S5P21.WP

MUSCLE FIBRE TYPES AND CARCASS CHARACTERISTICS IN WAGYU (JAPANESE BLACK CATTLE)

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INTRODUCTION

Japanese Black cattle (Wagyu), one of Japan's indigenous breeds, are famous for their high marbling performance. However there are many genetically different variations of Wagyu, because until recently genetic improvements of Wagyu were carried out within closed herd breeding systems. Therefore the performance of meat productivity vary with the different strains. It is well known that muscle fibre types are different between breeds. It is suggested that one of the reasons for this variability in performance of meat productivity may be attributed to muscle fibre types. The aim of the present study was to compare the three fibre types of the four main strains of Wagyu and study the correlations between fibre types, carcass characteristics and meat quality.

MATERIALS AND METHODS

Experimental animals

Forty-four Wagyu steers produced from nine sires of four strains from four Japanese prefectures were used in this study. The steers received the same feeding during the fattening periods. Mean slaughter weight and age are shown in Table 1.

Carcass measurements and grading

Each carcass was evaluated for meat quality and yield scores according to the new carcass grading standards of Japan (Japan Meat Grading Association, 1988)

Sampling procedures

The *longissimus thoracis* (LT) muscles were used for chemical and physical analysis as well as fibre type classification. Samples of the LT muscles were taken from the left side of the carcass in the area adjacent to the 6th thoracic vertebra on the fourth or seventh day after slaughter. Tissue samples were cut and frozen in liquid nitrogen and stored at -80°C for histochemical analyses.

Analyses for meat quality

The pH value was determined by inserting a needle type electrode into the LT muscles. Crude fat contents were measured by the ether extraction method (A.O.A.C.,1984). Warner-Bratzler shear force values were determined using ten 1.3 cm diameter cores obtained from steaks cooked at 70°C of internal temperature for 30 minutes. The colour of the LT muscle was measured with L*, a* and b* values.

Histochemical analysis

Transverse serial cross sections (10μm) were cut in a cryostat. The sections were stained for myosin adenosine triphosphatase(ATPase) at pH9.4 and for succinic dehydrogenase(SDH). Representative areas of these sections were photographed. From these photos, type βR,αR and αW fibres were identified according to Ashmore *et al.* (1972).

Statistical analysis

The significant differences of carcass characteristics, meat quality and fibre types between strains were determined by Harvey least-squares procedure (1975).

RESULTS AND DISCUSSION

Carcass characteristics and the physical and chemical properties of LT muscles from 44 steers in four strains are shown in Tables 2 and 3 respectively. Carcass weight, rib thickness, subcutaneous fat thickness and Beef Marbling Scores(BMS) were significantly different between strains, but rib eye areas were not. Strain A had the lowest body weight gain, thinner fat and the highest marbling score. On the other hand, strain B showed the highest body weight gain, and comparatively thicker fat and as well as the second highest marbling score. These two strains are representative of the trend in Wagyu for either fast growth rate or good marbling characteristics. The fat content of LT muscles was different statistically, and it was reflected in the BMS. The pH values and Warner-Bratzler shear force values were not different between strains. L* and b* values were highest in strain A. These colour values may be associated with intramuscular fat contents.

Fibre type compositions and fibre diameters in the four strains are summarized in Table 4. Fibre type compositions had significant differences between strains. Highest percentages of βR fibres appeared in strain B, which had lower αW fibres. Conversely, strain C had lower βR and αW fibre types. Of the total sample muscles βR composed on average 27%, αR 19% and αW 55% for the four strains. The percentages of these fibre types in Japanese Black steer were almost the same as those found by Iwamoto *et al.* (1991). There were no statistical differences in the fibre diameters between the three fibre types and there were only slight differences between strains. Simple correlations in all of steers used in this experiment between fibre type composition; fibre type diameter and body weight, age, daily gain, carcass characteristics and meat quality are presented in Table 5. The percentage of αW fibres had a positive correlation with age and a negative correlation with daily weight gain.αR fibres had a negative significant correlation with the marbling score and with the intramuscular fat content but had a positive correlation with Warner-Bratzler shear force value. Solomon *et al.* (1988) showed that *longissimus* muscles from lambs fed a high-energy diet, had more αW and fewer αR fibres than those of the low-energy groups. Steers had a significantly higher IIB(αW) and lower IIA(αR) fibres than bulls fibres in LT muscle (Young, 1984). These results suggest that a lower percentage of αR fibres could possibly increase the levels of intramuscular fat and consequently improve meat quality as shown in this study. On the contrary, Calkins *et al.* (1981), using cattle of unknown origin, found a positive correlation between αR fibre occurrence and intramuscular fat and meat tenderness. May *et al.* (1977) using certain crossbred steers could find no relationship between marbling scores and fibre types. As shown by many researchers, there is a great variation of muscle fibre types between breeds. Further research is needed to determine if a relationship exists between muscle fibre characteristics and meat quality. Negative significant correlations were also observed between the percentage of αR fibres and pH values. Young *et al.* (1984) showed that ultimate pH in LT muscles had a weak correlation coefficient with IIA(αR) fibre occurrence. It is expected that faster twitch muscles with a higher percentage of α fibre, which will have more glycogen contents, will be associated with lower ultimate pH, because lactic acid would be produced mainly through glycolysis. Results of this study suggest αR fibres are more important than αW fibres for ultimate pH value.

CONCLUSION

Muscle fibre types of *longissimus thoracis* muscle from the main strains in Wagyu (Japanese Black cattle) were determined. These results suggest that the muscles with fewer αR fibre types have a greater intramuscular fat content and hence improved Wagyu beef tenderness.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of Hyogo Prefectural Agricultural Institute, Shimane Prefectural Animal Husbandry Experiment Station, Okayama Prefectural Center for Animal Husbandry and Research, and Hiroshima Prefectural Animal Husbandry Experiment Station.

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Table 1. Body weight, age and daily weight gain of experimental animals.

Strains	# animals	slaughter weight, kg	Age, in months	Daily gain in kg/day
A	11	625^{b}±11	31.7^{a}±0.6	0.57^{c}±0.03
B	16	671^{a}± 9	24.8^{a}±0.5	0.79^{b}±0.02
C	8	683^{a}±13	25.4^{b}±0.7	0.77^{ab}±0.03
D	9	635^{b}±13	26.1^{b}±0.7	0.69^{a}±0.03
Total	44	654 ± 6	27.0 ±0.7	0.71 ±0.01

Values are shown as means ± standard error.
[a,b,c] Means with different superscripts are significantly different at 5% level.

Table 2. Carcass characteristics of experimental animals.

Strains	# animals	Carcass weight, kg	Rib eye area, cm^2	Rib thickness cm
A	11	383^{b} ± 7.7	48.7 ± 1.4	6.7^{ab}± 0.2
B	16	409^{a} ± 6.4	48.7 ± 1.1	7.1^{a} ± 1.1
C	8	411^{a} ± 9.0	47.4 ± 1.6	6.8^{ab}± 0.2
D	9	380^{b} ± 8.5	49.9 ± 1.5	6.5^{b} ± 0.2
Total	44	396 ± 4.0	48.7 ± 0.7	6.8 ± 0.1

Strains	Fat thickness cm	Beef Marbling Stnd, No.
A	1.8^{b} ± 0.2	10.2^{a}± 1.4
B	2.8^{a} ± 0.2	7.3^{b} ± 0.5
C	2.4^{ab}± 0.2	5.4^{c} ± 0.6
D	2.2^{bc}± 0.2	6.6^{bc}± 0.6
Total	2.3 ± 0.01	7.4 ± 0.3

Values are shown as means ± standard error.
[a,b,c] Means with different superscripts are significantly different at 5% level.

Table 3. Chemical and physical properties of longissimus thoracis muscle in experimental animals.

Strains	# animals	pH value	Fat content %	W-B shear value, lb
A	11	5.55 ± 0.02	27.6[a] ± 1.6	5.0 ± 0.4
B	16	5.58 ± 0.01	22.6[b] ± 1.3	6.3 ± 0.6
C	8	5.55 ± 0.02	12.5[c] ± 1.8	6.2 ± 0.5
D	9	5.57 ± 0.02	21.6[b] ± 1.7	
Total	44	5.57 ± 0.02	21.1 ± 0.8	5.8 ± 0.3

Strains	Meat colour L* value	a* value	b* value
A	48.2[a] ± 1.0	22.9 ± 0.8	16.9[a] ± 0.4
B	44.9[b] ± 0.9	22.2 ± 0.7	15.4[b] ± 0.3
C	43.3[b] ± 1.2	22.3 ± 0.7	15.5[b] ± 0.5
D	44.5[b] ± 1.1	21.6 ± 0.9	15.1[b] ± 0.5
Total	45.2 ± 0.6	22.2 ± 0.4	15.7 ± 0.2

Values are shown as means ± standard error.
[a,b,c] Means with different superscripts are significantly different at 5% level.

Table 4. Muscle fibre composition and diameter of *longissimus thoracis* in experimental animals.

Strains	# animals	Muscle fibre composition, %: ßR	αR	αW
A	11	$26.8^{b} \pm 1.4$	$17.0^{ab} \pm 1.2$	$56.2^{ab} \pm 1.7$
B	16	$30.8^{a} \pm 1.2$	$17.2^{b} \pm 1.0$	$52.1^{b} \pm 1.4$
C	8	$23.5^{bc} \pm 1.6$	$19.3^{ab} \pm 1.3$	$57.3^{a} \pm 2.0$
D	9	$26.0^{bc} \pm 1.5$	$20.6^{a} \pm 1.3$	$53.4^{ab} \pm 1.9$
Total	44	26.8 ± 0.7	18.5 ± 0.6	54.7 ± 0.9

Strains	# animals	Muscle fibre diameter, %: ßR	αR	αW
A	11	$51.2^{ab} \pm 1.6$	50.1 ± 1.7	$51.5^{ab} \pm 1.6$
B	16	$49.2^{b} \pm 1.2$	47.8 ± 1.4	$50.6^{b} \pm 1.3$
C	8	$51.4^{ab} \pm 1.7$	51.8 ± 2.0	$52.0^{ab} \pm 1.9$
D	9	$53.8^{a} \pm 1.6$	52.6 ± 1.9	$55.6^{a} \pm 1.8$
Total	44	51.4 ± 0.8	50.6 ± 0.9	52.4 ± 0.8

Values are shown as means ± standard error.

^{a,b,c} Means with different superscripts are significantly different at 5% level.

Table 5. Simple correlations in all of steers used in this experiment between fibre type composition; fibre type diameter and body weight, age, daily gain, carcass characteristics and meat quality of *longissimus thoracis* muscles.

	Muscle fibre composition			Muscle fibre diameter		
	ßR	αR	αW	ßR	αR	αW
Body weight	-.03	.220	-.120	-.089	.002	-.148
Age	-.139	-.275	.316*	.180	-.094	-.086
Daily gain	.133	.268	-.306*	-.169	.060	.011
Carcass weight	-.018	.148	-.088	-.030	-.097	-.173
Rib eye area	-.038	.123	-.050	-.030	.166	.238
Rib thickness	.224	.061	-.242	-.244	-.174	-.175
Fat thicness	.250	.145	-.173	.031	-0.16	.000
Beef Marbling Score	.081	-.358*	.030	-.045	-.179	-.131
Fat content	.254	-.338*	.014	-.076	-.280	-.110
pH value	.164	-.334*	.084	-.062	-.016	-.111
W-B shear force value	-.060	.554 **	-.261	-.094	-.004	-.022
Meat colour:						
L* value	-.140	-.148	.230	-.178	-.181	-.152
a* value	.209	-.158	-.075	.320*	.303*	.219
b* value	.003	-.150	.104	.160	.129	.045

Level of significance: ** P<0.01; * P<0.05.