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Effect of visual marbling on sensory properties and quality traits of pork loin

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ABSTRACT

Pork loins ($N = 53$) were selected from a commercial packing plant to determine the influence of subjective marbling score on sensory attributes and eating quality properties. The pork loins were obtained from commercially raised hybrid barrows (average carcass weight = 67.7 kg), originating from nine cooperating herds, and fed similar diets throughout the finishing period. Carcass quality measurements, trained sensory panel analyses, fatty acid composition, thiobarbituric acid-reactive substance (TBARS) index, and cholesterol content were assessed and analyzed on the individual pork loins. With an increase in marbling level, there was a corresponding decrease in drip loss ($P = 0.049$) and observed increases in pH ($P = 0.001$), sensory tenderness ($P = 0.001$), and sensory juiciness scores ($P = 0.017$). The most notable results demonstrated that protein concentrations were reduced as marbling levels amplified ($P = 0.012$). The increase in marbling score was observed to be a significant source of variation in polyunsaturated fatty acid (PUFA) concentrations. Linoleic and arachidonic acids decreased in both raw and cooked samples as marbling score increased. The data demonstrated that visual marbling score does have an influence on sensory properties and pork quality.

1. Introduction

The degree of marbling is important for estimating the potential eating quality of pork loins. It is generally accepted that an increase in the amount of intramuscular fat (IMF) has a positive influence on the sensory qualities of pig meat (Bejerholm & Barton-Gade, 1986; Brewer, Zhu, & McKeith, 2001; DeVol et al., 1988; Ellis, Webb, Avery, & Brown, 1996; Fernandez, Monin, Talmant, Mourot, & Lebret, 1999; Poste-Flynn, Butler, & Fortin, 1994; Støier, Olsen, & Magnussen, 1998; Wood, 1990; Wood et al., 2004). More specifically, the lipid content of pork whole muscle cuts has been shown to influence the sensory traits of the pork lean texture, tenderness, flavor, and juiciness (Buchter & Zeuthen, 1971; Candek-Potokar, Zlender, Lefoucher, & Bonneau, 1998; Fjelkner-Modig & Persson, 1986; Lonergan et al., 2007). Previous studies indicate that the fatty acid composition of IMF found in pork lean is related to eating quality of pork. Cameron and Enser (1991) observed that saturated and monounsaturated fatty acids were positively correlated with pork flavor while polyunsaturated fatty acids (PUFA) were negatively correlated with pork flavor. It is possible for pork flavor to decline based upon breeding selection strategies that may substantially reduce IMF content in the lean (Cameron, Nute, Brown, Enser, & Wood, 1999).

While the possible effects of IMF on pork quality have been studied before, there is minimal literature available on the effect of IMF on both raw and cooked pork loin chops, particularly the changes in composition during cooking. Therefore, the objective of the current study was to investigate the relationships between National Pork Producers Council visual marbling score (NPPC, 1999) and sensory properties, mechanical tenderness, fatty acid content, oxidative stability, cholesterol content, and cooking effects of both raw and cooked pork loin chops.

2. Materials and methods

2.1. Sampling method

A total of 53 fresh, boneless pork loins (longissimus muscle, LM) were selected in a commercial packing plant (Columbus, Ohio, USA) and were evaluated by trained university personnel based on their visual marbling scores (NPPC, 1999) to obtain significant variability in IMF (less than 1.5% to greater than 4%) content for subsequent testing. The loins were obtained from commercially raised hybrid barrows (average carcass weight = 67.7 kg) of similar genetic background (terminal line sires mated to crossbred, white-line females). Pigs were fed similar corn-soy (16% crude protein,

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0.90 lysine) based diets in the late finishing stage and were obtained from a group of producers in nearly equal proportions.

After carcass selection and assignment of marbling scores, the loins were packed and transported under refrigerated conditions to the Ohio State University Meat Laboratory, where they were aged for 7 days post-mortem at 4 °C. After aging, three chops of 2.5-cm in thickness, consisting only of the LM, were fabricated between approximately the 9th and 12th rib locations.

2.2. Meat quality traits

Objective quality measurements were evaluated on one of the three chops for Minolta L^*, a^* and b^* values (CR-310, 50 mm diameter head, 10° standard observer, D65 light source; Minolta Company, Ramsey, New Jersey), ultimate pH (Glass-tipped Probe Model FC201D, Hanna Instruments, Italy), and drip loss (as a percentage of weight loss after 2 days of storage at 4 °C; Lundstrom & Malmfors, 1985). Following the objective quality assessment, the chops were cooked on a two-sided electric grill (GRP4P, Applica/Black and Decker®) with a surface temperature of 190 °C in preparation for slice shear force tenderness evaluation. The chops were cooked to an internal temperature of 71.5 ± 0.5 °C; temperature was monitored using needle-type probes (Omega, Connecticut, USA). Cook loss (as percentage of weight loss after cooking), was recorded for all chops. The slice shear force tenderness evaluation was conducted in accordance with the procedures outlined by Shackelford, Wheeler, and Koohmaraie (2004). Peak shear force was measured using a Texture Analyzer (TAX Texture Analyzer, Texture Technologies Corp., Scarsdale, NY), equipped with a slice shear force attachment. The crosshead speed was set at 500 mm/min (Shackelford et al., 2004). The remaining two chops were vacuum-packaged and transported under refrigerated conditions to the Colorado State University Meat Laboratory where they were used for trained sensory panel evaluation, thiobarbituric acid-reactive substances (TBARS), proximate analysis, fatty acid composition, and cholesterol content.

Chemical composition, fatty acid composition, TBARS and cholesterol content of LM samples were evaluated in both the raw and cooked state. The LM samples were cooked identical to the samples utilized for the slice shear force tenderness analysis. Samples were trimmed free from all external fat and connective tissue and homogenized (HC306 1–1/2 Cup Chopper, Black and Decker®, USA). Aliquots were removed from the homogenate and analyzed for dry matter, protein, lipid, and ash contents using standard methods. Moisture content was calculated by the loss of sample weight 48 h of freeze-drying minced samples. Crude fat was determined using Ankom^{xt15} Extractor Technology Method (AOCS Official Procedure AM 5-04, NY, USA) with petroleum ether as a solvent in the high temperature extraction. Homogenized pork loin samples were evaluated for crude protein using a TruSpec CN Carbon/Nitrogen Determinator (LECO Corporation, St. Joseph, MI, USA, 2004). Finally, the determination of sample ash content was conducted utilizing a muffle furnace at 600 °C.

2.3. Trained descriptive sensory panel

The individuals for the trained sensory panel evaluation were screened and trained using the guidelines and procedures of Meilgaard, Civille, and Carr (2007). Each panelist was pre-screened with a personal interview to establish his or her interest, availability, and health. Following pre-screening, scaling exercises were used to evaluate each participant's ability to detect variations in pork flavor intensity, while triangle tests were conducted to evaluate the panellists' ability to detect sour, sweet, salty, and bitter flavors. A descriptive panel compiled a list of identifiers for specific off-flavors. Upon the completion of screening, six judges were selected to participate in the current study. Each sensory panel sessions was designed such that no more than eight samples were evaluated in any given session. An eight-point scale was used to evaluate tenderness, juiciness, and flavor intensity (Table 1).

2.4. Sample preparation for sensory analysis

The remaining loin chops were trimmed free of external fat and connective tissue and cooked to a final internal temperature of 72 °C on a two-sided electric grill (GRP4P, Applica/Black and Decker®, USA). When the samples reached the desired internal temperature they were removed from the grill and weighed to determine the cook loss. Samples were placed in a plexiglass sample sizer (dimensions of 14 cm long × 12 cm wide × 4 cm deep) with slots spaced appropriately in order to allow the researchers to produce 1.25-cm × 1.25-cm × 2.5-cm samples for sensory analysis. The resulting sub-samples were served to the panellists on ceramic plates in a randomized order.

2.5. Fatty acid composition

LM lipid extracts were analyzed in duplicate for fatty acid composition. Lipids from homogenized muscle tissue were extracted by chloroform/methanol (2:1) according to Folch, Lees, and Stanley (1957). The extracted lipid fractions were initially methylated with $NaOCH_3$ which was followed with a solution of HCl/methanol as described by Kramer et al. (1997). Both methylation procedures were conducted at 50 °C for 20 min each. Fatty acid composition of the LM was determined by gas chromatography using a Hewlett Packard (Avondale, PA) Model 6890 series II gas chromatograph fixed with a series 7683 injector and flame ionization detector. The instrument was equipped with a 100-m × 0.25-mm (id) fused silica capillary column (SP-2560 Supelco Inc., Bellefonte, PA). Fatty acid methyl ester preparations were injected (1-μL) using a split ratio of 100:1 at 180 °C with helium as the carrier. The oven temperature was programmed to increase from an initial temperature of 140 °C to a final temperature of 225 °C at 2.8 °C/min and the final temperature was held for 18 min. Chromatograms were recorded with a computing integrator (Agilent Technologies, Palo Alto, CA). Standard fatty acid methyl ester mixtures were used to calibrate the gas chromatograph system using reference standards KEL-FIM-FAME-5 (Matreya Inc., PA).

Identification of the fatty acids was made by comparing the relative retention times of fatty acid methyl ester peaks from product samples to those of standards. These were calculated as normalized area percentages of fatty acids.

2.6. TBARS determination

2-Thiobarbituric acid-reactive substance (TBARS) content of the pork chop samples was determined through the TBA distillation procedure of Tarladgis, Watts, Younathan, and Dungan (1960) as modified by Rhee (1978). The TBARS values for each sample were

Table 1
Eight-point hedonic scales used for sensory evaluation.

Scale	Tenderness	Juiciness	Off-flavor intensity
8	Extremely tender	Extremely juicy	No off-flavor
7	Very tender	Very juicy	Trace off-flavor
6	Moderately tender	Moderately juicy	Slightly off-flavor
5	Slightly tender	Slightly juicy	Small off-flavor
4	Slightly tough	Slightly dry	Modest off-flavor
3	Moderately tough	Moderately dry	Moderately off-flavor
2	Very tough	Very dry	Very off-flavor
1	Extremely tough	Extremely dry	Extremely off-flavor