INFLUENCE OF SLAUGHTER WEIGHT, SIRE, CONCENTRATE FEEDING AND MUSCLE ON THE PHYSICAL AND CHEMICAL CHARACTERISTICS IN JAPANESE BLACK BEEF

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Summary

Seventeen Japanese Black steers were used to evaluate the influence of slaughter weight (550 kg, 600 kg or 650 kg), sire (two sires), concentrate feeding (barley or corn) and muscle (six muscles) on the following characteristics: pH value, cooking loss, shear value, moisture and crude fat contents. Crude fat contents were higher, and moisture content and shear values were lower in muscles from the large slaughter weight group 650 kg than those from other slaughter weight groups. Cooking loss, shear value, moisture and crude fat contents differed between sires. Corn feeding increased crude fat content in muscle compared to barley feeding. Muscles containing a large amount of intramuscular fat showed lower shear values and less cooking loss than those containing a small amount of intramuscular fat.

(**Key Words**: Beef Cattle, Slaughter Weight, Sire, Barley, Corn, Muscle Characteristics)

Introduction

It is generally believed that physical and chemical characteristics of beef are influenced by the finishing stage, genetic background of the animal, diet and site of sampling. There are many reports of the effect of age or slaughter weight on the following characteristies: pH (Lawrie, 1961; Hawrysh and Berg, 1979; Turgut and Sink, 1983; Mitsumoto et al., 1987), cooking loss (Hawrysh and Berg, 1979; Sink et al., 1983), shear value (Zinn et al., 1970; Hunsley et al., 1971; Hawrysh and Berg, 1979; Yamazaki, 1981; Sink et al., 1983; Mitsuhashi et al., 1987), moisture and crude fat contents (Fukuhara et al., 1968; Hawrysh and Berg, 1979; Gifu Pref. et al., 1981; Mitsumoto et al., 1986b; Mitsuhashi et al., 1987; Mitsumoto et al., 1987). Only a few studies (Gifu Pref. et al., 1981; Mitsumoto et al., 1986b), however are available on meat qualities at different slaughter weights in Japanese Black cattle. Formerly, workers have reported differences between major beef muscles in pH (Swift and Berman, 1959; Mitsumoto et al., 1987; Ozawa et al., 1988), cooking loss (Ozawa et al., 1988), shear value (Zinn et al., 1970; Prost et al., 1975; Hawrysh and Berg, 1979; Yamazaki, 1981; McKeith et al., 1985; Ozawa et al., 1988), and moisture and crude fat contents (Swift and Berman, 1959; Lawrie et al., 1964; McKeith et al., 1985; Mitsumoto et al., 1987; Zembayashi, 1988). Studies of beef characteristics in cattle over 550 kg are limited (Hawrysh and Berg, 1979).

Progeny testing to evaluate sires used in the Japanese Black breed is common in Japan. These tests however do not include analysis of physical and chemical characteristics of beef. Studies examining the variation in physical and chemical characteristics of muscles in progeny of Japanese Black sires are limited (Gifu Pref. et al., 1981).

The most common feed stuffs used for finishing Japanese Black steers are barley and corn. Tsuchiya et al. (1964) compared milo and barley feeding in their effects on beef quality, and Reddy et al. (1975) evaluated effects of triticale (a hybrid obtained by crossing wheat and rye), corn and wheat in finishing beef cattle rations on meat quality. However, there are no comparisons of barley and corn feeding on beef muscle characteristics.

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The purpose of this study was to evaluate the influence of slaughter weight, sire, concentrate feeding and muscle on pH value, cooking loss, shear value, moisture and crude fat contents in Japanese Black beef.

Materials and Methods

Seventeen Japanese Black steers including two sire groups were used in this study. One sire group was Kumokawa 19 group (group K) that consisted of nine half-sib Japanese Black steers which were produced at Chugoku National Agricultural Experiment Station. The other group was Hatsuyo 14 group (group H) that consisted of eight half-sib Japanese Black steers which were purchased from the livestock market at Miyoshi-shi in Hiroshima Prefecture. All feeder cattle were reared mainly with roughage during their growing phase from 8-9 to 17 months of age. After 17 months of age, they were randomly allotted to the two concentrate treatments: barley feeding or corn feeding group (table 1). The cattle were also randomly allotted to three target slaughter weights of 550 kg, 600 kg and 650 kg. Animals were slaughtered as near to their target weights as possible. The mean slaughter age of each slaughter group was 23.2, 24.6 and 28.1 months, respectively. Details of the growth and feed efficiency and carcass characteristics were described in a previous paper (Mitsumoto et al., 1989).

TABLE 1. COMPOSITION OF THE EXPERIMENTAL CONCENTRATE

Item	Barley diet	Corn diet
Ingredient (%)		
Flaked barley	53.0	20.0
Flaked corn	19.0	38.0
Wheat bran	11.0	20.0
Rice with hull	10.0	15.0
Soybean meal	5.0	5.0
Salt	0.66	0.66
Mineral mixture[1]	1.16	1.16
Vitamin mixture[2]	0.18	0.18
Dry matter (%)	85.6	85.4
TDN (%)	71.6	71.8
DCP (%)	9.5	9.5

[1] $CaCO_3$, 800 g/kg; $CaHPO_4$, 180 g/kg; $MnSO_4$, 2,900 mg/kg; $FeSO_4$, 3,000 mg/kg; $CoCl_2$, 20 mg/kg; $ZnSO_4$, 100 mg/kg; $CuSO_4$, 300 mg/kg; KI, 15 mg/kg.
[2] Vitamin A, 10,000 IU/g; Vitamin D_3, 2,000 IU/g.

The following six muscles were dissected from the left side carcasses of the cattle at 48 hr post-mortem: semitendinosus (ST), semimembranosus (SM), psoas major (PM), latissimus dorsi (LA), longissimus thoracis (LT), supraspinatus (SS). The sample was cut from the center or thickest portion of each muscle and stored for 24 hr at 1℃ for subsequent analyses.

Physical and chemical analyses

A 10 g muscle sample was homogenized in 20 ml distilled water and pH values (at about 72 hr postmortem) were determined with glass electrode.

Cooking loss percentages and shear values were measured as follows; steaks (about 2 × 5 × 7 cm) from each sample were placed in a polyethylene bag, and cooked in water at 70℃. Internal temperature of each steak was maintained at 70℃ for 30 min. After being cooled to room temperature the sample was weighed and cooking loss determined. The Warner-Bratzler shear values were determined with ten 1.3 cm diameter cores obtained from the above cooked samples.

Moisture contents were measured by oven drying at 100℃ for 16 hr (A.O.A.C., 1984), and crude fat contents were determined by ether extraction (A.O.A.C., 1984).

Statistical analysis

Data were analyzed by least-squares procedures (Harvey, 1977) to estimate the effects of slaughter weight, sire, concentrate feeding and muscle on beef physical and chemical characteristics. The significance of the difference between means were determined by Tukey's studentized range test.

Results and Discussion

Effects of slaughter weight

Slaughter weight affected pH value, shear value, moisture and crude fat contents.

The mean pH value (figure 1) of the six muscles decreased from 5.57 to 5.50 as slaughter weight increased from 550 kg to 650 kg; this difference was small, but significant ($p < 0.001$). Separable fat percentages in experimental carcasses

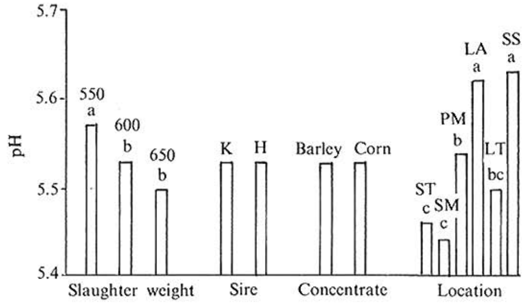

Figure 1. Least-squares means for pH value. a,b,c: within main effects, means with no common letters differ significantly ($p < 0.05$). 550 = 550 kg; 600 = 600 kg; 650 = 650 kg; K = Kumokawa 19; H = Hatsuyo 14; Barley = barley feeding; Corn = corn feeding; ST = semitendinosus; SM = semimembranosus; PM = psoas major; LA = latissimus dorsi; LT = longissimus thoracis; SS = supraspinatus.

increased with increasing slaughter weight from 24.3% at 550 kg live weight, to 25.3% at 600 kg live weight and 29.5% at 650 kg live weight (Mitsumoto et al., 1989). Since fat serves as insulation to heat transfer, the postmortem temperature of fatter carcasses will decrease more slowly than that of less fat carcasses. The gradual temperature decline causes rapid glycolysis, which is followed by fast pH decline resulting in a low ultimate pH compared to rapid temperature decline (Tarrant and Mothersill, 1977). The results in this study were therefore expected.

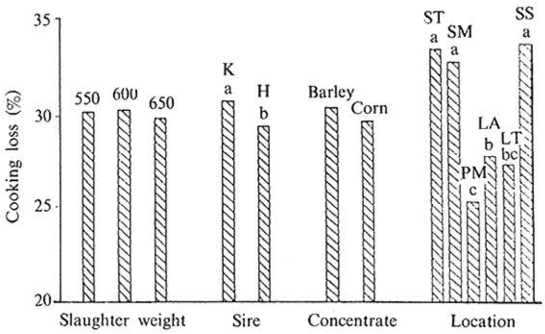

Figure 2. Least-squares means for cooking loss percentage. a,b,c: within main effects, means with no common letters differ significantly ($p < 0.05$). See figure 1 legend for treatment codes.

Mean shear values (figure 3) of six muscles slightly decreased from 3.6 kg to 3.3 kg with increasing slaughter weight. Hawrysh and Berg (1979) reported that shear values of ST and LT roasts showed no differences within four slaughter weight groups of Hereford bulls. The major components of meat that contribute to tenderness are connective tissue, muscle fibers and adipose tissue (Judge et al., 1989). Complexity of connective tissue increases with cattle age, tending to increase shear values (Judge et al., 1989). However, in this study, there was only 4.9 months difference in slaughter age between 550 kg group (mean 23.2 months of age) and 650 kg group (28.1 months), and fat deposition is also increased during finishing (figure 4), tending to reduce shear values. In this study, the influence of intramuscular fat deposition on meat tenderness is thought to be stronger than the influence of connective tissue linkage on meat toughness, resulting in lower than expected shear values.

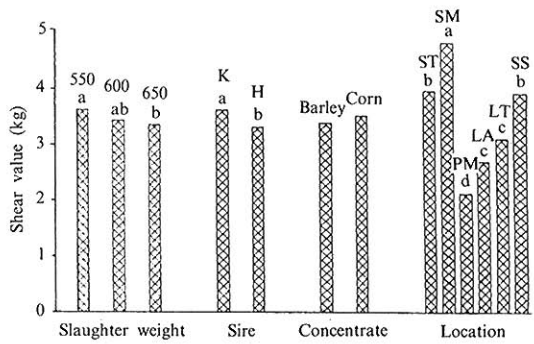

Figure 3. Least-squares means for shear value. a,b,c,d: within main effects, means with no common letters differ significantly ($p < 0.05$). See figure 1 legend for treatment codes.

Heavier slaughter weight 650 kg resulted in increased intramuscular fat content. The mean crude fat content (figure 4) increased from 9.6% to 11.5% during the growth of steers from 550 kg to 650 kg and a concomitant decrease in moisture content 69.1% to 67.5% was observed. Other workers (Fukuhara et al., 1968; Hawrysh and Berg, 1979; Gifu Pref. et al., 1981; Mitsumoto et al., 1986b; Mitsuhashi et al., 1987; Mitsumoto et al., 1987) have reported that fattening beef cattle enhanced intramuscular fat deposition.

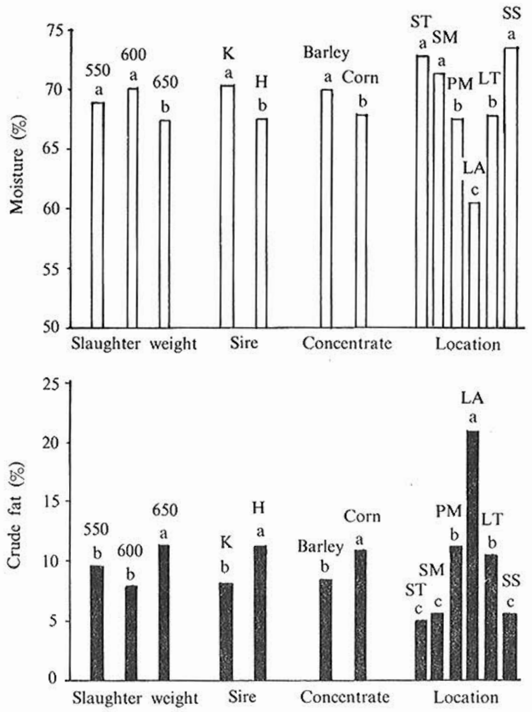

Figure 4. Least-squares means for moisture and crude fat percentage. a,b,c: within main effects, means with no common letters differ significantly ($p < 0.05$). See figure 1 legend for treatment codes.

Cooking loss (figure 2) did not significantly differ between slaughter weights. Hawrysh and Berg (1979) have reported that percent cooking losses for semitendinosus and longissimus dorsi roasts tended to increase with slaughter weight but differences were not statistically significant. Sink et al. (1983) also reported that cooking loss of longissimus dorsi muscle peaked in the 16 months group but returned to previous levels at 20 months of age.

Effects of sire

Differences between the two sire groups for cooking loss (figure 2), shear value (figure 3), moisture and crude fat contents (figure 4) were highly significant ($p < 0.01$), but those for pH value (figure 1) were not significant.

Group H showed higher crude fat content (11.2%) than group K (8.1%). The heritability of marbling score in LT muscle was reported as 40% (Yang et al., 1985), and that of shear value was described as about 60% (Judge et al., 1989). These support the suggestion that the differences are due to the genetic differences between the groups. Mitsumoto et al. (1986a) have reported that crude fat content negatively correlated with cooking loss, shear value and moisture content in the LT muscle. Differences between sire groups in intramuscular fat contents of muscles will therefore influence these other characteristics.

Effects of concentrate

The corn fed group showed higher crude fat contents (10.8%) than the barley fed group (8.6 %) across muscle sites (figure 4), despite TDN and DCP dietary levels being almost the same (table 1). On the other hand, the muscle and bone weight of the barley fed group were higher than those of the corn fed group (Mitsumoto et al., 1989). This suggests that barley feeding stimulates muscle and bone development whereas corn stimulates intramuscular fat deposition. The higher crude fat content of corn ($3.9 \pm 0.4\%$; mean $\pm$ standard error) compared to barley ($2.1 \pm 0.3\%$) (Agriculture, Forestry and Fisheries Research Council Secretariat, 1987) may in part explain these effects.

Type of concentrate fed did not affect pH (figure 1), cooking loss (figure 2) and shear value (figure 3). In general cooking loss and shear value are less responsive than moisture and crude fat contents.

Effects of muscle

The LA muscle had the highest curde fat content (20.8%) among the muscles examined, PM and LT muscles contained 11.1% and 10.3 % respectively, and ST, SS and SM muscles contained the least (4.9%, 5.4% and 5.6%, respectively) in figure 4. The LA, PM and LT muscles containing relatively high crude fat showed lower cooking losses and shear values than other three muscles. Also in a previous report (Mitsumoto et al., 1986a), curde fat content negatively correlated with cooking loss and shear value. These results suggested that muscle containing a large amount of fat was tender and exhibited lower cooking loss.

The LA and SS muscles had the highest pH values (5.62 and 5.63, respectively) and ST and SM muscles had the lowest (5.46 and 5.44, respectively) among the muscles examined as shown (figure 1). The pH value of each muscle was similar to those previously reported by Swift and Berman (1959). In general, the ultimate pH of normal meat is approximately 5.4-5.8 (Faustman and Cassens, 1990).

In conclusion, 1) Heavier slaughter weight 650 kg increased intramuscular fat content and tenderness. 2) Sire influenced intramuscular fat content, tenderness and cooking loss. 3) Corn feeding resulted in higher intramuscular fat content than barley feeding. 4) Muscles containing high intramuscular fat were more tender and showed lower cooking losses.

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