COMPARATIVE EVALUATION OF LARGE WHITE PIGS AND THEIR CROSSBREEDS MEAT NUTRITIONAL VALUE AND MINERAL CONTENT

Vigilijus Jukna, Vilma Valaitienė, Edita Meškinytė-Kaušilienė, Arūnas Jankauskas
Laboratory of Meat Characteristic and Quality Assessment, Veterinary Academy, LUHS
Tilžės 18, LT-47181 Kaunas; Lithuania
Phone: (8~37) 36 34 14; E-mail: vjukna@lva.lt; valaitiene@lva.lt; ajankauskas@vet.lt.

Abstract. The aim of the present study was to examine large white (LW) breed, large white x yorkshire (LWxY) and large white x landrace (LWxL) crossbreeds pork nutritional value and the concentration of essential elements like natrium (Na), magnesium (Mg), calcium (Ca), selenium (Se), copper (Cu), zinc (Zn), iron (Fe) and barium (Ba) with a particular focus on the variability of these trace elements. The parameters of nutritional value (dry matter, proteins, intramuscular fat and total minerals) were determined. The concentrations of natrium, magnesium, calcium, selenium, copper, zinc, iron and barium were determined by inductively coupled plasma mass spectrometry (ICP-MS) after microwave digestion. Various breeds of pigs had different contents of nutritional value and minerals in the longest back muscle. The highest amount of total minerals ($P<0.01$), trace elements of Na, Mg ($P<0.001$) and Ba was established in LWxY pig crossbreed meat. Trace elements of Ca, Zn ($P<0.001$), Se, Cu ($P<0.05$) and Fe were rich in LWxL meat. The highest amount of dry matter, protein and intramuscular fat was in LW pork. However, pork nutritional value and mineral content were affected by pig breed.

Keywords: nutritional value, mineral content, pig breed, crossbreed.

DIDŽIŲJŲ BALTŲJŲ VEISLĖS KIAULIŲ IR JŲ MIŠRŪNŲ MĖSOS MAISTINĖS VERTĖS BEI MINERALINIŲ MEDŽIAGŲ KIEKIO PALYGINAMASIS ĮVERTINIMAS

Vigilijus Jukna, Vilma Valaitienė, Edita Meškinytė-Kaušilienė, Arūnas Jankauskas
Gyvulių mėsinių savybių ir mėsos kokybės vertinimo laboratorija, Veterinarijos akademija, LSMU
Tilžės g. 18, LT-47181 Kaunas; tel. (8~37) 36 34 14
el. paštas: vjukna@lva.lt; valaitiene@lva.lt; ajankauskas@vet.lt

Santrauka. Šio darbo tikslas buvo palyginti maistinės vertės ir mineralinių medžiagų (natrio, magnio, kalcio, seleno, vario, cinko, geležies ir bario) kiekį, esantį didžiųjų baltųjų veislės, didžiųjų baltųjų x jorkšyrų ir didžiųjų baltųjų x landrasų kiaulių mišrūnų ilgiausiajame nugaros raumenyje. Nustatyti maistinės vertės rodikliai – sausosios medžiagos, baltymai, tarpraumeniniai riebalai ir bendras mineralinių medžiagų kiekis. Skirtingų mineralų koncentracija (natrio, magnio, kalcio, seleno, vario, cinko, geležies ir bario) nustatyta induktyviai susietos plazmos masių spektrometrijos (ICP-MS) metodu, kai mėginiai buvo mineralizuoti mikrobangų sistema. Skirtingų veislių mišrūnų mėsa skyrėsi mitybinės vertės ir mineralinių medžiagų, esančių ilgiausiajame nugaros raumenyje, kiekiu. Didžiausias bendras mineralinių medžiagų ($p<0,01$) bei atskirų mineralų Na, Mg ($p<0,001$) ir Ba kiekis buvo didžiųjų baltųjų x jorkšyrų mišrūnų mėsoje. Ca, Zn ($p<0,001$), Se, Cu ($p<0,05$) ir Fe daugiausia buvo didžiųjų baltųjų x landrasų kiaulių mišrūnų mėsoje. Daugiausia sausųjų medžiagų, baltymų ir tarpraumeninių riebalų buvo didžiųjų baltųjų kiaulių veislės mėsoje. Veislė ir veislių deriniai turėjo įtakos maistinei vertei ir mineralinių medžiagų kiekiui kiaulienoje.

Raktažodžiai: maistinė vertė, mineralinės medžiagos, kiaulių veislė, mišrūnai.

Introduction. Chemically meat is composed of four major components, including water, protein, lipid, carbohydrate, and many other minor components such as vitamins, enzymes, pigments and flavour compounds. The relative proportions of all these constituents give meat its particular structure, texture, flavour, colour and nutritive value (Olaoye, 2011). The nutrients of meat are indispensable for our vital functions; they play a vital role in normal growth and development and ensure the adequate delivery of essential micronutrients and amino acids (Nohr et al., 2007; Melo et al., 2008; Skobrák et al., 2011). Broadly, the composition of meat, after *rigor mortis* but before post-mortem degradative changes, can be approximated to 75 percent water, 19 percent protein, 3.5 percent soluble, non-protein, substances and 2.5 percent fat (Biesalski et al., 2009; Olaoye, 2011).

Biological value of meat depends on many factors including animal species, breed, sex, meat cuts, feed intake, slaughter age, farming type (conventional or organic), geographic origin, genetic defects and disease status, medication and hormone usage, amount of fat and protein, meat processing treatment: irradiation, fresh versus thawed meat and meat preparation; non-meat ingredient addition: additives and water (Muchenje et al., 2009; Ballin, 2010; Troy et al., 2010). While all of these factors play an important role in determining meat composition and can in most cases be manipulated to alter the nutritional profile of such products, diet is the factor which can most easily be manipulated and which has one of the most profound effects on meat composition (Troy et al., 2010).

For the genetic basis, the correct selection of breeds or lines is very important because the genetic influence on meat quality is very different among breeds as well as among animals in the same breed. Strong selection, especially in recent centuries, has resulted in the accumulation of new mutations, which can provide greater options, especially when molecular technology is used in breeding schemes (Yu Gao et al., 2007).

Meat is known as an excellent source of essential trace elements such as iron (Fe), zinc (Zn), selenium (Se), vitamins A, B12 and folic acid (Nohr et al., 2007; Gerber et al., 2009; Olaoye, 2011). Meat is an important source of several micronutrients due to the fact that some of them are exclusively present in meat or their bioavailability is much higher than from plant sources (Nohr et al., 2007; Biesalski et al., 2009; Troy et al., 2010). Minerals in diet are an essential factor for growth and development of individuals and maintenance of healthy life. The bioavailability and absorption of minerals can vary with the food source, composition of the diet, chemical forms, levels of other dietary components including vitamins, minerals, fibre, secondary plant compounds and the nutritional status of the individual (Melo et al., 2008; Ponnampalam et al., 2009). Minerals tend to be at higher levels in lean tissue than fat tissue, except in the case of calcium (Greenfield, 2009).

With increasing consumer's knowledge of food nutritional value, their demands also changes: demand for healthier products has stimulated the development of nutritionally enhanced meat foods (Jaworska et al 2009; Marques et al., 2010; Verbeke et al., 2010). Today, many consumers are concerned about the meat they eat, and accurate labelling is important to inform consumer choice (Ballin, 2010). This forces producers to expand meat product mix, use of improved raw materials, and reformulation of products or change of product composition (Marques et al., 2010; Verbeke et al., 2010).

Differences vary between groups of pigs that differ in breed, size, or nutritional background. This variability can be increased due to the different animal husbandry and feeding systems applied. Also, only limited information exists on nutrients in lean meat, which may vary to a greater extent than the nutrient composition of other food items. The accurate determination of these elements is therefore important in nutrition studies, particularly because meat, as a biological material, exhibits natural variations in the amounts of nutrients contained (Purchas et al., 2009; Gerber et al., 2009).

The aim of the present study was to examine large white breed (LW), large white x yorkshire (LWxY) and large white x landrace (LWxL) crossbreeds pork nutritional value and the concentration of essential elements like natrium (Na), magnesium (Mg), calcium (Ca), selenium (Se), copper (Cu), zinc (Zn), iron (Fe) and barium (Ba) with a particular focus on the variability of these trace elements.

Materials and methods. The research of nutrition and mineral content characteristics of various pig meat was carried out at the Laboratory of Meat Characteristics and Quality Assessment of Lithuanian University of Health Sciences and National Food and Veterinary Risk Assessment Institute. The samples for analysis were taken from: large white (LW) (12 samples), crossbreeds of landrace and large white (LWxL) (16 samples), crossbreeds of Yorkshire and large white (LWxY) (12 samples) pig carcasses. Pigs were held at the Control Feeding Station of Pigs under standard feeding and keeping conditions. Pigs were slaughtered at the weight of 95 kg at the same station. After carcass chilling (after 24 h), meat samples were taken from the longest back muscle (*M. longissimus dorsi)* for meat quality evaluation. Meat nutritive indexes were determined at the Laboratory of Meat Characteristics and Quality Assessment of the Lithuanian University of Health Sciences.

The evaluation of meat nutritive value was carried out for fixing: meat dry matter, intramuscular fat, total minerals and protein amount. The amount of dry matter was measured by the automatic scale for humidity assessment Scaltec SMO – 01, drying samples at 105ºC, intramuscular fat – by an automatic system for fat extraction Soclet SE 416 macro (ISO 1443:1973 Meat and meat products determination of total fat content), protein amount - according to Kjeldal method, total proteins – by organic matter incineration at 700ºC (ISO 936:1998 Meat and meat products determination of total ash).

The mineral content was determined at the Laboratory of Chemical Research of the National Food and Veterinary Risk Assessment Institute, after 48 h carcass cooling. The samples were held at + 4 ºC fridge temperature. Samples were digested using ETHOS 900 microwave digestion system. The sample digestion procedure was performed according to the NF EN 13805 standard "Foodstuffs –Determination of trace elements – Pressure digestion (Millour et al., 2011).

ICP-MS measurements were performed using ICP Mass Spectrometer ELAN DRC-e (Perkin Elmer Sciex). Interference studies were performed on the eight analytes: natrium (Na), magnesium (Mg), calcium (Ca), iron (Fe), copper (Cu), zinc (Zn), barium (Ba) and selenium (Se). Analytes were present at the concentration of 5 and 100 times matrix solutions (Nardi et al., 2009).

The data was analyzed by using statistical R pack statistical package and the Excel program for identifying signs of arithmetic averages and the errors of standard deviation, variation coefficients.

Results and discussion. The obtained data of the study are given in Table 1 and represent the difference of nutritional value among different pig breeds. The highest amount of dry matter and protein were in LW breed pig longest back muscle (Table 1), compared with LWxL the amount was respectively 1.1 percent ($P<0.01$) and 0.86 percent ($P<0.05$), compared with LWxY crossbreeds, even 1.34 percent ($P<0.05$) and 1.32 percent ($P<0.01$) higher. The largest variation coefficients for the both (the dry matter and the protein) was in LWxY pig crossbreed meat. Compared with the results obtained by Jukna (2007) the results obtained in the present study were the same; dry matter and protein were in greatest abundance in LW, less in LWxL and least in LWxY crossbreeds pig meat (Jukna[2] et al., 2007).

Table 1. **Nutritional value of meat**

Parameters	Symbols	LW	LWxL	LWxY
Dry matter, percent	X	27.33	26.23**	25.99*
	m_x	±0.33	±6.77	±0.40
	C_V	3.19	2.01	4.65
Proteins, percent	X	24.43	23.57*	23.11**
	m_x	±0.26	±6.09	±0.38
	C_V	2.84	4.10	5.03
Fat, percent	X	1.93	1.65	1.82
	m_x	±0.15	±0.42	±0.19
	C_V	19.88	33.66	31.94
Total mineral, percent	X	0.97	1.03*	1.06**
	m_x	±0.02	±0.27	±0.02
	C_V	5.49	6.46	5.91

* – P<0.05; ** – P<0.01; *** – P<0.001

The intramuscular fat content has a positive effect on meat juiciness, hardness and flavour (Alonso et al., 2009). The lowest amount of intramuscular fat was recorded in LWxL pig crossbreed meat; it was by 0.17 percent lower than in LWxY and even by 0.28 percent lower than in LW pig breed meat. The intramuscular fat is the most variable component of meat (Jukna et al., 2007). The variation coefficients of fat were several times as high as those of other meat ingredients; the highest was in LWxL crossbreed and lowest in LW meat.

The values of dry matter, protein and fat in the longest back muscle of LW breed was almost identical to the ones obtained by Juarez et al. (2011) references. Slightly lower content of dry matter and protein were determined by Jukna et al. (2005) and Latorre et al. (2008).

Knowing that the content of minerals in meat tend to low variability, the differences between crossbreeds and pure breed of LW were rather pronounced. The highest concentration of minerals was observed in LWxY crossbreed meat and the lowest in LW pig; the difference accounts for 0.09 percent (P<0.01). In LWxL the mineral content was by 0.03 percent (P<0.05) lower than in the longest back muscle of LWxY. Other results obtained by Tomovic et al. (2011) and Jukna et al. (2007): the total mineral content in the meat of LWxL pig breed was higher than in the LW pigs (Jukna[2] et al., 2007).

Minerals are important to the structure of body tissues and are involved in a variety of control functions (Choi et al., 2009). Comparison of the amount of different essential minerals in the longest back muscle (as shown in Table 2) showed that Na concentration was highest in LWxY crossbreed meat and the lowest in LW pig meat; the difference made 5.13 percent. According to Tomovic et al., the concentration of Na was higher in LW breed than in LWxL crossbreed (Tomovic et al., 2011).

The highest Mg content was observed in LWxY crossbreed pigs meat; in the meat of LW breed it was by 4.08 percent lower and in LWxL crossbreed meat by 9.2 percent (P<0.05) lower.

Table 2. **Mineral content of meat**

Parameters	Symbols	LW	LWxL	LWxY
Na, mg/kg	X	434.08	446.50	457.55
	m_x	±15.69	±8.19	±17.21
	C_V	9.56	7.10	11.28
Mg, mg/kg	X	290.00	274.6250*	302.32***
	m_x	±5.04	±70.91	±4.60
	C_V	4.60	5.52	4.56
Ca, mg/kg	X	55.9250	59.1250	58.32
	m_x	±1.47	±15.27	±2.71
	C_V	6.96	9.72	13.93
Zn, mg/kg	X	9.2163	10.6834***	10.0741*
	m_x	±0.25	±2.76	±0.31
	C_V	7.24	8.44	9.28
Se, mg/kg	X	0.1351	0.1406	0.1351
	m_x	±0.003	±0.04	±0.005
	C_V	6.75	9.65	11.64
Cu, mg/kg	X	0.4022	0.4536*	0.4323
	m_x	±0.02	±0.12	±0.008
	C_V	10.50	13.65	5.60
Fe, mg/kg	X	6.2596	7.4080	5.7445*
	m_x	±0.51	±1.91	±0.45
	C_V	21.59	25.97	23.65
Ba, mg/kg	X	0.0200	0.0191	0.0281
	m_x	±0.002	±0.005	±0.004
	C_V	19.89	42.46	44.61

* – P<0.05; ** – P<0.01; *** – P<0.001

The levels of minerals Ca and Zn were highest in LWxL crossbreed meat; in LWxY they were lower by 1.4 percent and 5.7 percent respectively and in LW pig meat by 5.4 percent and 13.8 percent (P<0.001) lower than in LWxL crossbreed. The highest variation ratios of these minerals were in LWxY crossbreed and the lowest in LW pigs.

Trace element Se is essential for the body's physical functions. It participates in oxidation-reduction reactions (Choi et al., 2009). The averages of trace element Se in LW and LWxY were the same, i.e. 4.07 percent lower than in LWxL crossbreed meat.

The highest concentration of Cu also was observed in LWxL crossbreed longest back muscle; the content of this mineral was by 4.7 percent lower in LWxY pig and even by 11.3 percent (P<0.05) lower in LW meat. Similar data has been reported by Tomovic et al. (2011) points in his studies.

The content of one of the most important trace element Fe in the meat of different crossbreeds or pure breeds of pig differed significantly. Based on the studies performed in different countries (Australia, Finland, Norway, USA), Fe content in different crossbreeds varied from 6 mg/kg to 9.4 mg/kg. The highest content of this mineral was recorded in LWxL, whereas the lowest in LWxY crossbreeds; the difference was as high as 22.5 percent (P<0.05); compared with the pure breed LW, the difference was lower: 15.5 percent. However, the variation coefficients of this mineral were among the largest.

The trace element Ba mostly was found in greatest abundance in LWxY and in smallest abundance in LWxL crossbreeds pig meat; the difference amounted to 32.03 percent. These results were not statistically significant because they varied within a very broad range.

Table 3 shows the breed (pure breed LW and LWxL, LWxY crossbreeds) influence on the meat nutritional value and mineral content. Breed had a significant influence on minerals Mg (P<0.001) and Zn (P<0.01) levels, also on Fe (P<0.05) and Ba (P<0.05) levels, but not so distinctly. The least influence of breed is produced on minerals Se, Ca and Na. Breed influence on the parameters of nutritional value were most marked in dry matter (P<0.01), total mineral content (P<0.05) and protein (P<0.05), and least marked on fat content.

The correlation between the parameters of various minerals and nutritional value properties in meat are shown in Table 4. The highest positive correlation was found between dry matter and protein; the same results have been reported by Žymantiene et al. (2008). Dry matter had a negative correlation with minerals Zn and Cu. Mineral Cu distinctly positively correlated, Ca and Zn weakly but positively, with all the trace elements. Proteins showed positive correlation with mineral Fe and significant negative correlation with Zn. The fat content positively correlated with the minerals Zn, Ca, Ba, Se, and Na, but negatively with Fe. The correlations of total mineral content and the trace elements were either weakly positive or negative. Similar results were obtained by Guang-zhi et al. (2008).

Conclusions

1. Highest nutritional value (the most of dry matter, proteins and fat) was in pure breed LW pig meat, but it was poor in minerals content compared with the crossbreeds.

2. Various breeds of pigs had different contents of minerals in the longest back muscle. The highest amount of total minerals (P<0.01), trace elements of Na, Mg (P<0.001) and Ba was observed in LWxY pig crossbreed meat. Trace elements of Ca, Zn (P<0.001), Se, Cu (P<0.05) and Fe were found in abundance in LWxL meat.

3. Breed had a significant influence on trace elements of Mg (P<0.001) and Zn (P<0.01). The influence of breed on the parameters of nutritional value (dry matter (P<0.01), proteins (P<0.05), total minerals (P<0.05) and minerals Fe (P<0.05), Ba (P<0.05), and Cu were not as distinct.

4. Trace elements had a significant positive correlation between each other (except Fe), but negative or weakly positive with the parameters of nutritional value. Protein had positive correlation with mineral Fe and significant negative correlation with Zn. Dry matter had significant positive correlation with the proteins and negative with minerals Zn and Cu.

Table 3. **Influence of breed on meat nutritional value and mineral content**

Parameters	Influence of breed
Dry matter	28.59**
Proteins	21.05*
Intramuscular fat	5.17
Total minerals	21.11*
Na	4.58
Mg	43.13***
Ca	4.41
Zn	33.33*
Se	4.34
Cu	15.90
Fe	17.98*
Ba	17.83*

* – P<0.05;** – P<0.01; *** – P<0.001

Table 4. **The correlation coefficients of nutritional value and mineral content**

	Dry mat.	Proteins	Fat	Tot. min.	Na	Mg	Ca	Zn	Se	Cu	Fe
Dry mat.	x										
Proteins	0.8597	x									
Fat	0.1671	-0.3545	x								
Tot.min	-0.386	-0.4402	0.0377	x							
Na	-0.0918	-0.1164	0.0708	-0.16	x						
Mg	-0.0474	0.0679	-0.215	-0.131	0.2529	x					
Ca	-0.0929	-0.17	0.1582	0.0664	0.2591	0.1737	x				
Zn	-0.4005	-0.4961	0.2523	0.1393	0.3827	-0.341	0.2887	x			
Se	-0.0962	-0.1408	0.1477	-0.223	0.0747	0.1338	0.1833	0.2802	x		
Cu	-0.2701	-0.2278	-0.067	0.0602	0.571	0.2221	0.3128	0.4862	0.1664	x	
Fe	0.1742	0.3511	-0.353	-0.247	-0.061	-0.101	0.0972	0.0933	-0.048	0.224	x
Ba	-0.1204	-0.1976	0.1729	-0.025	0.2324	0.0355	0.0813	0.2504	-0.26	0.141	-0.068

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