DIRECT AND CORRELATED RESPONSES OF SELECTION IN DIVERGENT SELECTION FOR INTRAMUSCULAR FAT IN RABBITS

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ABSTRACT

The objective of this study was to evaluate the genetic response for a divergent selection experiment on intramuscular fat (IMF) content and to estimate the correlated response in carcass and meat quality traits. Data from two generation of selection were used in this study. The base population was composed of 13 males and 83 females. High (H) and Low (L) lines had 8 males and approximately 40 females each one per generation. Selection was based on the average phenotypic IMF value of two full sibs measured in *Longissimus* muscle (LM). Two rabbits (male and female) of the first parity of each doe were slaughtered at 9 weeks of age. The following traits were recorded: live weight (LW), hot carcass weight, chilled carcass weight, reference carcass weight, scapular fat weight, perirenal fat weight, meat/bone ratio of hind leg, pH of LM, colour (lightness, L*; redness, a*; yellowness, b*) of the carcass and LM. *Longissimus* muscles were excised from the carcass and the IMF content was measured by near infrared reflectance spectroscopy. Data were analyzed using Bayesian methodology. Response to selection was estimated by the difference between H and L lines. The difference between lines for IMF content in the second generation of selection was 0.11 g/100g, which represents a direct response to selection of 9.8 %, of which a 6.8 % was obtained in the first generation and a 3 % in the second. There seems to be a negative correlated response on live weight, carcass and adipose tissues weights, with higher values in L line. However, the evidence for adipose tissue is rather weak. There is no evidence of changes in carcass and meat colour measurements as well as in meat/bone ratio and muscle pH.

Key words: Rabbits, divergent selection, selection response, intramuscular fat, near infrared reflectance spectroscopy.

INTRODUCTION

Intramuscular fat (IMF) content is generally considered one of the main factors affecting meat quality (Wood *et al.,* 2008). IMF can be improved by selection due to its high heritability (an average of 0.5 in pigs; Sellier 1998 and Suzuki *et al.,* 2005a) and variability. Rabbit meat has a low fat content, then selection for increasing IMF could improve its meat quality. Besides, rabbit is an excellent model for genetic studies in other species due to its reduced generation interval and the low cost of the carcasses.

Few studies tried to increase IMF by selection in cattle (Sapp *et al.,* 2002) and pigs (Suzuki *et al.*, 2005b; Schwab *et al.,* 2009) but there is no study in rabbits. Thus, there is scarce information about correlated responses in all species. Genetic programmes need a substantial amount of data to obtain estimates of genetic parameters with a minimal precision. Therefore, genetic correlations involving meat quality analysis are often not accurate. Divergent selection experiments can be an alternative to examine the genetic determination of the traits of interest. Direct and correlated responses can be studied by comparing the means of high and low lines for different traits after selection, which requires fewer individuals to obtain reasonable accuracies.

The objectives of this study were (1) to evaluate the direct selection response for IMF content, and (2) to determine the correlated response in carcass and meat quality traits.

MATERIALS AND METHODS

Animals and experimental design

A total of 502 rabbits from a divergent selection experiment for intramuscular fat content (IMF) were used in this study. Animals came from a synthetic line selected for ovulation rate (Laborda *et al.*, 2011), and then selection was relaxed for two generations. The base population was composed of 13 males and 83 females. The High (H) and Low (L) lines had 8 males and approximately 40 females each per generation. Data from two generations of selection were used in this study.

Two rabbits (male and female) of the first parity of each doe were slaughtered at 9 weeks of age. Carcasses were prepared as recommended by the World Rabbit Science Association (Blasco and Ouhayoun, 1996). The following traits were recorded according to the methodology described by Hernández *et al.* (2004): live weight (LW), hot carcass weight (HCW), chilled carcass weight (CCW), reference carcass weight (RCW), scapular fat weight (SFW), perirenal fat weight (PFW), meat/bone ratio of hind leg (M/B), pH of LM, colour (lightness, L*; redness, a*; yellowness, b*) of the carcass and LM muscle. *Longissimus* muscles were excised from the carcass. Meat obtained from LM was ground, freeze-dried and scanned with a monochromator (Model 5000, NIR Systems INC.) applying calibration equations previously developed (Zomeño *et al.*, 2012).

Selection was made on the second parity using the average phenotypic IMF value of two full sibs of the first parity. Selection pressure on does was 18% for the first generation and 34% for the second generation. Males were selected from litters of sibs with the highest or lowest IMF value for H line and L line, respectively. Males were selected within sire families in order to reduce inbreeding.

Statistical Analysis

Data were analyzed using the following model:

$$y_{ijk} = LG_i + SE_j + S_k + e_{ijk}$$

where LG_i is the effect of line-generation (5 levels: base population, high line-generation 1, high line-generation 2, low line-generation 1 and low line-generation 2), SE_j is the effect of season (two levels: winter and summer), S_k is the effect of sex, and e_{ijk} is the residual of the model.

A Bayesian analysis was performed. Bounded flat priors were used for all unknown parameters. Marginal posterior distributions for all unknown were estimated using Gibbs sampling. Convergence was tested using the Z-criterion of Geweke. We used a chain of 60,000 samples with a burn-in period of 10,000 for each trait. Details of the procedure can be found in Blasco (2001). The following parameters were obtained from the marginal posterior distributions of the differences between lines: the median of the marginal posterior distribution of the difference (D); the highest posterior density region at 95% ($HPD_{95\%}$); the probability of lines being different (probability of the difference between lines being higher than zero when this difference is higher than zero, or the probability of the difference between lines being lower than zero when this difference is lower than zero) (P); the lowest possible value of a difference with a probability of 95% (limit of the interval [k, +∞) when the difference is higher than zero) or the highest possible value with a probability of 95% (limit of the interval (-∞, k] when the difference is lower than zero) (k).

Response to selection was estimated by the differences between H and L lines.

RESULTS AND DISCUSSION

Descriptive statistics of the traits are given in Table 1. The different adipose tissues represented a very small percentage of the chilled carcass (0.44 % for SF, 1.05 % for PF and 0.12% 0for IMF), which is in line with our previous results (Zomeño *et al.,* 2010). LM showed a low lipid (1.18 g/100g muscle) since it is one of the leanest muscle of the carcass (Pla *et al.,* 2004). Values for carcass and meat colour variables and muscle pH are similar to those obtained in previous works (Hernández *et al.,* 2004).

Table 1: Descriptive statistics of the traits analyzed.

Trait	N	Mean	SD	CVx100
LW (g)	502	1757	177	10.1
HCW (g)	502	1057	117	11.0
CCW (g)	502	1009	117	11.6
RCW (g)	502	797	97	12.1
SFW (g)	499	4.39	1.34	30.5
PFW (g)	502	10.6	4.52	42.6
IMF (g/100 g)	494	1.18	0.16	13.9
C L*	502	53.8	2.5	4.7
C a*	502	3.13	0.84	26.8
C b*	501	0.97	1.32	137
M/B	352	4.72	0.60	12.6
LM L*	501	52.6	2.47	4.7
LM a*	501	3.66	0.99	26.9
LM b*	501	1.52	0.79	51.9
LM pH	497	5.53	0.10	1.8

N, number of animals; SD, standard deviation; CV, coefficient of variation; LW, live weight; HCW, hot carcass weight; CCW, chilled carcass weight; RCW, reference carcass weight; SFW, scapular fat weight; PFW, perirenal fat weight; IMF, intramuscular fat content of *Longissimus* muscle; C L*, Lightness of carcass surface; C a*, redness of carcass surface; C b*, yellowness of carcass surface; M/B, meat/bone ratio of hind leg; LM L*, Lightness of *Longissimus* muscle; LM a*, redness of *Longissimus* muscle; LM b*, yellowness of *Longissimus* muscle; LM pH, ultimate pH of *Longissimus* muscle.

Table 2 shows the features of the estimated marginal posterior distributions of the differences between H and L lines for all traits studied. Intramuscular fat content was higher in line H than in line L (P=1.00), which represents a direct response to selection of 9.8%. A 6.8% of response was obtained in the first generation and a 3% in the second. Selection experiments to increase IMF content have been previously conducted in pigs (Suzuki *et al.,* 2005b; Schwab *et al.,* 2009) and cattle (Sapp *et al.,* 2002), with an improvement of IMF content in line selected for increased IMF.

Live and carcass weights were slightly higher in line L than in line H (P>0.98), at least 24.6 g for LW and 5.62 g for CCW with a probability of 95% (k=-24.6 and -5.62, respectively; Table 2). Scapular and perirenal fat weights seem to be higher in line L (P=0.95 and P=0.91, respectively). However, evidences of differences for SFW and PFW were low as it is shown by their $HPD_{95\%}$ and k values (Table 2). Hence, there is a negative correlated response in LW and carcass weights but the evidence of correlated response in adipose tissue weights is rather weak. These results differed from those of Schwab *et al.* (2009) who obtained no correlated responses in growth performance traits and higher values of backfat measurements (mm) in a line selected for increased IMF. Genetic correlations between IMF and backfat thickness have been studied in pigs showing a wide range from 0.04 (reviewed by Sellier, 1998) to 0.64 (Solanes *et al.,* 2009). The magnitudes of these correlations suggest that part of the genetic variation of IMF is independent of the genetic variation in overall lipid content of the carcass. In fact, Sapp *et al.* (2002) obtained no correlated response on fat thickness in bulls selected for IMF content suggesting that selection for increased IMF can be achieved without increasing carcass fat. Moreover, no phenotypic relationship between IMF and perirenal fat was observed in a previous work in rabbits (Zomeño and Hernández, 2012).

Table 2: Features of the estimated marginal posterior distributions of the differences between High and Low line (H-L) for intramuscular fat content (IMF) (g/100g), live weight, carcass and adipose tissues weights (g), meat to bone ratio of hind leg and muscle pH.

Trait	Difference	D	$HPD_{95\%}$		P	k
IMF	H-L	0.11	0.06	0.15	1.00	0.07
LW	H-L	-64.6	-112	-16.7	1.00	-24.6
HCW	H-L	-33.9	-63.7	-1.92	0.98	-7.70
CCW	H-L	-32.6	-62.2	0.08	0.98	-5.62
RCW	H-L	-29.2	-56.0	-3.80	0.99	-8.03
SFW	H-L	-0.33	-0.71	0.05	0.95	0.00
PFW	H-L	-0.85	-2.02	0.53	0.91	0.20
C L*	H-L	-0.59	-1.37	0.10	0.95	0.00
C a*	H-L	0.13	-0.11	0.38	0.84	-0.07
C b*	H-L	0.06	-0.34	0.45	0.61	-0.28
M/B	H-L	-0.01	-0.18	0.18	0.55	0.14
LM L*	H-L	-0.42	-1.11	0.32	0.88	0.17
LM a*	H-L	0.19	-0.11	0.49	0.90	-0.06
LM b*	H-L	0.00	-0.24	0.22	0.50	-0.20
LM pH	H-L	-0.01	-0.03	0.03	0.61	0.02

D, median of the marginal posterior distribution of the difference; $HPD_{95\%}$, highest posterior density region at 95%; *P*, probability of the difference being greater than zero when D>0 and probability of the difference being lower than zero when D<0; k, limit of the interval [k, +∞) when D>0 and (-∞, k] when D<0.

Line L had higher values for carcass L* (P=0.95) and lower values for carcass a*, although the probability of the differences for a* was lower (P=0.84) and the $HPD_{95\%}$ was larger ($HPD_{95\%}$= [-0.11, 0.38]). No differences were observed between H and L lines for carcass b*. Line L also had higher values for muscle L* and lower for muscle a*, as it was observed in carcass. No differences were found between H and L lines for muscle b*, meat/bone ratio of hind leg and muscle pH. Similarly, Schwab *et al.* (2009) found that meat quality characteristics were almost no affected by selection for IMF.

CONCLUSIONS

Preliminary results show a response in IMF content after two generations of divergent selection for IMF, with a difference between High and Low lines of 0.11 g/100g; associated with negative correlated responses in live weight, carcass and adipose tissues weights. The evidence in response for adipose tissue is rather weak, while carcass and meat colour measurements as well as meat/bone ratio and muscle pH were almost not affected by selection.

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