Effect of size of type IIB fiber on meat quality and muscle fiber characteristics in pigs

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Astract: We investigated, in pigs, the effects that the size of type IIB fibers have on the quality of meat and muscle fiber characteristics. Three groups were formed, categorized by both size and proportion of type IIB fibers. Total fiber number, fiber area composition and fiber size of type I were higher in Group BS (high proportion of both small-sized and big-sized IIB fiber). Intramuscular fat (IMF) content and redness were also higher in Group BS ($p<0.05$). Water-holding capacity, however, was not significantly different among the groups ($p>0.05$). Pigs which have a high proportion of both small-sized and big-sized IIB fibers have lower muscle mass and a higher IMF content and redness.

Index Terms: muscle fiber, fiber size, meat quality, pig

I. INTRODUCTION

The relationship between meat quality traits and muscle fiber characteristics has been an area of interest for many years. The size and number of muscle fibers are factors that influence muscle mass and meat quality (Rehfeldt & Kuhn, 2006). In pigs, muscles with a larger fiber size, especially type IIB fiber, manifest as tougher meat than muscles with fibers of smaller size (Karlsson, Klont & Fernandez, 1999; Maltin, Warkup, Matthews, Grant, Porter & Delday, 1997). Moreover, increasing percentage of type IIB fiber are related to increases in drip loss and lightness, which seems to be associated with poorer meat quality (Ryu & Kim, 2006). Considering that the characteristics of muscle fiber, especially type IIB, are closely associated with meat quality traits, there are few reports concerning the effect of both the size and proportion of type IIB fiber on meat quality. With this lack of reported research in mind, we carried out this study on pigs to investigate the influences of the various sizes and proportion of type IIB fibers on meat qualities.

II. MATERIALS AND METHODS

Three groups of pigs (crossbred F_2 of Korean native Black pig and Landrace) were examined, each consisting of 20 animals. The pigs were selected at a commercial pork plant immediately after slaughtering. The groups were classified by both size and proportion of type IIB fiber. Group B consisted of a high proportion of big-sized (ø > 100μm) IIB fibers, Group BS consists of a high proportion of both big and small-sized (ø < 40μm) IIB fibers, and Group N consists of a high proportion of normal-sized (ø > 40μm, < 100μm) IIB fibers. Carcass weight (kg), loin-eye area (cm^2), and back-fat thickness (in mm, at the 4-5th thoracic vertebra) were measured. Within 45min post-mortem, muscle biopsies were taken at the adjacent 5th thoracic vertebra to determine muscle fiber characteristics. Myosin ATPase activity (Brooke & Kaiser, 1970) was detected after acid (pH 4.70) and alkaline (pH 10.70) pre-incubation for analysis of muscle fiber characteristics, such as total fiber number, fiber area composition (%), fiber density (fiber number/mm^2), and fiber diameter (μm).

Muscle samples were also taken at 24h postmortem, from the 5th thoracic vertebra, for meat quality trait analysis. Meat color (CIE L^*, a^* and b^*), moisture and intramuscular fat (IMF) content (%), as well as water-holding capacity [drip loss (%) and cooking loss (%)] were determined. The statistical analysis was performed by SAS (2000) program. The data were subjected to analysis of variance (ANOVA) and Duncan's test to compare the sample means. The significance level was 0.05.

III. RESULTS AND DISCUSSION

Cross-sections of longissimus muscle in different size and portion of fiber type IIB were presented in Figure 1 and Figure 2. As expected, Group B had significantly higher number of big-sized IIB fibers than Group BS and N ($p<0.05$), while small-sized, normal-sized, and total number of IIB fibers were the lowest values in Group B ($p<0.05$). These results agree with Dietl, Groeneveld & Fiedler (1993), who reported that total number of fibers was negatively correlated with fiber diameter. Figure 3 illustrates the muscle fiber characteristics of three groups categorized by fiber size of type IIB. Group BS, which had small-sized IIB fibers, had higher total number of fibers and fiber density of type IIB. Also, Group BS had higher fiber diameter and area composition of type I and type IIA, while fiber area composition and diameter of type IIB were lower in Group BS ($p<0.05$). Group BS, which had high portion of both small-sized and big-sized IIB fibers, had higher back-fat thickness and lower loin-eye area than Group B and Group N (Table 1) ($p<0.05$). Pigs with more muscle fibers grew faster and had a greater muscle mass (Handel and Stickland, 1998; Dwyer, Stickland & Fletcher, 1994), however, we found that Group BS, which had higher total fiber number, had lower muscle mass (lower loin-eye area and higher backfat thickness). Moisture content was higher in Group N, but IMF content and redness (a^*) were higher in Group BS ($p<0.05$). In general, IMF content is correlated with fiber type I (Karlsson et al, 1999; Calkins, Duston, Smith Carpenter & Davis, 1981). In this study, Group BS, having a higher value of fiber density, fiber diameter and area composition in fiber type I, had higher IMF content. In terms of water-holding capacity such as cooking loss and drip loss there were no significantly differences ($p>0.05$).

IV. CONCLUSION

Pigs which had high proportion of both small-sized and big-sized IIB fibers also had a higher total number of fibers, fiber composition and size of type I. As well, they had lower muscle mass and higher IMF content and redness, and thus done meat with more appealing characteristics.

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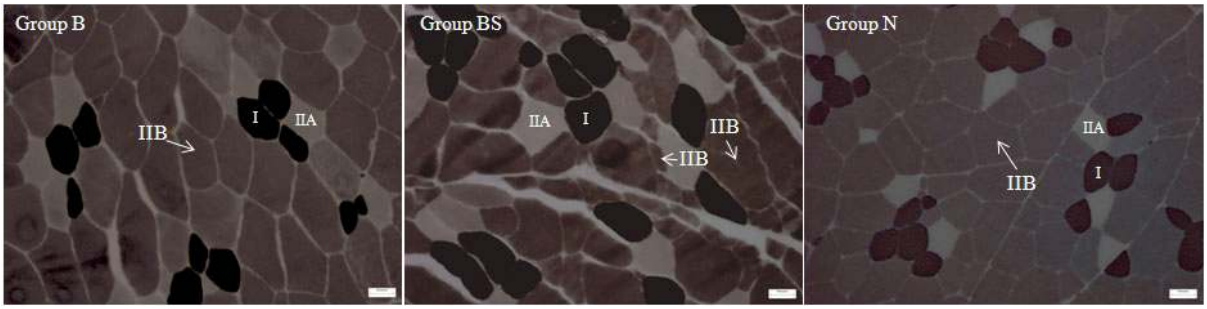

Figure 1. Cross-sections of longissimus muscle stained for myosin ATPase, after being pre-incubated in pH 4.70 (Bar = 50μm). I: fiber type I; IIA: fiber type IIA; IIB (arrows): fiber type IIB. Group B: the high portion of big-sized IIB fibers; Group BS: the high portion of both big-sized and small-sized IIB fibers; Group N: the high portion of normal-sized IIB fibers.

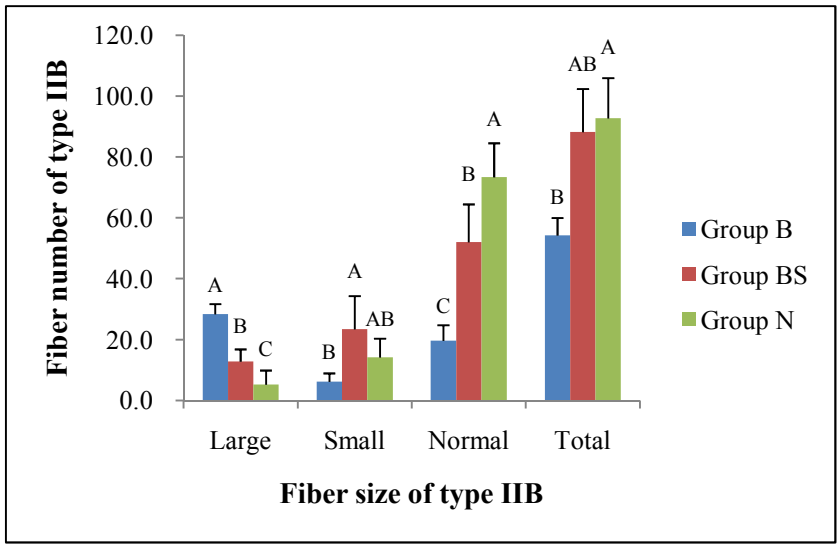

Figure 2. Fiber size and number of type IIB, in three groups categorized by size of type IIB. Significance ($p<0.05$) is indicated by differing letters ($^{A, B, C}$). Group B: the high proportion of big-sized (ø > 100μm) IIB fibers; Group BS: the high proportion of both big-sized and small-sized (ø < 40μm) IIB fibers; Group N: the high proportion of normal-sized (ø > 40μm, < 100μm) IIB fibers.

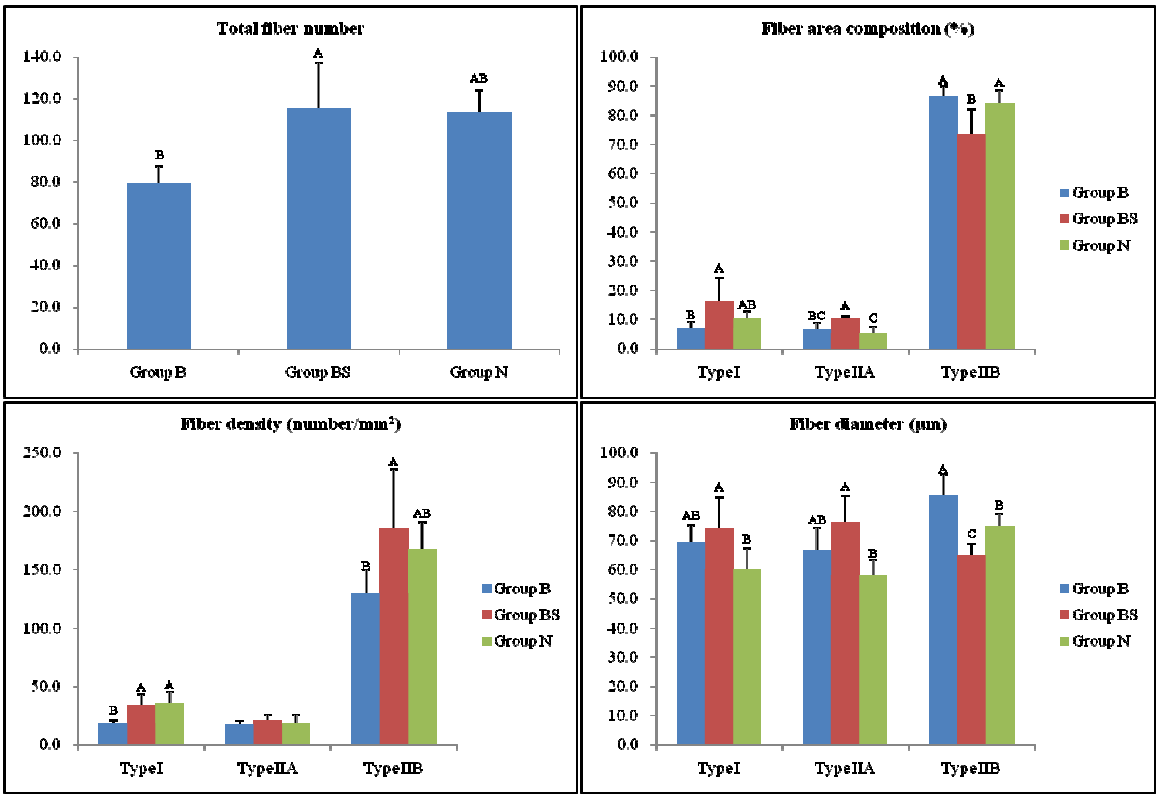

Figure 3. Muscle fiber characteristics of three groups, categorized by the size of type IIB fibers. Significance ($p<0.05$) is indicated by differing letters ($^{A, B, C}$). Group B: the high proportion of big-sized IIB fibers; Group BS: the high proportion of both big-sized and small-sized IIB fibers; Group N: the high proportion of normal-sized IIB fibers.

Table 1. Effect of type IIB fiber size on carcass traits and meat qualities

Traits	Group B[1)]	Group BS	Group N
Carcass traits			
Carcass weight (kg)	78.00±5.29	79.25±4.27	78.60±6.11
Loin-eye area (cm^2)	23.75±3.30^{A}	16.00±3.16^{B}	22.20±3.63^{A}
Backfat thickness (mm)	32.00±7.26^{AB}	39.50±4.20^{A}	30.20±3.35^{B}
Meat quality characterisics			
Moisture content (%)	73.63±0.78^{AB}	72.25±1.29^{B}	74.56±1.32^{A}
Intramuscular fat content (%)	2.00±0.57^{B}	5.13±1.84^{A}	2.18±0.86^{B}
Lightness (L^*)	49.55±8.83	49.43±2.97	47.86±7.40
Redness (a^*)	8.33±2.94^{AB}	12.40±3.24^{A}	7.80±1.73^{B}
Yellowness (b^*)	4.80±1.54	5.20±2.17	3.12±1.87
Cooking loss (%)	35.20±3.39	36.60±2.13	31.16±7.43
Drip loss (%)	4.50±3.22	1.58±0.62	3.84±2.78

$^{A, B}$ Means±SD within the same row with same letter are not significantly different.

[1)] Group B: the high proportion of large (ø > 100μm) IIB fibers; Group BS: the high proportion of both large and small (ø < 40μm) IIB fibers; Group N: the high proportion of normal (ø > 40μm, < 100μm) IIB fibers.