THE COMPARISON OF MEAT NUTRITIONAL AND TECHNOLOGICAL PROPERTIES IN DIFFERENT ANIMALS

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Abstract. The aim of performed study was to explore and compare the technological meat (pH, color, cooking loss, water holding capacity, tenderness, drip loss) and nutritional (dry matter, protein, fat, ash) properties of the different animals (cattle, pigs, sheep, wild boar, roes, snails). The six meat samples from: not castrated Lithuanian Black and White bull, Lithuanian White pig, Lithuanian Black Head sheep, wild boar, roe and snails. Samples were taken from the long back muscle (*musculus longissimus dorsi*) of animals and the meaty part of snails were investigayed. Highest levels of the dry matter and protein were found in pork and meat of wild boar, lowest in sheep and snail meat, respectively. The highest content of fat was found in roe and wild boar meat. The content of fat in snail meat was by 6 ($p<0.001$) and 5.97 ($p<0.001$) fold lower compared to roe and wild boar meat. The highest amount of minerals was found in snail meat and the lowest in sheep meat; the difference made up to 0.34% ($p<0.01$). Meat acidity was highest in snail and cattle, lowest in pork; the difference made up to 37.13% ($p<0.001$) compared to snail meat. Roe meat was most tender, almost twice as tender as sheep ($p<0,001$), wild boar ($p<0.05$) and cattle ($p<0.05$) meat. The highest loss was found in sheep meat and lowest in roe meat; the difference was up to 16.72% ($p<0.001$). The highest water holding capacity was found in cattle meat, all other animal meat had comparable measures.

Keywords: meat quality; Lithuanian Black and White cattle; Lithuanian White pig; Lithuanian Black Head sheep; wild boar; roe; snails.

ĮVAIRIŲ GYVŪNŲ MĖSOS MITYBINIŲ IR TECHNOLOGINIŲ SAVYBIŲ PALYGINIMAS

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Santrauka. Šio darbo tikslas – ištirti ir palyginti skirtingų gyvūnų rūšių (galvijų, kiaulių, avių, šernų, stirnų, sraigių) mėsos technologines savybes (pH, spalvingumą, virimo nuostolius, vandens rišlumą, kietumą, vandeningumą), maistinę vertę (sausąsias medžiagas, baltymus, riebalus, pelenus) ir jas palyginti. Tyrimui imta po 6 gyvūnų mėsos mėginius: Lietuvos juodmargių buliukų, Lietuvos baltųjų kiaulių, Lietuvos juodgalvių avių, laukinių šernų, stirnų ir sraigių. Mėginiai imti iš ilgiausiojo nugaros raumens *(musculus longissimus dorsi)*, sraigių – visa mėsingoji dalis. Daugiausia sausųjų medžiagų ir baltymų buvo kiaulienoje ir šernienoje, mažiausiai – avienoje ir sraigėse. Daugiausia riebalų rasta stirnienoje ir šernienoje; net 6 ($p<0,001$) ir 5,97 ($p<0,001$) karto mažiau riebalų rasta sraigėse. Mineralinių medžiagų daugiausia buvo sraigėse, mažiausiai – avienoje; skirtumas net 0,34 proc. ($p<0,01$). Mėsos pH didžiausias buvo sraigių ir galvijų, mažiausias – kiaulienos, net 37,13 proc. ($p<0,001$) mažesnis palyginti su sraigėmis. Švelniausia buvo stirniena, bemaž du kartus minkštesnė nei aviena ($p<0,001$), šerniena ($p<0,05$) ar galvijiena ($p<0,05$). Didžiausi virimo nuostoliai nustatyti avienos, o mažiausi – stirnienos; skirtumas siekė 16,72 proc. ($p<0,001$). Didžiausia vandens rišlumo geba buvo galvijienos; kitų gyvūnų mėsos jis labai tarpusavyje panašus.

Raktažodžiai: mėsos kokybė, Lietuvos juodmargiai galvijai, Lietuvos baltosios kiaulės, Lietuvos juodgalvės avys, laukiniai šernai, stirnos, sraigės.

Introduction. Meat and meat products are the most important animal source of high biological value protein (Jukna et al., 2007). Most of the micro and macro elements such as iron, selenium, vitamins A and B12, folic acid, biologically are absorbed mostly from meat (Bielaski et al., 2009). Biological value of meat depends on many factors including animal species, breed, genotype, growth rate, sex, age, muscle location, nutrition and, finally, slaughter (Muchenje et al., 2009).

With increasing consumers' knowledge in food nutritional value, their demands also are changing. This forces producers to expand meat product mix, change product composition (Verbeke et al., 2010). The demand for wild animal meat is growing due to increasing interest by consumers in healthy and safe food. Meat from wild animals is considered a delicacy and commands a high price compared to other sorts of meat. This is because it has a characteristic and intense flavor, is lower in fat and cholesterol, has high levels of polyunsaturated fatty acids and the animals are not treated with hormones or steroids (Daszkiewicz et al., 2007; Fajardo et al., 2008). Meat from roe is very different. Fallow roe meat is generally tenderer compared to bucks, even at older age. It is highly rated by consumers even though it is significantly darker

and has a stronger flavour (Huchison ir kt., 2010). Traditionally consumers are more interested in non-traditional snail meat, while in different European countries it was used as an exclusive food since ancient times. At present, large quantities of land snails are produced for human consumption because of their high nutritional value. They are considered a gastronomic delicacy in Europe. Snails used for human nutrition are distinguished by low-fat and high mineral content, including calcium, magnesium, zinc, copper, manganese, nickel, cobalt, aluminum, sulfur and iodine, as well as vitamin C, which makes it an almost complete food (Mezquita et al, 2007; Žymantienė et al., 2008).

Consumers' behaviour is strongly influenced by perception of psychological factor (Korzen et al., 2010). Researches describe how perceptions of meat qualities vary between contexts. In relation to meat, the authors describe two contexts: the "everyday context" (relating to buying, preparing and eating) and the "production context" (relating to primary production, slaughtering and meat processing) (Troy et al., 2010). The predominant "everyday context" cues for consumers are tenderness, juiciness, and flavour, which, after color, have the highest impact on the acceptability of meat and can be evaluated by the consumer at the point of purchase (Beriain et al., 2009). Consumers judge regarding meat quality by two points: the choice of purchase (appearance, odour, color) and after heat treatment (taste, firmness, juiciness and flavour), which determines the product choice (Banovic et al., 2009).

Other important criteria defining meat quality are connected to "production context": geographical origin, producer brand, food safety traceability, farming type (Beriain et al., 2009). For evaluation of nutritional value of products, consumers base on animal wellness as criteria (Wezemael et al., 2010). Thus, the flavour intensity factors usually is not the main criteria for consumers (Bonneau et al., 2008).

In the past "Food Quality" was more related to safety, sensory and shelf-life aspects of food products (Troy et al., 2010). Today foods are not intended to only satisfy hunger and to provide necessary nutrients for humans but also to prevent nutrition-related diseases and improve physical and mental well-being of the consumers (Siro et al., 2008). Creation of safe and complete food monitor system is a requirement in order to develop a coherent whole food production system (Warner et al., 2010). The increased transparency about the nutritional content of food products may lead to changes in consumer demand, and has already led producers to reformulate some of their products (Verbeke et al., 2010).

The aim of performed study was to explore and compare the technological meat (pH, color, cooking loss, water holding capacity, tenderness, drip loss) and nutritional (dry matter, protein, fat, ash) properties of the different animals (cattle, pigs, sheep, wild boar, roes, snails).

Materials and methods. The research of technological and nutritional characteristics of different animals was performed at the Laboratory of Meat Characteristics and Quality Assessment of Veterinary Academy, Lithuanian University of Health Sciences. Domesticated animals (Lithuanian Black and White cattle; Lithuanian White pig; Lithuanian Black Head sheep) were kept under standard feeding and keeping conditions. The pigs samples were collected from State Breeding Station of Pigs, Cattle were collected from "Šilutė Breeding Station" and sheep samples were collected from "Baisogala" farm. Wild animals (wild boar; roes; snails) were grown under natural climatic conditions in different districts of Lithuania. Samples were taken from the long back muscle (*musculus longissimus dorsi*) of animals and meaty part of snails. Meat quantitative indexes were determined at the Laboratory of Meat Characteristics and Quality Assessment at the Veterinary Academy, Lithuanian University of Health Sciences 36 hours after carcass cooling.

For evaluation of meat quality: meat pH, meat color, dry matter, meat tenderness, water holding capacity, drip loss, cooking loss, and the content of fat, ash and proteins were determined. The amount of dry matter was measured by the automatic scale, humidity was assessed by Scaltec SMO – 01, drying samples at 105ºC, pH by a pH-meter Inolab 3, by a contact electrode (pH ISO 2917:1999 Meat and meat products measurement of pH), color by a Minolta Chroma Meter, measuring L* values of lightness, a* values for redness and b* values for yellowness, drip loss was measured by a bag method, the meat was kept in a special bags for 24 hours at 4ºC. The weight loss, water holding capacity were defined according to Grau and Hamm (Offer and Knight, 1988), cooking loss by packaging under vacuum in a circulating water bath at 75^0C for 30 min., tenderness by Texture analyzer (Warner–Bratzler method 1949), 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). Furhermore, protein amount was determined by Kjeldal method, and ash by organic matter incineration at +700ºC (ISO 936:1998 Meat and meat products determination of total ash).

The arithmetic mean, standard deviation are used in presenting the data. The statisticall analysis, evaluation variation coefficients and significance was performed by statistical R pack statistical package and the Excel program.

Results and discussion. The data provided in Table 1 indicate that the highest amount of dry mater was found in pork and wild boar meat and a significantly lower amount in snail meat. The difference was up to 20.78% ($p<0.001$) and 10.44% ($p<0.001$). Compared to pork, the difference of the content of dry matter in roe, cattle and sheep meat less marked: 0.86%, 2.64%, ($p<0,01$) and 3.79% ($p<0,001$) respectively.

Protein is one of most important components of meat. The structure and contents of proteins are highly variable between the animal species (Jukna et al., 2007). The highest amount of proteins is characteristic of pork and meat of wild boar with difference appr. 1.0 %. The lowest amount of proteins is found in snails. Compared to pork and wild boar, the difference makes 9.96 % ($p <0.001$) and 8.88 % ($p <0.001$). The amount of proteins in mutton was lower on 5.8 % ($p <0.001$).

Table 1. **Nutritional characteristics of different animal meat** (36 h after slaughtering)

Index	Symbols	Sort of meat					
		Cattle	Pig	Sheep	Wild boar	Roe	Snail
Dry matter, %.	X	24.13**	26.77***	22,98***	26.43***	25.91	15.99
	m_x	0.42	0.74	0.24	0.60	0.40	0.77
	C_v	3.91	6.15	2.29	5.06	4.05	13.56
Proteins, %	X	21.65	24.11***	19.95***	23.03***	22.50	14.15
	m_x	0.43	0.79	0.30	0.67	0.39	0.76
	C_v	4.42	7.32	3.38	6.49	4.64	16.01
Intramuscular fat, %	X	1.37**	1.48**	2.0*	2.27***	2.28***	0.38
	m_x	0.12	0.09	0.13	0.28	0.10	0.11
	C_v	20.41	13.78	14.67	27.72	11.34	82.80
Ash, %	X	1.11**	1.18*	1.03**	1.12**	1.14**	1.37
	m_x	0.01	0.02	0.02	0.01	0.02	0.06
	C_v	1.25	3.12	4.83	2.47	4.56	11.95

*** significant differences between spices $p<0.001$; ** $p<0.01$; * $p< 0.1$.

At the point of purchase, the amount of visible fat is the strongest visual discriminative stimulus entering in the decision making process. Fatty meat was considered by consumers as unhealthy, that is why the market demand is for lean meat without fat cover (Jaworska et al., 2009). Hocquette, Gondret, Bae´za, Me´dale, Jurie and Pethick (2010) generally accepted that intramuscular fat positively influences flavour, juiciness, tenderness and/or firmness and the overall acceptability of meat in different animal species. The highest content of fat was found in roe and wild boar (in the latter, only by 0.01 % lower) and even 6 ($p <0.001$) and 5.97 ($p <0.001$) times lower amount of fat was found in snails. Mutton fat content, compared to roes was by 0.28 % ($p <0.1$), to pork by 0.8 % ($p <0.01$), and to beef by 0.91% ($p <0.01$) lower. Intramuscular fat variation ratios were among the highest, what shows that the fat content of meat is highly variable.

Table 2. **The meat technological characteristics in different animals** (36 h after slaughtering)

Index	Symbols	Sort of meat					
		Cattle	Pigs	Sheep	Wild boar	Roe	Snail
pH	X	6.38**	5.44***	5.64	5.48	5.50	7.46
	m_x	0.24	0.05	0.05	0.04	0.02	0.12
	C_v	8.27	1.87	2.02	1.44	0.97	4.50
Colour L*	X	33.98	54.55***	48.13***	46.14***	36.23	46.75
	m_x	1.52	0.72	0.95	3.24	1.82	1.14
	C_v	10.0	2.94	4.41	15.68	13.29	8.74
Color a*	X	16.11**	14.18*	16.26**	19.38	11.60	1.69**
	m_x	0.91	0.58	1.02	0.57	0.36	0.18
	C_v	12.64	9.18	13.97	6.62	8.29	29.83
Color b*	X	3.22	6.63	7.58	9.12	6.97	13.05
	m_x	0.56	0.85	0.35	1.78	0.53	0.61
	C_v	39.27	28.81	10.39	43.67	20.08	13.28
Tenderness, kg/cm^2	X	1.84*	1.49	2.12***	1.85*	1.09	-
	m_x	0.22	0.13	0.11	0.36	0.11	-
	C_v	26.48	19.35	11.58	43.05	27.03	-
Cooking loss. %	X	23.18	28.2	34.12	25.21	17.40***	-
	m_x	1.70	0.72	1.75	1.27	0.67	-
	C_v	16.44	5.72	11.45	11.30	10.24	-
Water holding capacity. %.	X	62.91	58.49	57.23	57.07	59.31	-
	m_x	1.36	1.03	0.92	1.12	0.57	-
	C_v	4.84	3.96	3.60	4.39	2.56	-
Drip loss. %.	X	-	6.96	-	9.34	39.91	-
	m_x	-	1.16	-	2.11	4.21	-
	C_v	-	37.24	-	50.64	27.91	-

*** highly significant differences between spices $p<0.001$; ** $p<0.01$; * $p< 0.1$

In agreement with the findings of other authors (Mezquita et al. 2007; Mayordomo, 2003) the highest content of minerals was found in snails. Table 1 shows that the determined content of minerals in snails was by 0.19 % ($p < 0.05$) higher than in pork, by 0.23 % ($p < 0.01$) higher than in roes, by 0.25 % ($p < 0.01$) higher than in wild boar, by 0.26 % ($p < 0.01$) higher than in cattle meat and by 0.34 % ($p < 0.01$) higher than in sheep meat.

The acidity of the meat determined in this study was comparable to the acidity values obtained by other authors (Carrasco et al. 2009; Muchenje et al. 2009; Žymantienė et al., 2008; Daskiewitz et al. 2008; Jawoska et al. 2009). Table 2 shows that the maximum acidity was characteristic to snail meat. The acidity of cattle meat differed by 16.92 % ($p < 0.01$) and the acidity of pork meat by 37.13 % ($p < 0.001$). However, cattle and snails coefficients of variation were relatively high.

The color of meat is an extremely important factor that influences a consumer's purchase decision as it is deemed a visual measure of freshness and quality (Muchenje et al., 2009; Khliji et al., 2010). A number of studies have been conducted of meat color differences between animal species, looking for factors influencing the rate and the search for connection to other technological properties of meat (McLean et al., 2009; Jaworska et al., 2009). Many authors have reported (Carrasco et al., 2009; Kerth, 2007), that meat color may be influenced by several factors, such as: enzymes, diet and age of the animal, and even the activity undertaken by the animal. Animals fed on pasture have a yellow fat color because of the high levels of beta carotene contained by grass (Hopkins et al., 2005; Huchison et al., 2010). The assessment of meat color showed, that the darkest was beef, which compared to pork was by 37.71 % ($p < 0.001$) darker. Compared with sheep and wild boar, the differences were lower and amounted to 29.4 % ($p < 0.001$) and 26.39 % ($p < 0.001$). The intensity of meat redness has a positive impact on product choice for consumers (Khliji et al., 2010). Most intensive redness was characteristic of wild boar in comparison to other animal meat. Wild boar meat redness was higher by 19.19 % ($p < 0.01$) compared with sheep, by 36.67 % ($p < 0.05$) compared with pork, by 20.30 % ($p < 0.01$) compared with beef and by 87.2 % ($p < 0.01$) compared with snails. The examination of meat color showed that yellowness was most intense in the meat of snails and wild boar, which were two times more intensive compared to beef. Coefficients of variation of color were very high, particularly regarding to the meat yellowness.

Several authors have reported, that sources of tenderness variation in meat, for instance, may be attributed to animal's age, sex, live weight, breed and ante-mortem stress. Tenderness varies mainly due to changes of the myofibrillar protein structure of muscle in the period between animal slaughter and meat consumption (Hopkins et al., 2005; Muchenje et al., 2009; Huchison et al., 2010). Comparing different species of meat tenderness, it was observed that the least tender was roe, almost twice softer than lamb ($p < 0.001$), wild boar ($p < 0.05$) and beef ($p < 0.05$), but the rate coefficients of variation was also very high.

One of the most important technological parameters is cooking loss. Cooking of meat is essential to achieve a palatable and safe product. However, heat treatment can lead to undesirable modifications, such a decrease in the nutritional value, mainly due to vitamin and mineral losses, and changes in the fatty acid composition due to lipid oxidation (Gerber et al., 2009). The largest cooking loss were in sheep and roes, the difference amounted to 16.72 % ($p < 0.001$).

Water-holding capacity is defined as the ability of meat to retain its water during application of external forces, such as cutting, heating, grinding or pressing. Most of the water in muscle is held by capillary forces between the thick and thin filaments. Water-holding capacity of meat is greatly affected by pH. It is important that during meat processing, as proteins are able to hold more water, they become more soluble (Muchenje et al., 2009). The highest water holding capacity was characteristic of cattle meat. The water holding capacity of other kinds of meat was very similar.

The results of the present study revealed that the meat with the highest drip loss value had a tendency to lose less weight during cooking. This is not surprising, as moisture lost prior to cooking obviously could not be lost during cooking. These data indicate that meat with a lowest drip loss would also tend to have higher water-holding capacity and meat with a highest drip loss tend to have lowest cooking loss.

Conclusions

1. The highest content of dry matter and protein was observed in pork and wild boar meat, the lowest amount in snail and sheep meat. The highest values of fat were found in roes and wild boar, which were bys 6 times ($p < 0.001$) and 5.97 ($p < 0.001$) time higher compared to fat found in snail. The intramuscular fat varying ratios were among the highest, what shows that the fat content of meat is highly variable.

2. The highest acidity was found in snail meat, which was on 16.92 % ($p < 0.01$) and on 37.13 % ($p < 0.001$) higher compared to beef and pork, respectively.

3. The darkest meat colour was found in beef and the lightest in pork. The most intensive redness was characteristic in wild boar meat and the highest intensity of yellowness in snail meat.

4. The lowest tenderness was registered in roe meat. Mutton ($p < 0.001$), wild boar ($p < 0.05$) and beef ($p < 0.05$) was two times softer, however, the rate coefficients of variation were very high.

5. The meat with the lowest drip loss had a higher water-holding capacity and the meat with the highest drip had the lowest cooking loss.

6. Wild animals (wild boar and roe) have higher nutritional value (proteins, intramuscular fat, minerals) compared to domesticated animals. Snails are characterized by significally higher content of minerals compared to meat of other animal species.

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