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Correlations of trained panel sensory values of cooked pork with fatty acid composition, muscle fiber type, and pork quality characteristics in Berkshire pigs

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ABSTRACT

The objective was to examine the relationship of trained panel sensory scores of cooked pork with fatty acid composition, muscle fiber type, and meat quality characteristics from Berkshire pigs. No or few associations were found between the panel sensory scores of cooked meat, especially tenderness attributes, and fatty acid composition; however, intramuscular fat content positively correlated with off-flavor score ($r=0.31$). On the other hand, the morphological characteristics of muscle fibers were correlated with panel sensory values. Muscles with smaller cross-sectional area and higher density of fibers were more closely associated with softer, more tender panel scores and a lower number of chews than muscles with larger fiber area and lower density of fibers. The water holding capacity test of filter-paper fluid uptake was moderately correlated with panel scores of softness ($r=0.33$), initial tenderness ($r=0.38$), chewiness ($r=0.40$), juiciness ($r=-0.27$), flavor intensity ($r=-0.23$), and off-flavor ($r=0.30$). Panel sensory values of Berkshire pig meat was moderately related to postmortem meat quality, especially water holding capacity. A more thorough understanding of the relationships between fatty acid composition and muscle fiber type with palatability is needed.

1. Introduction

Recently, meat quality has become a primary focus in the livestock industry, and better control of pork quality is of major importance for producers, packers, processors and retailers in order to satisfy the requirement of consumers for a consistently good product (Alonso, Campo, Espanol, Roncales, & Beltran, 2009; Picard, Lefaucheur, Berri, & Duclos, 2002). The value of meat is based on its degree of acceptability and the preferences of consumers; these criteria depend on unique individual sensory responses during meat consumption, including perceptions of tenderness, juiciness, and flavor. The major components of muscle and the postmortem meat quality state both contribute to the overall sensory quality of cooked pork, but they impact palatability in different ways.

Intramuscular fat (IMF) content and fatty acid composition are important factors that contribute to eating quality. These are influenced by both genetic and environmental factors, including genotype, gender, age, and diet. (Brewer, Zhu, & McKeith, 2001; Cameron & Enser, 1991; Fernandez, Monin, Talmant, Mourot, & Lebert, 1999). In general, IMF content positively correlates with the sensory quality of cooked meat, but the improvement of sensory quality with each incremental increase in IMF is not constant. As IMF content increase from l% to 3%, sensory quality increases at the highest rate. As IMF content increases from 3% to 6%, sensory quality improves further, but not as dramatically as that at the lower levels (Savell & Cross, 1988). Moreover, Bejerholm and Barton-Gade (1986) reported that the IMF content of pork needs to be greater than 2% before any noticeable effects on the sensory attributes of pork can be detected. However, in the last decade, pigs have been selectively bred for the rapid production of lean meat and to increase the lean-to-fat ratio of carcasses (Cameron, 1990). For this reason, most recent pig breeds have less than 2% IMF content in the *longissimus dorsi* muscle (Alonso et al., 2009; Sheard, Nute, Richardson, & Wood, 2005) with the exception of the Duroc and Berkshire breeds (Alonso et al., 2009; Suzuki, Shibata, Kadowaki, Abe, & Toyoshima, 2003). Therefore, studies on the influence of the IMF content of muscle on the sensory characteristics of cooked pork have generated conflicting results.

Muscle fibers, or the cellular structure of muscle, are the main component of muscle tissue (Schiaffino & Reggiani, 1996). The unique aspect of muscle fibers is their well-organized array of myofibrillar proteins that perform various functions. The morphological and biochemical characteristics of muscle fibers are major factors that influence energy metabolism within the skeletal muscle of live animals, as well as during the postmortem conversion of muscle to

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meat (Choe et al., 2008, 2009; Choi & Kim, 2009). Thus, the various characteristics of muscle fibers can influence meat quality (Ryu & Kim, 2006) and contribute to the sensory quality of cooked meat from different species (Klont, Brocks, & Eikelenboom, 1998; Picard et al., 2002). In general, fast-twitch fibers are energized primarily using the glycolytic pathway; their metabolism contributes to a fast metabolic rate during the early postmortem period. Thus, fast-twitch muscles contain high amounts of glycogen (Nemeth & Lowry, 1984). On the other hand, slow-twitch muscles contain more lipids, which produce a better flavor (Picard et al., 2002). In sheep, a positive relationship between flavor and the composition of slow-twitch fibers has been shown, and a negative correlation between tenderness and fiber cross-sectional area (CSA) has been reported (Renand, Picard, Touraille, Berge, & Lepetit, 2001). Moreover, the contractile state of the muscle fiber and the ability of the muscle proteins to bind water can affect the sensory quality of cooked meat, especially tenderness and juiciness.

The sensory quality of cooked meat also is affected by postmortem pork quality. Several studies have investigated the effects of postmortem meat quality, particularly in pale, soft, and exudative (PSE) pork, but the results remain controversial. In general, PSE pork scored lowest in overall acceptability of fresh pork (Livisay, Xiong, & Moody, 1996), but, after cooking, consumers could not distinguish PSE from red, firm, non-exudative (RFN)-condition pork (Nam, Choi, Jeong, & Kim, 2009; Toldra & Flores, 2000). Thus, the relationships between the major components of muscle or postmortem pork quality and the sensory quality of cooked meat are unclear. It is important to understand how the components or characteristics of meat impact sensory quality before we can understand how sensory quality can be managed, altered, or affected by live animal management, harvesting, or processing. Therefore, the objective of this study was to examine how the components of muscle, including fatty acid composition and muscle fiber, and postmortem meat quality characteristics influence the individual characteristics of the sensory quality of cooked pork.

2. Materials and methods

2.1. Animals and muscle samples

A total of 113 Berkshire pigs (65 gilts and 48 castrated male pigs) were used. All treatments and experimental procedures were approved by the Ministry of Food, Agriculture, Forestry, and Fisheries in Korea. Pigs were raised in separate pens (20 pigs per pen with 0.8 m^2 space per pig) and were fed a commercial diet, in accordance with the National Research Council (1998). Pigs were transported to a commercial abattoir and slaughtered at a similar live weights (110 ± 4 kg) in three batches (40, 40, and 33 pigs per batch) during the winter period, using standard procedures under the supervision of the Korean grading service for animal products. Following electrical stunning, pigs were exsanguinated. At 45 min postmortem, muscle samples were taken from the *longissimus dorsi* muscle at the 8–9th thoracic vertebrae for subsequent histochemical analysis, and muscle pH was also measured ($pH_{45\ min}$). After 24 h in a 4 °C cold room, the pork loins (the 10–13th thoracic vertebrae) were taken for meat quality measurements, and then were immediately stored at −20 °C without chopping until the measurements of sensory quality and fat characteristics were made.

2.2. Sensory quality

Samples were thawed at 4 °C and subsequently cut into 2 cm thick chops and the chops were roasted in a convection oven with fans and steam cooking function (MCS312CF4, Electrolux, Sweden) set at 180 °C, turning every 3 min, and to an internal temperature of 71 °C, which was measured using a thermometer with a handheld probe (TES-1300, TES Electrical Electronic Co., Taiwan). The cooked steaks were cut into 1.3 × 1.3 × 1.3 cm^3 pieces that were randomly selected to minimize bias. Samples were placed in lidded; 1-ounce glass jars labeled with three-digit random codes and were held in a water bath (54 °C) until presented to the panelists (Fortin, Robertson, & Tong, 2005).

Ten trained panelists were assigned to sensory booths to evaluate the sensory quality of 113 pork samples. Panelist training was performed according to published procedures (Meilgaard, Civille, & Carr, 1991), and the 10 panelists were trained to assess meat samples over 4 weeks. During sensory evaluation, the panelists were situated in private booths under incandescent lighting. A total of 43 sessions was performed with eight samples per session; each session was conducted for 1 h with a 10 min break. Water (at room temperature) and unsalted soda crackers were provided to purge the palate of residual flavor between samples. Panelists scored each sample on 15 cm unstructured line scales where each end point was tagged with a descriptor (low score to high score); softness: soft to hard, initial tenderness: tender to tough, chewiness: tender to chewy, rate of breakdown: fast to slow, juiciness: not juicy to extremely juicy, flavor intensity: no pork flavor to full pork flavor, off-flavor: none to strong off-flavor, mouth coating: none to very much, and amount of perceptible residue: none to abundant (Fortin et al., 2005). The experiment for sensory quality was repeated three times, and the average of three replications takem.

2.3. Intramuscular fat content and fatty acid composition

The content of IMF was determined by the Soxhlet method with a solvent extraction system (AOAC, 2000). The fat was extracted according to Folch, Lees, and Sloane-Stanely (1957). Briefly, 1.5 g of homogenized meat was blended with chloroform/methanol (2:1, v/v) twice, filtered, and then placed in a separator funnel and mixed with saline solution (0.9% NaCl). After separation, the aqueous methanol fraction was discarded and the chloroform lipid fraction washed with extraction solvent. After further filtration and evaporation by rotary evaporation, the lipid extracts were transferred to test tubes for subsequent gas chromatographic analysis. Duplicates of lipids were methylated by adding 2 ml of sodium methoxide, distilled water, and heptane. Gas chromatograph analysis was performed on a Gas Chromatography–Mass Selective Detector (GC, Agilent 7890N, USA; MSD, Agilent 5975A, USA) equipped with a HP-INNOWAX column (length 30 m, internal diameter 0.25 mm, film thickness 0.25 μm). The operating conditions were: a helium flow rate of 0.7 ml/min, the FID detector set at 260 °C, the split–splitless injector set at 220 °C with an injection rate of 120 ml/min, and an injection volume of 1 μl. The temperature program of the column was: 4 min at 140 °C and a subsequent increase to 220 °C at 4 °C/min. The retention time and area of each peak were computed using Agilent software. The individual fatty acid peaks were identified by comparing the retention times with those of known mixtures of standard fatty acids (FAME, Sigma-Aldrich CO, USA). Fatty acid composition was expressed as a percentage of total methylated fatty acid.

2.4. Histochemical analysis

Muscle samples were cut into 0.5 × 0.5 × 1.0 cm^3 pieces, promptly frozen in isopentane cooled by liquid nitrogen, and stored at −80 °C until subsequent analyses. Using a cryostat (CM1850, Leica, Germany) at −20 °C, serial transverse muscle sections (10 μm) were obtained from each sample and then mounted on glass slides. For classifying muscle fiber types in the samples, a staining method examining myosin adenosine triphosphatase (mATPase) activity was used (Brook & Kaiser, 1970; Lind & Kernell, 1991). The staining procedure was as follows: (1) unfixed sections were pre-incubated at room temperature for 10 min in a buffer consisting of 100 mM potassium