

Study on the Correlations between Mineral Contents in Musculus Longissimus Dorsi and Meat Quality for Five Breeds of Pigs

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Abstract: The correlations between mineral contents in musculus longissimus dorsi and meat quality for five breeds of pigs were studied in this experiment. Two imported breeds (Duroc and Yorkshires) and three local breeds (Huainan pig, Nanyang black pig, Queshan black pig) from Henan province of China were chosen in this trial. Ten 90 kg finishing pigs were selected randomly to slaughter from each breed. Mineral contents of K, Na, Ca, Fe, Mn, Cu and Zn in musculus longissimus dorsi were detected by atomic absorption spectrophotometry and their correlations with meat quality were also analyzed. The results showed : (1) Mn and protein contents had no significant difference among all the breeds ($p>0.05$), (2) K content in Duroc was higher than that in the other four breeds significantly ($p<0.01$), (3) Mineral contents of Na, Ca, Mn, Fe, Cu and Zn in local breeds were higher than that in the imported breeds significantly ($p<0.01$), (4) Marble stripes and meat colour in local breeds were superior to the imported ones, (5) Intramuscular fat content of local breeds was higher than that of the imported ones ($p<0.01$), (6) There was a significant positive correlation between Zn and the other mineral contents in the muscle ($p<0.01$ or $p<0.05$), (7) Both Cu and Fe contents had a significant positive correlation with meat color ($p<0.05$), but negative correlation with drip loss ($p<0.05$), (8) There was a positive correlation between Zn and intramuscular fat content ($p<0.01$), but negative correlation between Zn and drip loss ($p<0.01$). In conclusion, Minerals in muscle had significant correlations with meat quality elements, but no significant correlations with meat protein and fat contents.

Key words: Mineral contents in musculus longissimus dorsi, Meat quality, Pig breeds, Correlation

INTRODUCTION

With the improvement of the consumption level of pork, meat quality becomes the most important character considered by the people. When the lean meat proportion was pursued excessively in the swine production, the hyperirritable gene frequency will be increased and meat quality is declined^[1]. Both pig breed and nutritional management play the important roles in improving meat quality^[2]. Trace minerals are essential for the growth and metabolism of pigs. In practice, extra addition of some vitamins and trace elements can improve the carcass characteristics, including moisture loss, meat color, marble stripes, etc.,

so the relationship between trace elements and meat characteristics are important for improving meat quality. But few researches were conducted to compare the effects of mineral elements on pork quality of the local and imported breeds. In this study, minerals of K, Na, Ca, Fe, Mn, Cu and Zn in musculus longissimus dorsi in different breeds of pigs were detected and the correlations between meat quality and mineral contents were analyzed.

MATERIALS AND METHODS

The animals and breeds: Ten 90 kg finishing pigs were selected randomly from each breed (Huainan pig,

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Nanyang Black pig, Queshan Black pig, Duroc and Yorkshires pig) for slaughtering, respectively. The carcass were separated and 10 g fresh musculus longissimus dorsi were taken to be detected.

Reagent and equipment: The mixed acid: nitric acid (HNO₃, A.P) and perchloric acid (HClO₄, A.P) were mixed with 3:1. WFX—120 atomic absorption spectrophotometer (Beijing Reili analytical apparatus company) was used in this experiment.

Evaluation method of meat quality

Meat color: Middle portion of longissimus muscle were taken and stored in refrigerator at 0-4°C for 24 h. The samples were cut open and measured with eye-measurement by American system 5 score NPPC shade guide. It was permitted to give 0.5 score between two interstages. 1 score = Gray (abnormal colour), 2 scores = light gray, 3 scores = normal bright red, 4 scores = slightly cardinal red (normal colour), 5 scores = dull purple (abnormal colour).

Marble stripes: The segment in posterior rib of longissimus dorsi muscle was taken as the sample. The method of sample processing and test condition were done according to meat color evaluation. 1 score = Trace, 2 scores = Gleam, 3 scores = Jot, 4 scores = Optimum dose, 5 scores = excessive dose.

Water loss: The lumbar segment of longissimus muscle (stored at 0-4°C for 24 h) was cut into small pieces (2cm×3cm×5cm). The sample was held with a thin wire after weighing, then sealed in a plastic bag kept untouched to insure the plastic bag have enough space to contain the spillage. The bag with sample was hung in a refrigerator at 0-4°C for 24 h and then the sample was taken out, extracted with filter paper and weighed.

The cooked meat rate: The right psoas of carcass was weighed after removing the ect-sarcolemma, boiled for 45 min with a 2 kw electric cooker and then weighted after hanging in ambient temperature for 30 min to calculate the percentage of the cooked meat.

Tenderness: Took the fresh foreside of lumbar segments (1-5) of longissimus dorsi muscle as the sample, got rid of the surface fat, kept in a plastic bag for 24 h at 15-16°C. The meat was taken out and kept at 0-4°C for 48 h, kept at room temperature for 1 h and then dipped into a water bath at 75-80°C until the temperature of meat center got to 70°C, taken out and

cooled down to 20°C. Cut the core into several chops (1cm×1cm×2.5cm) and finally measured the shearing force with C-LM muscle tenderness instrument.

Estimating mineral contents in pork: Concentrations of calcium (Ca), ferrum (Fe), manganese (Mg), copper (Cu), zinc (Zn) were determined by dry ashing—atomic absorption spectrophotometer and potassium and sodium by flame photometer according to operational manual.

Data analysis: All the data were primary analyzed by EXCEL2003 and then multiply compared by General Linear Model of software SPSS11.5 and correlation analyzed by correlate program.

RESULTS AND DISCUSSION

Concentrations of mineral elements in musculus longissimus dorsi:

The results showed that five breeds of pigs had different contents of mineral element in musculus longissimus dorsi (Table 1). Duroc had more K level than that of Queshan Black pig ($p < 0.05$), but there was no significant difference among the other breeds ($p > 0.05$). Huainan pig had more Na content ($52.19 \text{ mg } 100\text{g}^{-1}$) than that of Yorkshires ($27.53 \text{ mg } 100\text{g}^{-1}$) and Duroc ($39.29 \text{ mg } 100 \text{ g}^{-1}$) significantly ($p < 0.01$). No significant differences were found among the five breeds for Mn contents. Fe, Ca and Zn contents of muscle in local breeds were higher than that in the imported breeds ($p < 0.05$). Queshan Black pig had the highest level of Cu among the five breeds ($p < 0.05$). No significant difference were found for mineral contents except Na between Duroc and Yorkshire ($p > 0.05$).

Nutrient compositions in musculus longissimus dorsi of different pig breeds:

Table 2 showed that: Queshan black pig had less muscle moisture (69.65%) than that of the Yorkshires (72.00%) ($p < 0.05$), but there was no significant difference among the other pig breeds. No differences were observed in protein content among the different breeds. The contents of intramuscular fat for the local breeds were higher than that for the imported breeds ($p < 0.01$). The ash content in the muscle of Queshan black pig was less than that of Huainan pig, Nanyang black pig and Yorkshires ($p < 0.01$), but without significant difference with Duroc ($p > 0.05$).

Table 1: Mineral contents in musculus longissimus dorsi of different pig breeds (mg 100 g⁻¹)

	K	Na	Ca	Mn	Fe	Cu	Zn
Queshan black pigs	340.15±23.53b	40.69±4.33bB	2.64±0.37aAB	0.0421±0.0165a	8.08±0.89a	3.16±0.18A	7.16±0.32aAB
Nanyang black pigs	357.52±14.25ab	41.49±2.10bAB	2.83±0.68aA	0.0693±0.0158a	11.51±3.47a	2.23±0.12bAB	6.47±0.36abABC
Huainan pigs	371.27±4.69ab	52.19±2.78aA	2.36±0.24abAB	0.0933±0.0266a	11.33±1.35a	2.34±0.24bAB	7.38±0.30aA
Yorkshires	373.96±8.91ab	27.53±2.70cC	1.30±0.36bcAB	0.0701±0.0263a	6.58±0.53b	1.67±0.17B	5.32±0.29bcBC
Durocs	391.26±4.94a	39.29±1.27bB	1.10±0.31cB	0.0504±0.0160a	5.01±0.88b	1.91±0.45B	4.94±0.91cC

Note: The average with different lower case superscripts are different at p<0.05; the average with different capital superscripts are different at p<0.01. The averages in the following tables had the same notes as this table

Table 2: Nutrient contents in musculus longissimus dorsi longissimus dorsi of pigs (%)

	Water	Protein	Intramuscular fat	Ash
Queshan black pigs	69.65±0.79b	22.37±0.44a	6.09±0.80aAB	0.88±0.19cC
Nanyang black pigs	70.71±0.34ab	21.97±0.71a	5.58±0.53aA	1.12±0.03aA
Huainan pigs	71.01±0.80ab	22.03±0.51a	7.30±0.82aA	1.04±0.03aAB
Yorkshire	72.00±0.55a	23.29±0.74a	4.16±0.55bBC	1.07±0.06aA
Duroc	71.49±0.49ab	22.31±0.85a	3.16±0.36bC	0.91±0.02bBC

Table 3: The quality of musculus longissimus dorsi in different pig breeds

	Rate of cooked meat (%)	Tender rate (kg)	Marble muscle (scores)	Meat color (scores)	Water loss(%)
Queshan black pigs	62.63±0.94ab	3.12v0.26abA	3.75±0.88abAB	2.75±0.11B	1.51±0.04C
Nanyang black pigs	61.03±1.19b	2.89±0.11abB	4.11±0.21aA	3.17±0.08A	1.44±0.02C
Huainan pigs	66.43±2.19a	2.72±0.32abAB	3.17±0.26bBC	2.92±0.15AB	2.62±0.07B
Yorkshire	62.24±1.01ab	2.52±0.24bAB	2.00±0.45cD	2.42±0.11C	4.83±0.11A
Duroc	62.60±1.14ab	3.41±0.27aA	2.42±0.58cCD	2.67±0.08B	4.83±0.11A

Table 4: Correlations among musculus minerals and meat quality

	Zn	Cu	Fe	Mn	Ca	K	Na
Zn	1						
Cu	0.6732**	1					
Fe	0.4976**	0.2715	1				
Mn	0.2709	-0.1145	0.4074*	1			
Ca	0.5026**	0.3801*	0.6770**	0.1360	1		
K	-0.239	-0.2683	-0.0840	-0.0881	-0.4741**	1	
Na	0.4232*	0.2697	0.3633*	0.2908	0.0864	0.1870	1
Moisture	-0.2358	-0.2937	0.0571	0.0931	0.0185	0.1452	-0.3184
Protein	-0.1896	-0.2804	0.0947	-0.1804	-0.0144	0.1614	-0.3453
Intramuscular fat	0.4398*	0.2552	0.2710	0.0931	0.3304	-0.2082	0.4405*
Ash	-0.0584	-0.2424	0.3055	0.2876	0.1580	0.0859	-0.0562

Note: "**" represents p<0.05 and "***" represents p<0.01

Table 5 correlations between musculus minerals and meat quality

	Zn	Cu	Fe	Mn	Ca	K	Na
Color	0.3465	0.3610*	0.5051*	0.0552	0.3164	0.0123	0.5305**
Marbling	0.3445	0.3774*	0.2234	-0.0667	0.4317*	-0.5149**	0.3295
Drip loss	-0.5229*	-0.4324*	-0.4323*	-0.0320	-0.5967**	0.3943*	-0.3707*
Cooked meat rate	0.0049	-0.1593	-0.1533	-0.1250	-0.2760	0.1743	0.2721
Tenderness	-0.233	0.1467	-0.3224	-0.2603	-0.4392*	0.0860	0.1251

Note: "*" represents $p < 0.05$ and "**" represents $p < 0.01$

The quality of musculus longissimus dorsi in different breeds of pigs:

The rate of cooked meat of Huainan pig was more than that of Nanyang black pig ($p < 0.05$), but without significant difference among the other breeds ($p > 0.05$). The tenderness of muscle was best for Duroc and Queshan black pig ($p < 0.01$), followed by Nanyang black pig, Huainan pig and Yorkshires. Duroc and Yorkshires had lower marbling score significantly than Queshan black pig, Huainan pig and Nanyang black pig ($p < 0.01$) and difference was also observed between Huainan pig and Nanyang black pig ($p < 0.01$). Meat color of Nanyang black pig were significant different from that of Queshan black pig, Duroc and Yorkshires ($p < 0.01$) and the difference also existed between Yorkshires and Huainan pig ($p < 0.01$). Water loss in muscle of the imported breeds was higher than that of the local breeds ($p < 0.01$) Table 3.

Correlation analysis of mineral contents and meat quality:

Correlations among mineral contents in musculus longissimus dorsi and meat quality were analyzed Table 4 and 5. There was a significant positive correlation between Zn and Cu, Fe, Ca ($p < 0.01$) and Na ($p < 0.05$). Cu had a significant positive correlation with Ca ($p < 0.05$), Fe had a significant positive correlation with Mn, Na ($p < 0.05$) and Ca ($p < 0.01$), Ca had a negative correlation with K ($p < 0.01$). Moisture, protein and ash contents in muscle had no correlation with the minerals. Both Zn and Na had significant positive correlations with the content of intramuscular fat ($p < 0.01$), Zn had a negative correlation with water loss ($p < 0.01$). Both Marbling and meat color had positive correlations with Cu ($p < 0.05$), but had negative correlations with water loss ($p < 0.01$). Fe had a positive correlation with meat color ($p < 0.01$), but a negative correlation with drip loss ($p < 0.05$). Ca had a positive correlation with Marbling ($p < 0.01$), but a negative

correlation with water loss ($p < 0.01$) and tenderness ($p < 0.05$). K had a negative correlation with Marbling ($p < 0.01$), but a positive correlation with water loss ($p < 0.05$). Na had a positive correlation with meat color ($p < 0.01$), but a negative correlation with water loss ($p < 0.05$).

The contents of minerals in musculus longissimus dorsi:

The contents of K and Na in muscle determined in this experiment are in agreement with the data measured by Li lianghua^[3]. Both Na and Ca contents in the imported breeds were less than that of local breeds. There is no significant deviation of Mn contents among different breeds, which indicated that muscle tissue was not the place of Mn enriching. Fe contents in local pigs were more than that of the imported breeds, showing that Fe ingestion of local pigs was better than that of the imported breeds. Zn content measured in this experiment was different from the reports by Lou and Li^[4], but agreement with Jin^[5]. The breeds, sample-part and metropolis might produce the differences.

The relationship between pork quality and breeds:

The contents of moisture and ash were agreement with the former report^[15]. The contents of intramuscularly fat in Queshan Black pig, Nanyang Black pig and Huainan pig were consistent with the report for local breeds^[6]. There was no significant difference in cooked meat rate among different breeds, but the water loss in local breeds was lower than that of the imported breeds, which indicated that local pigs lost little water during the storage and had more commercial value. Generally, marbling reflects the distribution of intramuscularly fat, the results showed that the three local breeds were better than the imported ones, it can help to improve the flavour and tenderness of the meat.

The corelation of musculus minerals with meat quality

Myoglobin and hemoglobin have great effect

on meat color and Fe is the essential ingredient of the myoglobin and hemoglobin. When the myoglobin (madder red) is combined with oxygen, it forms oxymyoglobin (bright red), when myoglobin is oxidized to metmyoglobin, i.e., Fe^{2+} is oxidized to Fe^{3+} the color will change to dark brown^[7]. It was reported that adding 100 ppm fuscous complex into pig's diet could improve meat color during the storage for sale^[8]. It indicated that Fe had positive correlation with color ($p < 0.01$). The relationship of elements and meat color shows that certain contents of minerals can improve meat color, but the result may be opposite if the contents are too high. Zn, Mn, Cu and Fe are the important ingredients of SOD, they can help to change superoxide anion to H_2O_2 , which can produce water with the help of peroxidase to protect integrity of cell membrane, to decrease the damage of the free radical to the meat color, thus improve meat quality^[9]. But the excess Fe and Cu will accelerate lipid peroxidation, so the contents of minerals would be kept in appropriate level. Content of K is the most affluent in muscle, the balance of K and Na is essential for maintaining the water holding capacity and appropriate pH in the tissues. The presence of Ca^{2+} will activate calcium-dependent proteinase increase proteolysis of muscle to improve the tenderness of muscle. Duckett *et al.* drenched calcium adhesive to cattle before killed (3-6 h), the tenderness of beef was improved^[10]. This result showed that calcium level and tenderness were correlative. Zhang found that adding Zn to feed had quadratic effects on the subcutaneous fat thickness^[11]. This research also indicated that Zn content of muscles had positive correlation with intramuscularly fat.

CONCLUSIONS

Various breeds of pigs had different contents of minerals in musculus longissimus dorsi. Mn content had no significant difference among all breeds. K content in Duroc was higher than that of the other four breeds significantly. Musculus minerals of Na, Ca, Mn, Fe, Cu and Zn in local breeds were higher than that in the imported breeds significantly.

There was a significant positive correlation between Zn and the other mineral elements in the muscle. Both Cu and Fe contents had significant positive correlations with meat color, but negative correlations with drip loss. Zn had a positive correlation with intramuscular fat, but a negative correlation with drip loss.

Intramuscular fat contents in local breeds were higher than that of the imported breeds, but the content of protein in muscle had no significant difference among the different breeds.

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