The effect of gene SKI polymorphism on carcass traits in pigs

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Phosprotein, the product of proto-oncogene SKI, plays a role in the control of cell growth and in skeletal muscle differentiation. The aim of this study was to characterize the polymorphism of gene SKI identified with restriction endonuclease BsmII in gilts of Polish Large White (PLW, n=117) and Polish Landrace (PL, n=51), and to analyse the relation between the SKI genotypes and carcass traits. The animals were free of RYR1T allele. In both breeds, the frequency of homozygote CC at the SKI locus occurred very low. The only significant relations between genotype and carcass traits were observed in PLW gilts for weight of loin and weight of sirloin.

KEY WORDS: carcass quality / gene polymorphism / pig / SKI

Selection for increased growth rate or decreased backfat thickness was important in pig breeding during last two decades, based, among others, on OTL identification. Within this area, one of the methods used is evaluation of candidate genes polymorphism effect on phenotypic variation [Kurył 2000 – a review].
Recently, the SKI proto-oncogene was suggested as potentially influencing carcass traits in pigs [Stratil et al. 2002]. SKI encodes a nuclear protein, binds to DNA in association with other cellular factors, and modulates transcription [Berk et al. 1997]. These proteins are involved in cell proliferation, differentiation and apoptosis. The gene SKI has also been found implicated in the control of myogenesis processes [Berk et al. 1997]. Earlier Colmenares and Stavnezer [1989] reported that the proto-oncogene SKI induces muscle cell differentiation. Transgenic pigs and mice carrying SKI sequences show marked muscle hypertrophy characterized by myofibre-type specificity [Sutrave et al. 1990, Pursel et al. 1992]. The induction of MYOD1 and MYF4 expression by the SKI suggests, that this proto-oncogene acts early in the pathway, perhaps in the determination step next to MYOD1 and(or) MYF5. Thus, induction of myofibre hypertrophy suggests the SKI activity during postnatal muscle growth, perhaps in cooperation with other genes [Colmenares et al. 1991]. In order to determine a normal function of this gene in vivo, Berk et al. [1997] have disrupted the mouse SKI gene. The results confirmed its function in skeletal muscle development and showed a novel role of the factor in the morphogenesis of craniofacial structures and the central nervous system. But the exact role of the gene in development of skeletal muscle still remains unclear.

In the porcine SKI mapped to pig chromosome 6, double nucleotide substitution CG→TC at positions 304-305 resulting in an amino acid substitution in the protein (Arg→Ser), was described by Stratil et al. [2002]. This polymorphism is located in exon 1, encoding functional domain responsible for transformation and muscle differentiation.

The aim of this study was to evaluate the effect of the mutation described on porcine growth rate and carcass traits. A similar analysis has not been reported in literature to date.

**Material and methods**

Included were Polish Large White (PLW, n=117) and Polish Landrace (PL, n=51) gilts free of RYRI^T allele. The pigs were fattened and slaughtered at the Pig Testing Station of the National Research Institute of Animal Production, Pawłowice near Leszno Wlkp, Poland. From 25 to 100 kg live body weight the commercial mixed feed was applied ad libitum. Right carcass side was dissected into lean, fat and bone according to the procedure described by Różycki [1996]. In the present study the following traits were considered: weight of right carcass side, weight of ham with shank, height of loin eye, loin eye area, loin weight, sirloin weight, meat content of valuable carcass cuts and meat content of carcass. Genomic DNA was isolated from leukocytes according to Kawasaki [1990]. The SKI genotyping was performed using PCR/RFLP technique with BsmAI (Alw26I) endonuclease, recognizing G→C substitution, according to Stratil et al. [2002]. An amplified 350 bp fragment encompassed part of SKI exon 1. Association analyses were carried out for each of two
breeds separately using the least squares method of the GLM procedure [Statistical Analysis Systems Institute Inc. 2001, according to the following model:

\[ Y_{ijkl} = \mu + G_i + O_j + \beta(x_{ij} - \bar{x}) + e_{ij} \]

where:
- \( y_{ij} \) – trait measured on \( ij \)-th animal;
- \( \mu \) – overall mean;
- \( G_i \) – effect of \( SKI \) genotype;
- \( O_j \) – sire effect;
- \( \beta(x_{ij} - \bar{x}) \) – linear regression for weight of right carcass side (for carcass traits) and age at slaughter (for growth rate traits);
- \( e_{ij} \) – random error.

Results and discussion

The frequency of genotypes and alleles at the \( SKI \) locus is shown in Table 1. The \( G305C \) polymorphism present in exon 1 was identified with enzyme \( BsmAI \). Three \( SKI/G305C \) genotypes were observed in breeds tested, but the frequency of genotype \( CC \) was low in both (11.1% in PLW and 1.96% in PL). In PLW the frequency of homozygotes \( GG \) was similar to that of heterozygotes whereas in PL the most frequent was \( GG \) genotype. Stratil et al. [2002] reported the highest frequency of \( SKI \) C allele in Pietrain pigs, whereas Meishan pigs appeared to be monomorphic for the allele \( G \). However, one should mention that in a cited study by Stratil et al. [2002] number of animals of individual breeds was very low (6 and 12, respectively).

Table 1. Frequency of genotypes and alleles at locus \( SKI \) in Polish Large White (PLW) and Polish Landrace (PL) gilts

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number of animals</th>
<th>Genotypes and frequency</th>
<th>Alleles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( GG )</td>
<td>( GC )</td>
</tr>
<tr>
<td>PLW</td>
<td>117</td>
<td>50 (42.7%)</td>
<td>54 (46.1%)</td>
</tr>
<tr>
<td></td>
<td>PL</td>
<td>51</td>
<td>37 (72.5%)</td>
</tr>
</tbody>
</table>

A significant relationship between production traits and the genotype at the \( SKI \) locus was observed for two traits and in PLW gilts only (Tab. 2). The tested transversion – \( G305C \) – was found significant for weight of loin and weight of sirloin.
The homozygotes of the G allele showed the highest value of these traits, compared to heterozygotes and homozygotes of allele C. Heterozygotes showed the lowest weight of loin compared to both homozygotes. Such phenomenon observed earlier for certain human genes was named a negative (or positive) heterosis – Comings and MacMurray [2000] – who suggested that if the regulation of the gene is dose-dependent, the presence of a regulatory sequence in a heterozygous state could modify the gene function. Similar associations were also observed in our earlier studies regarding MyoD genes family [Cieślak et al. 2002, Urbański et al. 2005, 2006, Wyszyńska-Koko et al. 2006].

We did not observe any significant relation between SKI genotypes and carcass traits in PL pigs tested in this study. A low number of animals (51 only) may be the reason for insignificance of associations studied (Tab. 1).

The SKI proto-oncogene has been mapped to chromosome 6 by Stratil et al. [2002], where two other genes – RYRI [Fujii et al. 1991] and H-FABP [Gerbens et al. 1997] – as well as QTLs important for growth rate and carcass traits [Paszek et al. 1999 and Geldermann et al. 2003] have been localized. The RYRI genotype is known to affect carcass quality. In the present study, however, this was excluded as the gilts analysed were free of RYRIT allele. Thus, the observed effect of SKI genotype on carcass traits has not been modified by RYRI gene linked to SKI locus.

REFERENCES


<table>
<thead>
<tr>
<th>Carcass trait</th>
<th>SKI genotype at nucleotide G305C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GG</td>
</tr>
<tr>
<td></td>
<td>LSM</td>
</tr>
<tr>
<td>Weight of sirloin (kg)</td>
<td>0.359&lt;sup&gt;a&lt;/sup&gt; 0.006</td>
</tr>
<tr>
<td>Weight of loin (kg)</td>
<td>6.769&lt;sup&gt;a&lt;/sup&gt; 0.089</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> – Within rows means bearing different superscripts differ significantly at: small letters – P ≤ 0.05; capital – P ≤ 0.01.
SKI gene polymorphism and carcass traits in pigs


10. KURYŁ J., 2000 – Geny cech ilościowych zwierząt gospodarskich – aktualny stan badań (The current state of research in the quantitative traits loci in farm animals – a review). In Polish, summary in English. Prace i Materiały Zootechniczne 56, 7-50.


WYSZYŃSKA-KOKO J., KURYŁ J., FLISIKOWSKI K., KAMYCZEK M., RÓŻYCKI M.,
2006 – Relation between the polymorphism in the coding and regulatory regions of the porcine MYF6 and MYOG genes, the expression of MYF6 gene in m. longissimus dorsi and productive traits in pigs. Journal of Applied Genetics 47(2), 131-138.

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Analiza wpływu polimorfizmu genu SKI na cechy tuszy świń

S t r e s z c z e n i e

Protoonkogen SKI pełni ważną rolę w procesie wzrostu i rozwoju organizmu oraz jest zaangażowany w proces rozwoju mięśni szkieletowych. Produktami tego genu są białka jądrowe, uczestniczące, między innymi, w indukcji procesów miogenezy. Celem badań była charakterystyka polimorfizmu genu SKI świń dwóch ras hodowanych w Polsce – wielkiej białej polskiej (PLW) i polskiej białej zwisłouchej (PL) – i ocena wpływu tego polimorfizmu na cechy tuszy. Badaniami objęto zwierzęta wolne od genu RYR1, aby wykluczyć wpływ genotypu RYR1 na cechy tuszy. W obu rasach zaobserwowano bardzo niską frekwencję osobników homozygotycznych CC. Istotne zależności między genotypem a badanymi cechami stwierdzono tylko w rasie wbp (PLW) i to wyklucznie w odniesieniu do masy polędwicy i masy polędwiczki. Autorzy wnioskują, że znajomość genotypu SKI może być przydatna w selekcji ukierunkowanej na poprawę wymienionych cech tuszy, jednak badania te powinny być kontynuowane na materiale obejmującym inne rasy i linie, aby stwierdzić, czy zaobserwowane zależności mają charakter uniwersalny.