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INFLUENCE OF STRESS FACTORS ON NUTRITIONAL CHARACTERISTICS OF PORK MEAT

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ABSTRACT

Qualitative alterations in pork – PSE (pale, soft, exudative) - are an accompanying feature of intensive breeding. Changes in internal biological conditions lead to an increased sensitivity of high yielding pigs to stress. Our investigations focused on changes in nutritional characteristics (total proteins and amino acids) of normal quality pork (*m. longissimus dorsi*) and pork with abnormal course of ageing and on subsequent qualitative changes - PSE. The following methods were used to identify PSE meat (n=6): - pH determination; - colour radiance determination; - loss of meat juice determination. Quantitative determination of total amino acids was carried out after acid hydrolysis at 110°C for 24 hours. According to our findings, pork meat with PSE, regarding total proteins and amino acids, is not nutritionally less valuable than that qualitatively unchanged. The results showed higher values of essential amino acids isoleucine, treonine, valine, leucine and phenylalanine, non essential ones being tyrosine, glutamic acid, cystine, aspartic acid and alanine in the fresh musculature of pigs with PSE meat. The findings were confirmed by the sum of essential amino acids in the PSE meat and correlated with ($P< 0.05$) higher values of total proteins in the PSE meat.

Key words: pig, stress, pork meat, nutritional characteristics, total proteins, amino acid

INTRODUCTION

Research of the gene sensitivity to stress (CRC) has been ongoing since 1980s. The latest results confirm that it determines the protein in the calcium ion channel of the sarcoplasmatic reticulum of muscular cells. A significant sign associated with the CRC genotypes is impaired quality of pork meat – PSE *(pale, soft, exudative)*. Qualitative changes of meat are influenced by genetically conditioned sensitivity to stress, conditions of swine breeding and intensity of stress before slaughter (transport, rest, way of stunning, etc.)

For PSE meat a fast course of glycolysis is typical. In musculature the concentration of Ca^{2+} ions is increased, which causes an increased activity of the ATPase enzyme. Due to the excess of ADP and inorganic phosphate a faster course of glycogenolysis occurs thereby releasing large amount of thermal energy and generated lactic acid induces a decrease in pH to the values of 5.8 and lower (Šimek et al., 2003; Korénekova and Korének, 2008; Korénekova and Turek, 2008).

Interaction of the increased musculature temperature and its elevated acidity induces partial denaturation of muscular proteins. This results in the limitation of the PSE meat capability to bind its own water thereby opening up the structure of the muscular tissue and large amount of meat juice thus drips spontaneously (Lawrie, 1998; Schäfer et al., 2001; Alvarado and Sams, 2002).

Proteins are the most significant components of meat from the nutritional and technological aspects. The protein content in the pure musculature is 18–22 %. These proteins are of great biological value because they are *"full-valuable proteins"* with balanced contents of essential amino acids (Pipek, 1995; Steinhauserová and Steinhauser, 2000). Therefore, in our work the values of total proteins (TP) and amino acids (AMA) of pork meat (*m. longissimus dorsi*) with normal course of ageing and

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Table 1: pH values in PSE and control pork meat MLD – (*m. longissimus dorsi*)

SAMPLE	pH_1 PSE	CONTROL	pH_{24} PSE	CONTROL	pH_{48} PSE	CONTROL
1	5.35	6.25	5.12	5.24	5.72	6.30
2	5.20	6.22	5.07	5.30	5.55	6.42
3	5.45	6.28	5.03	5.26	5.47	6.32
4	5.49	6.30	5.07	5.15	5.75	6.22
5	5.30	6.25	5.02	5.14	5.55	6.30
6	5.35	6.25	5.04	5.18	5.67	6.50
$\bar{x}$	5.36	6.26	5.06	5.21	5.62	6.34
SD	0.26	0.04	0.04	0.06	0.05	0.05
P	P < 0.01(**)		P < 0.01(**)		P < 0.01(**)	

$\bar{x}$ - mean value, *n = 6;* SD - standard deviation; P - level of statistical significance

that with abnormal course of ageing and subsequent PSE qualitative changes are investigated.

MATERIAL AND METHODS

Musculus longissimus dorsi (MLD) of twelve slaughtered Landrace pigs, weighing 90–110 kg served as the experimental material. Material was collected in winter period in the slaughter house where six pigs with atypical course of ageing and subsequent qualitative changes in PSE meat (experimental group), and twelve pigs with normal course of meat ageing (control group) were selected. After killing of the animals followed by 24 hours chilling in the chilling room at 4°C, material was collected on the production line by boning cutlet for laboratory examinations.

For the evidence of PSE meat with atypical course of ageing and subsequent qualitative changes following methods were used:

1. Determination of the values of pH_{1h} p.m. (*post mortem*) and $pH_{24\ h.}$ p.m. were measured electrometrically (pH meter DIGI 88) from the MLD muscle.
2. Determination of colour brightness by measurement of light remission at the wave length of 520 nm using the photometer SPEKOL 11 (Zeiss Jena) with adapter.
3. Determination of meat juice losses through spontaneous dripping were based upon the difference in weights of pork cutlet samples before and after 24 hours of storage in a refrigerator at 4°C and subsequent calculation to percentage.
4. Determination of the total amount of nitrogen according to the CSN 570 105 by Kjeldahl method.
5. Quantitative determination of total amino acids after sample processing by acid hydrolysis (meat homogenate, embedded 6N HCl). Hydrolysis was run in the drier at 110°C ± 3°C for 24 hours (Csapó et al., 1986; Dičáková et al., 2005). Amino acids were analysed by the classic method of column chromatography on ion exchangers using the automatic analyzer of amino acids AAA T 339 (Mikrotechna, Prague). Representation of individual amino acids was expressed in $g.kg^{-1}$ and in $mol.kg^{-1}$ of the total amount of amino acids.

Statistical analyses were performed by Student's T-test and ANOVA test.

RESULTS

The aim of our screening was to select a group of slaughter pigs with typical PSE changes. PSE occurrence of 20.68 % was recorded in the same breeding of pigs in one day slaughter. The differences between selected parameters of the meat quality with a qualitative deviation in PSE and control meat were significant ($P<0.01$). Qualitative characteristics revealed pH_1, pH_{24}, colour brightness measured by light remission and meat juice loss by dripping, which indicate that meat of the group PSE in fact had characteristics typical of PSE meat.

Table 2: Values of light remission and meat juice losses

SAM.	REMISSION (%) PSE	CONTROL	LOSS OF MEAT JUICE (%) PSE	CONTROL
1	17.60	10.40	6.24	2.53
2	17.20	9.40	5.79	2.08
3	17.40	8.40	5.66	2.13
4	17.20	11.40	5.72	2.41
5	20.30	10.00	5.96	2.40
6	17.30	6.00	5.86	3.00
$\bar{x}$	17.84	9.20	5.87	2.42
SD	1.74	1.80	1.25	0.33
P	P < 0.01(**)		P < 0.01(**)	

Table 3: Differences in the weight of pork halves after 24 hours of cooling at 0°C

SAMPLE	PSE			CONTROL		
	$WEIGHT_1$ (kg)	$WEIGHT_{24}$ (kg)	DIFFERENCE (%)	$WEIGHT_1$ (kg)	$WEIGHT_{24}$ (kg)	DIFFERENCE (%)
1	37.50	37.00	1.35	40.50	40.50	0.00
2	35.50	35.00	1.41	31.00	31.00	0.00
3	38.50	38.00	1.31	38.50	38.50	0.00
4	39.00	38.50	1.28	41.00	41.00	0.00
5	47.00	46.50	1.06	43.50	43.50	0.00
6	35.00	34.50	1.43	48.00	47.50	1.04
$\bar{x}$	38.75	38.25	1.31	40.42	40.33	0.17
SD	4.3445	4.3445	0.1337	5.6517	5.5197	0.1246
P	P<0.001 (***)					

$\bar{x}$ - mean value, *n = 6,* SD - standard deviation; *ns* - P > 0.05 *P < 0.05 **P < 0.01 ***P < 0.001

Table 4: Contents of water, fat and gross protein in fresh pork meat

SAMPLE	WATER		FAT		GROSS PROTEIN	
	PSE (%)	CONTROL (%)	PSE (%)	CONTROL (%)	PSE (%)	CONTROL (%)
1	71.55	72.69	4.33	4.23	22.40	22.10
2	72.03	73.83	2.54	2.28	22.80	20.40
3	72.36	74.54	1.47	3.03	22.30	22.60
4	72.72	74.56	3.76	2.17	22.90	22.50
5	72.01	72.01	3.09	3.02	21.30	21.30
6	72.15	73.93	1.91	2.84	13.30	22.10
$\bar{x}$	72.137	73.593	2.850	2.928	20.833	21.833
SD	0.3904	1.0318	1.0918	0.7371	3.7340	0.8383
P	P<0.001 (***)		ns		ns	

$\bar{x}$ - mean value, *n = 6,* SD - standard deviation; *ns* - P > 0.05 *P < 0.05 **P < 0.01 ***P < 0.001

Selected parameters of meat (Table 3,4)

In fresh meat the following observations were made:

- significantly (P<0.001) higher differences in the weight of pork PSE halves after 24 hours of chilling at 4°C;
- significantly (P<0.001) lower water content in fresh PSE meat than that in control meat;
- higher content of total proteins in PSE meat (P<0.05);
- non-significant differences in fat content in fresh pork meat between the groups compared.

The values of amino acids in tested meat (Table 5)

The portions of individual amino acids in meat was found to be on the upper limit of the range determined by the food tables for slaughter animal meat (pork cutlet) after Vojtaššáková et al. (2002).

In fresh meat the following results were obtained between the compared groups:

- higher values of amino acids in fresh musculature of pigs with qualitative changes in PSE meat;
- significantly (P<0.001) higher values in PSE meat were stated for essential amino acid isoleucine;
- significantly higher values (P<0.01) were stated for essential amino acid threonine, valine, leucine, non-essential ones being tyrosine, glutamic acid and cystine;
- significantly higher values (P<0.05) in PSE meat were also recorded for essential amino acids phenylalanine and non-essential amino acids aspartic acid and alanine;
- these results correlate with significantly higher (P<0.05) values of total proteins in fresh PSE meat.

Table 5: Amino acid contents (g.kg^{-1}) in tested meat

AMINOACID	PSE MEAT		CONTROL		T -test P
	$\bar{x}$	SD	$\bar{x}$	SD	
Threonine*	9.63	0.35	8.82	0.28	**
Valine*	10.72	0.09	10.30	0.47	**
Phenylalanine*	10.00	0.20	9.56	0.86	*
Isoleucine*	9.71	0.24	8.71	0.41	***
Leucine*	17.61	0.42	16.58	0.64	**
Lysine*	17.35	0.50	17.01	0.70	ns
Methionine*	5.56	0.42	5.78	0.38	ns
Alanine	10.96	0.29	10.70	0.55	*
Tyrosine	7.08	0.26	6.59	0.23	**
Aspartic acid	19.99	0.57	19.05	0.79	*
Glutamic acid	30.29	0.64	29.70	0.46	**
Cystine	0.85	0.06	0.73	0.05	**
Arginine	12.50	0.48	12.40	0.92	ns
Histidine	9.88	0.29	9.73	0.55	ns
Glycine	7.17	0.30	6.78	0.43	ns
Proline	8.35	0.62	7.79	1.00	ns
Serine	6.97	0.25	6.93	0.19	ns

* - esential amino acid; $\bar{x}$ - mean value, *n = 6;* SD - standard deviation; *ns* - P > 0.05 *P < 0.05 **P < 0.01 ***P < 0.001

DISCUSSION

Evaluation of the amino acids profile revealed significantly higher values in fresh PSE meat for essential amino acid isoleucine, threonine, valine, leucine and phenylalanine; for non-essential amino acids tyrosine, glutamic acid, cystine, aspartic acid and alanine.

Higher values of total proteins and some amino acids in PSE meat are probably partially caused by lower water content in PSE meat and subsequently by higher concentration of muscular proteins as well as by the influence of hormonal and metabolic changes taking place in the organism aimed at coping of animals with stress situation.

Part of the stress situation is increased secretion of the somatotropic hormon (STH) that is induced by dopaminergic stimulation (Pástorová, 2008; Pástorová et al., 2008). Biological significance of STH release in stress situation lies in proteoanabolism compensating the action of glucocorticoids. STH accelerates transport of amino acids through the plasma membrane and supports their incorporation into polypeptide chains on ribosomes of the granular endoplasmic reticulum as reported by Jelínek et al. (2003) as well as it stimulates the synthesis of nucleic acids and thereby it significantly supports proteosynthesis by which a positive nitrogen balance is attained in the organism of stressed animals.

CONCLUSION

According to our findings pork meat with a qualitative PSE deviation regarding total proteins and amino acids is not nutritionally less valuable compared to meat qualitatively unchanged.

The troubles related with PSE meat rather lies with its technological utilisation in meat production.

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