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The gender background of texture attributes of pork loin

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ABSTRACT

The tenderness of pork loins from castrates, entire males and females was quantified with sensory analysis and measurement of instrumental texture during ageing. Furthermore, the effects of intramuscular fat (IMF), collagen content and solubility, hot carcass weights and meat percentages on tenderness were examined. Meat from castrates was significantly ($p = 0.043$) more tender than meat from entire males and females as assessed by trained sensory panellists. Tenderness scores were positively affected by IMF content ($p = 0.008$) and hot carcass weight ($p < 0.001$), but no effect of collagen content and solubility was found. Meat from all three genders had the same tenderisation rate during ageing (two, five, seven and ten days). It is therefore suggested that meat from entire males and females should be aged for longer than meat from castrates to obtain the same level of tenderness.

1. Introduction

Animal welfare concerns regarding the surgical castration of male piglets have led several European countries and organisations to sign a voluntary declaration (European Commission, 2016) aimed at banning castration without anaesthesia by 1st January 2018. One of the primary reasons for castration is the risk of development of boar taint in the meat, although research shows that differences in tenderness between entire males and castrates also have a large impact on the consumers' perception of the eating quality (Aaslyng et al., 2007; Aaslyng, Broge, Brockhoff, & Christensen, 2016). This suggests that tenderness is important for the consumers and may be independent of boar taint. Studies have reported differences in tenderness between all three genders, with meat from entire males being less tender than meat from castrates, and meat from females being either in between, similar to or less tender than meat from entire males (Aaslyng et al., 2016; Jeremiah et al., 1999; Pauly et al., 2010). However, the background for the differences in meat tenderness between genders has not been investigated.

Meat tenderness depends on several factors. Protein degradation post mortem increases the tenderness over time, and factors such as intramuscular fat (IMF) content and connective tissue affect the tenderness of the meat. The IMF content has a positive effect on tenderness (Aaslyng & Støier, 2004; Crawford et al., 2010; Font-i-Furnols, Tous, Esteve-Garcia, & Gispert, 2012; Van Laack, Stevens, & Stalder, 2001; Wood, 1993). Meat from entire males has been reported to have lower contents of IMF compared with meat from both castrates and females (Channon, Kerr, & Walker, 2004; Gispert et al., 2010), and this might explain part of the observed differences in tenderness between genders. Intramuscular connective tissue is said to be responsible for the background toughness (Hopkins, Allingham, Colgrave, & Van De Ven, 2013). However, the content and quality have not been examined for entire males compared with castrates and females. Differences in growth rates between the genders (Elsbernd, Stalder, Karriker, & Patience, 2015) might influence the post mortem tenderisation because of upregulated levels of proteolytic enzymes which in turn increase the protein turnover (Kristensen et al., 2002). However, differences in post mortem tenderisation rate between all three genders have not been examined previously.

The aim of the study was to explain the differences in tenderness between pork loins from entire males, castrates and females by investigating variations in IMF content and intramuscular connective tissue content and solubility as well as the effect of ageing. We hypothesize that lower tenderness in entire males was mainly due to a lower content of intramuscular fat and to a lesser extend to differences in connective tissue, and that further ageing of the meat would counteract the differences in tenderness.

2. Materials and methods

The study consists of three parts: a sensory analysis, chemical analyses and an ageing experiment in which instrumental texture is measured. Seventy-three pigs (25 entire males, 25 castrates and 23 females)

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were collected at a commercial slaughterhouse on seven slaughter days between December 2014 (one day) and March 2015 (six days). On each day, meat from at least two genders and for five of the slaughter days meat from all three genders was selected. Of these, five pigs of each gender were chosen randomly for the ageing experiment divided on three slaughter days with at least two genders per day. The entire males were collected on the basis of the skatole concentration in the backfat (Mortensen & Sørensen, 1984). To achieve an even distribution of skatole concentrations, carcasses with skatole below 0.25 μg/g, between 0.25 and 0.35 μg/g and above 0.35 μg/g were chosen. The exact skatole concentration was used in the following data analysis. The meat from the castrates and female pigs was collected on the same dates as the meat from the entire males. The slaughterhouse provided hot carcass weights and meat percentages, which were determined according to methods for grading pigs in Denmark (European Commission, 2012). Loins (*M. longissimus dorsi thoracis et lumborum*) excised from the left side were used for the chemical and sensory analyses and were aged at 4 °C for two days. The right loins were used for the ageing experiment and were divided into four parts per loin, which were aged at 4 °C for two, five, seven or ten days. The meat was vacuum-packaged, aged, frozen at − 18 °C and kept at − 40 °C until use.

2.1. Chemical analysis

The content and quality of connective tissue as expressed by total and heat-soluble collagen were determined using the method described in Kristensen et al. (2002) with few modifications. The meat was thawed in a refrigerator overnight and was then chopped. The chopped meat (6.0 g) was mixed with 20 ml saline water and was placed in a water bath at 90 °C for 2 h. Samples were homogenised immediately afterwards for 1 min with an Ultra Turrax T25 (Ika Labortechnik, Staufen, Germany) at 9500 rpm, and the dispersing element was flushed with 10 ml saline water and the flushing water was added to the samples. The rest of the method was not modified.

The IMF content of lean meat was determined by gravimetric analysis modified after SBR (Schmid-Bodzinski-Ratzlaff) according to ISO 1443 (1973). The method is modified to be run on HydrotecTM 8000 hydrolysis system og SoxtecTM 8000 extraction system as described in the Application Note 3981 (2013) (FOSS, Denmark). The samples were treated with 8 M hydrogen chloride, dried and, the liberated fat was extracted with petroleum ether. The solvent was then evaporated and the fat weighed. The contents are reported as g IMF/100 g of meat.

The protein content was determined using the Kjeldahl method (mod. a. AOAC, 1983) (Kjeltec 1035/1038, Foss Analytical A/S Denmark). The samples were degraded with concentrated sulphuric acid and a catalyst mixture at 410 °C. The addition of sodium hydroxide liberated the ammonia, which was distilled into a receiver containing boric acid indicator. The absorbing solution was titrated with 0.1 M hydrochloric acid. Based on the total N-content, crude protein was calculated using the factor 6,25. The contents are reported as g protein/100 g of meat.

2.2. Sensory analysis

The loins were allocated to five sessions (one session per day), with loins from an equal number of entire males, castrates and females for each session. The loins were thawed overnight in a refrigerator at 4 °C and were then cut into five 2-cm thick chops. These chops were kept refrigerated up to 3 h until 30 min before use, at which point they were placed at room temperature. The chops were fried on a pan (PanoCopter, Friberg, Vara, Sweden) with a thin layer of sunflower oil (Coop, Denmark) at 170 °C until a core temperature of 70 °C was reached. The temperatures were measured using a thermometer with a handheld probe (Testo 926, Testoterm, Buhl and Bundsoe, Virum, Denmark). The chops were turned every 2 min. After frying, the chops were cut into 2.5 cm × 4 cm pieces and served immediately on heated plates to the sensory panel.

The sensory panel consisted of nine trained assessors: seven females and two males, all experienced in assessing pork. All assessors had received general training according to ASTM_NML13 (1992), ISO 4121 (2003) and ISO 13299 (2003). Two training sessions were held prior to the experiment using reference samples for the boar taint compounds as described in Aaslyng et al. (2016) and reference loin chops from castrates and entire males, but not females. Each of the assessors evaluated chops from all 73 pigs except one assessor, who only evaluated chops from 60 pigs. Cucumber, honeydew melon and tap water were available for the panellists to cleanse their palates between samples. The assessors evaluated 21 attributes: seven each for odour, taste and texture on a 15 cm line scale with anchors placed 1.5 cm from each end. However, only the texture attributes (tenderness, hardness, juiciness, crunchy sound during chewing, fibrousness, crumbliness and chewing time) are included in this study due to its scope.

2.3. Ageing experiment

The loin parts from each of the 15 out of 73 pigs, chosen randomly for the experiment and aged for two, five, seven or ten days, were thawed overnight at 4 °C. The loin parts were trimmed and boiled in a water bath at 85 °C until an internal temperature of 72 °C was reached. The temperatures were measured with thermal sensors inserted into the meat. Immediately afterwards, the boiled loins were put in cold water to rapidly reach a temperature of 2–5 °C and were then refrigerated overnight wrapped in aluminium foil. The next day, the loins were cut with a scalpel into five 10 mm slices parallel to the orientation of the muscle fibres, and from each of these slices a 20 mm middle strip was cut. The five strips were wrapped in aluminium foil and refrigerated until the texture measurement was performed.

The maximum compression force was measured in Newton with Volodkevich bite jaws attached to a TA.HDi texture analyser (Stable Microsystems Ltd., Godalming, UK). The strips were compressed perpendicular to the muscle fibres until 80% penetration was achieved. Measurements were run with a pre-test speed of 1.00 mm/s, a test speed of 0.40 mm/s and a post-test speed of 10.00 mm/s. Data were recorded with the software program Texture Expert Exceed (Stable Microsystems Ltd., Godalming, UK).

2.4. Statistical analysis

All data were analysed in R (ver. 3.3.1, R Core Team, 2016) except for the principal component analysis (PCA), which was performed in Unscrambler X (ver. 10.4.1, CAMO Software A/S, 2016). R packages used were lmerTest (Kuznetsova, Brockhoff, & Christensen, 2014, 2017) and lme4 (Bates, Maechler, Bolker, & Walker, 2014a, 2014b).

To be able to account for possible differences between genders in meat percentage and hot carcass weight, these parameters were tested with a one-way analysis of variance with the following models:

$$\text{Meat percentage} = \mu + \text{gender} + \varepsilon$$

$$\text{Slaughter weight} = \mu + \text{gender} + \varepsilon$$

The sensory texture attributes were modelled as mixed effects linear models with gender as fixed effect and assessor and interaction between assessor and gender as random effects. To adjust for correlations between the sensory attributes and carcass and meat attributes, meat percentage, slaughter weight, IMF and protein content, were included as covariate factors in the model The following model was used:

$$\text{Attribute} = \mu + \text{gender} + \text{meat percentage} + \text{slaughter weight} + \text{IMF} + \text{protein} + \textit{assessor} + \textit{gender} \times \textit{assessor} + \varepsilon$$

To investigate the effect of skatole concentration in the back fat on tenderness the following model was used for the data from the entire males: