EFFECT OF SNP MARKERS ON CARCASS CHARACTERISTICS AND FATTY ACID COMPOSITION OF DUROC BREEDING STOCKS IN KOREA

H. G. Choi[1], H. S. Choi[1], Y. C. Jung[2], K. S. Kim[1], Y. I. Choi[1] and J. S. Choi[3]

[1] Department of Animal Science, Chungbuk National University, Cheongju Korea 361-763

[2] Jung P&C Institute, Yongin Korea 446-982

[3] Department of Swine Science & Technology Center, Gyeongnam National University of Science and Technology, Jinju Korea 660-758

Abstract – This study was conducted to investigate the effect of three SNP markers (*FASN, CAST* and *MC4R*) on carcass characteristics and fatty acid composition of Duroc breeding stocks in Korea. Carcasses from Duroc with *FASN* AA genotype showed higher backfat thickness, stearic acid, oleic acid and poly-unsaturated fatty acid than *FASN* CC genotype. While the carcasses of pigs with *CAST* AA genotype showed thicker backfat, and lower palmitoleic acid and oleic acid content, they had higher stearic acid content than those from the *CAST* GG genotype. The *MC4R* AA genotypes were involved in increasing backfat thickness, carcass weight, SFA (saturated fatty acid) content, and decreasing USFA (unsaturated fatty acid) content in Duroc meat. As a result, it is determined that genetic information about carcass traits and fatty acids from domestic Duroc lines will be helpful to improve the pork quality effectively.

Key Words – Carcass traits, Fatty acid composition, Genotype

I. INTRODUCTION

Humans have domesticated pigs as a source of food for protein intake for about 9,000 years. Also, since then the pigs have been a valued source of food. Also, worldwide, there are 30−40 domesticated pig species today [1]. The quality of farmed pigs has been improved using both traditional statistical methods and molecular genetic methods to meet consumer demands. Recently, dramatic genetic progress has been achieved because SNP (Single nucleotide polymorphism) markers on pig phenotype information have been revealed [2].

In Korea, three way crossbred pigs (LY×D, Landrace × Yorkshire dam × Duroc sire) are mainly used for commercial pigs. The Duroc breed in which has both excellent growth rate and much intramuscular fat is used as a terminal sire when fattening pigs are produced [3].

Therefore, the objective of this study is to investigate the effect of SNP markers related to pork quality on carcass characteristics and fatty acid composition of Duroc breeding stocks in Korea.

II. MATERIALS AND METHODS

A total of 200 purebred Duroc gilts were raised by Korean Feeding Standard for Swine (KFSS), and reached market weight (110kg) were conventionally slaughtered and then chilled overnight. At 24 h postmortem, carcass traits including backfat thickness and carcass weight were measured by the people from the Animal Products Grading Services. Then, the *Longissimus dorsi* (LD) muscle from the left side of carcass between 5th and 13th rib was removed for fatty acid composition and genomic DNA analyses at Chungbuk National University.

III. RESULTS AND DISCUSSION

Table 1 shows phenotypic records of carcass trait and fatty acid composition in Duroc population. The effect of three SNP genotypes with the carcass traits of Duroc breeding stock populations are presented in Table 2. The *MC4R* gene was associated with the carcass weight and backfat thickness. The carcass from pigs with AA genotype had heavier carcass weight and thicker backfat than those carrying AG and GG genotypes. On the other hand, the A allele of the *FASN* gene significantly increased backfat thickness. The AA genotype of the *CAST* gene also significantly increased the backfat thickness. Kim *et al*. [4] reported that the *MC4R* NN genotypes of Duroc

breed increased daily gain, feed conversion, backfat thickness and meat yield. Similar results were observed in another study using an Italian Duroc breed [5].

Table 1. Phenotypic records of carcass trait and fatty acid composition in Duroc population

Traits		Mean	Std. Dev.[1)]	Min.	Med.	Max.
Carcass traits	Carcass weight (kg)	87.80	8.47	70.00	87.00	116.00
	Backfat thickness (mm)	22.54	4.84	8.00	23.00	34.00
Fatty acid composition (%)	C14:0	1.45	0.12	1.06	1.45	1.87
	C16:0	25.30	0.97	23.11	25.35	28.29
	C16:1n7	2.86	0.48	2.00	2.84	4.54
	C18:0	14.72	1.38	11.28	14.70	19.20
	C18:1n9	41.62	2.08	36.14	41.44	48.31
	C18:1n7	2.79	0.47	1.76	2.78	3.83
	C18:2n6	9.50	2.33	4.78	9.28	17.07
	C18:3n6	0.05	0.01	0.02	0.05	0.09
	C18:3n3	0.42	0.12	0.18	0.41	0.86
	C20:1n9	0.85	0.09	0.65	0.85	1.19
	C20:4n6	0.44	0.24	0.16	0.38	1.71
	SFA	41.47	2.04	36.44	41.32	47.43
	USFA	58.53	2.04	52.57	58.68	63.56
	Mono-USFA	48.12	2.74	41.22	48.01	57.52
	Poly-USFA	10.41	2.40	5.24	10.14	18.17

[1)] Standard deviation

The associations of three SNP genotypes with fatty acid composition of Duroc breeding stock population are reported in Table 3. All *FASN*, *CAST* and *MC4R* genes showed significant effects on the fatty acid composition of LD muscle of Duroc population. The *FASN* and *CAST* genes had significant effects in increasing or decreasing palmitoleic acid (C16:1n7), stearic acid (C18:0) and oleic acid (C18:1n9) content of meat. Furthermore, the meats from pigs that carry AA genotype of the *FASN* gene showed significantly lower arachidonic acid (C20:4n6), but higher linoleic acid (C18:2n6), linolenic acid (C18:3n3), and poly-unsaturated fatty acid content than CC genotype. The meats from pigs that carry AA genotype of the *CAST* gene showed significantly lower content of mono-unsaturated fatty acids than the AG and GG genotypes. The *MC4R* gene was significantly associated palmitic acid (C16:0), oleic acid (C18:1n7), linolenic acid (C18:3n6), arachidonic acid (C20:4n6), total saturated fatty acid, and total unsaturated fatty acid contents of LD muscle. Our results agreed with those of Ovilo *et al*. [6] who reported that the pigs with *MC4R* AA genotype showed higher saturated fatty acids and lower unsaturated fatty acids content than the GG genotype pigs.

Table 2. Effect of three SNP genotypes on carcass characteristics in Duroc breeding stock population

Traits	Marker	-log10 P-value[1]	Minor Allele	Average for DD[2]	Average for Dd[2]	Average for dd[2]
Carcass weight (kg)	*FASN*	0.06	C	85.16±9.73	88.90±9.50	87.42±7.02
	CAST	1.77	A	90.13±6.51	88.48±9.21	86.23±7.96
	MC4R	4.35	G	79.50±9.48	84.97±7.77	89.46±8.28
Backfat thickness (mm)	*FASN*	7.14	C	18.68±4.70	21.35±5.17	24.22±3.72
	CAST	3.69	A	25.19±3.81	22.72±4.45	21.36±5.10
	MC4R	4.32	G	17.00±3.87	21.07±5.07	23.44±4.52

[1] Significant when -log10 *P*-values are > 2.50
[2] Minor allele= "D", Major allele= "d"

Table 3. Effect of three SNP genotypes on fatty acid composition of the *Longissimus dorsi* muscle in Duroc breeding stock population

Traits	Marker	-log10 P-value[1]	Minor Allele	Average for DD[2]	Average for Dd[2]	Average for dd[2]
C14:0	*FASN*	0.43	C	1.47±0.09	1.46±0.13	1.44±0.11
	CAST	0.17	A	1.46±0.10	1.44±0.12	1.46±0.12
	MC4R	0.61	G	1.53±0.09	1.45±0.11	1.44±0.12
C16:0	*FASN*	0.54	C	25.27±0.88	25.43±0.98	25.20±0.96
	CAST	0.69	A	25.47±0.85	25.32±1.08	25.21±0.87
	MC4R	4.10	G	24.91±0.46	24.83±0.80	25.46±0.97
C16:1n7	*FASN*	4.64	C	3.15±0.39	2.97±0.48	2.73±0.43
	CAST	2.91	A	2.65±0.48	2.83±0.46	2.97±0.45
	MC4R	2.27	G	3.22±0.27	2.97±0.48	2.80±0.46
C18:0	*FASN*	4.64	C	13.88±1.35	14.73±1.54	14.86±1.16
	CAST	2.91	A	15.03±1.58	14.84±1.32	14.47±1.28
	MC4R	2.27	G	13.39±1.36	14.37±1.24	14.88±1.35
	FASN	6.15	C	40.90±1.7	42.21±2.1	42.96±1.8

				7	1	1
C18:1n 9	*CAST*	3.45	A	40.47±1.6 2	41.57±2.1 0	42.10±2.0 2
	MC4R	1.04	G	42.13±0.3 9	42.02±2.2 2	41.46±2.0 4
	FASN	6.18	C	2.63±0.45	2.90±0.44	3.13±0.43
C18:1n 7	*CAST*	3.28	A	2.56±0.48	2.76±0.45	2.90±0.44
	MC4R	6.49	G	3.47±0.29	2.98±0.46	2.68±0.42
	FASN	7.49	C	8.27±1.55	8.56±1.77	10.47±2.4 1
C18:2n 6	*CAST*	2.36	A	10.59±1.7 3	9.50±2.39	9.09±2.31
	MC4R	0.15	G	9.07±1.19	9.51±2.55	9.57±2.29
	FASN	0.24	C	0.05±0.01	0.05±0.01	0.05±0.01
C18:3n 6	*CAST*	0.54	A	0.05±0.00	0.05±0.01	0.05±0.01
	MC4R	2.58	G	0.06±0.01	0.05±0.01	0.05±0.01
	FASN	5.37	C	0.37±0.10	0.38±0.10	0.46±0.10
C18:3n 3	*CAST*	2.46	A	0.47±0.08	0.43±0.10	0.40±0.12
	MC4R	1.03	G	0.30±0.05	0.42±0.13	0.43±0.10
	FASN	0.50	C	0.87±0.09	0.86±0.10	0.85±0.08
C20:1n 9	*CAST*	1.09	A	0.87±0.07	0.86±0.09	0.84±0.09
	MC4R	0.13	G	0.82±0.05	0.85±0.09	0.85±0.09
	FASN	2.64	C	0.57±0.42	0.46±0.22	0.39±0.18
C20:4n 6	*CAST*	2.28	A	0.38±0.22	0.40±0.18	0.50±0.27
	MC4R	10.84	G	1.08±0.45	0.54±0.22	0.37±0.17
	FASN	0.51	C	40.63±1.9 2	41.62±2.2 5	41.51±1.8 3
SFA	*CAST*	1.36	A	41.96±2.0 7	41.61±2.0 6	41.14±1.9 3
	MC4R	4.01	G	39.83±1.4 7	40.66±1.6 7	41.79±2.0 5
	FASN	0.51	C	59.37±1.9 2	58.38±2.2 5	58.49±1.8 3
USFA	*CAST*	1.36	A	58.04±2.0 7	58.39±2.0 6	58.86±1.9 3
	MC4R	4.01	G	60.17±1.4 7	59.34±1.6 7	58.21±2.0 5
	FASN	7.17	C	50.11±2.3 6	48.93±2.7 5	47.11±2.3 3
Mono-USFA	*CAST*	3.87	A	46.55±2.3 6	48.01±2.7 5	48.82±2.5 7
	MC4R	2.06	G	49.65±0.4 9	48.82±2.9 6	47.79±2.6 3
	FASN	6.92	C	9.27±1.72	9.45±1.84	11.38±2.4 9
Poly-USFA	*CAST*	2.07	A	11.49±1.7 4	10.38±2.4 4	10.03±2.4 3
	MC4R	0.09	G	10.52±1.6 0	10.52±2.6 4	10.42±2.3 4

[1] Significant when -log10 *P*-values are > 2.50

[2] Minor allele= "D", Major allele= "d"

IV. CONCLUSION

All three SNP marker (*FASN*, *CAST* and *MC4R*) genes were significantly associated with the carcass traits and fatty acids of Duroc population. *FASN* gene AA genotype increased backfat thickness, stearic acid, oleic acid and poly-unsaturated fatty acid content, while *CAST* AA genotype increased backfat thickness, lowered palmitoleic acid and oleic acid, and increased stearic acid content in pork. *MC4R* AA genotype increased backfat thickness, carcass weight, SFA, and decreased USFA. Therefore, it is determined that genetic information about carcass traits and fatty acids from domestic Duroc lines will be helpful to improve the pork quality effectively.

ACKNOWLEDGEMENTS

This research was supported by Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries(IPET) through Agri-Bioindustry Technology Development Program funded by Ministry of Agriculture, Food and Rural Affairs(114073-3) and Priority Centers Program through National Research Foundation of Korea(NRF) funded by Ministry of Education(2009-0093813).

REFERENCES

1. Rothschild, M. F. & Ruvinsky, A. (2010). The genetics of pigs. Cambridge, MA: CABI.
2. Rohrer, G. A., Nonneman, D. J., Miller, R. K., Zerby, H. & Moeller. S. J. (2012). Association of single nucleotide polymorphism (SNP) markers in candidate genes and QTL regions with pork quality traits in commercial Pigs. Meat Science 92: 511-518.
3. Suzuki, K., Shibata, T., Kadowaki, H., Abe, H. & Toyoshima, T. (2003). Meat quality comparison of Berkshire, Duroc and crossbred pigs sired by Berkshire and Duroc. Meat Science 64: 35-42.
4. Kim, K. S., Shin, H. Y., Lee, J. J., Hong, S. K., Choi, B. H., Kim, T. H., Lee, H. K. & Cho, B. W. (2005). Investigation of porcine Melanocortin-4 receptor (MC4R) polymorphism on economic traits. Journal of Life Science 15: 968-971.
5. Davoli, R., Braglia, S., Valastro, V., Annarratone, C., Comella, M., Zambonelli, P., Nisi, I., Gallo, M., Buttazzoni, L. & Russo, V. (2012). Analysis of MC4R polymorphism in Italian Large White and Italian Duroc pigs: Association with carcass traits, Meat Science 90: 887–892.
6. Ovilo, C., Fernandez, A., Rodriguez, M. C., Nieto, M. & Silio, L. (2006). Association of MC4R gene variants with growth, fatness, carcass composition and meat and fat quality traits in heavy pigs. Meat Science 73: 42-47.