Comparative analysis of meat sensory quality, antioxidant status, growth hormone and orexin between Anqingliubai and Yorkshire pigs

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ABSTRACT
The pig breeds play an important role in post-mortem meat sensory quality. The aim of this study was to analyse the differences of meat sensory quality, antioxidative ability, growth hormone and orexin between Anqingliubai and Yorkshire pigs. Six Anqingliubai and Six Yorkshire pigs (approximately 100 kg ± 1.5 kg) were slaughtered to assess the longissimus dorsi meat sensory quality, antioxidant ability, serum growth hormone and orexin. Results showed that the Anqingliubai pigs exhibited higher pH, a* and intramuscular fat, but lower L* and cooking loss in longissimus dorsi compared with the Yorkshire pigs (P < 0.05). The malondialdehyde level in the longissimus dorsi muscle of the Anqingliubai pigs was lower than that of Yorkshire pigs. Compared with the Yorkshire pigs, the Anqingliubai pigs exhibited higher superoxide dismutase, catalase and total antioxidant capacity in longissimus dorsi muscle (P < 0.05). Meanwhile, the Anqingliubai pigs showed lower serum growth hormone, but higher serum orexin compared with the Yorkshire pigs (P < 0.05). The different meat sensory quality between two pig breeds may be partly caused by different muscle antioxidative ability, intramuscular fat, serum GH and orexin level.

1. Introduction
With the rapid development of the global economy, consumers’ demands for meat products have gradually changed from the requirements of quantity and basic safety to the requirements of meat quality, such as tenderness, colour, flavour, etc. (Zeng et al. 2016). The breeding direction of pig was higher growth performance and percentage of lean meat for a long time. However, this breeding method leads to a sharp decline in meat sensory quality (Kanis et al. 2005).

The meat sensory quality was affected by various factors, especially pig breeds (Te Pas et al. 2017; Zhang et al. 2015a; Muhlisin et al. 2014). Franco et al. (2014) and Ruusunen et al. (2012) reported that different pig breeds obviously showed different meat sensory quality. Western lean pig breeds have been intensively selected for higher body weight gain, feed efficiency, and lean meat percentage, which may have negative impacts on the meat sensory quality (Guo et al. 2011; Miao et al. 2009). For contrary breeding direction, Chinese local lard-pig breeds exhibit different meat sensory quality including pH, flavor, texture, and storage quality (Suzuki et al. 1991; Li et al. 2008; Liu et al. 2017). These differences in the meat sensory quality may be caused by intramuscular fat (IMF), which have a positive effect on the meat sensory quality of pig (Zhang et al. 2015b; Fernandez et al. 1999).

Anqingliubai pig is one of the most famous obese breeds which have the characteristics of early sexual maturity and good anti-stress ability (Zhang et al. 2015a). Yorkshire pig is an excellent lean pig breed in the world (Chen et al. 2012). It exhibits fast growth rate, good feed conversion efficiency, and high lean meat rate. There were many works reported the differences between the Chinese local lard and Western lean pig breeds. However, few studies investigate the differences in meat sensory quality, antioxidative ability, serum growth hormone (GH) and orexin secretion between Anqingliubai and Yorkshire pigs. Consequently, the aims of the present work were to quantify and compare the meat sensory quality, lipid oxidation, major antioxidant, GH and orexin levels between Anqingliubai and Yorkshire pigs, which could provide useful information to further understand the possible mechanisms of differences in lean and lard pigs.

2. Materials and methods
2.1. Animals and sample collection
The animal experimental work was approved by the Animal Care and Ethics Committee of Anhui Agricultural University (Permit number: SYKK 2016-007). Six Anqingliubai pigs and six Yorkshire pigs were used in this experiment. The pig diet was based on the corn-soybean meal and formulated according to...
National Research Council (NRC 2012). These pigs were fed ad libitum and housed in the cooperative farm of college of animal science and technology at Anhui Agricultural University. Due to the Anqingliubai and Yorkshire pigs being slaughtered at 100 kg in the market, the animal experiment lasted for 10 month for the Anqingliubai pigs and 6 month for the Yorkshire pigs according to similar slaughter weight (100 kg ± 1.5 kg). After fasting overnight, 12 pigs were slaughtered for sampling. And then, the longissimus dorsi muscles and blood were collected and stored at 4°C and −80°C, respectively, for meat quality and chemical analysis.

2.2. Determination of meat sensory quality

The colour (lightness: L*, redness: a*, yellowness: b*) of meat was measured 24 h post mortem (4°C preservation) from an average of values using a chromameter (Konica Minolta Chroma Meter CR-300, Japan). The meat pH was measured at the centre of the longissimus dorsi sample by pH instrument (Mettler-Toledo, Switzerland). The meat sample was suspended in an inflated plastic bag for 24 h at 4°C. Then this sample was reweighed, and the drip loss (DL) was calculated as a percentage of the initial weight. The cooking loss (CL) was measured as follows: meat sample was placed in steam for 30 min, and the CL was calculated as a percentage of the initial weight. IMF was detected using Association of Official Analytical Chemists (AOAC) methods as described (Fortin et al. 2005).

2.3. Determination of malondialdehyde (MDA)

A 0.5 g longissimus dorsi muscle was homogenized in a glass homogenizer with 4.5 ml of ice physiological saline (0.9% NaCl), and then the homogenate was centrifuged at 3500 rpm for 10 min (4°C) in refrigerated centrifuge (Eppendorf, Germany). The supernatant was stored at −80°C. The MDA assay kits (Jiancheng company, Nanjing, Jiangsu province, China; http://www.njcbio.com/) was used to detected MDA content according to the manufacturer’s instructions.

2.4. Determination of antioxidant activities

The activities of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSHPx), glutathione (GSH), and total antioxidant capacity (T-AOC) in longissimus dorsi muscle were measured by SOD, CAT, GSHPx, GSH, T-AOC assay kits (Jiancheng company, Nanjing, Jiangsu province, China; http://www.njcbio.com/) according to the manufacturer’s instructions.

2.5. Determination of serum GH and orexin levels

As the Li et al. (2012) described, the serum GH and orexin levels were detected by GH and orexin ELISA kits (ruicong mlbio company, Shanghai, China) according to the manufacturer’s instructions.

2.6. Statistical analysis

Statistical analysis was performed by SPSS 18.0 for Windows statistical software package (SPSS, USA). Every pig was regard as an experimental unit. The t-test was used to compare two groups, and P < 0.05 was considered as significance. The value expressed as means with a SEM.

3. Results

3.1. Meat sensory quality

The results of meat quality were shown in Table 1. Compared with the Yorkshire pigs, the Anqingliubai pigs showed higher pH and a* values, but lower L* and CL values (P < 0.05). Furthermore, the IMF was higher in the Anqingliubai pigs than that in the Yorkshire pigs. There were no significant differences in DL and b* values between Yorkshire and Anqingliubai pigs (P > 0.05).

2.3. Determination of malondialdehyde (MDA)

The MDA concentration of longissimus dorsi muscle in Yorkshire and Anqingliubai pigs was shown in Figure 1. Compared with the Yorkshire pigs, the Anqingliubai pig exhibited lower MDA concentration (P < 0.05).

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As the Li et al. (2012) described, the serum GH and orexin levels were detected by GH and orexin ELISA kits (ruicong mlbio company, Shanghai, China) according to the manufacturer’s instructions.
3.3. Antioxidant activities

The antioxidant activities of longissimus dorsi muscle in Yorkshire and Anqingliubai pigs were shown in Figure 2. Compared with the Yorkshire pigs, the Anqingliubai pigs exhibited higher SOD, CAT and T-AOC activities \((P < 0.05)\). However, there were no significant differences in GSH and GSHPx activities between two breeds \((P > 0.05)\).

3.4. Serum GH and orexin levels

The serum GH and orexin levels in Yorkshire and Anqingliubai pigs were shown in Figure 3. Compared with the Yorkshire pig, the Anqingliubai pigs exhibited lower serum GH, but higher serum orexin levels \((P < 0.05)\).

4. Discussion

Pig breed is one of the main factors affecting pork sensory quality (Pugliese and Sirtori 2012; Kouba and Sellier 2011; Zheng et al. 2018). Generally, the obese-pig and lean-pig breeds showed different meat sensory quality (Guo et al. 2011; Miao et al. 2009; Liu et al. 2017). Shen et al. (2014) reported Chinese Tibetan pig and Liang-Shan pig have higher IMF, pH45min, pH24h, pH48h and pH72h, but lower DL24h and DL48h than DLY pig, and there was a significant effect of
breed among three breeds. Zhang et al. (2015b) suggested that Chinese rongchang pig exhibited greater IMF, pH45min, pH24h compared with the Landrace pig. Chen et al. (2018) reported that Chinese local pig breeds (laiwu pig, Lulai pig, Wulian pig, Yantaipig and Yimeng pig) have better meat colour than commercial crossbreed pig DLY. Similar results of meat sensory quality were also found in the Anqingliubai and the Yorkshire pigs, which suggested that the Anqiquliubai pigs had greater meat sensory quality than that in the Yorkshire pigs. Furthermore, the Jinhu pig (Guo et al. 2011; Miao et al. 2009), Meishan pig (Suzuki et al. 1991), Taihu pig (Li et al. 2008), and Min pig (Liu et al. 2017) showed better meat sensory quality compared with the Landrace pig, Duroc × Landrace pig, Landrace pig, and Yorkshire pig, respectively.

It has been demonstrated that lipid oxidation affected the sensory quality in the post-slaughter meat of pig (Chen et al. 2018). MDA is one of the important circulating indicators which reflect the degree of lipid oxidation in muscle (Lykkesfeldt and Svendsen 2007; Del Rio et al. 2005). Chen et al. (2012) reported that the MDA content of longissimus dorsi muscle was lower in the Laiwu pigs (Chinese obese pig) than in the Yorkshire pigs after slaughter. Similarly, the Anqiquliubai pigs exhibited lower muscle MDA content compared with the Yorkshire pigs, suggesting that the longissimus dorsi muscle of Anqingliubai pig had lower level of lipid oxidation in the present experiment.

The oxidative degree of post-slaughter muscle which influences the meat sensory quality is retarded by the action of anti-oxidative (Chen et al. 2012; Chen et al. 2018). The antioxidant system included a non-enzyme system (GSH, Vp, polyphenol, etc.) and endogenous antioxidative enzymes (SOD, CAT, GSHPx, etc.). GSH, SOD, CAT and GSHPx play an important role in the protection of meat quality (Xia et al. 2017; Cheng et al. 2017). Some studies have shown that the post-slaughter muscle antioxidant system can decrease the concentrations of free radicals to inhibit the oxidation of polyunsaturated fatty acids, thus affecting the shelf-life of pork and maintaining the meat quality (Chen et al. 2018). Hernández et al. (2004) and Chen et al. (2018) suggested that the different breeds showed the different anti-oxidative capacity in the muscle. The SOD, CAT and T-AOC activates in Anqingliubai pigs were statistically significant higher than in the Yorkshire pigs. These results indicated that Anqingliubai pork meat have higher resistance to oxidative stress post-mortem.

IMF is one of the important factors affecting meat sensory quality such as flavor, meat colour, fibre type, tenderness and juiciness (Fernandez et al. 1999; Zhao et al. 2009). Generally, a decreased level of IMF has a negative influence on the meat sensory quality of pig (Zhao et al. 2009). It is well known that IMF content depends on fat metabolism including lipogenesis, lipolysis, exogenous fatty acid uptake, and fatty acid oxidation (Wood et al. 2008; Zhang et al. 2015b). GH (a peptide hormone) promoted the muscle growth and correlated negatively with lipogenesis (Cordoba-Chacon et al. 2015). However, orexin regulated food intake and correlated positively with lipid accumulation (Wojciechowicz et al. 2016). Therefore, the serum GH and orexin concentrations could partly explain the different IMF content between pig breeds. Oksbjerg et al. (1995) and Parr et al. (2016) reported that injection of porcine GH could markedly decrease pork IMF of longissimus dorsi muscle. Li et al. (2012) suggested that the Chinese Rongchang pig showed lower serum GH, but higher serum orexin levels than the Landrace pig. In the present study, Anqiquliubai pig exhibited higher IMF concentrations than the Yorkshire pig, which is consistent with its lower serum GH and higher serum orexin levels.

5. Conclusions

In conclusions, the longissimus dorsi meat sensory quality of Chinese Anqingliubai pig is different from the Yorkshire pig. Compared with the Yorkshire pig, the Anqiquliubai pig showed the higher muscle antioxidant ability and serum orexin level, but lower muscle MDA and serum GH level. The different meat sensory quality between two pig breeds may be partly caused by different muscle antioxidant ability, serum GH and orexin level. The present findings may provide valuable information for understanding the differences in meat quality between Anqingliubai and Yorkshire breeds.

Disclosure statement

No potential conflict of interest was reported by the authors.
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References

Association of Official Analytical Chemists. 1997. Official methods of analysis. 16th ed. Arlington (VA): Association of Official Analytical Chemists.

Chen W, Zeng Q, Xu H, Fang G, Wang S, Li C, Wang Y, Wang H, Zeng Y. 2018. Comparison and relationship between meat colour and antioxidant capacity of different pig breeds. Anim Prod Sci. 58:2152–2157.

Chen W, Zhu HL, Shi Y, Zhao MM, Wang H, Zeng YQ. 2012. Comparative analysis on antioxidative ability of muscle between laiwu pig and large white. Asian-Aust. J Anim Sci. 25:1190–1196.

Cheng C, Liu Z, Zhou Y, Wei H, Zhang X, Xia M, Deng Z, Zou Y, Jiang S, Peng J. 2017. Effect of oregano essential oil supplementation to a reduced-protein, amino acid-supplemented diet on meat quality, fatty acid composition, and oxidative stability of longissimus thoracis muscle in growing-finishing pigs. Meat Sci. 133:103–109.

Cordoba-Chacon J, Majumdar N, List EO, Diaz-Ruiz A, Frank SJ, Manzano A, Del Rio D, Stewart AJ, Pellegrini N. 2005. A review of recent studies on malodour perception with sugar cane extract on meat quality and oxidative stability in finishing pigs. Exp Biol Med. 241:1786–1795.

Del Rio D, Stewart AJ, Pellegrini N. 2005. A review of recent studies on malondialdehyde as toxic molecule and biological marker of oxidative stress. Nutr Metab Cardio VAS. 15:316–328.

Fernandez X, Monin G, Talmant A, Mourot J, Lebret B. 1999. Influence of intramuscular fat content on the quality of pig meat-I. Composition of the lipid fraction and sensory characteristics of m. longissimus lumborum. Meat Sci. 53(1):59–65.

Fortin A, Robertson WM, Tong AKW. 2005. The eating quality of Canadian pork and its relationship with intramuscular fat. Meat Sci. 69:297–305.

Franco D, Vazquez JA, Lorenzo JM. 2014. Growth performance, carcass and meat quality of the Celta pig crossbred with Duroc and Landrace genotypes. Meat Sci. 96:195–202.

Guo J, Shan T, Wu T, Zhu LN, Ren Y, An S, Wang Y. 2011. Comparisons of different muscle metabolic enzymes and muscle fiber types in Jinhua and Landrace pigs. J Anim Sci. 89:185–191.

Hernández P, Zomeno L, Arino B, Blasco A. 2004. Antioxidant, lipolytic and proteolytic enzyme activities in pork meat from different genotypes. Meat Sci. 66(3):523–529.

Kanis E, De Greef KH, Hemstra A, Van Arendonk JM. 2005. Breeding for societally important traits in pigs. J Anim Sci. 83:948–957.

Kouba M, Selleri P. 2011. A review of the factors influencing the development of intramuscular adipose tissue in the growing pig. Meat Sci. 88:213–220.

Li M, Wu H, Luo Z, Xia Y, Guan J, Wang T, Gu Y, Chen L, Zhang K, Ma J, et al. 2012. An atlas of DNA methylation in porcine adipose and muscle tissues. Nat Commun. 3:850.

Li M, Zhu L, Li X, Shuai S, Teng X, Xiao H, Li Q, Chen L, Guo Y, Wang J. 2008. Expression profiling analysis for genes related to meat quality and carcass traits during postnatal development of backfat in two pig breeds. Sci China Ser C. 51:718–733.

Liu Y, Yang X, Jing X, He X, Wang L, Liu Y, Liu D. 2017. Transcriptional analysis on excellent meat quality traits of skeletal muscles of the Chinese indigenous min pig compared with the Large White breed. Int J Mol Sci. 19:21.

Lykkesfeldt J, Svendsen O. 2007. Oxidants and antioxidants in disease: oxidative stress in farm animals. Vet J. 173:502–511.

Miao Z, Wang L, Xu Z, Huang J, Wang Y. 2009. Developmental changes of carcass composition, meat quality and organs in the Jinhua pig and Landrace. Animal. 3:468–473.

Muhlisin P, Lee SJ, Lee JK, Lee SK. 2014. Effects of crossbreeding and gender on the carcass traits and meat quality of Korean native black pig and Duroc crossbred. Asian Aust J Anim. 27:1019–1025.

National Research Council (NRC). 2012. Nutrient requirements of swine, 11th ed. Washington (DC): NRC, National Academy Press.

Oksbjerg N, Petersen JS, Sorensen MT, Henckel P, Agergaard N, Bejerholm C, Erlandsen E. 1995. The influence of porcine growth hormone on muscle fibre characteristics, metabolic potential and meat quality. Meat Sci. 39:375–385.

Parr T, Mareko MH, Ryan KJ, Hemmings KM, Brown DM, Brameld JM. 2016. The impact of growth promoters on muscle growth and the potential consequences for meat quality. Meat Sci. 120:93–99.

Pugliese C, Sintori F. 2012. Quality of meat and meat products produced from southern European pig breeds. Meat Sci. 90:511–518.

Rusununen M, Puolanne E, Sevon-Aimonen ML, Partanen K, Voutila L, Niemi J. 2012. Carcass and meat quality traits of four different pig crosses. Meat Sci. 90:543–547.

Shen L, Lei H, Zhang S, Li X, Li M, Jiang X, Zhu K, Zhu L. 2014. The comparison of energy metabolism and meat quality among three pig breeds. Anim Sci J. 85:770–779.

SPSS. 2008. Statistical package for social sciences (release 18.0.) for Windows. Chicago: SPSS Inc.

Suzuki A, Kojima N, Ikekuchi Y, Ikarashi S, Moriyama N, Ishizuka T, Tokushige H. 1991. Carcass composition and meat quality of Chinese purebred and European × Chinese crossbred pigs. Meat Sci. 39:31–41.

Te Pas MF, Lebret B, Oksbjerg N. 2017. Measurable biomarkers linked to meat quality from different pig production systems. Arch Anim Breed. 60:271–283.

Wojciechowicz T, Skrzypski M, Szczepankiewicz D, Hertig I, Kołodzijski PA, Billert M, Strowski MZ, Nowak KW. 2016. Orexins A and B stimulate proliferation and differentiation of porcine preadipocytes. Exp Biol Med. 241:1786–1799.

Wood JD, Enser M, Fisher AV, Nute GR, Sheard PR, Richardson RI, Hughes SJ, Whittington FM. 2008. Fat deposition, fatty acid composition and meat quality: a review. Meat Sci. 78:343–358.

Xia Y, Li Y, Shen X, Mizu M, Furuta T, Li C. 2017. Effect of dietary supplementation with sugar cane extract on meat quality and oxidative stability in finishing pigs. Anim Nutr. 3:295–299.

Zeng W, Wen W, Deng Y, Tian Y, Sun H, Sun Q. 2016. Chinese ethnic meat products: Continuity and development. Meat Sci. 120:37–46.

Zhang C, Luo QJ, Zhang P, Yu B, Huang ZQ, Mao XB, He J, Yu J, Chen JL, Chen DW. 2015. Differential expression of lipid metabolism-related genes and myosin heavy chain isoforms genes in pig muscle tissue leading to different meat quality. Animal. 9:1073–1080.

Zhang XD, Zhang SJ, Ding YY, Feng YF, Zhu HY, Huang L, Wu T, Zhou J, Yin ZI. 2015a. Association between ADSL, GARS-AIRS-GART, DGAT1, and DECR1 expression levels and pork meat quality traits. Genet Mol Res. 14:14823–14830.

Zhao SM, Ren LJ, Chen L, Zhang X, Cheng ML, Li WZ, Zhang YY, Gao SZ. 2009. Differential expression of lipid metabolism related genes in porcine muscle tissue leading to different intramuscular fat deposition. Lipids. 44:1029.

Zheng M, Huang Y, Ji X, Xiao S, Ma J, Huang L. 2018. Effects of breeds, tissues and genders on purine contents in pork and the relationships between purine content and other meat quality traits. Meat Sci. 143:81–86.