

Germplasm characteristics and conservation of Tongcheng pig: A case study for preservation and utilization of Chinese indigenous pig breeds

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Summary

The paper describes the breed characteristics, production performance including reproduction, growth, carcass and meat quality traits of the Tongcheng pig, one of the indigenous pig breeds suitable for a hybrid maternal line in central China. Based on the field investigation and data statistics from the farm recordings, the Tongcheng pig has early sexual maturity indicators, and the average litter size is 8.5 for first parity and 9.3 and 11.3 for the second and subsequent parities respectively. In a three-way crossing project launched recently, using the Tongcheng pig as the maternal parent and Landrace or Yorkshire pigs as the paternal parent, the performance testing results showed that Tongcheng pigs had a lower growth and meat production performance than these commercial pigs, but had superior meat quality. The production performance of the two crossing groups (Landrace/Yorkshire/Tongcheng pigs) (LYT) and Yorkshire/Landrace/Tongcheng pigs) (YLT) were improved in comparison to their parent lines, and the results further indicated that the LYT cross is a tri-crossing style convenient for farm and village areas in central China. Meanwhile, effective management measures taken towards Tongcheng pig preservation, and a genetic diversity evaluation on the Tongcheng pig

were reviewed. This paper offers the Tongcheng pig as a case study for the maintenance and utilization of indigenous pigs in China, which is rich in pig breeds but is also confronting the pig resource crisis.

Resumen

El artículo describe las características de la raza porcina Tongcheng, así como los rendimientos de producción, la reproducción, crecimiento, calidad de la canal y la carne. Se trata de una de las razas indígenas porcinas adecuadas para líneas híbridas maternas de la zona central de China. En base a las investigaciones de terreno y los datos estadísticos obtenidos en granja, la raza Tongcheng presenta síntomas de madurez sexual precoz, gran número de partos y una media de camada de 8,5 al primer parto y entre 9,3 y 11,3 a partir del segundo parto. Como demuestran los resultados de un reciente test llevado a cabo dentro de un proyecto con tres vías de cruce, utilizando como parental materno la raza Tongcheng y la raza Landrace, y la

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Yorkshire como parental paterno, la raza Tongcheng presenta un crecimiento y rendimiento de producción de carne inferior a las otras razas comerciales, pero la calidad de la carne resultó superior. Los resultados de producción de dos cruces con Landrace x (Yorkshire x Tongcheng) (LYT) y Yorkshire x (Landrace x Tongcheng) (YLT) resultaron mejorados en comparación con sus líneas parentales. Además, resultó que el cruce Landrace x (Yorkshire x Tongcheng) era el más conveniente de todos en granja y para las zonas centrales de China. Mientras tanto se revisaron las medidas efectivas de manejo de la raza y el tipo de conservación y evaluación genética de la diversidad. Este artículo presenta un estudio de caso de la raza Tongcheng para el mantenimiento e utilización de porcinos indígenas en China, país que posee numerosas razas porcinas pero que al mismo tiempo se enfrenta a una crisis en materia de recursos genéticos.

Keywords: *Exotic pig breeds, Synthetic pig lines, Morphometric characteristics, Production performance, Growth traits, Carcass traits, Meat quality.*

Introduction

The Tongcheng pig is one of the well-known indigenous pig breeds which are generally used as maternal parents in crossbreeding programs in central China. It has the distinctive morphological characteristics of 'two black ends and a wide white belt in the middle, with a small white spot on the head', and was recognized as the Huazhong Two-End-Black pig with six other pig breeds of the same origin but having different names which are distributed in Hubei, Jiangxi, Hunan and Guangxi Provinces (Zhang *et al.*, 1985; Ding *et al.*, 2004). During a large scale investigation into indigenous domestic animal resources launched by the Ministry of Agriculture from the late 1970s to the middle of the 1980s, the Tongcheng pig was classified as the Central China Type, one

of six pig types in China classified according to their geographic localities, and was also described in detail in *Pig Breeds in China* (Zhang *et al.*, 1985). Because of its advantageous specificities such as superior meat quality, high heterotic vigor capacity and strong fitness under extensive management, the Tongcheng pig was entered into the first of the key lists of indigenous pigs to be conserved in China in 2000.

With the introduction and popularization of exotic pig breeds and synthetic lines such as Duroc, Landrace, Large White and PIC pigs since the 1980s, most of indigenous pig breeds have been confronting critical challenges. Since indigenous pigs have lower growth rates and less lean meat percentage than these commercial breeds, local farmers are reluctant to raise these pigs and would rather rear commercial pig breeds, two-way crosses or three-way crossbred pigs. In the past two decades, a significant number of indigenous pig breeds have declined dramatically in population size, especially the numbers of unrelated sires, and some have even already become extinct. It was estimated that four pig breeds had disappeared, 31 breeds were on the verge of endangerment and 71% of total indigenous pig breeds were in potential crisis (Ma *et al.*, 2002). Having the advantageous specificities mentioned, the preservation of the Tongcheng pig has been taken into consideration and effective measures have been put into practice by local animal husbandry departments. At the present time the population size of the Tongcheng pig and sire numbers remain relatively high, compared to other indigenous pigs. It is estimated that there are 30 pure sires from 15 unrelated ancestral lines, which are raised in the Tongcheng County Pig Breeding Farms and six breeding stations in towns and villages. In addition, there are about 10 000 pure dams in total in Tongcheng county. Eighty breeding dams are reared in the Tongcheng County Pig Breeding Farm, 6 000 dams are in the breeding farms of villages and preservation regions, and others



Figure 1. Main reproduction areas of Tongcheng pig.

are kept by private holders. Until now less systematic studies on the Tongcheng pig have been reported. It was the purpose of this paper to present the characteristics of, and appropriate preservation measures for, the Tongcheng pig, and offer reasonable and effective measures for conservation and utilization of indigenous pigs.

Origins

The Tongcheng pig's main areas of origin are the highland areas of Tongcheng county ($29^{\circ}02'$ to $29^{\circ}24'N$; $113^{\circ}17'$ to $114^{\circ}03'E$), and it is also distributed throughout Chongyang, Puqi, Tongshan, Xianning and other counties in Hubei Province, a central district of China (Figure 1). Tongcheng county is adjacent to the Jiangnan Campaigna and the Dongting Lake, and has mild weather and abundant rain fall that contribute to the large areas of fertile cultivation. Crops are cultivated two or three times annually, rice being the most important crop followed by potato, rape, soybean and corn. The plentiful green forage and agriculture byproducts offer an ideal condition for pig breeding and production.

The Tongcheng pig has a long history of domestication in central China. Recorded in the Tongcheng County Annals, half of local commercial taxes came from pig husbandry in the time of the Ming Dynasty of AD 15, which indicated that pig farmers were very prosperous at that time. The Tongcheng pig was also highly praised for its delicious meat flavor and once chosen as a tribute for



Figure 2. Profiles of a sow of Tongcheng pig.



Figure 3. Frontal view of a Tongcheng pig.

emperors during the Ming and Qing Dynasties (Ding *et al.*, 2004).

Morphometric Characteristics

The Tongcheng pig is also named the 'Two-End-Black' pig because of its black and white coat color (Figure 2). The hair on the head, neck and tail end is black. There is a small patch of white hair on the head, which is called the 'white star' by local farmers (Figure 3). Some animals whose white hair extends from the head to the nose are called 'broken forehead'. The head is moderate in size and the wrinkles on the face are plentiful and deep, looking like the Chinese character 'One Thousand', while some others resemble the Chinese character 'One' because of the deep lateral wrinkles on their foreheads. The nose is commonly pale red and called 'cuticolor English mouse', while some are black and named 'iron mouse'. The long ears hang low. The length of the neck is medium and the neck links to the shoulder firmly. The four limbs and trunk are covered by white hair. Some animals have black or

several black cob spots on the trunk, which are called 'waist flower' or 'back flower' in response to different positions. The back and waist are sunken in the majority of pigs. The abdomen is big and dropped and most sows walk with their teats brushing against the ground. The hip is sloped. The color of the skin covered with white hair is mostly pale red.

The average body height of an adult boar is 72 cm, body length is 140 cm, heart girth is 115 cm and body weight is 132 kg. The respective indices are 70 cm, 134 cm, 123 cm and 146 kg for adult dams (Source from the *Breeds of domestic animal and poultry in Hubei Province*, Second edition, 2004).

Production Performance

In comparison to commercial pig breeds, the Tongcheng pig matures sexually relatively early. The boars first begin exhibiting sexual behaviour (Figure 4) at about 40 days and have normal mating ability at the age of 100 days. However, the optimum body condition for the first mating for boars is



Figure 4. Piglets of Tongcheng pig.



Figure 5. A nursing sow of Tongcheng pig.

usually achieved at 6-8 months of age, or 40-50 kg body weight. The female gilts display the first estrous signs at the age of 90 days or so, and the optimum body condition for the first mating is usually achieved at 6-8 months or 45-50 kg body weight.

A field investigation into the reproductive performances of 4 685 litters in 2001 showed an average litter size of first parity for the Tongcheng pig of 8.5 and an average litter size for the second and subsequent parities of 9.3 and 11.3, respectively with and some elite

Table 1. Reproduction traits of Tongchen pig dams.

Trait		Numbers of litters	Mean value \pm SE	C.V%
Total number born	First parity	104	8.8 \pm 0.3	33.9
	Multiparities	237	11.1 \pm 0.2	26.1
Number born alive	First parity	99	7.2 \pm 0.3	46.7
	Multiparities	234	10.1 \pm 0.2	24.7
Litter weight born (kg)	First parity	26	6.7 \pm 0.4	33.9
	Multiparities	172	8.0 \pm 0.2	27.7
Body weight per piglet born (kg)	First parity	26	0.7 \pm 0.0	24.7
	Multiparities	168	0.8 \pm 0.0	20.5
Litter weight at 21 days (kg)	First parity	12	22.3 \pm 1.7	25.9
	Multiparities	82	25.8 \pm 0.7	24.6
Litter weight at 60 days weaning (kg)	First parity	65	68.1 \pm 2.5	30.0
	Multiparities	239	89.1 \pm 1.5	26.9
Body weight per piglet at 60 days (kg)	First parity	64	9.7 \pm 0.3	20.3
	Multiparities	490	9.1 \pm 0.1	27.7
Number alive at 60 days	First parity	40	7.2 \pm 0.3	28.5
	Multiparities	309	8.8 \pm 0.1	29.1
Rearing rate (%)	First parity	43	87.9 \pm 2.4	17.5
	Multiparities	314	89.1 \pm 0.8	15.8

Source: The breeds of domestic animal and poultry in Hubei Province, First edition, 1986.

dams able to go up to 25 (Figure 5). The useful life of breeding dams is usually 5-7 years. The detailed reproduction traits of Tongcheng dams are shown in table 1 (Source from the *Breeds of domestic animal and poultry in Hubei Province*, First edition, 1986).

Growth Traits

The Tongcheng pig is good at consuming fresh and coarse fodder such as roughage and agricultural byproduct, so it is especially suitable for being farmed under extensive management in village and countryside areas. Raised on a low nutritional diet, the body weight of Tongcheng pigs can reach 65-75 kg at the age of 8-10 months. Generally speaking, 75 kg is a convenient body weight for slaughter, since Tongcheng pigs mostly increase flare fat and loose fat without increasing their proportion of lean meat after 75 kg is reached.

A performance testing scheme was carried out at the Tongcheng County Pig Breeding Farm by our research group in 2003, with the objective to make full use of the economic crossing of the Tongcheng pig. The pigs were surveyed under conditions of access to unlimited water and unrestricted feed, with their diet containing 16.05% crude protein and 3.12 MJ/kg digestible energy during the growing-finishing period, and some of the resulting major growth performance indices, including the age at 75 kg body weight, average daily gain and feed-to-gain ratio, are shown in table 2. With regard to these four measures, the Tongcheng pig achieved lower scores than Landrace or Large White pigs. It is also clearly shown that the growth performances of the three-way crossing groups (Landrace/Yorkshire/Tongcheng pig and Yorkshire/Landrace/Tongcheng pig) using the Tongcheng pig as the maternal parent, have been improved.

Table 2. Growth performances of Tongcheng pig compared with Landrace, Yorkshire and three-way crossbred pigs.

	Sample size	Age(day) ^a	ADG ₁ (g) ^b	ADG ₂ (g) ^c	FCR ^d
Tongcheng pig	33	200.1±4.2	348.2±5.8	449.4±21.4	5.0
Landrace	30	169.7±3.2	522.2±7.4	862.9±14.8	3.1
Yorkshire	32	173.9±3.4	501.3±7.7	790.5±17.2	3.3
LYT	33	167.2±3.6	544.8±9.6	849.4±17.1	3.1
YLT	34	163.9±3.3	559.2±7.7	807.6±17.0	3.2

^aAge: the days from birth to marketing, Tongcheng pig is 75 kg and other four groups are 90 kg at marketing.

^bADG₁, Average daily gain whole term (from birth to marketing).

^cADG₂, Average daily gain during the trial (from days at 25 kg body weight for Tongcheng pig, 30 kg for other four pig groups to marketing).

^dFCR, Feed conversion rate during the trial.

Carcass Traits

Following a middle to high nutritional level feeding schedule and at a body weight of 75 kg, 33 Tongcheng pigs were slaughtered in Tongcheng County Meat Packing Plant for carcass performance testing. Meat production performances comprising more than twenty traits were measured in accordance with the national guidance on

technical standards of performance testing for lean meat type breeding pigs in China (GB8467-87). The seven important measures of the Tongcheng pig are shown in table 3 and are compared with Landrace and Large White pigs and two other three-way crossbred pigs. The Tongcheng pig has inferior pork production performance as shown by some traits such as carcass length, average backfat thickness and longissimus



Figure 7. The Longissimus muscle area and backfat thickness of Tongcheng pig (255#) in comparison to Landrace×(Yorkshire×Tongcheng pig) (878#).

Table 3. Carcass performances of Tongcheng pig compared with Landrace, Yorkshire and three-way crossbred pigs (Landrace x (Yorkshire x Tongcheng pig), LYT; Yorkshire x (Landrace x Tongcheng pig), YLT).

	Tongcheng pig			
	33	30	32	34
Sample size	33	30	32	34
Dressing percentage (%)	73.5±0.5	76.2±0.5	78.1±0.6	76.4±0.4
Carcass length Max.(cm)	80.2±0.7	94.2±0.7	91.9±0.7	92.1±0.6
Carcass length Min. (cm)	68.3±0.5	78.5±0.5	77.1±0.5	76.9±0.4
Number of ribs	13.8±0.1	15.6±0.1	15.5±0.1	15.2±0.1
Average backfat thickness at 3 points (mm)	40.5±1.0	21.0±1.1	30.4±1.3	31.4±0.9
Skin thickness (mm)	4.4±0.2	2.3±0.2	2.8±0.2	2.8±0.2
Longissimus muscle area (cm ²)	19.4±0.7	40.2±0.7	35.6±0.7	33.8±0.6
Percentage of leaf fat (%)	5.2±0.2	1.4±0.2	2.2±0.2	2.7±0.2
Percentage of leaf and caul fat (%)	10.3±0.3	2.9±0.3	3.7±0.4	4.8±0.0
Percentage of ham in the carcass (%)	27.3±0.4	32.2±0.3	30.9±0.4	30.9±0.3
Proportion of lean and bone of the ham (%)	56.3±0.9	79.4±0.9	75.2±1.0	72.7±0.8

Table 4. Meat quality testing of Tongcheng pig in comparison to Landrace, Yorkshire and three-way crossbred pigs: Landrace x (Yorkshire x Tongcheng pig), LYT; Yorkshire x (Landrace x Tongcheng pig), YLT.

	Tongcheng pig			
	33	30	32	34
Sample size	33	30	32	34
Meat color score	3.3	3.0	3.2	3.0
pH value at 45-60min postmortem	6.6±0.0	6.5±0.1	6.3±0.0	6.4±0.0
Water loss percentage (%)	13.5±0.6	13.3±0.6	14.6±0.6	13.5±0.5
Muscle drip loss (%)	1.6±0.1	1.8±0.1	1.7±0.2	1.8±0.1
Muscle shear force (kg.f)	4.4±0.2	4.2±0.2	4.9±0.2	3.9±0.1
Marbling score	2.7	2.5	1.9	2.2
Intramascular fat content (%)	3.3±0.1	1.8±0.1	1.6±0.1	2.3±0.1

muscle area, but it displays strong fat deposit inclination in areas such as flare fat and loose fat content (Figure 6, Figure 7). The carcass performances of the three-way crossing groups was to some extent higher than that of the Tongcheng pig.

Meat Quality Traits

The Tongcheng pig has superior meat quality exhibiting desirable flavor, juiciness and tenderness. Meat quality testing of 33 Tongcheng pigs was conducted according to the national guidance on technical standards of performance testing for lean meat type breeding pigs (GB8467-87), following the carcass testing implementation. Meat quality measures including seven traits of Tongcheng pigs are shown in table 4, and compared with Landrace and Large White pigs and two other three-way crossbred pigs. Water binding capacity, intramuscular fat content and pork tenderness in the Tongcheng pig surpassed those of the commercial pigs, which might be a major reason for the superior meat quality of the indigenous pig. The meat quality measures of the three-way crossing groups fell between those of the Tongcheng pig and the commercial pig breeds, which indicated that a crossing style based on the Tongcheng pig as the maternal and commercial pigs as the paternal parents was effective for meat quality improvement.

Conservation Measures

The state-owned pig breeding farm engaged in the preservation of the Tongcheng pig was first established in 1957. Tongcheng county was approved to be the key conservation region in Hubei Province in 1982. In 1998 the Tongcheng Pig Standard was put into effect and these standards contribute to the pure pig verification, selection and grading measures for the breeding herd. In 2000, the Tongcheng pig entered into the first national

indigenous domestic animals conservation lists in China.

In order to take effective measures for the preservation of Tongcheng pigs, conservation farms and protectorates have been set up simultaneously since the early 1980s. At the present time there are eight boars in Tongcheng County Pig Breeding Farm each of which came from different ancestral line. In addition, there are 80 breeding dams in this state-owned farm. Selection approaches such as equal offspring numbers selected from each pedigree and long generation interval are implemented for these breeding pigs. In addition, there are five major natural countryside protectorates including Wuli, Magang, Guangdao, Sizhuang and Daping in Tongcheng county. In these conservation regions, pure Tongcheng pigs and two-way crossing dams are retained, while three-way crossbred pigs and commercial pig breeds are banned. Boars can be introduced and exchanged frequently among these conservation farms and protectorates. The performance testing for these boars is evaluated regularly, and the elite boars in the protectorates are registered by local departments of animal husbandry and transferred to conservation farms, mating stations and AI stations for preservation and wide-ranging utilization.

The number of pure boars available is important for the effective conservation of domestic animals. It is estimated that there are 30 breeding boars in Tongcheng county, which came from 15 different heredities with two individuals representing each heredity. Eight of them are reared in the County Pig Breeding Farm, and the other 22 boars are retained in mating stations and AI stations in towns and the countryside. The annual allowance for each boar is about 125 US\$ which is offered by local departments of animal husbandry.

There are 80 dams in Tongcheng County Pig Breeding Farm and others distributed amongst small pig breeding farms in towns and the countryside, key conservation villages and private owners. To reduce the cost of conservation, dams are allowed to be

mated with commercial boars for the first five parities, and the resulting crossbred offspring sold. Pure herd mating can be carried on after five parities for the renewal of the conservation population. The annual allowance for each dam is about 50US\$. In order to encourage farmers to raise pure pigs in conservation regions, some preferential terms were afforded to local farmers, for example, free services for disease treatment and artificial insemination, and the facilities for piglet marketing (Xu and Wu, 2001).

To facilitate the management of Tongcheng pig information including numbers, distribution locations and the production performance and inbreeding situation, computer software for an indigenous pig conservation information management system was designed and applied in Tongcheng County Pig Breeding Farm (Huang *et al.*, 2005). A standard individual ear tagging system is also in place, which is similar to that of the national breeding pig genetic evaluation program in China (www.cav.net.cn).

Crossing Utilization

Using Tongcheng pigs as the maternal parent, two-way crossing testing was implemented with Large White, Landrace and Duroc pigs as the paternal parent. The mean heterosis estimates were 20% and 30% for the growth rate of piglets and weaning litter weight, respectively. The heterosis estimates of three-way crossing were 13.2-16.5%, 13% and 50% for litter size, rearing rate and weaning litter weight, respectively (Xu and Wu, 2001).

Being considered for high hybrid vigor, coat color and environmental fitness, the Tongcheng pig was introduced into the breeding process of the Hubei White Pig. During the crossbred testing launched in Huazhong Agricultural University from 1973 to 1978, the Landrace × (Yorkshire × Tongcheng pig) was confirmed to be a superior cross combination model. From 1978 to 1986 through a series of systematic breeding measures using successive generation selection, sib selection and selection index, the two new lines of Hubei White Pig III and Hubei White Pig IV were



Figure 8. The two-way crossing sow of Yorkshire × Tongcheng pig.



Figure 9. The three-way hybrid pig Landrace \times (Yorkshire \times Tongcheng pig) named 'Eqing No. 1'.

developed (Peng *et al.*, 1986). In the following years, selection measures were further focused on improving growth rate and backfat thickness, and the VII maternal line of Chinese lean meat type was then formed.

In order to develop hybrid pigs suitable for villages and mountain areas operating under a low level nutritional feed diet and extensive management system while maintaining their fine meat quality, a crossbreeding project was started in Tongcheng County Pig Breeding Farm in 2000, which was a co-operative research project and was sponsored by the Department of Animal Genetics and Breeding (Huazhong Agricultural University), Tongcheng County Pig Breeding farm and the Youth League Committee of Hubei Province. There are five experimental groups including three pure groups of Tongcheng pig, Landrace, Yorkshire, and two three-way cross combinations of Landrace \times (Yorkshire \times Tongcheng pig) and Yorkshire \times (Landrace \times Tongcheng pig). Growth traits measures were obtained

during the fattening-finishing term, and carcass traits and meat quality traits were measured for Tongcheng pigs at 75 kg body weight and for the other four groups at 90 kg. The performance testing results showed that the production traits of three-way crossbred pigs were improved, and they were superior to the Tongcheng pig in terms of growth and carcass traits and were better than the Landrace and Yorkshire pigs in terms of meat traits (Figure 8, Figure 9).

Landrace \times (Yorkshire \times Tongcheng pig) exceeded Yorkshire \times (Landrace \times Tongcheng pig) in terms of body conformation and carcass traits.

Genetic Diversity Evaluation

Molecular markers have been developed and applied widely in the studies of genetic diversity for domestic animals, and greatly contribute to the rational conservation and utilization of indigenous pigs. Huang and Zhou (1989) analyzed the genetic relationships of six pig breeds with the

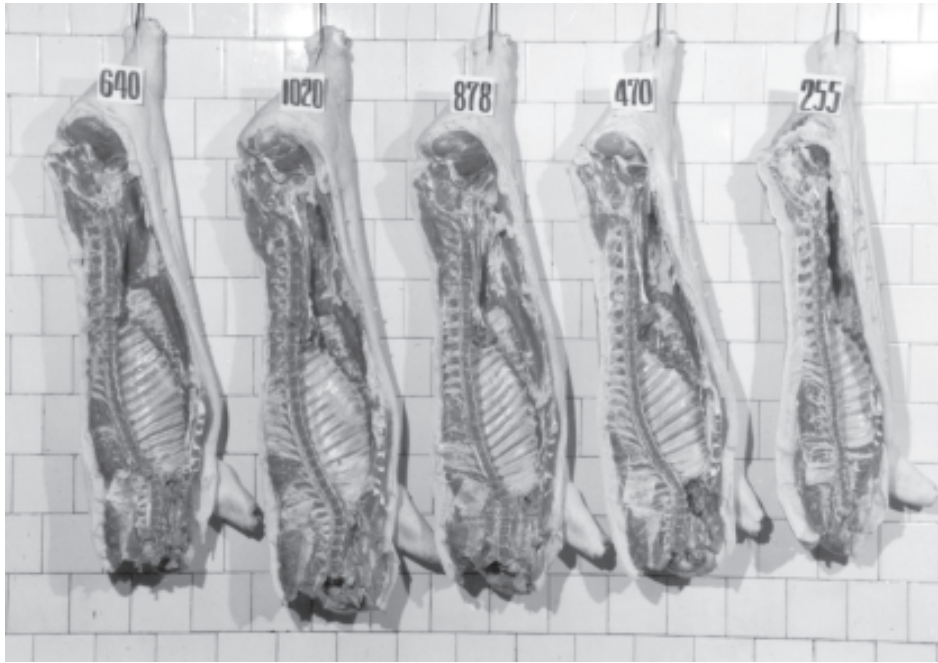


Figure 6. Carcass (left side) of Tongcheng pig (255#) in comparison to Landrace (1020#), Yorkshire (640#), Landrace×(Yorkshire×Tongcheng Pig) (878#) and Yorkshire ×(Landrace×Tongcheng Pig) (470#).

common appearance of 'Two-End-Black' using blood polymorphic markers, and suggested that these pigs are of one origin though they had different names. Recently, based on polymorphism analysis of ten blood protein loci, the genetic heterozygosity of the Tongcheng pig was 0.345 and it has the least distance from the Huainan Pig (Xiao *et al.*, 2004).

Revealed by DNA fingerprint and RAPD analysis, the Tongcheng pig was found to have higher genetic homogeneity than Qingping, Large White or Hubei White pigs, and had the least relationship with Hubei White pig (Jian 1998). The results from microsatellites detection demonstrated that the Tongcheng pig had a heterozygosity of 0.7489 and had a closer relationship with the Qingping pig, another pig breed in Hubei Province (Fan *et al.*, 1999). Recently, the national project 'Measure of Genetic Distances Among Indigenous Pig Breeds in China', started by the Ministry of Agriculture in 2000, has been completed. The Tongcheng pig had a mean genetic heterozygosity of

0.82 on the basis of 25 microsatellite loci and could be classified into the New Huazhong Type, while surprisingly it was far from other 'Two-End-Black' pig populations (Zhang *et al.*, 2003). Furthermore, Yang *et al.* (2003) presented the phylogenetic relationships of indigenous pigs using the near-complete mtDNA sequencing, and the Tongcheng pig was shown to have the closest relationship with Yushan Black Pig.

Conclusions

The Tongcheng pig represents a good maternal line in crossing programs and provides valuable breeding material for the development of new swine breeds, lines and cross combinations. The current measures on conservation and utilization play important roles for the maintenance of the Tongcheng pig, and their implementation would also be advisable for the preservation of other indigenous pig breeds in China.

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