

Project II.7

ORGANICPIGFEED

Pig feeding under organic farming conditions with emphasis on nutrient utilisation, product quality and health

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Danish Institute of Agricultural Sciences
Department of Animal Nutrition and Physiology
Research Centre Foulum
P.O. Box 50, DK-8830 Tjele

Title: (II.7) Pig feeding under organic farming conditions with emphasis on nutrient utilisation, product quality and health.**Acronym: ORGANICPIGFEED****Date: 06.02.2001****Summary in Danish**

FØJO gennemførte i 2000 en vidensyntese om økologisk svineproduktion. Resultaterne af dette arbejde viste, at nogle områder vedrørende fodring af økologiske svin har behov for en forskningsmæssig indsats. Endvidere er ønsket om en større selvforsyningsgrad med foder til økologisk husdyrproduktion stigende. Den økologiske svineproduktion har imidlertid under de nuværende forhold begrænsede muligheder for en tilfredsstillende forsyning med velegnede fodermidler. Med henblik på at imødekomme behovet for essentielle næringsstoffer (protein, aminosyrer, vitaminer og mineraler) i svinefoder er der derfor et stort behov for alternative afgrøder og fodringredienser. Behovet omfatter også en vurdering af såvel traditionelle som nye alternative fodermidler, der kan have potentiale som økologisk svinefoder.

Det overordnede formål med dette projekt er, at frembringe ny viden, der kan anvendes som grundlag for udvikling af en forbedret fodersammensætning og hensigtsmæssige fodringsstrategier til økologisk svineproduktion. Det planlagte arbejde er beskrevet og bliver gennemført i tre ”arbejds pakker”, der omfatter forsøg med både søer, fravænnede smågrise og slagtesvin.

Forventede resultater omfatter:

- Anvisning af metoder og egnethed af udvalgte fodermidler til opfyldelse af svinenes behov for protein og aminosyrer.
- Forbedring af viden om behovet for essentielle aminosyrer til fravænnede grise, slagtesvin og søer i det økologiske produktionssystem.
- Forbedring af videngrundlaget med henblik på fodringsmæssig dækning af grisenes behov for vitaminer og mineraler under frilandsforhold.
- Udvikling af strategier for fodring af grise i forbindelse med fravæning.
- Udvikling af fodringsstrategier, som kan forbedre grisenes modstandskraft mod infektionssygdomme i mave-tarmkanalen hos slagtesvin.
- Belysning af sammenhæng mellem foderets sammensætning og slagte- og kødkvalitet.

Det er hensigten, at forskningen skal give værdifulde informationer om effekten af varierende proteinindhold (aminosyrer) og lupiner i foderet på grisenes udnyttelse af næringsstoffer og kvaliteten af slagteprodukterne. Kvalitetskontrollen omfatter også skatol i rygspæk. Dette indebærer i positivt fald, at fodring med lupin kan være et hjælpemiddel til reduktion af ornelugt hos hangrise. Det er ligeledes hensigten med projektet, at nye resultater kan danne baggrund for anvisninger af hensigtsmæssig management i forbindelse med afgræsning og anvendelse af ensilage til drægtige søer. I denne forbindelse og ligeledes i tilslutning til andre forsøg vil de planlagte analyser af dyrenes vitamin- og mineralstatus give værdifulde informationer til brug ved vejledning om behovet for tilsætning af disse næringsstoffer til foderet. Forskningsresultaterne forventes ligeledes at give et forbedret grundlag for vurdering af fodringsmæssige muligheder for reduktion af problemer med fordøjelsesforstyrrelser hos fravænnede grise og infektionssygdomme i mave-tarmkanalen hos slagtesvin. Projektets resultater kan også medvirke til løsning af problemer, som kan være forårsaget af et højere infektionspres hos grise, der har adgang til udendørs arealer og halmstrøelse. Endvidere vil projektet i positivt fald være med til at skabe forbedret værktøj til anvendelse ved rådgivning med henblik på en miljøvenlig svineproduktion i Danmark, hvor terapeutisk brug af antibiotika, ormemedler m. fl. er minimeret.

1. Summary

A knowledge synthesis initiated by DARCOF revealed that some topics in relation to feeding of pigs under organic farming conditions need to be studied. The demand to be self-sufficient in feed for organic animal production is increasing, but pig production is restrained by the difficulty to provide feed ingredients for suitable nutrient supply. In order to meet the demands for protein, amino acids, vitamins and minerals from pigs, alternative feed crops and feed ingredients therefore have to be found. Thus, there is a great need for evaluation of traditional as well as alternative feed ingredients, which have potential as pig feed. The overall objective of this project is to obtain improved knowledge for development of suitable feed formulations and feeding strategies for organic pig production. The work will be conducted in three work packages and involves experiments with breeding sows, as well as weaned pigs and growing-finishing pigs.

The expected achievements comprise:

- Indication of methods and feedstuffs for suitable supplying of pigs with dietary protein and essential amino acids.
- Improvement of the knowledge about requirements for dietary essential amino acids of weaned pigs, growing-finishing pigs and breeding sows.
- Improvement of the knowledge about the demands for dietary supply of vitamins and minerals of pigs under outdoor conditions.
- Development of methods for feeding of piglets in connection with weaning.
- Development of feeding concepts that can be used to improve the animals resistance to infectious diseases of the gastrointestinal tract of growing-finishing pigs.
- Exposure of interactions between the diet composition and the carcass and meat quality in slaughter pigs.

The research is intended to give valuable information on the effect of lupine and dietary protein level on the performance and nutrient utilisation of growing pigs and product quality of organic pork. The effect of lupin on skatole in back fat is included. Thus, if lupin results in lower skatole in fat, this may be a way to reduce boar taint in entire male pigs. Output from the research also intend to comprise new knowledge, that can be used as basis for recommendation of management for efficient utilisation of pastures and silage in feeding of pregnant sows. In this connection and also in some of the other studies, monitoring of the mineral and vitamin status of the animals will give important informations for the guidance of dietary supplementations. The research will also give a better basis for evaluating the potential of using the diet to reduce digestive disturbances in piglets and infectious diseases in growing pigs. The project will also help to find ways to overcome problems that may occur because of higher infectious pressure for pigs with access to outdoor facilities and straw bedding. Furthermore, the project attempts to provide tools for an environmental friendly production of pigs in Denmark, with minimal use of therapeutic antibiotics and anthelmintics.

2. Research group

Viggo Danielsen (VDA), Head of Research Unit, M.Sc.Aagri., Department of Animal Nutrition and Physiology, DIAS, Ph.: +45 8999 1376; Fax: +45 8999 1525; E-mail: Viggo.Danielsen@agrsci.dk

Jose A. Fernandez (JAF), Senior Scientist, Ph.D., Department of Animal Nutrition and Physiology, DIAS, Ph.: +45 8999 1374; Fax: +45 8999 1525; E-mail: José.Fernandez@agrsci.dk

Søren Krogh Jensen (SKJ), Senior Scientist, Ph.D., Department of Animal Nutrition and Physiology, DIAS, Ph.: +45 8999 1117; Fax: +45 8999 1166 E-mail: SorenKrogh.Jensen@agrsci.dk

Hanne Damgaard Poulsen (HDP), Senior Scientist, Ph.D., Department of Animal Nutrition and Physiology, DIAS, Ph.: +45 8999 1386; Fax: +45 8999 1525; E-mail: HanneD.Poulsen@agrsci.dk

Martin Tang Sørensen (MTS), Senior Scientist, Ph.D., Department of Animal Nutrition and Physiology, DIAS, Ph.: +45 8999 1554; Fax: +45 8999 1525; E-mail: MartinT.Sorensen@agrsci.dk

Knud Erik Bach Knudsen (KBK), Professor, Ph.D., Department of Animal Nutrition and Physiology, DIAS, Ph.: +45 8999 1143; Fax: +45 8999 1378; E-mail: KnudErik.BachKnudsen@agrsci.dk

Ellen-Margrethe Vestegaard (EMV), Senior Scientist, Ph.D., Department of Animal Health and Welfare, DIAS, Ph.: +45 8999 1315; Fax: +45 8999 1500; E-mail: EllenM.Vestergard@agrsci.dk

Laurits Lydehøj Hansen (LLH) Senior Scientist, Ph.D., Department of Animal Product Quality, DIAS, Ph.: +45 8999 1255; Fax: +45 8999 1564; E-mail: LauritsLydehoj.Hansen@agrsci.dk

Christer Ohlsson (CHO) Senior Scientist, Ph.D., Department of Crop Physiology and Soil Science, DIAS, Ph.: +45 8999 1833; Fax: +45 8999 1839; E-mail: Christer.Ohlsson@agrsci.dk

Chris Claudi-Magnussen (CCM), Project Manager, Ph.D., Danish Meat Research Institute, Ph.: +45 4630 3251; Fax: +45 4630 3132; E-mail: ccm@danishmeat.dk

Hanne Maribo (HMA), Consultant, Department of Nutrition and Reproduction, Danish Bacon and Meat Council, Ph.: +45 3373 2626; Fax: +45 3314 2517; E-mail: hma@danskeslagterier.dk

3. Introduction

DARCOF has initiated and conducted a knowledge synthesis on organic pig production (Hermansen, 2000). Concerning feeding of pigs under organic farming conditions, three expert groups studied:

- *Supply of essential nutrients to pigs (protein/amino acids, vitamins and minerals)*
- *Stimulation of resistens against infections of pigs by feeding strategies*
- *The influence of feeding on product quality*

Based on the results and conclusions of the knowledge synthesis some topics were pointed out for research in order to improve knowledge for implementation in organic pig production (Hermansen, 2000). The need for research in feeding of organic pigs is evident from the title of this project.

As indicated by the project title, focus of this work has to be on the effects of feeding of pigs on nutrient utilization, product quality and health of the animals. Additionally, the research will be concerned with the supply of pigs with essential nutrients as amino acids, vitamins and minerals. Feed of organic farmed origin has to be highly emphasized and suitable feeding strategies for breeding sows, weaned pigs and growing-finishing pigs will be recommended.

In order to fulfill the aims of this project it is important to realize that specialized organic pig production is restrained by the difficulty to provide feed ingredients to fulfil the need of the animals. Some feed ingredients, which are normally used in conventional production, are not permitted in organic production. This is the case for byproducts after extraction with solvents (e.g. soybean meal), industrially produced amino acids and some vitamin and mineral sources. In order to meet the demands for protein, amino acids, vitamins and minerals in pig feed other alternatives therefore have to be found. Furthermore, the demand to be self-sufficient in feed for organic animal production is increasing. Consequently, there is a great need for evaluation of traditional as well as alternative crops, which currently are suitable for organic growing conditions and which have potential as feed for pigs in terms of delivery of essential nutrients. Since the quality of the meat potentially can be influenced by the quality of the supplied nutrients the product quality of the pigs is very important to track. In addition, the project should evaluate various feeding strategies for weaned pigs and growing-finishing pigs with emphasis on resistance to digestive disturbances after weaning and infections with porcine pathogens.

In the conventional Danish pig industry recommended standards for the dietary content of digestible amino acids, vitamins and minerals are usually followed by the feed formulators (Danske Slagterier/Landsudvalget for Svin, 2000). In organic pig production similar recommended standards do not exist. The conventional standards are usually taken over by diet formulators for organic pig production, but the question is, whether other dietary standards could be used with advantage. Especially in the actual situation, where the possibilities for satisfactory supply with amino acids, vitamins and minerals are limited, it is worth while to study the effects of lower nutrient standards in diets for pigs under organic farming conditions.

It is a commonly held belief that pigs kept under intensive production systems have a higher risk for developing digestive disturbances, diseases of the gastrointestinal tract and to house zoonotic bacteria than pigs produced under organic farming conditions. The background for this assumption is that pigs produced under intensive farming conditions are very stressed because of early weaning, high stocking density and feeding of concentrated pelleted feeds. These conditions have contributed to the steady increase in productivity in conventional pig production but may also have laid the ground for the increased frequency of production-related diseases and the outbreak of diseases in man caused by zoonotic bacteria. Contrary to that, pigs reared under organic farming conditions are less stressed because of later weaning, lower stocking density and the use of fibre rich roughage, which result in better resistance against infections with porcine pathogens.

In this project the work will be described and performed in three work packages. Feeding experiments involving breeding sows as well as weaned pigs and growing-finishing pigs will be conducted. The objective is to obtain new knowledge that can be used as basis for recommendation of relevant feeding strategies for the different categories of pigs.

4. State of the art

The supply of amino acids, minerals and vitamins to growing pigs and pregnant sows

Pigs in general require a minimum amount of dietary protein, which must contain a sufficient amount of essential amino acids in order to achieve a reasonable production level. The relative amino acid composition (ideal protein) is furthermore determinant for the efficient usage of the dietary protein consumed. The ideal protein varies according to the physiological status of the animal (age/live weight, reproduction and lactation), but a suboptimal level of any single essential amino acid will in all cases result in impaired performance.

Several proposals for the composition of ideal protein for growing pigs have been put forward (Wang & Fuller, 1989; Lenis, 1992; Boisen, 1997, a. o.) and recommendations for amino acid supply for all pig categories and production systems in Denmark have been published by Danske Slagterier (2000). In order to ensure an optimal protein utilisation and thereby reduce nitrogen losses from pig production, two complementary approaches can be used:

-the first one is to ensure adequate protein and amino acid supply at all times (phase-feeding) according to the physiological status of the animals. This requires a joint fitting of daily supplies of energy and amino acids to the animal's actual needs. Thus, in Denmark is recommended to use different diets for pregnancy, lactation, pre-weaning, weaning, growing (up to 50-60 kg LW) and finishing.

-the second approach is to improve dietary amino acid balance (ideal protein) and consequently reduce the protein content of the diet. This can be achieved through the combination of several protein sources and/or by the utilisation of industrially produced free amino acids. Both approaches have been proved to be efficient in reducing nitrogen losses and to improve feed utilisation.

Under organic conditions the use of industrial amino acids, synthetic vitamins with a structure different from the natural occurring or made on basis of GMO and of extracted soja protein concentrates is not allowed. These conditions represent a production constraint especially for the lactating sow and the growing pig. Regarding protein, the current alternative choices of importance are peas and rapeseed products, which if used in large proportions in diets for breeding sows and for growing pigs, can be detrimental for pig performance. It is therefore obvious, that introduction of new protein sources to organic production will not only be beneficial for pig feeding and for nitrogen utilisation but also for crop rotation. Such an alternative could be lupins (Fernández and Batterham, 1995), which up to now has not been commonly grown in Denmark and its application in animal feeding is therefore not well known. A new variety, suited to Danish conditions has recently been developed and is currently being cultivated.

Furthermore, in the absence of free amino acids particularly lysine and methionine, which usually are the first limiting amino acids, the dietary protein level necessary to achieve adequate amounts of these amino acids – as indicated by the recommendations for conventional pig feeding - becomes excessive.

Considering that lupin represents a large potential as a home-grown protein source for pigs, although the problem of amino acid supply, particularly of methionine will be exacerbated, it will be of significance for organic pig farming to understand the optimal use of lupin in pig feeding. In addition, it is not unreasonable to expect that a moderate reduced amino acid supply (and thereby also a reduction of dietary protein level) relative to the recommendations for conventional pig farming, will only have a modest negative effect (if any) on pig performance. In return, a reduced dietary protein level will reduce significantly the nitrogen output in faeces and urine (Fernández, 1997) and might also lead to a better animal well-being. It can therefore be of significance to study the consequences of a reduced dietary level of amino acids (relative to recommendations for conventional production).

In addition to amino acids, vitamins and minerals are essential nutrients for all pig categories (Danielsen et al., 2000). However, the vitamin supply to organic produced pigs represents in particular a serious challenge. Due to the rapid growth, the high milk or egg production of domestic animals and the high energy density and protein content in most feedstuffs of plant origin, it is seldom possible to cover the animal's need for vitamins and minerals through grain feeding. Several of the common used vitamins are manufactured by chemical synthesis. Some of these synthetic vitamins have another stereochemical configuration than the natural occurring form. This means that the chemical synthesized forms may have a lower biological activity compared to the natural form. Certain types of roughages may - on the other hand - contain an appreciable amount of several vitamins and minerals and thereby serve as valuable vitamin and mineral sources. However, the knowledge regarding the content and bioavailability of vitamins present in feed plants is very limited. Preliminary studies have shown that fibrous feeds may to some extent contribute to the mineral supply of growing pigs (Lærke et al., 2000).

Of all pig categories, pregnant sows have the largest potential for intake and utilisation of roughages such as clover grass. Under Danish conditions, Sehested et al.(2000) demonstrated that pregnant sows on pasture were able to consume enough clovergrass to meet half of their energy requirement. Therefore, it can be expected that clover grass can contribute substantially, not only to the energetic keeping of the pregnant sow, but can also supply significant amounts of protein/amino acids, vitamins and minerals. Consequently, it is important to elucidate if the pregnant sow's nutrient requirement can be fulfilled by using cereals combined with pastured clover grass in summertime and of silage in wintertime.

Feeding strategies for weaned pigs and growing-finishing pigs with emphasis on gut health

The weaned piglets are highly disposed for diseases as a consequence of the weaning process. Although piglets are at least 7 weeks old at weaning in organic farming, and therefor supposedly more resistant than conventionally farmed 4-weeks old weaned piglets, weaning diarrhoea (i.e. diarrhoea 3-10 days after weaning) is still a serious problem in organic farming (Søren Bak, personal communication; Hermansen, 2000). Due to limitations in the use of medicine in organic farming, there is considerable interest in elucidating the possibilities to prevent diarrhoea via feeding strategies.

Weaning diarrhoea is a multifactorial problem, and in addition to dietary factors (diet composition, level of nutrient intake), also factors such as bacterial load (presence of toxic *Escherichia coli* strains) and social stress (absence of the sow, moving and mixing) act and interact (see review by Pluske et al., 1997). From the literature it is not easy to rank these factors in order of importance because multifactorial experiments are rarely conducted probably due mainly to technical limitations. However based on experimental data and data from conventional farms, Madec (1994) and Madec et al. (1998) suggested that a high feed intake is the most important factor avoiding weaning diarrhoea followed by hygiene (if at the farm level) and number of pigs per pen (if at the pen level); pig size/age and air quality are also important factors. Thus in organic farming, feed intake and hygiene are probably important factors, while neither pig age nor air quality are probable initiating factors; number of pigs per pen may be important.

The finding of Madec and co-workers that a high feed intake is important is somewhat controversial, since it is a common practice to restrict feed intake in order to limit weaning diarrhoea of piglets in organic (Søren Bak, personal communication) as well as conventional (Johansen & Callesen, 2000) farming. It may be that rather than the feeding level *per se*, it is the absence of protective nutrients or growth factors from sow milk that makes the intestines more vulnerable, since sow milk is rich in such factors (Zabielski, 1998). However, it may also be due to inappropriate levels or sources of specific nutrients, e.g. protein, zinc, vitamin E and fibres.

While moving and mixing is not a main initiating factor, since piglets moved from a problem farm to a non-problem farm can resist diarrhoea, whereas those staying on the problem farm develop diarrhoea (Madec, 1994), the moving and mixing factor may still be disposing for the development of diarrhoea either in interaction with other factors such as diet and bacterial load or because the factor may be associated with crowding in the pen.

Weaning diarrhoea is often associated with one or more infectious pathogens (*Escherichia coli* O138 or O 149), but to what extent the diet can affect infectious diarrhoea is poorly understood. Feed intake during the nursing period (Nabuurs, 1995) and source of polysaccharides (McDonald et al. 1999) are suggested to play a role.

In growing-finishing pigs parasites and pathogenic bacteria can have a major economical impact on the productivity through reductions in daily live-weight gain and feed conversion. It is well established that the dietary composition plays an important role for maintaining a normal and healthy gut. The feed composition and in particular the level and type of carbohydrates and feed processing have a major impact on the physiochemical properties of digesta materials, digestibility of nutrients, microbial composition, endogenous response, gut morphology and the mucus and immune response. All these factors are important for maintaining a normal functioning healthy gut, which is even of bigger importance under organic pig production as the use of drugs is restricted relative to conventional farming.

The normal flora of the gut is a dynamic environment partly determined by the feed composition. For instance type and level of plant carbohydrates will have a major impact on the activity and composition of the microflora as it provides the substrate, but also factors as organic acids or fermented liquid feeds will influence the flora composition. Thus, recently a group in Australia found that a highly digestible diet was protective against the development of swine dysentery (*Serpulina hyodysenteriae*), while most pigs fed on diets with higher levels of nondigestible plant materials and consequently lower overall digestibility developed colonic changes and disease (Pluske et al., 1996; Siba et al., 1996; Durmic et al., 1998). These findings, however, have not been confirmed in a Danish investigation (Lindecrona et al., 2000), whereas fermented liquid feed was found to reduce the excreting of *Serpulina hyodysenteria* after experimentally infection (Lindecrona et al., 2000).

Pigs kept under organic farming conditions are expected to be more exposed to parasites in particular *Ascaris suum*, *Trichuris suis* and *Oesophagostomum dentatum* than pigs kept under conventional farming conditions (Nansen & Roepstorff, 1999). Especially *T.suis* is very pathogenic to pigs and severe outbreaks with 25% mortality have recently been observed in pigs turned out on contaminated outdoor areas (e.g. Jensen & Svensmark, 1996). In collaborative studies between Danish Centre for Experimental Parasitology, KVL and the DIAS, it was found that the diet composition had a strong influence on the establishment of infection with *O. dentatum* in growing pigs (Petkevicius et al., 1995; Petkevicius et al., 1996; Petkevicius et al., 1997; Petkevicius et al., 1999; Petkevicius et al., 2000). Diets leading to a high establishment were characterised by high levels of insoluble dietary fibre and a relatively low digestibility, while diets providing readily degradable nutrients to the large intestine and with relatively high digestibility provided unfavourable conditions for the establishment of *O. dentatum*.

More recently (Petkevicius et al., 2000) it was also documented that feeding the two contrasting diets could be used to reduce egg excretion and worm numbers (the digestible diet) or to increase egg excretion and worm number (the resistant diet). Thus, the dietary composition and dietary fibre (DF) in particular appears to have a significant influence in controlling *O. dentatum* infection. These findings are in agreement with an epidemiological investigation that points to non-starch polysaccharides (NSP) as the most important factor controlling parasite infection in growing pigs in

the UK (Pearce, 1999). The study of Pearce (1999) also indicates that infection with *Trichuris suis* was followed by a higher incidence of *L. intracellularis*.

Recent investigations point to the dietary composition as a factor controlling parasite and bacterial infections. Since the use of drugs in organic pig production is restricted there are obvious reasons to investigate the possibility of improving the resistance against infection with porcine pathogens.

Effects of nutrient supply on product quality

The limitations of feed ingredients for organic pigs may lead to the use of feedstuffs that influence the product quality in a negative way. Especially the use of alternative protein sources may lead to alterations in taste and fatty acid composition of the meat. A slower growth of the organic pigs may also influence the tenderness (Danielsen et al., 2000) and marbling of the meat.

Lupin (*Lupinus*) seed is one of the alternative protein sources that can be used for organic pig production, although the influence on the sensory quality and fatty acid composition is debated (Flis et al., 1989, Zettl et al., 1995). The use of lupin has been shown to reduce skatole production in the gut and the skatole level in blood (and backfat) (Jensen et al., 1997; Jensen et al., 1998). A new type of lupin, PRIMA, has shown potential on the field in Denmark and the first tests on growing-finishing pigs has started in a collaboration between Landsudvalget/Danske Slagterier, Slagteriernes Forskningsinstitut and Danmarks JordbrugsForskning. However, there is a strong need for knowledge concerning the effects of lupin in the feed on product quality.

In an attempt to improve protein utilisation in organic pig farming, one may reduce the protein content in the feed. It is uncertain to what extent this will slow down the growth rate of the pigs leading to lower tenderness and lower marbling of the meat.

Pork from organic grown pigs is already known to have a different meat quality compared to conventional pork. A screening test has shown lower tenderness, higher content of PUFA, higher content of pigment, lower content of intramuscular fat (marbling) and higher driploss in organic pork products (Claudi-Magnussen, 1999). The causes are not known, but feedstuffs are believed to play a major role. Danmarks JordbrugsForskning and Slagteriernes Forskningsinstitut are currently investigating the influence of organic feed (not including lupin), roughage and feeding strategy on the product quality (Anonymous, 1998).

The *perceived* eating quality of organic pork does not meet the high *expectations* by the consumers (Grunert and Andersen, 1999). An increased consumption of organic pork is therefore believed to depend on an improved quality of the product. This project will concentrate on studying the effects of using lupin as an alternative protein source and of using reduced total protein in the feed for growing-finishing pigs.

5. Objectives and expected achievements

The overall objective of the project is to obtain new knowledge, that can support the recommendation of suitable dietary composition and feeding strategies for organic pig production. The emphasis will be placed on feedstuffs of organic farmed origin and the nutritional requirements for performance, carcass quality, meat quality and health of the pigs will be studied. Expected achievements comprise:

- Indication of methods and feedstuffs for suitable supplying of pigs with dietary protein and essential amino acids.
- Improvement of the knowledge about requirements for dietary essential amino acids of weaned pigs, growing-finishing pigs and breeding sows.
- Improvement of the knowledge about the demands for dietary supply of vitamins and minerals of pigs under outdoor conditions.

- Development of methods for feeding of piglets in connection with weaning.
- Development of feeding concepts that can be used to improve the animals resistance to infectious diseases of the gastrointestinal tract of growing-finishing pigs.
- Exposure of interactions between the diet composition and the carcass and meat quality in slaughter pigs.

5.1. *Adequate supply of dietary protein, vitamins and minerals to sows and growing-finishing pigs*

The activities of this part of the project will focus on, developing feeding concepts for growing-finishing pigs and for breeding sows that improve the utilisation of home-grown crops. Following aspects will be included:

- The quality of lupin as feedstuff for pigs and its optimal inclusion for diets.
- The optimal level of protein and amino acid for growing finishing pigs, here under specifically the significance for performance of reducing dietary levels of protein and amino acids.
- The supply of minerals and vitamin E to growing-finishing pigs and breeding sows
- The mineral and nitrogen balance in slaughter pig production
- The rational use of pasture for the nutrition of the breeding sow and its relation to supplementary concentrate feeding.

It is expected that these activities will result in the formulation of recommendations for the content of amino acids in growing-finishing pigs diets. In addition, the adequacy of the supply of mineral and vitamin E to growing-finishing pigs and breeding sows under organic conditions will be assessed. This part of the project will also contribute with new knowledge on the practical utilisation of lupin and of clover grass in the feeding of the growing-finishing pig and the breeding sow.

5.2. *Feeding strategies for weaned pigs and growing-finishing pigs with emphasis on gut health*

The main objective of this part of the programme will be to develop feeding concepts that can be used to improve the animals' resistance against infectious diseases of the gastrointestinal tract. Specifically the activities will address the following questions:

- develop feeding strategies that minimises weaning diarrhoea in organic pig farming
- create a platform for further improvements of these strategies
- evaluate the effects of diets varying in digestible and nondigestible carbohydrates on the resistance to *T. suis* infection
- evaluate the effects of diets varying in carbohydrate composition on establishment of dual infections with *T. suis* and *B. pilosicoli* infection

The research will give a better basis for evaluating the potential of using the diet to reduce problems with digestive disturbances in piglets and infectious diseases in growing pigs. The project will also help to find ways to overcome problems that may occur because of higher infectious pressure for pigs with access to outdoor facilities and straw bedding. Furthermore, if the project becomes successful it will provide tools for an environmental friendly production of pigs in Denmark, with minimal use of therapeutic antibiotics and anthelmintics.

5.3. *Effects of nutrient supply on product quality*

The objective is to investigate the effect of lupin and the total protein content in the feed on product quality of organic pork. Included is the effect of lupin on skatole in back fat (boar- and manure odour in pigs).

It is the aim to decide if it can be recommended to use lupin as an alternative protein source and to use reduced total protein in the feed for organic growing-finishing pigs as far as product quality is concerned. If lupin results in lower skatole in back fat, this may be a way to reduce boar taint in entire male pigs.

6. Description of workpackages including methods

Table 1: Workpackage list

WP No	WP title	Responsible participant	Budget	Start	End	Deliverable, No
-	Co-ordination	VDA	248.500	01.04.2001	30.6.2005	
1	Adequate supply of dietary protein, vitamins and minerals to sows and growing-finishing pigs.	JAF	1.900.000	01.07.2001	31.12.2004	D1.2-D1.10
2	Feeding strategies for weaned and growing-finishing pigs with emphasis on gut health.	KEBK	1.900.000	01.07.2001	30.06.2005	D2.1-D2.5
3	Effects of nutrient supply for growing-finishing pigs on product quality.	CCM	951.500	01.01.2002	31.12.2004	D3.1-D3.3
Total			5.000.000			

Table 2: Description of workpackages

WP1: Adequate supply of dietary protein, vitamin and minerals to pregnant sows and growing-finishing pigs
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Workpackage number:	1
Start date or starting event:	01.07.2001
Responsible person:	J. A. Fernández
Contributing persons:	H. D. Poulsen, V. Danielsen, S. K. Jensen, C. Ohlsson, H. Maribo
Person-months:	22 scientific + 10 technical

Objectives:

The activities of Workpackage 1 will endeavour to develop feeding concepts for slaughter pigs and pregnant sows, under consideration of following factors:

- Reduction of the amino acid supply to slaughter pigs
- Incorporation of significant amounts of lupin seed in the diet of slaughter pigs
- the bioavailability of minerals and vitamin E in lupin based diets
- mineral and nitrogen balances in slaughter pig production
- the potential of pastures for the nutrition of the pregnant sow
- the relations between level of concentrate feeding and pasture utilisation by pregnant sows
- the effect of feeding cereals and clover grass to pregnant sows on mineral and vitamin status

Description of work:**Task 1.1**

Production experiment with growing pigs will be carried out at the organic farm Rugballegård. Littermate growing female pigs and male castrates (25-30 kg) will be fed until slaughter (105 kg) with 2 diets (a grower diet to 60 kg and a finisher diet thereafter) containing different level of lupin, each level formulated to fulfil either the recommended amounts of amino acids for conventional reared pigs or reduced to 85%, according to the experimental plan below:

Treatment	1	2	3	4	5	6
Amino acid supply, %	100	100	100	85	85	85
Lupin, % in diet	0	10	20	0	10	20

Pigs will be group fed (5 per pen) ad-lib in pens with access to outdoor facilities. The experiment will comprise a total of 240 pigs distributed in 6 treatments replicated 8 times. Feed composition, feed consumption, feed utilisation and growth rate will be determined. Nitrogen, phosphorus and selected trace element flow will be estimated and pig health recorded.

Task 1.2

Digestibility and balance experiments will be carried out at Foulum with 4 of the experimental diets (from Task 1.1) and with two ingredients of special interest (lupin and oats). Diets will be fed restrictively to littermate pigs kept in metabolism cages under standardised conditions appropriate for protein and mineral studies. Lupin and oats will be fed mixed at different levels with wheat starch. The nutritive value of the diets and of the 2 ingredients will be assessed in terms of FUp (net energy for growing pigs) and of nitrogen utilisation. In addition, the availability of calcium,

phosphorus selected trace minerals and vitamin E will be determined.

Task 1.3

Production experiment with pregnant sows will be conducted at the organic farm Rugballegård by the use of first year clover grass. Three plots will be used by three different groups of grazing sows. Each plot will be divided into 3 paddocks for rotational grazing. Fifteen sows in their first stage of pregnancy will be divided in three groups of 5 and allotted the experimental plots. Sows within plots will be given access to rotational grazing by weekly occupation of each paddock. Across plots sows will be subjected to three different feed strategies. The experiment will consist of four turns of 8 weeks each. In two turns sows will be given concentrate diets varying in composition, and in two turns different levels of daily concentrate allowance will be tested. The experiment with grazing will thus comprise four batches of 15 sows. In wintertime sows will be offered clover grass silage ad libitum.

Grass intake of sows will be estimated by the difference between measured herbage mass before and after grazing plus the herbal growth in between. Botanical composition before and after grazing will be measured to calculate selection by the sows. Sow production will be evaluated by measuring weight changes and condition score twice monthly. Concentrate and grass intake will be recorded. The overall N balance will be estimated. Vitamins and mineral status of the sows will be monitored in blood samples prior to farrowing and in blood and milk samples after farrowing.

Deliverables.

- D1.1. Protocol for experiment with pregnant sows, 1.replicate.
- D1.2. Protocol for digestibility experiments
- D1.3. Protocol for experiment with slaughter pigs, 1.replicate.
- D1.4. Progress report
- D1.5. Progress report
- D1.6. Progress report including the results of digestibility and balance experiments
- D1.7. Progress report including the results of experiments with pregnant sows
- D1.8. Progress report including the results of experiments with slaughter pigs
- D1.9. Final report
- D1.10. Dissemination of results

Milestones

- M1.1. Formulation of recommendations for organic pig production with respect to the usage of lupin under consideration of:
 - overall performance of pigs
 - impact on the environment of N and P output
- M1.2. Formulation of recommendations for organic pig production regarding the supply of vitamin and minerals to slaughter pigs
- M1.3. Formulation of recommendation for outdoor keeping of pregnant sows under consideration of summer and winter feeding methods

WP2: Feeding strategies for weaned pigs and growing-finishing pigs with emphasis on gut health

Workpackage number:	2
Start date or starting event:	01.07.2001
Responsible person:	Knud Erik Bach Knudsen
Contributing persons:	M. T. Sørensen, E.-M. Vestergaard, S. K. Jensen, H. D. Poulsen, H. Maribo
Person-months:	16 scientific + 16 technical

Objectives

The main objective of this work packet will be to develop feeding concepts that can be used to improve the animals' resistance against infectious diseases of the gastrointestinal tract. Specifically we will address the following questions:

- Develop feeding strategies that minimises weaning diarrhoea in organic pig farming
- Create a platform for further improvements of these strategies
- Evaluate the effects of diets varying in digestible and nondigestible carbohydrates on the resistance to *T. suis* infection
- Evaluate the effects of diets varying in carbohydrate composition on establishment of dual infections with *T. suis* and *B. pilosicoli* infection

Description of work

Task 2.1:

Gut challenge and diet screening

One of the obstacles with work on prevention of diarrhoea is that diarrhoea seldom is present in experimental animals, therefor making tests of potential cures difficult. One way to overcome this drawback is to introduce a challenge at the gut level that will initiate or imitate diarrhoea conditions. Could diarrhoea conditions be initiated or imitated, test of factors with potential anti-diarrhoea effects would be more reliable. We intend to challenge the gut by an oral dose of *E. coli* O149 and screen different dietary factors (and factor levels) for their relative importance before they are tested under practical conditions (see task 2.2). Diets with defined levels of protein, energy etc. will, one factor at the time, be fed to newly weaned individually stalled piglets, coming from an outdoor system and weaned at 7 weeks of age. Pairwise on each diet factor level, the piglets serve as control respective get a challenge with *E. coli* (10^{10} cfu/day) orally by stomach tube on days 1-3 after weaning. Clinical signs of diarrhoea, feed intake and growth will be monitored for two weeks. It may be necessary with some modification of this infection model with respect to inoculation dose and duration as it was developed to induce diarrhoea in piglets at 4 weeks of age.

Task 2.2:

Effect of dietary factors on weaning diarrhoea

Different diets will be offered to piglets and weaned pigs to study their effect on weaning diarrhoea. Selection of diets to be studied will be based on results from the literature, common practice and the outcome of the screening in task 2.1. Among potential factors to be studied are energy/feeding level and the dietary level of protein, milk products, nondigestible carbohydrates, vitamin E and zinc. The selected diets will be given to different organic farmed litters from 4 weeks of age. They continue with the same diet after weaning at 7 weeks of age. Clinical signs of diarrhoea, feed intake and growth will be monitored for two weeks after weaning. A blood sample will be taken at day 7 after weaning and measured for vitamin E, zinc, and growth factors when appropriate. Representative

pigs will be slaughtered at day 14 after weaning and gut tissue samples will be taken and analysed for villi morphology, cell proliferation, thickness of the mucus layer and immunological responses when appropriate.

Task 2.3:

Effect of diets varying in digestible and nondigestible carbohydrates on *T. suis* infection

Two diets with contrasting digestibility of carbohydrates will be formulated from wheat, grass, soybean, lupins as the main ingredients. The main dietary constituent will be wheat. Grass will be used as a source of insoluble resistant fibre and lupins (lupins are ~40 % DF) and chicory roots as sources of soluble and fermentable DF. Amino acid levels and composition will be balanced (as much as possible) by soybean. The two types of diets will be fed to four groups of animals; two of the groups will receive the diet with insoluble resistant fibre and the other two groups the diet with soluble and fermentable fibre. Of the two on each diet, one will be infected with 2000 infectious larva of *T. suis*. The pigs will be slaughtered 8 weeks post infection, the gastrointestinal tract removed and samples taken from the last fourth of the small intestine, the caecum and five, by length, equal sections of colon for parasitological investigations, characterisation of chemical composition and physiochemical properties, organic acid concentrations and gut tissue samples. Parameters measured on the gut tissue samples will be neutral, acidic, and sulfomucins, the volume, height and density of the crypt, the thickness of the muscularis externa, the mitotic counts and apoptosis. Parameters to characterise parasite infection will be faecal egg counts, intestinal worm burdens, worm length and female fecundity.

Task 2.4:

Effect of diets varying in carbohydrate composition on establishment of dual infection with *T. suis* and *B. pilosicoli*

The two diets as used in task 2.3 will be fed to eight groups of pigs; one of the groups on each diet will be the control group (non-infected), one of the groups will be infected only by *T. suis*, another group will be infected by *B. pilosicoli* and the last group will be dual infected with *T. suis* and *B. pilosicoli*. The same procedure as described under task 1 will be followed for collections of samples from the gastrointestinal tract at slaughter and for parasite examination. Additionally, bacterial infections will be monitored by bacteriological examination of faeces and by gross- and histopathological examinations of the intestine.

Methods

The infection model is based on *E. coli* O 149 and will be established at the Danish Institute of Agricultural Sciences as a result of an ongoing Ph.D. project – The influence of feed intake during lactation on piglets susceptibility to post-weaning diarrhoea. *E. coli* O 149 will be applied to the piglets by stomach tube in three daily doses of 1×10^{10} cfu/day. Sows and boars, which deliver the experimental piglets, will be tested genetically for susceptibility to O 149 at RVAU before the piglets are used. The success rate to provoke clinical response is 70-80 percent when *E. coli* is administered to weaned piglets at 4 weeks of age. The challenge has never been carried out before in weaning piglets at 7 weeks of age. Thus the number of inoculation days might be raised from 3 in order to compensate for the difference in piglet age at weaning. Test for *E. coli* O 149 in faecal samples will be performed at the Danish Institute of Agricultural Sciences.

The procedures for performing the infection with *T. suis* and *B. pilosicoli* are established at the Danish Centre for Experimental Parasitology, KVL and the Danish Veterinary Laboratory, which are collaborators for the study with growing-finishing pigs. Sampling of digesta content and gut tissue as well as the methods for analysing the chemical components, gut tissue samples, parasitological samples and bacterial samples are all well established as results of previous achievements. Analyses of feed, digesta and tissue samples will be performed at Danish Institute of Agricultural Sciences, parasitological samples at the Danish Centre for Experimental Parasitology, KVL and the bacterial samples at the Danish Veterinary Laboratory.

Ethic

Application is made to the Danish Board for experimental animals in order to carry out the challenge experiments at DIAS. At the moment EMV has got a 5 years licence from the council to carry out experiments in pigs including specified levels of strain. This challenge model will not exceed the strain of *E. coli* infection at normal production level.

Deliverables

- D2.1 Formulation of feeding strategies for weaned pigs in organic farming
- D2.2 Paper concerning challenge with *E. coli* O 149 and dietary factors
- D2.3 Paper concerning dietary effects on weaning diarrhoea in organic farming
- D2.4. Paper concerning the effect of diets varying in digestible and nondigestible carbohydrates on *T. suis* infection
- D2.5 Paper concerning the impact of carbohydrate composition on the establishment of dual infection with *T. suis* and *B. pilosicoli*

Milestones

- M2.1: Preliminary evaluation of the procedure for gut challenge and diet screening
- M2.2: Final evaluation of the procedure for gut challenge and diet screening
- M2.3: Evaluation of dietary factors on weaning diarrhoea
- M2.4: Preliminary evaluation of dietary effects on *T. suis* infection
- M2.5: Final evaluation of dietary effects on *T. suis* infection
- M2.6: Evaluation of dietary effects on dual infection with *T. suis* and *B. pilosicoli*

WP3: Effects of nutrient supply for growing-finishing pigs on product quality

Workpackage number: **3**
 Start date or starting event: **01.07.2001**
 Responsible person: **Chris Claudi-Magnussen**
 Contributing persons: **L. L. Hansen, H. Maribo**
 Person-months: **7 scientific + 6 technical**

Objectives: It is the objective to investigate the effect of lupin content in the feed on product quality of organic pork. Included is the effect of lupin on skatole in back fat. It is the aim to decide if it can be recommended to use lupin as an alternative protein source in the feed for organic growing-finishing pigs as far as product quality is concerned. If lupin results in lower skatole level in backfat, this may be a way to reduce boar taint in entire male pig.

Furthermore, it is the objective to investigate the effect of the total protein content in the feed on product quality of organic pork. It is the aim to decide if it can be recommended to reduce total protein in the feed for organic growing-finishing pigs as far as product quality is concerned.

Description of work:**Task 3.1.**

From each of 4 treatments (two levels of lupin and two levels of protein) carcass samples are delivered from 20 gilts and 20 male castrates reared in the experiment described in WP1. The following traits will be analysed:

- Sensory profiling of pork loin (*M. longissimus dorsi*).
- Fatty acid composition in backfat.
- Intramuscular fat in pork loin (*M. longissimus dorsi*).
- Pigment in *M. longissimus dorsi*.
- Warner Bratzler shear force in pork loin (*M. longissimus dorsi*).
- Skatole in backfat (skatole equivalents using the colorimetric method described by Mortensen and Sørensen (1984)).
- pH 24 hours after slaughter in *M. longissimus dorsi*
- Driploss in *M. longissimus dorsi* by the Honnikel method.

Deliverables: D3.1 Protocol for collecting and analysing meat samples July 2002
 D3.2 Half way progress report December 2003
 D3.3 Final report December 2005

Milestones:

M3.1 Formulation of recommendations for organic pig production with respect to the usage of lupin and protein supply under consideration of:

- Product quality of organic pork
- Effect of lupin on reduction of skatole level in blood and backfat.

7 Implementation and time schedule

The project group intends to visualise continuously the results and achieved knowledge for farmers and their advisors. Implementation will be organised through meetings, publications and activities at Research Center Foulum and the organic research station Rugballegård, where most of the experiments will be conducted.

Table 3: Deliverables list

Deliverable, No	Deliverable title	Delivery date	Meeting	Nature
D 1.1	Protocol for experiments with pregnant sows, 1 replicate	Quarter 3 2001		Working document
D 1.2	Protocol for digestibility experiments	Quarter 3 2001		Working document
D 1.3	Protocol for experiment with slaughter pigs, 1. replicate	Quarter 3 2001		Working document
D 1.4	Progress report	Quarter 4 2001		Intern Report
D 1.5	Progress report	Quarter 4 2002		Intern Report
D 1.6	Progress report including the results of digestibility and balance experiments	Quarter 4 2003		DIAS-Report
D 1.7	Progress report including the results of experiments with pregnant sows	Quarter 4 2004		DIAS-Report
D 1.8	Progress report including the results of experiments with slaughter pigs	Quarter 4 2004		DIAS-Report
D 1.9	Final report	Quarter 4 2004		Report
D 1.10	Dissemination of results	Quarter 4 2004	X	Articles
D 2.1	Formulation of feeding strategies for weaned pigs in organic farming	Quarter 2 2005		Report
D 2.2	Paper concerning challenge with <i>E. coli</i> O149 and dietary factors	Quarter 3 2004		Paper
D 2.3	Paper concerning dietary effects on weaning diarrhoea in organic farming	Quarter 2 2005		Paper
D 2.4	Paper concerning the effect of diets varying in digestible and nondigestible carbohydrates on <i>T. suis</i> infection	Quarter 3 2004		Paper
D 2.5	Paper concerning the impact of carbohydrate composition on the establishment of dual infection with <i>T suis</i> and <i>B. pilosicoli</i>	Quarter 2 2005		Paper
D 3.1	Protocol for collecting and analysing meat samples	Quarter 3 2002		Working document
D 3.2	Half way progress report	Quarter 4 2003		Report
D 3.3	Final report	Quarter 4 2004		Report

Table 4: Timetable

TITL E	Co-ordination Quarter	2001*				2002*				2003*				2004*				2005*			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.1 1.2 1.3 M1.1 M1.2 M1.3	WP1: Adequate supply of dietary protein, vitamin and minerals to pregnant sows and growing finishing pigs			X	X	X	X	X	X	X	X	X	X	X	X	X	X				
						X	X	X	X	X	X	X	X	X	X	X	X				
					X	X	X	X	X												
				X	X	X	X	X	X	X	X	X	X	X							
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2.1 2.2 2.3 2.4 M2.1 M2.2 M2.3 M2.4	WP2: Feeding strategies for weaned pigs and growing-finishing pigs with emphasis on gut health			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
				X	X	X	X	X	X	X	X	X	X								
					X	X	X	X	X	X	X	X		X	X	X	X				
								X	X	X	X	X	X	X	X	X					
									M					M							
									M				M								M
																					M
3.1 M3.1	WP3: Effects of nutrient supply for growing-finishing pigs on product quality					X	X	X	X	X	X	X	X	X	X	X	X				
						X	X	X	X	X	X	X	X	X	X	X	X				M

8. Collaborative partners

This project has strong links to the recently appointed EU project QLRT 30162 "Sustainability in the production of pork with improved nutritional and eating quality using strategic feeding in outdoor production" (SUSPORKQUAL) through the project co-ordinator Dr. Anders Hans Karlsson Head of Research Unit for Muscle Biology and Meat Quality at the Danish Institute of Agricultural Sciences. Furthermore, the co-ordinator of WP1 in this project (JAF) is also the co-ordinator of WP1 (Sustainable Pig Production) in the EU project. The two projects, although with different goals, will complement each other. The ultimate goal of SUSPORKQUAL is to improve the nutritional value, increase eating quality (tenderness), shelf life and technological quality of pork. This will be achieved by combining strategic feeding resulting in compensatory (accelerated) growth in the time up to slaughter, with known feeding strategies (enrichment with E-vitamin, PUFA etc.) that gives rise to improved nutritional value of the out-coming pork.

This project is also linked to the DARCOF II project I.5: "Grain legumes and cereals – new production methods for increased protein supply in organic farming systems", which is co-ordinated by Erik Steen Jensen, professor at KVL and in which Knud Erik Bach Knudsen is partner. KEBK is further collaborating with the Danish Centre for Experimental Parasitology, KVL (Allan Roepstorff) and the Danish Veterinary Laboratory (Kristian Møller) and a joint Ph.D. student funded by the Research School for Animal Production will use the data generated from tasks 2.3 and 2.4 in WP2 as parts of her Ph.D. thesis. Ellen-Margrethe Vestergaard is collaborating with professor Jens Peter Nielsen, KVL about the challenge model with *E. coli* O 149 to be used in tasks 2.1 and 2.2. The challenge model is supposed to be implemented as a result of the Ph.D. project – "The influence of feed intake during lactation on piglets susceptibility to post-weaning diarrhoea", which is funded within the framework of the Research School for Animal Production.

The project in question has links to two other DARCOF projects on organic pig production: II.9 "Resource use, environmental impact and economy in organic pig production systems", co-ordinated by John E. Hermansen and II.8 "Management in relation to health and health safety in organic pig production co-ordinated by Jan Tind Sørensen. Both projects are parts of the same DARCOF research programme as this project. The three projects are complementary, but also synergetic, why the collaboration is relevant for the total output.

The project has also links to the project: "Organic production of steers and bioactive forages for grazing livestock". The links are through the project co-ordinator Stig Milan Thamsborg and one of the tasks of the project "Influence of bioactive forages on animal health with emphasis on parasitic infections and effects on meat and eating quality" in steers and pigs. There are links to the organic project "Effect of organic pig production on meat and eating quality" too, project co-ordinator Henrik J Andersen.

Furthermore, the project has links to lupin testing project "Lupinforsøg, Undersøgelser vedrørende kød- og spisekvalitet" by Danske Slagterier (Hanne Maribo).

9. Budget

Institution 1 (DIAS)	2001	2002	2003	2004	2005
Months (scientific)	5	12	12	13,5	4
Months (technical)	1	9	10,5	8	0
Salary (scientific)	190.000	474.000	492.000	574.500	176.000
Salary (technical)	25.000	234.000	284.000	224.000	0
Operation equipment	–				
Operation - other	97.000	336.000	304.000	265.000	30.000
Overhead	62.000	209.000	216.000	213.000	41.000
Total	374.000	1.253.000	1.296.000	1.276.500	247.000

Total amount, DKK 4.446.500

Institution 2 (DMRI)	2001	2002	2003	2004	2005
Months (scientific)		0,7	1,2	1,4	
Months (technical)		0,1	1,8	1,7	
Salary (scientific)		36.600	74.400	88.200	
Salary (technical)		3.600	64.900	66.400	
Operation equipment	–	0	0	0	
Operation - other		6.000	65.100	56.000	
Overhead		9.300	40.900	42.100	
Total		55.500	245.300	252.700	

Total amount, DKK 553.500

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- Petkevicius, S., Nansen, P., Bach Knudsen, K. E. & Skjøth, F. 1999. The effect of increasing levels of insoluble dietary fibre on establishment and persistence of *Oesophagostomum dentatum* in pigs. *Parasite* 6: 17-26.
- Pluske, J. R., Hampson, D. J. & Williams, I. H. 1997. Factors influencing the structure and function of the small intestine in the weaned pig: a review. *Livestock Production Science* 51: 215-236.
- Pluske, J. R., Siba, P. M., Pethick, D. W., Durmic, Z., Mullan, B. P. & Hampson, D. J. 1996. The incidence of swine dysentery in pigs can be reduced by feeding diets that limit the amount of fermentable substrate entering the large intestine. *Journal of Nutrition* 126: 2920-2933.
- Sehested, J., Søgaard, K., Danielsen, V. & Kristensen, V.F., 2000. Mixed grazing with sows and heifers – effects on animal performance and pasture. In: *Ecological Animal Husbandry in the Nordic Countries*, (eds.) J.E. Hermansen, V. Lund & E. Thuen. DARCOF Report no. 2/2000, 35-39.
- Siba, P. M., Pethick, D. W. & Hampson, D. J. 1996. Pigs experimentally infected with *Serpulina hyodysenteriae* can be protected from developing swine dysentery by feeding them a highly digestible diet. *Epidemiology and Infection* 116: 207-216.
- Stege, H., Jensen, T. K., Møller, K., Bækbo, P. & Jorsal, S. E. 2000. Prevalence of intestinal pathogens in Danish finishing pig herds. *Preventive Veterinary Medicine* : (Submitted).
- Wang, T.C., Fuller, M.F., 1989. The optimum dietary amino acid pattern for growing pigs. 1. Experiments by amino acid deletion. *Br. J. Nutr.* 62, 77-89.
- Zabielski, R. (1998). Regulatory peptides in milk, food and in the gastrointestinal lumen of young animals and children. *Journal of Animal and Feed Science* 7: 65-78.
- Zettl, A., F. Lettner, and W. Wetscherek, 1995: Use of white sweet lupin seed (*Lupinus albus* var. Amiga) in a diet for pig fattening. *Bodenkultur*, 46: 165-175.

Appendix:

CV's of central persons, and description of role, qualifications, capacity and experience.

The research group comprising 11 scientists represents a wide fan of expertise, knowledge and experience in relation to as well basic as applied research in pigs.

Viggo Danielsen is responsible for co-ordination of the project and participates in the conduction of WP 1. He has great experience in research on nutrition and feeding of sows. In recent years he has conducted research concerning application of fibrous feeds, roughage and pasture for sows. Experienced in project leading; member of two research groups under DARCOF I (1997-1999).

José A. Fernández is responsible for the co-ordination of Workpackage 1 and for the conduction of Task 1.1 and 1.2. He has many years of experience in research related to the nutrition of the growing pig, particularly on digestion, absorption and utilisation of nutrients from feedstuffs and diets.

Søren Krogh Jensen is responsible for the vitamin part of the project (WP1). During the last decade, He has carried out research within biochemical and physiological important aspects of fat, fatty acids, fat-soluble vitamins (including their antioxidative properties) and the physiological importance of anti-nutrients in rapeseed and legumes

Hanne Damgaard Poulsen is responsible for the mineral part of the project (WP1). She has several years of experience in research of the nutritional and physiological importance of minerals in pigs. In recent years many of her studies relate to nutrient and mineral balances. She collaborated in the project Fibrous feed for growing pigs, DARCOF I (1997-1999).

Martin Tang Sørensen is responsible for the research regarding experiments with the weaned pigs in WP 2.2. He has many years of experience in planning and conducting nutritional experiments with pigs. In recent years he has conducted research with regard to nutrition of gilts in order to maximise subsequent milk production.

Knud Erik Bach Knudsen is responsible for the research on feeding strategies for growing-finishing pigs with emphasis on gut health. KEBK has several years of experience in research in analytical, nutritional and health aspects of carbohydrates. He is member of the research group I.5 under DARCOF II

Ellen-Margrethe Vestergaard is responsible for the research regarding weaning diarrhoea (WP2.1). She has got 5 years experience in laboratory work on bacteriology and more than 10 years of experience in combining the disciplines nutrition and ethology in pigs. In the recent years her work has been related to production diseases and immunology, especially gut immunology in calves and piglets. She holds a 5 year licence to carry out animal surgery and other types of experiments which imply specified levels of strain upon pigs.

Laurits Kristian Lydehøj Hansen Research in understanding of aroma development in fresh and cooked meat including boar taint. Central research areas are the importance of production conditions (feed ingredients and environment) for flavour and aroma development in fresh and cooked meat as well as overall meat quality. In WP3 he is responsible for transport and slaughtering procedure. Besides taking care of measurements of some of the meat qualities.

Christer Ohlsson is responsible for forage production and management in relation to summer (Clovergrass pasture) and winter (Clovergrass silage) feeding of breeding sows (WP 1.3). He has considerable experience in the areas of protein use and protein quality of forages, forage conservation, feed use of forage crops and forage management.

Chris Claudi-Magnussen is responsible for WP3. At Danish Meat Research Institute he is responsible for the effects of primary production factors on meat and eating quality and he has experience as project manager in several projects - including international projects - concerning meat and sensory quality.

Hanne Maribo is participating in WP 1,2 and 3. She is responsible for advising and co-ordination of the research done under the three work packages in relation to the work done in The National Committee for Pig Production. She has worked with nutrition of pigs for the last 3 years and with meat quality in pigs before that. At the moment she is the leader of a project concerning the performance of growing pigs, fed diets containing the Lupin type Prima.

Curriculum Vitae

Viggo Danielsen - born November 3, 1935.

Education

1964 M.Sc. with husbandry as major, the Royal Veterinary and Agricultural University

Employment

1964 - 1984 Scientific assistant the National Institute of Animal Science, Dept of Research in Pigs and Horses.

1984 - Head of Research Unit at the National Institute of Animal Science, Dept of Research in Pigs and Horses, later called the Danish Institute of Agricultural Sciences, Dept of Animal Nutrition and Physiology.

Research Area

Head of Research Unit in the department's group for Nutrient metabolism, growth and lactation. My own research is mainly concentrated on nutrition and feeding of pigs, especially sows, piglets and weaners. During recent years, the focus has been on the effect of feeding strategies and diet composition on sow reproduction, milk yield and the development of piglets. The work on young pigs is especially aimed at optimising feeding in connection with weaning. Some of the present experiments are carried out under organic production conditions with outdoor sows and growing finishing pigs in alternative housing systems. Experienced as project leader. I am main author or co-author of 251 publications.

Relevant publications

Danielsen, V., Lydehøj Hansen, L., Møller, F., Bejerholm, C. & Nielsen, S., 2000. Production results and sensory meat quality of pigs fed different amounts of concentrate and ad lib. Clover grass and clover grass silage. Proc. NJF-seminar, 303: Ecological Animal Husbandry in the Nordic Countries, 79-86.

Danielsen, V., Poulsen, H.D., Jensen, S.K., Ohlsson, C. 2000. [The supply of pigs with essential nutrients and roughage] In: Økologisk svineproduktion, udfordringer, muligheder og begrænsninger (J.E. Hermansen, ed.) FØJO-report no.8, 95-119.

Kristensen, V.F., Sehested, J., Danielsen, V., Søegaard, K. & Kristensen, T., 1998. [Joint grazing for pigs and cattle]. In: [Research in organic pig production] (J.E. Hermansen, ed.). FØJO-report no. 1, 53-55. Research Center for Organic Farming.

Sehested, J., Søegaard, K., Danielsen, V. & Kristensen, V.F., 2000. Mixed grazing with sows and heifers – effects on animal performance and pasture. In: Ecological Animal Husbandry in the Nordic Countries, (eds.) J.E. Hermansen, V. Lund & E. Thuen. DARCOF Report no. 2/2000, 35-39.

Vestergaard, E.-M. & Danielsen, V., 1998. Dietary fibre for sows: Effects of large amounts of soluble and insoluble fibres in the pregnancy period on the performance of sows during three reproductive cycles. *Animal Science* 68, 335-362.

Curriculum Vitae

José Adalberto Fernández
Danish Institute of Agricultural Sciences, Tjele

Born 11. 07 1943

Education and degrees

Master of Sciences in Agriculture: The Royal Veterinary and Agricultural University, Copenhagen, Denmark, 1974

Ph.D. in monogastric nutrition. The Royal Veterinary and Agricultural University, Copenhagen, Denmark, 1992

Positions

Jul. 1974 - : Scientific assistant at the Royal Veterinary and Agricultural University's study administration office.

Sept. 1977 - 1993: Research officer at the National Institute of Animal Science, Department for Research in Pigs and Horses.

March 1993 - : Senior Research Scientist at (formerly) The National Institute of Animal Science, Department for Research in Pigs and Horses, (currently) Department of Animal Nutrition and Physiology, Danish Institute of Agricultural Sciences, Tjele.

Selected publications

Fernández, J. A. and Batterham, E. S., 1995. The nutritive value of lupin-seed and dehulled lupin-seed meals for growing pigs as evaluated by different techniques. *Anim. Feed Sci. Technol.*, 53, 279-296.

Fernández, J. A. 1999. Ernæringsmæssig vurdering af grovfoder og fiberrige fodermidler til svin. I: Jakobsen K. og Danielsen V.(red.) Temamøde vedr. grovfoder og fiberrige fodermidler til svin. Marts 1999. DJF Intern rapport nr. 117: 30-33.

Danfær, A. & Fernández, J.A. 1999. Developments in the prediction of nutrient availability in pigs - a review. *Acta Agric. Scand., Sect. A, Anim. Sci.* 49, 73-82.

Fernández, J.A., Poulsen, H. D., Boisen, S. & Rom, H.B. 1999. Nitrogen and phosphorus consumption, utilisation and losses in pig production: Denmark. In: Fernández, J.A. & Fuller, M.F. (Eds.), Nitrogen and phosphorus nutrition of the pig. *Livest. Prod. Sci.* 58, 225-242.

Jørgensen, H., Gabert, V.N. & Fernández, J.A. 1999. Influence of nitrogen fertilisation on the nutritional value of high-lysine barley determined in growing pigs. *Anim. Feed Sci. Technol.* 79, 79-91.

**Curriculum Vitae
for Senior research scientist
Søren Krogh Jensen, agronomist, Ph.D**

Graduated as master of science in agronomy from KVL in 1987 and as Ph. D. in 1991. Since 1991 he has worked at DIAS with research within animal nutrition with special emphasis on fat soluble vitamins, antioxidants, lipids and lipid oxidation in relation to nutrition, animal product quality and animal health. In addition part of the research has been within the area of antinutrients in rapeseed and legumes. A considerable part of the research has been developing of analytical methods within the area, preferable on HPLC and GC.

Relevant experience of the responsible scientist: Søren Krogh Jensen has during the last decade carried out research within biochemical and physiological aspects the importance of fat, fatty acids, fat-soluble vitamins (including their antioxidative properties), as well as the physiological importance of anti-nutrients in rapeseed and legumes. The work has been published in more than 60 publications within the area of basic physiology, the importance of nutrition on animal product quality and animal health, as well as development of new sensitive analytical methods on HPLC and GLC.

References:

- Johannsen, A.K.B., Jensen, S.K. & Jakobsen, K. 1998. A note on vitamin A activity of β -carotene in broilers. *Acta Agric. Scand. Sect. A Animal Sci.* (48) 260-263.
- Jensen, S.K., Engberg, R.M. & Hedemann, M.S. 1999. All-*rac*- α -tocopherol acetate is a better vitamin E source than all-*rac*- α -tocopherol succinate for broilers. *Journal of Nutrition* (129) 1355-1360.
- Jensen, S.K., Johannsen, A.K.B. & Hermansen, J.E. 1999 Quantitative secretion and maximal secretion capacity of retinol, β -carotene and α -tocopherol into cow's milk. *Journal of Dairy Research* (66) 511-522.
- Grela, R.G., Jensen, S.K. & Jakobsen, K. 1999. Fatty acid composition and content of tocopherols in raw and extruded grass pea (*Lathyrus sativus* L). *Journal of the Science of Food and Agriculture* (79) 2075-2078.
- Lauridsen, C., Jensen, S.K., Skibsted, L.H. & Bertelsen, G. 2000. Influence of supranutritional vitamin E and copper on α -tocopherol deposition and susceptibility to lipid oxidation of porcine membranal fractions of *M. Psoas major* and *M. Longissimus dorsi*. *Meat Science* (54) 377-384.

Curriculum vitae
Hanne Damgaard Poulsen

Born: 1952 February 25th

Education:

1994 Ph.D., The Royal Veterinary and Agricultural University, Copenhagen
1980 cand. scient. (biology), University of Aarhus

Positions:

1996- Senior Research Scientist, Danish Institute of Agricultural Sciences
1994-1995 Research Scientist, National Institute of Animal Science
1991-1993 Post graduate student, Danish Research Academy/National Institute of Animal Science
1984-1991 Research Scientist, National Institute of Animal Science
1981-1984 High school teacher

Working field:

Nutrition of pigs. Metabolism of minerals. Availability and utilisation of minerals. Interactions between minerals. Mineral requirement. Nitrogen and mineral balances.

Selected publications:

Danielsen, V., Poulsen, H.D., Jensen, S.K. & Ohlsson, C. (2000). Svinenes forsyning med næringsstoffer og grovfoder. I: Hermansen, J.E. (red.): Økologisk svineproduktion. Udfordringer, muligheder og begrænsninger. FØJO rapport nr. 8, 95-119

H.D. Poulsen, A.W. Jongbloed, P.Latimier and J.A. Fernández (1999). Phosphorus consumption, utilisation and losses in pig production in France, The Netherlands and Denmark. *Livest. Prod. Sci.* 58, 251-259

Carlson, D., Lærke, H.N., Poulsen, H.D & Jørgensen, H. (1999). Roughages for growing pigs, with emphasis on chemical composition, ingestion and faecal digestibility. *Acta Agric. Scand., Sect. A., Anim. Sci.* 49, 129-136

Carlson, D., Johansen, H.N., Poulsen, H.D. & Jørgensen, H. (1998). Fordøjelighed og udnyttelse af grovfoder til slagtesvin. FØJO-rapport nr. 1, 13-17

Poulsen, H.D. (1998). Zinc and copper as feed additives, growth factors or unwanted environmental factors. *J. Anim. and Feed Sci.* 7, 135-142

**Curriculum for
Martin Tang Sørensen
Senior research scientist, Ph.D.**

Department of Animal Nutrition and Physiology, Foulum Research Centre, DIAS.
Phone 89991554, Fax 89991525, E-mail: martint.sorensen@agrsci.dk

CV (brief): Born 1949. Cand. agro. 1977 (RVAU), M.Sc. 1979 (University of Guelph, Canada), PhD 1987 (RVAU). Positions at National Institute of Animal Science and Danish Institute of Agricultural Science since 1979.

Referee: Various "animal science" journals.

Sabbaticals: 1977-79 University of Guelph, Guelph, Canada. 1989-90 Pennsylvania State University, State College, USA. 1996 Agriculture Canada, Lennoxville, Canada.

Main research:

Nutrition of pigs, e.g. nutritional effects on mammary gland development in gilts. Lactation physiology in sows and cows (hormones, cell proliferation, apoptosis, enzyme activities). Hormone receptor work. Effects of growth hormone on tissue deposition in pigs.

Experience as project leader:

Project leader experience of projects financed by SJVF, European Union, Ministry of Agriculture and private sources.

Publications

1. Sørensen, M.T., Oksbjerg, N., Agergaard, N. & Petersen, J.S., 1996. Tissue deposition rates in relation to muscle fibre and fat cell characteristics in lean female pigs (*Sus scrofa*) following treatment with porcine growth hormone (pGH). *Biochem. Physiol.* 113A, 2, 91-96
2. Sørensen, M.T., Danielsen, V. & Busk, H., 1998. Different rearing intensities of gilts. I. Effects on subsequent milk yield and reproduction. *Livest. Prod. Sci.* 54, 159-165.
3. Sørensen, M.T. (1998). Yverets udvikling hos svin – muligheder for påvirkning. I: Ernæring af pattegrise og smågrise (red. Kirsten Jakobsen og Viggo Danielsen). Intern Rapport nr. 107, Danmarks JordbrugsForskning, 5-7.
4. Farmer, C., Sorensen, M.T., Roberts, S. & Petitclerc, D., 1999. Administrating exogenous porcine prolactin to lactating sows: Milk yield, mammary gland composition, and endocrine and behavioral responses. *J. Anim. Sci.* 77, 1851-1859.
5. Nielsen, O.L., Pedersen, A.R. & Sørensen, M.T. 2001. Relationships between piglet growth rate and mammary gland size of the sow. *Livestock Production Science* 67, 273-279.

Curriculum Vitae for Knud Erik Bach Knudsen

Personal data:

Born June 10, 1952, Stauning, Denmark

Education:

1977 M.Sc. in agronomy (Nutrition), Royal Veterinary and Agricultural University, Copenhagen

1980 Ph.D. (Lic. agro.), Royal Veterinary and Agricultural University, Copenhagen

Employment:

1974-1975 Scholarship, Royal Veterinary and Agricultural University, Dept. of Plant Nutrition

1977-1980 Research grant, Royal Veterinary and Agricultural University, Dept. of Animal Physiology

1980-1983 Researcher, Carlsberg Research Laboratory, Dept. of Biotechnology

1983-1986 Senior research grant, Royal Veterinary and Agricultural University, Dept. of Animal Physiology

1986-1991 Research scientist, National Institute of Animal Science, Dept. of Animal Physiology and Biochemistry

1992-1998 Senior scientist, Danish Institute of Agricultural Sciences, Dept. of Animal Nutrition and Physiology

1998- Head of Research Unit, Danish Institute of Agricultural Sciences, Dept. of Animal Nutrition and Physiology

2000- Professor, Danish Institute of Agricultural Sciences, Dept. of Animal Nutrition and Physiology

Studies abroad:

1984 Visiting scientist, Swedish Agricultural University, 1984

1987-1988 Visiting scientist, USDA-Human Nutrition Research Center, Nutrient Composition Laboratory, Beltsville, MD.

Relevant publications

Petkevicius, S., K. E. Bach Knudsen, P. Nansen, A. Roepstorff, F. Skjøth and K. Jensen (1997). The impact of diets varying in carbohydrates resistant to endogenous enzymes and lignin on populations of *Ascaris suum* and *Oesophagostomum dentatum* in pigs. *International Journal of Parasitology* **114**, 555-568.

Petkevicius, S., M. Larsen, K. E. Bach Knudsen, P. Nansen, J. Grønvold, S. Aa. Henriksen and J. Wolstrup (1998). The effect of nematode-destroying fungus *Duddigittinia flagrans* against *Oesophagostomum dentatum* larvae in faecal from pigs fed different diets *Helminthologia* **35**, 111-116.

Petkevicius, S., P. Nansen, K. E. Bach Knudsen and F. Skjøth (1999). The effect of increasing levels of insoluble dietary fibre on the establishment and persistence of *Oesophagostomum dentatum* in pigs. *Parasite* **6**, 17-26.

Bach Knudsen, K. E., H. Jørgensen and N. Canibe (2000). Quantification of the absorption of nutrients deriving from carbohydrate assimilation: Model experiment with catheterised pigs fed on wheat and oat based rolls. *British Journal of Nutrition* **84**, 449-458.

Petkevicius, S., K. E. Bach Knudsen, P. Nansen and K. D. Murrell (2001). The effect of dietary carbohydrates with different digestibility on the population of *Oesophagostomum dentatum* in the gastrointestinal tract of pigs. *Parasitology* (Submitted).

Curriculum Vitae
Ellen-Margrethe Vestergaard (EMV)

Date of birth: 12. November, 1954
Nationality: Danish
Qualifications: 1982. Veterinary scientist (DVM) from RVAU
1991. M. Sc. Animal Science from RVAU
1998. Ph.D. from RVAU
Present position: Senior scientist, Unit for Production Diseases and Immunology, Dept. of Animal Health and Welfare, Danish Institute of Animal Science, Foulum, DK-8830 Tjele, Denmark

Research experience

1982 (Jan.-Marts). Meat inspecting officer, Danish Slaughterhouses, Odense, DK. 1982 (April-December) Food public health officer, Municipal Food Control, Silkeborg, DK. 1983-87. Scientist at the Danish Veterinary Laboratory, Copenhagen, DK, employed to develop and use ELISA to identify Salmonella dublin infected cattle, including bacteriological verifications of the serological responses. From 1988 scientist at Dept. of Research in Pigs and Horses, DIAS, and from 1995 scientist at Dept. of Animal health and Welfare, DIAS. From 1999 senior scientist at the unit of Production Diseases and Immunology, combining the knowledge of nutrition, ethology and immunology in animal experiments. Carry experimental licence from the Danish National Board to make surgical procedures and other types of experiments involving specified levels of strains applied upon pigs.

Membership of scientific societies

Member of the Danish Veterinary Association and the Association of Agricultural Candidates.

Selected publications

Danielsen, V. & Vestergaard, E.-M. (2001). Dietary fibre for pregnant sows: - effect on performance and behaviour. Anim. Feed Sci. and Techn. (in press).

Olsen, A.W., Vestergaard, E.-M. & Dybkjær, L. (2000). Roughage as additional rooting substrates for pigs. Anim. Sci., 70, 451-456.

Vestergaard, E.-M. (1998). The effect of dietary fibre on welfare and productivity of sows. PhD.-thesis from RVAU, pp. 104.

Vestergaard, E.-M. & Danielsen, V. (1998). Dietary fibre for sows: Effects of large amounts of soluble- and insoluble fibres in the pregnancy period on the performance of sows during three reproduction cycles. Animal Science, 68: 355-362.

Vestergaard, E.-M. & Jørgensen, E. 1998. Stochastic dynamic modelling of respiratory diseases in pigs. Biology of Animal stress: Implications for Animal Well-Being. Conference at University of California, Davis, poster and abstract.

CURRICULUM VITAE

I. Personal data.

Name: Laurits Kristian Lydehøj Hansen.
 Born: 14th. February 1947 in Allerslev sogn.
 Address: Vingevej 33, Ørum, DK-8830 Tjele.
 General Certificate of Education: Undergraduate (Student mat. fys.) from Herlufsholm.
 Agricultural education: Agricultural school (Næsgaard Agerbrugsskole) and practice on farms in the period 1967-69.
 Position: Senior scientist,
 Private Telephone no.: (+45) 86 652495

II. Scientific Education.

Graduate: Cand. Agro. 1973 from The Royal Veterinary and Agricultural University, Copenhagen. Dept. of Animal Science (Pig Breeding and Feeding)
 Special subject: Congenital inheritance in *Sus Scrofa*.
 Scientific Education: Mathematics and statistics (Ph.D. education), The Royal Veterinary and Agricultural University of Copenhagen. 1976.
 Philosophiae Doctor (Ph.D.) at The Department of Animal Science & Health The Royal Veterinary & Agricultural University, Copenhagen, 1995.
 A dissertation for the Ph.D.-degree: "Influence of environment and genetics on boar taint (skatole) in females, castrates, and entire male pigs", 60 pp. Sct. Antonius Price in 1994.
 Price:

III. Positions:

Danish Institute of Animal Science: Research Scientist at The Danish Institute of Animal Science Dept. for Research in Pigs and Horses, from 1st of July 1974¹ to 31st of July 1995, and then at The Dept of Product Quality until 31st Marts 1997.
 Danish Institute of Agricultural Sciences: Senior Scientist 1st of April 1997 at The Danish Institute of Agricultural Sciences, Dept. of Animal Product Quality

IV. Research Activities.

Scientific work: Chairman of Research Area IV: "Environment, production technique and economy" in the period 1983-85.

Research Activities: My research work has been concentrated on the effects of environmental factors in the pig house on behaviour, health, production results and meat quality in swine (in the period from 1974 to 1991). In the period from 1992-1997 my work was on the influence of environment and genetics on boar taint. This resulted in a dissertation for the Ph.D.-degree: "Influence of environment and genetics on boar taint (skatole) in females, castrates, and entire male pigs", 60 pp, several international publications and chapter 8 "Influence of environmental factors and antibiotics on skatole in pigs" in the book "Skatole and boar taint" published by Danish Meat Research Institute, 1998.

From the 1st of April 1997 my research work contributes to a basal description and understanding of aroma development fresh and cooked meat. Central research areas are: The importance of production conditions for flavour- and aroma development in fresh and cooked meat.

V. References.

1. * Hansen, L.L., Larsen, A.E., Jensen, B.B., Hansen-Møller, J. & Barton-Gade P., 1994. Influence of stocking rate and faeces deposition in the pen at different temperatures on skatole concentration (boar taint) in subcutaneous fat. *Anim. Prod.* **59**, 1, 99-110.
2. * Hansen, L.L., Larsen, A.E., Jensen, B.B. & Hansen-Møller, J. 1997. Short time effect of zinc bacitracin and heavy fouling with faeces plus urine on boar taint. *Animal Science*, **64**, 351-363.
3. * Hansen, L.L., Mikkelsen, L.L., Agerhem, H., Laue, A., Jensen, M.T. & Jensen, B.B. 1997. Effect of fermented liquid feed and zinc bacitracin on microbial metabolism in the gut and sensoric profile of *M. Longissimus dorsi* from entire male and female pigs. In: Bonneau, M., Lundström and Malmfors, B (editors) Boar taint in entire male pigs. Proceedings of a meeting of the EAAP working group "Production and Utilisation of Meat from Entire Male Pigs". EAAP Publication No. 92, Stockholm, Sweden, 1-3 October 1997, Wageningen Pers, 92-96.
4. *Hansen, L.L., Mikkelsen, L.L., Agerhem, H., Laue, A., Jensen, M.T. & Jensen, B.B. 2000. Effect of fermented liquid food and zinc bacitracin on microbial metabolism in the gut and sensoric profile of *m. longissimus dorsi* from entire male and female pigs. *Anim. Sci.* **71**, 65-80.
5. Danielsen, V., Hansen, L.L., Møller, F., Bejrholm, C. & Nielsen, S. 2000. Production results and sensory meat quality of pigs fed different amounts of concentrate and ad lib. clover grass or clover grass silage. In: Hermansen, J.E., Lund, V. and Thuen, E. (editors) Ecological Animal Husbandry in the Nordic Countries. Proceedings from NJF-seminar No. 303, Horsens, Denmark 16–17 September 1999. Danish Research Centre for Organic Farming 2000, 79-86.

Curriculum Vitae

Family Name: Ohlsson
First Name: Christer
Date of Birth: 24 March 1961
Nationality: Swedish
Civil Status: Married

Education:

Name of Institution: Iowa State University, Dept. Agronomy.
 Ames, Iowa USA
 Date of Start: April, 1987
 Date of Completion: January, 1991
 Degree or Diploma: **Ph.D.** Crop Production and Physiology

Name of Institution: Iowa State University, Dept. Agronomy.
 Ames, Iowa USA
 Date of Start: January, 1985
 Date of Completion: April, 1987
 Degree or Diploma: **M.Sc.** Crop Production and Physiology

Name of Institution: University of Minnesota, St. Paul, Dept. Agronomy.
 St. Paul, Minnesota USA
 Date of Start: March, 1982
 Date of Completion: December, 1984
 Degree or Diploma: **B.Sc.** Agronomy

Employment:

Date of Start: September, 1993
 Date of Completion: Still holding position

Senior Scientist at the Department of Crop Physiology and Soil Science. Danish Institute of Agricultural Sciences, Research Center Foulum, Denmark. Areas of work include protein use and protein quality of forages, forage conservation, feed use of forage crops, and system studies at dairy farms.

Date of Start: March, 1991
 Date of Completion: September, 1993

Research leader (Ass. Professor) at the Department of Animal Nutrition and Management, in the section of forage preservation and technology, Swedish University of Agricultural Sciences, Uppsala. Areas of work included use of additives in silage conservation, forage management, and feeding trials with reindeer.

Date of Start: February, 1990
 Date of Completion: January, 1991

Full-time predoctoral research associate at the Department of Agronomy, Iowa State University. Leader of forage research project for 12 months until a full time replacement was found.

Five recent and relevant publications:

Ohlsson, C. 1998. Grass baleage - Chapter 10. *In* Grass for Dairy Cattle (Eds. D. Cherney and J. Cherney). Pp. 253-282. CABI Publishing, Wallingford Oxon, UK.

Sundberg, M. and C. Ohlsson. 1998. Skörd och ensilering av helsäd. Teknik för Lantbruket 71:1-15. Jordbrukstekniska Institutet, Uppsala Sverige. ISSN 0282-6674.

Ohlsson, C. 1998. Effects of silage additives, harvest date and particle reduction on quality of whole-crop barley ensiled in round bales in Denmark. G. Nagy and K. Petö (eds.). *Grassland Science in Europe* 3:813-817.

Nielsen, K.A., C. Ohlsson, R. Thøgersen & E. S. Nielsen. 1998. Ensilering. Pp. 1-27. Landbrugets Rådgivningscenter, Udkærvej 15, Skejby, 8200 Århus N.

Lättemäe, P., C. Ohlsson, and P. Lingvall. 1996. The combined effect of molasses and formic acid on quality of red-clover silage. *Swedish J. agric. Res.* 26:31-41.

Sammendrag af CV for Chris Claudi-Magnussen

Age: 45
Education: M.Sc., Ph.D.
Place of work: Danish Meat Research Institute
Occupation: Project manager in Department of Pork and Beef Quality

Selected publications:

C. Claudi-Magnussen. **1999**. Økologisk svineproduktion. Sammenligning af økologiske og konventionelle detailprodukters kød- og spisekvalitet. Rapport af 22. september. Ref. nr. 17.258/01 (0071). Slagteriernes Forskningsinstitut. Roskilde.

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CURRICULUM VITAE

Name: Hanne Willemoes Maribo
Date of birth: 31. august 1963
Education: M.Sc, PhD, Animal Science
1990: M. Sc. Animal Science Royal Veterinary and Agricultural University
1998: PhD Meat Technology: Thesis: Effect of Slaughter Process on Temperature, pH fall and Meat Quality in Pigs.

Employment:
1990-1998 Danish Meat Research Institute Project leader
1998- The National Committee for Pig Production Danish Baon and Meat Council. The Department for Nutrition and Reproduction

Publications: Maribo, H., Ertbjerg, P., Olsen, E.V., Barton-Gade, P.A. & Juel Møller, A. 1999. Electrical stimulation of Pork .- Effect on pH fall, Meat Quality and cathepsin B+L activity. *Meat Sci.*, 52 (179-187).

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At as result of my latest employment, I have been writing several Danish reports and articles on nutrition of pigs.