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Effect of the insulin-like growth factor-II and RYR1 genotype in pigs on carcass and meat quality traits

K. Van den Maagdenberg [a], A. Stinckens [b], E. Claeys [a], N. Buys [b], S. De Smet [a,*]

[a] *Laboratory for Animal Nutrition and Animal Product Quality, Department of Animal Production, Ghent University, Proefhoevestraat 10, 9090 Melle, Belgium*

[b] *Laboratory of Livestock Physiology, Immunology and Genetics, KULeuven, Kasteelpark 30, 3001 Heverlee, Belgium*

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Abstract

Recently, a new QTN (quantitative trait nucleotide), which is located in the regulatory sequence of the imprinted IGF-II gene was discovered in the pig and is associated with a significant increase in IGF-II mRNA expression in skeletal muscle during postnatal growth. The aim of the current study was to investigate the effect of the IGF-II paternal allele (Apat and Gpat animals that inherited, respectively, the mutant and wild type paternal allele of interest) on carcass and meat quality traits in Nn and NN RYR1 genotypes. A total of 141 animals were measured, almost equally distributed over the IGF-II and RYR1 genotypes and gender. The Apat allele increased carcass lean meat percentage with approximately 4.5% ($P < 0.001$) as a result of decreased backfat thickness. Average live weight daily gain was not affected, hence average daily lean meat gain was significantly higher for Apat compared to Gpat animals. The IGF-II mutation had no noticeable effect on meat quality in contrast with the RYR1 mutation. No interaction effects of both mutations on meat quality were noticed.

Keywords: Calpain activity; Carcass quality; IGF-II mutation; Meat quality; RYR1 mutation

1. Introduction

During the last decades, pig breeding programs have been strongly focusing on selection for fast growth of lean meat. The search for new QTL (Quantitative Trait Loci) and mutations in candidate genes offer a genetic basis for the selection for these production traits. However, meat quality traits are often neglected in selection programs. After all, increased carcass leanness may be accompanied with a negative effect on certain meat quality characteristics because of unfavourable correlated responses (De Smet et al., 1995; Hamilton, Ellis, Miller, McKeith, & Parret, 2000; Sellier, 1998). In this context, possibilities for new QTL or candidate genes with effects on muscle growth and percentage lean meat should be carefully evaluated for their influence on pork quality.

Recently, a new QTN (quantitative trait nucleotide), which is located in the regulatory sequence of the imprinted insulin-like growth factor-II (IGF-II) gene, was discovered in the pig (Van Laere et al., 2003). A significant increase in IGF-II mRNA expression in skeletal muscle was observed during postnatal growth probably because of the abrogation of a repressor (Stinckens et al., 2007). This mutation has an effect on muscle growth, fat deposition and size of the heart, but has no effect on birth weight. Jeon et al. (1999) found a large effect of this QTN on the lean meat content in the ham, heart weight and backfat thickness in a Wild boar/Large White intercross and Nezer et al. (1999) concluded that the IGF-II genotype causes an increase in carcass lean content at the expense of fat, but found no evidence for an effect on growth performance in a Large White/Piétrain intercross. However, the effect of

* Corresponding author.
E-mail address: Stefaan.DeSmet@UGent.be (S. De Smet).

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the IGF-II mutation on meat quality has not yet been reported.

On the other hand, the effects of the ryanodine receptor (RYR1) genotype on carcass and meat quality traits have been widely described. Fujii et al. (1991) identified the mutation in the porcine RYR1, which is associated with increased lean meat content in pigs but also with malignant hyperthermia or the porcine stress syndrome. This results in a higher incidence of PSE (Pale, Soft, and Exudative) meat in nn or Nn pigs compared to homozygous negative pigs (NN) (De Smet et al., 1996; Hamilton et al., 2000; Sellier, 1998) and various pork tenderness traits were negatively influenced by the n allele of RYR1 (Monin et al., 1999). Therefore, major economic losses in the pork industry have arisen as a result of the high frequency of this mutation in some pig populations. However, it is unknown at present whether the effect of the IGF-II mutation on carcass leanness is additive to the effect of RYR1 genotype.

Therefore, the aim of the current study was to investigate the effect of the IGF-II paternal allele (Apat vs. Gpat) on carcass and meat quality traits in relation to the RYR1 genotype (Nn vs. NN) to rule out possible unfavourable correlated responses of the IGF-II mutation and to examine interactions between these two major genes.

2. Materials and methods

2.1. Experimental set-up and carcass measurements

Pigs (barrows and gilts) originated from 28 litters from sows of a commercial hybrid sow and two sires of a synthetic dam line (Rattlerow-Seghers, Lebbeke, Belgium). The sires were heterozygous for IGF-II (Apat and Gpat alleles). Apat animals inherited the IGF-II mutation which is related to the higher percentage lean muscle mass versus the Gpat animals carrying the paternal wild type allele. Because of the paternal imprinting of the IGF-II gene (Nezer et al., 1999), the genotype of the mother was not considered. Piglets were genotyped for IGF-II and RYR1 as soon as possible after birth following the protocol as described by Stinckens et al. (2007). Complete litters and randomly chosen piglets from incomplete litters were used, totalling 141 animals. The number of pigs per genotype, sire and gender is shown in Table 1.

Piglets were weaned at four weeks of age. From three to eight weeks of age, the piglets were fed a commercial starter diet. At approximately eight weeks of age (±22 kg), the pigs were moved to the finishing barns and changed to a commercial growing–finishing diet. Pigs were fed *ad libitum* until slaughter and were housed in group. Live weight was recorded at birth, at three and eight weeks of age, and at slaughter. Average daily gain (ADG) was calculated as the live weight at slaughter divided by the number of days from birth to slaughter. At a target weight of 110 kg, the pigs were killed after an overnight fast, in a commercial slaughterhouse (Braems, Herzele, Belgium) after CO_2 stunning.

Table 1
Number of pigs per IGF-II and RYR1 genotype, sire, and gender

Sire	Gender	IGF-II	RYR1		Total
			Nn	NN	
Sire 1	Barrow	Apat	13	7	19
		Gpat	12	6	18
	Gilt	Apat	14	10	24
		Gpat	12	2	14
Sire 2	Barrow	Apat	7	6	13
		Gpat	9	10	19
	Gilt	Apat	7	8	15
		Gpat	9	9	18

Apat and Gpat: IGF-II genotype carrying, respectively, the mutant and original paternal allele of interest.

Lean meat percentage (LMP) in the carcass was estimated by optic light measurements using a 'Capteur Gras-Maigre' device (CGM) equipped with an 8 mm diameter Sydel probe (SYDEL, Lorient, France) in the slaughter line. Average daily carcass lean meat growth (ADLMG) was calculated as the carcass weight multiplied by the percentage lean meat, divided by the number of days from birth to slaughter. Directly after splitting the carcass, heart, lungs, spleen, liver and kidneys were removed from the progeny of sire 1 and weighed. The weight of each organ was expressed relative to the carcass weight. At 40 min *postmortem*, the pH (pH_{40}) was recorded in the loin between the third and fourth last rib (*m. Longissimus* (LD)) and in the ham (*m. Semimembranosus* (SM)) of both carcass sides using a Knick Portamess 654 pH meter (Knick, Berlin, Germany) equipped with a Mettler Toledo LoT406-M6-DXK-S7/25 electrode (Urdorf, Switzerland). At 24 h *postmortem*, the pH (pH_{24}) and the conductivity (Pork Quality Meter, (PQM), Intek, Aichach, Germany) were recorded in the loin and the ham of both carcass sides. Carcass length was assessed as the distance from the posterior edge of the symphysis pubis to the cranial edge of the first rib and backfat thickness was measured on the cutting edge at the level of the first rib, the seventh rib and the fourth vertebra of the right carcass side with a ruler. Ham angle and ham width were measured at both carcass sides. The average values of pH_{40}, pH_{24}, PQM, ham angle and ham width measurements of both carcass sides per animal were used further.

Carcasses were cut according to a commercial Belgian protocol. The results are expressed relative to the carcass weight. The LD was removed from the loin cut and weighed. The weight of the LD was expressed relative to the carcass weight (PKLD). The cross-sectional area of the LD was measured manually after cutting the loin at the level between the third and fourth last rib.

2.2. Meat quality

Meat quality measurements were done on LD and *m. Triceps Brachii* (TB) of the left carcass side. The muscles