Glycolytico –energetical resources as determinants of raw pork meat quality

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Abstract— **The aim of this study was determination of diagnostic value of glycolytico –energetical resources expressed by glycogen, lactate content, R_1 indicator (IMP to ATP ratio) and pH_1 to prediction of pork raw meat quality attributes. The investigations covered 110 stress resistant fatteners 50 crossbredings of (Landrace x Yorkshire)x Duroc and 60 (Landrace x Yorkshire)xHampshire. The results of canonical analysis performed in this work shown that among analysed sets of determinants (R_1 & glycogen; R_1 & lactate, pH_1& R_1; R_1, glycogen & lactate and pH_1 R_1 & glycogen) the set involving R_1, glycogen and lactate parameters was a best determinant of physico – chemical traits of raw pork meat quality. In calculations we grouped traits in 5 sets as follows: pH_1 pH_{24} electrical conductivity measured in 2 and 24h post mortem (EC_2 EC_{24}), meat lightness 48h post mortem (L*) and drip loss measured in 48, 96 and 144h after the slaughter – 1st set; pH_1 pH_{24} EC_2 EC_{24} L*, drip loss measured in 48, 96 and 144h after slaughter and WHC – 2nd set; EC_2 EC_{24} L*, drip loss measured in 48, 96 and 144h after slaughter WHC, share force measured in 144h after the slaughter and water content – 3rd set; pH_{24}, intramuscular fat content (IMF), protein content, dry matter and meat yield in the curing and thermal processing (72 ˚C), expressed by TY (Technological yield) indicator – 4th set and IMF, protein content, dry matter, L*, drip loss measured in 48, 96 and 144h after the slaughter, WHC, TY and share force measured in 144h – 5th set. For (Landrace x Yorkshire)x Duroc crossbreedings composed determination coefficients (R_C^2) were from 0.61 for 5th set of variables to 0.62 for 1st set of variables while for (Landrace x Yorkshire)x Hampshire were from 0.74 for 5th set to 0.86 for 3rd set respectively.**

Keywords— **canonical analysis, glycolytico-energetical resources, raw pork meat quality.**

I. INTRODUCTION

Muscle metabolism in the *post mortem* period has the impact on variation in meat quality traits. The one of the fundamental changes in the conversion of muscle to meat is metabolism of glycogen [18]. The *post mortem* degradation of glycogen through glycogenolysis and glycolysis provides ATP to help meet energy demand and decreases pH by generating lactate and H+ [17]. It was shown that that glycogen consumption during slaughter is similar in groups of stress resistant ($RYR1^{CC}$) and heterozygous ($RYR1^{CT}$) animals [9]. Variations in pH depends to a large extent on the glycogen level of the muscle at death [15]. Also, the R-value is useful parameter for examining the glycolytic rate in the early *post mortem* period [6; 7; 19]. Factors that affect the state of the myofilament lattice, such as the rate and extent of the muscle acidification that occurs *post mortem*, will also affect the amount of drip lost from the meat [12; 21]. A reduced extent of acidification and high ultimate pH results in low drip loss while high rates of initial acidification lead to increased drip loss. The rapid initial pH fall occurs at a time when carcass temperature is still relatively high and may lead to myosin denaturation resulting in greater shrinkage of the myofilament lattice [20].

The aim of this study was determination of diagnostic value of glycolytico –energetical resources expressed by glycogen, lactate content, R_1 indicator (IMP to ATP ratio) and pH_1 to prediction of pork raw meat quality attributes.

II. MATERIAL AND METHODS

The investigations covered 110 stress resistant fatteners 50 crossbredings of (Landrace x Yorkshire) x Duroc and 60 (Landrace x Yorkshire) x Hampshire. The animals were kept under the same environmental conditions and fed a full bath feed. The animals were slaughtered 2-4 hours after transportation using electrical stunning method and recumbent bleeding out (Midas system, Inarco). The carcasses were chilled using the three-phase chilling tunnel (-10ºC - 15 min, -

15ºC - 25 min and -5ºC - 40 min. with air velocity 3m/s). The following meat quality characteristics were determined: pH of meat measured directly in *Longissimus lumborum* (LL) muscle (45 min and 24 h after the slaughter) using pH-Master apparatus produced by Draminski, electrical conductivity (EC) measured with a LF-Star conductometer (Ingenieurbüro Matthäus, Noblitz, Germany) 2 h and 24 h *post mortem* (EC_2, EC_{24}), colour lightness (L*) of the muscle tissue, was assessed 24 h *post mortem* with a Minolta Portable Chroma Meter (model CR 310, Minolta, Osaka, Japan) using D65 illuminant and 50 mm orifice, WHC, determined by the filter paper method according to the method of [5] as modified by [13], 24 h *post mortem* drip loss determined in 48, 96 and 144 h *post mortem* according to [14] and meat yield in the curing and thermal processing (72 ˚C), expressed by TY (Technological yield) indicator, according to [11] as modified by [8]. Rate of ATP breakdown, expressed by R_1 = IMP/ATP indicator, determined 45 min *post mortem* on meat samples taken after last rib, according to the method of [6]. Besides, an analysis of the protein, water, intramuscular fat (IMF) and dry matter content in LL muscle tissue was conducted. The RYR1 genotypes were established according to [4]. At 45 min. postmortem, samples from LL muscle were collected into the tubes with 0.5M PCA for determination of glycogen [3] and lactate [1]. On the basis of them the glycolytic potential (GP) was calculated according to formula proposed by [10]. The estimation of the usefulness glycolytico–energetical resources expressed by glycogen, lactate content, R_1 indicator (IMP to ATP ratio) and pH_1 for the determination of pork meat quality was performed on the basis of coefficients of canonical correlation (C_R) and composed determination coefficients (R_C^2) (respective squared value) [22].

III. RESULTS AND DISCUSSION

The results of canonical analysis performed in this work shown that among analysed five sets of determinants (x_1 -R_1 & glycogen; x_2 - R_1 & lactate, x_3 - pH_1& R_1; x_4 - R_1, glycogen, lactate and x_5 - pH_1 R_1 and glycogen) the set involving R_1, glycogen and lactate parameters has a best determinant of physico – chemical traits of raw pork meat quality. In calculations analyzed traits were grouped in 5 sets as follows: pH_1 pH_{24} electrical conductivity measured in 2 and 24h post mortem (EC_2 EC_{24}), meat lightness 48h post mortem (L*) and drip loss measured in 48, 96 and 144h after the slaughter – 1st set (y_1); pH_1 pH_{24} EC_2 EC_{24} L*, drip loss measured in 48, 96 and 144h after slaughter and WHC – 2nd set (y_2); EC_2 EC_{24} L*, drip loss measured in 48, 96 and 144h after slaughter WHC, share force measured in 144h after the slaughter and water content – 3rd set (y_3); pH_{24}, intramuscular fat content (IMF), protein content, dry matter and meat yield in the curing and thermal processing (72 ˚C), expressed by TY (Technological yield) indicator – 4th set (y_4) and IMF, protein content, dry matter, L*, drip loss measured in 48, 96 and 144h after the slaughter, WHC, TY and share force measured in 144h – 5th set (y_5). For (Landrace x Yorkshire)x Duroc crossbreedings composed determination coefficients (R_C^2) were from 0.61 for 5th set of variables(y_5) to 0.62 for 1st set (y_1) of variables while for (Landrace x Yorkshire)x Hampshire were from 0.74 for 5th (y_5) set to 0.86 for 3rd set (y_3) respectively.

[2] shown that ultimate pH explain 79% of the variation in color, 57% of variation in drip loss, and 77% of the variation in purge loss. [16] shown that glycogen account for 60%, lactate for 80%, IMP for 71% and pH to 24 h *post mortem* for 85% explain variation in drip loss.

IV. CONCLUSIONS

Obtained results indicate that early *post mortem* measurements of indicators of glycolytical and energetical changes as glycogen, lactate and IMP/ATP (R_1 ratio) are useful to predict raw pork meat quality.

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Tab.1 Values of canonical correlations and respective squared canonical correlation revealing relationship between independent sets (x_1 - x_5) containing glycogen, lactate, pH_1 and R_1 value and dependent variables sets (y_1 – y_5) determining raw meat quality of (LxY)xH fatteners.

Dependent variables (y)		Independent variables (x)				
		$x_1 = R_1$, glycogen	$x_2 = R_1$, lactate	$x_3 = pH_1$, R_1,	$x_4 = R_1$, glycogen lactate	$x_5 = pH_1, R_1$, glycogen
y1 = pH_1, pH_{24}, EC_2, EC_{24}, L*, drip loss 48, 96 144h	C_R R_C^2	0.74** 0.55	0.89** 0.79	-	0.90** 0.81	-
y2 = pH_1, pH_{24}, EC_2, EC_{24}, L*, drip loss 48, 96, 144h, WHC	C_R R_C^2	0.75** 0.56	0.89** 0.79	-	0.90** 0.81	-
y3 = EC_2, EC_{24}, L*, drip loss 48, 96, 144h, WHC, water content	C_R R_C^2	0.73* 0.53	0.85** 0.72	0.83** 0.69	0.86** 0.86	0.74** 0.55
y4 = pH_{24}, IMF, protein content, dry mater, TY	C_R R_C^2	0.87** 0.76	0.56* 0.31	0.54* 0.29	0.89** 0.79	0.89** 0.79
y5 = IMF, L*, protein content, dry mater, drip loss 48, 96, 144h , WHC, TY	C_R R_C^2	0.85** 0.72	0.64* 0.41	0.68* 0,46	0.86** 0.74	0.85** 0.72

** - significant statistically at $p \leq 0.01$; * - significant statistically at $p \leq 0.05$

Tab.2 Values of canonical correlations and respective squared canonical correlation revealing relationship between independent sets (x_1 - x_5) containing glycogen, lactate, pH_1 and R_1 value and dependent variables sets (y_1 - y_5) determining raw meat quality of (LxY)xD fatteners.

Dependent variables (y)		Independent variables (x)				
		$x_1 = R_1$, glycogen	$x_2 = R_1$, lactate	$x_3 = pH_1$, R_1,	$x_4 = R_1$, glycogen lactate	$x_5 = pH_1, R_1$, glycogen
y1 = pH_1, pH_{24}, EC_2, EC_{24}, L*, drip loss 48, 96 144h	C_R R_C^2	0.78** 0.61	0.70** 0,49	-	0.79** 0.62	-
y2 = pH_1, pH_{24}, EC_2, EC_{24}, L*, drip loss 48, 96, 144h, WHC	C_R R_C^2	0.79** 0.62	0.71* 0.51	-	0.80** 0.63	-
y3 = EC_2, EC_{24}, L*, drip loss 48, 96, 144h, WHC, water content	C_R R_C^2	0.63* 0.40	0.53NS	0.79** 0.63	0.66* 0.44	0.84** 0.70
y4 = pH_{24}, IMF, protein content, dry mater, TY	C_R R_C^2	0.62* 0.38	0.29NS	0.25NS	0.77** 0.59	0.63* 0,40
y5 = IMF, L*, protein content, dry mater, drip loss 48, 96, 144h , WHC, TY	C_R R_C^2	0.70** 0.49	0.47NS	0.49NS	0.78** 0,61	0.73** 0.53

** - significant statistically at $p \leq 0.01$, * - significant statistically at $p \leq 0.05$, NS – not statistically significant