope of the resting platform had no effect on resting behaviour, but a slope of 5 % resulted in a significantly lower amount of manure and a lower moisture score. Thus, FB-shaped resting platforms of solid wood may be a relatively cheap and convenient way of increasing the resting time and comfort of sheep housed in fully slatted floor pens, presupposed there is enough effective perimeter length available.

Andersen and Bøe (2006) investigated the size of the solid lying area (0.5; 0.75; 1 m^2 per head) and one or two lying levels for goats. Total resting time and the degree of synchronized lying behaviour decreased with decreasing size of the lying area, irrespective of one or two lying levels. A two-floor lying area reduced the aggression level significantly because low-status goats chose the least attractive spots. Furthermore, the goats preferred to lie close to a wall, but in a distance to the next goat. The authors concluded that lying platforms in two levels for goats is a good system that also utilizes the pens' total area in three dimensions. Additional partition walls in the resting area are shown to meet the goats' preference for wall support when resting, without consequences for aggression or resting pattern (Ehrlenbruch et al. 2010). Bøe (2007) found that lactating goats preferred rubber matrass and solid wooden floors in cold temperatures (-12 ^oC). The goats responded to cold by increasing the time spent active and eating at the expense of lying time. In moderate thermal conditions (+ 10 ^{o}C), however, expanded metal flooring was the most and straw the least preferred flooring material. Solid floors should be cleaned every day, but a small floor gradient reduces the need for cleaning (Henriksen et al. 2007). Dirty udders and teats might represent a hygienic problem in dairy goat production.

5.1.4.1 *Conclusion*

Access to solid lying floors is increasingly important with decreasing temperatures. Access to straw bedding or a wooden lying floor the first weeks after shearing increases resting time, and thus may improve sheep welfare, but solid floors are not necessary for welfare reasons to fully fleeced sheep. A solid floor area of 0.75 m^2 per goat, preferably in two levels, is positive to animal welfare. However, flooring materials with low thermal conductivity, as wooden floors or straw bedding, is not necessary in insulated goat buildings. The floors should be cleaned regularly.

5.1.5 Suckling period

Organic lambs and goat kids should be fed milk, preferably maternal milk for minimum 45 days. Suckling is recommended, however not stated in the regulations. The milk must be based on purely natural ingredients, thus milk substitutes with non-approved additives as synthetic amino acids, fat extracted chemically and so on are not allowed. Organically approved dried milk powder for small ruminants is allowed.

Conventionally, as well as organically farmed lambs in Norway are usually raised together with their dam until slaughter at the age of 5-6 months. The organic regulations are therefore more than fulfilled, and in practice there is little difference between the two farming systems. Thus, this issue will not be discussed further on. When organic approved milk powder is impossible to obtain, bottle-reared lams must be kept separate and slaughtered as conventional lambs.

Most male kids are slaughtered/euthanised right after birth, both in conventional and organic dairy goat production. Organic female (breeding) kids might stay with their mothers the first weeks, or all the time until weaning at around 45 days of age. Dependent on the season of birth, suckling goats with their kids may graze at separate pastures and do not need milking. Alternatively, the kids might suckle their dams either during the day or during the night. In some organic farms management of the milk feeding period could be very similar to conventional practice, without breaking the regulations; Female kids are separated from their mothers after the first meals of colostrum and raised on organic approved milk powder in automatic teat feeders the next two months with increasing amounts of roughage and concentrate in the diet. The normal weaning age (from milk feeding) of kids in conventional farms is 6-8 weeks. In other organic dairy goat farms, kids are fed fresh goat milk the first two months in preference to milk powder, but this will be on the expense of the total milk yield produced at the farm. Both organic and conventional kids of meat and fur breeds are usually dam-reared.

Very little research on goat kid welfare during the milk feeding period has been conducted. Some parallels might however be drawn between results found in studies of lambs and calves:

Ewe-reared lambs have higher weight gain compared to early weaned lambs (Ekiz et al. 2012) and they have better social competence and show more investigative behaviour than bottle-fed lambs (Napolitano 2002, 2003). A gradual separation from the mothers from day 7-12 adversely affects behavioural, immune and endocrine responses of bottle-fed lambs compared to both dam-reared lambs and lambs that were abruptly removed from their dams 24-30 h post partum (Sevi et al. 2003). Provision of ewe milk or a mix of ewe milk and milk substitute during the first post-separation week can be a suitable strategy to sustain the welfare and production performance in artificially bottle-fed lambs (Sevi et al. 2001). Much of the same mechanisms are shown for calves regarding separation distress (Weary and Chua 2000; Flower and Weary 2001), social competence (Flower and Weary 2001) and higher weight gain when suckling their mothers or fed milk *ad libitum* compared to calves on restricted milk feeding (Flower and Weary 2001; Jasper and Weary 2002). Given a*d libitum* access to milk the calf will drink more than twice a "normal" restricted milk ration (10 % of body mass) (Broom 1998; Jasper and Weary 2002; Kahn et al. 2011). Intake of higher milk amounts are also associated with reduced incidence of disease, lower frequencies of stereotypies and abnormal behaviours, increased frequency of play behaviour, improved feed efficiency and better total animal welfare (Kahn et al. 2011). Krohn et al. (1999) and Wagenaar and Langhout (2007) have also shown that calves penned together with their mothers the first days started eating concentrates and roughage earlier and in greater amounts compared to calves separated at once, indicating that the interest for solid feed might be learned.

5.1.5.1 *Conclusion*

The significance of different milk feeding strategies in goat kids is poorly documented, but studies of lambs and calves show that suckling increases the growth rate, gives better social competence and more exploratory behaviour. The same might be assumed for goat kids. Thus, the organic recommendation of feeding lambs and kids maternal milk in preference to natural milk for a minimum of 45 days is likely to be positive to animal welfare.

5.2 Data gap and future research

In general, more research comparing the behaviour and welfare of small ruminants in organic versus conventional farming are needed. More specific, studies documenting synchronized lying behaviour and number of displacements of goats housed in group pens (not on deep litter flooring systems) with different animal densities should be conducted. The effect of indoor and outdoor space allowance to lamb and goat kid welfare needs documentation, and more knowledge regarding the effects of different milk feeding regimes and the length of the suckling period on the behaviour and welfare of goat kids are needed.

The assessment of positive and negative short-term affective states (emotions) in animals and their modulation by long-term affective states (mood) is an on-going challenge (Riefmann et al. 2012). Such assessments may be important for documenting possible effects of farming system on cognitive responses in livestock.

6 Animal health in organic and conventional pig production

In Norway in 2012 there were 12 herds with organic piglet production with a total of 269 breeding sows. There is very limited information on the health and welfare of sows in organic production systems. They have more behavioural freedom, but may be exposed to greater climatic challenges, parasite infestation and risk of body condition loss. There is also a lack of information regarding health and production problems of organic suckling piglets and fattening pigs (Edwards, 2011)

6.1 Hazard identification and characterization

6.1.1 Suckling period

The differences in weaning age between conversional and organic pig farming is 28 versus 40 days. According to InGris, Norwegian pig herds practice an age of weaning of less than 35 days (InGris, Annual report, 2012). Hence, the real difference in weaning age between organic and commercial pig production is five days in Norway.

Under natural conditions weaning is a gradual process and the average weaning time of piglets is more than 17 weeks (Jensen and Recèn, 1989). There are not many studies conducted that look at the differences in weaning age between 28 days and 40 days. Most research is conducted to look at health and welfare aspects in shortening the weaning period and some studies look at whether delayed weaning and outdoor rearing can compensate for the removal of antimicrobials from piglet (Miller et al., 2009). The latter research looked at the relationship between gut development (diarrhea) and weaning age where they conclude that management increased weaning age and different diets play important roles. Van der Maulen et al., (2010) found that piglets weaned at 7 instead of 4 weeks of age had significant lower stress at the time of weaning. The longer lactation length does, however, have a negative effect on overall productivity due to fewer weaned litters per year

Reproductive performance is often reported to be poorer in organic herds than in conventional herds, but it is often very difficult to conclude that this is related to health and not less professional management. To achieve a competitive reproductive performance in organic pig farming is a major challenge for this farming practice. Lindgren et al., (2013) looked at reproductive performance in sows in Sweden and concluded that it was lower in the organic herds and the variation in reproductive performance among the organic herds was larger than among the conventional ones. Leenhowers et al (2011) looked at sow and litter performance from over 2000 crossbred sows from 2006 to 2007 collected on 11 to 14 Dutch organic pig herds, respectively, and compared with conventional herds. Results showed that organic herds had lower farrowing rates (3.6 % to 7.5 %), more live born piglets per litter (0.4 % to 1.2 %) and higher preweaning mortality rates (7 % to 13 %) compared to conventional herds.

Piglet mortality is a major source of production loss and therefore economic loss to the pig industry. Preweaning piglets die from a variety of causes, mortality attributed to low viability, trauma, starvation and diarrhoea (Christensen and Svensmark, 1997) respectively. However, the most prevalent cause of death is crushing by the sow, accounting for between 19 % and 58

% of live born mortality (Christensen and Svensmark, 1997;Roehe et al., 2009). High piglet mortality has been observed in organic swine herds but exact figures were not published (Vaarst et al. 2000). Data from the Netherlands for the year 2001 showed a markedly higher mortality of piglets until weaning in organic (mean 21 %; range 14-39 %) than in conventional (mean 12.7 %) systems and piglet mortality after weaning was 4.9 % (range 0.6-11.2 %) on organic compared with 2.2 % on conventional farms (Kijlstra 2006). In conventional pig farms, crushing accounts for a high percentage of mortality (about one third) and is lower indoor than outdoor where it may account for more than 50 % of total deaths (Edwards et al., 1995). In outdoor conventional farms, crushing occurs mainly at farrowing and at night during the first 12 hours after farrowing, and involves changes of position of the sow (Vieuille et al., 2003). Similarly, in outdoor organic farms, the majority of piglet mortality occurs within 3 days of age (about 75 %) and is also related mainly to crushing by the mother (about 65 %) and to weakness/starvation of the piglets (about 25 %) (Feenstra, 1999). Kilbride et al., 2012 conducted a large cohort study in England where they concluded that in all four commercial production systems; outdoor, farrowing crates, crate/loose farrowing systems and indoor loose housed systems, there were similar levels of mortality. There could be that numerous factors associated with crushing are more related to management than farming type (Weary et al., 1996, 1998).

6.1.1.1 *Conclusion*

An increase in weaning length from 28 to 40 days is positive when it comes to welfare for the piglets in terms of reduced stress. To reduce post-weaning diarrhea problems, feeding strategies are the most important factor. Reproduction performance is probably poorer in organic versus conventional herds. If this is due to lower fat reserves due to longer lactations, longer weaning periods or access to outdoor where temperature and light may impact on the reproduction performance is not fully understood. However since most of the piglets in conventional farms in Norway are weaned at 35 days, these differences may be less important.

6.1.2 Space allowance sows and piglets in the lactation period

According to Commission Regulation No 889/2008, Annex III, organic reared farrowing sows should have an indoor area of minimum 7.5 m^2 and access to an outdoor area of minimum 2.5 m^2. According to Article 11 in the regulation for conventional Norwegian pig production, the minimum space requirements for farrowing sows are 6.0 m^2 and there is no demand for an outdoor area.

Norway prohibited confinement of sows in the lactation period. Hence the space allowance is quite similar in the two farming type and the literature could not reveal any differences when it comes to indoor space allowance. Outdoor space allowance for sows and piglets in the lactation period during winter in Norway is probably not conducted. Hence indoor space allowance is the factor which is studied here.

6.1.2.1 *Conclusion*

The difference in animal health between organic and conventional pig production seem to be minor when considering the indoor space allowance. It seems like there are both positive and negative aspects when it comes to floor space and that pigs manage to adapt to their environment.

6.1.3 Space allowance for dry sows

According to Commission Regulation No 889/2008, Annex III, dry sows should have a minimum indoor space allowance of 2.5 m2 per sow and the dry sows should in addition have access to an outdoor area of 1.9 m2 per sow. Whereas in conventional housing the minimum space allowance is 2.25 m2 per dry sow and there is no demand for outdoor access in conventional pig production. The difference in required indoor space between the farming types is small and there are no publications that could document differences in health related to the indoor space.

Hemsworth et al (2013) looked at the effects of group size and floor space on sow welfare using behavioural, physiological, health, and fitness variables. They concluded that, based on aggression and cortisol results, sow welfare improve with increased space. However, from a sow welfare perspective, the experiment had insufficient precision to determine what an adequate space allowance for sows is. This is also confirmed by Salak-Johnson et al (2009) who concluded that there were fewer lesions on sows in larger pens. Slak-Johnson et al (2012) conducted a small study were they had different floor space and they concluded that as floor space increased, walking and aggression also increased. On the basis of behavioural and physiological responses neither floor space nor stall environment provided adequate or quality of space to improve sow well-being. However, the differential behavioural and physiological mechanisms initiated by sows in response to their specific environment shows that sows were able to evoke the appropriate response(s) needed to adequately adapt to their environment.

The review by Schrøder-Petersen and Simonsen (2001), work by Randolph et al. (1981) and the large-scale survey by Moinard et al. (2003) concluded that tail-biting is associated with high stocking density. Tail-biting in the injury stage will reduce welfare of the bitten pig and the possible spread of infection is a health as well as welfare problem. Moinard et al. (2003) also found association between tail-biting and increased post-weaning mortality and respiratory diseases. However, Schmolke et al (2003) found no correlation between tail-biting and group size and Kritas and Morrison (2004) found no correlation between tail-biting and space allowance in commercial herds. Schmolke et al (2003) looked at different housing of growing-finishing pigs in groups of up to 80 pigs and concluded that group size was not detrimental to productivity and health if space allowance is adequate and feed resources are evenly distributed. Street and Gonyou (2008) found no effects of space allowance or group size ($P > 0.05$) on the proportion of animals receiving medication for a health problem or the proportion of animals that had to be removed from the trial due to illness or death. Similarly, there was no interaction effects ($P > 0.05$) of group size and space allowance for the proportion of animals receiving medication or for the number of animals removed from the trial.

The positive aspect of outdoor housing is an increase in physical condition and natural behaviour. Physical condition is important in strengthening the musculoskeletal structures and as a consequence of lack of exercise, leg weakness and lameness could occur. The negative aspects of outdoor space is a potential increase in exposure to various viral, bacterial and parasitic infections normally not present indoor due to high hygienic measures. Some of these agents may only influence the animals' own health and welfare whereas other ones may pose a food safety (Campylobacter, Salmonella) problem to the consumer. Another negative aspect with access to outdoor living could be an increase in aggression lameness and fight injuries such as tail biting.

Lameness in sows is an animal welfare problem which also presents an economic challenge to pig producers. Information about the prevalence of herd lameness in organic sows is relatively scarce. Knage-Rasmussen et al (2014) has conducted a large study where they examined differences in the prevalence of sow lameness between outdoor organic and indoor conventional herds. They concluded that an organic sow had a decreased risk of lameness (OR=0.28, P<0.001) as compared with a conventional sow. Vaarst et al (2000) noted that physical injuries causing lameness, skin trauma and sunburn were prominent findings in sows in four organic herds studied in Denmark. Large scale comparison of sows kept in indoor and outdoor systems has been conducted for conventional herds in the UK, where ~40 % of conventional herds are kept in outdoor systems. Whilst these herds do not have many of the constraints on both indoor and outdoor systems imposed by organic standards (organic feeds, space and bedding, weaning age etc), it is of interest to note the contrasts (BPEX, 2008) These data indicate that outdoor management may result in slightly better health, as reflected by mortality and replacement rates, but poorer reproductive performance, as reflected by litters/sow/year and litter size, but not conception rate.

Exposure to outdoor conditions will also give sows access to natural light, whereas many conventional sows will be kept in conditions of artificial light and controlled fixed photoperiod. The importance of natural light (in terms of intensity and spectrum) for sow health has not been determined. Sows do show some response to photoperiod, having evolved as seasonal breeders, and it is possible that poorer fertility sometimes reported in organic sows may be partly influenced by seasonal endocrine changed induced by changes in photoperiod (Love et al., 1993).

A key aspect of health management is the practice of good biosecurity. Because organic units are generally more extensive and have outdoor access, it is more difficult to control pathogens from wildlife and visitors. The prevalence of infectious disease may be determined by the presence of clinical signs, or from serology. No published data on clinical disease prevalence between organic and conventional pig production have been found. 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 of 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 2006). In a comparative study conducted in the Netherlands, the prevalence of coccidiosis and Ascaris suum in pigs was higher on organic than non-organic farms, but there was no difference in the prevalence of Oesophagostomum spp. and Trichuris suis among farm types (Eijck et al. 2005). 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 found 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 and none of the pigs showed clinical signs of scabies or lice. Results may reflect that a majority of herds had had outdoor pigs for only a few years. Carstensen et al. (2002) found organic pigs had higher infection rates with helminth parasites compared to sows and pigs housed indoor in intensive systems (comparisons were made with a study by Roepstorff et al., 1998). However, the prevalences were generally lower than those found in Danish organic farms surveyed in 1990 and 1991 (Roepstorff et al., 1992).

6.1.3.1 *Conclusion*

The indoor space allowance is important when it comes to animal health and welfare. However, in Norway, the requirement of indoor space is quite similar between the farming types and larger than space allowance used in reviewed literature. Hence, there is probably little difference in health status when it comes to dry sow's kept indoor. It seems like there are both positive and negative aspects when it comes to floor space and that pigs manage to adapt to their space allowance. However, access to outdoor areas will increase the space allowance for dry sows in organic production which might improve the welfare for the sows but could potentially lead to a heavy parasite burden. The risk of lameness is probably lower in organic farms.

6.1.4 Space allowance for fattening pigs

According to Commission Regulation No 889/2008, Annex III, the minimum indoor space allowance for fattening pigs in organic production should be 0.80 m2 per animal for pigs < 50 kg and the fattening pigs should have access to an outdoor area. In conventional pig production the minimum space allowance is lower, and there is no demand for an outdoor area.

Caracass quality is one indirect way of measuring animal health status in organic versus conventional pig farms. Hansson et al. (2000) compared organic and conventional carcass quality by analyzing all Swedish slaughterhouse statistics from 1997. Meat inspectors from the Swedish National Food Administration register pathological and other findings at a postmortem inspection of all slaughtered animals. The study involved about 3.9 million conventionally reared pigs and 3484 organically reared pigs. There was a significant difference at the postmortem inspection of growing-fattening pigs; 28 % of the conventional and 17 % of the organic pigs had one or more registered lesions. Ascariasis in the liver was the most common pathological finding in the organic pigs (4.1 %).

6.1.4.1 *Conclusion*

Indoor space allowance does not seem to influence on animal health. Hence, the difference in animal welfare between organic and conventional pig production seem to be minor when considering the indoor space allowance. However, access to outdoor areas will increase the space allowance for dry sows in organic production which might improve the welfare for the sows but could potentially lead to a heavy parasite burden. The risk of lameness is probably lower in organic farms.

6.1.5 Feeding

The feeding in organic pig production differs in two ways from the conventional production: The mandatory use of/access to roughage and the ban on use of synthetic amino acids. For animals housed outdoor in paddocks with grass cover, grass may of course constitute the roughage component. However, growing pigs reared indoor with access to an outdoor run with no possibility to graze, needs to be provided with for instance silage or hay.

6.1.6 Roughage

The major difference between organic and conventional pig production concerning roughage seems to be that the regulation for organic production demand that the pigs must be supplied with feedstuffs that they can and will eat, whereas in conventional production the rationale is to provide material that the pigs can explore. The differences between the farming types will therefore depend on what rationale the conventional pig producers use. There could be no differences if they provide the same material or there could be larger differences if the conventional provided material is not eatable but just used to enrich the environment.

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. On the other side, data obtained at slaughter from Austria indicate that pulmonary health in organic pigs was better than that observed in regular pigs (Baumgartner et al 2003). Both Schneweis et al (2005) and Bernhoft et al., (2012) concluded that wheat from an organic farming does not have higher mycotoxin-contamination than wheat from the conventional farming system.

Gastric ulcers in fattening pigs from intensive pork production can cause sudden deaths on farm and many researches have been conducted to address this problem. Gastric ulcer is a complex problem where many risk factors, both infectious and feeding related, have been identified. To make the phenomenon even more complex, Swaby and Gregory (2012) revealed that there was a significantly higher frequency of oesophago-gastric lesions in the groups of pigs that were held at the abattoir overnight, compared with those slaughtered on the day of arrival. A research conducted in Norway revealed that 29 % of the pigs at slaughter had severe gastric ulcers (Skadsem et al., 2011). The results did not include risk factors and the pigs were slaughtered in different regions, in different slaughterhouses where different inspectors scored the gastric mucosa use. Ljøkjel and Ekker (2013) conducted a pilot study on a research farm in Norway were they looked at different risk factors related to gastric ulcers. They concluded that hay may have a positive effect, although not significant, and that use of straw had no effect. Martino et al. (2013) concluded that the presence of straw acted as a protective factor for gastric ulcers and they suggest that the absence of rooting material may have a stronger effect on welfare. Amory et al (2006) concluded that housing environment was important and that pigs on slatted floors had a significantly higher mean ulcer severity score ($P<0.001$) than pigs housed on solid concrete floors, which had a significantly higher score ($P<0.01$) than pigs housed on straw bedding.

6.1.6.1 *Conclusion*

It is difficult to conclude if the use of roughage can have a negative impact on the pulmonary health of pigs. The literature shows discrepancy. When it comes to roughage and gastric ulcers there are literature that shows reduce risk of gastric ulcers when pigs are given roughages. But the risk factors for developing gastric ulcers in pigs are many and there are no data on the prevalence of gastric ulcers in organic versus conventional farmed pigs.

6.1.7 Ban on use of synthetic amino acids

The amino acid supply of the growers is known to have effects on growth, feed conversion and lean meat percentage. Nevertheless sub-optimal levels may be considered in organic production due to disproportionate costs in trying to fulfil these levels. It is important for organic pig producers to find an optimal protein source which do not have a negative effect on carcass and meat quality. Sundrum et al (2000) conducted an experiment to evaluate the effects of a restriction to home-grown feedstuffs and abstinence from supplementation with synthetic amino acids as ideal objectives in organic pig production. Their data showed that the feeding the organic diets without synthetic amino acids supplementation caused a marked decrease in feed consumption and weight gain during the growing period a reduction in pig performance but in an increase in intramuscular fat content.

6.1.8 Other feeding related challenges

Heavy metals are ubiquitous in soil, water, and air. The general population is exposed to lead from air and food in roughly equal proportions. During the last century, lead emissions to ambient air have caused considerable pollution, mainly due to lead emissions from petrol. Cadmium (Cd) compounds are currently mainly used in re-chargeable nickel-cadmium batteries. Cd emissions have increased dramatically during the 20th century, one reason being that cadmium-containing products are rarely re-cycled, but often dumped together with household waste. High concentration of Cd can cause damages to the kidneys and there is a significant negative linear relationship between Cd concentration in kidney and kidney weight (Lindèn et al 2001). Organic pigs, with access to outdoor, have higher Cd levels in manure than conventional pigs, indicating a higher Cd exposure from the environment, such as ingestion of soil. Differences in feed compositions and bioavailability of Cd from the feed components may also explain the different kidney levels of Cd (Lindèn et al 2001). There were no literature found that found that outdoor reared pigs had an increase in kidney related problems or any signs of lead poisoning.

6.1.8.1 *Conclusion*

The ban on use of synthetic amino acids could lead to reduced weight gain and caution should be made when replacing the synthetic amino acids. Organic pigs, with access to outdoor, have a higher Cd levels in manure than conventional pigs, indicating a higher Cd exposure from the environment, such as ingestion of soil, but there were no literature found that found that outdoor reared pigs had an increase in kidney related problems.

6.1.9 Medication

Under organic livestock management, preventative husbandry and management practices must be introduced to avoid and minimise pest and disease problems, and to minimise reliance on chemical treatments. Phytotherapeutic, homeopathic products and trace elements shall be used in preference to chemically-synthesized allopathic veterinary treatment or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended. This means that alternative medicine is preferred in organic farming given an effect of the medicine.

Proliferative enteropathy is a group of disease conditions in pigs where the disease may vary from subclinical to critical with bloody loose feces. The etiological agent is the obligate intracellular bacteria *Lawsonia intracellularis*. In Norway, proliferative enteropathy is a problem in some pig production farms, and *Lawsonia intracellularis* was isolated in 31 % of the pigs in one study (Åkerstedt et al., 2013). There is one study (Papatsiros et al., 2009) which shows that administration of Virbamix PE (plant extracts of Origanum vulgaris and Allium sativum, added to the feed at one single dose) reduced the prevalence of Lawsonia intracellularis in the intestine at the end of the treatment period, as compared to a negative control group. The diarrhoea score was also significantly higher in the control group in comparison with the treatment group. However, no significant differences were noticed between the treatment group and the negative control group during the treatment of proliferative enteropathy). Conclusively, the results of present study indicate that the use of Virbamix PE could be an alternative and economic method for the control of proliferative enteropathy.

A randomised placebo-controlled trial to prevent Escherichia coli diarrhoea in neonatal piglets was performed (Camerlink et al 2010). They concluded that piglets of the homeopathic treated group had significantly less E. coli diarrhoea than piglets in the placebo group (P<.0001). Especially piglets from first parity sows gave a good response to treatment with Coli 30K. The diarrhoea seemed to be less severe in the homeopathically treated litters, there was less transmission and duration appeared shorter. Soto et al (2008) found no differences between placebo and homeopathic treatment but they found a significant decrease in diarrhoea in weaned piglets in commercial swine production compare to control group. The treatments groups in both these trials are very small and conducted in only one herd.

6.1.9.1 *Conclusion*

There are some trials that have looked at the effect of homeopathic medicine on diarrhoea. Although the results are positive, the trials are unfortunately too small to draw any conclusions and more research is warrant in this field.

6.2 Data gap and future research

The conditions in organic livestock production lead to novel challenges concerning social interactions, physical requirements, climatic conditions and infectious burden which require certain breeds of animals that differ considerably from the conventionally held animals. A significant risk to animal health arises if animals are not genetically suited to the production systems in which they are placed. Pig breeds in conventional systems have been selected for high prolificacy and leanness, which has often been associated with reduced appetite. These characteristics might make them unsuitable for organic systems. More research is needed to identify these breeds whereby breeding selection criteria specific to organic conditions and principles should be used

Organic livestock production leads to an increase or re-emergence of certain zoonotic diseases (salmonellosis, campylobacteriosis, toxoplasmosis). Research into the prevalence of certain zoonotic infections, risk factors, farm management, post slaughter decontamination and consumer perception/education is needed.

7 Differences in animal welfare between organic and conventional pig production

In Norway in 2012 there were 12 herds with organic piglet production with a total of 269 breeding sows. Some of these pig herds are collaborating and market their pig meat under the brand "Grøstad gris". These herds also have made their own regulations, stricter than the requirements for organic farming, and all pigs are kept in outdoor production systems with quite large enclosures.

7.1.1 Duration of the suckling period

According to Commission Regulation No 889/2008, Article 20, all young animals should be fed on maternal milk in preference to natural milk, for a minimum of 40 days for piglets, which imply that minimum age at weaning is 40 days. For conventional pig production (Regulation for keeping of pigs) the minimum age of weaning is set to 28 days, but very few Norwegian pig herds practice an age of weaning of less than 35 days (InGris, Årsstatistikk, 2012). Even though we have no data on weaning age in Norwegian organic pig production, information from advisers indicates that weaning at 40 days is common practice. Hence, the real difference in weaning age between organic and commercial pig production is only five days.

Under natural conditions weaning is a gradual process and the average time of piglets is more than 17 weeks (Jensen and Recén, 1989). When introducing a system where the sows can decide how much time she will spend with her piglets, more than half of the sows weaned their piglets before 10 weeks of age (Bøe, 1991). In modern pig industry, weaning occurs abruptly by separating the piglets from the sow, and consequently a change in diet and often also a change in physical (moving to new pen) and social (mixing with unfamiliar piglets) environments. In order to improve productivity in the swine industry, the lactation period has been considerably reduced, and weaning at 3 – 4 weeks post partum is considered most profitable (Te Brake, 1978). Weaning at four weeks of age is common both in Great Britain and Denmark whereas weaning down to two weeks of age is common in commercial herds in USA.

Considering the fact that many sows will wean their piglets quite early (Bøe, 1991; Bøe, 1993a) suggests that early weaning is not a heavy strain for the sows. On the contrary, a long lactation period can give a large weight loss for the sows which will entail a decrease in subsequent reproduction performance (Taker and Bilkei, 2005). A prolonged lactation period, especially combined with high litter sizes, will then increase the weight loss of the sows (e.g. Lewis and Bunter, 2011). However, Andersen et al. (2000) did not find any difference in sow weight loss in organic production between a weaning age of five or seven weeks. For the piglets however, early weaning will absolutely influence their behaviour and welfare.

Generally, abrupt weaning as early as four weeks of age is a considerable stressor for piglets, often resulting in growth depression. Some studies comparing weaning at two and four weeks of age, which both must be regarded as early weaning, have been reported (Metz and Gonyou, 1990; Worobec et al., 1999; Colson et al., 2006). All of these studies show, among others, that especially piglets weaned as early as two weeks develop belly-nosing behaviour. More relevant when comparing Norwegian commercial and organic pig production is however experiments including weaning at five to six weeks of age. Fraser (1978) observed the behavioural develpoment in piglets during the first six weeks after birth. Belly-nosing was virtually never seen before weaning, but was common after weaning in piglets weaned at three weeks of age. Bøe (1993b) found that piglets weaned at four weeks of age had a significantly higher frequency of massaging and sucking pen mates than piglets weaned at six weeks of age, whereas Devillers and Farmer (2009) found that piglets weaned at three weeks showed more aggression and exploration than piglets weaned at six weeks. Mason et al (2003) found that piglets weaned at day 21 had more high vocalization and higher salivary cortisol at weaning. Interestingly, also van der Meulen et al. (2010) showed that plasma cortisol response at the day of weaning was lower in piglets weaned at seven weeks compared with piglets weaned at four weeks. When comparing weaning at five or seven weeks in organic production (Andersen et al., 2000), the only difference was in piglet behaviour was that piglets weaned at five weeks appeared to be more fearfull towards humans.

The intake of creep feed for piglets in the lactation period is modest before 20 days of age (Bøe, 1991; Pajor et al., 1991), and then start to increase. Bøe (1991) indicate that piglets at six weeks of age consume almost 250 g of concentrates per day. This explains the growth depression seen in early weaned piglets.

7.1.1.1 *Conclusion*

Considering the small difference in weaning age between organic (40 days) and commercial (35 days) pig production, the difference in animal welfare seems to be negligible.

7.1.2 Space allowance sows and piglets in the lactation period

According to Commission Regulation No 889/2008, Annex III, farrowing sows should have an indoor area of minimum 7.5 m^2 and access to an outdoor area of minimum 2.5 m^2. However, according to Article 11 in the regulation for conventional Norwegian pig production (Regulation for keeping of pigs, 2004), the minimum space requirements for farrowing sows is 6.0 m^2, but most farmers have installed farrowing pens that provide at least 7.0 m^2 per sow. There is no demand for an outdoor area, and in conventional production very few farmers provide access to an outdoor area.

In most countries with intensive pig production, the sows are kept in small pens with crates for the whole lactation period. Only Sweden, Switzerland and Norway have regulations that prohibit confinement of sows in the lactation period. However, in some countries like England and France, outdoor production in the lactation period is common, and the preweaning mortality seem to be at the same level as for indoor piglet production (KilBride et al., 2012). Even in Norway some organic producers have outdoor farrowing systems inspite of the long winter period with snow and low temperatures. Still, the focus in comparing commercial and organic pig production here is put on the space allowance in farrowing pens for loose housed sows.

The size and especially the width of the pen affect the locomotion and turning around in sows (Bøe et al., 2011) and Cronin et al. (1998) showed that the size and the width of the farrowing "nest" in a loose farrowing pen system affected the sow and piglets behaviours that may be relevant to piglet survival. In a survey in Swiss pig herds (Weber et al., 2009), the mean size of the farrowing pens for loose housed sows were 7.0 m^2 (range 5.1 m^2 - 8.6 m^2), whereas in a survey in Norwegian pig herds, the mean size of the farrowing pen was 6.4 m^2 (Andersen et al., 2007). When developing new farrowing pens for loose housed sows, the size of the pen usually exceeds 7.0 m^2 (Cronin et al., 1998, Andersen et al., 2014). Still, there seem to be no direct effect of farrowing pen size on piglet survival (Andersen et al., 2007; Weber et al., 2009). Another reason for increasing the space and lay-out of the farrowing pen can be the effect on cleanliness and hygiene (Weber and Schick, 1996).

7.1.2.1 *Conclusion*

The small difference in indoor space allowance in farrowing pens for loose housed sows between organic and commercial piglet production suggests that the actual difference in animal welfare is negligible.

7.1.3 Space allowance for dry sows

According to Commission Regulation No 889/2008, Annex III, dry sows should have a minimum indoor space allowance of 2.5 m^2 per sow, whereas in conventional housing the minimum space allowance is 2.25 m^2 per dry sow. Hence, the difference in indoor space allowance is almost negligible. However, in organic pig production the dry sows should in addition have access to an outdoor area of 1.9 m^2 per sow, whereas there is no demand for outdoor access in conventional pig production.

The rationale for demanding access to outdoor areas seems to be the behavioural needs of the animals. In the outdoor area the animals will be exposed to "fresh air", sunshine and rain and probably a more enriched environment. The "fresh air" argument actually imply that the air quality in the building is poor, but the air quality both in insulated, warm buildings with mechanical ventilation and especially in more open, uninsulated, cold buildings is mainly good. A more simplistic way is just look at the outdoor area as a part of the total available area. The minimum requirement in organic production is that the outdoor area for the sow should be 1.9 m^2 per sow, and the ground is usually made of concrete, so the possibilities for rooting are very limited.

Weng et al., (1998) reported an experiment where the space allowance was from 2.0 m^2 to 4.0 m^2 per dry sow. The total frequency of social interactions and aggressive behaviour and body lesion score both increased with decreasing space allowance. In a study with dry sows in a dynamic group, Remience et al. (2008) found that the mean number of one-way aggressions and the mean number of injuries was significantly lower when dry sows had a space allowance of 3 m^2 per animal compared to 2.25 m^2 per animal. Barnett et al. (1992) working with gilts, found that the plasma cortisol level was higher at mixing at a space allowance of 0.98 m^2 than 1.97 m^2 per gilt. Corresponding results were found by Hemsworth et al. (1986). Salak-Johnson et al. (2007) reported that skin lesions were higher when space allowance was 1.4 m^2 per sow, but there was no difference between 2.3 m^2 per sow and 3.3 m^2 per sow.

7.1.3.1 *Conclusion*

The indoor space allowance is quite similar in organic and conventional housing systems for dry sows. However, access to outdoor areas will increase the space allowance for dry sows in organic production which might improve the welfare for the sows. Environmental enrichment and the provision of roughage can however be more important for the welfare of the sows than the space allowance per se (see section 5 on roughage).

7.1.4 Space allowance for fattening pigs

According to Commission Regulation No 889/2008, Annex III, the minimum indoor space allowance for fattening pigs in organic production should be 0.80 m^2 per animal for pigs < 50 kg (Table 7) and in addition the fattening pigs should have access to an outdoor area. In conventional pig production the minimum space allowance is lower, and there is no demand for an outdoor area.

Table 7. Minimum space allowance for fattening pigs in organic and conventional production.

	Organic production, indoor area (m^2/animal)	Organic production, outdoor area (m^2/animal)	Conventional production (m^2/animal)
< 50 kg	0.80	0.60	0.50
< 85 kg	1.10	0.80	0.65
< 110 kg	1.30	1.00	1.00

Conventional pig herds in Norway mainly use the minimum space allowance for growing-finishing pigs.

The space allowance can be expressed on an allometric basis by means of a k-value, which among others allows a homogenization and thus a way of comparing results within the existing scientific literature (Gonyou et al., 2006). Space allowance can then be expressed as $S = kW^{0.667}$, where W is the body weight in kg (Petherick, 1983).

Averos et al. (2009) using a meta-analysis, found using broken-line regression a k-value threshold of 0.039 for lying behaviour/lying time. This corresponds to a space allowance of 0.53 m^2 at 50 kg body weight, 0.76 m^2 at 85 kg body weight and 0.90 m^2 at 110 kg body weight, which in fact is a more than the required space allowance at 85 kg body weight and less than required for 110 kg body weight.

In an experiment with growing-finishing pigs, the pigs were allocated to space allowances of 1.52 m^2/pig (high), 1.01 m^2/pig (medium) and 0.51 m^2/pig (low) (Meuner-Salaün et al. 1987). Daily gain was significantly lower at low space allowance than at medium and high. Gonyou et al. (2006) using broken-line analysis found that the critical k-value, below which daily gain was decreased as space allowance was further restricted varied from 0.0317 – 0.0348. This corresponds to a space allowance of 0.61 m^2 to 0.67 m^2 for a pig at 85 kg.

Jensen et al. (2010) found that growing-finishing pigs maintained at 1.0 m^2 per animal manipulated the rooting material more than pigs maintained at 0.64 m^2 per animal, but for behaviours like manipulating pen components and pen mates, the space allowance had no effect. Further, Schmolke et al (2003) found no correlation between tailbiting and group size and Kritas and Morrison (2004) found no correlation between tailbiting and space allowance in commercial herds.

Access to an outdoor area will not only provide more space but might also a more enriched environment. Olsen et al. (2001) studied growing pigs kept in pens with outdoor runs and found that the pigs spent around 15 % of the time in the outdoor run depending on the weather conditions. In the same experiment, Olsen (2001) showed that even if the pigs had access to ample straw, space and activity areas, access to a combination of shelter and roughage reduced penmate-directed oral activities. Generally, providing an enriched environment, often by supplying straw, undesirable oral activities can be reduced (e.g. van Putten, 1980). Studnitz et al. (2007) conclude in their review that exploratory behaviour in pigs is best stimulated by materials that are complex, changeable, destructible, manipulable and contain sparsely distributed edible parts.

7.1.4.1 *Conclusion*

Space allowance per se do not seem to influence either average daily gain or lying behaviour or tail biting. Hence, the difference in animal welfare between organic and conventional pig production seem to be minor when considering the indoor space allowance. However, environmental enrichment is of significant importance (see next section on roughage).

7.1.5 Roughage to pigs

According to Commission Regulation No 889/2008, Article 20, roughage, fresh or dried fodder, or silage should be added to the daily ration for pigs and poultry. For conventional pig production, the regulations state that pig should have continuous access to an ample amount of materials which they can explore and be occupied. Materials like straw, hay, sawdust, peat and earth can be used. The major difference between organic and conventional pig production concerning roughage seems to be that the regulation for organic production demand that the pigs must be supplied with feedstuffs that they can and will eat, whereas in commercial production the rationale is to provide material that the pigs can explore. According to the Swedish standards (KRAV, 2007) high quality hay or silage should be included in the diet in organic pig production.

The wild boar, Sus scrofa, are predominantly herbivorous animals. Studies of pigs kept in semi-natural environments showed that they spent 20 % of the daylight period rooting and 30 % grazing (Stolba and Wood-Gush, 1989). In commercial pig production however, all pigs are usually fed concentrates only. Lactating sows and growing-finishing pigs mainly have free access to food (ad lib) whereas the dry sows are fed restricted amounts, often 2.2 – 2.4 kg per day. Several studies have shown that limiting the amount of feed to dry sows involve a significant increase in mouth based stereotypies (Appleby et al., 1987; Terlouw et al., 1991). Spoolder et al. (1995) noted that provision of straw reduced excessive chain and bar manipulation in sows fed restricted amounts of concentrates.

Van Wieren (2000) noted that pigs in general were reluctant to fibrous food, even to that extent that for some animals it was necessary to mix the roughage with a high quality pig diet. A Norwegian experiment with roughage to dry sows (Bøe and Jenssen, 2000) showed that there was a high individual variation in the intake of roughage, from 0.16 to 1.31 kg DM per day. Provision of roughage increased the sows' activity. Also Olsen (2001) found reduced penmate-directed oral activities when providing roughage to growing pigs and thus an indication of improved animal welfare. Further, Høøk Presto et al. (2009) showed that provision of roughage to growing-finishing pigs increased the general activity and reduced aggressive behaviour. Environmental enrichment is considered to be important for the welfare of the animals and the feeding methods is absolutely one of the relevant factors (Newberry, 1995).

7.1.5.1 *Conclusion*

Provision of roughage is definitely beneficial for the welfare of pigs. The difference in animal welfare between organic and conventional production will depend on the amount of straw and/or roughage that are used in conventional pig production.

8 Animal health and welfare in organic and conventional poultry production

The Norwegian production systems for conventional and organic egg and broiler production and the number of produced animals in Norway (n) in 2013 are presented in Table 8:

Table 8. The Norwegian production systems for conventional and organic egg and broiler production and the number of produced animals in Norway (n) in 2013.

	Production system	Conventional (n)	Organic (n)
Egg production	Furnished cages	1 342 267*	
	Free range indoor	1 913 073*	
	Free range indoor/outdoor		151 095**
Broiler production	Free range indoor	63 806 788*	
	Free range indoor/outdoor		28 299**
Turkey production	Free range indoor	1 349 409*	
	Free range indoor/outdoor		**11500****

*Source: Animalia - Kjøttets tilstand 2013 (http://animalia.no/Kjottets-tilstand/Kjottets-tilstand-2013/)

**Source: Debio – Statistikk 2012 (http://www.debio.no/_upl/statistikkhefte1.pdf)

For laying hens, it has to be emphasized that the term “conventional production systems” includes of a wide variety of housing systems including cage systems (i.e. furnished cages of different designs and group sizes), and non-cage systems (i.e. various designs of deep litter systems and aviaries or free-range systems indoor). There are probably several non-organic units that practice both free range and use of outdoor range, but in a strict commercial context only organic farms use an outdoor range for their poultry. Moreover, these systems differ e.g. in designs, available space, flock sizes and stocking densities. Effects of these conventional systems on health and welfare are reviewed extensively (Lay et al., 2011). Norwegian standards related to stocking density in conventional poultry production differ from European standards in furnished cages and for broiler chicken. Since it would be very difficult and not relevant to compare the animal health and welfare of layers in furnished cages with layers in organic systems, it is in this report chosen to compare the animal health and welfare in conventional free range systems to organic systems. Welfare aspects of various systems to keep laying hens were extensively reviewed by EFSA (2005).

Freedom of movement is an important part of organic animal husbandry and the laying hens in organic poultry production are kept loose housed on litter and often also slatted floor or tiers. In practice, the housing systems applied for larger organic flocks (>1000 birds) of laying hens do not differ much from that used for conventionally kept loose-housed hens, except for the lower stocking density (6 hens/m^2 vs 9 hens/m^2 in conventional production). The main difference is that the organic hens are given access to an outdoor area during the warm season, and when the hens use the outdoor runs the stocking density is even lower and the hens have possibility to display motivated behaviours such as foraging and exploration. This outdoor area should be mainly covered with grass or other types of vegetation. Natural shelters like trees and bushes are also necessary if the animals are to use these areas. Access to outdoor areas does also apply to broiler chicken, and when they use the outdoor runs the stocking density is lower.

Other relevant characteristics of organic production systems for broiler chicken that differ from conventional production systems is the use of slow growing hybrids and a longer growth period.

8.1 Hazard identification and characterization

8.1.1 Space allowance for broilers

According to national legislation the normal density for conventional broilers is 25 kg/m^2. Broiler farmers that are members of an animal welfare program (Bagley, 2013) may be allowed to produce with densities of 36 kg/m^2. The animal welfare program will at least contain the following elements:

1. A veterinary surveillance agreement
2. A system for quality assurance and that deviations from the standard are closed within a reasonable time period
3. A foot health surveillance program

The incidence of foot pad lesions, measured by a food pad score between 0 and 2 is the main part of the program. Because of this program most (100 %) conventional broiler farmers are members of the program and the statistics of this factor is rather good. The average score is 26 and the number of farmers that delivers chicken with bad foot health is decreasing.

Since 100 % of conventional broiler farmers are members of the program, most broilers in Norway are kept in houses at a max density of 36 kg/m^2.

The animal welfare consequences of different densities of broilers in conventional meat production was reviewed by VKM in 2009 (VKM, 2008) on the background of a report made by the Norwegian University of Life Sciences (Janczak, 2008). The conclusive remarks were as follows: "It was not possible to find proper studies of effects of animal density on social relations, aggression and frustration. There are few documented effects of animal density on physiological stress parameters. Nevertheless, effects of other behavioural and health parameters show that animal welfare is reduced when animal density increases above 25 kg/m^2."

Since organic broilers are reared at densities lower than 25 kg/m^2 (max. density is 21 kg/m^2), the regulations with concern to the animal welfare program do not apply. Therefore we do not have numbers of footpad lesions for organic broilers in Norway. Normally low density is associated with low prevalence of foot pad lesions, but an article (Pagazaurtundua and Wariss, 2006) refers to a prevalence of footpad lesions of 98,1 % in 70 days old organic broilers. The literature is therefore contradictorily with regard to this parameter.

8.1.1.1 *Conclusion*

Organic broilers are produced indoor with a max density of 21 kg/m^2 and have in addition access to an outdoor range 2.5 m^2/animal. According to the findings of VKM in 2009 this should be beneficial for the health and welfare of organic broilers compared to conventional production.

8.1.2 Space allowance for turkeys

According to national legislation the max density for conventional turkeys for meat production are 38 kg/m^2 when the average weight of the animals is < 7 kg. For animals weighing more than 7 kg the density should not exceed 44 kg/m^2.

The density of broilers was reviewed by VKM on the background of a report made by the Norwegian University of Life Sciences (Janczak, 2008). The conclusive remarks were as follows: It was not possible to find proper studies of effects of animal density on social relations, aggression and frustration. There are few documented effects of animal density on physiological stress parameters. Nevertheless, effects of other behavioural and health parameters show that animal welfare is reduced when animal density increases above 25 kg/m^2.

8.1.2.1 *Conclusion*

There are no data available to confirm if this is also the fact with regard to turkeys, but it is natural to extrapolate that animal welfare in slaughter turkeys is reduced when densities of turkeys of 38 kg/m^2 (< 7 kg live weight) and 44 kg/m^2 (> 7 kg live weight) is used in conventional production compared to 21 kg/m^2 that is used in organic production.

8.1.3 Slow-growing poultry strains in organic chicken production

Until 2009 no slow growing hybrids were commercially available for organic chicken meat production. According to the legislation, only commercial hybrids were available for organic meat production and this demanded 81 days for production. Bokkers and de Boer (2009) reviewed the sustainability of organic broiler production and compared slow and fast growing hybrids. The slow growing hybrids performed better with regard to the following parameters:

a) Time spent for walking
b) Gait score
c) Heart abnormalities
d) Mortality

Available slow growing hybrids are essential for the welfare in organic chicken production.

Because of limited access to breeding material suited for organic broiler production, the animal welfare problems in organic broilers are related to growth. Rearing conventional broiler hybrids as long as 81 days, will make them too heavy and it is necessary to develop new feeding strategies to avoid leg weakness and other metabolic disturbances. From 2009 Ross Rowan is accepted as a slow growing hybrid in Norway by the Norwegian Animal Health Authority (Debio, 2014). This hybrid is at present commercially available and can be used in organic broiler production. Because organic produced day-old chickens are not available, the legislation demands a 70 days waiting period where chicken are fed on organic feed until slaughter. This waiting period is then the normal age of slaughter.

8.1.3.1 *Conclusion*

The legislation for organic poultry meat production demands slow growing hybrids. If slow growing hybrids are not used, the minimum slaughter age is 81 days. The difference in slaughter age of 70 – 81 days may be a big animal welfare challenge in organic poultry meat production because of the genetic potential of growth in all available hybrids. Use of slow growing hybrids is likely to reduce the problem.

8.1.4 Slow-growing poultry strains in organic turkey production

No slow growing hybrids are approved for commercial organic turkey meat production in Norway, but slow growing cross-breeds, Norfolk Black x BUT, are available in small scale and perform better than conventional hybrids (Bjørn Pedersen, Pers. Comm.). Sarica et al (2009) made an experiment with a fast growing turkey hybrid, a slow growing breed (bronze) and a mixture of these under barn and free range housing systems. They concluded that the development in growth performances was as expected related to strain, but that the traits at slaughter were related to both strain and sex and were unaffected by housing system. From this we may conclude that it is safe to include commercial turkey hybrids in organic systems.

8.1.4.1 *Conclusion*

According to Commision regulation (EC) No 889/2008, Art. 12, nr. 5 organic turkeys that are not slow growing hybrids should not be slaughtered until 100 days of age for females or 140 days of age for males. The slaughter age of 100-140 days may be an animal welfare challenge in organic turkey production because of the genetic potential of growth commercially available hybrids.

8.1.5 Access to and use of outdoor range

The main difference between organic and conventional poultry production is the access to an outdoor area.

Therefore, aspects related to expressions of natural behaviour, the consequences this may have in terms of emotions and biological functioning and on how health may be affected by access to outdoor areas is relevant to this review. Knierim (2006) reviews animal welfare effects of providing an outdoor run to laying hens. Although not mentioned, the review is most likely relevant also to broiler chicken. Compared with barn systems, the provision of an outdoor run leads to higher space allowances and lower stocking density, a higher number and diversity of behavioural and physiological stimuli, and freedom to change between different environments with for instance different climatic conditions. On the positive side, and depending on factors such as quality and attractiveness of the outdoor areas, especially exploratory and foraging behaviours are stimulated by such environments. Diversity of plants may elicit pecking, scratching, tearing, and biting. Foraging is a high priority behaviour in hens (Cooper and Albentosa, 2003), and insufficient opportunities to forage may cause welfare problems such as feather pecking (Blokhuis and Wiepkema, 1998).

Feather pecking is one of the most obvious welfare problems in laying hens. It is seen in all types of housing systems. Poultry kept in loose housing systems may be affected by a number of behavioural disturbances. The most common problem in organic and conventional kept laying hens is feather pecking and cannibalism (Berg, 2001). Although banned in some countries (e.g. Norway and Sweden), beak trimming is generally used to reduce the damage caused by this behaviour worldwide. In organic farming, where beak trimming is prohibited, the animals are being kept in a less intensive way than in conventional farming in order to improve their welfare. Thus, a direct comparison of feather pecking between organic and conventional laying hens is difficult from international studies and would not be relevant under Norwegian conditions.

In a Dutch study (Bestman and Wagenaar, 2003), farm-level factors that could be associated with feather pecking of layers kept in organic farming systems were monitored in 63 flocks from 26 farms located in different areas of The Netherlands. Data on housing and management practices were collected and plumage damage as a measure of feather pecking was scored at 50 weeks of age or older. No or little plumage damage was found in 18 (29 %) flocks, moderate damage in 12 (19 %) flocks and severe damage in 33 (52 %) flocks. A high percentage of hens in the flock using the outdoor run, a young age at purchase and an increasing number of cockerels present in the flock were found to significantly decrease feather pecking damage at 50 weeks or older. Factors associated with increased usage of the outdoor run were smaller flock size, a young age at purchase, an increasing number of cockerels present in the flock and a higher percentage of cover in the run. Based on these results organic farmers are likely to benefit from rearing their own layers. They should keep cockerels with their layers. Other practices resulting in low feather pecking damage are stimulating the use of the outdoor run by making it attractive with vegetative or artificial cover or keeping the flock size at around 500 birds.

Thus, a good use and a high proportion of birds using the outdoor run may reduce feather pecking (Nicol et al., 2003). Other behaviours such as sunbathing and locomotion others than exploration and foraging, e.g. running, flying are stimulated. Compared with conventional and furnished cages, outdoor hens have stronger bones, however a comparison with non-cage indoor systems are not available. Dust bathing in groups is often seen in outdoor runs.

Knierim (2006) concludes that several factors in outdoor runs may have positive welfare effects for the hens. However, due to the complex interaction with other factors, this is not necessarily always the case. Outdoor runs may, at the same time, impose increased welfare risks associated with an increased contact with infectious agents, greater difficulties to maintain good hygienic standards, possibly imbalanced diets and predation threats.

Range use is important as it has been linked to a number of issues that can affect health and welfare. Several studies in laying hens have found that increasing range use is inversely related to feather pecking (reviews: Knierim 2006; Van de Weerd and Elson, 2006). Organic flocks that spend more time outside are generally better feathered than those do not range well, which may indicate less feather pecking (Bestman & Wagenaar, 2005). However, access to outdoor range does not necessarily imply range use. Providing organic hens a range that stimulates range use will thus improve welfare. Means to stimulate range are by increasing the attractiveness of the range by providing trees, bushes or hedges or artificial structures (reviewed by van de Weerd et al., 2009).

In the outdoor range, additional feed sources promote feeding behaviour. The access to this range allows for a variety of feeding behaviours (ground peck and scratch, eating valued feed resources that are not available in conventional systems; e.g. worms, insects and grass). Feeding behaviour may be linked to a positive affective state related to anticipation and consumption of valued food items and thus promotes good animal welfare (Moe et al., 2011, 2012, 2013).

In conventional broiler production fast growth rate is generally accompanied by decreased locomotor activity and extended time spent sitting or lying. The lack of exercise is considered a main cause of leg weakness, and extreme durations of sitting on poor quality litter produces skin lesions at the breast and the legs (Bessei, 2006). Thus, means to stimulate locomotor activity could improve welfare. Access to outdoor range in organic broiler production stimulates locomotion, thus causing greater bone strength in the tibia (Fanatico et al., 2005a, 2005b). However, suitable breeds for organic broiler production will be those that are active and inquisitive as they are likely to be better rangers and foragers than the less active broiler hybrids.

Berg (2001) also reviews the drawbacks of outdoor range. Birds kept outdoor are more exposed to predators, microorganisms and parasites than birds kept indoors. Foxes, mink, badgers and birds of prey are natural enemies for both wild and free-range fowl. Electric fences and natural shelters like bushes may improve the situation. Outdoor pastures may attract rodents and wild birds and therefore bacterial diseases like erysipelas, salmonellosis and pasteurellosis may cause losses in organic poultry flocks. Stockholm et al, 2010 reports flock mortalities ranging from approximately 2 % to 91 %, with a mean of 20.8 % for organic flocks compared with 7 % for confined flocks on deep litter (kept indoor). Bacterial infections that do not cause disease like *Campylobacter* spp. are normal and must be taken into consideration from a food-safety point of view. The infection with *Campylobacter* spp. seldom or never causes animal health problems. Prophylactic treatment with antibiotics is not allowed under the organic legislation and treatment with antibiotics is seldom used because of the large economically and practical losses caused by the withdrawal time, causing large quantities of eggs that have to be destroyed.

Recent data from Norway (Brunberg et al, 2014; Hannele Hestetun, pers. comm.) show that the mortality in commercial organic layers is about 4 % and therefore far lower than what is reported in the international literature. The mortality in conventional free range systems (kept indoor) in Norway is in comparison, 3.69 % (Hestetun, 2014).

Brunberg et al (2014) reports the mortality in 3 organic broiler flocks in Norway to be 3.3, 5 and 5 %. The mortality in conventional broilers in Norway in 2014 is in comparison, 2.87 % (Nortura, 2014).

8.1.5.1 *Conclusion*

Use of the outdoor range is probably positive for the welfare of poultry to perform motivated behaviours, more physical activity and thereby good bone strength, and space allowance. On the opposite there is a risk of infectious disease or subclinical infections with zoonotic agents caused by direct or indirect contact with wild birds and other animals, risk of trauma because of free movement and risk of death caused by predators. The average mortality in organic egg production is approximately equal to the mortality in conventional free range systems.

8.1.6 Natural Light

According to the legislation houses for organic poultry production should permit plentiful natural light to enter. This is not a demand for conventional poultry.

On request by VKM, the effects of light for poultry is thoroughly reviewed by Kristensen (2011) in the report: "The effects of light intensity, gradual changes between light and dark and definition of darkness for the behaviour and welfare of broiler chickens, laying hens, pullets and turkeys". The conclusive remarks were as follows:

The light intensity may affect many aspects of welfare in broiler chickens, laying hens and turkeys. Poultry may develop eye abnormalities if reared in dim and/or continuous lighting. There is conflicting evidence for the effects of light intensity on feather pecking; some studies have found increased feather pecking in high light intensity, although others have found no effects of light intensity, which may be due to confounding different aspects of the light environment. Birds appear to show reduced fear of humans in 5 lux, but it is uncertain whether this is due to the light intensity per se or to relative changes in light intensity. Layers, broilers and turkeys prefer brightly lit (200 lux) environments at two weeks of age, whereas 6-weeks old layers and broilers prefer dimmer light environments (6 lux). Turkeys maintain their preference for the brighter environments (20-200 lux) and avoid entering environments lit by <1 lux. The findings on the effects of light intensity on poultry welfare require commercial scale validations before firm conclusions can be drawn.

Gjefsen et al. (2011) recommends that the windows of houses for organic layers should be placed along the ceiling to avoid direct sunlight into the stable. Direct sunlight may cause feather pecking or cannibalism.

8.1.6.1 *Conclusion*

The literature is sparse when it comes to comparisons between rearing poultry in natural light compared to artificial light. Chickens develop eye abnormalities when they are reared in dim or continuous lightning and this is probably not beneficial for their welfare. When managed properly, natural light in the poultry house is beneficial with regard to health and welfare, but may be a challenge for the egg production as a whole because of the natural moulting that is induced by shorter day-length.

8.1.7 Space allowance in loose-housing systems for layers

<u>Density of layers</u>

The max density of layers is 6 hens per m^2 indoor area in organic and 9 hens per m^2 in conventional egg production. The benefits and challenges of loose housed hens are thoroughly discussed in the chapter "Access to outdoor areas" and will not be discussed further.

<u>Nest area per hen</u>

There is a demand for 7 birds per nest in organic vs 7 in conventional egg production, but if common nests are used the space demands are 83 cm^2/hen in conventional vs 120 cm^2 in organic. We have found no scientific background for the benefit of this regulation, but Rieber and Nielsen (2013) found that the initial preference of a hen for a single nest box probably is due to a combination of isolation and view of the surroundings. More nest boxes to choose from will keep the possibilities open for this kind of choices.

Perch size per hen

There is further a demand for 18 cm perch/hen in organic vs 15 cm per hen in conventional egg production. Struellens and Tuyttens (2009) experienced in their experiments that the legislated minimum perch length provided per hen (15 cm) adequately allows for synchronized roosting behaviour on straight perches. However, in crosswise perch designs, hens require more perch length per as the area close to the cross cannot be used optimally. Struellens et al (2008) recommended that the legislation and guidelines about the minimal perch length per hen should be refined to take into account the arrangement of the perches. A perch of 30 cm cross-wise to another perch should not be included in the total amount of perch length provided to the hens. For longer cross-wise perches, the precise distance near the cross that should be excluded remains to be determined (LeVan et al, 2000). The literature does not answer wherever 18 cm perch size/hen in organic production provides better or worse animal welfare than 15 cm.

8.1.7.1 *Conclusion*

There is general demand of more space allowance in organic egg production compared to conventional. The literature is sparse or inconclusive with regard to the differences in perch and nest sizes, but when it comes to housing space in general, it must be considered as beneficial with regard to natural behaviour, health and welfare to increase the area per bird. If the living areas are further expanded outdoor there are indeed challenges with regard to health and hygiene that has to be compensated through the management procedures.

8.1.8 Feed and feeding

Nutritional requirements

Commission regulation (EC) No 889/2008, Art. 19-23 regulates the requirements of feed for organic animal production. Gjefsen et al (2011) have in their report reviewed the demands for a diet for organic layers. Today the commercial feed mills cooperate with commercial organic poultry farmers and therefore provide concentrates that fulfills the requirements of the regulation. Non-balanced feeding for organic poultry is therefore rare.

8.1.8.1 *Conclusion*

Commercial feed mills cooperate with commercial organic poultry farmers and provide concentrates that fulfills the requirements of the regulation. Non-balanced feeding for organic poultry is therefore rare.

8.1.9 Roughage

According to Commission regulation (EC) No 889/2008, Art. 20, Roughage, fresh or dried fodder, or silage shall be added to the daily ration for pigs and poultry.

Kalmendal and Wall (2012) investigated the feeding of a high level oil and fiber diet containing 260 g/kg organically produced cold pressed sunflower cake or supplemental roughage to aviary-housed Lohmann Selected Leghorn (LSL) and Lohmann Brown (LB) layers between 20 and 74 weeks of age with outdoor access during summer. They concluded that supplemental roughage reduced ventricular injuries and was correlated with foraging activities. Feeding 260 g/kg sunflower cake negatively affected hygiene in aviary hens.

Lay et al (2011) concludes that access to pasture provides a substantial opportunity for laying hens to ingest forage material affecting their nutrition. Pastures allow for saving on feed costs, but present an opportunity for diets to be unbalanced.

Gjefsen et al (2011) informs that roughage should be supplemented on a daily basis. Possible types of roughage are fresh grass, hay and grass silage that also gives colour to the yolk.

8.1.9.1 *Conclusion*

According to Commision regulation (EC) No 889/2008, Art. 20, roughage, fresh or dried fodder or silage shall be added to the daily ration for pigs and poultry. In spite of the challenges of hygiene and management it causes, roughage is beneficial for poultry health and welfare.

8.1.10 Pharmaceuticals

According to Commission regulation (EC) No 889/2008, Art. 24, chemically synthesized allopathic veterinary medicinal products or antibiotics may be used under the responsibility of a veterinarian. The use of pharmaceuticals in organic productions should be limited, but there is a term in the organic legislation that says that sick animals should be treated as fast as possible.

Since the use of pharmaceuticals in all kinds of commercial poultry production of is limited the doubled withdrawal period usually does not cause increased animal welfare challenges. Coccidiostats that are compulsory in conventional broiler production is prohibited in organic flocks. An increased incidence of coccidiosis or necrotic enteritis caused by *Clostridium perfringens* is expected when coccidiostats are not used. There are no national statistics that say that the difference in legislation for organic poultry vs. conventional are treated less than conventional poultry, but experience from the field (Atle Løvland, pers. comm.) show that some therapeutic antibiotics are used more frequent in organic broilers.

8.1.10.1 *Conclusion*

The ban on coccidiostats in organic broiler and turkey production may cause gut health challenges and increased use of antibiotics in organic broiler production. This may be prevented through vaccination against coccidia or by strict hygienic measures.

8.1.11 Flock size

According to Commision regulation (EC) No 889/2008, Art. 12 the poultry house shall not contain more than 4 800 chickens, 3 000 laying hens or 2 500 turkeys.

Gjefsen et al (2011) reviews in their report the general social attitude for poultry. The natural flock size for the chicken is 3-4 cocks and 5-15 hens. Flocks of this size have a stable rank order. In larger flocks there will be social stress when the rank is difficult to establish, but in spite of this, these flocks usually behave rather well without obvious problems. Even in organic flocks a group size of 15 hens and cocks is difficult to establish, but Gjefsen et al recommends one or two cocks per sub-group 25-50 hens in a larger flock.

8.1.12 Layers

There are no data available to estimate if max flock size of 3000 is better than with regard to health and welfare parameters than 7500 that is the normal flock size used in conventional egg production in Norway.

8.1.13 Broilers

There are no data available to estimate if max flock size of 4800 is better with regard to health and welfare parameters than the normal flock size of 20 000 used in conventional broiler production in Norway.

8.1.14 Turkeys

There are no data available to estimate if max flock size of 2500 is better with regard to health and welfare parameters than the normal flock sizes used in conventional turkey production in Norway of 6000 - 12 000 (Arild Lysaker, pers comm).

8.1.14.1 *Conclusion*

According to Commission regulation (EC) No 889/2008, Art. 12 the poultry house shall not contain more than 4 800 chickens, 3 000 laying hens or 2 500 turkeys. Even though smaller flocks usually are easier to manage than larger flocks there are no scientific evidence that these flocks sizes are more robust according to animal health and welfare than the flock sizes used in conventional poultry production.

8.2 Data gaps and future research

In general, more research comparing the behaviour, health and welfare of poultry in organic versus conventional farming are needed under Norwegian conditions. More specific, studies documenting the ideal flock sizes, limits of animal densities, factors related to pasture access and behavioural aspects of pasture use, and studies of health and welfare in slow-growing hybrids are needed. Especially, studies with regard to organic turkey production are lacking.

9 Animal health and animal welfare in organic and conventional apiculture/beekeeping

According to No 889/2008, section 3, article 19, (2 and 3); at the end of the production season hives should be left with enough honey and pollen reserves to survive the winter. Feeding is only permitted where survival is endangered due to climatic conditions. Feeding should only be with organic honey, organic sugar syrup or organic sugar. No other feed is allowed, thus pollen supplement is not permitted in organic production. In conventional production both sugar syrup and pollen supplement feeding is allowed.

According to No 889/2008, section 4, article 25 (2): only physical treatments for disinfection of apiaries such as steam or direct flame are permitted in organic production units. The most commonly used disinfectant in conventional beekeeping is caustic soda (sodium hydroxide). Caustic soda is a very efficient agent to prevent diseases and the ban against using this disinfecting agent may cause severe problems to organic beekeeping.

9.1 Hazard identification and characterization

The field of organic beekeeping in Norway is fairly new and no in depth research has been preformed with regards to the main health hazards. Therefore, the risk assessments are drawn from the vast research documenting risks to health and welfare of honey bees worldwide. The main risk factors are related to nutrition and hygiene.

Apiculture / beekeeping in Norway are not comparable to other European countries with respect to the foraging opportunities provided for the bees. Most apiaries in Norway are situated in areas where indignant plant species constitute the main forage whereas European countries mostly provide farmed monocultures for forage. Thus a large part of the production of honey in Norway is close to organic in nature. Apiculture in Norway has severe environmental restraints due to the very short flowering season and the relatively harsh winter conditions. Thus, the availability of the nectar and pollen essential for the bees is ephemeral in several areas of the country, and feeding bees with sugar syrup and pollen supplements during the foraging dearth in spring and autumn ensures health and survival in conventional apiculture. In Norway there are two main foraging events; the summer forage (mainly wildflowers and raspberry), and the early autumn forage (flowering heather). After the honey is harvested the bees in conventional production units are fed sugar syrup and pollen supplements, which enable the bees to produce healthy offspring for winter survival. Normally a lot of the bees that were working during summer and fall die before winter, so bees produced in autumn are vital for winter survival. Organic apiaries are allowed fed with honey from their own production or with organic sugar syrup and pollen harvested from the same apiary, whereas commercially produced pollen supplements are not allowed. Organically produced pollen supplements are not for sale in Norway, but is possible to import. Surplus sugar syrup or honey is necessary as food during the winter dearth and normally no offspring is produced in the cold season. The following spring the queen commences egg laying and the food requirements for the colony increases. In early spring the weather conditions in Norway are unstable and the pollen and nectar sources are few and vary geographically. In some areas additional feeding with sugar syrup and pollen is necessary for a healthy colony development. It is not allowed to feed organic pollen supplements in organic beekeeping. Honeybees primary source to carbohydrates is nectar (and later honey), which contains very low amounts of amino acids (Crailsheim, 1990a). Pollen is the only source honey bees have for protein, fat, vitamins and minerals (Di Pasquale et al., 2013). Sufficient feeding of pollen is necessary for larval development, the young imago and overall survival abilities (Crailsheim, 1990a; Di Pasquale et al., 2013; Eckert et al., 1994; Keller et al., 2005a, b; Maurizio, 1950, 1954; Seehuus et al., 2006a; Seehuus et al., 2013). Thus, the main concern regarding organic apiculture in Norway is the ban against feeding pollen supplements to bee colonies in periods with low natural pollen availability. The risks of badly developed bees with a chance of impaired longevity due to physiological deficits are high with poor nutrition.

Pollen is the only source bees have for fat, protein, several vitamins and minerals (Di Pasquale et al., 2013). Ample feeding during the larval stage and the young adult stage is vital for development of the immune defense (Claudianos et al., 2006; Seehuus et al., 2013), development of enzymes in the intestinal organs (Crailsheim, 1988; Kunert and Crailsheim, 1988), and the development of both the hypopharyngeal glands (brood food producing glands in head) and the fat body (equivalent to liver or white adipose tissue) (Amdam et al., 2004; DeGrandi-Hoffman et al., 2010; Naiem et al., 1999; Snodgrass, 1956). The protein content at emergence of a honey bee worker depends on the availability of food outside the hive during the nursing season; the difference between bees nursed during bad pollen harvesting conditions and between those nursed during good conditions amounts to more than 13 % (Crailsheim, 1990b, 1991, 1992; Crailsheim et al., 1992). Pollen is a major factor influencing the longevity of individuals (Haydak, 1970), and is important at the colony level as it enables the production of jelly by nurse bees which feeds larvae, drones, hive mates and the queen (Camazine et al., 1998; Crailsheim, 1986, 1992; Crailsheim et al., 1992). A decrease in pollen availability is likely to cause a deficiency of health of individuals, and affect the resistance to stressors such as pathogens and pesticides (Alaux et al., 2011; Alaux et al., 2010; DeGrandi-Hoffman et al., 2010; Di Pasquale et al., 2013; Naug, 2009; Seehuus et al., 2006b). Bees destined for winter survival have higher protein content than summer bees despite the lack of pollen forage; however the amount of stored pollen is usually high in this period (study made in Europe (Kunert and Crailsheim, 1988)). In Norway the amount of pollen stored in the hives late autumn and winter is dependent on the pollen availability late summer and early autumn, and varies between years and geographically. The ban against feeding pollen supplements in organic production is thus a cause for concern in years and areas where pollen availability is scarce early spring, late summer and early autumn. It is allowed to feed organic production colonies pollen harvested from the same apiary, although the quality of the harvested pollen is greatly reduced with time (Haydak, 1933, 1967, 1970), and is strongly dependent on the existence of a pollen surplus being harvested by the worker bees in summertime. The ban may also deter organic apiculture in the mid and the far north of Norway where the foraging season is especially short. The consequences of poor nutrition may be hazardous to the survival of honeybees in Norway.

A major concern for organic beekeeping is the EU ban against using caustic soda and green soap to disinfect housing materials for the bees. Caustic soda and green soap is in use by conventional beekeepers in Norway and has been allowed in use in organic farming since the first organic apiculturists started in 2002 in Norway. Caustic soda is made by mixing sodium hydroxide with boiling water and green soap into a 5 % sodium hydroxide solution and all frames and equipment used by apiculturists are lowered into the boiling solution for 15 minutes before being rinsed off with water. According to the previous organic regulation EC no 2092/91, Annex 1C, article 8 (7): for cleaning and disinfecting materials, buildings, equipment, utensils and products used in beekeeping only the appropriate substances listed in Annex II Part E are permitted. Caustic soda is known to kill off spores from both types of American foulbrood. One type of American foulbrood can produce spores that survive in beekeeping equipment for years and are a threat to beekeeping all over Europe (Hansen and Brodsgaard, 1999).

9.1.1.1 *Conclusion*

A main concern for Norway in organic versus conventional apiculture is the ban against feeding bee colonies with pollen supplements in periods with low pollen availability. Organic pollen supplements are available outside Norway. By allowing organic apiculture to import and feed the bees with organic pollen supplements the health and viability of hives during pollen dearth will most likely greatly improve.

Another main problem for organic beekeeping is the ban against using caustic soda to disinfect equipment. Disinfection with caustic soda and soap is known to kill spores of foulbrood, whereas flaming is not as efficient. The most efficient preventive measure against foulbrood is treating equipment with caustic soda. If foulbrood is diagnosticiced in a colony in both conventional and organic production, the Norwegian standard is to burn all hives and all equipment to hinder the spread of the disease. By allowing the previous organic regulation for cleaning and disinfecting equipment the chance of spread of disease and infection will diminish.

10 Feed and Feeding

10.1 Hazard identification and characterization

The production of feed, fodder and pasture for the livestock in organic farming have to follow the rules for organic production, which first of all means without synthetic pesticides and synthetic fertilisers. In organic production, the processing of protein feed materials has to be done without chemically synthesized solvents, which are allowed in conventional production. Therefore, organic protein feed materials are often made of cold-pressed sources, for example organic soy-beans or pressed soy-cake. Synthetic flavour and colour additives are not allowed in organic feed. These differences of organic and conventional feed production concerning pesticides, fertilisers, chemically synthesized solvents, flavours and colours could possibly influence the composition of the animal products but differences of effects on animal health and welfare remains to be shown.

Neither are synthetic amino-acids allowed in organic feed. Thus, in organic feed production balancing of optimal content of amino acids is more demanding as it has to be based on the selection of protein sources. For example, more fish-meal is used as protein/amino-acid source in organic feed (pigs and poultry) than in conventional feed. The more complicated adjustment of amino acid composition in organic feed production usually results in some higher protein content in organic than in conventional compound feed. The organic compound feed usually also contains a more complex mixture of feed materials than conventional compound where synthetic amino-acids are used for fine-tuning of the nutrient balance.

Concerning vitamins and minerals, concentrations and sources are similarly allowed in organic and conventional feed production.

The contents of nutrients, bioactive secondary plant compounds as well as contaminants as mycotoxins and pesticide residues may differ between organically and conventionally produced plants for food and feed as shown in Part I Plant health and plant production and Part V Human health – pesticide residues. In Part III Human health – nutrition and contaminants is presented available data on effects from human studies, animal model studies and biomarker studies by intake of organic or conventional food.

More clover and other legumes are used in organic than in conventional production, and often also more pasture, fresh forage or grass silage, whereas higher amounts of concentrates are used in conventional production. Large qualitative differences of composition of animal diet may certainly influence the animal production including, animal growth, health, welfare and products for human consumption. However, available data on standardized comparison of health effects of livestock animals fed organic or conventional feed are sparse. Furthermore, effects by the feed are difficult to separate from other factors as housing and husbandry. Finally, detection of health effects of livestock animals due to quantitative differences of specific nutrients, bioactive compounds or contaminants is organic and conventional feed seem hard to detect.

A search in Web of Science in March 2014 with [organic conventional feed animal health] resulted in 58 hits. Only one of the studies were suitable to evaluate health effects related to possible differences of nutrients included bioactive plant compounds in the feed. That is a two-generation study on chickens fed organically and conventionally produced feed (Huber et al. 2009), which is described and assessed as an animal model study in Part III Human health – nutrition and contaminants. Shortly, animals of both groups were healthy. The conventionally fed chickens showed a higher weight gain during life span than those organically fed. The different immune parameters examined indicate an immune modulation by the feeds and tendencies towards an enhanced immune responsiveness or immune competence of the animals on organic feed.

10.1.1 Cattle

Suckling and maternal milk

According to the regulations, the required length of the suckling period in organic production is three days, and all young calves should be fed on maternal milk in preference to other natural milk, for a minimum of three months. There is no demand of suckling or maternal milk for calves in conventional farming. In practice, calves in conventional dairy herds receive maternal milk usually for some days. For calves in beef herds, free suckling is normal in organic and conventional production.

To our knowledge there is no literature comparing conventional and organic farming, concerning health in calves related to the length of milk feeding period. Several papers indicate that calf suckling their mothers have larges risk of getting 'Failure of Passive Transfer' (FPT), and thus less immunity in the newborn stage. This could be counteracted by securing that calves getting enough colostrum by manual feeding with good quality colostrum, as well as extremely good hygiene at the maternal cows. The significance of different milk feeding strategies for calves´ welfare show that suckling increases the growth rate, gives better social competence and more exploratory behaviour. (See 1.2.1, 1.2.2 and 2.1.1 for extended text).

Feed

According to the regulations, the livestock shall be fed with organic feed, preferently produced at the farm or otherwise produced locally. At least 60 % of the feed for cattle shall come from the farm unit itself or in case this is not feasible, be produced in cooperation with other organic farms in the same region. There is no requirement for producing feed at own farm in conventional production. At least 60 % of the dry matter in daily rations for cattle shall consist of roughage, fresh or dried fodder, or silage. A reduction to 50 % for animals in dairy production for a maximum period of three months in early lactation is allowed. There are no specific requirements for the proportion of roughage for cattle in conventional production, but according the regulations, the feed should promote good health and welfare and be adapted to the animals age, live weight and the physiological and behavioural needs.

The feed composition may influence and reflect the composition of the animal products. Cattle diet primarily based on pasture, fresh forage as well as grass silage is shown to improve the profile and amount of conjugated linoleic acid (CLA) isomers and increase the ratio of n-3/n-6 polyunsaturated fatty acids in the milk compared to diets of higher amounts of concentrate (Butler et al., 2009; Bilik et al., 2010; Benbrook et al., 2013; Adler et al., 2013). Such a profile of fatty acids and CLA is shown in organically produced milk and is assumed to be favourable for the consumers´ health.

Less use of concentrate and more roughage in the feed will improve the rumen fermentation, less risk for developing Sub-Acute Ruminal Acidosis (SARA) and the diseases related to SARA. Less concentrate in the dry period and first part of lactation could also be related to a delayed peak and less increase in lactation yield. A very high yield early in lactation (first week) is shown to be a reason for mastitis later in lactation. Less use of concentrate in organic farming could be the reason why organic farms usually are associated with having less clinical mastitis. Furthermore, ruminants on intensive concentrate feeding that results in chronical ruminal acidosis, or animals with other metabolic diseases, as well as animals that in other ways are forced to provide high production rates, may be more sensitive to adverse effects of mycotoxins than ruminants in normal rumen-physiological balance. (See 1.2.6 and 1.2.7 for extended text).

Outdoor area

According to the regulations, cattle in organic farming shall have access to pasturage for grazing whenever conditions allow. For bulls above one year, access to an open air area is acceptable. In conventional farming, cattle (except uncastrated males of more than six months) shall be kept on pasture preferentially, for a period of minimum eight weeks during the summer or alternatively the cattle shall have access to open air area.

Provided satisfactory management and from the view of feeding, the extended access to pasture has to be regarded as positive for animal health and welfare.

10.1.2 Sheep and goats

Suckling and maternal milk

According to the regulations, in organic farming lambs and goats should be fed on maternal milk in preference to other natural milk, for a minimum of 45 days. In conventional farming there is not such demand, but in practice, lambs have free access to suckling. Thus, the suckling period length and the use of maternal milk to lambs are the same in both farming types. (See 3.1.1 for extended text).

It is important that kids get colostrum only from their own mother to avoid spreading any infectious diseases. Thereafter they might still get milk from their own mother, or milk replacer. Literature on comparison of organic and conventional kid suckling and intake of maternal milk is not found. The significance of different milk feeding strategies in goat kids is poorly documented, but studies of lambs and calves show that suckling increases the growth rate, gives better social competence and more exploratory behaviour. The same might be assumed for goat kids. Thus, the organic regulations of feeding lambs and kids maternal milk in preference to natural milk for a minimum of 45 days is likely to be positive to animal welfare. (See 4.1.1, 4.1.2 and 5.1.5 for extended text).

Feed

According to the regulations, the livestock shall be fed with organic feed, preferently produced at the farm or otherwise produced locally. At least 60 % of the feed for sheep and goats shall come from the farm unit itself or in case this is not feasible, be produced in cooperation with other organic farms in the same region. There is no requirement for producing feed at own farm in conventional production. At least 60 % of the dry matter in daily rations for sheep and goats shall consist of roughage, fresh or dried fodder, or silage. There are no specific requirements for the proportion of roughage for sheep and goats in conventional production.

Large excess of fast fermented carbohydrates are a cause of diarrhea and Clostridium intoxication in small ruminants. Furthermore, ruminants on intensive concentrate feeding that results in chronical ruminal acidosis, or animals with other metabolic diseases, as well as animals that in other ways are forced to provide high production rates, may be more sensitive to adverse effects of mycotoxins than ruminants in normal rumen-physiological balance. (See 1.2.7 for extended text).

The farmers usually lack information on the status of minerals and vitamins in his/hers soil and feedstuff. Fewer rations with concentrate and more local feedstuff could increase the risk of vitamin and mineral deficits. There is probably no difference, under Norwegian condition, between conventional and organic small ruminant farming when regards to vitamin and mineral deficits. (See 3.1.4 for extended text).

Outdoor area

According to the regulations, in organic farming, sheep and goats shall have access to pasturage for grazing whenever conditions allow. In conventional farming, these animals shall be kept on pasture for a period of minimum 16 weeks during the summer if not prevented by climatic or animal welfare conditions. In practice in Norway the grazing period for sheep may be regarded as similar in organic and conventional herds. Also the goat production is mainly based on a long pasturing season in organic and conventional herds. However, organic goats should have access to outdoor area the whole year. There is not identified literature illustrating the effect of outdoor area the whole year for goats.

10.1.3 Pigs

Suckling and maternal milk

According to the regulations, in organic production piglets should be fed on maternal milk in preference to other natural milk, for a minimum of 40 days, which imply that minimum age of weaning is 40 days. In conventional production, the minimum age at weaning is set to 28 days. However, very few herds practice an age of weaning of less than 35days.

An increase in weaning length from 28 to 40 days is positive when it comes to welfare for the piglets in terms of reduced stress. Furthermore, feeding strategies are the most important factor to reduce post-weaning diarrhea problems. Since most of the piglets in conventional farms in Norway are weaned at 35 days, these differences may be less important. (See 6.1.1 for extended text).

Feed

According to the regulations, at least 20 % of the feed for pigs in organic production shall come from the farm unit itself or in case this is not feasible, be produced in the same region in cooperation with other organic farms or feed business operators. In practice in this context the national level is such a region, and most organic pig herds use commercial organic compound feed. Most conventional herds use commercial compound feed and there is no requirement concerning where the conventional feed is produced. Where farmers are unable to obtain protein feed exclusively from organic production, the use of a limited proportion of non-organic protein feed is allowed for pig production. The maximum percentage of non-organic protein feed authorized per period of 12 months shall be 5 % for calendar years 2012, 2013 and 2014. The figures shall be calculated annually as a percentage of the dry matter of feed from agricultural origin. The operator shall keep documentary evidence of the need for the use of this provision.

Furthermore, in organic production, roughage, fresh or dried fodder, or silage shall be added as part of the daily ration for pigs. In conventional production roughage is not common as part of the feed for the pigs, but they shall have continuous access to an ample amount of materials like straw, hay, sawdust, peat and earth which they can explore and be occupied.

There are available results showing reduced risk of gastric ulcers when pigs are given roughages. However, there are no data comparing the prevalence of gastric ulcers in organic versus conventional farmed pigs. Provision of roughage is definitely beneficial also for the welfare of pigs, and the difference in animal welfare between organic and conventional production will depend on the amount of straw and/or roughage that are used in conventional pig production. (See 6.1.6 and 7.1.5 for extended text).

Ban of synthetic amino-acids in organic feed involves some challenges: The amino acid supply of the growers is known to have effects on growth, feed conversion and lean meat percentage. In organic feed production balancing of optimal content of amino acids is more demanding as it has to be based on the selection of protein sources. It is important for organic pig producers to find optimal protein source satisfactory effect on animal health and carcass and meat quality. For example, more fish-meal is used as protein/amino-acid source in organic feed than in conventional feed. The more complicated adjustment of amino acid composition in organic feed production usually results in some higher protein content in organic than in conventional compound feed. (See 6.1.7 for extended text).

Outdoor area

According to the regulations, pigs in organic farms shall have permanent access to open air areas, preferably pasture, whenever weather conditions and the state of the ground allows this. There is no demand for access to an outdoor area in conventional farming.

Pigs in organic production with access to outdoor, may have a higher exposure of environmental contaminants from f.ex. ingestion of soil. Adverse health effects are not expected from such exposure (See 6.1.8 for extended text).

10.1.4 Poultry

Genetic growth potential

According to the regulations, organically farmed poultry shall either be reared until they reach a minimum age or else shall come from strains from slow-growing strains. The minimum age at slaughter shall be 81 days for chickens. In Norway the herds with organic production usually use slow-growing poultry strain (Ross rowan) from conventional chick production with a minimum period of 70 days before slaughtering as organic product. There is no specific demand for slow growing strains for conventional production.

By adapting the feeding to the growth gain potential of slow-growing strain no negative effects by using these strains are expected. Rather one may expect improvement of animal health and welfare in organic poultry production.

Feed

According to the regulations, at least 20 % of the feed for poultry in organic farms shall come from the farm unit itself or in case this is not feasible, be produced in the same region in cooperation with other organic farms or feed business operators. Some organic poultry farmers produce at least 20% of the feed at the farm. However as for organic compound feed for pigs, the national level is considered as a region, and several organic poultry herds use commercial organic compound feed. Most conventional herds use commercial compound feed. Use of cocciostatics in poultry feed is allowed in organic farming but is normally only used in feed for broiler chicken and turkeys in conventional production. In Norway naracin has been for decades the selected compound. Where farmers are unable to obtain protein feed exclusively from organic production, the use of a limited proportion of non-organic protein feed is allowed for poultry species. The maximum percentage of non-organic protein feed authorized per period of 12 months shall be 5 % for calendar years 2012, 2013 and 2014. The figures shall be calculated annually as a percentage of the dry matter of feed from agricultural origin. The operator shall keep documentary evidence of the need for the use of this provision.

Roughage is beneficial for poultry health and welfare. Ban of synthetic amino-acids in organic feed involves some challenges. Balancing of optimal content of amino acids is more demanding as it has to be based on the selection of protein sources. It is important for organic poultry producers to find optimal protein source satisfactory for animal health and product quality. For example, more fish-meal is used as protein/amino-acid source in organic feed than in conventional feed. The more complicated adjustment of amino acid composition in organic feed production usually results in some higher protein content in organic than in conventional compound feed. (See 8.1.9 for extended text).

<u>Outdoor area</u>

According to the regulations, poultry in organic farms shall have access to open air areas for at least one third of their lives. This can be pasture or other outdoor area. There is no demand for access to an outdoor area in conventional farming.

Poultry in organic production with access to outdoor areas, may have a higher exposure of environmental contaminants from f.ex. ingestion of soil and soil organisms. Adverse health effects are not expected from such exposure.

10.1.4.1 *Conclusions*

- More clover and other legumes are used for ruminants in organic than in conventional production, and often also more pasture, fresh forage or grass silage, where higher amounts of concentrates are used in conventional production.
- The influence of differences of organic and conventional feed production concerning use of pesticides, fertilisers, chemically synthesized solvents, flavours and colours, and synthetic amino acids on animal health and welfare remains to be shown.
- The contents of nutrients, bioactive secondary plant compounds as well as contaminants as mycotoxins and pesticide residues may differ between organically and conventionally produced plants for feed but the influence on animal health and welfare is sparsely documented.
- In general, a longer suckling increases the growth rate, gives better social competence and more exploratory behaviour. Calves suckling their mothers may have larger risk

of getting 'Failure of Passive Transfer' and thus less immunity in the newborn stage. This could be counteracted by securing that calves getting enough colostrum by manual feeding.

- In ruminants, less use of concentrate and more roughage in the feed will improve the rumen fermentation, and may reduce the problem of clinical mastitis, and improve the defense against f.ex. mycotoxins.
- In pigs provision of roughage in shown to reduce the risk of gastric ulcers. Provision of roughage is definitely beneficial also for the welfare of pigs.
- For all livestock animals from the view of feeding, the extended access to pasture has to be regarded as positive for animal health and welfare provided satisfactory management.

Conclusions

The panel on Animal Health and Welfare agreed to conclude this assessment with the following statements regarding organic and conventional husbandry systems:

Significant differences between the national regulations for animal welfare and health for organic and conventional animal production have been identified. Compared to other European countries, the Norwegian regulations for conventional animal production concerning farm animal health and welfare are stricter. Hence, the differences between animal health and welfare regulations in Norway for organic and conventional animal production are less than in most other countries.

For dairy cattle, the difference in proportional rate of antimicrobial resistant bacteria between the two systems is small and insignificant. The presence of antimicrobial resistant bacteria in both production systems is very low in Norway compared to other countries in Europe and overseas countries. The literature reveals that there could be a difference between organic and conventional farming in countries where the use of antibiotics is considerably higher than in Norway.

For cattle, the requirement in organic farming that calves should suckle their own mother may increase the risk of insufficient supply of colostrum and may be a risk factor both for FPT (Failure of Passive Transfer), as well as exposure of serious pathogens. However, good farm management can overcome this. There are no data to document any effect of milk feeding period on animal health and welfare. The ban on single boxes for calves in organic production is positive for animal welfare but might increase the risk of infectious diseases. The length of the pasture period is longer in organic farming and some conventional farmers will probably choose the outdoor yard alternative. For dairy cows, the difference in space allowance between organic or conventional production seems to be negligible. For calves, the required space allowance is somewhat higher in organic compared to conventional production, but it is unclear if this difference will have any significant effect on animal welfare. For growing cattle > 300 kg live weight, the differences in required space allowance is higher in organic than conventional production, and data suggests that this will have a significant effect on animal welfare. Solid flooring in the resting area for bulls and heifers in existing builings is positive for animal welfare. The use of less concentrates and more roughage in organic production probably explains the reduced milk yield production, and the lower level of clinical mastitis. Research may indicate that alternative therapy as homeopathic therapy, which can be used in organic farming, has no better effect than the self-cure rate.

Cattle

Positive or negative effects (+/-) in organic cattle production compared to conventional cattle production. ? = lack of relevant scientific literature	Animal welfare	Animal health
Suckling own mother for three days	+/-	-
Length of milk feeding period		
Group pens for calves	+	-
Access to pasture or outdoor areas	+	+/-
Space allowance	+	?
Roughage		+

Solid flooring in the resting area for bulls and heifers	+	
Organic fertilizers/manure		(-)
Withdrawal time medication		-

For sheep, data indicate that the higher required space allowance in organic production entails a better animal welfare than in conventional production, but without clear effects on animal health. When considering solid lying floor, access to pasture, access to outdoor area, length of the suckling period, the proportion of roughage in the diet and veterinary treatments, the differences between conventional and organic production in Norway are negligible.

Sheep

Positive or negative effects (+/-) in organic sheep production compared to conventional sheep production. ? = lack of relevant scientific literature	Animal welfare	Animal health
Space allowance	+	
Solid lying floor		
Access to pasture	+/-	+/-
Access to outdoor area		
Suckling period		
Proportion of roughage in the diet		
Veterinary treatments		

For goats, data indicate that the higher required space allowance in organic production entails a better animal welfare than in conventional production, but there is probably no effect on animal health. Access to a solid lying area is beneficial for animal welfare in uninsulated buildings with slatted floor pens at low temperatures. For access to pasture and outdoor area the differences in the regulation for organic and conventional production are small. Concerning the length of the suckling period, the proportion of roughage and veterinary treatments, no relevant literature on the comparison between organic and conventional farming was found.

Goat

Positive or negative effects (+/-) in organic goat production compared to conventional goat production. ? = lack of relevant scientific literature	Animal welfare	Animal health
Space allowance	+	?
Solid lying floor	(+)	
Access to pasture		
Access to outdoor area	(+)	?
Suckling period	?	?

Proportion of roughage in the diet	?	?
Veterinary treatments	?	?

For pigs in Norway, the age at weaning is higher than the required minimum both in conventional and organic production. The available data do not show differences in animal health and welfare between the production systems. The difference in indoor space is small, but the access to an outdoor area in organic production is positive for animal welfare. However, it is more difficult to control pathogens from wildlife and visitors, and predators might be a problem when pigs have access to outdoor areas. In general, provision of roughage is beneficial for the welfare and gastric health of pigs, and the difference in animal welfare between organic and conventional production depends on the amount of straw and/or roughage that is used in conventional pig production.

Pig

Positive or negative effects (+/-) in organic pig production compared to conventional pig production. ? = lack of relevant scientific literature	Animal welfare	Animal health
Suckling period		
Indoor space allowance		
Access to outdoor area	+	+/-
Roughage	+	(+)
Veterinary treatments		

For poultry, organic production systems for layers were compared with conventional free range production systems, and furnished cages were not considered. The increased space allowance in organic production for broilers and layers, use of slow growing strains and use of roughage and natural light are beneficial for both health and welfare. There are no data to support positive effects on welfare and health of small flock sizes. On the other hand, access to outdoor areas in organic production is positive for animal welfare but increases the risk of parasites, infectious disease or subclinical infections with zoonotic agents (example: influenza and Newcastle disease). There might also be an increased risk of death caused by predators.

Poultry

Positive or negative effects (+/-) in organic poultry production compared to conventional poultry production. ? = lack of relevant scientific literature	Animal welfare	Animal health
Space allowance broiler	+	+
Slow growing strain, broiler		+
Access to outdoor area	+	-
Space allowance layers	+	(+)
Natural light	+	+
Roughage	+	+
Veterinary treatments		
Flock size		

More clover and other legumes are used in organic than in conventional production, and often also more pasture, fresh forage or grass silage, where higher amounts of concentrates are used in conventional production. The influence of differences of organic and conventional feed production concerning use of pesticides, fertilisers, chemically synthesized solvents, flavours and colours and synthetic amino acids on animal health and welfare remains to be shown. The contents of nutrients, bioactive secondary plant compounds as well as contaminants such as mycotoxins and pesticide residues may differ between organically and conventionally produced plants for feed but the influence on animal health and welfare is sparsely documented. In general, longer suckling increases the growth rate, gives better social competence and more exploratory behaviour. Calves suckling their mothers may have larges risk of getting 'Failure of Passive Transfer' and thus less immunity in the newborn stage. This could be counteracted by securing that calves getting enough colostrum by manual feeding. In ruminants, less use of concentrate and more roughage in the feed will improve the rumen fermentation, and may reduce the problem of clinical mastitis, and improve the defence against f.ex. mycotoxins. In pigs, providing roughage is shown to reduce the risk of gastric ulcers. Provision of roughage is definitely beneficial also for the welfare of pigs.

Feed

Positive or negative effects (+/-) in organic production concerning feed and feeding compared to conventional poultry production. ? = lack of relevant scientific literature	Animal welfare	Animal health
Feed production concerning use of pesticides, fertilisers, chemically synthesized solvents, flavours and colours, and synthetic amino acids	?	?
Feed contents of nutrients, bioactive secondary plant compounds as well as contaminants as mycotoxins and pesticide residues	?	?
Suckling in cattle		
Ruminants, less use of concentrates		+
Roughage to pigs	+	+

For honeybees there is a main concern regarding welfare in organic versus conventional culture related to the ban in organic farming against feeding bee colonies with pollen supplements in periods with low pollen availability. Another main problem for organic beekeeping is the EU ban against the disinfection of equipment with caustic soda.

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Appendix 1

Literature Search

Conventional and Organic production-Cattle Health:

The literature search was done by using ScholarGoogle.com with the search word: organic and conventional, dairy, health, Norway, health OR dairy OR welfare. And additionally the exact wording "organic and conventional" should be included. The search was done in two parts; firstly the search included 1300 paper, and restricting to the period after 2009 included 562 papers (as of 29th of November 2013). Of these 60 was referred to after judging the title content and the summary. A new literature search with the same search word but restricted during the time for publication from 1991 till 2009 gave 722 additional papers. This was finally done 25th January 2014. After checking all these references 100 of these were judged from title and short description as relevant for further reading and after reading the summary 26 papers were referred to. Altogether, 86 relevant papers were identified by this search, and additionally papers found in the references during this search were also included.

This is almost the same at Simoneit et al., (2012) found. They found 569 papers. From these they reviewed 33 %. Of these, 42 papers had general topics and 211 described cattle. All these 569 papers were looked closer at and 36 were reviewed, judged as relevant and used in this assessment.

Table 1. Search string, number of counts and number of references cited.

Search string	**Date**	**Hits**	**Jugded relevant from title and abstract**	**Cited**
Topic= organic and conventional, dairy, health, Norway, health OR dairy OR welfare Included exact wording "organic and conventional " Published period after 2009	29.11.13	562	225	60
Topic= organic and conventional, dairy, health, Norway, health OR dairy OR welfare Included exact wording "organic and conventional " Published period 1991 til 2010	25.01.14	722	100	26

Conventional and Organic production-Cattle welfare:

Literature searches were conducted using the ISI Web of Science data base (Table 2).

Very few of the articles that are comparing organic and conventional cattle farming are cited (Table 2), partly because they were not relevant to animal welfare and partly because the type of conventional system was not relevant under Norwegian conditions. Further, several articles are used in the text which did not show up in the literature search.

Table 2. Search string, number of counts and number of references cited.

Search string	Date	Hits	Cited
Topic=(welfare organic conventional); cattle		29	2
Topic=(welfare organic); cattle		73	2
Topic=(welfare suckling period); cattle		12	0
Topic=(welfare single housing); calves		19	3
Topic=(welfare access to pasture); cattle		25	3

Conventional and Organic production - Sheep Health:

Literature searches were conducted using www.pubmed.com and www.sciencedirect.com (Table 3).

The literature search did not revealed any international peer reviewed publication comparing animal health in sheep in organic versus conventional production. There are two publication that gives an review of organic production (Hovi et al., 2003;Kilstra et al., 2006) and one meta-analysis conducted on alternative treatment on gastrointestinal nematodes in sheep farming. Due to the small number of relevant articles, remaining searches within each of the hazards were run separately and did not include organic versus conventional since there were no hits when these two words were included (Table 1). The reason why so few of the total hits were cited is that most of the publications deal with effects on health in conventional herds, very few in organic or they did not focus on the hazards we were interested in.

Table 3. Search string, number of counts and number of references cited.

Search string	Date	Pubmed hits	Pubmed cited	Science direct hits	Science direct cited
Topic=(sheep animal health organic conventional); Refined by topic = sheep animal health "organic conventional" in Science direct	25.02.14	11	5	25	1
Topic=(suckling period lamb)	25.02.14	60	0*	5	0*
Topic=("lamb mortality" risk factors); Refined by topic = "risk factors" " lamb mortality" organic conventional in Science direct	25.02.14	9	2	7	1
Topic=(Space allowance sheep)	25.02.14	7	1	1	0
Topic=(Outdoor access sheep), refined by topic = "outdoor access" sheep	25.02.14	4	2	53	1*
Topic=(solid lying floor sheep);refined by topic=lamb	25.02.14	0	0	0	0
Topic=(forage organic conventional sheep); Refined by topic = lamb, refined by topic = forage "organic conventional" sheep in science direct	25.02.14	2	0*	9	0*
Topic=(homeopathic medicine sheep); Refined by topic = lamb	25.02.14	8	3	68	3
Topic=(Phytoterapeutic sheep); Refined by topic = lamb	25.02.14	1	1	0	0

*No publications found regarding differences between the farming types

Conventional and Organic production - Pig health:

Literature searches were conducted using www.pubmed.com and www.sciencedirect.com (Table 4).

The literature search did not revealed any international peer reviewed publication comparing animal health in pigs in organic versus conventional production. There are two publication that gives an review of organic production (Hovi et al., 2003;Kilstra et al., 2006) Due to the small number of relevant articles, remaining searches within each of the hazards were run separately and did not include organic versus conventional since there were no hits when these two words were included (Table 1). The reason why so few of the total hits were cited is that most of the publications deal with effects on health in conventional herds, very few in organic or they did not focus on the hazards we were interested in.

Table 4. Search string, number of counts and number of references cited.

Search string	**Date**	**Pubmed hits**	**Pubmed cited**	**Science direct hits**	**Science direct cited**
Topic=(pig animal health organic conventional); Refined by topic = pig health "organic versus conventional" in Science direct	26.02.14	17	2	9	1
Topic=(suckling period weaning age piglets) Refined by topic = "suckling period" "weaning age" piglets in Science direct	26.02.14	57	1*	43	0*
Topic=(wean observation free-ranging piglets)	26.02.14	0	0	70	1
Topic= (space allowance pigs)	26.02.14	48			
Topic=(risk factors piglet mortality) Refined by topic = "risk factors" "piglets mortality" in Science direct	26.02.14	21	1	83	0
Topic=(preweaning mortality risk factors piglet) Refined by topic = "risk factors" "piglets mortality" in Science direct	26.02.14	21	1	190	4
Topic=(reproduction performance organic sows) Refined by topic = "reproduction performance organic sows" in Science direct	26.02.14	11	1	53	1*
Topic=(outdoor pig production animal health) Refined by topic = "outdoorc pig production" "animal health" in science direct	26.02.14	20	1	44	2
Topic=("organic pig production" animal health); Refined by topic = "organic pig production" "animal health" in science direct	26.02.14	3	1	47	2
Topic=(use of roughage animal health sows); Refined by topic = "roughage" "pigs" in science direct	26.02.14	9	0*	33	2
Topic=(risk factors gastric ulcers in pigs); Refined by topic = "risk factors gastric ulcers in pigs" in science direct	26.02.14	6	1	406	2
Topic=(prohibition synthetic amino acids organic pig); Refined by topic = "prohibition synthetic amino acids" "organic pig" in science	26.02.14	0	0	111	2

direct					
Topic=(heavy metals exposure organic pig); Refined by topic = "heavy metals exposure organic pig" in science direct	26.02.14	9	1	83	1
Topic=(homeopathic medicine pigs); Refined by topic = "homeopathic medicine" pigs in science direct	26.02.14	19	3	138	3
Topic=(Phytoterapeutic pigs), Refined by topic = "Phytoterapeutic pigs" in science direct	26.02.14	0	0	0	0

*No publications found regarding animal health, mostly animal behaviour differences

Two publication (Åkerstedt et al., 2013; Løkjel and Ekkel., 2013)) were found at http://www.umb.no/husdyrforsoksmoter/artikkel/husdyrforsoksmoteboken-2013

One report (Annual report 2012, Ingris) were found at http://www.google.no/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=3&ved=0CDgQFjAC&url=http%3A%2F%2Fwww.norsvin.no%2Fcontent%2Fdownload%2F4664%2F31638%2Ffile%2F%25C3%2585rsstatistikk%25202012.pdf&ei=WSUPU5KPKIbnygPhzYFQ&usg=AFQjCNH7duVvXWruLsJ4IJopva0mhFAX-w

Conventional and organic production pig welfare:

Literature searches were conducted using the ISI Web of Science data base (Table 5).

Very few of the articles that are comparing organic and conventional pig farming are cited (Table 5), partly because they were not relevant to animal welfare and partly because the type of conventional system was not relevant under Norwegian conditions. Some of the articles were in French or German and some articles only presented at congress or workshop and not in peer-reviewed journals. The same is also the case for the other literature found. Further, several articles are used in the text which did not show up in the literature search.

Table 5. Search string, number of counts and number of references cited.

Search string	Date	Hits	Cited
Topic=(welfare organic conventional); pig*		25	1
Topic=(welfare organic); pig*		73	2
Topic=(welfare suck*); pig* or sow*		97	3
Topic=(welfare roughage); pig* or sow*		19	3
Topic=(welfare space); pig* or sow*		237	15

Conventional and Organic production - Sheep and Goat Welfare:
Literature searches were conducted using the ISI Web of Science data base (Table 6).

The literature search only revealed one relevant international peer reviewed publication comparing the welfare of small ruminants in organic versus conventional production (Table 6). Due to the small number of relevant articles, remaining searches within each of the hazards were run irrespective of farming system (Table 6). The reason why so few of the total hits were cited is that most of the publications deal with effects on health parameters rather than focusing on the behavioural or ethological part of the welfare issue, or they did not focus on the hazards we were interested in.

Table 6. Search string, number of counts and number of references cited.

Search string	**Date**	**Hits**	**Cited**
Topic=(welfare organic conventional); Refined by Topic=sheep	25.08.13	6	1
Topic=(welfare organic conventional); Refined by Topic=goat*	25.08.13	1	0
Topic=(welfare organic); Refined by Topic=sheep	30.08.13	26	2*
Topic=(welfare organic); Refined by Topic=goat	30.08.13	11	0
Topic=(space welfare); Refined by Topic=sheep	30.08.13	28	2*
Topic=(space welfare); Refined by Topic=goat	30.08.13	8	2
Topic=(solid floor welfare); Refined by Topic=sheep	30.08.13	3	1*
Topic=(solid floor welfare); Refined by Topic=goat	30.08.13	1	0
Topic=(suck* welfare); Refined by Topic=lamb	30.08.13	32	7*
Topic=(suck* welfare); Refined by Topic=goat kid*	30.08.13	0	0
Topic=(space* welfare); Refined by Topic=lamb	03.01.14	18	1
Topic=(space* welfare); Refined by Topic=goat kid*	03.01.14	3	0

*Of which four are the same references

The remaining publication for sheep and goats were found at http://www.umb.no/iha/artikkel/miljo-til-sau (4 publications cited), http://www.umb.no/iha/artikkel/fysisk-og-sosialt-miljo-for-geit-2 (5 publications cited) and through communication via colleagues (13 publications cited).

Conventional and Organic Production-Poultry Welfare:
Literature searches were conducted using the Thomson Reuters Web of Science data base (Table 7).

Table 7. Search string, number of counts and number of relevant references.

Search string	Date	Hits	Relevant
Organic agriculture welfare* laying hen	29.10.13	4	4
Organic farming welfare* laying hen	29.10.13	28	16
Ecological farming welfare* laying hen	29.10.13	4	4
Ecological agriculture welfare* laying hen	29.10.13	1	1
Organic agriculture health* laying hen	24.02.14	5	4
Organic farming health* laying hen	24.02.14	21	18
Ecological farming health* laying hen	24.02.14	4	4
Ecological agriculture health* laying hen	24.02.14	1	1
Organic agriculture welfare* broiler chicken	29.10.13	3	1
Organic farming welfare* broiler chicken	29.10.13	14	4
Ecological agriculture welfare* broiler chicken	29.10.13	1	1
Ecological farming welfare* broiler chicken	29.10.13	1	1
Organic agriculture health* broiler chicken	24.02.14	3	2
Organic farming health* broiler chicken	24.02.14	21	12
Ecological farming health* broiler chicken	24.02.14	3	2
Ecological agriculture health* broiler chicken	24.02.14	1	1
Organic agriculture welfare* turkey	24.02.14	1	0
Organic farming welfare* turkey	24.02.14	5	2
Ecological farming welfare* turkey	24.02.14	1	1
Ecological agriculture welfare* turkey	24.02.14	0	0
Organic agriculture health* turkey	24.02.14	12	0
Organic farming health* turkey	24.02.14	15	1
Ecological farming health* turkey	24.02.14	3	1
Ecological agriculture health* turkey	24.02.14	6	1

We have not identified investigations from Norway that compare conventional and organic systems with regard to the status of health and welfare in egg or poultry meat production. Since adequate comparative data from Norway are lacking, a comparison of organic and conventional poultry production must therefore as discussed above rely on studies carried out in other countries, were the production practices and other conditions cannot necessarily be extrapolated to Norway. Comprehensive reviews with regard to organic poultry production (not comparisons) have been published by Berg (2001) and Van de Weerd et al (2009). Reviews with regard to health and welfare in organic livestock production in general have been published by Kijlstra and Eijck (2006), Lund and Algers (2003) and Thamsborg (2001). Knierim (2006) has reviewed the animal welfare aspects of outdoor runs for laying hens (in Norway only organic poultry use such outdoor runs), while Lay et al (2011) has reviewed hen welfare in different housing systems (only free range systems are legal in organic egg production). Tuyttens et al (2008) compared health and welfare in broilers in organic and conventional production systems.

Conventional and Organic Apiculture/Beekeping:

Literature searches were conducted using the ISI Web of Science data base (Table 8).

Table 8. Search string, number of counts and number of references cited.

Search string	Hits	Cited
Topic=(Crailsheim)	113	10
Topic=(pollen nutrition and bee health)	12	5
Topic=(population size and foraging in honey bees)	57	1
Topic=(immunocompetence and diet and bee)	3	1
Topic=(pesticide and environmental response and honeybee)	6	1
Topic=(honeybee workers and longevity)	74	2
Topic=(somatic maintenance and honeybee worker)	3	1
Topic=(Brodsgaard and American foulbrood)	5	1

The remaining publications for honeybees were found at the Bee facility library at Semb, Asker (1994).