КАЧЕСТВО НА ЖИВОТИНСКАТА ПРОДУКЦИЯ

CONTENT OF ESSENTIAL MINERAL ELEMENTS AND MEAT QUALITY TRAITS OF LARGE WHITE PIGS AND THEIR CROSSBREEDS MEAT

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Pork plays an important role in the nutrition of Lithuanias‘ inhabitants as source of full-rate proteins, irreplaceable amino acids, fat-soluble vitamins, makro- and micro- elements and other important components of nutrition (**Garmienė et.al.,** 2010). Meat is known as an excellent source of essential trace elements such as iron (Fe), zinc (Zn), selenium (Se), vitamins A, B_{12} 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 (**Biesalski et al.,** 2009; **Troy et al.,** 2010). Many minerals that meat contains are vital for human organism, while they participate in its‘ various significant functions. A decreased biological accessibility of mineral elements might determine organisms‘ functions disorders (**Melo et. al.,** 2008).

Biological value of meat depends on many factors including animal species, breed, sex, meat cuts, feed intake, slaughter age, farming type, 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. 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; **Ballin,** 2010). 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).

Consumer’s demand for healthier products has stimulated the development of nutritionally enhanced meat foods. This forces producers to expand meat product mix, use of improved raw materials, reformulation of products or change product composition (**Jaworska et al.,** 2009; **Marques et al.,** 2010; **Verbeke et al.,** 2010). A precise determination of micro- and macro- elements is very important for the essentials of human nutrition science, because natural fluctuation of nutrients processes in meat as in biological origins‘ substance. Therefore it is very important that the data of nutrients (including the amount of micro- and macro- elements) would be regularly renewed and possible changes would be observed with an available data (**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 meat quality traits and the concentration of essential elements (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.

MATERIAL AND METHODS

Animals and muscle samples.

Control pigs' growth was performed at Lithuanian National Pigs Breeding Station in the year 2012, in standardized feeding and keeping conditions. AB "Jonishkio grudai" complete fodder and additives were used for pigs' feeding. Younglings were slaughtered after they have reached 180 days of age, average 100 -110 kg weighing samples were taken for the analysis in an even proportion in regard to animals' sex. Control slaughtering was performed after 24 hours of starvation. Water was not supplied after there were 3 hours left to the slaughtering. Pigs were slaughtered 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 and mineral content evaluating. The samples (12 samples each) for analysis were taken from: pure breed large white (LW), crossbreeds of landrace and large white (LWxL), crossbreeds of yorkshire and large white (LWxY) pig carcasses.

Meat quality measurements.

Meat quality indexes were determined at the Laboratory of Meat Characteristics and Quality Assessment at Lithuanian University of Health Sciences. Evaluation of meat quality traits was carried out for to fix: meat dry matter, intramuscular fat, total minerals, protein amount, pH, color, water drip, cooking loss, rigidity. 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). Meat pH (estimated with pH-meter INOLAB3) (pH ISO 2917:1999 Meat and meat products measurement of pH). Meat color by CIE – LAB method, estimated meats‘ indexes are: lightness (L*), redness (a*), yellowness (b*) (Minolta Chroma Meter 410). Meat drip loss is estimated according to meats‘ weight reduction while keeping it suspended in bags with nets in +4 °C temperature for 24 hours. Meat rigidity by Bratzler method (**Bratzler,** 1949). Meat cooking loss by Shilling method (**Shilling,** 1966).

Analysis of mineral content.

Mineral content was carried out at the National Food and Veterinary Risk assessment Institute, laboratory of the chemical reasearch, after 48 h carcass cooling. The samples were held at the fridge + 4 C 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).

Statistical analysis.

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

RESULTS AND DISCUSSION

Meats' quality.

Meats' quality indexes of analyzed pure breed LW and its' crossbreeds pigs is given in Table 1. The highest amount of dry matter and protein were in LW breed pig longest back muscle, compared with LWxL the amount was respectively 1.1 % (P<0.01) and 0.86 % (P<0.05), compared with LWxY crossbreeds, even 1.34 % (P<0.05) and 1.32 % (P<0.01) higher. The largest variation coefficients for the both (the dry matter and the protein) was in LWxY pig crossbreed meat.

Table 1. **Meat quality traits of LW and it's crossbreeds**

Parameters		LW	LWxL	LWxY
Dry matter, %		27.33 ± 0.33	26.23 ± 6.77**	25.99* ± 0.40
Proteins, %		24.43 ± 0.26	23.57 ± 6.09*	23.11 ± 0.38**
Fat, %		1.93 ± 0.15	1.65 ± 0.42	1.82 ± 0.19
Ash, %		0.97 ± 0.02	1.03 ± 0.27*	1.06 ± 0.02**
pH		5.44 ± 0.03	5.44 ± 0.01	5.50 ± 0.03
	L*	59.80 ± 1.08	56.96 ± 0.42***	61.69 ± 0.84***
Color	a*	12.66 ± 0.68	14.53 ± 0.34	13.31 ± 0.43
	b*	9.23 ± 0.66	7.43 ± 0.19	8.43 ± 0.54
Water drip, %		4,66 ± 0.55	5.31 ± 1.37	4.22 ± 0.44
Cooking loss, %		26,24 ± 0.50	26.15 ± 6.75	26.48 ± 0.29
Rigidity, kg/cm²		1.96 ± 0.16	1.95 ± 0.11	1.87 ± 0.22

* - *P*<0.05; ** - *P*<0.01; *** - *P*<0.001

Table 2. **The amount of mineral elements in pure LW and it's crossbreeds meat**

Mineral elements	LW	LWxL	LWxY
Na, mg/kg	434.08 ± 15.69	446.50 ± 8.19	457.55 ± 17.21
Mg, mg/kg	290.00 ± 5.04	274.6250 ± 70.91*	302.32 ± 4.60***
Ca, mg/kg	55.9250 ± 1.47	59.1250 ± 15.27	58.32 ± 2.71
Zn, mg/kg	9.2163 ± 0.25	10.6834 ± 2.76***	10.0741 ± 0.31*
Se, mg/kg	0.1351 ± 0.003	0.1406 ± 0.04	0.1351 ± 0.005
Cu, mg/kg	0.4022 ± 0.02	0.4536 ± 0.12*	0.4323 ± 0.008
Fe, mg/kg	6.2596 ± 0.51	7.4080 ± 1.91	5.7445 ± 0.45*
Ba, mg/kg	0.0200 ± 0.002	0.0191 ± 0.005	0.0281 ± 0.004

* - *P*<0.05; ** - *P*<0.01; *** - *P*<0.001

Compared with the author **Jukna** (2007), results were the same, dry matter and protein were mostly in LW, less in LWxL and at least in LWxY crossbreeds pig meat (**Jukna et al.,** 2007).

Intramuscular fat positively influences flavour, juiciness, tenderness, firmness and the overall acceptability of meat (**Hocquette et al.,** 2009). The lowest amount of intramuscular fat was in LWxL pig crossbreed meat, it was 0.17 % less than in LWxY and even 0.28 % less than in LW pig breed meat. Intramuscular fat is the most variation component of meat (**Jukna et al.,** 2007). Their coefficients of variation were several times higher than other meat ingredients; the largest was in LWxL crossbreed, and lowest in LW meat.

Compared with the author **Juarez et al.** (2011) references, dry matter, protein and fat in LW breed longest back muscle were almost identical. Slightly lower dry matter and protein were determined by authors **Jukna et al.** (2005) and **Latorre et al.** (2008).

LWxY crossbreeds meat had the highest pH, pure breed LW and LWxL pH was identical. JxLW pig breed distinguished for having the lightest meat, the darkest meat had LxLW pigs breed, the difference was 4.73 L* unit (*P*<0.001). LWxL pigs

Table 3. **Influence of breed on meat quality traits and mineral elements**

Parameters, %		Influence of breed
Dry matter		28.59**
Proteins		21.05*
Intramuscular fat		5.17
Total minerals		21.11*
pH		30,86***
	L*	8,33**
Color	a*	34,82***
	b*	35,58***
Water drip		13,30
Cooking loss		17,80*
Rigidity		41,18***
Na		4.58
Mg		43.13***
Ca		4.41
Zn		33.33*
Se		4.34
Cu		15.90
Fe		17.98*
Ba		17.83*

* - $P<0.05$; ** - $P<0.01$; *** - $P<0.001$

breed crossbreeds meat distinguished for having the biggest redness intensity, LW breed meat had the lowest. LW purebreed pigs meat had the biggest intensity of meats‘ yellowness, the least belonged to – LxLW breeds‘ pigs meat, the difference reached 1.80 b* unit.

LxLW breed crossbreeds pigs meat distinguished for having the biggest water drip, JxLW pigs breeds‘ meat had the least, the difference had reached 1.09 % Cooking losses were very similar: LxLW pigs breed crossbreeds meat had the least cooking losses, whereas JxLW pigs breeds crossbreeds‘ meat – the biggest, the difference had reached only 0.33%.

Content of essential mineral elements.

Mineral content of meat is low variable rate, so the differences between crossbreeds and pure breed of LW was enough large. Most minerals were in LWxY crossbreed meat, at least in LW pig, the difference was 0.09% ($P<0.01$). LWxL mineral content was 0.03 % ($P<0.05$) lower than in LWxY crossbreed longest back muscle. Other results obtained **Tomovic et al.** (2011) and **Jukna et al.** (2007) – LWxL pig breed’s total mineral content was higher than the LW pigs (**Jukna [2] et al.,** 2007).

Meat and meat products are important sources of minerals that are essential for a variety of biochemical functions in organisms (**Horita et al.,** 2011; **Bilandzic et al.,** 2012). Comparing the amount of different essential minerals in the longest back muscle (as shown in Table 2), mineral of Na mostly were in LWxY crossbreed meat, at least in LW pig meat, the difference was 5.13 %. According author Tomovic et al. data, greater amount of Na were in LW breed pigs than in LWxL crossbreed (**Tomovic et al.,** 2011).

The highest Mg content was in LWxY crossbreed pigs meat, 4.08 % less of this mineral was in LW breed meat, and 9.2 % (*P*<0.05) less in LWxL crossbreed meat.

Minerals of Ca and Zn levels were highest in LWxL crossbreed meat, respectively 1.4 % and 5.7 % were less in LWxY. At least in LW pig meat - by 5.4 % and 13.8 % (P < 0.001) less than LWxL crossbreed. The largest varying ratios of these minerals were in LWxY crossbreed and the lowest LW pigs.

Essential element of Se is essential for the body's physical functions, participate 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% less than in LWxL crossbreed meat.

The most Cu was also in LWxL crossbreed longest back muscle, 4.7 % less of this mineral was in LWxY pig and even 11.3 % (*P*<0.05) less in LW meat. Similar data author **Tomovic et al.** (2011) points in his studies.

One of the most important trace element Fe content in different crossbreeds or pure breeds of pig meat differed significantly. Based on this studies performed in different countries (Australia, Finland, Norway, USA), Fe content in different crossbreeds variated from 6 mg/kg to 9.4 mg/kg. Most of this mineral was in LWxL, while least – in LWxY crossbreeds pig meat, the difference was as high as 22.5 % (*P*<0.05) and compared with the pure breed LW, the difference was lower – 15.5%. However, the variation coefficients of this mineral were among the largest.

The trace element of Ba mostly were in LWxY, least in LWxL crossbreeds pig meat, the difference amounted to 32.03%. These results were not statistically significant reliable, varied in a very broad range.

The breed (pure breed LW and LWxL, LWxY crossbreeds) influence on the meat quality parameters and mineral content is given in Table 3. 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. At least influence of breed on minerals content were on Se, Ca and Na. Breed influence on the parameters of meat quality greatest were on rigidity (*P*<0.001), color a* (*P*<0.001) and b* (*P*<0.001), pH (*P*<0.001), dry matter (*P*<0.01), total mineral content (*P*<0.05) and protein (*P*<0.05), and the lowest - fat content.

CONCLUSIONS

Various breeds of pigs had different contents of minerals in longest back muscle. Highest amount of total minerals (*P*<0.01), trace elements of Na, Mg (*P*<0.001) and Ba was 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 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.

Breed had a significant influence on trace elements of Mg (*P*<0.001) and Zn (*P*<0.01), meat quality parameters of rigidity (*P*<0.001), color a* (*P*<0.001) and b* (*P*<0.001) and pH (*P*< 0.001). The influence of breed on the meat quality parameters (dry matter (*P*<0.01), proteins (*P* <0.05) and total minerals (*P*<0.05)) and on the minerals (Fe (*P*<0.05), Ba (*P*<0.05), Cu) were not so distinctly.

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CONTENT OF ESSENTIAL MINERAL ELEMENTS AND MEAT QUALITY TRAITS OF LARGE WHITE PIGS AND THEIR CROSSBREEDS MEAT

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SUMMARY:

The aim of this study was to determine the essential mineral elements and meat quality traits in large white (LW) breed, large white x yorkshire (LWxY) and large white x landrace (LWxL) crossbreeds pork. The concentrations of natrium, magnesium, calcium, nickel, copper, zinc, barium, selenium, and iron were determined by inductively coupled plasma mass spectrometry (ICP–MS) after microwave digestion. The parameters of quality traits (dry matter, proteins, intramuscular fat, total minerals, pH, color, water drip, cooking loss, rigidity) were determined. Various breeds of pigs had different contents of minerals and meat quality traits in longest back muscle. Highest amount of total minerals ($P<0.01$), trace elements of Na, Mg ($P<0.001$) and Ba was 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 mineral content and meat quality traits were affected by pig breed.

Key words: *mineral elements, meat quality traits, pigs breed, crossbreed.*

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