PE1.46 Glycogen Content And The Rate Of Glycolytic Changes As The Indicator Of Pork Meat Quality 300.00

Maria Koćwin-Podsiadła (1) kocwin@ap.siedlce.pl, Andrzej Zybert(1), Katarzyna Antosik (1), Wojciech Podsiad³y (2), Halina Sieczkowska (1), El¿bieta Krzęcio (1)
(1)University of Podlasie
(2)Warsaw Agricultural University

Abstract— Glycogen and lactate content (measured 45 min. after the slaughter), rate of glycolytic changes expressed by glycogen breakdown from 45 min. to 48h postmortem, and pH changes (from 45 min. to 144h after the slaughter) were investigated in 50 stress resistant (Landrace x Yorkshire)x Duroc fatteners for culinary and technological attributes of meat. Glycogen and lactate content (measured 45 min postmortem) explains : 45% of differences in nutritive value of meat (IMF and protein content), 76% in sensory, 38% of variation in drip loss (from 24 to 144h after the slaughter), 34% differences in fluid loss from MAP and VAC packed chops and from 62 to 64% variation in pH. In the present work, has also been found, that pH changes from 45 min to 144h post-mortem higher than GP components and rate of glycolytic changes, explain differences in sensory traits, drip loss and fluid loss from MAP and VAC packed meat (at 94, 49, 44 and 52% respectively), and in similar degree explain differences in cooking loss and TY.

Index Terms—canonical analysis, glycogen, lactate, pH changes, pork meat quality.

I. INTRODUCTION

Glycogenolysis is a fundamental biochemical process in the post mortem conversion of living muscle to meat. Post mortem glycogenolysis involves the breakdown of glycogen to glucose and then to lactic acid, in the absence of oxygen, in order to form ATP (adenosine triphosphate). The accumulation of lactate, results in pH decline in muscle post mortem. Many factors influence the rate and extent of pH decline in post mortem muscle. [12] identified a condition in animals that had normal rates of muscle pH decline post mortem; however, the ultimate pH was relatively low and the meat was of low quality. This so-called 'acid meat' condition has been attributed to high muscle glycolytic potential (GP) and high accumulation of glycogen in muscles. These authors suggested the use of glycolytic potential as an index of the muscle's capacity for post mortem glycolysis. Glycolytic potential is an estimate of the levels of all compounds in the muscle that are involved in the transformation of glycogen to lactic acid. Glycogen and lactate concentration can be utilized to predicting the ultimate pH of postmortem muscle. In turn, the ultimate pH of meat is highly correlated to water holding capacity, colour, processing characteristics and consumer acceptability. So, measurement of glycogen combined with a measure of lactate, is a way of predicting quality attributes of meat [9]. The aim of this study was determination of diagnostic value of glycogen and lactate content (measured 45 min. after the slaughter), rate of glycolytic changes expressed by glycogen breakdown from 45 min. to 48h postmortem, and pH changes (from 45 min. to 144h after the slaughter) for culinary and technological attributes of (Landrace x Yorkshire)x Duroc crossbreedings which are a main component in mass production of fatteners in Europe and had good quality of meat.

II. MATERIALS AND METHODS

The investigations covered 50 stress resistant (Landrace x Yorkshire)x Duroc fatteners. 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 (-10 ºC - 15 min, -15 ºC - 25 min and -5 ºC - 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, 2, 3, 24, 48, 96 and 144 h after the slaughter) using pH-Master apparatus produced by Draminski, drip loss determined in 48, 96 and 144 h post mortem according to [14] and liquid loss from chops packed (at 24h after the slaughter) in modified atmosphere (MAP) and vacuum (VAC) and meat yield in the curing and thermal processing

(72 °C), expressed by TY (Technological yield) indicator, according to [13] as modified by [10]. Cooking loss and sensory analysis concerning flavour, colour and its uniformity, tenderness, juiciness, aroma, fat perceptibility and general quality were determined according to [2]. 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 [6]. At 45 min, 24 and 48 h post mortem, samples from LL muscle were collected into the tubes with 0.5M PCA for determination of glycogen [4] and lactate [3]. On the basis of them the glycolytic potential (GP) was calculated according to formula proposed by [12]. The estimation of the usefulness of glycogen, lactate, the rate of glycogen breakdown (from 45 min to 24h and from 45 min. to 48h post mortem) and pH changes (from 45 min to 144h after the slaughter) for the determination of the quality properties of meat and its technological value was performed on the basis of coefficients of canonical correlation (CR) and composed determination coefficients (RC2) (Statistica.PL 6.0). Additionally, coefficients of simple phenotypic correlation (r) and regression (b) between glycogen content at 45 min. after the slaughter and drip loss and GP45 and meatiness estimated using Ultra-Fom 300 (SFK Technology, Denmark) apparatus have been calculated.

III. RESULTS AND DISCUSSION

We shown that variation in glycogen and lactate content (measured 45 min postmortem) explains : 45% of differences in nutritive value of meat (IMF and protein content), 76% in sensory, 38% of variation in drip loss (from 24 to 144h after the slaughter) and 34% differences in fluid loss from MAP and VAC packed chops (Tab. 1). These results induced us to additional calculations concerning correlations between glycogen content (at 45 min post-mortem) and drip loss (measured at 48, 96 and 144h after the slaughter) and TY indicator. It was found, that 10μmol/g increase of glycogen content in muscle results in increase of drip loss (from 0.9 to 1.6% at 48 and 144h post mortem respectively) and 1.4% decrease in TY. It also has been observed that GP components (glycogen and lactate) highly (from 62 to 64%) explain the variation in pH, such during meat aging as its storage (Tab.1). Studies conducted by [17, 18] demonstrate that glycolytic potential variation accounts for a maximum 40% of the difference in pHu of pork loin. The similar to mentioned above, explain variation in rate of glycogen changes expressed in μmol/g/h (Tab.1). The investigations of [19], conducted on (LxY)xD fatteners, shown that glycogen degradation continues to 48h after the slaughter. In the present work, has also been found, that pH changes from 45 min to 144h post-mortem higher than GP components and rate of glycolytic changes, explain differences in sensory traits, drip loss and fluid loss from MAP and VAC packed meat (at 94, 49, 44 and 52% respectively), and in similar degree explain differences in cooking loss and TY (Tab. 1). [15] reported, that pH24 h explained only 4% of the variation in WHC in meat from crossbred Duroc, Landrace and Yorkshire pigs. In contrast, pH measured early post mortem in the same material, e.g. pH1 h, explained 72%of the variation in WHC. The results of canonical analysis performed in this work, confirm the previous data obtained on the non-carriers of RN- gene [7, 8, 9]. Moreover, obtained in this work results, show that GP components, rate of glycolytic changes and pH changes are suitable determinants to predicting quality attributes of pork meat. A high diagnostic value of glycogen in muscles for predicting pork meat quality and the controversies concerning the gene responsible for glycogen content [1, 5, 11] and complexity of glycolytico-energetical processes [16] in muscle tissue post-mortem create the argument that not only the one gene is responsible for variability in glycogen content in muscles. It tend to search for the genes responsible for the variability on glycogen in vivo or immediately post-mortem or alternative (and quick) methods to it estimation in muscles. The findings mentioned above, tend us to set the optimum for glycogen content in tissue at 45 min after the slaughter which would be guarantee a good quality of meat. Preliminary results showed that meat with glycogen content less than 40 μmol/g tissue has a high quality meat but it requires animals with meatiness 55-58% and hot carcass weight 79-92kg. We also shown, that lean meat content exceeded 58% is negatively correlated with glycogen content (r=0.43** b=0.08) and results in deterioration in culinary and technological usefulness of meat. Resuming, the profits connected with increasing of lean meat content in carcasses are counterbalanced by mentioned above deteriorations in drip loss (to 144h postmortem) and TY indicator as the result of the accretion of glycogen.

ACKNOWLEDGEMENT

The project of pork quality system has been applied into the activation in Ministry of Agriculture and Rural Development

REFERENCES

1. Andersson L. (2003). Identyfication and characterization of AMPK3 mutations in the pig. Biochemical Society Transactions, 31, 1, 232-235.

2. Bary³ko Pikielna N. (1975). Sensory analysis of food. PWN, Warsaw, Poland (in polish)

3. Bergmeyer H. U. (1974). Methods of enzymatic analysis. New York: Academic Press.

4. Darymple R. H. & Hamm R. (1973). A method for the extraction of glycogen and metabolites from a single muscle sample. Journal of Food Technology, 8, 439-444.

5. Fontanesi L., Davoli R., Nanni Costa L., Sotti E., Russo V. (2003). Study of candidate genes for glycolytic potential of porcine skeletal muscle:identyfication and analysis of mutations, linkage and physical mapping and association with meat quality traits in pigs. Cytogenetic and Genome Research, 102, 145-151.

6. Fujii J., Otsu K., Zorzato F., de Leon S., Khanna S., Weiler V. K., O'Brien P. J. & MacLennan D., H. (1991). Identification of a mutation in porcine ryanodine receptor associated with malignant hyperthermia. Science, 253, 448-451.

7. Koæwin-Podsiad³a M. (1993). The method of evaluation of pork foulty meat. Zesz. Nauk. WSRP w Siedlcach, Monografie, 26, 1-112. (in polish)

8. Koæwin-Podsiad³a M., Krzêcio E., Pospiech E., £yczyñski A., Antosik K., Grzeœ B., Zybert A., Sieczkowska H. (2005) Selection of pork meat quality traits. Estimation of culinary and technological quality on the basis of measurements after slaughter. Fleischwirtshaft, 2, 21–23.

9. Koæwin-Podsiad³a M., Krzêcio E., Przybylski W. (2006). Pork quality and methods of its evaluation – a review. Polish Journal of Food and Nutrition Sciences, 15/56, 3, 241-248

10. Koæwin-Podsiad³a M., Kury³ J., Krzêcio E., Antosik K., Zybert A. & Sieczkowska H. (2004). An association between genotype at the CAST (calpastatin) locus and carcass quality traits in pigs free of RYR1T allele. Animal Science Papers and Reports, 22, 497–505.

11. Meadus W.J., MacInnis R., Dugan M.E.R., Aalhaus J.L. (2002). A PCR-RFLP method to identify RN- gene in retailed pork chops. Canadian Journal of Animal Science, 82, 449-451.

12. Monin G. & Sellier P. (1985). Pork of low technological quality with a normal rate of muscle pH fall in the immediate post-mortem period: The case of the Hampshire breed. Meat Science,13, 49-63.

13. Naveau J., Pommeret P. & Lechaux P. (1985). Proposition d'une méthode de mesure du rendemnet technologique: La „méthode Napole". Techni-Porc, 8, 7–13.

14. Prange H., Juggrt L. & Scharner E. (1977). Untersuchungen zur Muskel fleischqualitaet beim Schwein. Archives of Experiments in Veterinary Medizin, 31, 2, 235 – 248.

15. Schafer A., Rosenvold K., Purslow P. P., Andersen H. J., & Henckel P. (2001). Critical post mortem pH and temperature values in relation to drip loss in pork. In Proceedings of 47th International Congress on Meat Science and Technology (pp. 206–207). Krakow, Poland.

16. Scheffler T.L., Gerrard D.E. (2007). Mechanisms controlling pork quality development: The biochemistry controlling postmortem energy metabolism. Meat Science, 77, 7–16.

17. van Laack R.L.J.M. & Kauffman R.G. (1999). Glycolytic potential of red, soft, exudative pork longissimus muscle. Journal of Animal Science, 77, 2971-2973.

18. van Laack R.L.J.M., Kauffman R.G. & Greaser M.L. (2001). Determinants of ultimate pH of meat. In Proceedings of 47th International Congress on Meat Science and Technology (pp. 22-26). Krakow, Poland.

19. Zybert A., Krzêcio E., Sieczkowska H., Podsiad³y W. & Przybylski W. (2007). The influence of chilling method on glycolytic changes and pork meat quality. 53rd International Congress of Meat Science and Technology (pp. 293-294), 5-10 August, Beijing, China.

Tab.1 Values of canonical correlations and respective squared canonical correlation revealing relationship between independent sets containing GP components, rate of glycogen breakdown and pH changes and dependent variables sets describing wide spectrum traits of meat quality and culinary and technological usefulness of pork

Independent variebles / Dependent variebles	Glycolytic potential components (45 min. postmortem	Rate of glycogen breakdown (μmol/g/h)	pH changes
	Glycogen lactate	45min-24h 45min-48h	from 45 min to 144h postmortem
Nutritive value: IMF, protein content	C_R= 0.67* R_C^2= 45%	C_R=0.65* R_C^2= 42%	C_R=0.58* R_C^2= 34%
Sensory value: tenderness, juiciness, flavour, colour, fat perceptibility, general quality	C_R= 0.87** R_C^2= 76%	C_R=0.83* R_C^2= 69%	C_R=0.97** R_C^2= 94%
Drip loss from 24 to 144h postmortem	C_R= 0.62** R_C^2= 38%	C_R=0.66** R_C^2= 44%	C_R=0.70** R_C^2= 49%
Purge from MAP packed meat (from 24 to 144h post-mortem)	C_R=0.58* R_C^2= 34%	C_R=0.63** R_C^2= 40%	C_R=0.66** R_C^2= 44%
Purge from VAC packed meat (from 24 to 144h post-mortem)	C_R=0.58** R_C^2= 34%	C_R=0.54* R_C^2= 29%	C_R=0.72** R_C^2= 52%
TY and cooking loss	C_R=0.86** R_C^2= 74%	C_R=0.85** R_C^2= 72%	C_R=0.86** R_C^2= 74%
pH_{45}, pH_{24}, pH_{48}	C_R=0.79** R_C^2=62%	C_R=0.66** R_C^2=44%	-
pH_{24}, pH_{48}, pH_{96}, pH_{144}	C_R=0.79** R_C^2=62%	C_R=0.72** R_C^2=52%	-
pH_{45}, pH_{24}, pH_{48}, pH_{96}, pH_{144}	C_R=0.80** R_C^2=64%	C_R=0.79** R_C^2=62%	-

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