FORMATION OF HETEROCYCLIC AROMATIC AMINES IN RELATION TO PORK QUALITY AND HEAT TREATMENT PARAMETERS

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Abstract – The aim of the research was to analyze the influence of the chemical composition, technological and sensory pork quality on the formation of heterocyclic aromatic amines (HAAs) in meat after heat treatment. Material for analysis was taken from 36 samples of pork with different ultimate pH. The results showed that the studied meat was characterized by a significant variation in chemical composition, especially in precursors of HAAs. The formation of HAAs in meat was significantly related to its quality, chemical composition and heat treatment temperature. These studies also demonstrated the increased amount of HAAs in meat with higher temperature of grilling and in meat with lower pH. The formation of HAAs was associated with the decreasing of sensory quality of grilled meat.

Key Words – pork, glucose, ultimate pH, HAAs

I. INTRODUCTION

The meat is an essential component of the human diet due to the unique chemical composition, nutritional value and the content of balanced protein. Relative high nutritional value could be modified during heat treatment, where negative compounds could create, like heterocyclic aromatic amines that have proved to be strong mutagens and carcinogens (Skog *et al.* 2000, Polak *et al.* 2009, Gibis and Weiss, 2015). They are formed during the high temperature heat treatment of the animal origin food (especially grilling and frying) (Skog *et al.* 2000, Polak *et al.* 2009, Gibis and Weiss, 2015). Temperature and time of heat treatment as well as pH significantly influenced on its formation (Polak *et al.* 2009, Gibis and Weiss, 2015). Despite the significant amount of research in this field there are no specific national recommendations for gastronomy regarding meat selection and heat treatment temperature to ensure the preparation of meat with high sensory quality, safe and at the same time retaining a high nutritional value. For this reason the aim of the study was to analyze the influence of the chemical composition, technological and sensory pork quality on the formation of heterocyclic aromatic amines (HAAs) after heat treatment in different temperatures and formulation of recommendation for gastronomy as well as consumers.

II. MATERIALS AND METHODS

The study was realized on 36 samples of pork (*Longissimus* muscle selected from 383 pigs) with different ultimate pH from the mass population. Samples taken 24 hours after slaughter were divided into 2 groups: the I group of muscle with lower pH (<5.50), the II group of samples with higher pH (≥5.50). Technological quality and chemical composition of the raw meat was determined by: pH_{24} and pH_{48} (WTW 340i pH meter, Weilheim, Germany), drip loss (Prange *et al.* 1977), colour parameters (CIE $L^*a^*b^*$system; Minolta CR400, Osaka, Japan), protein content (The Kjeldahl method; FOSS Tecator 1035 Analyzer), fat content (Soxhlet and Folch extraction method), water and ash content, glucose and lactic acid (Accu-Chek Active glucometr, Roche, Germany), content of creatine and creatinine (HPLC Alliance 2695, Waters with UV-Vis detector; according to Rak and Morzyk 2002). In meat samples after grilling (in temperature 180°C and 220°C) content of heterocyclic aromatic amines: MeIQ (2-amino-3,4-dimethyl-imidazo[4,5-f]quinoline); 4,8-DiMeIQx (2-amino-3,4,8-trimethylimidazo[4,5-f]quinoxaline); 7,8-DiMeIQx (2-amino-3,7.8-trimethylimidazo[4,5-f]quinoxaline); PhIP (2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine) were evaluated. (Oz and Zikirov 2015; HPLC Alliance 2695, Waters with UV-Vis detector and Acquity UPLC - QTOF Premier system, Waters). Sensory analysis of meat after heat treatment with Quantitative Descriptive Analysis was evaluated (ISO 13299:2003). The obtained data were developed using Statistica version 12.0 software (StatSoft, Inc., 2014). Pearson's simple correlation coefficients and nonlinear models of regression between analyzed traits were also calculated. The multivariate regression and canonical analysis were used to estimate the relations between the formation of heterocyclic aromatic amines (as dependent variables) with the attributes of technological quality of meat and its chemical composition (as explanatory variables). All significances were tested at the level of P_α 0.05 and 0.01.

III. RESULTS AND DISCUSSION

Meat of the studied groups differed significantly in the following parameters: pH_{24} and pH_{48}, protein content, ash, glucose, lactic acid and the brightness (L*) and b* parameter of raw meat (Table 1). Meat of I group with lower pH *post mortem* have contained more protein, ash, glucose, lactic acid and was characterized by a lighter colour (L*) and the higher value of the parameter b*. After grilling in 180°C the HAAs were detected only in group I (Fig. 1).

Table 1. Physico-chemical characterization of raw pork in groups with varying ultimate pH

Traits	Groups	
	I (n=18)	II (n=18)
pH_{24}	5.46 A	5.79 B
pH_{48}	5.38 A	5.67 B
Protein [%]	23.7 a	23.2 b
Fat content [%]	2.76	2.58
Water content [%]	73.6	73.8
Ash content [%]	1.16 a	1.13 b
Glucose [mg/dL]	177 A	95.2 B
Lactic acid [mmol/L]	103 A	88.6 B
Colour parameters: L*	55.3 A	49.1 B
a*	7.80	6.87
b*	4.44 A	3.51 B
Drip loss [%]	5.03	4.12
Creatine [%]	0.480	0.456
Creatinine [%]	0.013	0.006

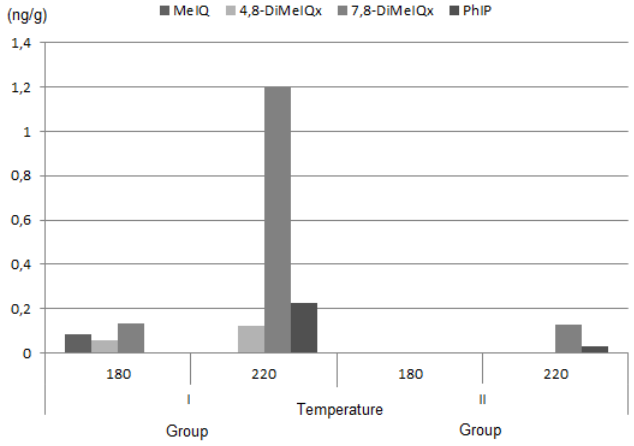

Fig 1. The content of heterocyclic aromatic amines in meat samples both group after grilling in 180°C and 220°C

Means with different letters differs at Pα≤0,01 (capital letter) and at Pα≤0,05 (small letter).

Grilling in 220°C has increased the amount of HAAs in I group (twice of 4,8-DiMeIQx and ninefold of 7.8-DiMeIQx) and was contributed to its formation also in II group. The observed values of HAAs were similar to reported by Szterk *et al.* (2012), Gibis and Weiss (2015). The results showed a significant, simple and linear relationship between pH (r=0.7-0.9; Pα≤0,05), glucose (r=0.6; Pα≤0,05), L* value (r=0.6; Pα≤0,05), drip loss (r=0.7; Pα≤0,05) and HAAs and also curvilinear relationship with b* parameter (r=-0.9; Pα≤0,05) and HAAs. Some of above mentioned relationships were similar to Polak *et al.* (2009) and Gibis and Weiss (2015) study. The results showed also that increase of HAA during grilling was associated with sensory quality deterioration. The canonical analysis showed that HAAs (created during heat treatment) in 99% depended on pH, glucose, creatine and fat content as well as b* colour parameter.

IV. CONCLUSION

The results showed the significant effect of ultimate pH, glucose, creatine, fat and colour b* parameter and heat treatment on formation of HAAs in meat during grilling. It would be advisable to choose meat with a higher pH (range 5,6-5,8) due to lower glucose content which is a precursor of HAAs. It could be stated that the heat treatment should necessarily be carried out at a temperature not higher than 180°C, guaranteeing the smaller amount formation of HAAs.

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