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Evaluation of Growth Performance, Carcass Characteristics and Meat Quality of Shaziling Pigs and its Hybrids Crossbred with Berkshire Pigs

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ABSTRACT

Background: The Chinese Shaziling pig is representative of good meat quality but has been scarcely utilized on commercial farms because of the unpleasing growth and carcass traits.

Methods: The growth performance, carcass characteristics, meat quality and fatty acids profile were analyzed among (Berkshire × Shaziling) × (Berkshire × Shaziling) (BS × BS), BS × S, Shaziling (S × S) and S × BS pigs.

Result: BS × BS pigs exhibited higher growth rate and superior carcass performance. Each breed possessed desirable meat quality, as evidenced by moderate pH, color score, IMF content and shear force value, among which the performance of S × BS pigs was prominent. Take account of the contents of SFAs, MUFAs, PUFAs and PUFAs/SFAs value, the eating quality of S × BS pigs was favorable and the meat of BS × BS pigs, by contrast, was helpful for human health with advanced nutritional value. In summary, BS × BS pigs is more effective for commercial development of Shaziling pigs and providing healthy pork products.

Key words: Carcass characteristics, Crossbreeds, Growth performance, Meat quality, Shaziling pigs.

INTRODUCTION

The growth performance, carcass characteristics and meat quality in pigs are considerable economic traits. It is well known that the western pig breeds Berkshire, Duroc, Yorkshire and Landrace, characterized by superior growth rate and lean percentage, represent the majority of pig breeds on the market. However, the accompanying defect is the decline in pork quality (Keenan, 2016). With the promotion of people's life quality, the focal point of meat consumption demand has gradually altered from 'quantity' to 'quality' and therefore, improvement of meat quality has dramatic effect on pig industry (Ilavarasan and Abraham 2018).

The Shaziling pig, an indigenous Chinese breed mainly reared in Hunan province, is representative of slow growth rate, poor feed conversion and low lean percentage, in spite of the properties of good meat quality and strong adaptability (Chen *et al*., 2021; Yang *et al*., 2016). Given the outstanding characteristics of western and indigenous pig breeds, there is a rising trend to improve the efficiency of commercial pig production with the advantages of both type breeds by crossbreeding systems (Guo *et al*., 2017; Jiang *et al*., 2011).

In the current study, the Berkshire × Shaziling crossbred pigs were used to form the primary population and then the intercross offspring was produced (named as BS × BS). The crossbreeds of BS × S, S × BS and Shaziling pigs (named as S × S) were cultivated, respectively. The growth performance, carcass trait, meat quality and fatty acids (FAs) profile were examined. This study provides the scientific basis for industrial improvement of Shaziling pigs and exploitation of special pork products.

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MATERIALS AND METHODS

The experiment was performed in accordance with the guidelines for the Animal Care and Use Committee of Hunan Institute of Animal and Veterinary Science.

Animals and experimental design

A total of 80 healthy pigs (50% castrated male and 50% female) with similar initial body weight were randomly selected including BS × BS, BS × S, S × S and S × BS. Each group consisted of two pens with ten pigs each and the pigs were raised under similar conditions. All pigs were hand-fed two times daily and water was provided *ad libitum*. The feeding experiment lasted for 98 days after 7 days of adaptation period. The ingredient and chemical composition of the experimental diet offered to all pigs was presented in Supplementary Table 1.

Growth performance

The initial body weight and final body weight were recorded

Supplementary Table 1: Ingredient and chemical composition of experimental diet.

Item	Growing (30 kg-60 kg)	Fattening (60 kg)
Ingredient, %		
Paddy	50.40	50.50
Corn	5.30	7.90
Soybean meal	11.90	5.00
Rice	-	10.00
Wheat bran	6.00	4.60
Oil bran	20.00	18.00
Soybean oil	2.40	-
Premix†	4.00	4.00
Total	100.00	100.00
Chemical composition		
Digestible energy, MJ kg^{-1}	13.02	12.71
Crude protein, %	13.51	11.00
Calcium, %	0.60	0.62
Total phosphorus, %	0.64	0.76
Available phosphorus, %	0.18	0.17
Lysine, %	0.75	0.60
Methionine, %	0.22	0.18

Supplied, per kilogram of diet: 19.8 mg $CuSO_4 \cdot 5H_2O$; 0.20 mg KI; 400 mg $FeSO_4 \cdot 7H_2O$; 0.56 mg $NaSeO_3$; 359 mg $ZnSO_4 \cdot 7H_2O$; 10.2 mg $MnSO_4 \cdot H_2O$; 5 mg vitamin K (menadione); 2 mg vitamin B_1; 15 mg vitamin B_2; 30 ìg vitamin B_{12}; 5400 IU vitamin A; 110 IU vitamin D_3; 18 IU vitamin E; 80 mg choline chloride; 100 mg Fungicide.

in each pig and feed intake was also recorded for determining the average daily gain (ADG) and feed intake to body gain ratio (Feed/Gain).

Slaughter procedure

At the end of the experiment, pigs with medium weight per pen were selected and the slaughter weights of BS × BS (n=6), BS × S (n=4), S × S (n=4) and S × BS (n=4) pigs (50% castrated male and 50% female) were recorded. Pigs were slaughtered at a local commercial slaughter house.

Carcass measurements

Carcass composition was determined following the Technical Regulation for Testing of Carcass Traits in Lean-type Pig (NY/T 825-2004) and the loin-eye area of *longissimus dorsi* muscle at the last rib was determined by measuring its width and height (GB/T 8467-1987). The left side of carcass was then divided into lean, fat, skin and bone tissue and tissue percentage was individually calculated.

Meat quality measurements

Longissimus thoracis (LT), *longissimus lumborum* (LL) and psoas muscles on the left side of carcass were immediately harvested within 1 h postmortem. The meat quality was assessed according to the methods represented in technical code of practice for pork quality assessment (NY/T 821-2019) and determination of meat tenderness-shear force method (NY/T 1180-2006). In LT sample, pH values at 1 h (pH_1) and 24 h (pH_{24}) postmortem were recorded, meat color was exhibited as L*, a* and b*. Marbling score was evaluated based on the National Pork Producers Council (NPPC, 2000). In LL sample, intramuscular fat (IMF) content and drip loss were measured according to the methods described previously (Latimer, 2012; Lee *et al*., 2012). For evaluating water loss, meat slice was put on the platform of unconfined pressure instrument, maintaining pressure of 35 kg for 5 min. For cooking yield, psoas muscle was weighed and steamed for 30 min, then the sample was hung at room temperature for 20 min and weighed. Inosine monophosphate (IMP) concentration was determined using the method as described in detail (Li *et al*., 2018).

Determination of FAs composition

The composition of FAs in LL sample was detected according to the methods previously described (Liu *et al*., 2015) and the content of individual FA was represented with percentage of total FAs.

Statistical analysis

Experimental data were analyzed by one-way ANOVA procedure with SPSS 20.0 software. Duncan method was used for multiple comparison and significance test. Result was expressed as mean and SEM, $P \leq 0.05$ was considered significant.

RESULTS AND DISCUSSION

Growth performance

The final body weight in BS × BS pig was significantly higher ($P<0.01$) than that in Shaziling pigs and BS × BS pigs had the highest ADG ($P < 0.01$) and lowest Feed/Gain (Table 1). The result is consistent with the former studies that the growth performance of crossbred pigs was superior to the indigenous pigs (Franco *et al*., 2014; Gopinathan and Usha 2011; Jiang *et al*., 2011; Touma and Oyadomari 2020). Meanwhile, BS × BS pigs had an advantage of growth performance in comparison with BS × S and S × BS pigs. This phenomenon may be explained by the fact that BS × BS pigs contained higher proportion of Berkshire gene.

Carcass characteristics

Compared with other three groups, BS × BS pigs exhibited advantages in carcass parameters including carcass length, average backfat thickness, loin-eye area and lean percentage, although not all the differences were to the level of statistical significance (Table 2), indicating that BS × BS pigs possess excellent carcass characteristics.

Meat quality

Considerable differences were observed in a_1* value, color score and shear force among different groups (Table 3). Specifically, a_1* value was significantly lower ($P < 0.01$) in BS × S pigs than that in other pig breeds and consumers may be more willing to accept the meat of BS × BS, Shazíling and S × BS pigs (Corlett *et al*., 2021). In addition, color score ranged from 3.13 to 3.88, indicating that all breeds had good meat color (NPPC, 2000). IMF contents in four groups were all higher than 2%, which could meet the demand for pork products with pleasing taste quality (Chen *et al*., 2016). Furthermore, compared color score, IMF content and shear force value among BS × S, Shaziling and S × BS pigs, the results showed that color score was 3.13, 3.50 and 3.88 and IMF content was 2.55, 3.90 and 4.58 and shear force value was 14.06, 7.60 and 6.42, respectively, suggesting that the performance of S × BS pigs was prominent and the influence of paternity maybe greater than that of maternity in terms of the three indicators. In summary, each pig breed possessed desirable meat quality.

FAs composition

In four groups, the predominant components in FAs were C18:1n-9c, C16:0, C18:0 and C18:2n-6c, which accounted for 90% of all the FAs. Additionally, monounsaturated fatty acids (MUFAs) and saturated fatty acids (SFAs) were the most abundant components (Table 4). These results are in

Table 1: Growth performance of BS × BS, BS × S, S × S and S × BS pigs.

Item	BS × BS	BS × S	S × S	S × BS	SEM	p-value
Initial body weight, kg	32.40	30.19	31.02	32.27	0.35	0.08
Final body weight, kg	93.24^{a}	77.06^{b}	76.94^{b}	88.12^{a}	1.22	< 0.01
ADG, g d^{-1}	607.93^{a}	523.71^{b}	472.42^{c}	534.69^{b}	8.52	< 0.01
Feed/Gain	3.83	3.90	4.08	3.93		

$^{a-c}$ Within a row, values with different superscript letters differ (P<0.05).

Table 2: Carcass characteristics of BS × BS, BS × S, S × S and S × BS pigs.

Item	BS × BS	BS × S	S × S	S × BS	SEM	p-value
Slaughter weight, kg	92.23^{a}	88.30^{a}	83.43^{b}	90.85^{a}	1.03	< 0.01
Carcass weight, kg	67.31^{a}	64.38^{ab}	61.13^{b}	66.63^{a}	0.79	< 0.01
Dressing percentage, %	72.98	72.89	73.26	73.35	0.46	0.95
Carcass straight length, cm	90.92	86.75	87.63	86.75	0.75	0.09
Carcass slanting length, cm	78.58	75.88	76.13	76.00	0.54	0.16
Average backfat thickness, cm	3.22	3.51	3.81	3.86	0.12	0.13
Skin thickness, cm	0.54	0.49	0.51	0.49	0.02	0.90
Loin-eye area, cm^2	25.16	24.56	19.53	23.63	0.97	0.17
Ham percentage, %	26.38	25.79	26.11	27.12	0.21	0.17
Lean percentage, %	46.79^{a}	43.32^{ab}	40.66^{b}	41.41^{b}	0.93	0.04
Fat percentage, %	27.74^{b}	30.68^{ab}	33.63^{a}	33.74^{a}	0.94	0.03
Skin percentage, %	13.51	15.02	15.10	12.51	0.50	0.24
Bone percentage, %	11.97	10.98	10.61	12.34	0.29	0.14

$^{a,\ b}$ Within a row, values with different superscript letters differ (P<0.05).

Table 3: Meat quality of BS × BS, BS × S, S × S and S × BS pigs.

Item	BS × BS	BS × S	S × S	S × BS	SEM	p-value
pH_1	6.51	6.44	6.51	6.42	0.05	0.88
pH_{24}	5.76	5.70	5.81	5.76	0.04	0.84
L_1*	33.49	34.23	32.16	33.26	0.46	0.54
a_1*	5.03^{a}	3.70^{b}	4.88^{a}	4.59^{a}	0.16	< 0.01
b_1*	1.16	1.04	0.66	0.95	0.09	0.27
L_{24}*	40.47	43.16	36.75	39.70	0.94	0.15
a_{24}*	4.99	4.45	5.67	6.22	0.36	0.40
b_{24}*	1.20	1.51	0.58	1.55	0.20	0.36
Color score	3.33^{bc}	3.13^{c}	3.50^{b}	3.88^{a}	0.08	< 0.01
IMF, %	2.23^{c}	2.55^{bc}	3.90^{ab}	4.58^{a}	0.32	0.01
IMP, mg g^{-1}	2.08	2.07	2.00	1.92	0.07	0.85
Drip loss, %	1.18	1.07	0.94	0.68	0.10	0.33
Water loss, %	11.36	10.12	8.94	10.65	0.43	0.28
Cooking yield, %	64.19	66.07	67.68	68.99	0.77	0.10
Shear force, N	10.42^{ab}	14.06^{a}	7.60^{b}	6.42^{b}	1.00	0.03

$^{a-c}$ Within a row, values with different superscript letters differ (P<0.05).

Table 4: Fatty acids profile of BS × BS, BS × S, S × S and S × BS pigs.

Item	BS × BS	BS × S	S × S	S × BS	SEM	p-value
C14: 0, %	1.44	1.46	1.65	1.62	0.04	0.25
C16: 0, %	24.02^{b}	25.03^{ab}	25.83^{a}	26.53^{a}	0.33	0.02
C16: 1, %	3.17	3.35	3.52	3.35	0.10	0.69
C17: 0, %	0.15	0.14	0.14	0.12	0.004	0.14
C18: 0, %	12.18	12.38	13.38	13.78	0.27	0.10
C18: 1n-9t, %	0.12^{a}	0.10^{b}	0.10^{b}	0.10^{b}	0.003	0.03
C18: 1n-9c, %	38.57	40.25	39.18	40.55	0.50	0.47
C18: 2n-6c, %	14.72^{a}	12.33^{ab}	11.58^{b}	10.18^{b}	0.59	0.02
C20: 0, %	0.16^{b}	0.19^{a}	0.18^{ab}	0.20^{a}	0.01	0.03
C20: 1, %	0.63	0.72	0.70	0.75	0.02	0.36
C18: 3n-3, %	0.54^{a}	0.39^{b}	0.42^{ab}	0.40^{b}	0.02	0.04
C20: 2, %	0.42	0.35	0.38	0.33	0.02	0.17
C20: 3n-6, %	0.38	0.36	0.34	0.25	0.02	0.16
C20: 4n-6, %	3.37^{a}	2.90^{a}	2.47^{ab}	1.78^{b}	0.21	0.03
SFAs†, %	37.97^{c}	39.19^{bc}	41.16^{ab}	42.25^{a}	0.60	0.02
MUFAs‡, %	42.49	44.42	43.49	44.75	0.48	0.31
PUFAs§, %	19.56^{a}	16.37^{ab}	15.30^{b}	13.03^{b}	0.84	0.02
UFAs¶, %	620.05^{a}	60.78^{ab}	58.79^{b}	57.78^{b}	0.60	0.02
SFAs + MUFAs, %	80.46^{b}	83.61^{ab}	84.65^{a}	87.00^{a}	0.84	0.02
PUFAs/SFAs	0.52^{a}	0.42^{ab}	0.38^{b}	0.31^{b}	0.03	0.01

$^{a\text{-}c}$ Within a row, values with different superscript letters differ (P<0.05).

†SFAs = C14:0 + C16:0 + 17:0 + C18:0 + C20:0.

‡MUFAs = C16:1 + C18:1n-9t + C18:1n-9c + C20:1.

§PUFAs = C18:2n-6c + C18:3n-3 + C20:2 + C20:3n-6 + C20:4n-6.

¶UFAs = MUFAs + PUFAs.

line with earlier investigations in Chinese indigenous and foreign pig breeds (Dostálová *et al*., 2020; Franco *et al*., 2014; Huang *et al*., 2020; Jiang *et al*., 2011), hinting that there is a certain pattern in FAs composition. It is well known that FAs composition is closely related to pork quality, nutritional value and shelf life of meat. From the point of view of pork quality, SFAs and MUFAs are generally positively associated with eating quality including flavor, tenderness and juiciness, while PUFAs is negatively correlated with eating quality (Cameron *et al*., 2000; Cameron and Enser 1991). In the present study, BS × BS pigs had the lowest SFAs content, MUFAs content and the highest PUFAs content and S × BS pigs presented the exact opposite phenomenon, albeit not all the differences reached statistical significance. This finding implied that the eating quality of BS × BS pigs may have potential inferiority. In regard of nutritional value and human health, the increase in PUFAs intake is beneficial for lowering the risk of cardiovascular diseases (Scollan *et al*., 2017). BS × BS pigs had the highest PUFAs content provided the idea that BS × BS pigs could be used to develop functional pork products. In addition, the PUFAs/SFAs value in foodstuff is an important measure of the relative risk factor of the cholesterol content and cardiovascular diseases (Heck *et al*., 2017; Xiong *et al*., 2017). The higher the ratio, the healthier a foodstuff is considered and the recommended daily allowance of PUFAs/SFAs for human is greater than 0.45 (Hoffman *et al*., 2013). The ratio in BS × BS pigs was 0.52, thus we can think of the meat being a healthy byproduct. However, UFAs is susceptible to oxidation, leading to the development of rancidity and reduction of shelf life of meat (Wood *et al*., 2004). As described above, all these findings supported the conclusion that the meat of BS × BS pigs is helpful for human health with advanced nutritional value, but at the expense of eating quality and shelf life.

CONCLUSION

BS × BS pigs exhibited superior growth rate and carcass performance. In addition, each pig breed possessed desirable meat quality, as evidenced by moderate pH, color score, IMF content and shear force value, among which the performance of S × BS pigs was prominent. Take account of the contents of SFAs, MUFAs, PUFAs and the PUFAs/SFAs value, the eating quality of S × BS pigs was favorable and the meat of BS × BS pigs, by contrast, was helpful for human health with advanced nutritional value. In light of the importance of growth performance, carcass characteristics and meat quality in pig industry, BS × BS pig breed is more effective for commercial development of Shaziling pigs and providing healthy pork products.

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Conflict of interest

The authors declare that there is no conflict of interest.

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