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Performance and carcass quality of fully or partly outdoor reared pigs in organic production

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Abstract

Outdoor rearing of finishers can be considered a relevant option in organic pig production. The performance and carcass characteristics of 245 organically produced and free-range born crossbred pigs allocated to five treatments were compared. The five treatments were: transfer to a barn with free access to feed (1) at weaning and until slaughter, (2) at a live weight of 40 kg and until slaughter, (3) at live weight of 80 kg and until slaughter, or reared at pasture (4) with free or (5) limited access to concentrates until slaughter. Pigs fed ad libitum fed indoor compared to pigs fed ad libitum outdoor had a significant lower feed consumption (5 MJ ME /kg gain), lower lean percentage (2.3%), and a higher backfat depth (1.1 mm)(all $P<0.05$). Compared with outdoor pigs fed ad libitum, restricted feeding outdoor resulted in a significantly lower daily gain (107 g), a lower feed consumption (6.3 MJ ME/kg gain), higher lean percentage (2.1% units), and a reduced backfat (1.8 mm) (all $P<.001$). Pigs, which at a live weight of 40 kg, were transferred to indoor facilities with free access to feed compensated almost completely before slaughter, while pigs transferred at 80 kg live weight only compensated little. Although the housing environment (in- or outdoor) seems to affect performance and carcass traits, the length of energy restriction appears to be of greater importance.

Keywords: Organic; Pig production; Housing; Feeding; Compensatory growth

1. Introduction

In several countries, organic sows are kept on grassland throughout their lives, while their progeny are transferred at weaning to a barn with free access to an outdoor pen. However, valid barns for organically reared pigs can be very expensive considering the large area required according to the EU regulations (The Council of the European Union, 1999). In addition, it may be questioned if pigs reared under indoor conditions comply with consumer expectations of organic farming and animal welfare (Grunert et al., 2004).

Alternatively, the slaughter pigs can be reared outdoors. However, limited data on production results obtained in outdoor rearing exist. Some investigations

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indicate that growth rates obtained in an outdoor system can be comparable to growth rates of indoor production (Lee et al., 1995; Andresen et al., 2001; Gustafson and 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) whereas in other investigations, a higher feed consumption per kg gain has been reported from other periods of the year (Stern and Andresen, 2002; Sather et al., 1997).

In addition, in relation to the deposition of manure in the outdoor paddocks, outdoor rearing may have drawbacks such as increased risk of nitrate leaching (Eriksen, 2001; Watson et al., 2003) and ammonia volatilisation (Sommer et al., 2001). These negative aspects are related to the amount of manure deposited on the land. Strategies, which combine indoor and outdoor rearing and result in a relatively large proportion of the manure placed indoors, may be superior seen from an overall perspective. Following this idea, a strategic feeding of the finishers may be appropriate. This could be a lower feed allowance while on grassland followed by a higher feed allowance inhouse. Several authors found that a compensatory growth could take place when ad libitum feeding followed a period of restrictive feeding (Prince et al., 1983; Oksbjerg et al., 2002; Therkildsen et al., 2002). This might further support the before mentioned feeding strategy.

The purposes of this investigation were to quantify differences in performance and carcass quality traits of pigs reared outdoor or indoor, and to investigate the effects of a combined outdoor and indoor rearing based on a restrictive feeding regimen outdoors followed by ad libitum feeding indoor.

2. Materials and methods

The experiment took place from January 2002 to April 2003. To cover the changes in the climate conditions, five replicates began in January, April, August, October, and December, respectively. The average maximum temperature (24 h) was 10.9 (−8.2–28.8) °C and the average minimum temperature (24 h) was 4.4 (−17.7–19.1) °C. The rainfall was 851 mm during the period.

2.1. Animals and experimental design

The experiment was conducted with 245 crossbred pigs (Danish Large White × Danish Landrace mated to Danish Duroc boars). The pigs were from 34 litters, individually marked, and reared outdoor until weaning at 52 days of age. Immediately after weaning, pigs were randomly allocated to one of five treatments:

- IA: transferred to indoor rearing and fed ad libitum until slaughter
- I40A: reared on pasture and fed restrictively until transfer indoors at 40 kg live weight and fed ad libitum until slaughter
- I80A: reared on pasture and fed restrictively until transfer indoors at 80 kg live weight and fed ad libitum until slaughter
- OR: reared on pasture and fed restrictively until slaughter
- OA: reared on pasture and fed ad libitum until slaughter

At each weaning (replicate), five castrates and five female pigs were randomly allocated to each treatment except in one replicate with only four castrates and five female pigs.

2.2. Diets and feeding

To prevent diarrhoea after weaning, all pigs were fed restrictively for 3 weeks with a typical piglet diet supplemented with 10% crushed oats. In week 3, the experimental diet for finishers was gradually introduced. The experimental concentrates consisted of 25.3% wheat, 22% barley, 16% yellow peas, 14.4% rapeseed cake, 10% sweet lupin, 10% full fat soya beans, and 2.3% mineral and vitamin mixture. The concentrates contained 13.8 MJ ME per kg, 19.2% protein, and 10.5 g lysine per kg. In addition to concentrates, all pigs had ad libitum access to clover grass silage except for outdoor pigs in the summer period, where they had access to fresh clover grass in the pens.

The amount of concentrates and clover-grass silage allotted was adjusted to the feed intake of the previous day. On grassland, the concentrate was allocated daily in a trough with simultaneous access for all pigs. The restrictively fed animals at pasture were fed approximately 80% of the expected ad libitum intake according to the Danish recommendation for indoor pigs. The indoor pigs fed ad libitum could eat two at a time from an automatic feeder. It was ensured that the ad libitum fed pigs left feed until the next day's feeding.

2.3. Housing

The grassland was a second-year clover grass pasture. Each treatment in each replicate was introduced on a new paddock. The field areas per pig in treatments I40A, I80A, OR, and OA were 20.5 m^2, 77.6 m^2, 110.8 m^2 and 110.8 m^2, respectively. The stocking rate was calculated to equal 2.8 animal units per hectare, based on the national definition of an animal unit and the national guidelines related to a 2-year crop rotation (European Commission, 2000; Miljøministeriet, 2002). The huts, feeding and water troughs were moved every fourth week to minimize the environmental load from the manure, urinary and feed waste. A wallow was established in each pen in the summertime.

Pigs on treatments IA, I40A, and I80A were reared in a barn with access to an outdoor concrete area. The barn was without insulation and had natural ventilation and deep litter. The indoor area was adjusted to the average live weight per pig, conforming to the EC regulations for animal density (The Council of the European Union, 1999). The solid floor in the outdoor pen was half covered with a roof.

2.4. Recordings and calculations

All the concentrate and roughage offered in each pen were recorded daily. The feed conversion ratio was calculated as an average for each pen. All pigs were individually weighed at weaning, at transfer, and at slaughter before delivery. Estimation of compensatory growth was calculated from these live weights.

The pigs were slaughtered at an abattoir for organically produced slaughter pigs. The carcass weight was recorded, and backfat depth, lean percentage in the central piece, and the carcass were measured at an electronic classification centre (Madsen, 1993; Olsen, 2003). Post-mortem lesions were assessed in routine carcass inspections carried out by veterinarians and trained technicians.

The live weight at slaughtering was estimated from the carcass weight by use of the formula: live weight (kg) = 1.19 × carcass weight (kg) + 6.71 kg/7.31 kg for castrates and females, respectively (Andersen et al., 1999). Estimation of the overall daily gain was based on this final live weight, and this weight was also used as a covariate in the statistical analyses.

2.5. Statistical analyses

Treatment effects on performance and carcass traits were assessed by analysis of variance using the SAS System for Mixed Models (SAS Institute, 2004). Model (1) was used for overall daily gain, age at slaughter, lean percentages, backfat depth, and feed conversion.

$$Y_{ijkl} = \mu + T_i + R_j + S_k + \beta_0 IW_l + \beta_1 EW_l + \beta_2 EW_l^2 + e_{ijkl} \quad (1)$$

where Y_{ijkl} was the response variable of the lth animal of kth sex in the jth replicate subjected to the ith treatment, μ was the overall mean, T_i was a treatment effect, R_j was a replicate effect, S_k was a sex effect. The coefficients β_0, β_1, and β_2 were regression coefficients for the weight at insertion (IW_l) and live weight at slaughter in first (EW_l) and second order (EW_l^2). All these effects were fixed effects. e_{ijkl} was the residual error, which was assumed independent and identically distributed as $N(0, \delta^2)$. In addition,

Table 1
Initial age and weight, warm carcass weight at slaughter and estimated final body weight, mean (standard deviation)

Treatment	Indoor ad lib (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	Outdoor restricted (OR)	Outdoor ad lib (OA)
Number of pigs at insertion	49	49	49	49	49
Number of dead pigs	1	4	4	1	1
Initial age, days	53 (3.4)	53 (3.4)	53 (3.8)	52 (3.1)	52 (3.5)
Initial body weight, kg	18.3 (4.5)	18.5 (4.6)	18.9 (4.6)	18.3 (4.4)	18.3 (4.2)
Warm carcass weight, kg	74.1 (5.2)	77.6 (8.7)	74.3 (4.9)	73.1 (5.2)	76.9 (5.3)
Estimated final body weight, kg	95.2	99.3	95.5	94.0	98.5

Table 2
The consumption of concentrates in different periods; Least square means and SEM, kg per day

Treatment	Indoor ad lib (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	Outdoor restricted (OR)	Outdoor ad lib (OA)	S.E.M.
Until 74 days	1.10	0.89	0.87	0.96	1.11	0.13
75 to 95 days	1.48[ab]	1.38[ab]	1.27[a]	1.21[a]	1.60[b]	0.10
96 to 149 days	2.46[a]	2.65[ad]	2.29[a]	1.83[b]	2.88[cd]	0.10
149 until slaughter	2.70[a]	2.96[ad]	2.54[a]	1.98[b]	3.19[cd]	0.12

Different letters within each row indicate a significant difference ($P<0.05$) (*df* of error term = 16).

pen was included as a random effect and used as error term in the test of treatment effects. When the response variable was feed conversion rate, the effect of sex in model (1) was excluded, because the pen/paddock was the experimental unit.

Model (2) was used to estimate and test the differences between growth curves of the pigs in the different treatment groups.

$$Y_{ijl} = \mu + T_i + \beta_1 A_{jl} + \beta_{i1} A_{jl} + \beta_2 A_{jl}^2 + \beta_{i2} A_{jl}^2 + e_{ikl} \quad (2)$$

where Y_{ijl} was the weight of the lth animal at the jth age subjected to the ith treatment. The coefficients β_1 and β_2 were regression coefficients for the first (A_{j1}) and second order (A_{j1}^2) terms of mean polynomium shared between all animals, whereas β_{i2} and β_{i3} were regression coefficients for corresponding treatment specific deviations from the mean polynomium. The random effect e_{ikl} was the residual error and still assumed $N(0, d^2)$, but a correlation between weights measured at different ages was modelled by allowing the residual errors for each pig to be dependent over time. A repeated statement was specified in the PROC MIXED procedure with age as a random effect. Since weights of pigs in different treatments were measured at different times with unequal laps between times, the exponential correlation functions from the class of spatial correlations were used.

3. Results

3.1. Performance

In Table 1, the initial age and weight as well as the uncorrected final carcass weight are given.

Pigs were uniform at insertion, but at slaughter some variation existed within treatment due to practical conditions. However, only small differences existed in the average weight at slaughter between treatments. A few pigs died in the groups transferred to the barn at 40 kg or 80 kg. The deaths took place in different replicates and no specific reason could be established.

In Table 2, the daily consumption of concentrates at the different age stages is shown. The consumption was significantly affected by age ($P<0.0001$), and the interaction between age × treatment ($P<0.001$) reflecting a difference in intake pattern between treatments. Compared with pigs reared indoor and fed ad libitum, pigs transferred to indoor facilities at

Table 3
Performance traits achieved in five rearing strategies compared at the same live weight as slaughter; Least square means, S.E.M. and *P* values for significance of differences between treatments

Treatment	Indoor ad lib (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	Outdoor restricted (OR)	Outdoor ad lib (OA)	S.E.M.	*P* value
Age at slaughter, days[1]	156[a]	161[a]	170[b]	177[b]	160[a]	2.2	<0.0001
Daily gain, g/day[1]	767[a]	728[a]	672[b]	634[b]	737[a]	14	<0.0001
Concentrate, kg per kg gain	2.81[a]	3.03[ab]	2.95[ab]	2.64[a]	3.15[b]	0.12	<0.05
Roughage, kg per kg gain	0.21[a]	0.23[a]	0.43[b]	0.46[b]	0.39[b]	0.06	<0.05
Feed conversion, MJ ME/kg gain	37.3[a]	40.2[ab]	39.9[ab]	36.0[a]	42.3[b]	1.7	<0.05

Different letters within each row indicate a significant difference ($P<0.05$) (*df* of error term = 16).
[1] Adjusted to a final live weight of 97 kg.

Table 4
Live weight (kg) at different ages; Least square means and S.E.M.

Treatment	Indoor ad lib (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	S.E.M.	*P* value
Age 53 days	17.6^{a}	18.5^{a}	18.2^{a}	2.13	ns
Age 95 days	45.8^{a}	41.6^{b}	38.4^{b}	2.32	<0.05
Age 149 days	90.8^{a}	90.4^{a}	80.7^{b}	2.00	<0.001
Age 162 days	103.1^{a}	105.3^{a}	93.6^{b}	2.18	<0.001

Different letters within each row indicate a significant difference ($P<0.05$).

40 kg (95 days) had a numerically (but not significant) higher intake of concentrates in the subsequent periods. A change in rearing conditions at 80 kg did not proportionally increase the consumption of concentrates more than the ad libitum fed pigs in the entire period. The difference in intake of concentrates between ad libitum or restrictively fed outdoor pigs became more and more pronounced with increased age ranging from 32% in the period 75–95 days to 61% from 149 days of age until slaughter.

In Table 3, least square means of the performance traits and feed conversion rates, corrected to an common live weight, are given.

The daily gain and age at slaughter were significantly affected by the weight/age at transfer to the barn. The length of the pasture period with restricted feeding seemed directly related to a decrease in the overall daily gain in treatments IA, I40A, I80A and OR. However, the feed conversion rate was not significantly different among these treatments. Age at slaughter, daily gain and feed conversion ratio differed significantly between pigs fed ad libitum (OA) or restrictively (OR) outdoor. The restrictively fed pigs had a higher age at slaughter (17 days), a lower daily gain (133 g), and an improved feed conversion rate (−6.3 MJ ME/kg gain). Compared to the indoor reared pigs (IA), the outdoor reared pigs (OA) had a small numerically lower daily gain and a higher age at slaughter, while the feed conversion was significantly poorer (13.4%). The performance traits were in addition influenced by sex in a well-known manner in that castrates had a significant higher growth rate (32 g day^{-1}).

The pigs reared at pasture had a significantly higher intake of roughage compared to indoor pigs, although the latter also had the possibility of grazing and rooting. The outdoor pigs with free access to concentrates consumed 60% more roughage than the indoor reared pigs. Roughage consumption did not differ significantly between outdoor reared pigs fed restrictively or ad libitum, although roughage intake was increased by 18% numerically for the restrictively fed pigs. The contribution of ME intake from roughage in percentage of total ME intake was significantly higher in treatments I80A, OR, and OA than for indoor reared pigs (IA) (≈ 4.4% versus 2.8%).

The growth rate at different stages for treatments IA, I40A, and I80A was investigated in more detail. Table 4 shows the least square means of the live weights at different ages obtained from model (2). Pigs transferred at 40 kg (I40A) had almost compensated fully in live weight at 149 days of age and continued to grow fast. The compensatory index (Hornick et al., 2000) was 152% in the I40A-treatment. Compared to this, pigs transferred at an average pen weight of 80 kg were unable to totally compensate before slaughter. The compensatory index was 5.9% in the I80A-treatment.

3.2. Carcass characteristics

All carcass traits were significantly affected by the treatments (Table 5). Pigs reared outdoor throughout their life or until 80 kg live weight had significantly

Table 5
Carcass characteristics of pigs as a result of five rearing strategies; Least square means, S.E.M. and *P* values for significance of differences between treatments

Treatment	Indoor ad lib (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	Outdoor restricted (OR)	Outdoor ad lib (OA)	S.E.M.	*P* value
Lean in total carcass, %	57.5^{a}	57.6^{a}	60.4^{b}	61.9^{c}	59.8^{b}	0.39	<0.0001
Back-fat depth, mm	17.6^{a}	18.4^{ab}	15.9^{d}	14.7^{e}	16.5^{ac}	0.51	<0.001
Lean in central piece, %	61.9^{a}	61.4^{a}	65.4^{d}	67.3^{e}	64.2^{d}	0.57	<0.0001

Different letters within each row indicate a significant difference ($P<0.05$) (*df* of error term = 16).

higher meat content than pigs reared indoor. Back-fat depth showed the opposite results. There were no significant differences in the lean percentage between I80A and OA pigs. The carcass traits were also significantly affected by sex in that castrates had a higher back-fat depth (2.9 mm) and a lower lean percentage (2.1%).

4. Discussion

The ad libitum fed outdoor reared pigs had a slightly poorer daily gain and a considerably poorer feed conversion ratio than the pigs fed ad libitum and reared indoor. This is probably caused by a higher energy requirement for thermoregulation and activity in the outdoor housed pigs (Guy et al., 2002; Gustafson and Stern, 2003). Studies carried out in the summer period showed a higher growth rate for outdoor reared than for indoor reared pigs (Stern et al., 2001; Gentry et al., 2002). Numerically, however, the differences in growth rate reported were small. It seems that, from an overall point of view, there is no reason to expect marked differences in growth rates between indoor and outdoor rearing, when fed equal diets ad libitum—even taking the relatively cold Danish winter period into consideration.

The restrictively fed outdoor pigs had no possibility to consume more concentrates in the cold periods and, consequently, had less metabolizable energy for fat deposition and growth, which corresponds with the findings of Affentranger et al. (1996) and Stern and Andresen (2002).

The design of the experiment did not allow for an appropriate statistical evaluation of the seasonal effects since each replicate only included one pen per treatment. However, if we considered each pig as the experimental unit, only small treatment × replicate interactions were found indicating that the treatment effect did not depend on the season.

Although significantly lighter (4.2 kg) at transfer to indoor housing than pigs in treatment IA at the same age, pigs in treatment I40A reached the same average weight 54 days later, demonstrating a compensatory growth response. Previous studies demonstrated a compensatory growth due to an improved feed conversion ratio and without an increased feed uptake (Oksbjerg et al., 2002; Therkildsen et al., 2004; Prince et al., 1983; Campbell et al., 1983). In other studies, the compensatory growth was associated with increased feed uptake (Donker et al., 1986). In the present investigation, the daily feed consumption was numerically higher for pigs showing a compensatory growth.

In the present investigation, the daily gain was considered using either carcass or live weight as a basis. Based on carcass weight, the daily gain obtained in treatment I40A was slightly lower than the one obtained in treatment IA (Table 3), whereas based on live weight no significant differences in live weight were observed at the same age (close to slaughter) (Table 4). It is expected that using the carcass weight as a basis is most appropriate here since a difference in roughage intake may impact on the dressing percentage (Gustafson and Stern, 2003; Whittemore et al., 2003). Therefore, it seems that a total compensatory growth following a moderate restriction in feed intake until 40 kg live weight was not obtained, but the numerical difference in daily gain was low. Restricted feeding until 80 kg resulted in a markedly lower daily gain.

Because the feed restriction in this trial was done at pen level, the high ranging pigs could be less restricted than the low ranking pigs with no or a little compensation afterwards. Also, daily feed intake of some pigs could be limited, caused by a lack of appetite (Georgsson and Svendsen, 2002). However, the standard errors of age at slaughter appeared to be similar in all treatments, indicating that the restriction did not add extra variability in the performance results.

Although they had the possibility to graze and root, pigs reared outdoor with free access to concentrate consumed 85% more roughage than indoor pigs. This indicated a synergy between foraging and access to a variety of feeds in an enriched environment (Table 3) as discussed by Andresen (2000).

Compared with ad libitum fed pigs reared outdoor, the restrictively fed pigs had the highest lean percentage and the thinnest backfat. Similar effects of restricted energy were found by Leymaster and Mersmann (1991), Ramaekers et al. (1996), Affentranger et al. (1996), and Danielsen et al. (2000). The IA pigs had a lower lean percentage and thicker backfat than the OA pigs. This corresponds to the findings of Guy et al. (2002) and Stern et al. (2001).

Opposed to this, Gustafson and Stern (2003) and Gentry et al. (2002) found no such difference between indoor and outdoor pigs in the summertime. An explanation could be that pigs at pasture in cold periods use more energy to maintain body temperature than indoor pigs with access to an outdoor pen.

The difference obtained in carcass characteristics in the present investigation between indoor and outdoor rearing and depending on feeding strategy can be very important in organic production. In some situations, like in Danish organic production, the renumeration of the slaughter pig depends very much on whether the carcass characteristics fulfil certain thresholds values in relation to a minimum lean percentage and a maximum backfat. The financial effect of this can overrule the financial effect related to daily gain and feed consumption. The present investigation highlights the fact that outdoor rearing of organic finishers may be a competitive option even in a temperate climate and all year round.

From a practical point of view, the strategy where, after a period of restricted feeding, outdoors pigs are transferred to indoor conditions and fed ad libitum, seems interesting even if such pigs had only a low compensatory growth. Compared with outdoor pigs fed restrictively or ad libitum during the entire growing period, intermediate results can be obtained as regards daily gain, feed conversion, lean percentage, and backfat and in addition a non-neglective part of the manure can be collected whereby the risk of nitrogen leaching from the pasture is reduced.

5. Conclusions

When fed ad libitum with concentrates throughout the growing period outdoor rearing compared with indoor rearing did not affect growth rate significantly, but feed consumption was increased and lean percentage was increased. When outdoor pigs were fed restrictively with concentrates, daily gain was reduced, lean percentage was increased, and back-fat depth was reduced compared with ad libitum fed pigs and feed conversion was not significantly different from indoors ad libitum fed pigs. A moderate feed restriction (for 6 weeks) until 40 kg live weight resulted in a 152% compensatory growth, and similar feed conversion ratio, lean percentage, and backfat depth as pigs fed ad libitum after the weaning period.

The effect of housing, indoor or outdoor, on performance and carcass traits seems to be significant, but the effect of the moderate concentrates restriction compared to ad libitum feed seems to be of an even greater importance for the production results.

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