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Research article

Effects of polymorphisms in *PIT1*, *H-FABP*, *PIK3C3* and *CAST* genes on chemical composition, amino acid content in meat of Vietnamese indigenous fatty pig breed "I"

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Abstract

This study aimed to evaluate the effects of polymorphisms of *PIT1/RasI*, *H-FABP/HinfI*, *PIK3C3/Hpy8I*, *CAST/HinfI* genes and gender on chemical composition, amino acid content in meat of Vietnamese indigenous fatty pig breed "I" raised under industrial condition at Dabaco Breeding Pig Company, Phu Tho Province, Vietnam. Samples of *longissimus dorsi* muscle from 23 "I" pigs (12 gilts and 11 barrows) at 8 months of age were used to measure chemical composition (dry matter, protein, lipids and ash) and content of 17 amino acids (aspartic, glutamic, serine, histidine, glycine, threonine, alanine, arginine, tyrosine, valine, methionine, phenylalanine, isoleucine, leucine, lysine, proline, cystine); while ear tissues were collected to identify polymorphisms of these genes. Chemical compositions were analyzed using ISO methods (1973, 1978, 1997, and 1998). The content of amino acids was quantified using high-performance liquid chromatography (HPLC) methods. The polymorphisms of four genes were identified by the PCR-RFLP technique. The results indicated that *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* had no effects on chemical compositions and amino acid contents ($P>0.05$). Inversely, the contents of amino acids (aspartic, serine, threonine, arginine, phenylalanine, leucine, and lysine) were significantly different between gilts and barrows ($P<0.05$).

Keywords: Gender, Meat quality, Native pigs, Nutrition content.

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INTRODUCTION

Pork is one of the most consumed meats all over the world. According to the data from FAO, 112.582 thousand tons of pork was consumed in 2022, accounted 33.72% of total global meat consumption (OECD, 2023). The demand for pork is expected to rise in the near future (OECD, 2023). To increase the production of pork, improving the growth rate and carcass yield is necessary. On the other hand, consumers also focus on the quality of meat and meat products. Not only technological and organoleptic characteristics, but also the nutritional values affect the pork's quality. According to López-Bote (2017), meat contains water (75%), protein (19%), fat (2.5%) and other substances including inorganic compounds (3.5%). Water content has been considered a contributor to the texture, smell, taste, and color of meat (Ruan and Chen, 1997). Fat matter and fatty acid composition were factors related to tenderness, juice, and flavor (Wood et al., 2008). Protein and amino acid contents are the factors that influence nutritional and sensory traits, including the flavor of fresh and processed pork (Chen and Liu, 2004; Khan et al., 2015).

At the world level, Vietnam has the second-largest pork consumption per capita basis of 27.732 kg (OEDC, 2023). As the annual level of pork consumption basis, Vietnam is the 5th largest pork consumption worldwide (OEDC, 2023). To meet the high demand, the industrial system for pig production has been applied, and exotic breeds have been imported. At the end of 2022, the sow population has reached 3.2 million heads, in which exotic sows make up 80% of grandparents and great-grandparents (Tam An, 2023). Consequently, numerous indigenous pig breeds have become extinct, while others are endangered (Ba et al., 2020). In the list of rare and precious animal breeds in Vietnam, the "I" pig is one of the four breeds that must be conserved (Vietnam National Assembly, 2018). This pig has extraordinary characteristics, including adaptability to harsh climates, poor-quality feeds, and disease resistance. In addition, meat of "I" pig was well-known as tasty and flavorful (Ly, 1999). However, due to the low productive and reproductive performance, the "I" pig population was gradually replaced by other native and exotic breeds (Dang-Nguyen et al., 2010). Therefore, the conservation of these animals is urgently required to avoid biodiversity erosion. According to our knowledge, little information is available on the meat quality of "I" pigs, especially on nutritional values.

Numerous researches suggest the candidate genes related to meat quality including Pituitary-specific transcription factor (*PIT1*) (Franco et al., 2005), heart fatty acid-binding protein (*H-FABP*) (Jankowiak et al., 2010; Lee et al., 2010), Porcine phosphoinositide-3-kinase, class 3 (*PIK3C3*) (Kim et al., 2005; Hirose et al., 2011), Calpastatin (*CAST*) (Đurkin et al., 2009; Ngu et al., 2012; Ropka-Molik et al., 2014). However, there is no information about the association of polymorphism of candidate genes with chemical and amino acid compositions in the meat of "I" pigs. The study was conducted to evaluate the effect of polymorphism in *PIT1*, *H-FABP*, *PIK3C3, CAST* genes, and gender on chemical composition and amino acid contents in the meat of "I" pig.

MATERIALS AND METHODS

Experimental animals were raised, transported, and slaughtered according to regulations stated in Article No. 72, Law on Animal Husbandry (Vietnam National Assembly, 2018). The study protocol was approved by the Faculty Council, Faculty of Animal Science, Vietnam National University of Agriculture under approval number FAS-VNUA-2020/8.

Animals and Sample collection

A total of 96 pigs "I" used in this study were raised in 4 pens at Phu Tho Dabaco Breeding Pig farm in Phu Tho province, Vietnam. Pigs were reared in the closed building with cooling pads. Animals had free access to water and were fed commercial feed. At three stages (weaned to 90 days of age, 91 to 150 days of age, and 151 days of age to end of the experiment), the pigs were fed feeds containing 3000 Kcal ME, 16% crude protein, 3050 Kcal ME, 15% crude protein and 2900 Kcal ME, 13% crude protein, respectively. The feed supply per day was calculated at approximately 3% of the body weight. At 8 months of age, 23 pigs (12 gilts and 11 barrows) were randomly selected from above 96 pigs for slaughter in a private slaughterhouse according to Vietnam National Standard TCVN 3899-84 (State Committee of Science and Engineering, 1984). The *longissimus dorsi* muscle sample was collected from the left half-carcass at the 1st-4th last ribs immediately after slaughter. Each sample was kept in an individual plastic bag at 4°C and transported to the laboratories of Vietnam National University of Agriculture (VNUA). The samples were frozen at -20°C for subsequent chemical composition and amino acid profile analysis.

Chemical compounds and amino acid contents

The composition of dry matter, protein, lipids, and ash (g/100 g raw meat) was analyzed at the Center laboratory, Faculty of Animal Sciences of VNUA. The samples were dried at 103°C until their weight was unchanged to calculate dry matter (ISO 1442: 1997). The crude protein concentration of *longissimus dorsi* muscle was estimated by the product between total nitrogen (N) and 6.25 (ISO 937: 1978). Fat contents were determined by ether extraction (ISO 1443: 1973). Ash was estimated through high-temperature ashing (ISO 936: 1998).

Amino acids content (g/100 g dry meat), including aspartic, glutamic, serine, histidine, glycine, threonine, alanine, arginine, tyrosine, valine, methionine, phenylalanine, isoleucine, leucine, lysine, proline, cysteine) was performed at the Department of Animal Feeds and Products Analysis, National Institute of Animal Science, Vietnam. Before analysis, meat samples were ground and dried at 80 °C for 6 hours; after that, the temperature was increased up to 103 °C, and the samples were dried until they were of unchanged weight. Powders of dried meat samples were hydrolyzed with 10 ml 6N HCl solution (containing 1% phenol) under vacuum at 110°C±3°C for 24 hours. Amino acid-separated columns (AccQ-Tag Column, 60 Å, 4 µm, 3.9 mm×150 mm, 1/pk) with fluorescent wavelengths from 250 to 395 nm were applied. The amino acid content was measured by high-performance liquid chromatography (HPLC) methods on Alliance system e2695 (Waters, USA).

Determination of *PIT1*, *H-FABP*, *PIK3C3* and *CAST* genotypes

Ear tissues were collected in the slaughterhouse to identify genotypes of *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* genes. The genotypes of *PIT1/RasI*, *H-FABP/HinfI*, *PIK3C3/Hpy8I*, and *CAST/HinfI* genes were identified by PCR-RFLP according to methods described in studies of Yu et al. (1994), Gerbens et al. (1998), Kim et al. (2005) and Ernst et al. (1998), respectively at Genetic laboratory of VNUA. Detailed information on primer sequences, PCR product size, restriction enzymes and allele sizes are presented in the previous study by Tuoi et al. (2022).

Statistical analysis

Effects of polymorphisms and gender on chemical composition and amino acid contents were performed with the following statistical model:

$$Yijklmn=\mu+PIT1_i+H\text{-}FABP_j+PIK3C3_k+CAST_l+G_m+\varepsilon_{ijklmn}$$

Where: Y_{ijklmn}=studied variables; µ=overall mean; $PIT1_i$=effect of *PIT1* genotypes (AA, AB, and BB); $H\text{-}FABP_j$=effect of *H-FABP* genotypes (HH, Hh, and hh); $PIK3C3_k$=effect of *PIK3C3* genotypes (CC, CT, and TT); $CAST_l$=effect of *CAST* genotype (AA, AB, and BB); G_m=effect of genders (gilts and barrows) and ε_{ijklmn}=residual error. The data was analyzed using SAS software version 9.1 (SAS, 2002). The statistical parameters were sample size (n), Least square mean (LSM), and Standard error of the mean (SE). The Tukey test was used for pairwise comparison between LSMs with a significant level of 0.05.

RESULTS

The levels of significance of *PIT1, H-FABP, PIK3C3, CAST*, and gender on chemical composition and amino acid contents are presented in Table 1. The polymorphisms of *PIT1/RasI, H-FABP/HinfI, PIK3C3/Hpy8I,* and *CAST/HinfI* genes did not affect investigated parameters. Inversely, contents of 7 amino acids (aspartic, serine, threonine, arginine, phenylalanine, leucine, and lysine) in *longissimus dorsi* muscle of "I" pigs were significantly different between gilts and barrows (P<0.05).

Table 1 Effects of *PIT1*, *H-FABP*, *PIK3C3*, *CAST* genes and gender on chemical composition, amino acid content in meat of "I" pig

Variable	*PIT1*	*H-FABP*	*PIK3C3*	*CAST*	Gender	R^2 (%)
Chemical composition						
Dry matter	0.51	0.78	0.71	0.59	0.32	31.50
Protein	0.79	0.75	0.90	0.45	0.74	13.29
Lipids	0.74	0.75	0.70	0.47	0.12	42.69
Ash	0.57	0.18	0.89	0.56	0.83	51.53
Amino acid content						
Aspartic	0.85	0.52	0.95	0.83	0.03	53.35
Glutamic	0.72	0.97	0.98	0.84	0.19	26.15
Serine	0.95	0.92	0.70	0.63	0.03	51.20
Histidine	0.56	0.39	0.56	0.49	0.12	53.79
Glycine	0.75	0.29	0.51	0.44	0.12	53.81
Threonine	0.45	0.32	0.99	0.65	0.04	36.99
Alanine	0.62	0.66	0.99	0.69	0.36	23.06
Arginine	0.95	0.89	0.79	0.93	0.04	47.89
Tyrosine	0.58	0.11	0.92	0.39	0.15	39.69
Valine	0.64	0.97	0.87	0.88	0.50	14.07
Methionine	0.22	0.73	0.30	0.83	0.28	32.53
Phenylalanine	0.53	0.22	0.73	0.28	0.045	51.66
Isoleucine	0.40	0.28	0.66	0.30	0.06	56.09
Leucine	0.61	0.89	0.82	0.79	0.0498	40.76
Lysine	0.25	0.27	0.22	0.42	0.01	49.25
Proline	0.58	0.27	0.52	0.56	0.16	47.82
Cystine	0.40	0.83	0.50	0.62	0.87	27.46

Values in the table are p-values (level of significance), R^2: coefficient of determination matter.

Effect of *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* on chemical composition and amino acid content

Chemical composition and amino acid content according to *PIT1/RasI, H-FABP/HinfI, PIK3C3/Hpy8I*, and *CAST/HinfI* genotypes are shown in Table 2, 3, 4, 5, and 6 respectively.

There are three genotypes (AA, AB, and BB) of *PIT1/RasI* were detected in the "I" pig population (Table 2). The contents of dry matter, protein, lipids, and ash in the *longissimus dorsi* muscle were similar in pigs with different *PIT1* genotypes (P>0.05). There was no association between polymorphism of the *PIT1* gene and the contents of seventeen amino acids in the *longissimus dorsi* muscle of "I" pigs (P>0.05).

Table 2 Chemical composition and amino acid content in meat of "I" pig according to *PIT1* genotypes

Variable	AA (n=9)		AB (n=11)		BB (n=3)	
	LSM	SE	LSM	SE	LSM	SE
Chemical composition *(g/100 g raw meat)*						
Dry matter	27.93	0.81	26.84	0.66	26.59	1.30
Protein	21.54	0.30	21.77	0.25	21.51	0.49
Lipids	3.03	0.67	2.38	0.54	2.70	1.08
Ash	1.12	0.03	1.08	0.02	1.11	0.04
Amino acid content *(g/100 g dry meat)*						
Aspartic	7.71	0.36	7.63	0.29	7.99	0.57
Glutamic	10.20	0.56	10.70	0.45	10.14	0.90
Serine	2.82	0.15	2.76	0.12	2.80	0.25
Histidine	2.43	0.30	2.30	0.25	1.82	0.49
Glycine	2.50	0.29	2.46	0.24	2.11	0.47
Threonine	4.30	0.22	4.64	0.18	4.32	0.36
Alanine	2.91	0.22	3.03	0.18	3.32	0.36
Arginine	4.24	0.18	4.19	0.14	4.27	0.29
Tyrosine	2.37	0.35	2.75	0.29	2.24	0.57
Valine	4.76	0.34	5.03	0.28	5.34	0.55
Methionine	4.11	0.16	4.43	0.13	4.03	0.26
Phenylalanine	2.40	0.26	2.54	0.21	2.02	0.42
Isoleucine	3.05	0.34	3.04	0.28	2.24	0.55
Leucine	4.45	0.26	4.75	0.21	4.80	0.41
Lysine	9.83	0.25	10.32	0.21	9.76	0.41
Proline	2.21	0.35	2.07	0.29	1.52	0.57
Cystine	0.79	0.04	0.72	0.03	0.71	0.07

Three genotypes (HH, Hh, and hh) in *H-FABP/HinfI* of "I" pigs were identified (Table 3). The effects of *H-FABP* polymorphism on chemical composition and amino acid content in the *longissimus dorsi* muscle of "I" pigs were not found (P>0.05).

Table 3 Chemical composition and amino acid content in meat of "I" pig according to *H-FABP* genotypes (%)

Variable	HH (n=8)		Hh (n=11)		Hh (n=4)	
	LSM	SE	LSM	SE	LSM	SE
Chemical composition *(g/100 g raw meat)*						
Dry matter	26.54	1.02	27.41	0.70	27.40	1.26
Protein	21.40	0.38	21.77	0.26	21.66	0.48
Lipids	2.20	0.84	2.69	0.58	3.22	1.04
Ash	1.14	0.03	1.13	0.02	1.04	0.04
Amino acid content *(g/100 g dry meat)*						
Aspartic	8.13	0.45	7.46	0.31	7.74	0.56
Glutamic	10.47	0.70	10.27	0.48	10.30	0.87
Serine	2.83	0.19	2.74	0.13	2.80	0.24
Histidine	2.54	0.38	2.31	0.26	1.71	0.47
Glycine	2.74	0.37	2.51	0.25	1.82	0.45
Threonine	4.41	0.28	4.72	0.19	4.13	0.35
Alanine	3.03	0.28	2.93	0.19	3.30	0.35
Arginine	4.31	0.22	4.18	0.15	4.21	0.28
Tyrosine	2.70	0.44	3.03	0.31	1.62	0.55
Valine	5.08	0.43	4.97	0.30	5.08	0.53
Methionine	4.06	0.21	4.25	0.14	4.27	0.26
Phenylalanine	2.45	0.33	2.68	0.22	1.84	0.40
Isoleucine	3.07	0.43	3.11	0.30	2.15	0.53
Leucine	4.80	0.32	4.64	0.22	4.57	0.40
Lysine	9.58	0.32	10.28	0.22	10.05	0.39
Proline	2.32	0.45	2.22	0.31	1.26	0.55
Cystine	0.72	0.05	0.76	0.04	0.73	0.06

Three genotypes (CC, CT, and TT) of *PIK3C3/Hpy8I* polymorphisms were observed in the “I” pig population (Table 4). In this study, chemical composition and amino acid content were not significantly influenced by genotypes of the *PIK3C3* gene (*P*>0.05). The analysis of *CAST/HinfI* in “I” pig, 3 genotypes (AA, AB and BB) were recorded (Table 5). The chemical composition and amino acid content in meat of “I” pigs were not significantly affected by *CAST* polymorphism (*P*>0.05).

Table 4 Chemical composition and amino acid content in meat of “I” pig according to *PIK3C3* genotypes

Variable	CC (n=9)		CT (n=8)		TT (n=6)	
	LSM	SE	LSM	SE	LSM	SE
Chemical composition *(g/100 g raw meat)*						
Dry matter	26.43	1.00	27.48	0.99	27.45	0.97
Protein	21.46	0.38	21.72	0.38	21.65	0.37
Lipids	2.21	0.83	2.79	0.82	3.10	0.80
Ash	1.09	0.03	1.12	0.03	1.10	0.03
Amino acid content *(g/100 g dry meat)*						
Aspartic	7.71	0.44	7.76	0.44	7.86	0.43
Glutamic	10.32	0.69	10.29	0.69	10.43	0.67
Serine	2.89	0.19	2.79	0.19	2.69	0.18
Histidine	2.51	0.38	2.05	0.37	1.99	0.36
Glycine	2.72	0.36	2.10	0.36	2.24	0.35
Threonine	4.43	0.28	4.43	0.27	4.39	0.27
Alanine	3.06	0.28	3.11	0.27	3.08	0.27
Arginine	4.28	0.22	4.28	0.22	4.13	0.21
Tyrosine	2.61	0.44	2.34	0.43	2.41	0.42
Valine	5.14	0.42	4.85	0.42	5.13	0.41
Methionine	4.00	0.20	4.18	0.20	4.40	0.20
Phenylalanine	2.49	0.32	2.31	0.32	2.17	0.31
Isoleucine	3.07	0.42	2.68	0.42	2.57	0.41
Leucine	4.58	0.32	4.62	0.32	4.81	0.31
Lysine	9.49	0.31	10.37	0.31	10.04	0.30
Proline	2.32	0.44	1.81	0.44	1.67	0.42
Cystine	0.69	0.05	0.79	0.05	0.74	0.05

Table 5 Chemical composition and amino acid content in meat of “I” pig according to *CAST* genotypes (%)

Variable	AA (n=7)		AB (n=10)		BB (n=6)	
	LSM	SE	LSM	SE	LSM	SE
Chemical composition *(g/100 g raw meat)*						
Dry matter	27.82	0.90	26.80	0.71	26.74	1.08
Protein	21.81	0.34	21.79	0.27	21.23	0.41
Lipids	3.14	0.74	2.07	0.58	2.90	0.89
Ash	1.08	0.03	1.12	0.02	1.11	0.04
Amino acid content *(g/100 g dry meat)*						
Aspartic	7.74	0.40	7.63	0.31	7.96	0.48
Glutamic	10.19	0.62	10.60	0.49	10.25	0.75
Serine	2.72	0.17	2.72	0.13	2.93	0.21
Histidine	2.10	0.34	2.48	0.27	1.97	0.41
Glycine	2.24	0.32	2.66	0.26	2.17	0.39
Threonine	4.54	0.25	4.49	0.20	4.22	0.30
Alanine	3.07	0.25	2.95	0.20	3.24	0.30
Arginine	4.18	0.20	4.26	0.16	4.25	0.24
Tyrosine	2.63	0.39	2.74	0.31	1.99	0.47
Valine	4.92	0.38	5.01	0.30	5.20	0.46
Methionine	4.25	0.18	4.23	0.14	4.10	0.22
Phenylalanine	2.28	0.29	2.66	0.23	2.03	0.35
Isoleucine	2.60	0.38	3.22	0.30	2.51	0.46
Leucine	4.82	0.29	4.63	0.23	4.56	0.34
Lysine	10.02	0.28	10.21	0.22	9.68	0.34
Proline	1.82	0.39	2.24	0.31	1.74	0.47
Cystine	0.74	0.05	0.77	0.04	0.71	0.06

Effect of gender on chemical composition and amino acid content

There was no significant effect of gender on the compositions of dry matter, protein, lipids, and ash in the *longissimus dorsi* muscle of "I" pigs (Table 6). However, the contents of 7 amino acids (aspartic, serine, threonine, arginine, phenylalanine, leucine, and lysine) in the meat of barrows were higher than those of gilts ($P<0.05$).

Table 6 Chemical composition and amino acid content in meat of "I" pig according to gender

Variable	Female (n=12)		Barrow (n=11)	
	LSM	SE	LSM	SE
Chemical composition *(g/100 g raw meat)*				
Dry matter	27.67	0.82	26.57	0.76
Protein	21.54	0.31	21.68	0.29
Lipids	3.43	0.68	1.97	0.63
Ash	1.11	0.03	1.10	0.03
Amino acid content *(g/100 g dry meat)*				
Aspartic	7.21^{b}	0.36	8.35^{a}	0.33
Glutamic	9.83	0.57	10.86	0.52
Serine	2.54^{b}	0.16	3.04^{a}	0.14
Histidine	1.85	0.31	2.52	0.28
Glycine	2.04	0.30	2.68	0.27
Threonine	4.09^{b}	0.23	4.75a	0.21
Alanine	2.95	0.23	3.23	0.21
Arginine	3.96^{b}	0.18	4.50^{a}	0.17
Tyrosine	2.09	0.36	2.81	0.33
Valine	5.20	0.35	4.89	0.32
Methionine	4.07	0.17	4.31	0.15
Phenylalanine	1.94^{b}	0.26	2.70^{a}	0.24
Isoleucine	2.32	0.35	3.23	0.32
Leucine	4.30^{b}	0.26	5.04^{a}	0.24
Lysine	9.45^{b}	0.26	10.49^{a}	0.24
Proline	1.58	0.36	2.28	0.33
Cystine	0.73	0.04	0.74	0.04

LSMs within a row with different superscripts are significantly different at $P<0.05$.

DISCUSSION

Effect of *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* on chemical composition and amino acid content

The nutritional composition of meat varies by many factors such as breed, feeding source, climate, genetics of animals, and meat cut (Pereira and Vicente, 2013; Ahmad et al., 2018). In our study, the chemical compositions of pork in "I" pigs were not significantly different between boars and gilts, nor were polymorphisms of *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* genes.

The results for the effect of *H-FABP* genotype in the present study were consistent with the finding by Jankowiak et al. (2010), in which water and protein content were not affected by *H-FABP* polymorphisms. Additionally, Nechtelberger et al. (2001) did not find any association between genotypes of *H-FABP/HinfI* and intramuscular fat content in Landrace, Large White, and Piétrain pigs. On the other hand, previous studies by Wei-Jun et al. (2006) and Jankowiak et al. (2010) found a significant effect of *H-FABP/HinfI* on intramuscular fat content but in controversial results. The muscle of pigs with the hh genotype of *H-FABP/HinfI* showed higher intramuscular fat content than pigs with the HH genotype (Jankowiak et al., 2010). In contrast, Wenjun et al. (2006) found that pigs with the HH genotype had higher intramuscular fat content than pigs with the Hh genotype.

The effect of the *CAST* gene on pork quality in our study agreed with the finding of Rybarczyk et al. (2012), who reported no relation between polymorphism of *CAST/TaqI* and total protein, fat, ash, and dry matter contents in the meat of hybrids Piétrain pigs. Similarly, no association between *CAST* polymorphism and fat contents in the muscles of pigs was demonstrated (Đurkin et al., 2009). In addition, Ropka-Molik et al. (2014) found no effect of *CAST/HinfI* genotypes on intramuscular fat content in the muscle of Landrace, Large White, Piétrain, and Duroc pigs. In contrast, genotypes of *CAST/HinfI* affected protein content in the *longissimus dorsi* muscle of crossbred pigs (Đurkin et al., 2009). The polymorphisms of *CAST/RsaI* and *CAST/PvuII* genes did not have a significant effect on dry matter, total protein, fat, and ash contents, except for the association of *CAST/PvuII* polymorphism with protein content in meat of Piétrain crossbred pigs (Rybarczyk et al., 2012). The results in the effect of *PIT1/RasI* genotypes on intramuscular fat content in this study agreed with Piórkowska et al. (2013), who reported no relation between PIT1 polymorphism and intramuscular fat proportion of pork. In agreement with our study, Kim et al. (2005) found no association between the *PIK3C3* gene and the intramuscular fat content of pigs. In contrast, Hirose et al. (2011) concluded that polymorphism of the *PIK3C3* gene significantly affected the intramuscular fat content of Duroc pig, in which pigs with TT genotype had lower intramuscular fat content than pigs with TC and CC genotypes.

The amino acids in muscle were strong flavoring agents related to the specific taste of meat products (Bogolyubova and Zaĭtsev, 2020). According to Kęska and Stadnik (2017) and Flores (2022), amino acids were divided into 5 basic tastes including (1) umami (glutamic and aspartic), (2) sweet (glycine, proline, valine, lysine, alanine, proline, serine, threonine, and methionine), (3) bitter (phenylalanine, proline, arginine, leucine, isoleucine, valine, tyrosine, cysteine, and tryptophan), (4) sour (threonine, aspartic, and glutamic) and (5) salty (aspartic). The total amount of amino acids in muscle was another indicator to reveal the nutritional value (Neupokoeva, 2019). Breeds, keeping conditions, age of animals, meat storage, and meat processing conditions were the factors that influenced the amino acid content in the muscle (Neupokoeva, 2019).

The amino acid contents in the muscle of "I" pigs were not affected by polymorphisms of *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* genes. According to our knowledge, information about the effects of polymorphisms of studied genes on the composition of amino acids in the muscles of pigs is not available.

Effect of gender on chemical composition and amino acid content

In this study, gender did not significantly affect the chemical composition in the meat of "I" pigs. The results were consistent with studies of Bahelka et al. (2020) and Cai et al. (2010), which reported that crude protein, crude fat (or intramuscular fat), and water contents of gilts and barrows were not significantly different. Similarly, ash and protein in Okrouhlá et al. (2006) and intramuscular fat content in Franco and Lorenzo (2013) were not different between barrows and gilts. Inversely, Okrouhlá et al. (2006) reported that the water content of meat in crossbred gilts was higher than that of boars (P<0.05). Franco and Lorenzo (2013) demonstrated the moisture content in the meat of Celta barrows was higher than that of gilts. Okrouhlá et al. (2006) confirmed that the intramuscular fat of barrows was higher than that of gilts. According to Correa et al. (2006), gender did not affect dry matter, while gilts had higher protein but lower intramuscular fat content than barrows.

In our study, gender significantly affected the content of 7 among 17 amino acids in the muscle of "I" pigs. Barrows showed higher contents of aspartic, serine, threonine, arginine, phenylalanine, leucine, and lysine than those in gilts. In contrast, Bahelka et al. (2020) found that the contents of phenylalanine, arginine, isoleucine, leucine, lysine, methionine, threonine, and valine in crossbred gilts were higher than those in barrows. Similarly, the study by Okrouhlá et al. (2006)

demonstrated that lysine content in gilt muscles was higher than in barrows. Nevertheless, the contents of eighteen amino acids in the muscles of Celta gilts and barrows were not significantly different (Franco and Lorenzo, 2013).

In the present study, Glutamic acid showed the highest content (>10%), and cystine is the lowest content (<1%) of seventeen measured amino acids. The total content of 17 investigated amino acids in "I" barrows and gilts were 76.42% and 65.53%, respectively. Jiang et al. (2011) and Wang et al. (2018) found that breed was determining factor that affected the amino acid content in muscles. The total amino acid content in "I" pigs was similar to that in Dahe (76.15%) and Dawu pigs (77.46%) in research by Jiang et al. (2011); Celta pigs (56.98-57.77%) in a study of Franco and Lorenzo (2013). The total content of amino acids in "I" pigs was higher than that in the study by Neupokoeva (2019) on Landrace, Landrace×Yorkshire, and Landrace×Yorkshire×Duroc pigs (21.701-22.561%); and the study of Cai et al. (2010) on Large White barrows (19.17%).

The results of glutamic acid contents in the present study were lower than those in hybrid barrows (14.20%) and gilts (14.26%) (Okrouhlá et al., 2006), in Celta pigs (12.53 and 13.00% for barrows and gilts) (Franco and Lorenzo, 2013), but higher than Bamei pigs (8.44%), Yorkshire pigs (7.33%) (Cai et al., 2010) and Huong, a Vietnamese native pig breed (4.19%) (Ninh, 2022). The composition of glutamic acid, aspartic acids, and lysine are amino acids related to a strong sweet taste (Salazar et al., 2020). These amino acids were higher than other amino acids in the meat of the "I" pig. In contrast, the contents of cystine, phenylalanine, and proline, the representatives of bitter amino acids, were low in meat of 'I" pigs. The results suggest that pork from "I" pigs has a specific taste.

The inconsistent results regarding amino acid content in different studies might relate to breeds, slaughtering age, and feed nutrition (Bogolyubova and Zaïtsev, 2020). According to Ma et al. (2020), many factors affect the nutritional value and flavor of pork, such as the breed, nutrition, feeding method, and age of the animals. However, the results of amino acid contents in the meat of "I" pigs in this study suggest that "I" pigs might have aspired taste.

CONCLUSIONS

Polymorphisms of *PIT1*, *H-FABP*, *PIK3C3*, and *CAST* genes did not affect the compositions of dry matter, protein, fat, ash, and content of 17 amino acids in *longissimus dorsi* muscle of "I" pigs. There was no association between gender and chemical compositions while contents of aspartic, serine, threonine, arginine, phenylalanine, leucine, and lysine in the muscle of "I" barrows were higher than those of gilts.

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AUTHOR CONTRIBUTIONS

Do Duc Luc, Nguyen Hoang Thinh; Conceptualization and design the experiment, supervision, editing and finalization.

Phan Thi Tuoi, Nguyen Thai Anh, Tran Xuan Manh, Nguyen Van Hung; data collection.

Phan Thi Tuoi, Do Thi Phuong, Mai Thi Xoan; data analysis, manuscript preparation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

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