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Effect on pig performance of feed restriction during the growth period

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Abstract

Two experiments were conducted to determine the compensatory responses of pig to feed restriction during the growth period. Eighty Dalland pigs (40 boars and 40 gilts) and 60 Large White × (Large White × Landrace) barrows were used in two different experiments. They were slaughtered at 97 and 122 kg. During the restriction period, the animals were restricted by 46% and 25% of their *ad libitum* consumptions in experiment 1 and 2 respectively. The restriction periods lasted 28 and 35 days respectively. Considering the whole study period, in experiment 1 the average daily weight gain and food intake were lower for restricted pigs compared to those fed *ad libitum*: 762 *vs* 856 g ($P < 0.03$) and 2147 *vs* 2396 g ($P < 0.08$). However, the feed conversion ratio was no different: 2.83 *vs* 2.80 g g^{-1} ($P < 0.81$). In this experiment, the interaction *treatment x sex* was not significant in either test. When performance over the total period was examined in experiment 2 (moderate restriction), a stronger trend was seen towards a greater average daily weight gain in groups with restricted access to feed (853 *vs* 821 g in those fed *ad libitum*, $P < 0.11$). No significant differences were observed for average daily feed intake, feed conversion ratio and dorsal fat thickness (measured at the 14th rib by ultrasound) (2638 *vs* 2635 g, 3.09 *vs* 3.2 g g^{-1} and 16,9 *vs* 16.2 mm respectively).

Key words: compensatory growth, feed restriction.

Resumen

Efecto de la restricción de alimento durante el periodo de crecimiento sobre los índices productivos de cerdos en cebo

Se realizaron dos experimentos para estudiar el efecto de la restricción de alimento sobre el crecimiento de cerdos en cebo. En el experimento 1 se utilizaron 80 cerdos Dalland, 40 machos enteros y 40 hembras y en el experimento 2, 60 machos castrados Large White × (Large White × Landrace) que se sacrificaron a los 97 y 122 kg, respectivamente. En el periodo de crecimiento la mitad de los cerdos recibieron alimentación restringida al 46 y 25% del consumo *ad libitum* durante 28 y 35 días en los experimentos 1y 2 respectivamente. En el experimento 1, durante el periodo total de cebo, la ganancia media diaria y el consumo medio diario de pienso fueron menores en los cerdos con alimentación restringida que en los que recibieron alimentación *ad libitum*: 762 *vs* 856 g ($P < 0,03$) y 2147 *vs* 2396 g ($P < 0,08$). Sin embargo, no se apreciaron diferencias significativas en el índice de transformación del alimento (2,83 *vs* 2,80 g g^{-1}; $P < 0,81$). En este experimento la interacción *tratamiento x sexo* no fue significativa. En el experimento 2 la restricción más moderada aplicada durante la fase de crecimiento se tradujo en que los cerdos con alimentación restringida tendieron a crecer más que los que recibieron alimentación *ad libitum*: 853 *vs* 821 g día^{-1} ($P<0,11$), no observándose entre ellos diferencias en el consumo medio diario de pienso, índice de transformación y espesor de la grasa dorsal estimado mediante aparato de ultrasonidos a nivel de la decimocuarta costilla: 2638 *vs* 2635 g, 3,09 *vs* 3,2 g g^{-1} y 16,9 *vs* 16,2 mm, respectivamente.

Palabras clave: crecimiento compensatorio, restricción de pienso.

Introduction

Restricting the amount of feed given to pigs during their growth period leads to greater food consumption and daily growth during the fattening period (Lovatto *et al.*, 2000). However, the influence of feed restriction on production indices over the growth period, and on meat quality, depends very much on its degree and duration (Campbell *et al.*, 1983; Prince *et al.*, 1983; Donker *et al.*, 1986; Critser *et al.*, 1995). Further, different outcomes are obtained for the same degree of

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restriction depending on the growth potential of the pigs in question (Donker *et al.*, 1986). However, no differences in compensatory growth response have yet been recorded between males and females of the same genetic type (Donker *et al.*, 1986; Critser *et al.*, 1995).

Further research is justified in this area since feeding strongly influences the final cost per kilogram at slaughter, and since some authors have reported positive effects of compensatory growth on the final results (Campbell *et al.*, 1983; Prince *et al.*, 1983; Donker *et al.*, 1986). The present paper reports two experiments on compensatory growth, the first on boars and gilts slaughtered at the conventional weight of 90-100 kg, and the second on barrows slaughtered at approximately 120 kg for cured meat products.

Material and Methods

Animals

The animals used in experiment 1 were 80 Dalland pigs (40 boars and 40 gilts) with an initial mean weight of 37.05 kg. In experiment 2, the experimental animals were 60 Large White × (Large White × Landrace) barrows with a mean initial weight of 32.8 kg.

Experimental design

Experiment 1 had a factorial design (2 treatments × 2 sexes). Feed was provided either *ad libitum* (AL) or was restricted by 46% of the *ad libitum* quantity (R) for the first four weeks of the experiment. All animals then followed an *ad libitum* feeding regimen until the end of the experiment. Each treatment was replicated four times: two for each sex, with 10 pigs per replicate.

Experiment 2 involved two treatments. Feed was provided either *ad libitum* (AL) or restricted by 25% of the *ad libitum* quantity (R) for the first five weeks of the experiment, followed by *ad libitum* feeding to the end of the study period. Each treatment was replicated three times (10 animals per replicate).

For both experiments, all replicates were randomly distributed in an experimental housing facility. The initial weight of the animals by treatment and replicate was homogenised as much as possible.

The endpoint for the first experiment was the point at which the animals reached approximately 95 kg, the conventional slaughter weight of boars for the Spanish fresh meat market. Since the second experiment involved barrows for the meat products market, a slaughter weight of 120 kg was chosen, sufficient for the production of fresh hams weighing 9.5 kg or more, as required by EEC regulation no. 2082/92 (OJ, 1992) for the production of cured *serrano* ham.

Animal feed

In both experiments, animals were fed a commercial, cereal-soybean-based feed with 2950 kcal ME kg^{-1}, 17% crude protein and 0.88% lysine in experiment 1, and with 3000 kcal ME kg^{-1}, 16.5% crude protein and 0.8% lysine in experiment 2; contents estimated according to FEDNA (1999).

Data recorded

In experiment 1, records were made of individual pig weight and feed consumption per replicate on days 0, 28, 56 and 74 (end of the experiment). In experiment 2, the same variables were measured on days 0, 35, 71 and 106 (end of the experiment). On day 106, the dorsal fat thickness (DFT) was measured at the level of the 14^{th} rib, taking two readings with a RENCO Lean-Meter ultrasound apparatus. Environmental temperature was monitored in both experiments using a maximum-minimum thermometer.

Installations

Each replicate was provided with a manger and a linear (0.3 m/pig) feed box, as well as a water supply. Thirty percent of the floor was taken up by slats. The available surface area available per pig was 1.1 m^2. The housing facility was ventilated by air extractors.

Statistical analysis

The results obtained in experiment 1 were treated by analysis of covariance. The main variables were treatment and sex, and the interaction between them. The covariable for the dependent variables of weight and daily growth was the initial weight, while the covariable for the dependent variables feed consumption and

feed transformation index was the mean initial weight of the replicas.

In experiment 2, the main variable was the treatment, but included the initial weight of the pigs as the covariable for weight and growth, and the weight of the replicates as the covariable for feed consumption and food transformation. The final weight of the pigs at 106 days was introduced as a covariable for DFT.

In both experiments, each pig was considered as an experimental unit in the study of the variables weight, daily growth and DFT. For the variables feed consumption and transformation, however, the experimental unit considered was the entire replicate.

With respect to weight and daily growth, the interaction of the main variables with time was studied by repeated measures analysis. All analyses were made using the GLM procedure of the SAS statistical package (1998).

Statistical significance was set at $P < 0.05$; the assumed error was 5-15%.

Results

The mean temperatures recorded during the growth period (feed restriction) and fattening period (food provided *ad libitum*) were 13.1ºC and 20.1ºC in experiment 1, and 18.5ºC and 23ºC in experiment 2 respectively.

Tables 1 and 2 show the results of experiment 1. The R pigs, which consumed 54% the amount consumed by AL pigs during the restriction period, showed a significantly poorer transformation index than the latter ($P < 0.05$). However, in the following period of *ad libitum* fattening (28-56 days), the R pigs grew significantly more ($P < 0.02$) than the AL pigs. No significant differences were seen between the two groups with respect to mean daily feed consumption or feed conversion ratio in the periods 28-56 days and 56-74 days.

In the R pigs, the increase in weight and feed intake during the *ad libitum* fattening period did not compensate for the reduction in these variables during the restriction phase. As a consequence, they showed a smaller daily weight gain ($P < 0.03$) and a tendency to consume less feed ($P < 0.08$) than the AL pigs over the entire 74 day period, although their feed transformation indices were similar. The slaughter weight of the AL pigs was greater ($P < 0.06$) than that of the R pigs.

The boars grew more than the females (from a mass of around 50 kg to slaughter weight). However, the feed transformation indices were only significantly different between 56 and 74 days ($P < 0.03$). At the end of the study, the weight and transformation indices of the males tended to be better than those of the females ($P < 0.13$). The interaction *treatment × sex* was significant for none of the variables studied ($P < 0.66$).

Table 1. Effect of feed restriction during the growing period, and sex, on pig weight and *treatment × sex* interaction (Experiment 1)

	Weight (kg)			
	0 d	**28 d**	**56 d**	**74 d**
Treatment (T)				
R (40)	36.9	47.5	77.7	93.3
AL (40)	37.2	59.4	86.6	100.6
Sex (S)				
Boars (40)	36.0	52.2	82.1	98.2
Gilts (40)	38.1	54.8	82.2	95.7
Interaction (T × S)				
R × Boars (20)	35.0	45.9	76.8	93.5
R × Gilts (20)	38.9	49.2	78.6	93.2
AL × Boars (20)	37.1	58.4	87.4	102.9
AL × Gilts (20)	37.3	60.4	85.9	98.2
SEM	3.75	4.65	4.31	4.75
Contrasts				
R *vs*. AL	0.94	0.005	0.01	0.06
Boars *vs*. Gilts	0.60	0.59	0.97	0.15
Interaction (T × S)	0.65	0.90	0.73	0.66

R: restricted. AL: *ad libitum*. SEM: standard error of the mean. In brackets, number of animals. Except for initial weights, all values are least squares means.

Repeated measured analysis showed significant interactions between time and treatment ($P < 0.0001$) during the *ad libitum* fattening phase, and between time and sex ($P < 0.01$) for the total experimental period (until sacrifice) the weight of the pigs and daily growth.

Tables 3 and 4 show the results obtained in experiment 2. This more moderate feed restriction led to no significant differences between R and AL pigs with respect to the feed conversion ratio during the restriction phase. However, during the *ad libitum* fattening phase, the R pigs grew and consumed significantly more feed ($P < 0.023$) than the AL pigs, and even improved their feed conversion ratio ($P < 0.047$) in the period from day 71 to 106. Taking the entire experimental period into account, R pigs tended to grow more than AL pigs but showed mean daily feed intakes and feed

Table 2. Effect of treatment and sex on average daily weight gain (DWG, g), average daily feed intake (DFI, g) and feed conversion ratio (FCR, g g^{-1}) per period (Experiment 1)

Period (days)	Treatment		Sex		SEM	Probability	
	R	AL	Gilts	Boars		1	2
0 - 28							
DWG	380	793	590	584	55	0.002	0.73
DFI	1,113	2,041	1,580	1,574	125	0.003	0.92
FCR	2.95	2.57	2.76	2.76	0.21	0.05	0.96
28-56							
DWG	1,076	973	984	1,065	28	0.02	0.04
DFI	2,737	2,565	2,594	2,708	104	0.19	0.36
FCR	2.55	2.64	2.64	2.55	0.05	0.56	0.57
56-74							
DWG	868	773	743	898	63	0.16	0.02
DFI	2,840	2,686	2,768	2,759	77	0.13	0.91
FCR	3.31	3.52	3.73	3.10	0.20	0.30	0.03
0-74							
DWG	762	856	776	842	33	0.03	0.10
DFI	2,147	2,396	2,252	2,291	73	0.08	0.64
FCR	2.83	2.80	2.90	2.72	0.09	0.81	0.13

All values are least squares means. SEM: standard error of the mean. R: restricted. AL: *ad libitum*. 1: treatment. 2: sex. The interaction was significant for none of the variables studied ($P < 0.49$).

transformation indices that were no different. The slaughter weight of R pigs tended to be greater ($P < 0.11$) in the R than in the AL pigs. No significant differences were seen between treatments with respect to DFT. During the *ad libitum* fattening phase of experiment 2, the interaction *time × treatment* had a significant effect ($P < 0.04$) on pig weight and daily growth.

Table 3. Effect of treatment on change in pig weight (Experiment 2)

Treatment	Weight (kg)			
	0 d	35 d	71 d	106 d
R (30)	33.3	54.5	95.5	123.3
AL (30)	32.4	61.7	95.5	120.0
SEM	0.95	1.5	1.4	1.5
Comparisons				
R *vs.* AL	0.64	0.0001	0.99	0.11

R: restricted. ( ): no. of animals. AL: *ad libitum*. SEM: standard error of the mean. Except for initial weights, all values are least squares means.

Discussion

In pigs maintained under a feed restriction regimen similar to that of experiment 1, Campbell *et al*. (1983) reported a reduction in growth of 45% during the restriction period. The feed conversion ratio during that period, however, was similar to that seen in pigs fed *ad libitum*. This contrasts with the results of experiment 1, in which the reduction in daily weight gain in R pigs compared to AL pigs was 52%, and as a result of which they showed a poorer transformation index. This might be explained by the mean temperature (13.1°C) of the restriction period. There is ample literature (Daza, 1988; Whittemore, 1993) showing that below a critical lower temperature (around 20°C for pigs in the growth phase), pigs with restricted diets see their growth potential more reduced than normally-fed pigs, which has a negative effect on the feed transformation rate. There is no shortage of papers (Donker *et al.*, 1986; Chiba *et al.*, 1999) indicating that temperature can modify overall results in compensatory growth experiments – as would seem to be that case in experiment 1. However, it is possible that the Dalland pigs of experiment 1, highly selected for the production of

Table 4. Effect of diet restriction during the growth phase on average daily gain (DWG, g), average daily feed intake (DFI, g) and feed transformation index (FCR, g g^{-1}) (Experiment 2)

Period (days)	Treatment			
	R	AL	SEM	Probability
0-35				
DWG	618	823	31	0.0001
DFI	1,601	2,125	97	0.0001
FCR	2.51	2.57	0.09	0.63
35-71				
DWG	1,137	938	36	0.0001
DFI	3,205	2,845	68	0.013
FCR	2.81	3.06	0.15	0.35
71-106				
DWG	796	700	39	0.023
DFI	3,154	2,946	50	0.034
FCR	3.78	4.18	0.09	0.047
0-106				
DWG	853	821	27	0.11
DFI	2,638	2,635	29	0.96
FCR	3.09	3.20	0.10	0.51
DFT (day 106)	16.9	16.2	0.9	0.67

All values are least squares means. R: restricted. AL: *ad libitum*. SEM: standard error of the mean. DFT: dorsal fat thickness.

lean meat, were more sensitive to severe feed restriction during the growth phase than the theoretically more fatty 3/4 Large White + 1/4 Berkshire pigs studied by Campbell *et al.* (1983). Evidence supporting this is available in the literature (Campbell and Taverner, 1988; Whittemore, 1993).

In experiment 2, in which food restriction was more moderate and the pigs were in thermoneutral conditions, there was no significant difference between the indices of feed transformation of the R and AL pigs during the restriction phase. These results agree with those of other authors (Campbell *et al.*,1983; Prince *et al.*, 1983; Donker *et al.*, 1986).

In agreement with the results of Lovatto *et al.* (2000), during the period of *ad libitum* fattening, the R pigs showed a greater daily weight gain than the AL animals in both experiments. However, in experiment 1, the pigs were subjected to severe restriction and could not fully compensate during the *ad libitum* fattening phase the significant reduction experienced in this variable. This is in agreement with that reported by Campbell *et al.* (1983), Valaja *et al.* (1992) and Critser *et al.* (1995). The relationship between restriction severity and the increase in growth rate during the *ad libitum* fattening phase is poor (Mersmann *et al.*, 1989). Therefore, strong restriction during the growth phase can lead to worse production indices over the entire growth period than in the restriction period (Critser *et al.*, 1995). However, if feed restriction is moderate, as in experiment 2, compensation by R pigs during the *ad libitum* fattening phase can be complete with respect to growth, and may even significantly improve the feed conversion ratio for the whole period beyond that of AL pigs (Campbell *et al.*, 1983) — or at least tend to improve it (Prince *et al.*, 1983; Donker *et al.*, 1986).

Repeated measurements analysis showed unequal development of daily growth during the *ad libitum* fattening period in R and AL pigs. Further, in experiments 1 and 2, compensatory growth continued to occur even four or five weeks after the end of restriction. The differences in daily growth became less over time when the restriction was moderate, in agreement with that reported by Kuhn and Burgstaller (1996).

The lack of any difference in DFT between R and AL pigs at slaughter agrees with that reported by Prince *et al.* (1983), Valaja *et al.* (1992) and Critser *et al.* (1995). It may be that greater differences in feed consumption between R and AL pigs would have had to occur during the *ad libitum* fattening phase (Mersmann *et al.*, 1989; Remaekers *et al.*, 1996) or for the whole experimental period (Campbell *et al.*, 1983; Donker *et al.*, 1986) for there to be any significant difference in DFT.

With respect to the effect of sex, much evidence exists to show how boars have a greater daily growth rate and higher food transformation index than gilts during the fattening period (English *et al.*, 1988; Whittemore, 1993). In the present experiment, the increase in weight over time and the daily growth of boars was different ($P < 0.01$), but compensatory growth was similar. These results agree with those of Donker *et al.* (1986) and Critser *et al.* (1995), although these authors compared barrows and gilts.

In conclusion, moderate feed restriction during the growth period (25% of the *ad libitum* quantity) improves overall productivity indices. However, more severe restriction (approx. 50%) does not improve these indices and may even worsen them in high growth potential pigs exposed to low temperature during the growth period.

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