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PHAM HAI NINH

**BIOLOGICAL CHARACTERISTICS AND PRODUCTIVITY
OF HUONG PIG**

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EXECUTIVE SUMMARY OF PhD THESIS

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Supervisors:

1. PhD. Pham Cong Thieu
2. Assoc. Prof. PhD. Le Thi Thanh Huyen

Reviewer 1: Assoc. Prof. PhD. Phan Xuan Hao

Reviewer 2: Assoc. Prof. PhD. Nguyen Manh Ha

Reviewer 3: PhD. Pham Sy Tiep

The dissertation will be defended in front of the PhD thesis evaluation committee of the institute level at National Institute of Animal Science, Thuy Phuong, Bac Tu Liem, Ha Noi

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PUBLISHED PAPERS RELATED TO THE THESIS

1. Carcass performance and quality of Huong pork. Journal of Livestock Science and Technology No. 276, April 2022, pp. 14-24.
2. Reproductive production of Huong pigs over three generations. Journal of Livestock Science and Technology No. 281, October 2022, pp. 15-23.

INTRODUCTION

1. RATIONABLE

Vietnam is a country with high biodiversity and various animal gene resources, especially indigenous pig breeds. Huong pig was originated from some highland districts along Vietnam - China border at Cao Bang province long time ago. Previously, there have been some authors doing research in Huong pig (e.g.: Nguyen Van Ba et al., 2016; Pham Cong Thieu, 2017; Nguyen Hung Cuong, 2018; Nguyen Hoang Thinh et al., 2019). However, these studies were mainly focused on conformation description, evaluation of reproductive performance and growth rate of Huong pig. Biological characteristics, reproductive performance through selection of generations, growth ability, performance, meat quality and especially have not been systematically studied, especially there was no studies on the nutritional value and composition of meat, saturated and unsaturated fatty acid contents in Huong loin. Therefore, the study "Biological characteristics and productivity of Huong pig" was conducted.

2. OBJECTIVE OF STUDY

2.1. Overall objective

Some biological characteristics and production abilities of Huong pig have been identified in order to contribute to biodiversity conservation as well as to effective exploitation and Huong pig gene resource development in our country.

2.2. Specific objective

Some biological characteristics of Huong pig have been identified through three selective generations.

Reproductive performance of Huong pig has been evaluated through three selective generations.

Growth ability, carcass yield and meat quality of Huong pig have been evaluated.

3. SCIENTIFIC AND PRACTICAL VALUE OF THESIS

3.1. Scientific value

The thesis is a systematic study from a detailed and complete description of conformation, physiological and physiological characteristics of gilts, reproductive performance of sows, growth ability, carcass quality and Huong pork quality.

The research results have been provided a scientific basis for selection of Huong pig bred and are valuable references for conservation, scientific research and lecture.

3.2. Practical value

The research results of the study are scientific basis for faster conservation, storage and selection and more exact way in improving productivity and quality of Huong breed pig for production and trade, high quality products in the midland and mountainous provinces, especially in the trend of biosafety farming towards organic.

The results of the research have selected for Huong pig herd over three generations, which is a valuable gene resource for conservation, exploitation and development, and an important source of raw materials for genetic work in Vietnamese pig selection, especially in organic farming.

4. NEW CONTRIBUTIONS OF THESIS

The thesis is a systematic scientific research work from biological characteristics to reproductive performance, growth ability, carcass performance and quality of Huong pork. Especially, amino acids and fatty acids were identified, in which the content of Glutamic acid, Linoleic acid (Omega-6), Oleic acid (Omega-9) was higher than that of some other pig breeds.

The results of thesis have been contributed to the orientation of conservation, exploitation and effective and sustainable development of Huong pig gene resources.

CHAPTER 1. LITERATURE REVIEW

1.1. SCIENTIFIC BASIS OF THE THESIS

On the basis of analysis and evaluation of the results published in national and international, there have been a number of studies on Huong breed pig in recent years. However, up to now, there has been almost no studies that have conducted in-depth and systematic research on biological characteristics, productivity of Huong pigs and especially there have not been any study on nutrient composition, value in meat, saturated and unsaturated fatty acids content of Huong pork loin. This is the reason why the current study conducted to evaluate the biological characteristics and productivity of Huong pigs over three generations.

1.2. SITUATION OF RELEVANT RESEARCHES IN VIETNAM AND INTERNATION

The thesis has evaluated the situation of national and international researches on biological characteristics and productivity of indigenous pig breeds in general and Huong breed pig in particular.

On the basis of analysis and evaluation of the results published in national and international journals, there have been a number of studies on Huong breed pig in recent years. However, those studies mainly focus on conformation, evaluating reproductive performance and growth ability of Huong pig. Up to the present time, almost no research has conducted in-depth and systematic research on biological characteristics, reproductive performance through selective generations, growth ability, performance, quality. Especially, there have not been

any studies on nutritional value composition of meat, the content of saturated and unsaturated fatty acids in Huong loin. Therefore, the evaluation of biological characteristics and productivity of Huong pig over generations is necessary.

CHAPTER 2. CONTENTS AND METHODS

2.1. Materials

2.1.1. Objectives

Reproductive Huong pig herd was raised through three generations: 60 sows of the first generation with 263 litters, 40 sows of the second generation with 173 litters and 30 sows of the third generation with 150 litters.

Commercial Huong pig herd: 293 Huong pigs (166 females and 127 castrated males) were born from the 3rd generation at the ages from 50 days to 8 months.

An examination slaughtering of 8 pigs (4 females and 4 castrated males) at the age of 8 months was implemented to evaluate carcass yield and Huong pork quality.

2.1.2. Study area

Reproductive Huong pig herd over three generations was raised at Cao Bang Agricultural and Forestry Breeding and Extension Center and Thien Thuan Tuong Quang Ninh Mining Joint Stock Company.

Commercial Huong pig herd was raised at Thien Thuan Tuong Quang Ninh Mining Joint Stock Company.

Quality and chemical compositions of Huong pork were analyzed at the National Institute of Food Safety and Hygiene, Ministry of Health.

2.1.3. Study duration

From January 2017 to June 2022, research was conducted on

Huong pigs that reproduced through three generations.

From September 2020 to April 2021, research on commercial Huong pig herds.

April-May, 2021: An examination slaughter was conducted to evaluate carcass performance and quality of Huong pork.

2.2. Study contents

Research on biological characteristics of Huong pig over three generations.

Research on productivity of Huong pig.

2.3. Methods

2.3.1. Research on biological characteristics of Huong pig over three generations

2.3.1.1. Research on conformation of Huong pigs

The physical characteristics were studied and identified on 528 purebred Huong pigs through 3 selective generations at 8 months of age by common measurement and obsestive methods.

2.3.1.2. Measurement of some basic body dimentions

A stick and a tape were used to directly measure the size of several body dimensions of pig to identify the conformation, 30 females and 30 males at 8 months age was randomly selected from each generation.

2.3.1.3. Research on physiological parameters of gilts

60 gilts of the 1st generation, 40 gilts of the 2nd generation and 30 gilts of the 3rd generation were recorded. Recording indicators include: Age at first estrus (days), age at the first sucessfully mating(day), weight at the first conception (kg), age at the first farrowing (day) and estrus cycle (day).

2.3.2. Research on productivity of Huong pig

2.3.2.1. Research on productivity of Huong pig over 3 generations

To determine the reproductive performance criteria of pig herd before selection, the research used the method of observing and recording over 60 breeding sows and used the 6 best boars at the 1st generation (263 litters), 40 breeding sows and used the 4 best boars at the 2nd generation (173 litters), and 30 breeding sows and the 3 best boars at 3rd generation (150 litters) from parity 1 to parity ≥ 6 . After the 2 first farrowings, good Huong pigs in each generation were selected and unqualified individuals were discarded. The study was conducted simultaneous selection of Huong pigs over 3 generations according to phenotypes with some main selection criteria such as: hair color, number of newborn piglets/litter, number of a live newborn piglets/litter, number of weaned piglets/litter newborn piglet weight/litter and weaned piglet weight/ litter. Reproductive parameters of Huong pig over 3 generations were determined according to the National Standard TCVN 11910:2018.

2.3.2.2. Evaluation of growth rate, carcass yield and quality of commercial Huong pork

** For growth rate*

Experimental layout: 293 piglets (127 castrated males and 166 females) from 50 days of age to slaughter at 8 months of age in litters with typical characteristics of Huong breed pig were considered in this study.

Methods and monitoring indicators: weaned weight was recorded at, 3, 4, 5, 6, 7 and 8 months of age. The study indicators include body weight (kg/pig), average daily weight gain (g/day) and relative growth in weight (%).

** For carcass performance and meat quality*

Slaughter for survey was carried out according to Vietnam Standard (TCVN 3899-84) to evaluate carcass performance and take loin samples to analyze meat quality. A total of 8 pigs (4 castrated males and 4 female pigs) born from maternal pigs and different litters were obtained from commercial Huong pig production model, whose body weights were randomly selected around the population mean for examination surgery. Each loin muscle sample, each weighing about 0.5 kg, was taken at the position between the 10th-14th ribs right away after the pig was slaughtered to evaluate the meat quality criteria and analyze the chemical composition of the meat.

Evaluation of Huong carcass performance: Weighing to determine slaughtered weight, dressing carcass percentage, carcass percentage, lean percentage, fat percentage, bone and skin percentage, carcass length and back fat thickness according to TCVN 3899-84.

Evaluation of meat quality: pH value of loin muscle, meat color were evaluated according to method of Warner et al. (1997), the rates of dehydration during storage and processing after 24 and 48 hours were measured according to the method of Honikel (1998), chemical composition of loin, amino acids and composition of saturated and unsaturated fatty acids according to TCVN.

2.4. Data analysis

The data were analysed by using biological statistical software, Excel program, SAS9.1 with general linear model (GLM).

CHAPTER 3. RESULTS AND DISCUSSIONS

3.1. Biological characteristics of Huong pig

3.1.1. Conformation

3.1.1.1. Hair and skin color characteristics

All Huong pigs had white hairs and belly skin (100%), most of them had black spots on the head and rump, accounting for 72.50% in the 1st generation, 86.73% in the 2nd generation, and 95.35% in the 3rd generation. The proportions of pigs with black spots on the back and shoulders was decreased sharply over the generations, from 16.25% (the 1st generation) to 4.07% (the 3rd generation); Pigs with black and white streaks were decreased gradually over generations, from 11.25% (the 1st generation) to 0.58% (the 3rd generation).

3.1.1.2. Body shape

** Hair morphology and density*

Huong pig over 3 generations with straight hair was accounted for majority, from 95.63 (the 1st generation) to 96.51% (the 3rd generation); The percentage of pigs with curvled hair was very low (3.49-4.37%). Percentage of Huong pigs with average hair density was accounted for the highest (56.88-57.14%); followed by thick hairs (28.06-28.49%) and the lowest was sparse hair (14.53-15.00%).

** Skin morphology*

The rough skin percentage of Huong pig was the highest with 43.37-46.51% and wrinkled skin was 40.70-41.84%, and only a small percentage of smooth skin (12.50-14.79) %).

** Face and muzzle shape*

The percentage of straight faces accounted for 96.88% (the 1st generation), 97.96% (the 2nd generation) and 98.26% (the 3rd generation). The long snout percentage of Huong pig accounted for 94.38-95.93% over 3 generations, short snout percentage was very low (3.06-5.62%).

** Ear shape*

The perforated ears of Huong pig accounted for the majority over 3 generations (73.75-81.93%), the horizontal ear accounted low percentage (18.02-26.25%).

** Back and belly shape*

Maily Huong pigs had saggy back (88.75-89.53%), straight back and arched back percentages were low, a sagging belly was the majority (74.38-80.81%), slim belly percentage was low (19.19-25.62%).

** Walking style*

Huong pig were mainly hoofed, accounting for 96.88% in the 1st generation, 97.96% in the 2nd generation and 98.26% in the 3rd generation.

** Number of teats*

The even teat percentage of Huong pig was high, in which 10 main teats was 61.63-68.75%, followed by pigs with 12 teats (20.63-30.81%).

3.1.1.3. Size of some body dimentionns

The body length of Huong pig over 3 generations was ranged from 63.38-65.55cm, shoulder height was 36.65-37.63cm. Body length and shoulder height were higher in boars than in female pigs in all 3 generations ($P>0.05$).

The head length of Huong pig over 3 generations was ranged from 25.12 to 26.33cm; there was differences in generation 1 compared to generation 2 and 3 ($P<0.05$), but there was no differences between generation 2 and generation 3 ($P>0.05$). The indicator of head length of Huong sows over 3 generations was 24.63-26.00 and there was a difference between the 1st generation and the 2nd generation ($P<0.05$) but no difference compared to the 3rd generation ($P >0.05$); Huong males over 3 generations were 25.60-26.67cm ($P>0.05$).

The average ear length of Huong pig over 3 generations ranged from 9.55-10.60cm, and there was a significant difference between the 2nd and 3rd generation and the 1st generation ($P<0.05$), but there was no difference between the 2nd and 3rd generation ($P>0.05$). The ear length in three generations of Huong males and females ranged 9.50-10.47cm and 9.60-10.73cm, respectively ($P>0.05$).

3.1.2. Physiological characteristics of Huong gilts

3.1.2.1. Factors influencing physiological and sexual characteristics of Huong gilts

For Huong gilts, the generation factor did not influence to research parameters on sexual physiology.

Table 3.1. Factors influencing to reproductive physiology of Huong gilts

Indicators	Generation	Parity
Age at the first estrus	ns	***
Age at the first conception	ns	***
Body weight at the first conception	ns	*
Age at the first farrowing	ns	***

*Note: ns: $P\geq 0,05$; *: $P<0,05$ and ***: $P<0,001$.*

** Maternal parity: gilts born at parities of sows were observed.*

Maternal parity factors that significantly influenced to physiological and reproductive traits were age at the first heating, age at mating with the first pregnancy and age at the first farrowing ($P<0.001$).

3.1.2.2. Age at the first heating

The first heating of Huong pig was the earliest age in litter 4 with 185.99 days and the earliest in litter 5 was 163.60 days. Maternal age 5 was a statistically significant different compared to litter 3 and 4 ($P<0.05$) but there was no difference in litter 2 ($P>0.05$).

The age at the first heating of Huong pig in the 1st generation was 174.34 days, 3.14 days earlier compared to the 2nd generation and 0.8 days earlier compared to the 3rd generation, but there was no difference among 3 generations. $P>0.05$). Thus, Huong pig over 3 selective generations was a relatively stable in the age at the first heating.

3.1.2.3. Age at the first conception

The age at the first conception of Huong pig was different among mothers. The gilts born from litter 5 with the age of successful mating for the first time as early as 212.51 days, 21.76-23.96 earlier than litters 3 and 4 ($P<0.05$) and 8, 72 days compared to the second litter, but the difference was not statistically significant ($P>0.05$). The age at the first conception of Huong pig in the 3rd generation was 225.51 days, 1.45 days earlier than that of the 2nd generation and 0.38 days in the 1st generation, but the difference among 3 generations was not statistically significant ($P>0.05$).

3.1.2.4. Body weight at the first conception

The weights at the first conception of Huong sow through parities 2, 3 and 5 was similar and ranged from 36.21 to 36.54 kg/head ($P>0.05$); 3.61-3.94 kg lower than the 4th parity of sow and the difference was statistically significant ($P<0.05$). After 3 generations, the body weight at the first conception of Huong sow was 36.32-38.04 kg and there was no difference between 3 generations in terms of body weight at the first conception ($P>0.05$).

3.1.2.5. Age at the first farrowing

According to the litter of maternal pig, the age at the first farrowing of Huong pig born from parity 5 was the earliest with 326.49 days; 21.58-23.78 days earlier than parity 3 and 4 ($P<0.05$) and 8.51 days compared to parity 2 but there was no difference

($P>0.05$). By generation, the age at the first farrowing of Huong pig was ranged from 339.32 to 340.98 days and there was no difference among 3 generations ($P>0.05$).

3.2. Productivity of Huong pigs

3.2.1. Reproductive performance of Huong sows

3.2.1.1. Factors influencing to reproductive performance of Huong sows

The generation factor almost did not influence to research parameters on reproductive performance of Huong sows, except for weight of newborn piglets /litter. External factors such as season and year of birth also did not influence to reproductive performance of sows. Meanwhile, the parity factor significantly influenced to most reproductive traits of Huong pig ($P<0.001$) and significantly influenced to parity interval trait ($P<0.01$).

Table 3.2. Factors influencing to reproductive performance of Huong sows

Indicators	Maternal parity	Generation	Parity	Season	Year
Number of newborn piglets/litter	**	*	***	ns	ns
Number of weaned piglets/litter	**	ns	***	ns	ns
Weight of newborn piglets/litter	**	ns	***	ns	ns
Weight of weaned piglets/litter	**	*	***	ns	ns
Parity interval	*	ns	**	ns	ns

Note: ns: $P\geq 0,05$; *: $P<0,05$; **: $P<0,01$ and ***: $P<0,001$.

3.2.1.2. Number of newborn piglets per litter and influencing factors

The number of newborn piglets per litter of Huong pig was the highest of 9.34 piglets in the second parity; decreased to 9.21 piglets from the 3rd parity; 8.86 piglets from the 4th parity and 9.04 piglets from the 5th parity. The number of newborn piglets per litter in the 2nd parity was different from that in the 4th parity ($P < 0.05$), but there was no difference compared to the 3rd and 5th parities ($P > 0.05$), while the 3rd parity was significant different with the 4th parity, but there was no difference compared to the 5th parity ($P > 0.05$).

Consideration of Huong pig over 3 generations, the results showed that number of newborn piglets per litter in the first generation was the lowest of 8.71 piglets; increased to 9.25 piglets in the 2nd generation and the highest of 9.38 piglets in the 3rd generation. The comparison among 3 generations showed that the number of newborn piglets in the 3rd generation was increased by 0.13 piglets (1.41%) compared to the 2nd generation and 0.67 piglets (7.69%) compared to the 1st generation. In comparison with the difference in the number of newborn piglets, there was a difference between the 1st generation compared to the 2nd and 3rd generation ($P < 0.05$).

Over parities, the lowest number of newborn piglets per litter in parity 1 was 8.59 piglets; increased in parity 2 was 9.37 piglets; the highest in parity 3 of 9.53 piglets; the 4th generation started showing signs of decreasing to 9.26 piglets; litter 5 was 9.08 piglets and litter ≥ 6 was 8.84 piglets. The number of newborn piglets per litter at parity 1 was different from that of the 2nd, 3rd, 4th and 5th parities ($P < 0.05$), but not different from the ≥ 6 th parity ($P > 0.05$). The number of newborn piglets per litter of Huong pig in the Winter-Spring season was 9.10 piglets, lower than in the Summer-Autumn season of 9.12 piglets ($P > 0.05$). The indicator of number of newborn

piglets per litter in 6 years (2017-2022) was fluctuated from 9.03 to 9.26 piglets ($P>0.05$).

3.2.1.3. Number of alive newborn piglets /litter and influencing factors

The number of alive newborn piglets /litter of Huong pig that born from the second parity was 8.53 piglets; was the highest from the 3rd parity with 8.62 piglets; 8.22 piglets in the 4th parity and the lowest was 8.18 piglets born from 5th parity. The number of alive newborn piglets per litter in the 3rd parity was statistically significant different compared to the 4th and 5th parities ($P<0.05$), but there was no difference from the 2nd parity ($P>0.05$), while the 2nd parity was no different with the 4th parity ($P>0.05$), but there was a difference with the 5th parity ($P<0.05$). After 3 generations, the number of alive newborn/litter per litter was the lowest in the 1st generation (8.00 piglets); increased to 8.33 piglets in the 2nd generation and the highest in the 3rd generation (8.84 piglets). The number of alive newborn piglets /litter in the 3rd generation was increased by 0.51 piglets (6.12%) compared to the 2nd generation, and 0.84 piglets (10.5%) compared to the 1st generation. Statistical comparison showed that there was significant difference between the 3rd generation compared to the 1st and 2nd generations ($P<0.05$), but there was no difference between the 1st and 2nd generations ($P>0.05$).

Table 3.3. Number of alive newborn/litter of Huong pig (pig)

Factors	n (litters)	LSM \pm SE
Maternal parity	2	8.53 ^{ab} \pm 0.08
	3	8.62 ^a \pm 0.16
	4	8.22 ^{bc} \pm 0.16
	5	8.18 ^c \pm 0.14

Generation	1	263	8.00 ^b ±0.14
	2	173	8.33 ^b ±0.16
	3	150	8.84 ^a ±0.25
Parity	1	129	7.72 ^d ±0.15
	2	127	8.56 ^{bc} ±0.12
	3	91	8.94 ^a ±0.12
	4	91	8.78 ^{ab} ±0.13
	5	91	8.28 ^c ±0.17
	≥6	57	8.06 ^{cd} ±0.30

Note: In the same row, LSM values with different letters are statistically significant differences $P < 0.05$.

The number of alive newborn piglets per litter of Huong pig was significantly different among parities, the 1st parity was significantly different ($P < 0.05$) compared to the 2nd, 3th, 4th, 5th parities, but not different from ≥ 6 th parities ($P > 0.05$). The number of alive newborn piglets per litter of Huong pig in the Winter-Spring season was 8.40, higher than that of the Summer-Autumn with 8.38 piglets ($P > 0.05$). Similarly, the number of alive newborn piglets per litter in 6 years (from 2017 to 2022) ranged from 8.29 to 8.53 piglets ($P > 0.05$).

3.2.1.4. Number of weaned piglets/litter and influencing factors

The number of weaned piglets per litter of Huong pig born from the second parity was highest with 8.05 piglets; followed by the third maternal litter was 8.04 piglets; 7.70 piglets from the 4th parity and the lowest was 7.58 piglets in the 5th parity. The number of weaned piglets per litter born from the 3rd parity was significantly different compared to the 4th and 5th parities ($P < 0.05$), but there was no difference compared to the 2nd parity ($P > 0.05$), while from the 2nd parity was different with the 5th parity ($P < 0.05$), but there was no difference compared to the 4th parity ($P > 0.05$).

Table 3.4. Number of weaned pig per litter of Huong pig (pig)

Factors		n (litters)	LSM±SE
Maternal parity	2	358	8.05 ^{ab} ±0.09
	3	67	8.04 ^a ±0.16
	4	67	7.70 ^{bc} ±0.16
	5	94	7.58 ^c ±0.15
Generation	1	263	7.42 ^b ±0.14
	2	173	7.84 ^b ±0.16
	3	150	8.26 ^a ±0.26
Parity	1	129	7.16 ^c ±0.15
	2	127	7.85 ^b ±0.12
	3	91	8.41 ^a ±0.13
	4	91	8.21 ^a ±0.14
	5	91	7.82 ^b ±0.17
	≥6	57	7.61 ^{bc} ±0.31

Note: In the same row, LSM values with different letters are statistically significant differences $P < 0.05$.

The number of weaned piglets per litter of Huong pig was increased over generations, specifically, the lowest was 7.42 piglets from the 1st generation; increased to 7.84 piglets from the 2nd generation and the highest was 8.26 piglets in the 3rd generation. The comparison among 3 generations showed that from the 3rd generation, an increase of 0.42 pig (5.36%) compared to the 2nd generation and 0.84 pig (11.32%) compared with the first generation. There was a statistical difference among the 3rd generation and the 1st and 2nd generations ($P < 0.05$), but there was no difference between generation 1 and generation 2 ($P > 0.05$). The number of weaned piglets per litter of Huong pig was increased gradually from the first to the third parity, then tended to decrease gradually and was

lowest at parity ≥ 6 . There was no difference in the number of weaned piglet/litter in parities 3 and 4 ($P > 0.05$), but there was a statistically significant difference with all other parities ($P < 0.05$).

3.2.1.5. *Body weight of newborn piglets/litter and influencing factors*

The body weight of newborn piglets/litter of Huong pig born from the second parity was 3.79kg; the highest in the 3rd parity was 3.83kg; 3.64kg from the 4th parity and the lowest was 3.62kg from 5th parity. The body weight of newborn/litter in the 3rd parity was statistically significant different with the 4th and 5th parities ($P < 0.05$), but there was no difference compared to the 2nd parity ($P > 0.05$), while the 2nd parity had difference with the 5th parity ($P < 0.05$), but there was no difference compared to the 4th parity. The body weight of newborn piglets/litter of Huong pig in the first generation was 3.56kg; lower than the 2nd generation with 3.71kg and the 3rd generation with 3.88kg ($P > 0.05$). The body weight of newborn piglets/litter was different among parities, specifically, 3.40kg at the first parity; increased to 3.84kg at the second parity; the highest was 3.97kg at the 3rd parity; 3.85kg at the 4th parity and 3.63kg at the 5th and 6th parities.

Table 3.5. Body weight of newborn/litter of Huong pig (kg)

Factors		n (litters)	LSM±SE
Maternal parity	2	358	3.79 ^{ab} ±0.04
	3	67	3.83 ^a ±0.08
	4	67	3.64 ^{bc} ±0.08
	5	94	3.62 ^c ±0.07
Generation	1	263	3.56±0.07
	2	173	3.71±0.08
	3	150	3.88±0.12

Parity	1	129	3.40 ^c ±0.07
	2	127	3.84 ^b ±0.06
	3	91	3.97 ^a ±0.06
	4	91	3.85 ^{ab} ±0.06
	5	91	3.63 ^c ±0.08
	≥6	57	3.63 ^{bc} ±0.15

Note: In the same row, LSM values with different letters are statistically significant differences $P < 0.05$.

Comparison in body weight of newborn piglets/litter showed that the 3rd parity had a statistically significant difference with parities 1, 2, 5 and ≥6 ($P < 0.05$), but there was no difference with the 4th parity ($P > 0.05$). However, parity 4 was only significant different with parities 1 and 5 ($P < 0.05$), but not different from parity 2 and ≥6 ($P > 0.05$). There was no difference in body weight of newborn piglets per litter of Huong pig in terms of season and born year ($P > 0.05$).

3.2.1.6. Body weight of weaned piglets/litter and influencing factors

The body weight of weaned piglets/litter of Huong pig from mother born in the second litter was 34.48kg; similar to the third maternal's parity was 34.83kg; The 4th parity was 32.85kg and the lowest was 32.47kg from the 5th parity. The body weight of weaned piglets per litter from the 3rd parity was statistically significant different compared to the 4th and 5th parities ($P < 0.05$), but there was no difference compared to the 2nd parity ($P > 0.05$), while the 2nd parity was a different with the 5th parity ($P < 0.05$), but there was no difference compared to the 4th parity ($P > 0.05$). The body weight of weaned pigs/litter of the 1st generation Huong pig was 31.40kg, the 2nd generation was 33.61kg and the 3rd generation was 35.96 kg/litter.

Comparison among 3 generations, it was found that the body weight of weaned piglets per litter from the 3rd generation was 2.35kg (6.99%) higher than that of the 2nd generation and 4.56kg (14,99%) from the 1st generation (52%). Statistical comparison shows that there was no difference in weaned piglet weight per litter of Huong pig in generation 1 and generation 2 ($P > 0.05$), but there was a statistically significant difference with generation 3 ($P > 0.05$). The body weight of weaned piglets/litter also was different among parities, specifically reached 30.11kg at parity 1; increased to 33.33kg at the second parity; highest was 36.79kg in the 3rd parity; 35.76kg in the 4th parity; 34.04kg in the 5th parity and 31.90kg in the ≥ 6 th parity. Statistical comparison was showed that there was no difference in seasonal factors and born year in terms of weaned piglet weight per litter ($P > 0.05$).

Table 3.6. Body weight of weaned pigs/litter of Huong pig (kg)

Factors		n (litters)	LSM \pm SE
Maternal parity	2	357	34.48 ^{ab} \pm 0.41
	3	67	34.83 ^a \pm 0.76
	4	67	32.85 ^{bc} \pm 0.76
	5	94	32.47 ^c \pm 0.70
Generation	1	263	31.40 ^b \pm 0.68
	2	172	33.61 ^b \pm 0.78
	3	150	35.96 ^a \pm 1.23
Parity	1	129	30.11 ^c \pm 0.71
	2	127	33.33 ^b \pm 0.59
	3	91	36.79 ^a \pm 0.61
	4	91	35.76 ^a \pm 0.65
	5	90	34.04 ^b \pm 0.81
	≥ 6	57	31.90 ^{bc} \pm 1.47

Note: In the same row, LSM values with different letters are statistically significant differences $P < 0.05$.

3.2.1.7. Farrowing interval and influencing factors

The farrowing interval of Huong pig born from the 2nd litter was 168.84 days; increased to 170.79 and 173.41 days from the 3rd, 4th and 5th parities with 169.79 days. Farrowing interval of Huong pig in the 2nd and 5th parities was a significantly different ($P < 0.05$) compared to the 4th parity, but there was no difference compared to the third parity. The farrowing interval of Huong pig over 3 generations was 173.09 days in the 1st generation, decreased to 168.71 days in the 2nd generation and 170.32 days in the 3rd generation ($P > 0.05$). The farrowing interval of Huong pig was different between parities. Specifically, the farrowing interval of Huong pig was the shortest in parity 2-3 and 4-5, reached 167.47 and 168.73 days ($P > 0.05$), respectively, followed by parities 5-6, 3-4 and 1-2 were 170.89 respectively; 171.46 and 172.05 days. Parities 1-2, 3-4 and ≥ 6 were significantly different with parities 2-3 ($P < 0.05$), but there was no difference compared to other parities ($P > 0.05$). Research results also show that there was no difference and difference in seasonal factors and born year on this indicator ($P > 0.05$).

3.2.2. Growth rate, carcass yield and quality of commercial Huong pork

3.2.2.1. Growth rate of commercial Huong pig

** Body weight of commercial Huong pig*

The body weight of Huong pig at 50 days of age was 4.95 kg/pig. Body weight of Huong pig tends to increase over the months of age during time of fattening, specifically: on average of 9.92kg at 3 months of age; 17.40kg at 4 months; 25.84kg at 5 months; 34.43kg at 6 months; 39.22 kg at 7 months; and 42.72 kg at 8 months of age. The growth rate of castrated males was higher than female pigs at the same age and there was a significant difference ($P < 0.001$) at all stages.

Table 3.7. Body weight of commercial Huong pig over months of age (kg)

Months of age	Female (n=166)	Castrated male (n=127)	Average (n=293)
Weaned	4.79 ^b ±0.04	5.15 ^a ±0.05	4.95±0.03
3	9.58 ^b ±0.06	10.36 ^a ±0.07	9.92±0.05
4	16.95 ^b ±0.10	17.99 ^a ±0.13	17.40±0.09
5	25.09 ^b ±0.09	26.82 ^a ±0.08	25.84±0.08
6	33.25 ^b ±0.12	35.98 ^a ±0.12	34.43±0.12
7	38.10 ^b ±0.11	40.69 ^a ±0.11	39.22±0.11
8	40.98 ^b ±0.16	45.00 ^a ±0.18	42.72±0.17

Note: In the same row, LSM values with different letters are statistically significant differences $P < 0.05$.

** Body weight gain of commercial Huong pigs*

The average body weight gain of commercially raised Huong pig over the months from weaned to the 8th month of age was 124.25; 249.49; 272.21; 286.40; 154.46, 116.72 g/day, respectively. The average body weight gain of the whole period was 196.75 g/day. The average body weight gain of castrated males over the whole period of was 207.58 g/day, which was higher than that of the female pigs with an average weight gain of 188.46 g/day and there was a very significant difference ($P < 0.001$).

** Relative growth rate in body weight of commercial Huong pigs*

For castrated males, the relative growth rate in body weight of Huong pig from weaning to 3 months of age was 67.26%; decreased to 53.74% at 3-4 months of age, then decreased very quickly to 39.59% in the period of 4-5 months of age. For Huong females from weaned to 3 months of age, the growth rate was 66.65%; then decreased to 55.54% during 3-4 months of age; rapidly decreased to 38.88% in the period of 4-5 months of age. The end of 8 months of age, the growth

rate for castrated males was 10.00% and for females was 7.24%; and an average of growth rate was 8.44%. Between castrated males and females, the relative growth rates of body weight at weaned-3 months and 4-5 months of age were similar and the difference was not statistically significant ($P>0, 05$), while in the remaining age stages, the relative growth in body weight gain of the castrated male and female pigs was significantly different ($P<0.05$).

3.2.2.2. Carcass performance of Huong pork

The dressing carcass percentage of castrated males was tended to be higher than that of female pigs ($P>0.05$) and the average was 74.21%. The carcass rate of Huong pig was 64.50% in castrated males, 62.11% higher than that of female pigs and 63.31% on average of castrated males and female pigs.

Table 3.8. Carcass performance of Huong pork

Indicators	Females (n=4)	Castrated males (n=4)	Average (n=8)
Slaughter weight (kg)	39.63 ^b ±0.85	44.63 ^a ±1.28	42.13±1.18
Dressing carcass percentage (%)	73.37±1.59	75.04±0.53	74.21±0.84
Carcass percentage (%)	62.11±1.00	64.50±0.41	63.31±0.67
Lean percentage (%)	41.27±0.59	42.12±0.64	41.69±0.43
Fat percentage (%)	34.77 ^a ±0.43	29.13 ^b ±0.59	31.95±1.12
Skin percentage (%)	11.89 ^b ±0.23	13.42 ^a ±0.48	12.65±0.38
Bone percentage (%)	12.08 ^b ±0.39	15.33 ^a ±0.53	13.71±0.69
Carcass length (cm)	54.75 ^b ±1.36	63.95 ^a ±1.05	59.35±1.91
Back fat thickness (mm)	25.60±0.09	24.30±0.09	25.00±0.06

Note: In the same row, LSM values with different letters are statistically significant differences $P<0.05$.

The lean percentage of castrated male Huong pig was a higher than that of female pigs ($P>0.05$) and the average was 41.69%; The

average fat percentage was 31.95%, in which female pigs tended to accumulate more fat than castrated males ($P < 0.05$). The skin percentage of female pigs was lower than that of castrated males ($P < 0.05$), however, the bone percentage of castrated males was higher than female pigs ($P < 0.05$). The average back fat thickness of Huong pig was 25mm and the carcass length was 59.35cm.

3.2.2.3. *Meat quality of Huong pig*

* *pH Value*

The pH value at 45 minutes after slaughtered in loin muscle was not different ($P > 0.05$) between castrated male and female pigs, the average was 6.03. The pH value of loin muscle at 24 and 48 hours after slaughtered reached 5.62-5.72 between castrated male and female pigs also was not statistically significant different ($P > 0.05$).

* *Meat color*

L* value of loin muscle at 24 and 48 hours after slaughtered in castrated males and females were not different ($P > 0.05$) and averaged 48.85 and 53.72, respectively. a* and b* value at 24 h after slaughtered of Huong pig were 10.34 and 7.12, respectively.

* *Preservation and processing dehydration rate*

The average preservation dehydration rates at 24 and 48 hours after slaughtered in Huong pig were 2.76 and 3.49%, respectively, there was no statistical difference between castrated male and female pigs ($P > 0.05$). The processing dehydration rates at 24 and 48 hours after slaughtered were higher in female than in castrated female pigs ($P < 0.05$). The average processing dehydration rate after 24 hours in Huong pig was 19.45% and after 48 hours was 22.05%.

* *Chemical composition of loin muscle*

Except for crude protein rate in castrated male and female pigs, the dry matter and crude fat in loin of castrated males was higher than in female pigs, but the total mineral rate was lower ($P<0.05$). The dry matter rate of Huong pork was 27.58%, protein was 20.13%, crude fat was 6.43% and total mineral content was 1.02%.

Table 3.91. Chemical composition of loin muscle in Huong pig

Indicators	Females (n=4)	Castrated (n=4)	Average (n=8)
Dry matter (%)	25.44 ^b ±0.72	29.73 ^a ±0.48	27.58±0.90
Crude protein (%)	19.99±0.49	20.28±0.58	20.13±0.36
Crude fat (%)	4.36 ^b ±0.38	8.50 ^a ±0.43	6.43±0.83
Total mineral (%)	1.05 ^a ±0.01	1.00 ^b ±0.02	1.02±0.02

Note: In the same row, LSM values with different letters are statistically significant differences $P<0.05$.

** Amino acid composition of loin muscle*

Glutamic was an amino acid with the highest content in Huong pork loin. Overall, amino acid values in loin muscle were not significantly different between castrated male and female pigs ($P>0.05$). Glutamic acid content in loin muscle in female pig tended to be higher than in castrated males with values of 4.69 and 3.68%, respectively ($P>0.05$). Glycine content in the loin sample of the castrated males was 2.65%, tended to be 1.81% higher than that of females ($P>0.05$).

** Fatty acid composition of loin muscle*

The main fatty acids available in Huong pork loin were C16:0, C18:0, C18:1n-9c, C18:2 and C18:3n3. Among saturated fatty acids, palmitic acid value in Huong pork loin was the highest and the average value was 24.33%; stearic acid was 11.96%.

Table 3.10. Fatty acid composition of loin muscle in Huong pig

Indicators	Females (n=4)	Castrated (n=4)	Average (n=8)
Oleic (C18:1n9c)	45.20±0.38	44.54±0.79	44.87±0.42
Palmitic (C16:0)	25.18±0.81	23.49±0.77	24.33±0.61
Stearic (C18:0)	12.47±0.15	11.45±0.78	11.96±0.42
Linoleic (C18:2n6c)	7.13±0.37	6.42±0.82	6.78±0.44
Linolenic (C18:3n3)	0.32±0.07	0.18±0.04	0.25±0.05
Saturated fatty acid (SFA)	43.72 ^a ±0.30	46.28 ^b ±0.27	45.00±0.52
Unsaturated fatty acids (UFA)	56.28 ^a ±0.30	53.72 ^b ±0.27	55.00±0.52
MUFA	48.82±0.48	47.12±0.89	47.97±0.57
PUFA	7.46±0.39	6.60±0.85	7.03±0.46
UFA/SFA	1.29 ^a ±0.02	1.16 ^b ±0.01	1.22±0.03

Note: In the same row, LSM values with different letters are statistically significant differences $P < 0.05$.

The ratio of fatty acids C18:1 (Omega-9), C18:2 (Omega-6) and C18:3 (Omega-3) in Huong pork loin was 44.87; 6.78 and 0.25%. The percentages of saturated fatty acids (SFA) and unsaturated fatty acids (UFA) in Huong pork loin were 45.00 and 55.00%, respectively, and there was a significant difference by sex ($P < 0.05$). The average UFA/SFA ratio of fat in Huong pork loin muscle was 1.22.

CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

Huong pig over 3 generations selected according to phenotypic value for hair and skin has improved typical conformation of the breed, with white hairs and belly skin, black spots on the head and top of the rump were in the majority. The percentage of pigs with black spots on the head, back, shoulders and buttocks was low and

the percentage of pigs with black and white spots was almost nonexistent. The majority of hairs were straight (96.51%), average hair density was 57.14%, rough skin (46.51%) and wrinkled (41.84%), straight face (98.26%), long snout (95.93%), pointed ears (81.98%), saggy belly and saggy back (80.81 and 89.53%). Huong pig with 10 teats accounted for a high percentage (61.63%), 12 teats accounted for 30.81%. The body length, shoulder height, head length, head width and ear length of Huong pig were similar to some indigenous pig breeds of Vietnam.

Huong pig over 3 selective generations has improved markedly for reproductive traits: age at first heating was 175.14 days, age at the first mating was 225.51 days and age at the first farrowing was 339.57 days. The number of alive newborn piglets per litter was 8.84, and the number of weaned piglets per litter was 8.26. Newborn piglet weight/litter was 3.88 kg, weaned piglet weight/litter was 35.96 kg, and farrowing interval was 170.32 days. These indicators in Huong pig were high in parities 3 and 4, then tended to decrease gradually.

Selective Huong pig has improved in phenotypic value of newborn piglet weight/litter and weaned piglet weight/litter at 8 months of age with a body weight of 42.72 kg. Average body weight gain from weaning to 8 months of age was 196.75 g/day. The carcass performance of Huong pigs slaughtered at 8 months of age was good, the dressing carcass and carcass was at medium level, the lean percentage in Huong pig was quite positive, and the fat percentage was low.

The pH values during preserving after 45 minutes, 24 and 48 hours did not change after slaughtered and the L* values of Huong pork were limited in the medium meat quality. The water storage

ability in Huong pork was good, the meat was not soft, dry and solid. The dehydration rate during preservation and processing of meat was low. The crude fat in muscle of Huong pork was a higher than most of the native Vietnamese pig breeds. The Glutamic acid and Glycine acid content was higher than other pig breeds which produced the sweet flavor of Huong pork. The Oleic acid and unsaturated fatty acid percentages were high at 44.87 and 55.00%, respectively.

4.2. RECOMMENDATIONS

Genotyping some traits such as number of a live newborn piglets per litter, body weight gain to improve high-quality pure breed for production, especially for organic farming methods of biosecurity and research on reasonable nutritional values in order to promote the strong characteristics of this pig breed.