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ORIGINAL ARTICLE

Protein metabolism, physicochemical properties and chemical composition of muscle tissue in Large White weaners

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We presented the blood serum biochemical parameters, physicochemical properties and chemical composition of muscle tissue in Large White weaners of British origin. We found that serum biochemical parameters in five months weaners were within the physiological norm (the content of total protein was 71.28 g/l (CV = 8.16%), creatinine concentration was 155.62 μmol L^{-1} (CV = 14.13%). Studies of physicochemical properties and chemical composition of samples of Longissinus dorsi muscle of Large White young pigs show that the number of high quality samples in terms of moisture holding capacity, % is 12.0%, colour intensity, units of ext.×1000 – 16.0%, tenderness, s – 12.0% and fat content, % – 16.0%. We revealed significant correlations between moisture holding capacity and protein content (r = -0.484, tr = 2.65), moisture holding capacity and hygroscopic moisture content (r = 0.402, tr = 2.11). The correlation between total protein content in blood serum and fat content in muscle tissue was -0.257 (tr = 1.28), whereas the correlation between serum total protein content and calcium content in muscle tissue was 0.375 (tr = 1.94).
Key words: weaners, breed, protein metabolism, blood serum, physicochemical properties, chemical composition, muscle tissue, correlation.

Introduction

Modern pig farming is based on improving the conditions of keeping and feeding pigs of different classes. In Ukraine, the assessing of pig meat productivity, reproductive qualities of sows and boars, fattening and meat qualities of their offspring have been studied by Bazhov & Komlatskiy (1989), Kabanov (2009), Tatulov (2009), Rybalko et al., (2010), Fedorenkova et al., (2012), Aknevskyy et al., (2013), Bankovskaja & Voloschuk (2015), Balatskii et al., (2015, 2018), and Khalak et al., (2020a). The problems of early prediction of fattening, slaughter and meat qualities of pigs, physicochemical properties and chemical composition of muscle tissue and blubber are pf great importance and being studied by domestic and foreign scientists (Eidrigevich & Rayevskaya, 1966; Christianson, 1991; Allison & Laven, 2000; Levchenko, 2002; Berezovskyy & Khatko, 2005; Tatulov, 2009; Susol, 2015; Tserenyuk, 2017, 2018; Kramarenko et al., 2018, 2019; Khalak et al., 2020b).

The aim of the work is to study physicochemical properties and chemical composition of muscle tissue in Large White weaners taking into account class of their distribution by total protein content and serum creatinine concentration, as well as to calculate the level of correlations between the main quantitative traits.

Material and methods

The study was conducted at breeding farm for Large White pigs of LLC "AF "Dzerzhynets" (Dnipropetrovsk region, Scientific Research Centre of Biosafety and Environmental Control of Resources, Agro-Industrial Complex of the Dnipro State Agrarian and Economic University, LLC "Hlobinskii miasokombinat", Poltava region, Laboratory of Zoochemical Analysis of the Institute of Big Breeding and Agro-Industrial Production of National Academy of Agrarian Sciences, Ukraine, and Laboratory of Animal Husbandry of the State Establishment Institute of Grain Crops of National Academy of Agrarian Sciences, Ukraine. The work was performed according to the research program of National Academy of Agrarian Sciences No 30 "Pig Breeding".

The formation of experimental groups was carried out according to their distribution into classes due to the content of total protein and the creatinine concentration in the blood serum of weaners. The deviation from the arithmetic mean of the trait

was equal to ± 0.67σ. Thus, in weaners of class M^+ total protein content was 77.53 g/l and more, creatinine concentration - 171.06 μmol/l and more. In animals of the opposite class (M^-) these values ranged from 58.67 to 66.30 g/l and 102.59-137.86 μmol/l, respectively.

Blood sampling from animals of the experimental group (n = 25) was performed at the age of five months. Serum was tested for total protein (g L^{-1}) and creatinine concentration (μmol L^{-1}) (Vlyzlo et al., 2012; Hryban at al., 2001; Kamyshnikov, 2002). Control fattening of young pigs was carried out according to requirements of modern research methods in pig breeding (Methods of assessment of boars and sows for..., 2005). We determined the pH – active acidity, moisture holding capacity, colour intensity, tenderness, loss during thermal processing, energy value of muscle tissue, hygroscopic moisture content, air-dry matter, total moisture content, crude ash, crude fat, crude protein, calcium and phosphorus content (Metodicheskiye rekomendatsii po otsenke ..., 1987, Polivoda et al., 1977, Polyvoda, 1976).

A comprehensive assessment of meat quality was determined according to Polyvoda (1976) (Table 1).

Table 1. Meat assessing scale

Grade	moisture holding capacity, %	colour intensity, (extinction coefficient × 1000)	tenderness, sec	fat, %	melting point of blubber, degrees
Limits	46.8-71.8	27-119	5.8-15.5	0.7-4.8	23.5- 46.8
High quality	≥ 67.0	≥ 83	≤ 7.9	≥ 3.1	-
Standard quality	53.0-66.0	48-82	8.0-12.0	1.2-3.0	32.5-41.5
Low quality	≤ 52.0	≤47	≥12.1	≤1.1	≥ 41.6 ≤ 32.4

Results and discussion

The analysis of the obtained data shows that total protein and creatinine in the blood serum in weaners from experimental group were within the physiological norm (Table 2).

Table 2. Biochemical parameters of blood serum of young pigs in the experimental group, n=25.

Parameter	Norm	Biometric indicators		
		mean ± SD	σ ± Sσ	CV ± S_{CV}. %
Total protein, g L^{-1}	79.0–89.0	71.28±1.16	5.82±0.82	8.16±1.15
Creatinine, μmol L^{-1}	140–240	155.62±4.39	21.99±3.11	14.13±1.99

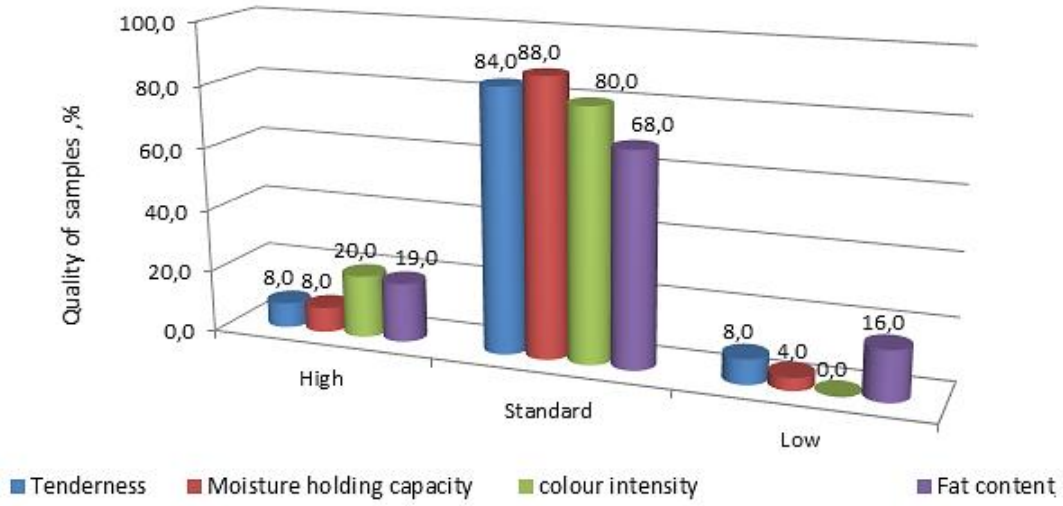

Fig. 1. The quality of muscle tissue of young pigs

We registered, that in the samples of Longissinus dorsi muscle the pH was 5.62, moisture holding capacity - 60.10 %; colour intensity - 73.60 units of ext. × 1000, tenderness - 9.41, crude fat - 2.28 % (Table 1). The moisture content was 74.13 %, hygroscopic moisture - 1.47 %, air-dry matter - 27.25 %; crude ash - 1.13 %, crude protein - 22.36 %, crude fat - 2.28 %, calcium - 0.045 %, and phosphorus - 0.126 %. The loss of absolute mass of the muscle tissue sample during thermal processing was 22.36 %, and its energy value is 121.88 kcal. All the parameters had high variability, thus the CV of pH was 2.49 and CV of crude fat content was

(pH, acidity units) to 74.56 %. According to the scale of meat quality assessment (Polyvoda, 1976), the high quality samples in terms of moisture holding capacity was 12.0 %, colour intensity, units of ext. × 1000 - 16.0%, tenderness - 12.0 % and the crude fat content - 16.0 % (Fig. 1).

Analysis of the data shows that the minimum values of pH - 5.46, colour intensity of 71.40, tenderness of 8.97 s, loss during thermal processing of 21.46%, hygroscopic moisture of 1.38 %, air-dry matter of 26.84 %, crude ash of 1.07 %, crude protein of 20.71 %, calcium of 0.042 %, and phosphorus of 0.124 % were characterized the samples of muscle tissue from the weaners with a total protein content of 58.67-66.30 g/l (distribution class M-).

Table 3. Longissinus dorsi muscle parameters

Parameter	total protein, g/l			creatinine, μmol/l		
	77.53-83.70	67.40-74.45	58.67-66.30	171.06-194.23	144.28-166.52	102.59-137.86
	M^+	M^0	M^-	M^+	M^0	M^-
	4*	16	5	8	11	6
pH**	5.63±0.06	5.66±0.03	5.46±0.08	5.61±0.05	5.60±0.05	5.66±0.05
	2.03±0.72	1.90±0.34	3.08±0.97	2.43±0.61	2.98±0.64	1.99±0.58
moisture holding capacity, %	59.94±1.79	59.46±1.36	62.27±1.79	59.02±1.22	59.58±1.76	62.84±1.91
	5.96±2.11	9.16±1.62	6.44±2.04	5.83±1.46	9.77±2.08	7.48±2.16
tenderness, s	9.92±1.02	9.43±0.36	8.97±0.41	9.55±0.52	8.95±0.34	10.09±0.69
	20.46±7.23	15.07±2.67	10.30±3.269	15.50±3.88	12.77±2.72	16.85±4.87
colour intensity, units of ext. × 1000	72.25±6.02	74.62±2.57	71.40±5.94	70.50±3.85	74.81±3.61	75.50±3.60
	16.56±5.86	13.75±2.43	18.59±5.88	15.46±3.87	15.99±3.41	11.69±3.38
loss during thermal processing, %	24.04±2.18	21.71±0.81	21.46±1.26	21.58±1.31	22.10±0.91	22.49±1.61
	18.11±6.40	15.00±2.65	13.14±4.16	17.13±4.28	13.65±2.91	17.47±5.05
energy value, kcal	116.55±2.57	121.50±2.56	127.38±13.94	119.80±1.65	127.34±6.06	114.68±5.59
	4.41±1.56	8.41±1.49	24.47±7.74	3.90±0.98	15.78±3.36	11.93±3.45

* number of animals, **mean and SD, CV and S_{cv}.

Table 4. Chemical composition of Longissinus dorsi muscle

Parameter	total protein, g/l			creatinine, μmol/l		
	77.53-83.70	67.40-74.45	58.67-66.30	171.06-194.23	144.28-166.52	102.59-137.86
	M^+	M^0	M^-	M^+	M^0	M^-
	4*	16	5	8	11	6
total moisture **	73.93±0.38**	74.06±0.51	74.54±1.65	74.40±0.17	73.44±0.81	75.05±1.07
	1.03±0.37	2.75±0.49	4.95±1.57	0.64±0.16	3.67±0.78	3.48±1.01
hygroscopic moisture	1.64±0.08	1.45±0.03	1.38±0.14	1.48±0.05	1.46±0.06	1.46±0.10
	9.67±3.43	9.06±1.60	22.35±7.07	9.90±2.48	13.84±2.95	17.07±4.93
air-dry matter	27.20±0.43	27.39±0.49	26.84±1.71	27.07±0.14	28.01±0.79	26.07±1.11
	3.16±1.12	7.27±1.29	14.26±4.51	1.47±0.37	9.35±1.99	10.38±3.0
ash	1.16±0.02	1.14±0.02	1.07±0.05	1.14±0.01	1.12±0.04	1.12±0.05
	3.92±1.39	8.29±1.47	11.40±3.61	2.60±0.65	10.33±2.20	11.15±3.22
protein	22.99±0.39	22.72±0.49	20.71±1.0	22.40±0.26	22.74±0.76	21.61±0.91
	3.37±1.19	8.57±1.52	10.80±3.42	3.23±0.81	11.03±2.35	10.25±2.96
fat	1.40±0.17	2.06±0.19	3.67±1.54	2.04±0.26	2.68±0.72	1.87±0.47
	23.97±8.50	36.97±6.54	93.49±2.96	35.37±8.84	88.43±18.86	61.20±17.69
calcium (Ca)	0.05±0.0	0.045±0.0	0.042±0.0	0.046±0.0	0.045±0.0	0.042±0.0
	12.50±4.43	11.84±2.10	13.88±4.39	9.95±2.49	13.19±2.81	13.12±3.79
phosphorus (P)	0.13±0.01	0.124±0.01	0.124±0.0	0.115±0.01	0.134±0.01	0.124±0.01
	21.64±7.67	16.16±2.86	26.95±8.53	14.01±3.50	17.12±3.65	23.82±6.88

* number of animals, **mean and SD, CV and S_{cv}.

We did not reveal certain pattern in the qualitative composition of muscle towards concentration of creatinine in the serum. Thus, the maximum indicators of moisture holding capacity is 62.84%, colour intensity - 75.50 units of ext. × 1000, tenderness - 10.09%, loss during thermal processing - 22.49%, total moisture content - 75.05% and hygroscopic moisture - 1.46%; they were found in class M^- animals (serum creatinine concentrations fluctuate from 102.59 to 137.86 μmol/l).

Indicators of muscle tissue samples of class m^0 animals with serum creatinine concentration ranged from 144.28 to 166.52 μmol/l; they were characterized by a higher energy value - 127.34 kcal, air-dry matter content - 28.01%, protein - 22.74%, fat - 2.68% and phosphorus - 0.134%. Young pigs of class M^+ (serum creatinine concentration ranged from 171.06 to 194.23 mmol/l) outclassed the weaners from M^0 and M^- in ash content by 0.02 (td = 0.55, P> 0.05) and 0.02% (td = 0.39, P> 0.05), respectively;

in calcium content by 0.001 (td = 0.42, P> 0.05) and 0.004 % (td = 1.44, P > 0.05), respectively.

Table 5. Correlation between physicochemical properties and chemical composition of Longissinus dorsi muscle (Large White weaners, n = 25)

Parameter	pH	moisture holding capacity	tenderness	colour intensity	loss during thermal processing
total moisture	0.12±0.21	0.29±0.19	0.18±0.21	0.32±0.19	0.13±0.21
	0.58*	1.49	0.87	1.61	0.62
hygroscopic moisture	0.18±0.21	0.40±0.19*	0.13±0.21	0.11±0.21	–0.05±0.21
	0.88	2.11	0.60	0.53	0.24
air-dry matter	–0.12±0.21	–0.28±0.20	0.15±0.21	–0.30±0.19	–0.12±0.21
	0.58	1.39	0.72	1.51	0.57
ash	–0.12±0.21	–0.36±0.19	0.06±0.21	0.23±0.20	0.08±0.21
	0.60	1.86	0.28	1.11	0.38
protein	–0.05±0.21	–0.48±0.18*	–0.09±0.21	–0.21±0.20	0.08±0.21
	0.26	2.65	0.41	1.02	0.38
fat	–0.11±0.21	0.18±0.21	–0.14±0.21	–0.15±0.21	–0.25±0.21
	0.52	0.85	0.76	0.73	1.24
calcium	–0.16±0.21	–0.31±0.19	0.02±0.21	–0.02±0.21	0.06±0.21
	0.78	1.56	0.10	0.10	0.30
phosphorus	–0.21±0.20	0.06±0.21	–0.25±0.21	0.13±0.21	0.16±0.21
	1.01	0.29	1.26	0.63	0.75

P<0.05, * r ± Sr, tr (r ± Sr – correlation coefficient and semi-partial correlation)

Table 6. Correlations between chemical composition of Longissinus dorsi muscle and blood serum parameters (Large White weaners, n = 25)

Parameter	total protein		creatinine	
	r ± Sr	tr	r ± Sr	tr
Pн	0.29±0.19	1.44	–0.15±0.21	0.72
moisture holding capacity	–0.12±0.21	0.59	–0.18±0.21	0.87
tenderness	0.22±0.20	1.06	–0.04±0.21	0.19
colour intensity	0.03±0.21	0.16	–0.05±0.21	0.24
loss during thermal rocessing	0.08±0.21	0.38	–0.02±0.21	0.07
total moisture	–0.19±0.20	0.91	0.06±0.21	0.31
hygroscopic moisture	0.36±0.19	1.87	–0.08±0.21	0.37
air-dry matter	0.17±0.21	0.84	–0.03±0.21	0.13
Ash	0.27±0.20	1.33	0.03±0.21	0.16
Protein	0.37±0.19	1.89	0.14±0.21	0.70
Fat	–0.26±0.21	1.28	–0.18±0.21	0.87
Calcium	0.38±0.19	1.94	0.24±0.20	1.17
Phosphorus	0.14±0.21	0.65	–0.22±0.20	1.10

r ± Sr – correlation coefficient and semi-partial correlation

Conclusions

We revealed that the biochemical parameters of weaners serum - total protein and creatinine concentration were within the physiological norm. The number of samples of Longissinus dorsi muscle of high quality in terms of moisture holding capacity is 12%, fat content - 16%, tenderness - 12% and colour intensity - 16%. We did not register a significant correlation between the physicochemical properties and chemical composition of We determined significant correlations between moisture holding capacity and protein content (r = – 0.48, tr = 2.65), moisture holding capacity and hygroscopic moisture content (r= 0.40, tr = 2.11). The correlation between total protein in blood serum and fat content in muscle tissue was -0.27 (tr = 1.28), whereas the correlation between total protein content in serum and calcium content in muscle tissue was 0.38 (tr = 1.94), but this was insignificant.

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