Effect of cattle breed on finishing performance, carcass characteristics and economic benefits under typical beef production system in China

Xiangxue Xie, Qingxiang Meng, Liping Ren, Fenghua Shi, Bo Zhou
College of Animal Science and Technology, China Agricultural University, Beijing, China

Abstract

This study compared the finishing performance, carcass characteristics and economic benefits of two imported (Limousin and Simmental) and three local (Luxi, Jinnan and Qinchuan) cattle breeds slaughtered at 18.5 months of age under the typical Chinese beef production system. All cattle (n=71) were reared under the same production system and fed the same finishing diet for 105 days. Eight bulls from each breed were randomly selected for slaughtering. Compared with the three local breeds, the two imported breeds had higher average daily gain, dry matter intake and gain efficiency. Regarding carcass characteristics, the two imported breeds had higher carcass weight, bone weight, net meat weight, and ribeye area (P<0.001). However, the local breeds had higher (P<0.01) marbling scores than the imported breeds. The imported breeds showed higher economic benefits (P<0.001) than the local breeds. In conclusion, the imported cattle breeds had better growth performance, carcass traits and economic benefits compared with the local cattle breeds at 18.5 months old under the typical Chinese feeding conditions whereas, in this study, the local breeds may have some advantage in terms of meat quality.

Materials and methods

Introduction

In China, there are approximately sixty-nine local cattle breeds, the four most dominant being Luxi, Qinchuan, Jinnan, and Fuzhou (Zheng et al., 1986). Before 1980, although there was a large population of cattle, they were mainly used for draft purposes and only older animals were slaughtered for their meat (Zhou et al., 2001). With the economic development of the last 30 years, beef consumption has risen rapidly (Shi, 2008) in China. However, the local cattle cannot meet the demand for meat from farmers and retailers because of their low growth performance and dressing percentage (Huang et al., 2000; Liu et al., 2006, 2009).

Since the 1970s, China has imported some high producing cattle breeds, such as two European breeds (Limousin and Simmental). In China, the two imported cattle breeds have become nearly pure breeds as a result of more than five generations of grading and crossing. It is well known that the two European cattle breeds usually have excellent growth performance and meat production under intensive feeding conditions (Chambaz et al., 2003; Cuvelier et al., 2006; Vieira et al., 2007). However, because of the high price of concentrates, farmers, especially those with small family farms, typically raise cattle under a beef production system that has a moderate level of nutrition and slaughter them at a similar age regardless of their breed. Nevertheless, little information is available about the comparison of growth performance and carcass characteristics of the two European and the local breeds under the typical Chinese moderate feeding system in cattle of the same age. It is known that breed influences growth performance and carcass characteristics (Cozzi et al., 2009; Nancy and Nelson, 2009). Thus, rearing different breeds of cattle may obtain different economic benefits. However, few reports are available comparing the economic effects of local and imported cattle breeds based on the same typical feed resources. The objective of the present study was to compare the finishing performance, carcass traits and economic benefits of two European and three local breeds slaughtered at the same age under typical Chinese feeding conditions.

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Corresponding author: Prof. Liping Ren, College of Animal Science and Technology, China Agricultural University, Yuanmingyuan Xilu 2, Beijing 100193, China. Tel. +86.10.62733799 – Fax: +86.10.62829699. E-mail:renlp@cau.edu.cn

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housed individually in tie stalls and had free access to the same total mixed ration during the study period. Animals also had free access to fresh water. All procedures were conducted under the approval of the China Agricultural University Animal Science and Technology College Animal Care and Use Committee.

**Body measurement and growth performance**

Body length, straight length, height, hip height, chest circumference and cannon circumference were measured according to Zhou et al. (2006). Dietary dry matter intake (DMI) was individually measured based on the difference between the amount of diet offered and refused daily. Body weight was measured before morning feeding on two consecutive days at the beginning and on the final day of the study. Average daily gain (ADG) was calculated as the difference between initial and final live weight. Gain efficiency (gain:feed) was calculated by the ratio of individual ADG to dietary DMI.

**Slaughter characteristics**

Eight bulls from each breed were randomly selected for slaughtering at 18.5 months old. On the day prior to slaughtering, the animals were weighed and kept overnight at the holding pens of the abattoir without feeding. The animals had free access to water at all times. Slaughter and dressing procedures were carried out in one day following usual commercial procedures at the China Agricultural University Experimental Abattoir in Daxing, Beijing. Hot carcass weight was individually recorded to calculate cold dressing percentage. The cold carcass weight was calculated based on feed price, output / input = (ADG×MPBW)/(DMI×MPF)

where ADG is the average daily gain (kg/head), MPBW is the average market price of body weight (Euro/kg), DMI is the daily DM intake (kg/head/day), and MPF is the market price of feeds (Dong et al., 2006).

**Statistical analysis**

The effects of breed on body measurement, growth performance, carcass characteristics and economic return values were subjected to one-way analysis of variance using SAS Generalized Linear Models procedures (SAS, 2000). The significant differences between least square group means were compared using the SAS PDIFF test (SAS, 2000). All the results from imported and local breeds were also analysed using Student’s t-test (SAS, 2000).

**Results**

**Body measurements and growth traits**

Differences in body structural traits among cattle breeds are presented in Table 2. Imported

| Breed | Imported | Local | Contrast, P value |
|-------|----------|-------|-------------------|
| No. of bulls | 15 | 15 | - | - | <0.001 | <0.001 |
| Body length, cm | 152* | 142* | 1340 | 137* | 134* | 1.727 | <0.001 | <0.001 |
| Body straight length, cm | 137* | 136* | 112* | 120* | 117* | 1.65 | <0.001 | <0.001 |
| Withers height, cm | 131* | 124* | 117* | 119* | 118* | 1.136 | <0.001 | <0.001 |
| Hip height, cm | 139* | 129* | 119* | 121* | 119* | 1.257 | <0.001 | <0.001 |
| Cannon circumference, cm | 195* | 179* | 168* | 172* | 171* | 2.007 | <0.001 | <0.001 |
| Cannon circumference, cm | 21* | 19* | 17* | 17* | 17* | 0.29 | <0.001 | <0.001 |

*Means in the same row with different superscripts are significantly different (P<0.05). LIM, Limousin; SIM, Simmental; LX, Luxi; JN, Jinan; QC, Qinchuan.

| Table 1. Feed ingredient and composition used during growing and finishing periods. |
| Item | Growing period | Finishing period |
|------|----------------|-----------------|
| Ingredients, % DM | | |
| Maize | 9.00 | 44.00 |
| Cotton seed meal | - | 3.00 |
| Soybean pomace | 13.10 | 8.80 |
| Brewers dried grain | 5.90 | 11.00 |
| Maize stalk silage | 70.00 | 30.00 |
| Limestone | - | 0.56 |
| Dicalcium phosphate | 0.10 | 0.14 |
| Sodium bicarbonate | 0.10 | 0.70 |
| Salt | 0.30 | 0.30 |
| Vitamin/trace mineral premix | 1.50 | 1.50 |
| Composition | | |
| Dry matter, % | 28.8 | 54.6 |
| Metabolizable energy, MJ/kg DM | 8.70 | 11.10 |
| Crude protein, % DM | 9.40 | 11.70 |
| NDF, % DM | 56.50 | 40.00 |
| ADF, % DM | 35.40 | 19.60 |
| Calcium, % DM | 0.43 | 0.51 |
| Phosphorus, % DM | 0.21 | 0.30 |

*Contained per kg of vitamin/trace mineral premix: Mg, 476 g; Zn, 65.7 g; Mn, 29 g; Fe, 3866 mg; Cu, 3866 mg; I, 1160 mg; Co, 386 mg; Se, 150 mg; vitamin A, 1.2×107 U; vitamin D, 2,500,000 U; vitamin E, 1900 mg; vitamin K, 390 mg; choline, 90,000 mg; vitamin B1, 1900 mg; vitamin B2, 900 mg; vitamin B12, 7 mg. DM, dry matter; NDF, neutral detergent fibre; ADF, acid detergent fibre. Calculated values.

| Table 2. Effect of breed on body measurements of young bulls. |
| Breed | LIM | SIM | LX | JN | QC | SEM | P import vs local |
|-------|-----|-----|----|----|----|-----|-----------------|
| No. of bulls | 15 | 15 | 13 | 13 | 15 | - | <0.001 |
| Body length, cm | 152* | 142* | 130* | 137* | 134* | 1.727 | <0.001 |
| Body straight length, cm | 137* | 136* | 112* | 120* | 117* | 1.65 | <0.001 |
| Withers height, cm | 131* | 124* | 117* | 119* | 118* | 1.136 | <0.001 |
| Hip height, cm | 139* | 129* | 119* | 121* | 119* | 1.257 | <0.001 |
| Cannon circumference, cm | 195* | 179* | 168* | 172* | 171* | 2.007 | <0.001 |
| Cannon circumference, cm | 21* | 19* | 17* | 17* | 17* | 0.287 | <0.001 |

*Means in the same row with different superscripts are significantly different (P<0.05). LIM, Limousin; SIM, Simmental; LX, Luxi; JN, Jinan; QC, Qinchuan.
breeds had greater body structural traits than local breeds (P<0.001). Between imported breeds, LIM had higher values than SIM in all body structural traits (P<0.05), whereas the three local breeds were mostly similar for withers height, hip height, chest circumference and cannon circumference traits. Only body length and body straight length differed: LX cattle were shorter than JN cattle (P<0.05). Highly significant differences were observed between the imported and the local breeds for final body weight (FBW), ADG, DMI and gain efficiency (GE) (P<0.001) (Table 3). Between imported breeds, LIM had higher FBW, ADG, DMI and GE than SIM. For all growth performance traits, there were no significant differences among local breeds. It was interesting that LM cattle had much lower (P<0.001) DMI expressed as percentage of body weight than the other four breeds of cattle.

**Carcass characteristics**

Data concerning carcass characteristics are presented in Table 4. The two imported breeds had much heavier (P<0.001) carcass weight than the three local breeds. Also, the LIM breed had higher (P<0.001) hot and cold dressing percentages than both the SIM breed and the other three local breeds. Although the two imported breeds had heavier (P<0.001) bone weight and net meat weight than the local breeds, there was no difference in bone percentage and ratio of meat to bone (P>0.05) between the imported and the local breeds. LX had the thinnest backfat in all breeds, whereas the other four breeds showed no significant differences (P>0.05) in backfat thickness. Compared with the imported breeds, the local breeds had lower ribeye areas (P<0.001) and yield index (P<0.05) but higher (P<0.001) marbling scores.

**Economic benefits**

The daily feed cost of the different breeds, live weight gain and economic data are shown in Table 5. The imported breeds had significantly (P<0.001) higher profits than the local breeds and LM cattle had the highest profits among the five breeds. The imported breeds had significantly higher (P<0.001) economic benefits than the local breeds. As a result, the cost of BW gain per kilogram was 1.16 Euro for LIM, followed by 1.30 Euro for SIM, and 1.50, 1.61 and 1.60 Euro for the breeds of LX, JN and QC, respectively (Table 5).

### Table 3. Effect of breed on growth and feed efficiency traits of young bulls.

| Breed | Imported | Local | SEM | P | Imported vs local |
|-------|----------|-------|-----|---|--------------------|
| No. of bulls | 15       | 15    | 13  | 13 | 15                 |
| Initial body weight, kg | 398b     | 298a  | 245 | 251 | 256               | 11.87 | <0.001 | <0.001 |
| Final body weight, kg | 555b     | 422a  | 330 | 339 | 334               | 12.56 | <0.001 | <0.001 |
| Average daily gain, kg | 1.50     | 1.20a | 0.82 | 0.82 | 0.78             | 0.050 | <0.001 | <0.001 |
| Dry matter intake, kg/d | 8.47     | 7.51a | 6.12 | 6.30 | 6.02             | 0.137 | <0.001 | <0.001 |
| Dry matter intake, % BW | 1.82b    | 2.11a | 2.08 | 2.14 | 2.07             | 0.065 | 0.005  | 0.056  |
| Gain efficiency# | 0.177a   | 0.159a | 0.136 | 0.131 | 0.130            | 0.007 | 0.001  | 0.007  |
| #Means in the same row with different superscripts are significantly different (P<0.05). LIM, Limousin; SIM, Simmental; LX, Luxi; JN, Jinnan; QC, Qinchuan. | |

### Table 4. Effect of breed on carcass traits of young bulls.

| Item | Imported | Local | SEM | P | Imported vs local |
|------|----------|-------|-----|---|--------------------|
| No. of bulls | 8       | 8     | 8   | 8   | 8                 |
| Slaughter weight, kg | 559b   | 461a  | 330 | 339 | 342               | 13.754 | <0.001 | <0.001 |
| Hot carcass weight, kg | 330b   | 262a  | 185 | 197 | 190               | 8.624  | <0.001 | <0.001 |
| Hot dressing percentage, % | 59.0a  | 56.7b | 55.5 | 56.1 | 55.5             | 0.572  | <0.001 | <0.001 |
| Cold carcass weight, kg | 327a   | 257a  | 181 | 194 | 187               | 8.501  | <0.001 | <0.001 |
| Cold dressing percentage, % | 58.5a  | 55.7b | 54.2 | 54.4 | 54.6             | 0.598  | <0.001 | <0.001 |
| Bone weight, kg | 41a     | 32a   | 22  | 22  | 23                | 1.206  | <0.001 | <0.001 |
| Bone percentage, % | 12.7    | 12.5  | 11.9 | 11.6 | 12.3             | 0.437  | 0.455  | 0.122  |
| Net meat weight#, kg | 285a   | 225a  | 159 | 171 | 164               | 7.883  | <0.001 | <0.001 |
| Net meat weight/bone weight | 6.98   | 7.04  | 7.54 | 7.70 | 7.14             | 0.315  | 0.406  | 0.123  |
| Backfat thickness, mm | 2.88a   | 2.63a | 1.60 | 1.64 | 1.71             | 0.433  | 0.203  | 0.925  |
| Marbling score# | 1.50a   | 1.63a | 2.19 | 2.25 | 2.13             | 0.242  | 0.078  | 0.004  |
| Ribeye area, cm² | 101.86a | 72.88b | 57.32 | 60.64 | 56.72           | 3.953  | <0.001 | <0.001 |
| Yield index | 71.03a | 69.07b | 69.50c | 68.30c | 68.47c      | 0.624  | 0.029  | 0.037  |
| Yield grade | 3.00a  | 2.81a | 2.88 | 2.25 | 2.75            | 0.118  | <0.001 | <0.001 |

*Means in the same row with different superscripts are significantly different (P<0.05). LIM, Limousin; SIM, Simmental; LX, Luxi; JN, Jinnan; QC, Qinchuan. *Estimated as the sum of high, medium, low-value and fat cuts, expressed as the percentage of carcass weight. #Marbling score from 1 to 5 (1, devoid; 5, abundant).

### Table 5. Effect of breed on economic traits of young bulls.

| Item | Imported | Local | SEM | P | Imported vs local |
|------|----------|-------|-----|---|--------------------|
| Feed price, Euro/kg DM | 0.20    | 0.20  | 0.20 | 0.20 | 0.20              |
| Feed intake, kg/head 105d | 907b   | 788a  | 634 | 662 | 632              | 14.78  | <0.001 | <0.001 |
| Daily feed cost, Euro/d | 1.74a   | 1.51a | 1.22 | 1.27 | 1.22             | 0.028  | <0.001 | <0.001 |
| Cost per kg gain, Euro/kg | 1.16a  | 1.30b | 1.50 | 1.61 | 1.69             | 0.067  | <0.001 | <0.001 |
| Market price of body weight, Euro/kg | 2.13  | 2.13  | 2.25 | 2.25 | 2.25           |
| Live-weight gain, kg/head 105d | 162a  | 124a  | 85  | 79  | 86               | 5.250  | <0.001 | <0.001 |
| Profit, Euro/head/d# | 1.45a   | 1.02a | 0.63 | 0.58 | 0.58             | 0.092  | <0.001 | <0.001 |
| Economic benefits, output/input¹ | 1.88  | 1.68  | 1.52 | 1.46 | 1.48            | 0.075  | 0.004  | 0.004  |

¹²Means in the same row with different superscripts are significantly different (P<0.05). LIM, Limousin; SIM, Simmental; LX, Luxi; JN, Jinnan; QC, Qinchuan. *Profit, MPBW×ADG-DFC where MPBW is the average market price of body weight, ADG is daily average gain, and DFC is daily feed cost. #Economic benefit, (ADG×MPBW)/(DMI×MPF) where ADG is daily average gain, MPBW is the average market price of body weight, DMI is the daily DM intake (kg/head/day), and MPF is the market price of feeds.

**Note:** Table 3 and Table 5 have been abbreviated for the sake of space.
Discussion

Effect of breed on body measurement and growth traits

Before this study, all bulls had been reared in similar feeding conditions and fed similar traditional diets over 15 months. Because these breeds have different genetic potential for growth, the initial body weight for the two imported breeds was heavier than the three local breeds in this study. Visual muscularity and skeletal scores are useful as early predictors in breed characterisation, especially in animals selected for breeding programmes (Drennan et al., 2008). As in a previous study (Alberti et al., 2008), significant differences were found among the morphological measurements at 18.5 months between the imported and the local breeds in this study; these confirmed the large phenotypic variability among cattle breeds. However, no differences were observed within the local breeds. According to the cattle breed grouping method reported by Alberti et al. (2008), using body size and carcass traits, LIM, SIM and the three local breeds in the present study could be classified as specialised, intermediate and local cattle breeds, respectively. The imported breeds had greater body size than the local breeds, which was in agreement with the results of Hua et al. (2008).

In cattle breeds, live weight is largely the result of body size at maturity, biological type, and growth rate (Chambaz et al., 2003; Alberti et al., 2005). In this study, the same diet with a moderate level of nutrition was used for all cattle breeds. The final body weight of LIM and SIM was heavier than that of the local breeds, which might be due to a breed-specific difference in mature size. In addition, in the current study, the ADG of Limousin bulls was similar to the data reported by Alberti et al. (2008) and higher than those found by Hoving-Bolink et al. (1999) at a similar age. These data indicate that excellent growth performance of LIM cattle can be maintained under typical Chinese feeding conditions. However, the ADG and slaughter weight of SIM cattle from this study was lower than that of LIM cattle, which is in contrast to previous reports (Chambaz et al., 2003; Clarke et al., 2009). Furthermore, compared to the ADG data from Hoving-Bolink et al. (1999), using an intensive feeding system, the ADG of SIM in the present study was lower. Therefore, it may be suggested that the typical Chinese beef production system with a moderate level of nutrition and slaughter at the same age does not represent the best management choice for achieving optimal results from the SIM breed. The typical husbandry conditions are probably better suited to the LIM breed than for the SIM breed.

Effect of breed on carcass characteristics

Breed-specific differences in growth rate can affect carcass weight (Vieira et al., 2007). The relative lower carcass weights of the three local breeds in this study might be due to breed-specific differences in growth rate. LIM had a relatively higher dressing percentage, which resulted from its lower percentage of visceral fat and lower weights taken from the fifth quarter (articular tract, visceral organs, hide, feet and head) (Vieira et al., 2007). The higher dressing percentage of the LIM breed was also observed by Chambaz et al. (2003) and Sañudo et al. (2004). However, there was no difference in dressing percentage of SIM compared with the local cattle breeds, which may be due to its higher fifth quarter values (Simões et al., 2005).

In the present study, there was no statistical difference in bone percentage between these five breeds, in spite of the higher bone weights observed in the imported breeds. The bone percentage of the two imported breeds was slightly lower than the value reported by Nancy and Nelson (2009), which may be due to the different feeding systems adopted in the two studies. A high degree of marbling is usually associated with meat quality and is a decisive factor in the market price of beef products in China. In the present study, local breeds had a slightly higher marbling score which means that, in China, the price of beef products from local cattle breeds is higher. Backfat thickness and marbling score of carcass of LIM and SIM bulls were similar to those found by Sami et al. (2004), Clarke et al. (2009) and Nancy and Nelson (2009) at a similar slaughter age, but significantly lower than that reported by Chambaz et al. (2003). Panjono et al. (2009) found that backfat thickness and marbling score of steers were significantly higher than those of bulls. So the lower values of the two traits in these breeds in the present study was lower than that of LIM cattle, which is in contrast to previous reports (Chambaz et al., 2003; Panjono et al., 2009). Furthermore, compared to the ADG data from Hoving-Bolink et al. (1999), using an intensive feeding system, the ADG of SIM in the present study was lower. Therefore, it may be suggested that the typical Chinese beef production system with a moderate level of nutrition and slaughter at the same age does not represent the best management system for efficient and cost-effective beef production under typical Chinese conditions.

Effect of breed on economic benefit

In the present study, because of the relatively low level of nutrition offered to all the cattle, the feed price was only 0.2 Euro per kg DM. The typical feeding conditions, with a low feed price, to some extent reduced the cost of feed. In addition, Cruz et al. (2010) observed that gain:feed (G:F) ratio alone or DMI and ADG together could explain 98.5% of the difference in cost of body weight gain. Therefore, under the feeding conditions of this study, obtaining better gain efficiency in feeding the imported breeds would reduce feed consumption and consequently reduce feed costs.

The market price of local breeds was higher than the imported breeds because of their better marbling and flavour. The price is approximately 2.25 Euro per kg live weight for the local breeds and 2.13 Euro per kg live weight for the imported breeds. Even if the imported breeds had a lower market price, the two breeds had higher profit and economic benefits than the three local cattle breeds because of their better feed conversion ratio. Li (2009) also reported a higher economic benefit in Simmental cattle compared to Jinguan cattle under the same management conditions. Given this, rearing imported breeds for cattle production should be extended and accepted more widely by individual family and large-scale producers in China.

Conclusions

The two European cattle breeds, Limousin and Simmental, had better growth performance, gain efficiency, carcass weight, net meat weight, ribeye area and yield index than the local breeds at the same age under the typical Chinese beef production system. In addition, the moderate feeding conditions were suitable for the LIM breed but were not the best choice for achieving optimal growth performance by the SIM breed in China. Furthermore, the local breeds had a slightly higher marbling score, which is the most important index for good production and exportation.
meat quality in China. The imported breeds showed larger body size, better carcass traits and higher economic benefits, which should encourage farmers to rear the imported cattle breeds.

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