ANTIOXIDANT ACTIVITY AND SENSORY QUALITY OF GRILLED PORK WITH DIFFERENT ULTIMATE PH

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Abstract

The aim of this study was to determine the antioxidant activity and sensory quality of grilled pork in relations to ultimate pH. In meat sample of 24 pigs in *Longissimus* muscle were measured ultimate pH (24 and 48 h *post mortem)*, colour parameters in CIE Lab system, drip loss, glucose and lactate, protein, ash, fat and water content. Samples were grilled at 180ºC and 220ºC and after that the sensory quality was evaluated with QDA method. In grilled meat, antioxidant activity to stable radicals (DPPH) was measured. The meat samples was divided into two groups with different levels of ultimate pH – I group (n=12) pigs with lower pH (≤5.5) and II group (n=12) with higher pH (>5.5). The results showed significant differences between groups in protein, ash, glucose, lactate content and colour (L* and b*) in raw meat. In grilled samples there were significant differences between antioxidant activity in 220 °C. Juiciness, acid as well as burnt flavour and overall quality also differs significantly at 180ºC and 220 ºC. The grilled meat with lower pH was characterized by darker and more red colour, higher antioxidant activity in 220 ºC and lower sensory quality for 180ºC.

Key Words – meat quality, DPPH, glucose

I. INTRODUCTION

The pork quality depends from changes occurring in muscle tissue after slaughter. The extent of *post mortem* changes accurately reflects the ultimate pH, which significantly depends on the level of glycogen before slaughter [1]. Several studies have shown that meat with low ultimate pH is characterized by high glycolytic potential [2, 3]. Such meat also contains a large amount of free glucose [1, 3]. Meinert et al. [4] showed that glucose and glucose 6-phosphate appeared to be important flavour precursors in pork during frying. Maillard reaction between reducing sugars and amino acids is a common reaction in food during heating processing [5]. In the end of this process substances with high molecular weight (melanoidins) with antioxidant activity are formed [6]. Melanoidins that are the Maillard reaction products (MRPs) are responsible for the flavour, the odour and the colour of food products [7]. Their antioxidant properties have been investigated in a number of model systems [6] and food, especially in coffee, beer, wine and in food after heat treatment (only a few in meat [8]). Meat with different quality in combination with the temperature may also determine the formation after heat treatment substances f.e. heterocyclic aromatic amine compounds and the products of the Maillard reaction – melanoidines with an antioxidant activity [8,9].

The aim of the study was to determine the antioxidant activity and sensory quality of pork grilled in different temperatures in relation to various pH and glucose level.

II. MATERIALS AND METHODS

The samples of *Longissimus dorsi* muscle from 24 pigs (from cross breeding of Landrace x Large White breeds) were collected at 24 hours after slaughter. The pH value was measured at 24 and 48 h after slaughter using a pH-meter WTW i330. On the basis of pH_{24} the pigs were divided to two groups – I with $pH_{24} \leq 5.5$ and II with $pH_{24} > 5.5$ values. The meat colour was evaluated at 48 h using a chromameter Minolta CR310 (in CIE L*a*b* system). The drip loss was determined according to Prange et al. [10] method. Intramuscular fat, protein, ash and water content were determined according to Polish Standards. Glucose and lactate was determined in muscle juice using enzymatic method on the Accutrend Plus apparatus Roche Mannheim Germany.

Meat was grilled in 180ºC and 220ºC (to a temperature of 72 ºC in geometric centre of sample). Just after heat treatment meat colour in CIE L*a*b system was evaluated.

In the grilled meat the antioxidant activity to stable radicals (DPPH) was measured according to [11] using spectrophotometer Evolution 600 Thermo Scientific. The calibration curve was made using Trolox as an antioxidant and the all results were calculate in mg Trolox/100 cm^3 methanolic extract of the sample.

The sensory quality of pork after grilling was evaluated using Quantitative Descriptive Method (QDA). Sensory eating quality was based on 5 odour attributes: meat, acid, burnt, fatty and other, colour attribute (tone of colour), 3 texture attributes: fibrosity, tenderness and juiciness, 6 flavour attributes: meat, acid, burnt, fatty, other and salty taste and overall quality of grilled pork. The conventional unit scale (0-10 convenience units [c.u.]) was used. The results were alaborated by using Statistica 10.0 ver. Both group were compared using t-Student test. The simple correlation between antioxidant activity of grilled meat and other traits was also calculated.

III. RESULTS AND DISCUSSION

The groups were significantly different at ultimate pH, protein and ash content, glucose and lactate in the *Longissimus* muscle tissue (Table 1). The significant differences were also observed in L* and b* colour parameters. The first group were characterized by meat with lower pH_{24} and $pH_{48,}$ higher glucose (174 mg/dL versus 88 mg/dL) and also lactic acid level. Meat from these groups appeared as paler and more yellow. After grilling significant differences in an antioxidant activity (to stable radical DPPH calculated in mg Trolox/100 cm^3 methanolic extracts) was obtained only in 220°C temperature (Table 1). Meat with lower ultimate pH and higher glucose level had higher Trolox activity. The results showed also that raw meat from carriers with higher level of glucose characterized by significant higher content of protein and ash.

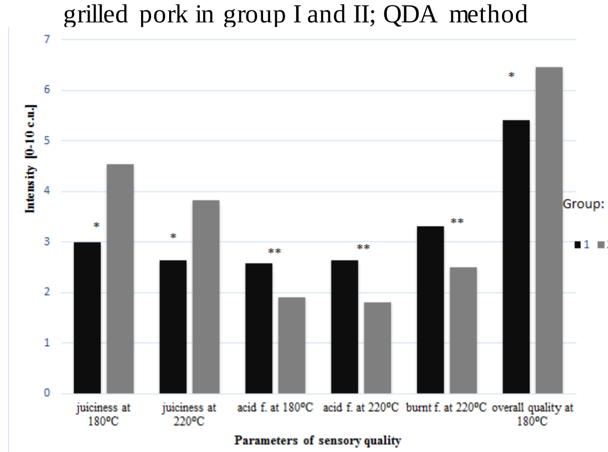
Table 1 Characteristics of raw meat quality and colour of meat after grilling in group I and II

Group	I	II
Number of animals	12	12
pH_{24}	5.45A ± 0.03	5.84B ± 0.19
pH_{48}	5.36A ± 0.03	5.70B ± 0.20
protein [%]	23.9a ± 0.3	23.3b ± 0.9
fat [%]	2.15 ± 0.90	2.46 ± 0.86
water [%]	74.2 ± 0.73	74.3 ± 1.5
ash [%]	1.16a ± 0.04	1.12b ± 0.04
glucose [mg/dL]	174A ± 62	88.3B ± 29.8
lactic acid [mmol/L]	107A ± 8	88.5B ± 15.6
colour at 48 h L*	55.4A ± 2.4	50.3B ± 3.0
a*	7.81 ± 1.46	7.18 ± 1.65
b*	4.59A ± 0.86	3.29B ± 1.16
drip loss [%]	5.66 ± 1.67	4.33 ± 1.75
Trolox [mg]/180°C	0.096 ± 0.023	0.080 ± 0.019
Trolox [mg]/220°C	0.140a ± 0.048	0.102b ± 0.032
colour L* at 180°C	46.4 ± 2.8	48.7 ± 4.2
at 220°C	37.4A ± 4.4	42.8B ± 5.2
colour a* at 180°C	14.4A ± 1.2	12.3B ± 1.9
at 220°C	15.1 ± 1.1	14.5 ± 1.2
colour b* at 180°C	26.8 ± 1.2	26.1 ± 3.0
at 220°C	21.1A ± 3.0	25.4B ± 2.8

The tables shows arithmetic means ± standard deviation. A,B – means P≤0,01; a,b – means P≤0.05.

Meat with higher level of glucose (group I) characterized lower brightness of meat colour (L*) and b* parameter at 220 ºC (meat was darker and less yellow) and higher a* parameter in 180 ºC (meat was more red than in group II).

Figure. 1. Comparision of choosen attributes of grilled pork in group I and II; QDA method



Explanations: f.–flavour. Significant of differences: ** – means P≤0,01; * – means P≤0.05.

The significant differences in sensory quality of samples grilled in 180ºC there are shown on Figure 1. Meat with higher level of glucose characterized higher intensity of acid flavour, lower juiciness and overall quality. Samples grilled in 220 ºC (Fig. 1) had significantly lower juiciness and higher intensity of acid and burnt flavour. The correlations between an antioxidant activity to stable radical DPPH in meat grilled in 180 and 220ºC calculated in mg Trolox's with all other analyzed traits are presented in Table 2.

Table 2. Correlations between raw meat quality and sensory quality of meat after grilling and Trolox in 180 °C and 220 °C

	Trolox [mg]	
Temperature of grilling	180 °C	220 °C
pH_{24}	***-0,59***	***-0,56***
pH_{48}	***-0,58***	***-0,56***
protein [%]	0,38	0,30
fat [%]	-0,09	-0,10
water [%]	***-0,47***	***-0,51***
ash [%]	***0,44***	***0,46***
glucose [mg/dL]	***0,87***	***0,89***
lactic acid [mmol/L]	***0,59***	***0,51***
colour at 48 h L*	0,22	0,22
a*	***0,68***	***0,76***
b*	***0,43***	***0,51***
drip loss [%]	0,30	0,28
meat odour intensity	-0,09	-0,08
acid odour intensity	-0,41	***-0,73***
fatty odour intensity	-0,23	***-0,74***
burnt odour intensity	***0,58***	0,37
other odour intensity	***0,63***	0,15
tone of colour	***0,46***	***0,52***
juiciness	-0,07	-0,38
tenderness	0,01	-0,02
fibrosity	-0,37	-0,09
meat flavour intensity	-0,06	0,22
acid flavour intensity	0,10	***0,54***
salty taste	-0,25	-0,09
burnt flavour intensity	***0,51***	***0,51***
fatty flavour intensity	***-0,42***	***-0,74***
other flavour intensity	***0,52***	-0,01
overall quality	-0,06	-0,04
colour of grilled meat L*	-0,30	0,04
a*	***0,50***	-0,11
b*	0,07	-0,34

Correlations in Table 2 signed as italic are significant with $P \leq 0,05$.

The highest and positive correlation were obtained between glucose content and an antioxidant activity of meat grilled in 180 and 220ºC (r=0,87 and r=0,89 respectively). In higher temperature samples showed higher antioxidant activity. Significant relationship were also obtained between antioxidant activity of meat grilled and ultimate pH, water and ash content, lactate, colour parameters (a*, b*) and many sensory quality traits (Table 2). The correlation coefficient showed that more substances with antioxidant properties could be formed during heat treatment in meat with low pH and water content and also in meat that appeared as more red and yellow. The formations of Maillard reaction products in 180ºC is also related to burnt and other odour and flavour intensity. The grilling of meat in 220ºC causes an increase of burnt flavour intensity and decreases acid odour intensity and also fatty flavour and odour intensity (Table 2).

The obtained results are in agreement with results obtained by Namysław et al. [12], Young et al. [1] and Meadus and MacInnis [13]. The authors showed that meat with lower ultimate pH is characterized by higher level of glycogen, glucose and lactate. Polak et al. [9] showed also higher level of glucose in PSE meat during ageing to 10 day. Namysław et al. [12] showed significant associations between residual glycogen, glucose and attributes of the sensory quality of grilled pork, especially browning level. According to Manzocco et al. [6] during Maillard reaction the formations of brown melanoidins with high antioxidant capacity was observed. Manzocco et al. [6] stated that one of the indicators of antioxidant properties may be the existence of relationship with colour of the products. Although in its early stages Maillard reactions leads to the formation of well-known Amadori and Heyn's products. The antioxidant properties of Maillard reactions products have been reported to be strongly affected by the physic-chemical properties of the system and by the processing conditions. The factors that influenced on formations of MRPs in model systems were as heating time, initial pH, sugar-amino acid combination, molecular weight of MRPs fractions and reactants ratio [6]. In many tested models, during heating glucose with amino acids the linear correlations between antioxidant activity and colour ranged 0.88 to 0.99. It can be also observed that browning with stronger antioxidant properties in food of plant origin occurs mainly during the first minutes of roasting [6]. Serpen et al. [8] showed that in beef, chicken and pork the antioxidant activity of meat increased during the first five minutes of heat treatment at 180 degrees. The our study show also significant effect of pH/glucose level and temperature of grilling on formation of antioxidant activity of meat. The temperature of heat treatment and glucose level influenced on sensory quality of grilled pork. In the presented study meat with lower pH and higher level of glucose grilled in 220°C was characterized by higher burnt flavour (Fig. 1). Also Meinert et al. [13] observed effect of frying temperature (150 versus 250°C) on increasing of the sensory fried and burnt attributes. Meinert et al. [4, 14, 13] has shown also that glucose appeared to be important flavour precursors in pork. They showed that meat with higher level of glucose had more intensive fried flavour than meat with naturally lower glucose content [13].

IV. CONCLUSION

These results have shown that meat with lower ultimate pH was characterized by higher level of glucose and lactate, higher protein and ash content. This meat after grilling (especially at temperature 220°C) had significantly higher antioxidant activity, and it's darker and less yellow with more intensive burnt flavour. Other sensory attributes like juiciness and overall quality of these meat were reduced. The study showed also significant relationship between antioxidant properties of grilled meat and glucose (r=0.87-0.89), technological and sensory meat quality traits.

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