SENSORY AND INSTRUMENTAL ANALYSIS OF LONGITUDINAL AND TRANSVERSE TEXTURAL VARIATION IN PORK *LONGISSIMUS DORSI*

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Background

Longitudinal and transverse textural variation in pork *longissimus dorsi* has been widely reported (e.g. Onate and Carlin, 1963; Rust et al., 1972; Alsmeyer et al., 1965; Weir, 1953; Møller and Vestergaard, 1986). It is essential to understand this variation when measuring different aspects of meat quality such that what is measured is the actual difference between treatments and not differences within muscles.

Objectives

The objective of the present study was to investigate the texture variation in pork *musculus longissimus dorsi* (LD) through sensory and instrumental analysis. Specifically, the aims were to determine how the transverse and longitudinal texture varied within and between left and right muscles. A further objective was to determine the dynamic nature of texture variation occurring in and between left and right muscles of pigs and as a function of ageing. Overall, in the present case the predictive and causal association of these methodologies was considered paramount, such that confusion and misrepresentations as to what textural variation in pork meat means from a sensory perspective versus texture measurement from instrumental perspective.

Materials and methods

Twenty seven pigs were selected at random from an abattoir production line with regard to weight at slaughter (73-79 kg), lean meat percentage (58-62%), and ultimate pH (5.5-5.8). Both left and right *Longissimus dorsi* (LD) from the pigs, a total of 54 muscles, were excised. During excision subcutaneous fat and bones were removed. The LD muscles were divided into two halves at the 13th rib (cranial and caudal ends) and vacuum packed in oxygen impermeable bags. The muscles were aged for 0, 4, and 7 days respectively at 4˚C before they were frozen at -20°C.
Both the cranial and caudal ends of the loins were sliced into 20 mm thick chops from the 13th rib upwards and downwards (producing 9 chops in each direction). The pork chops were pan cooked in neutral oil (grape seed oil) at 155˚C for approximately 8 minutes until a core temperature of 65˚C was reached.
The transverse sample cores for the sensory descriptive texture profiling were excised by using a template (4×5 cm) and then divided into three equally sized pieces (approximately 17 mm wide, 20 mm thick, and 40 mm long). For instrumental analysis transverse sample cores were excised parallel to the muscle fibre orientation to the cut chop surface as recommended in AMSA (1995). The cores from each chop were denoted according to their position on the chop from inner to outer edge, a (nearest spinal column, dorsal), b (medial), and c (lateral).
The samples were measured using sensory descriptive texture profiling (ISO 11036, 1994; Meilgaard et al., 1999) and a Texture Analyser (Stabel Micro Systems, UK) mounted with a Volodkewich shear blade.
In the present study a special use of 'two block' Partial Least Squares Regression (PLSR) known as APLSR (the 'ANOVA like use of PLSR') was utilised. This form of PLSR projects the response variables onto the design variables in order to determine to which degree each of the design variables in **X** contribute to the variation in the response variables **Y** (Martens & Martens, 2001).
In relation to significance testing at the 5% level, i.e. $P \leq 0.05$, a re-sampling technique termed 'jack-knifing', which is part of cross-validation, was utilised. All multivariate analyses were performed using the Unscrambler Software, Version 8.0 (CAMO ASA, Norway).

Results and discussion

In the sensory determined transverse muscle variation a trend (non-significant) in decreasing tenderness from the dorsal position (nearest the spinal column) to the medial position was found. Instrumental analysis showed that hardness increased from the dorsal to the lateral position, both being significant. It should however be mentioned that the medial position could not be ascribed any significance level. The sensory and instrumental analysis agreed that the dorsal position was the most tender, but neither method was able to determine if the medial or the lateral position was the least tender of the three positions investigated (see Figure 1). The reason for the dorsal position being most tender can be attributed to the anatomic location. This position is supported by the spinal column, thus less work is performed in this muscle area.

Transverse variation was better described instrumentally than from a sensory perspective, in that significance levels could be ascribed. This was most likely because fibre orientation when assessed in sensory analysis was more inconsistent in its orientation when physically placed in the mouth by panellists.

In the sensory determined longitudinal muscle variation a significant decrease in tenderness was found from the anterior to the posterior part of the muscle. The reason for the cranial end being the most tender was most likely related to the anatomical location of the muscles. The cranial end is strongly supported by the ribcage and thus less work is performed in this muscle part. Instrumental analysis showed a trend (non-significant) in decreasing hardness when approaching the caudal end of the muscle.

Variation between individual chops was found when assessed by the sensory panel but not when measured instrumentally. Because the instrumental measurements lacked information about the longitudinal texture variation, specific examination of the texture was only carried out using data from the sensory analysis (see Figure 2).

When tenderness ratings were determined as a function of individual chops for each of the three ageing periods it appeared that the first 7 chops showed similarity in tenderness level for 0, 4, and 7 days respectively. A marked decrease in tenderness took place at the region near the end of the ribcage. Below the ribcage the tenderness was rated as being constant or tending to slightly increase. As tenderness decreased hardness was found to concurrently increase. The turn-over point in tenderness could be applied to a general textural turn-over point in that hardness and juiciness also showed marked changes in this specific region of the muscle. A markedly higher difference between individual chops was seen in the cranial versus the caudal end at 0 days of ageing. When the meat was aged, larger individual chop variation occurred in the caudal end. It seemed that the individual chop variation in the cranial end decreased, whereas the variation in the caudal end concurrently increased when the meat was aged.

Marked differences between left and right muscles were observed. Right muscles showed bigger internal variation throughout the loin, when compared to left muscles. Moreover, it appeared that the longitudinal variation was more distinct and interacting in the right loins compared to the left loins. Qualitatively left and right loins displayed the same trends but differed quantitatively in the levels of variation. A plausible explanation may be that the majority of the pigs in the present study were ‘right-footed’. If this was the case, right muscles would perform more work than left muscles which may explain why the right side muscles varied considerably more internally than the left side muscles.

Both sensory and instrumental analyses were able to differentiate significantly between 0, 4, and 7 days of ageing. As expected 0 days of ageing was positively correlated to hardness. Ageing for 4 and 7 days respectively resulted in equally tender meat. The sensory analysis revealed that 4 and 7 days of ageing were differentiated by the levels of crumbliness and cohesiveness, 7 days of ageing leading to more crumbly and less cohesive meat.

Sensory and instrumental data revealed significance differences between left and right muscles. The left muscles were found to be significantly more tender than the right muscles in both the sensory and instrumental analysis.

The textural variation lengthwise was better described when assessed by the panel compared to when measured instrumentally. Of considerable importance regarding this discrepancy the shear force apparatus only measured deformation in terms of force (Newton) used for compression of the sample, whereas the sensory profiling described what caused the differences in the longitudinal variation.

Sensory and instrumental measurements were found to be predictive indexes of each other (see Figure 1) however these methods did not measure the same textural properties in the muscles. This is due to the fact that texture testing instruments are calibrated to respond linearly to the intensity of the tested mechanical property, which does not apply in the human perception of texture (Szczesniak, 1987). According to Spadaro et al. (2002) linearity will only occur if the biological material is homogeneous.

Conclusions

A trend of decreasing tenderness from dorsal to medial transverse positions was found in sensory analysis. Instrumentally determined transverse variation was found to significantly decrease from dorsal to lateral position, though the medial position did not display significance. Overall, the dorsal position was the more tender of the three positions (dorsal, medial, and lateral).

It was clear that the cranial end was significantly more tender than the caudal end when evaluated from a sensory perspective. However, no significance could be applied to the instrumental measurements hereof.

The individual chops in the left and right sides generally showed a gradual change in tenderness from cranial to caudal end of loins. Significance was found for most sensory evaluated individual chops, which again could not be derived from the instrumental analysis. A marked change in texture was observed at the end of the rib cage. Instrumental analysis was found unable to predict lengthwise texture variation. Sensory analysis was found to consistently describe the longitudinal variation.

An effect of ageing on the transverse variation could not be assigned. A greater decrease in tenderness between individual chops was seen in the cranial than in the caudal end at 0 days of ageing. When the meat was aged more pronounced individual chop variation occurred in the caudal end. Ageing was found to be similar qualitatively in left and right LD

Transverse and longitudinal variation was found to be more distinct in right LD compared to left LD. Furthermore, the decrease in tenderness longitudinally, was markedly higher and more defined into stages in the right loins. The cranial ends were more similar in tenderness from both left and right side of the animals than the caudal ends.

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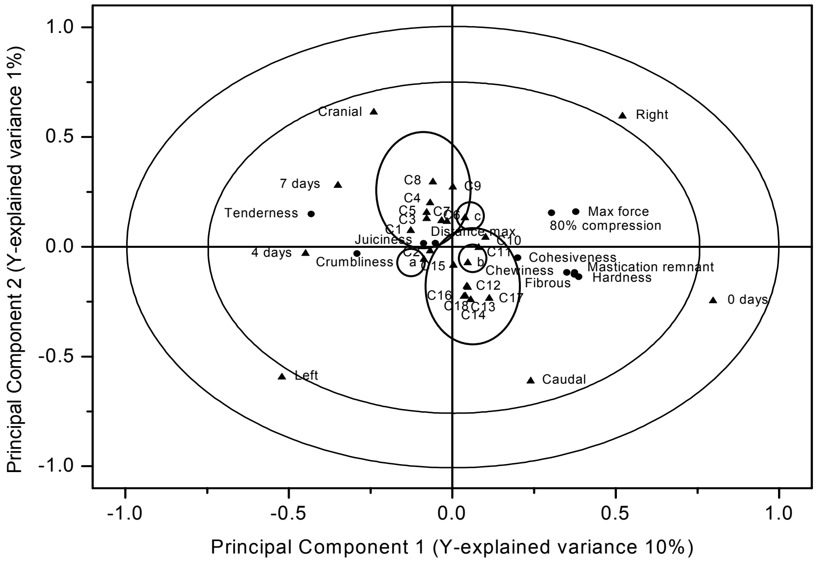

Figure 1. Instrumental and sensory predictive and causal analysis. ANOVA Partial Least Squares Regression (APLSR) correlation loading plot of the first two Principal Components (PCs). Total design (transverse positions and various chops, cranial/caudal, ageing, left/right) in the X-matrix and sensory and instrumental terms in the Y-matrix. Ellipses represent r^2=50 and 100%.

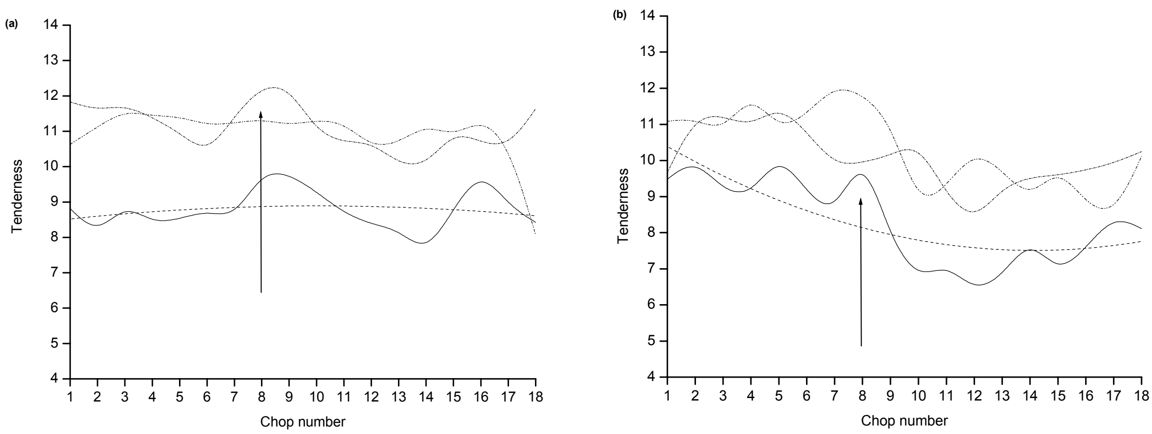

Figure 2. Longitudinal variation of tenderness in (a) left and (b) right loins within each ageing period. muscles respectively, at 0 The solid line represent 0 days of ageing. The dashed and dotted (–¨–) line represent 4 days of ageing. The dotted (¨) line represent 7 days of ageing. The dashed (---) lines represent the average of changes in left and right muscles respectively at 0 days of ageing. Data is averaged over transverse sample positions (a, b, and c) within each chop. Arrows indicate the change point at chop 8.