Meat Science 102 (2015) 27–34

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effects of ractopamine administration and castration method on muscle fiber characteristics and sensory quality of the *longissimus* muscle in two Piétrain pig genotypes

Hui Li [a,b,c,f,1], Claude Gariépy [b,*], Ye Jin [a,1], Maria Font i Furnols [d], Jacinthe Fortin [b], Luiene M. Rocha [c,e], Luigi Faucitano [c]

[a] College of Food Science and Engineering, Inner Mongolia Agricultural University, Hohhot, Inner Mongolia 010018, China
[b] Agriculture and Agri-Food Canada, Food Research and Development Centre, Saint-Hyacinthe, QC J2S 8E3, Canada
[c] Agriculture and Agri-Food Canada, Dairy and Swine and Development Research Centre, Sherbrooke, QC J1M 0C8, Canada
[d] IRTA, Finca Camps i Armet, Monells 17121, Spain
[e] Département des sciences animales, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, HoustonPavillon Paul-Comtois, Québec City, QC G1V A06, Canada
[f] Institute of Agricultural and Livestock Products, Inner Mongolia Academy of Agricultural & Husbandry Sciences, Hohhot, Inner Mongolia 010031, China

ARTICLE INFO

Article history:
Received 24 January 2014
Received in revised form 18 June 2014
Accepted 25 October 2014
Available online 30 October 2014

Keywords:
Castration
Genotype
Ractopamine
Muscle fiber
Sensory quality
Pork

ABSTRACT

Single and combined effects of ractopamine supplementation (RAC, 7.5 vs. 0 ppm), castration method (surgical castration: SC vs. immuno-castration: IM) and genotype (genotype A: GA vs. GB containing 25% or 50% Piétrain) were determined on longissimus muscle (LM) fiber traits and quality of pork ($n = 512$). RAC increased fiber IIX cross-sectional area ($P = 0.009$) and decreased glycolytic potential ($P = 0.02$) and pork tenderness ($P < 0.001$). Fiber traits indicated that LM of IM pigs was more oxidative ($P < 0.05$) and meat had slightly higher ($P = 0.04$) off-flavor score and WBSF than SC. LM from GB pigs was paler ($P < 0.05$) and had greater ($P < 0.05$) glycolytic potential, IIX fiber cross sectional area and pork off-flavor than GA. RAC supplementation, castration method and genotype or their combination affected some fiber traits and some quality parameters but differences reported were small indicating these treatments or their combination could be used without major prejudice to meat quality.

1. Introduction

One of the most important objectives of the pork industry aims at balancing growth performance, carcass yield, meat quality and welfare-friendly production for its overall economic benefit (Beermann, 2009). Genetic selection, nutrition management, use of growth promoters and castration are the main approaches for carcass yield and efficiency improvement (Lawrie & Ledward, 2006). The livestock and meat industry are however constantly seeking new alternatives to promote animal performance and improve carcass characteristics which, altogether with consumer preference for leaner pork, have resulted in the production of high lean breeds, such as Piétrain. When compared to other four modern pig breeds, including Large White, Landrace, Duroc and Meishan, Gispert et al. (2007) reported the highest carcass lean yield in halothane negative Piétrain. According to Rehfeldt, Fiedler, and Stickland (2004), however, in some modern meat type breeds, such as Piétrain, muscle fiber number and size, which determine lean growth potential, are possibly at the limit of their correlated response to selection for leanness and complementary strategies must be applied to attain further changes.

Ractopamine is a β-adrenergic agonist known to increase muscle protein accretion (Apple et al., 2007) as a result of increased myofibrillar protein synthesis (Adeola, Ball, & Young, 1992; Helferich et al., 1990). Using classic histochemical procedure (ATPase staining), Aalhus, Schaefer, Murray, and Jones (1992) have shown that feeding pigs with 20 ppm ractopamine increased the proportion of white muscle fibers at the expense of the intermediate ones with a concomitant increase in the size of the two types, which, according to these authors, could have contributed to their observed increase in meat shear force values. Feeding pigs a higher dose (60 ppm) of ractopamine also increased the relative abundance of type IIB myosin heavy chain and decreased that of type IIX (Depreux, Grant, Anderson, & Gerrard, 2002). However, to our knowledge, no other histological study has been conducted at the lower ractopamine levels (5–10 ppm) now recommended. In a meta-analysis of results obtained in 23 studies from 1990 to 2006, Apple et al. (2007) have shown that, except for increased shear forces, dietary administration of ractopamine (5–20 ppm) has generally no deleterious effect on pork quality parameters, such as color, firmness, water-

* Corresponding author. Tel.: +1 450 768 3261; fax: +1 450 773 8461.
E-mail address: claude.gariepy@agr.gc.ca (C. Gariépy).
[1] First authors.

http://dx.doi.org/10.1016/j.meatsci.2014.10.027

holding capacity, marbling score and intramuscular fat content. The reduced pork tenderness may be explained by increased lysine level in ractopamine supplemented diets (Apple et al., 2007). More recent reports, however, indicate that even low doses (5 or 7.5 ppm) of ractopamine in the diet for the last 4 weeks such as used respectively by Patience et al. (2009) and Rocha et al. (2013) produced paler and less tender and flavorful pork. Different doses and application of ractopamine involving different muscles and/or cooking conditions may explain variability in responses as reviewed by Schinckel, Richert, Herr, Einstein, and Kendall (2001) who also indicated that ractopamine effects on performances and meat quality would not be influenced by pig genotype. However, no experiment was ever conducted on pigs of Piétrain genetics which do not appear to respond to growth factors, such as pST, because they already exhibit the largest muscle fibers among pig breeds as reported by Rehfeldt et al. (2004).

Surgical castration is a common management practice in swine production in many countries as it helps eliminate the risk of boar taint in cooked pork (Aluwé et al., 2013). However, this practice is considered painful and stressful for pigs (Prunier et al., 2006) and its ban is currently under consideration in several countries in terms of animal welfare (von Borell et al., 2009). Immunization against GnRF, which suppresses testicular function after the second injection of a GnRF analog (Improvest®, Zoetis Animal Health, Pointe Claire, Canada) 4 to 6 weeks before slaughter, represents a novel approach for pig castration. Recent studies have shown that Improvest® can delay puberty, reduce aggressiveness and produce untainted pork when compared to entire males (Fàbrega et al., 2010; Font i Furnols et al., 2008; Turkstra et al., 2011). However, the effects of immunization against GnRF on overall pork quality aside from boar taint are conflicting. Results from a meta-analysis covering studies between 1990 and 2010 and comparing surgical castrates, immuno-castrates, gilts and entire males indicate that, except for shear force which was higher in entire males, castration method and sex had no impact on sensory tenderness and juiciness and on standard physico-chemical quality parameters, such as color, drip loss and pH (Pauly, Luginbühl, Ampuero, & Bee, 2012). On the other hand, more recent studies (Aluwé et al., 2013; Rocha et al., 2013) reported a negative effect of immunocastration on drip loss, juiciness and tenderness when compared with surgical castration.

Similar to ractopamine or other β-agonists, the anabolic effect of androgens on muscle growth is based on muscle fiber hypertrophy and not on fiber multiplication (Rehfeldt et al., 2004). Following the induction of antibodies against GnRF to produce a temporary immunological suppression of testicular function, the difference, if any, in muscle fiber characteristics between surgical castrates and immuno-castrates may explain the variation in performances and meat quality. To our knowledge, there is no report on the effect immunization against GnRF on muscle fiber characteristics in pigs. Therefore, the assessment of muscle fibers traits in immunized males combined with the use of Pietrain genetics and dietary ractopamine supplementation may provide insights on the contribution of these practices on growth performance and meat quality traits variation in pigs since they represent an important meat quality determinant relatively uninfluenced by any indirect or short-term effect such as pre-slaughter handling or stress or indirect effect of some treatments on animal behavior and physiology.

The purpose of this study was therefore to determine the single and combined effects of Piétrain genotype, ractopamine administration, and immunization against GnRF on *longissimus* muscle fiber characteristics, glycolytic potential and sensory quality.

2. Material and methods

2.1. Animals and treatments

This study was conducted at a commercial swine growing-finishing farm and at a commercial slaughter plant in Eastern Canada. A total of 1488 pigs (115 ± 5 kg liveweight) were distributed according to a 2 × 2 × 2 factorial design. The first factor was ractopamine supplementation (Paylean, Elanco Animal Health, Guelph, Canada) with 2 groups of pigs (744 pigs each) receiving 7.5 ppm of ractopamine (RAC) or not (NRAC) in the diet during the last 28 days of the finishing period. The second factor was the castration method with 744 surgically castrates (SC) and 744 immunized males (IM), and the third factor was the genotype with 2 crossbreeds containing 25% (genotype A or GA; $n = 744$) or 50% (genotype B or GB; $n = 744$) of Piétrain genetics. Pigs were progenies from crosses of Piétrain purebred and Duroc × Piétrain crossbred sire lines with commercial hybrid sows (F-20 developed by Genetiporc Inc., St.-Bernard, Canada) resulting in crossbreds containing 25% and 50% Piétrain genetics, respectively. Piétrain sire lines were free of the halothane gene (Hal^N). Surgical castration took place at 2 days of age, while immunization against GnRF was performed through 2 subcutaneous injections (2 mL per animal) of gonadotropin-releasing factor analog (Improvest®; Zoetis Animal Health, Pointe Claire, Canada) at 10 and 4 weeks before slaughter. Details on the raising conditions at the farm, and pre-slaughter and slaughter procedures can be found in Rocha et al. (2013). In brief, within each treatment combination, pigs were raised in finishing pens of 15 pigs at an average density of 0.76 m^2/pig. Feed was withdrawn for a total of 13 h before slaughter and pigs were mixed within each treatment combination at loading. After 45 min transportation, pigs were unloaded at the plant using a whip only and driven to separate lairage pens based on the treatment combination group (no mixing). At the end of a 120 min lairage period, pigs were electrically stunned (head-to-chest electrical stunning) and exsanguinated in the prone position.

All experimental procedures performed in this study were approved by the institutional animal care committee based on the current guidelines of the Canadian Council on Animal Care (2009).

2.2. Loins selection

At 24 h post-mortem a total of 672 loins (336 left and 336 right loins, in terms of 7 loins per treatment combination × 6 replicates or slaughter days) were collected on the cutting line after overnight cooling. The left loins were used for meat quality evaluation of the *longissimus* muscle (LM) and a sub-sample of them (192 loins, in terms of 4 loins per treatment combination × 6 replicates or slaughter days) was also sampled for immunohistochemistry and glycolytic potential analyses in the LM. The right loins were *only* used for the sensory quality analysis.

2.3. Meat quality measurements

Meat quality was assessed by measuring pH at 24 h post-mortem (pH24) in the LM at the third/fourth last rib level using a pH meter (Oakton Instruments Model pH 100 Series, Vernon Hills, IL) fitted with a Cole Parmer spear type electrode (Cole Palmer Instrument Company, Vernon Hills, IL) and an automatic temperature compensation (ATC) probe. At 24 h post-mortem, the following measurements were also taken in the LM: light reflectance by a Minolta Chromameter CR 300 (D65 light source with 0° viewing angle geometry) according to the reflectance coordinates (CIE L^*, a^*, b^*) and subjective color score with the Japanese Color Standards (from 1 = pale to 6 = dark color; Nakai, Saito, Ikeda, Ando, & Komatsu, 1975) after exposing the muscle surface to 30 min blooming time. Subjective marbling was measured at the same muscle location by using a 10-point scale ranging from 1 (devoid) to 10 (abundant) (National Pork Producers Council, 2000). Drip loss was measured by a modified EZ-Driploss procedure (Correa, Méthot, & Faucitano, 2007). Briefly, 3 25-mm-diameter cores were removed from the center of 2.5 cm thick LM (removed at third/fourth last rib level) by a cork borer, weighed, and placed into plastic drip loss containers (Christensen Aps Industrivaengetand, Hilleroed, Denmark) before being stored for 48 h at 4 °C. At the end of the 48 h storage period, muscle cores were removed from their container,