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A SCREENING OF SELECTED PIG MEAT COMPONENTS AND SOME PRECURSORS OF HETEROCYCLIC AMINES AS RELATED TO FEEDING REGIME, RN GENOTYPE AND SEX

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Background

The wholesomeness of the meat we consume is a very important issue. Environmental as well as genetic factors are crucial in determining the final concentrations of various chemical components influencing the overall quality of the meat. When altering the production systems of slaughter pigs we must be able to predict the consequences on the nutritional quality and safety of the meat.

A safety aspect of meat was introduced some 20 years ago when Japanese scientists discovered a new group of highly mutagenic compounds, the heterocyclic amines, HAs, in the crust of cooked meat and fish. It is today established that cooked pork can exhibit a ten- to 100-fold variation of the concentration of HA in the same dish due to different cooking conditions. To what extent differences in levels of HA-precursors in raw meat contributes to variation of HA concentration in cooked meat remains to be studied. It is therefore of great interest to screen the variation of the chemical components that serve as precursors of HA in the meat from an animal material where important environmental and genetic factors have been surveyed.

Objectives

A large animal material, well defined in terms of RN genotype, sex and feeding regime (conventional or ecological feed), was subject to screening of some technological meat quality traits, chemical components and precursors of heterocyclic amines. The results of the technological and chemical analyses were related to RN genotype, sex and feeding regime in order to investigate the effect of these factors on the overall meat quality. The concentration of glycogen, glucose + glucose-6-phosphate and creatine was determined in their role as precursors in the formation of heterocyclic amines.

Methods

The animal material consisted of 344 Hampshire cross breeds, divided into four experimental groups, fed either conventional slaughter pig feed or feed composed after ecological principles (e.g. no addition of synthetic amino acids), with or without the addition of roughage, aiming to study the effects of ecological feed on production traits. The pigs were all reared indoors in conventional slaughter pig pens.

From this material 99 animals were chosen for further analysis of meat quality. By means of a quick method to measure glucose levels in meat juice using a device developed for checking blood glucose levels in humans (Glukometer Elite™, Bayer Diagnostics) the RN genotype could be roughly predicted already in the slaughter house. It was therefore possible to collect a well balanced material that represented each experimental group, both sexes (castrates and gilts) and carriers and non-carriers of the RN^- allele at an early stage. Assessment of technological meat quality was performed in *M Longissimus dorsi* (LD). Ultimate pH (pH_u), internal reflectance (FOP), marbling score, water-holding capacity (as drip loss after four days) as well as crude protein and intramuscular fat (IMF) content, dry matter and ash content were analysed according to Enfält *et al.* (1997b). The RN genotype was determined both by means of meat juice (concentration of glucose + glucose-6-phosphate (G-6-P)) from LD as described by Lundström and Enfält (1996) and as extracted from muscle tissue (concentration of glycogen and glucose + G-6-P) (Fernandez *et al.*, 1992). Creatine was extracted from the meat and thereafter quantified by a spectrophotometric method as described by Arvidson *el al.* (1998). All analyses were carried out in duplicates.

Data were analysed using Minitab (Minitab Statistical Software, Release 12). The model comprised the fixed factors; feeding regime (as no effect of the addition of roughage could be observed the original four experimental groups were pooled to two, conventional or ecological feeding), RN genotype and sex. Two way interactions were included when significant ($p< 0.05$).

Results and Discussion

Chemical and technological meat quality traits

The correlation between the glucose levels in the meat juice, measured with the Glukometer Elite™ and the glucose + G-6-P concentration in the muscle tissue was 0.53 (p-value 0.001). In the samples where enough meat juice to carry out the measurement was obtained, 85% were classified as the correct RN genotype already in the slaughterhouse.

In this study the RN genotype has greatly affected many of the technological properties of the pig meat. Carriers of the RN^- allele produced meat with significantly lower ultimate pH and dry matter content but with a higher drip loss and ash content than did the non-carriers (Table 1). These effects have been observed in other Swedish studies (Enfält *et al.*, 1997a, Lundström *et al.*, 1998). Regarding the internal reflectance and crude protein content of the meat, a significant interaction between the factors RN genotype and sex occurred which is accounted for in Table 2. Feeding the pigs according to ecological standards has led to a significantly

higher intramuscular fat content (Table 1). The study also showed that castrates produced meat with a higher content of intramuscular fat than did the gilts, 2.3 vs. 2.0 % (p = 0.019).

Precursors of heterocyclic amines

The level of creatine in the meat samples (n=54) that were analysed ranged from 4.2 mg/g meat to 6.4 mg/g meat (fresh weight). The level of creatine in the meat has been affected by an interaction between the factors RN genotype and sex (Table 2). The large variation in glycogen and glucose + G-6-P concentrations due to whether the pigs were carriers or non-carriers of the RN allele, 20 vs. 64 μmol/g, will be an interesting feature when relating it to HA concentrations in the cooked meat. Analysis of the content of free amino acids and ribose are in progress. All these precursors will be related to the concentrations of HA formed in the same meat after frying.

Conclusions

In this study the RN genotype has by far been the most important factor in determining the nutritional quality of the meat. Many technological traits together with relevant nutritional components as water content and crude protein levels are affected by the RN gentype. In addition, both the measured precursors of heterocyclic amines are affected by the RN genotype, this presumably leading to a variation of the HA concentration in the fried end product. The type of feeding (ecological or conventional) and the sex of the animals have solely affected the intramuscular fat content in the meat.

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Table 1. *Technological properties as a result of feeding regime and RN genotype, least-squares means ± standard error*

		Feeding regime			Genotype		
Variable	*n*	Ecological	Conventional	p-value	rn+/rn+	RN-/-	p-value
pH_u	94	5.48 ± 0.01	5.47 ± 0.01	0.548	5.54 ± 0.01	5.42 ± 0.01	0.001
Marbling score [1]	99	1.55 ± 0.01	1.4 ± 0.01	0.271	1.49± 0.01	1.45 ± 0.01	0.817
Drip loss, %	99	8.42 ± 0.3	8.05 ± 0.3	0.404	6.87 ± 0.3	9.6 ± 0.3	0.001
Dry matter, %	61	25.1 ± 0.16	24.9 ± 0.13	0.221	25.4 ± 0.14	24.6 ± 0.15	0.001
Ash, %	61	1.1 ± 0.01	1.1 ± 0.01	0.370	1.1 ± 0.01	1.2 ± 0.01	0.001
Intramuscular fat, %	99	2.4 ± 0.1	1.9 ± 0.1	0.001	2.2 ± 0.1	2.01± 0.1	0.737
Glycogen and glucose + G-6-P μmol/g	99	43.2 ± 1.4	40.5 ± 1.5	0.182	19.7 ± 1.5	63.9 ± 1.4	0.001

1) Scale 1-5, 1=low; 5=high marbling.

Table 2. *Illustration of the interactions between sex and RN genotype regarding the variables, crude protein, internal reflectance and creatine, least-squares means*

		Castrates		Gilts	
Variable	*n*	rn+/rn+	RN-/-	rn+/rn+	RN-/-
Internal reflectance FOP	99	36.2^{a}	35.1^{ab}	32.4^{b}	35.3^{ab}
Crude protein, %	98	22.7^{a}	22.0^{b}	23.3^{a}	21.6^{b}
Creatine, mg/g	54	5.2^{a}	6.0^{b}	5.5^{ab}	5.6^{ab}

Means within a row lacking a common superscript letter differ (p < 0.05)