DETERMINATION OF HOLES AND CRACKS IN MEAT WITH IMAGE ANALYSIS

– on slices of tumbled and non-tumbled cured-smoked loins from carriers and non-carriers of the RN⁻ allele

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Background

Cross-sections of processed pig meat often shows holes and cracks, clearly visible to the eye. This is unappealing for the consumers and thus negative for the processing industry. The reason for the holes are not understood yet, but the degree of holes are probably affected by both genetic and environmental factors. A major gene influencing pig meat quality, known as the RN^- gene and only present in pigs of the Hampshire breed or crosses with Hampshire, gives rise to weaker meat structure (Estrade et al., 1993; Monin, 1995). Therefore, it could be expected that processed meat from carriers of the RN^- gene show more holes and cracks at slicing (Eber & Müller, 1999).

The processing method influences the structure of meat as well. When curing meat products, tumbling is often included in the process. Tumbling is known to affect proteins in the meat and distributes the injected salt more evenly, which increases the water-holding capacity of the product. As tumbling give rise to alterations in cell structure of meat (Cassidy et al., 1978) it is possible that holes and pores in the meat are influenced by this processing step. However, the effects of tumbling on the degree of holes in meat have not been frequently studied (Müller, 1991; Brauer, 1992) and no quantitative method is available to evaluate the number of holes present.

Objectives

The aim of this investigation was to study the effects of RN genotype and tumbling on the degree of holes and cracks in processed pig meat with the tool of image analysis. Evaluation of holes manually appears to be infeasible, especially in case of large number of holes. As the use of image analysis for this purpose is new, the results are compared with the results of a trained sensory panel and a visual scoring of images.

Methods

The study comprises two separate trials, T1 and T2. T1 and T2 included material from 30 and 32 randomly selected crossbred female pigs [Hampshire x (Swedish Landrace x Swedish Yorkshire)], respectively, raised commercially and slaughtered at an average live weight of 115 kg. The *M. longissimus dorsi* (LD) from the right half of the carcass in T1 and from both sides in T2 were selected 24 h post mortem. In T1, the loins were processed at a commercial processing plant together with a commercial batch, whereas for T2 an experimental processing plant was used. Loins were cured by multi-needle injection with brine containing 16% NaCl to a quantity of approximately 16% of green weight. Loins in T1 were tumbled in a commercial tumbler before being smoked and heated to an internal temperature of 67°C. In T2, loins from the right side of the carcasses were tumbled for 4 hours, whereas left side loins were held in plastic trays during the time the other loins were tumbled. T2 loins were then smoked and heated to an internal temperature of 68°C. All pigs were genotyped (rn^+rn^+ or RN^-rn^+) according to Milan et al. (2000).

Cross-sections of cured-smoked loins were photographed with a digital camera (Olympus C-1400L, Olympus Optical Co, Tokyo, Japan) and examined with image analysis (Ballerini & Hullberg, 2002). Images were 1344 x 1024 pixel matrices with a resolution of 0.13 x 0.13 mm (Figure 1). The holes to be analysed were dark on a lighter background (Figure 2). The objects were segmented from the background by thresholding the images with histogram analysis techniques (Gonzalez & Woods, 1992). A size constrained labelling procedure was then applied to remove very small objects, which were probably noise and not holes. An area of 10 pixels (0.17 mm^2) was used as a minimum hole size. The number, size distribution, and spatial distributions of the extracted holes were measured (Figure 3).

A descriptive test was carried out by a selected and trained sensory panel (Hullberg et al. 2002). The samples were judged for degree of pores on a continuous scale from one to hundred with higher values indicating higher amount of holes.

The images used for the image analysis in T1 were also scored subjectively for visible degree of pores and holes. Six assessors judged each image visually twice according to the degree of holes and cracks on a scale from 1 (low intensity) to 5 (high intensity).

Data was statistically analysed using the procedure MIXED (SAS, version 6.12). The models used included the fixed effects of RN genotype (T1 and T2) and tumbling (T2) and when appropriate the random effect of assessors. Correlations between methods were calculated on mean values.

Results and discussion

In T1, cured-smoked loins from carriers of the RN^- gene (RN^-rn^+) had more holes and cracks than loins from non-carriers (rn^+rn^+), even if the difference was significant only for the subjectively scored images (Table 1). The results are in agreement with the results of Eber and Müller (1999), where processed meat from RN^- carriers were judged to have a greater amount of pores than meat from non-carriers. There was no difference in mean area per hole between RN genotypes, which means that the holes were of the same size in both RN genotypes. The results for T2 are in agreement with T1 regarding RN genotype.

Tumbling decreased the total number and total area of holes noticeable irrespective of RN genotype (Table 2). Tumbled loins without the RN^- allele had on average only half the amount of holes compared with tumbled loins with the RN^- allele. Non-tumbled loins had smaller mean area of holes than tumbled loins (34.6 and 47.2 pixel, respectively; p=0.001). The sensory scores are in agreement with the image analysis results.

There were high positive correlations between the different methods of determining the degree of holes. The highest correlation was found between total amount of holes measured by image analysis and the subjective scoring performed in T1 (r=0.90; p=0.001). The correlation between total amount of holes measured by image analysis and sensory scores was r=0.80 for both trials (p=0.001).

Conclusions

Cured-smoked loins carrying the RN^- gene had a greater number of holes compared to non-carriers. The size of holes was equal for both genotypes. Tumbling clearly decreased the number of holes and holes were bigger in size after tumbling. The high correlations between the three methods for determination of holes indicate that image analysis is a good tool in this type of investigations.

Pertinent literature

Ballerini, L. and Hullberg, A. (2002) *Swedish Symposium on Image Analysis SSAB'02*, Lund.
Brauer, H. (1992) *Fleischwirtschaft* **72**, 164-166.

Cassidy, R. D., Ockerman, H. W., Krol, B. et al. (1978) *Journal of Food Science* **43**, 1514-1518.
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Table 1. The degree of holes measured by image analysis, subjectively on images, and with a trained sensory panel on slices of cured-smoked loins of different RN genotypes in trial 1 – least-squares means and standard error (SEM). Areas are in the unit pixel

	rn^+rn^+ n=15	RN^-rn^+ n=15	SEM	*p*-value
Total no of holes	62.7	74.0	7.1	0.265
Total area of holes	3326	4072	366	0.161
Mean area of holes	53.7	56.5	3.5	0.579
Subjective image score	2.4	3.4	0.3	**0.013**
Sensory panel score	44.4	51.1	3.1	0.189

Table 2. The degree of holes measured by image analysis and with a trained sensory panel on slices of tumbled and non-tumbled cured-smoked loins of different RN genotypes in trial 2 – least-squares means and pooled standard error (SEM). Areas are in the unit pixel

	rn^+rn^+		RN^-rn^+		SEM	*p*-value
	non-tumbled n=18	tumbled n=16	non-tumbled n=15	tumbled n=15		
Total no of holes	54.9^{c}	15.7^{a}	60.0^{c}	33.7^{b}	3.3	**0.015**
Total area of holes	2037^{c}	840^{a}	2022^{c}	1510^{b}	178	**0.011**
Mean area of holes	36.2	49.7	33.1	44.7	3.1	0.738
Sensory panel score	52.8	24.0	55.9	30.9	2.5	0.056

[a] Means with different letters in rows indicate significant differences ($p<0.05$) between experimental groups.

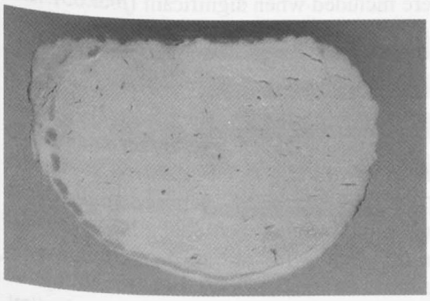

Figure 1. Digital camera image of cured-smoked loin from a representative pig sample.

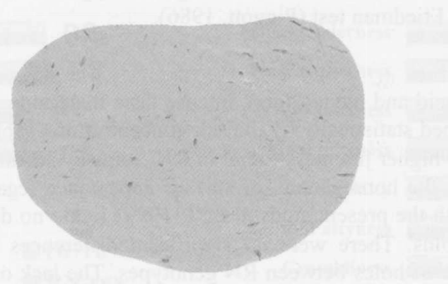

Figure 2. Image of loin with selected region of interest and corrected background.

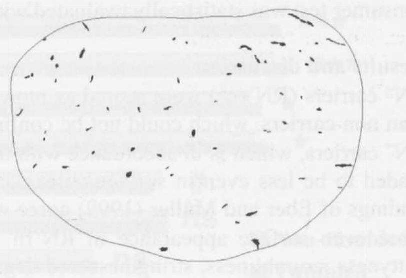

Figure 3. Holes extracted from the slice of loin in Figure 1.

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Table 2. The degree of holes measured by image analysis and with a trained sensory panel on slices of tumbled and non-tumbled cured-smoked loins of different RN genotypes in trial 2 – least-squares means and pooled standard error (SEM). Areas are in the unit pixel

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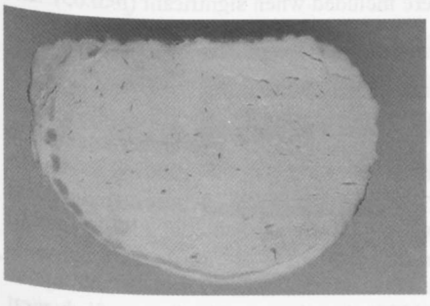

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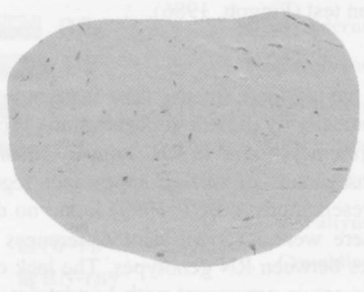

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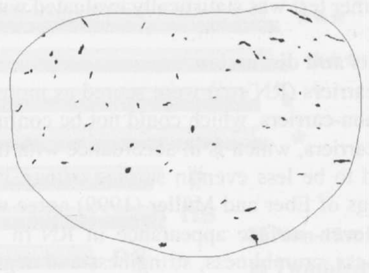

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