PE1.58 Effects of morphological characteristics of muscle fiber on growth performance,carcass traits, and meat quality 369.00

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***Abstract*— This study focused on the effects of total number of muscle fibers (TNF) and cross-sectional area of muscle fibers (CSAF) on meat mass and meat quality. TNF and CSAF were classified into two clusters (high or low and large or small, respectively) by cluster analysis. For growth rate, the high TNF group had a greater rate of growth than the low TNF group. The high TNF and large CSAF (HL) group had the highest daily gain and reached a 90 kg body weight more rapidly ($P < 0.001$). Although significant differences in carcass yield were not found, the HL group had the highest carcass weight and the low TNF and small CSAF (LS) group had the lowest carcass weight ($P < 0.001$). For loin-eye area (LEA), effects by both TNF and CSAF were observed ($P < 0.001$). Also, the high TNF group showed greater backfat thickness than the low TNF low group ($P < 0.001$). In terms of meat quality, meat quality measurements did not significantly differ within the TNF and CSAF groups except for a^* (redness).**

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***Index Terms*—Growth performance, carcass traits, morphology of muscle fiber, meat quality**

I. INTRODUCTION

During the past decades, pig producers and industry have tried to produce leaner meat while at same time improve productivity by rapid production. However, in some breeds, aspects of rapid lean meat production have lead to poor pork quality [2]. Muscle fiber characteristics have been studied in terms of both improving lean meat production ability and meat quality as selection traits [11]. Some studies support that muscle fiber characteristics are possible predictors of muscle mass and meat quality [21].

Muscle growth potential is related to the total number of muscle fibers (TNF) and cross sectional area of muscle of fiber (CSAF) [11, 18, 21]. TNF and CSAF are inversely correlated with each other, and are positively correlated with muscle mass [4, 5, 7, 8, 12, 18]. However, identifying the relationships among meat quality, TNF, and CSAF still remains a complex task. In fact, a positive correlation between TNF and meat quality has generally been reported [11, 18], but the correlation between CSAF and meat quality has not been consistent [6, 12, 18]. Therefore, the overall relationship between CSAF and meat quality remains controversial.

Although some studies have reported a relationship between TNF and CSAF, and each effect muscle mass and meat quality, their combined effect on growth performance, carcass traits, and meat quality in pigs has not been fully established. Therefore, the aim of this study was to investigate the interaction between both TNF and CSAF, taken from porcine *longissimus* muscle (LM), on growth performance, carcass traits, and pork quality.

II. MATERIALS AND METHODS

1. Animals and Muscle samples

A total of 124 commercial crossbred pigs were evaluated (Landrace x Yorkshire x Duroc, n = 124). Pigs from the same farm were fed the same commercial diet, and the days at 90 kg of body weight were counted. During the winter period at 173.7 ± 5.36 days of age, the pigs were slaughtered at a commercial abattoir by standard procedures under the supervision of the Korean Grading Service for Animal Products. The final live body weights were measured just before slaughtering. The daily gains were calculated by gathering weights per slaughter days. The local slaughter plant used an electrical stunning and traditional scalding-singeing process. After evisceration, the carcasses were weighed and backfat thickness was measured at the 11th and last *thoracic vertebra*. The mean of these two measurements was used as the backfat thickness. The loin-eye area (LEA) was measured at the level of the last rib. Within 45 min postmortem, muscle samples were taken from the *longissimus* muscle (LM) at the 8th *thoracic vertebra* for histochemical analysis. Following 24 h

of chilling, the LM was taken to evaluate the meat quality traits.

2. Morphological analysis of muscle fiber

At 45 min postmortem, muscle samples were cut into 0.5 x 0.5 x 1.0 cm pieces, promptly frozen in isopentane cooled by liquid nitrogen, and stored at -80 ºC until subsequent analyses. Serial transverse muscle sections (10 μm) were obtained from each sample with a cryostat (CM1 850, Leica, Germany) at -20 ºC and mounted on glass slides. The myosin adenosine triphosphatase activities of the samples were detected after acid (pH 4.7) preincubation [1]. All histochemical samples were examined by an image analysis system. The operational system consisted of an optical microscope equipped with a CCD color camera (IK-642K, Toshiba, Japan) and a standard workstation computer, which controlled the entire image analysis system (Image-Pro Plus, Media Cybernetics, L.P., USA). All portions of the analyzed sections were free from tissue disruption and freeze damage. Approximately 600 fibers per sample were evaluated. The cross-sectional area of the muscle fiber was determined as the ratio of the total area of muscle fiber measured to the total number of fibers counted. Fiber density was calculated from the mean number of fibers per mm^2, and then the total number of muscle fibers was calculated as the LEA multiplied by the fiber density.

3. Meat quality measurements

Muscle pH was measured directly on the carcasses at the $7^{th}/8^{th}$ *thoracic vertebra* using a spear-type electrode (IQ 150; IQ Instrument, San Diego, CA, USA) at 45 min ($pH_{45\ min}$) and 24 h ($pH_{24\ h}$) postmortem. Drip loss was determined by suspending muscle samples that were standardized for surface area in inflated plastic bags for 48 h at 4 ºC [9]. Filter-paper fluid uptake (FFU) was also measured. [10]. The color of the meat was measured at 24 h postmortem with a chromameter (CR-300, Minolta Camera Co., Japan) after exposing the surface to the air for 30 min at 4 ºC. The average of triplicate measurements was recorded, and the results were expressed as the Commission Internationale de l'Eclairage (C. I. E) L^*, a^*, and b^* values.

4. Statistical analysis

Cluster analysis was used to classify TNF and CSAF using the FASTCLUS procedure of the SAS Institute [22]. The observations were allocated to the groups based on the smallest Euclidean distance from the initial seeds in the cluster. The data were classified into two clusters according to TNF (high, n = 58; low, n = 66), and into another two clusters based on CSAF (large, n = 54; small, n = 70). A General Linear Model was used to evaluate the differences ($P < 0.05$) between TNF, CSAF, and TNF x CSAF. The results are presented as least-square means (LSMs) for the groups together with the standard errors of LSMs.

III. RESULTS AND DISCUSSION

Table 1 exhibits the LSMs of TNF and CSAF categorized according to TNF and CSAF. In this study, the mean ± SD for TNF was 1207 ± 245 x 10^3 (ranging from 626 to 1939 x 10^3) and the mean ± SD for CSAF was 3908 ± 609 μm^2 (ranging from 2637 to 6051 μm^2). Significant differences in TNF and CSAF were clearly observed among 4 groups.

The effects of TNF and CSAF on growth performance and carcass traits are exhibited in Table 2. For live weight, the high TNF and large CSAF (HL) group significantly differed from the LL group ($P < 0.001$). An increase in body weight has been reported to be positively related to greater CSAF [15]. Daily gains and days at 90 kg of body weight directly indicated the growth rate. The daily gain of the TNF high group significantly differed from that of the TNF low group ($P < 0.01$). However, the CSAF groups did not influence daily gain within each TNF group. Significant differences in growth rate were observed between LS and the other groups, especially in days at 90 kg of body weight, the LS pigs grew more slowly than the other groups ($P < 0.01$). For carcass traits, although significant differences in carcass yield were not found, carcass weights were significantly different among all groups ($P < 0.001$), HL showed the highest carcass weight and LS showed the lowest carcass weight. Backfat thickness and LEA are represented in lean meat production ability. A previous study reported that TNF was strongly positive correlated with backfat thickness and LEA [11]. In this study, the HL group exhibited greater backfat thickness than the LS group ($P < 0.001$). And LEA was significantly different among these groups ($P < 0.001$). Noticeably, The HS group had a significantly larger LEA than the LL group ($P < 0.001$).

Meat quality can be explained by numerous factors such as genetics, pre- and post-slaughter conditions, nutritional impacts, and environment, as well as muscle fiber characteristics [3, 19, 20]. In addition, muscle metabolic patterns can determine ultimate meat quality, which are affected by muscle fiber characteristics such as fiber type composition and fiber morphology [22, 24]. The data in Table 2 do not show significant differences for most meat quality measurements within the TNF and CSAF groups. Only the a^* value was significantly differenct, and the LS group had the lowest a^* value among the groups.

A previous study reported that increased CSAF is one of the muscle characteristics that causes deterioration in meat quality traits, particularly water holding capacity and tenderness [18]. However, the effects of CSAF on meat quality traits

were limited in this study. According to several studies [12, 13, 14, 16, 17], it was suggested that a high TNF with moderate CSAF guarantees an increase in muscle growth potential without meat quality deterioration. This study is in agreement with these previous results by showing that the TNF high groups had greater growth performance and carcass weight with normal meat quality.

IV. CONCLUSION

Base on the results, although significant differences in carcass yield were not found, growth performance and carcass weight were affected by both TNF and CSAF. However, meat quality measurements did not significantly differ among the groups. As a result, this study suggests that both high TNF and large CSAF lead to increases in overall muscle mass without negative changes in meat quality.

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Table 1. Least square means of total number of muscle fibers and cross-sectional area of muscle fibers in groups categorized by TNF and CSAF

TNF	High		Low		Level of significance		
CSAF	Large (n=18)	Small (n=40)	Large (n=36)	Small (n=30)	TNF	CSAF	TNF x CSAF
TNF (x 10^3)	1344^{b} $(35.2)^{1}$	1441^{a} (22.8)	1000^{d} (24.9)	1059^{c} (25.6)	***	**	NS
CSAF (μm^2)	4399^{a} (82.5)	3391^{c} (53.3)	4537^{a} (58.3)	3635^{b} (60.0)	**	***	NS

Level of significance: NS = not significant; ** $P < 0.01$, *** $P < 0.001$.
[a-d] Least-square means with different superscripts in the same row significantly differ ($P < 0.05$).
[1] Standard error of least-square means.

Table 2. Carcass traits and growth performance in groups categorized by TNF and CSAF

TNF	High		Low		Level of significance		
CSAF	Large	Small	Large	Small	TNF	CSAF	TNF x CSAF
Live weight (kg)	113.7^{a} $(3.02)^{1}$	108.7^{ab} (1.97)	105.3^{ab} (2.13)	97.4^{b} (2.19)	***	**	NS
Daily gain (g/day)	907.1^{a} (27.62)	856.8^{ab} (18.30)	810.2^{bc} (19.53)	760.6^{c} (20.09)	***	*	NS
Days at 90 kg body weight	148.3^{b} (3.56)	149.6^{b} (2.36)	152.7^{b} (2.52)	163.4^{a} (2.59)	**	*	NS
Carcass weight (kg)	85.00^{a} (2.19)	79.74^{b} (1.42)	78.72^{b} (1.55)	72.06^{c} (1.60)	***	***	NS
Carcass yield (%)	74.90 (0.54)	73.68 (0.35)	74.85 (0.38)	74.09 (0.39)	NS	NS	NS
Backfat thickness (mm)	19.28^{a} (1.48)	16.93^{ab} (0.96)	15.36^{bc} (1.05)	12.47^{c} (1.08)	***	*	NS
Loin-eye area (cm^2)	56.64^{a} (1.39)	49.92^{b} (0.93)	45.26^{c} (0.99)	38.84^{d} (1.07)	***	***	NS

Level of significance: NS = not significant; * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.
[a-d] Least-square means with different superscripts in the same row significantly differ ($P < 0.05$).
[1] Standard error of least-square means.

Table 3. Meat quality traits in groups categorized by TNF and CSAF

TNF	High		Low		Level of significance		
CSAF	Large	Small	Large	Small	TNF	CSAF	TNF x CSAF
Drip loss (%)	4.83 $(0.48)^{1}$	4.54 (0.32)	4.39 (0.34)	4.57 (0.37)	NS	NS	NS
FFU (mg)	43.85 (8.82)	44.60 (5.92)	54.64 (6.24)	45.98 (6.83)	NS	NS	NS
L^*	45.73 (0.66)	46.46 (0.45)	46.12 (0.47)	46.05 (0.52)	NS	NS	NS
a^*	6.17^{ab} (0.32)	6.51^{a} (0.22)	6.56^{a} (0.23)	5.81^{b} (0.25)	NS	NS	*
b^*	3.79 (0.28)	3.97 (0.19)	3.80 (0.20)	3.37 (0.21)	NS	NS	NS
$pH_{45\ min}$	5.95 (0.07)	5.93 (0.05)	5.99 (0.07)	6.07 (0.09)	NS	NS	NS
$pH_{24\ h}$	5.54 (0.03)	5.51 (0.02)	5.53 (0.03)	5.50 (0.04)	NS	NS	NS

Level of significance: NS = not significant,* $P < 0.05$.
[a-b] Least-square means with different superscripts in the same row significantly differ ($P < 0.05$).
[1] Standard error of least-square means.
Abbreviation: FFU, Filter-paper fluid uptake