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Puberty Related Changes in Hormonal Levels, Productive Performance, Carcass Traits, and Their Interactions in Slovakian White Gilts*

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ABSTRACT : The aim of this experiment was to evaluate the levels of hormones (progesterone, IGF-I and IGFBP-3) in blood plasma, growth, carcass traits and their interactions of sexually immature (n = 18) and sexually mature (n = 17) gilts. To calculate average daily weight gain (ADG), gilts were individually weighed at the beginning of the trial and at slaughter (110±10 days old). Blood concentrations of progesterone, IGF-I and IGFBP-3 were determined by RIA. The right hot carcass sides were dissected and the individual basic parts from carcasses were weighed to record the carcass traits. IGFBP-3, ADG and carcass traits were not affected by pubertal maturation. Compared to sexually immature gilts, mature gilts had higher blood concentrations of progesterone and IGF-I. High correlations were noted between levels of some hormonal substances, productive performance and carcass traits of sexually immature and mature gilts. (**Key Words :** Gilt, Progesterone, IGF-I, IGFBP-3, Productive Performance, Carcass Traits)

INTRODUCTION

It is well established that reproductive function is metabolically gated (Barb et al., 2008). Puberty is a fundamental development process experienced by all reproductively competent adults, yet the specific factors regulating age at puberty remain elusive in pigs (Yang et al., 2008).

Progesterone is produced by porcine ovarian granulosa cells (Sirotkin et al., 2008) and the *corpora lutea* in ruminants (Al-Dabbas et al., 2008; Arellano-Rodriguez et al., 2008; Blaszczyk et al., 2009). Progesterone is an ovarian steroid hormone that is essential for normal breast development (Hagan et al., 2009). Progesterone levels remain normal during the early to midfollicular phase, but do not reach ovulatory or luteal phase levels, confirming lack of ovulation in women (Arnhold et al., 2009). The actions of progesterone are largely mediated through binding to its cognate steroid hormone receptor, the progesterone receptor (Hagan et al., 2009).

IGF-I is produced by porcine (Budacova et al., 2001; Sirotkin et al., 2004; Roychoudhury et al., 2009), chicken (Sirotkin et al., 2006) and human (Karamouti et al., 2007) ovarian cells. Changes in liver IGF-I secretion that arise from perturbations of the somatotropic axis have a direct effect on the ovary through the endocrine actions of IGF-I (Lucy, 2008). It plays a significant role in the control of growth (Lucy, 2008; Ortega et al., 2008) and the regulation of ovarian folliculogenesis (Ortega et al., 2008) in pig and cattle. A threshold of IGF-I protein in follicular fluid may be met by local ovarian (paracrine/autocrine) and endocrine sources of IGF-I (Lucy, 2008). IGF-I has important growth promoting and metabolic effects and is expressed in virtually every tissue of the body. The highest expression is found in the liver, but the physiological role of liver-derived IGF-I remain unknown. It has been difficult to separate the endocrine effects of liver-derived IGF-I from the autocrine/paracrine effects of locally produced IGF-I in peripheral tissues (Sjögren et al., 2002). Many factors regulate the linear growth (Hutchison et al., 2007). The IGF-I receptor (IGFIR) has an important effect on growth, carcass, and meat quality traits in many animal species (Lei et al., 2008). Enhancing IGF-I specifically in skeletal muscle reportedly had a positive effect on carcass composition of terminal cross market swine (Pursel et al., 2000). Plasma IGF-I is influenced by dietary energy source

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at particular times of year (Staniar et al., 2007). Its effects are mediated via the type I IGFIR and IGF-binding proteins (IGFBPs) (Sullivan et al., 2008). In pigs, a paternally imprinted mutation in the insulin-like growth factor II (IGF-II) gene is associated with increased muscle mass and decreased backfat thickness. The IGF-II mutation altered body composition in pigs by favouring myofibre hypertrophy and repressing adipose cell development in subcutaneous adipose tissue (Gardan et al., 2008).

IGFs and IGFBPs are paracrine regulators of tissue growth and development, and are expressed at the sites of biological action (Carter et al., 2006). The IGFBPs are important in that they bind the IGFs (Nakatani et al., 1991). IGFBPs regulate the biological functions of IGFs and may affect cell growth through IGF-independent actions. Growth factors and hormones have been shown to alter IGFBP production by target cells suggesting that the effects of these factors may be partially mediated by the local production of IGFBP (Yi et al., 2001). IGFBP-3 is localized in cells containing the muscle specific protein desmin, thus establishing the presence of this IGFBP in myogenic cells. IGFBP-3 occurs in the cytoplasm of all myogenic cells and is also detectable in fused myotubes (Xi et al., 2007).

The aim of this study was to evaluate the levels of hormonal substances (progesterone, IGF-I, IGFBP-3) in blood plasma, productive performance, carcass traits, and their correlations in sexually immature and mature gilts.

MATERIALS AND METHODS

Animals

Animal handling followed the recommendations of European Union directive 86/609/EEC concerning animal care and was approved by the Animal Ethics Committee of the Slovak University of Agriculture, Nitra, Slovak Republic.

Thirty-five healthy gilts of Slovakian White breed, 110±10 days old, with a starting live weight of about 25±2.5 kg were used for this experiment. The trial was carried out in the Experimental Centre for Farm Animals at the Department of Special Zootechniques, Slovak University of Agriculture in Nitra. During the trial, animals were fed the complete feed mixture (Table 1) for pigs twice daily and had free access to water *ad libitum* according to standard requirements and supplied on a basis of 9% of live weight$^{0.75}$. The complete feed mixture contained Schaumacit as feed additive for conversion of acidity in stomach. The bactericidal and fungicidal effects of organic acids were described previously (Galik et al., 2007). To calculate average daily weight gain (ADG), gilts were individually weighed (in the morning after an overnight fast) at the beginning of the trial and at slaughter.

Table 1. Composition of experimental diets fed to gilts

Feed	Period		
	30-45 kg	45-75 kg	75-till slaughter
Ingredients (g/100 g) diet)			
Wheat	28.80	34.80	37.00
Corn	20.00	20.00	15.00
Barley	20.20	20.00	25.00
Wheat bran	3.00	3.00	6.00
Soya	22.50	16.50	13.50
Schaumacit	0.50	0.50	0
Enerfarm	1.50	1.50	0
Mineral premix	3.50	3.70	3.50
Chemical composition			
Lysine (g/100 g diet)	1.18	11.01	10.00
Methionine (g/100 g diet)	3.40	3.29	3.14
Threonine (g/100 g diet)	0.23	0.22	0.20
Crude fiber (g/100 g diet)	2.72	2.66	2.85
Cysteine (g/100 g diet)	6.29	5.70	5.50
Tryptophan (g/100 g diet)	0.69	0.65	0.59
P (g/100 g diet)	0.61	0.59	0.62
Ca (g/100 g diet)	0.85	0.70	0.68
Net energy (MJ/kg DM)	13.56	13.24	12.93

Blood plasma

Blood was collected from *jugular vein* with the help of syringe at the time of slaughter of animals and collected in the heparinised glass tubes. Thereafter, blood plasma was separated from whole blood by centrifugation at x 400g for 15 minutes and samples were stored at -70°C until RIA analysis. Concentrations of progesterone, IGF-I and IGFBP-3 were determined in duplicate in 20-100 µl samples by RIA. Progesterone and IGFBP-3 were assayed using RIA kits from DSL (Webster, Texas, USA) according to the manufacturer's instructions. IGF-I was assayed as described previously (Makarevich and Sirotkin, 1999).

Slaughter surveys

All the animals were slaughtered the same day at 110±10 days of age in a commercial slaughterhouse, located 200 metres from the experimental farm, where they were kept for a minimum of 12 h prior to slaughter. Gilts were electrically stunned, exsanguinated and processed at a local slaughterhouse.

Gilts were divided into two groups: sexually immature (n = 18) and sexually mature animals (n = 17) according to visual characteristics of ovaries (presence of preovulatory follicles, *Corpora lutea or Corpora alba*).

Right carcass side was dissected according to the standard STN 46 61 64 norms, and the individual basic parts from the hot carcass were weighed (Krska et al., 2002).

The following parameters of carcass traits were

recorded: weight of ham (WH), percentage of lean in ham (LH), bacon thickness (BTH), weight of dorsal bacon (WDB), weight of ham bacon (WHB), weight of total bacon (WTB), percentage of valuable lean cuts (VLC). VLC refers to ham, shoulder, loin and neck taken together.

Analysis

All data were analysed by Student's test and chi-square (x^2) test with Statistical Analysis System SAS (SAS Institute Inc., USA, 2001) software package. The results are given as means along with their standard deviations. Simple correlations were calculated among all variables using the same statistical package. Differences were considered significant at levels $p<0.001$ and $p<0.05$.

RESULTS AND DISCUSSION

This study was conducted to determine the levels of progesterone, IGF-I and IGFBP-3 in blood plasma of sexually immature and mature gilts, as well as the productive performance and carcass traits of these animals. In addition, correlations were calculated to examine the relationship among all variables studied.

The concentrations of progesterone of sexually mature gilts were significantly higher than sexually immature ones (20.75±2.56 vs. 0.44±0.26 ng/ml, respectively; $p<0.001$). Similarly, blood concentrations of IGF-I in sexually mature gilts (10.17±5.85 ng/ml) were significantly higher ($p<0.05$) in comparison to sexually immature ones (2.78±1.26 ng/ml). Lower concentration of IGFBP-3 of sexually immature gilts was detected (20.39±3.51 ng/ml) in comparison with mature animals (22.17±5.59 ng/ml), but this not statistically different ($p<0.05$). Sexually mature gilts had higher ($p<0.001$) concentrations of progesterone in blood plasma than sexually immature animals. Similarly, pubertal maturation was associated with the increase in blood concentrations of sexual steroids in primates, rats and cattle (Prunier and Louveau, 1997). Bulls with higher blood serum IGF-I concentrations were found to have heavier carcasses along with lower backfat thickness (Davis and Simmen, 2000). In our study, the concentration of IGF-I was found to be significantly higher in sexually mature animals than sexually immature ones. Langendijk et al. (2008) showed a positive relationship between peripheral progesterone and IGF-I concentrations *in vivo* during the early luteal phase of sows. During pubertal maturation, the increase in blood concentrations of sexual steroids was associated with a spurt in plasma IGF-I in primates, rats and cattle. Plasma IGF-I levels were reported to increase with age ($p<0.01$) (Prunier and Louveau, 1997). In the present study, we also found ($p<0.05$) lower concentrations of IGFBP-3 in blood plasma of sexually immature gilts in comparison with mature animals. Plasma 43-39 kDa IGFBP levels were found to increase whereas plasma 34 kDa IGFBP were decreased with age ($p<0.01$) (Prunier and Louveau, 1997). Slaughter weight, ADG, weight of ham, percentage of lean in ham, percentage of valuable lean cuts, bacon thickness, weights of dorsal and ham bacon, and weight of total bacon did not differ ($p>0.05$) between sexually immature and mature animals (Table 2).

Correlations between hormonal substances, productive performance and carcass traits of sexually immature and mature gilts are recorded in Table 3 and 4, respectively. Positive high correlation has been found between LH-WH (r = 0.81), LH-VLC (r = 0.93), WH-VLC (r = 0.73), WDB-WHB (r = 0.95), WDB-WTB (r = 0.99) and WHB–WTB (r = 0.98) in sexually immature gilts. Negative high correlation has been noted between LH-WDB (r = -0.81), LH-WHB (r = -0.72), LH-WTB (r = -0.79), WDB-VLC (r = -0.83), WHB-VLC (r = -0.80), WTB-VLC (r = -0.83) in sexually immature gilts. Highly positive correlation has been found between P-IGF-I (r = 0.67), P-ADG (r = 0.78), IGF-I-ADG (r = 0.83), SW-WH (r = 0.68), LH-WH (r = 0.80), LH-VLC (r = 0.97), WH-VLC (r = 0.66), BTH-WDB (r = 0.98), BTH-WHB (r = 0.94), BTH-WTB (r = 0.97), WDB-WHB (r = 0.99), WDB-WTB (r = 0.99) and WHB-WTB (r = 0.99) in sexually mature gilts. In sexually mature gilts highly negative correlation has been seen between P-

Table 2. Least square means and standard deviation for productive performance and carcass traits of sexually immature and mature gilts

Group	Immature gilts	Mature gilts	Significance
Slaughter weight (kg)	101.55±3.58	104.50±5.26	ns
ADG (g d^{-1})	879.18±75.67	856.75± 91.91	ns
Weight of ham (kg)	8.08± 0.70	7.45±0.72	ns
Lean in ham (%)	20.00±1.55	18.43±1.33	ns
Lean cuts[a] (%)	49.49±2.71	46.51± 3.33	ns
Bacon thickness (cm)	2.19±0.47	2.21±0.61	ns
Weight of dorsal bacon (kg)	3.05±0.60	3.79±0.65	ns
Weight of ham bacon (kg)	1.96±0.35	2.19±0.42	ns
Weight of total bacon (kg)	5.08±0.93	5.98±1.07	ns

Significance level: ns = Not significant. [a] Ham, shoulder, loin and neck.

Table 3. Coefficients of linear correlations between hormonal levels, productive performance and carcass traits of sexually immature gilts

	P	IGF-I	IGFBP-3	SW	ADG	LH	WH	BTH	WDB	WHB	WTB	VLC
P	1	-0.11	0.23	-0.27	0.44	0.06	-0.13	-0.31	-0.03	-0.05	-0.04	0.07
IGF-I		1	0.10	0.20	-0.31	-0.21	-0.01	0.13	0.31	0.24	0.29	-0.14
IGFBP-3			1	- 0.29	0.29	-0.03	-0.11	0.06	0.07	0.12	0.09	-0.05
SW				1	-0.56	-0.10	0.42	0.21	0.22	0.18	0.21	-0.13
ADG					1	0.07	-0.36	-0.12	-0.16	-0.19	-0.17	0.08
LH						1	0.81***	-0.61	-0.81***	-0.72***	-0.79***	0.93***
WH							1	-0.44	-0.61	-0.53	-0.58	0.73***
BTH								1	0.63	0.58	0.62	-0.64
WDB									1	0.95***	0.99***	-0.83***
WHB										1	0.98***	-0.80***
WTB											1	-0.83***
VLC												1

P = Progesterone, IGF-I = Insulin-like growth factor I, IGFBP-3 = IGF-binding protein 3, LH = % of lean in ham, WH = Weight of ham, VLC = Valuable lean cuts, BTH = Bacon thickness, WDB = Weight of dorsal bacon, WHB = Weight of ham bacon, WTB = Weight of total bacon, SW = Slaughter weight, ADG = Average daily weight gain.
*** $p<0.001$.

Table 4. Coefficients of linear correlations between hormonal levels, productive performance and carcass traits of sexually mature gilts

	P	IGF-I	IGFBP-3	SW	ADG	LH	WH	BTH	WDB	WHB	WTB	VLC
P	1	0.67***	-0.17	0.49	0.78***	0.31	-0.09	-0.70***	-0.55	-0.44	-0.51	0.33
IGF-I		1	0.14	0.07	0.83***	-0.50	-0.68***	0.03	0.24	0.35	0.28	-0.48
IGFBP-3			1	-0.94***	-0.43	-0.45	-0.77***	0.10	0.16	0.15	0.16	-0.23
SW				1	0.62	0.54	0.68***	-0.35	-0.36	-0.32	-0.35	0.36
ADG					1	-0.11	-0.15	-0.14	0.02	0.13	0.06	-0.20
LH						1	0.80***	-0.82***	-0.92***	-0.94***	-0.93***	0.97***
WH							1	-0.34	-0.50	-0.55	-0.52	0.66***
BTH								1	0.98***	0.94***	0.97***	-0.89***
WDB									1	0.99***	0.99***	-0.97***
WHB										1	0.99***	-0.99***
WTB											1	-0.98***
VLC												1

P = Progesterone, IGF-I = Insulin-like growth factor I, IGFBP-3 = IGF-binding protein 3, LH = % of lean in ham, WH = Weight of ham, VLC = Valuable lean cuts, BTH = Bacon thickness, WDB = Weight of dorsal bacon, WHB = Weight of ham bacon, WTB = Weight of total bacon, SW = Slaughter weight, ADG = Average daily weight gain.
*** $p< 0.001$.

BTH (r = -0.70), IGF-I-WH (r = -0.68), IGFBP-3-SW (r = -0.94), IGFBP-3-WH (r = -0.77), LH-BTH (r = -0.82), LH-WDB (r = -0.92), LH-WHB (r = -0.94), LH-WTB (r = -0.93), BTH-VLC (r = -0.89), WDB-VLC (r = -0.97), WHB-VLC (r = -0.99) and WTB-VLC (r = -0.98). A strong positive correlation ($p<0.01$) between IGF-I and IGFBP-3 concentrations was apparent with increasing age of the animals (Lee et al., 2002). On the other hand, we did not notice any significant difference between the groups of gilts in case of slaughter performance (% lean in ham, weight of ham, % of valuable lean cuts, bacon thickness, weight of dorsal bacon, weight of ham bacon and weight of total bacon). However, this study confirms the relationship between slaughter weight and ham weight (Alfonso, 2005). Lee and co-investigators (2002) suggested that growth rate and backfat thickness can be decreased by a moderate restriction of feed or energy intake with no accompanying changes in circulating IGF-I and IGFBP-3 concentrations. Moreover, both IGF-I and IGFBP-3 concentrations may be useful as growth indices in pigs. We did not find any significant differences between the two experimental groups in growth performance. Also, no correlations were observed between the carcass traits and IGF-I in young fattening bulls (Istasse et al., 1990). According to Ong and co-workers (2007), rapid infancy weight gain is associated with subsequent higher circulating IGF-I levels in normal children.

Higher blood concentrations of progesterone and IGF-I

in sexually mature gilts in comparison to immature animals suggest their association with porcine pubertal maturation. Pubertal maturation did not affect growth performance and carcass traits in gilts. Obtained data indicate puberty-related changes in some hormonal regulators (progesterone and IGF-I) of ovarian function in gilts. Results from this study also suggest puberty-associated correlations between some hormonal substances, productive performance and carcass traits in immature and mature gilts.

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