Organic pig production – With particular reference to Danish production conditions

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Abstract

While there is a markedly growth in organically farmed land and in the organic food sector as such in Europe and North America, the organic pig sector has not developed correspondingly in most countries. This weaker development seems most likely to be due to difficulties for pig producers to comply with the organic standards, which impose comparatively more pronounced changes in the way of production than e.g. in ruminant production systems. Pig should have access to roughage and to grazing in the summer period although finishers can be kept in barns if access to an outdoor rum. A common way to comply with these regulations is to have sows on grassland all year round, but to rear the finishers in stables. Outdoor piglet production can be very efficient but careful measures needs to be taken to avoid environmental risks. Ringing of sows to avoid rooting on the grassland is a matter of concern. The regulations for housing include a considerable larger area per pig than in conventional production. This support good production and health results in the finisher production, and the regulation stating no tail docking does not seem to impose problems. However, such stables are often very expensive to establish and outdoor rearing of finishers throughout the growing period should be considered. Recent results indicate that this is a viable option. The ban on use of synthetic amino acids and GMO products for feeding represent a challenge in the feeding of finishers. There is a risk regarding carcass quality when soybean meal and amino acid are substituted with more oil rich ingredients for protein supply. On the other hand inclusion of new protein sources in the diet may results in particular meat quality characteristics including positive effects. It is concluded that there is a need in organic pig production to produce “new” products, which differ from the conventional pork products in order to comply with consumer expectations.

1. Introduction

There is a growing interest in organically produced food in Europe and North America. In the EU-15 the organically farmed area grew by 67% from 1998 – 2000 (Duchateau, 2003) and the estimated animal growth within the organic food sector is estimated to 5 – 25% in several European countries and in North America in the period 2003 – 2005 (ITC, 2002).

Livestock often plays a major role in organic production, due to the ability of livestock to recycle plant nutrients within the farming system. However, an imbalance exists in that ruminants and layers are the major livestock species reared under organic production conditions compared to pork and broilers. In Denmark, for instance, the share of organic holdings with milk- and egg production

are approximately the same as the share within conventional production (18 and 12% respectively) whereas the share of pig herds within the organic holdings amount to only 8% in comparison with 23% for conventional holdings (Plant Directorate, 2004b). In UK, it is estimated that only 2.5% of all registered organic producers had pigs in 1999 (ADAS, 2001) and in Germany, the proportion of organic pork production of total pork production was estimated to 0.25% (corresponding to 10,000 tonnes) whereas organic milk production had a share of 1.2% of total milk production (Willer, *et al*., 2002). In Belgium and The Netherlands, the organic pig production is reported to grow very fast from 1999 – 2000 and amounting to 10,000 and 25,000 pigs, respectively in 2000 (Duchateau, 2003). Contrary to this development, the size of the organic pig production in Denmark stabilized in the period since 1999. In table 1 is given the development of the organic pig production in Denmark. It appears that following a markedly growth from 1996 to 1999, the number of sows and finishers produced have stabilized around 4,000 and 70,000, respectively. In the same period, number of herds declined considerably, reflecting an increased professionalism in the production. In fact, only 30 organic pig producers produce approximately 50% of the finishers.

Table 1. Scale of organic pig production in Denmark, 1996 – 2003.

Year	Number of herds	Sows *(n)*	Finishers produced *(n)*
1996	210	1,073	18,000
1997	335	1,726	20,000
1998	448	2,966	47,000
1999	535	4,084	63,000
2000	483	3,344	64,000
2001	400	3,939	62,500
2002	364	4,078	74,000
2003	292	3,694	70,000

As recent Danish (Bredahl, 2004) and American (Wheatley, 2003) investigations indicate that there is a place for organic pork consumption, there is no reason to believe that the weaker development of organic pig production compared to other organic branches is related to a different consumer preference. It is more likely that the feeble development is due to the fact that it is far more difficult for farmers to change the production system for pigs compared to production systems for cows and other ruminants in a way that provides a harmonious balance between the different aims of organic farming.

2. Guidelines and regulations

Organic production methods must meet the basic standards of the International Federation of Organic Agricultural Movements (IFOAM, 2000). These basic principles are not very detailed, but form the foundation for legal regulation in local, national, or international bodies. The IFOAM basic standards state, in relation to livestock, that the farming practice should facilitate: Production of food of high quality in sufficient quantities; interactions in a constructive and life-enhancing way with natural systems and cycles; maintenance of the genetic diversity of the production system, creation of a harmonious balance between crop production and animal husbandry; and for all livestock, provision of life conditions with due consideration for the basic aspects of their innate behaviour. Recently, the joint FAO/WHO Standard Programme, the Codex Alimentarius Commission, has developed guidelines for organic animal production in order to facilitate a fair trade with organic products.

Within the EU, organic production must also meet the rules laid down in Council Regulation (EC) No. 1804/1999 of 19 July 1999. The EU regulation is very detailed and is a good example of how the basic standards of organic farming are implemented. It includes specifications for housing conditions, animal nutrition, and animal breeding, as well as animal care, disease prevention, and veterinary treatment. In different countries or different certification bodies, stricter rules can be implemented. As a consequence, it is possible to have several organic pig production methods due to different practices or different regulations in different countries. In Denmark, e.g. it is not allowed to wean the piglets before 49 days of lactation (compared to 40 days required by the EU legislation) and in Sweden it is mandatory to keep finishers on grassland in the period May-September.

Some of the regulation within the EU, which characterise organic pig production and thereby distinguish the production conditions markedly from the conventional pig production, are:

- The pigs needs access to grazing area at least 150 days in summer time. However, growing pigs may be housed in barns if they have access to outdoor areas for at least 80% of their lifetime
- Increased area requirements for housing (e.g. 2.3 m^2/pig for finishers)
- Weaning age of minimum 40 days
- All animals needs access to roughage
- 100% organically produced feed (from 2005) and no use of synthetically produced amino acids
- No tail docking

A more detailed overview of the regulation is given by Hermansen et al. (2003). In the following it will be discussed how this regulation affects the layout and the management of the production systems and further, which consequences the regulation may have for productivity, animal welfare, environment, and product quality, which are important issues in organic production and prerequisites for an expansion of the organic pig production.

3. Sows on pasture

According to the organic regulations, sows have to be on pasture for at least 150 days during summertime. However, in Denmark most of the organic producers have chosen to keep the sows on pasture throughout the year. The reason for this is probably that a number of conventional farmers had positive experiences with keeping sows outdoors all year round. In this way, only one production system is necessary for the sow herd instead of both a system for summer housing and a system for winter housing. In this kind of system the productivity on a per-litter basis is comparable to indoor systems, whereas, due to the longer lactation length, the overall productivity with respect to number of weaned pigs per sow per year is lower. Five Danish sow herds thus weaned in average ten piglets per litter and 20.5 piglets per sow annually (Lauritsen et al., 2000). Regarding the layout of the paddocks, this differs between farms and depends on soil type and the land available to the individual farm. The paddocks are usually moved to a new field every spring, often in a two-year crop rotation - one year with barley with an under-sown grass-ley and one year with sows on pasture. The stocking rate is adjusted to an excretion of 140 kg nitrogen (N) in pigs manure per ha and year (often practised as 280 kg N/ha every second year).

One of the major concerns in keeping sows on grass in intensively managed production is the potential environmental impact due to high excretions of plant nutrients, especially N and phosphor (P) in the manure. To a great extent, the environmental impact of outdoor pig production is related to the amount of nutrients in the supplementary feed for the pigs and the stocking density. Danish investigations have shown a surplus of 330-650 kg N per hectare of land used for grazing sows on organic farms (Larsen et al., 2000). Although this level is lower than that found on average in conventional outdoor sow herds, the present nutrient surplus definitely represents an environmental risk. Eriksen et al. (2002) found that the N-input in feed to lactation paddocks could be accounted for in piglets (44%), as ammonia volatilisation (13%), as denitrification (8%), or as nitrate leaching (16 - 35%).

Another concern for outdoor production is the maintenance of the grass sward. A well-maintained grass sward serves several important purposes. The uptake of nitrogen and water by the grass decreases the risk of nitrate leaching (Watson and Edwards, 1997). In paddocks for lactating sows, a high level of grass cover is one of the factors, which seem to decrease piglet mortality (Kongsted

and Larsen, 1999), probably related to the ability of the sow to keep the hut dry and clean. In addition, for pregnant sows, grass can constitute a significant part of their daily energy requirement (Sehested et al., 2004; Rivera Ferre et al., 2001).

In Denmark, the sows kept outdoors are typical ringed to prevent them from rooting and damaging the sward. However, the placing of a ring in the snout of sows prevents the sows from rooting, which is one of the sows' basic behaviours, by creating pain for the animal. This is in disagreement with organic ideals for animal husbandry and should be avoided, if possible. By rooting, the pigs search for, locate and harvest food. Studnitz et al. (2003b) demonstrated that rooting is the preferred explorative behaviour of pigs and rooting behaviour is considered to be a behavioural need of pigs (Horrel et al., 2001). The UK Soil Association prohibits ringing of sows, and from September 2001, ringing is prohibited in The Netherlands, too (Mul and Spoolder, 2000).

Preliminary results from a Danish investigation indicate that a ring in the snout does not affect the grazing behaviour of the sows but to some extent prevents rooting/damaging of the grass cover, especially in paddocks with pregnant sows (Studnitz et al., 2003a). However, some results suggest that alternatives to ringing of sows might exist. It might be possible to reduce rooting behaviour by providing the sows with a fibre-rich diet (Brouns et al., 1994; Martins and Edwards, 1994; Braund et al., 1998), edible and manipulable overground enrichment (Edge et al., 2004), a sacrificial rooting area (Bornet et al., 2003) and by a lower stocking rate (Andresen, 2000).

Ringing is, however, not the only welfare problem, which under some circumstances may be a consequence of keeping the sows outdoors in paddocks. Sunburn is reported to be a problem in some organic sow herds (Vaarst et al., 1999; Borell and Sørensen, 2004). Due to a very sparse hair coat, the pig is very vulnerable toward direct sunlight. Further, the pig is only supplied with very few sweat glands. These circumstances make the physical heat regulation of the pig very limited (McGlone, 1999). In semi-natural environments, sows wallow in deep mud holes if the temperature gets above 18 °C (Stolba & Wood-Gush, 1989). Access to wallows or at least suitable shadow facilities may thus be crucial for the well-being of outdoor housed pigs in warm seasons, especially for sows due to their higher heat production. According to the EU legislation, outdoor areas must provide sufficient protection against sun and extreme temperatures (Council Regulation (EC) No. 1804/1999 of 19 July 1999). According to the Danish regulation, all outdoor housed pigs above 20 kg must have access to wallow or sprinkling facilities in the hot season (Ministry of Justice, 2001). Further studies are needed to define "sufficient protection" against sun and extreme temperatures to ensure appropriate heat regulation systems and management in organic pig production.

4. Weaning age of minimum 40 days

In organic pig production, the minimum lactation length is 40 days according to the EU legislation and 49 days according to the Danish rules (Plant Directorate, 2004a).

It has been speculated that the longer lactation period (compared to the four-five weeks practised in conventional pig production) may compromise the welfare of the sow because of weight loss and a growing conflict between the willingness of the sow to suckle and the piglets' demand for food. However, in a study comparing a weaning age of five and seven weeks, Andersen et al. (2000b) found no differences in weight loss (-4 versus -3 kg), restlessness, or aggression towards the piglets related to weaning age. The authors concluded that overall there was no indication that sows suffered more by seven weeks of lactation than by five weeks of lactation, but the piglets seemed to profit by a suckling period of seven weeks compared to weaning after five weeks. It was specified that the missing effect of lactation length on restlessness and piglet-directed aggression in the present study might be due to the outside housing in a paddock, which allowed the sows to avoid the piglets by merely walking away.

The longer lactation length does, however, as mentioned in chapter 3 have a negative effect on overall productivity due to fewer weaned litters per year. Furthermore, the longer lactation period might cause poorer reproduction due to an irregularity after weaning caused by lactational oestrus.

However, with the proper management, lactational oestrus might be a possible way to increase the number of farrowings per sow per year. If the sows were able to conceive during lactational oestrus, this would decrease the number of non-productive days in the herd without affecting the welfare of the piglets. Alonso-Spilsbury et al. (2004) have recently reviewed lactational oestrus as a way to increase the number of farrowings per sow per year and they conclude that three factors appears crucial to an effective induction of oestrus during lactation. First, the lactation length needs to be longer than 45 days, secondly, the sows have to be group housed during lactation with a mature boar present and thirdly, the sows needs to be fed ad libitum to minimize weight loss. Unfortunately, no practical experiences in such systems are available at the moment but it seems that this is a subject, which merits more attention in organic pig production.

5. Housing of growing pigs and typical production results

The rearing of organic growing pigs in barns with an outdoor run is common practise in several European countries, including Denmark (Hermansen & Jakobsen, 2004). The most commonly used type of stable in Denmark by full time producers is a system with deep litter in the entire indoor area or deep litter/straw bed in half the area while the outdoor area consists of a concrete area. The use of a concrete area, from which the manure can be collected, is a way to comply with the

environmental regulations stating that the outdoor run should be constructed in a way that prevents leaching. Typical flock sizes are 40-60 pigs per pen (Strudsholm, personal communication 2004).

Compared with conventional pig production the space requirement per pig is considerable larger. For finishers of 85-100 kg live weight, the indoor space required is equivalent to 1.3 m^2/pig (of which at least .65 m^2 must consists of a solid floor) and 1.0 m^2 outdoor run (Council Regulation (EC) No. 1804/1999 of 19 July 1999). In addition, each lying zone, i.e. straw bedding area, must be able to accommodate all pigs at a time.

A comprehensive work programme has been carried out in Denmark in relation to the construction of pig houses with access to outdoor runs. Møller (2000), Olsen (2001) and Olsen et al. (2001) investigated the influence of the type of the indoor floor (deep-bedded and partly slatted floors), the size of outdoor run and a partial cover of the outdoor run on production and behaviour. In all cases, the stables were naturally ventilated and the floors of outdoor runs were solid (concrete). Overall, very good production results were obtained in these systems, >900 g daily weight gain from 30-100 kg, low feed consumption and a lean content of approximately 60%. Aggression levels among pigs were low, tail biting did not occur, and the indoor climate was good with a low concentration of ammonia, carbon dioxide, and dust. This was partly a result of the fact that most of the manure (>80%) was placed on the outdoor run which minimized the risk of manure contamination of the straw bedded area. This resulted in a low straw consumption compared to conventional systems based on deep litter. This type of stabling and, particularly, the type described in detail by Olsen (2001) can doubtless function very well, but they are expensive to establish.

The production results from commercial holdings with production of finishers are highly varying. Based on the slaughtering of approximately 6,000 pigs from six Danish herds Strudsholm (pers. comm. 2003) found an average daily gain of 740 g in the interval 20-100 kg live weight and ranging from 588 to 907 g among herds. Feed consumption per kg gain was only marginally higher than in conventional production.

In Denmark, the premium payment for an organically produced pig depends on the quality of the carcass. In the major enterprise handling organic pigs (Friland A/S) the following criteria are used for obtaining maximum premium: Carcass weight from 68-86 kg, lean content minimum 56% (in mid piece minimum 59%) and back fat ranging between 10 and 22 mm. Based on a survey including 42,000 pigs from 20 herds during the years 2000-2003, Strudsholm (2004) found that 22% of the pigs did not meet the requirement of minimum 59% lean meat in mid piece and 19% had a back fat outside the accepted range. The overall carcass results obtained were lean percentage 58.9%, in mid piece 63.2%, and back fat 17.5 mm. The observed lean percentage was

approximately 1% lower than observed in conventional production. A significant seasonal pattern in lean percentage was observed with the highest lean percentage obtained in pigs slaughtered during November – March.

The major post mortem lesions observed in the investigation (Strudsholm, 2004) were chronic adhesive pleurisy (9.7%) and milk spots (3.6%). Corresponding figures for chronic adhesive pleurisy in conventional production in Denmark showed approximately 22% infected. This illustrates the very good lung health observed in organic systems, probably related to the high space allowance and partly outdoor conditions. Infections caused by tail biting had a very low frequency (0.2%). The housing conditions for organic growers clearly support good production and health results.

4. Growing pigs on pasture

The rearing of organic growing pigs in barns with an outdoor run is heavily constrained by the fact that building costs are considerable higher than for conventional production systems due to higher requirements for area etc. At the same time, it may be questioned if pigs reared under such conditions comply with the consumers' expectations of organic farming. This calls for a reconsideration of the appropriateness of the system. One alternative to this system is keeping growing pigs outdoor on pasture.

Several investigations indicate that the growth rate obtained in outdoor systems can be comparable to the growth rate in indoor production (Lee et al., 1995, Andresen et al., 2001 Gustafson & Stern, 2003). However, variable feed conversion rates have been obtained. In the summer, a feed conversion comparable to indoor conditions has been obtained in some investigations (Sather et al., 1997; Stern and Andresen, 2003), whereas in other periods of the year or in other investigations, a higher feed consumption per kg gain have been reported (Sather et al., 1997).

Growing pigs can consume grass and other herbage up to 20% of daily dry matter intake when fed concentrate restricted (Carlson et al., 1999). However, when concentrate is provided *ad libitum*, the intake is much lower, e.g. 4% of organic matter (Mowat et al., 2003). The overall contribution to the energy supply of the pig when fed *ad libitum* with concentrate mixtures is thus low. This means that most feed given to the pigs at pasture needs to be concentrates with a consequent high risk of environmental impact unless measures are taken to counteract this.

In a recent study, strategies combining grazing and rearing in barns were investigated (Strudsholm & Hermansen, 2004). The overall idea was to reduce the risk of environmental impact and at the same time allow growing pigs to have plenty of space when they are young and most active.

Treatments included fully or partly outdoor rearing. The results showed no significant differences in growth rates between the pigs fed *ad libitum* outdoor (767g/day) or *ad libitum* indoor (737 g/day). However, the feed intake per kg gain outdoor was increased by 13% when fed *ad libitum*. On the other hand, outdoor kept pigs, which were restricted in energy intake (70% of *ad libitum*), had the same feed conversion rate as the pigs housed indoor and fed ad libitum and in addition a significantly higher lean content (approximately 4 percentage points), but growth rate was, of course, reduced (17%). A very interesting finding was in a strategy with restricted feeding in pigs kept outdoor until 40 kg live weight followed by *ad libitum* indoor. The strategy resulted in feed conversion rate and daily gain comparable to indoor ad libitum feeding. Pigs kept outdoor until 80 kg live weight followed by *ad libitum* indoor until slaughter resulted in a feed conversion rate comparable to indoor feeding and the overall daily gain was only reduced by 12 % compared to *ad libitum* feed indoor.

These results indicate that options are available in order to get very good production results from outdoor kept finishers. With the stocking rate applied (100 m^2 per outdoor pig kept from 20-100 kg live-weight), however, all vegetation in the paddocks was destroyed. The risk of nitrogen leaching from the paddock depending on stocking rate was inevitable. However, it was demonstrated that a careful planned movements of huts and feeding troughs made it possible to have an acceptable distribution of the nutrient load. It was concluded that organic finishers housed outdoor in parts of or in the entire growing period might be a competitive option even in a temperate climate and all year round, particular due to the higher lean percentage obtained. There is a need to develop such systems further. Probably a lower stocking rate than used in our investigation and more focus on the management is needed.

An alternative concept where pigs are born and raised from birth to slaughter in a climate tent system is at present being investigated (Jensen et al., 2002). A facility in this system is the availability of a deep-bedded area placed on the top of a layer of seashells, where a considerable amount of the manure is deposited. This system allows rearing of intact litters without being to costly, and it is expected that the environmental load related to outdoor rearing can be diminished.

5. Feeding and carcass quality

In a recent review, Guy & Edwards (2002) discussed how a range of factors related to organic pig production might impact meat quality. The present paper focuses on meat quality aspects related to feeding only.

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.

In organic pig production all animals shall have access to roughage. 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. According to the Danish rules (in opposite to the EU legislation) straw of cereals is not defined as roughage due to its low nutritional value for pigs. Several investigations have focussed on the use of different roughage materials for finishers. For instance, Danielsen et al. (2000) investigated the effect of restricting concentrate on the *ad libitum* intake of clover grass and clover grass silage, in two experiments, as well as on production results and sensory meat quality. Restricting concentrate to 70% of *ad libitum* intake on a daily basis resulted in a lower daily gain (12-16%), a lower feed consumption per kg gain (10%), an increased lean content (1-2%), and a reduced tenderness of the meat. Roughage intake was increased by 20-30 % but, nevertheless, only amounting to 5-6 % of total energy intake.

Strudsholm & Hermansen (2004) observed that outdoor *ad libitum* fed finishers (with concentrates) had significant higher roughage consumption than indoor. Nevertheless, whereas the type of roughage, or particular the fibre in the roughage, may have some effects on the health of the pigs, the major effects on production and carcass quality seems related to the type of concentrate and the feeding strategy with concentrates.

Hansen et al. (2001) investigated a range of aspects of meat and sensory quality. Treatments included non-organic production in the same environment as the organic production except that no access was given to either outdoor run or roughage. In three other treatments, organic concentrates were given without access to roughage or with access to two different types of roughage and, at the same time, a reduced level of concentrates. The main results are given in Table 2.

The organic production resulted in a slightly lower daily gain and a slightly higher content of polyunsaturated fatty acids (FA) in the fat, whereas no differences were observed in lean content, tenderness, and vitamin E content in the muscles. Restricting concentrates gave the same results as in the investigation of Danielsen (2000) in relation to lean content and tenderness, i.e. higher lean content and a reduced tenderness. In addition, a marked reduction in intramuscular fat and vitamin E content in muscles and a higher content of polyunsaturated FA in fat were observed. Also (data not shown), organic feeding and access to outdoor run led to a higher proportion of ham muscles in the carcass. These results are much in line with the results of Millet et al (2004) who found that organic housing lead to a higher muscle and back fat thickness.

Table 2. Production results and carcass characteristics in growers fed organic or conventional concentrates *ad libitum*, or restricted amounts of organic concentrates together with silage *ad libitum* (After Hansen et al., 2001)

Concentrates	Conventional (*ad lib*)	Organic (*ad lib*)	Organic (70% of *ad lib*)
Silage:	No	No	Yes
Outdoor area:	No	Yes	Yes
Daily gain (g)	999	935	728
Feed conversion (SFU[1)]/kg gain)	2.99	3.09	2.96
MJ per kg gain	23.1	23.9	22.8
Lean content (%)	60.6	60.4	61.6
In muscles			
Intramuscular fat (%)	1.6	1.5	1.2
Vitamin E	3.13	3.15	2.81
Tenderness	8.7	8.6	7.5
In fat			
Saturated FA (%)	41	40	39
Monosaturated FA (%)	45	43	42
Polyunsaturated FA (%)	14	15	18
Iodine value	68.3	72.2	74.6

[1)] Scandinavian Feed Units for pigs

In the Danish experiments mentioned above (Hansen et al., 2001), soybean meal was the primary source of protein. It appears that even in this situation the organic feeding, and especially if fed restrictively, resulted in an increased content of polyunsaturated FA. At present, and perhaps also in the future, alternative protein sources will be used because of the ban on GMO-products and products resulting from fat extraction with chemical solvents (Council Regulation (EC) No. 1804/1999 of 19 July 1999). Therefore, probably more fat-rich sources will have to be considered. The above-presented results indicate that it will be important in this situation to consider possible harmful effects on the 'fat-quality' of the pork in relation to appearance and oxidation risk.

Level of concentrate is also found to affect the meat colour of organically produced pigs (Oksbjerg et al., 2004). Whereas no differences existed between indoor or outdoor *ad libitum* fed pigs, pig fed restrictively had significant lover redness and a lower concentration of pigment in the loin.

Until now, feeding of organic pigs has often included a supplement of conventional feed (up to 20% of dry matter (DM)) mainly to obtain a good protein and vitamin supply (Jakobsen and Hermansen, 2001). However, from year 2005, according to the EU legislation, only organic feed is accepted. 100% organic feed means that use of (fat extracted) soybean meal, which is the most favoured protein source in conventional production (Sundrum, 2001), will be prohibited because it is prepared with the use of chemical solvents. This, in addition with the prohibition on the use of synthetic amino acids, places high demands on feeding management of organic pigs.

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. In a recent work, Fernandez (2004) investigated a reduction in the amino acid supply to organically reared growers relative to Danish recommendations for conventional production and evaluated lupine with peas as the protein source. The amino acid concentration in the diet was reduced by 15%, but balanced among the most important amino acids. Only small effects of the reduction were found on daily gain and feed conversion and lean meat was only slightly reduced. The reduction in lean percentage following a reduced amino acid supply tended to be counteracted by the inclusion of lupine in the diet. The highest amount of lupine in the diet (25%) tended to reduce daily gain. On the other hand preliminary results indicates that the high concentration of lupine tended to reduce the concentration of scatole in the back fat and also to affect a number of other meat characteristics (FOEJO, 2004).

It seems that both positive and negative effects on carcass and meat quality can be expected when new protein sources are implemented, but that at present there is a need to elucidate such effects.

6. Future production systems

A number of issues are still to be investigated in order to optimise the present systems of organic pig production. However, at the same time there may be a need to further develop the organic pig production in order to comply with consumer expectations.

A smaller consumer survey in Denmark (Beck, 2004) indicated a paradox in the promotion of organic pork. The consumer segments mostly used to and interested in pork products were very prize sensitive and not in particular interested in organic products as such. On the other hand the very organically oriented consumers did not value pork very much. This calls for a consideration that organic pork products should be different *per se* from conventional pork products i.e. as regards taste, cuttings etc.

Another topic coming up is the question of avoiding castration of male pigs. Whereas such a strategy is accepted in UK, it is a controversial topic in Denmark and Germany, due to the risk of boar taint and an elevated concentration of androstenone in the products. However, it can be foreseen, that castration may not be an accepted procedure in organic production in the future due to reluctance to impair body parts of the animals in organic production. In Norway the Parliament has passed a law banning a routinely castration of male pigs to become in force from 2009 (Frederiksen et al., 2004). Such initiatives may put further pressure on the organic production methods. At the moment, a few projects in Denmark are focussing on management initiatives in organic production, which can be used to minimise risk of boar taint and/or to propose strategies for entire male pigs production. This may include different feeding strategies and different slaughtering weights compared to the present practice. This way, in fact, the two challenges mentioned, new products and entire male pig production, may support each other in the future development of organic pig production system.

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