PE1.07 Effects of grass-fed and grain-fed on carcass composition and meat quality of Japanese black cattle 82.00

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Abstract The objective of this study was to investigate the effect of indoor feeding of large amounts of roughage on carcass composition and meat quality in cattle. Ten Japanese Black Cattle aged 10 months were separated randomly into grass-fed and grain-fed groups. All cattle were fed a combination of concentrate ad libitum and grass hay until 16 months of age in a stall barn. After this control period, the grass-fed cattle were fed a combination of grass hay ad libitum and concentrate at 2.0 kg/day, whereas the grain-fed cattle continued on the concentrate diet. The cattle were slaughtered at 28 months of age. The grain-fed group showed final body weight, daily gain, TDN intake, rib eye area, and rib thickness were greater than those of the grass-fed group, although no difference was found in BMS and BFS between groups. Lipid in muscle tended to increase in the grain-fed group, but protein contents were higher in the grass-fed group. In contrast to the grain-fed group, drip loss and cooking loss in muscle after aging were lower in the grass-fed group, indicating that water-holding capacity is improved by grass feeding. However, shear force in muscle did not differ. Furthermore, the grass-fed group muscle exhibited higher relative contents of C18:0 and C18:3n-3 than that of grain-fed cattle. These results demonstrate that meat quality was altered by indoor grass hay feeding.

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Index Terms - beef cattle, grass-fed, carcass composition, meat quality

I. INTRODUCTION

Most beef cattle in Japan are reared individually in free stanchion barns and are generally finished indoors on a concentrate-based diet throughout the fattening period until slaughter. Recently, beef cattle production has made use of grazing, with effective utilization of the roughage in the field. The beef marbling standard (BMS) number is lower in grazed Japanese Black cattle than in cattle fattened in free stanchion barns. Moreover, the meat values of L*, a*, and b*, and drip loss of grazed cattle are higher than those of fattened cattle (Tanimoto et al., 2004). The α-tocopherol and β-carotene contents in the muscle of the pasture-fed Japanese Shorthorn steer are higher than those of concentrate-fed cattle (Muramoto et al., 2005). Results of previous studies also show that pasture finishing decreases drip loss of the beef. Regarding effects of roughage on beef production, although several comparisons between outdoor grazed and indoor concentrate-fed cattle have been reported, few comparisons examine grass-fed and concentrate-fed cattle kept indoors. The objective of this study was to investigate the effect on beef cattle carcass composition and meat quality from indoor feeding of large amounts of roughage.

II. MATERIALS AND METHODS

A. Animal Management

Management of cattle and all procedures in this study were performed according to the Animal Experimental Guidelines of the National Agricultural Research Center for Western Region (WeNARC), Japan. Ten Japanese Black Cattle aged 10 months, which had been bred at WeNARC, were divided randomly into two groups: grass-fed and grain-fed. All cattle were first housed individually in a stall barn and fed a combination of concentrate ad libitum and grass hay at 1.5 kg/d until 16 months of age. After that control period, the five grass-fed cattle were fed a combination of grass hay ad libitum and concentrate at 2.0 kg/d in the stall barn; the other five grain-fed cattle continued the concentrate diet in the same environment. Cattle were slaughtered at 28 months of age, and skeletal muscle tissue from the M. semitendinosus (ST) and M. longissimus lumborum (LL) were obtained for use in analyses.

B. Carcass Evaluation and Sample Preparation

Carcasses were kept in a refrigerator at 0°C for 24 h; they were then evaluated by their dressing percentage and by measurement of beef marbling standard (BMS), beef fat color standard (BFS), rib eye area, rib thickness, and subcutaneous fat thickness of the section between the sixth and seventh ribs. To analyze meat characteristics such as drip loss, cooking loss, and the Warner-Bratzler shear force (WBSF), muscles were removed from carcasses. Subsequently, they were processed into 2.5-cm-thick steaks, vacuum-packaged, stored in a refrigerator at 2°C for 2 and 30 days after slaughter, and frozen at -80°C until analyses.

C. Nutrient Elements in Muscle

Muscle tissues were minced to determine the amounts of crude protein and extractable lipid, and fatty acid composition. Crude protein was calculated through quantitative analysis of nitrogen using Kjeldahl method with copper sulfate and potassium sulfate as catalysts (AOAC, 1990). Lipid was extracted with diethyl ether for 16 h using a Soxhlet extractor (AOAC, 1990). To analyze the fatty acid composition in muscle, extracted lipid was converted to fatty acid methyl esters; then they were analyzed using gas chromatography (AOCS, 2005).

D. Meat Characteristics

Steaks were thawed for 24 h at 4°C, then carefully mopped dry using paper tissue. Drip loss was calculated from the weight difference before and after storage. Following the measurement of drip loss, these samples broiled on electric grills to an internal temperature of 70°C; then they were wrapped in plastic to prevent desiccation and stored at 4°C for approximately 12 h. Cooking loss was calculated from the weight difference before and after cooking. Six cores (1.3 cm diameter) were removed from each steak parallel to the longitudinal orientation of the muscle fibers. All cores were sheared using a WBSF machine. The peak shear force was recorded.

E. Statistical analyses

All measurement values are presented as means ¡Ó SEM. The relations between the measurement value and the hay-fed group or grain-fed group were analyzed using one-way ANOVA and a post hoc Scheffe's test. Results for which $P < 0.05$ were inferred as statistically significant.

III. RESULTS AND DISCUSSION

Table 1 presents performance and carcass characteristics of grass-fed and grain-fed cattle. Although all cattle at 10 months of age had similar body weight (initial body weight), final body weight and daily gain were significantly greater for the grain-fed group than for the grass-fed group ($p<0.05$). In addition, the TDN intake in the grain-fed group was significantly higher than that in the grass-fed group ($p<0.05$). When cattle were reared by restricted feeding of concentrate and roughage ad libitum, slaughter body weight, carcass weight, and TDN intake of those cattle were significantly lower than those consuming concentrate ad libitum (Muramoto et al., 2002). These results suggest that the decreased final body weight and daily gain in the grass-fed group are attributable to lower TDN intake than that of the grain-fed group. Although the half-dressed carcass weight was also significantly less in the grass-fed group than in the grain-fed group, the dressing percentage was not significantly different between groups (Table 1).

Moreover, the rib eye area and rib thickness in the grass-fed group were significantly smaller than that in the grain-fed group, although BMS and BFS were not significantly different in the groups. Several studies found decreased marbling scores and dressing percentages when cattle were fed a large amount of roughage (Srinivasan et al., 1998; Tanimoto et al., 2004). In contrast, Muramoto et al. (2002) reported that cattle fed a combination of roughage ad libitum and restricted feeding of concentrate showed no difference in the dressing percentage and BMS compared with the concentrate ad libitum. These results suggest that the grass-fed cattle do not affect the meat quality, but the evaluation of the meat quantity decreases because of body weight reduction. Figure 1 portrays the nutrient elements in ST and LL muscle of the grass-fed and grain-fed cattle. Srinivasan et al. (1998) reported that the protein content in muscle was lower in grass-fed cattle than in cattle fed a combination of grass and concentrate. In contrast, no difference was found in protein contents in longissimus muscle between cattle fed both concentrate and a large amount of roughage in comparison with concentrate-fed cattle (French et al., 2000; Schroeder et al., 1980). Consistent with their reports, we found no difference in protein contents in LL muscle samples of the two groups (Fig. 1A).

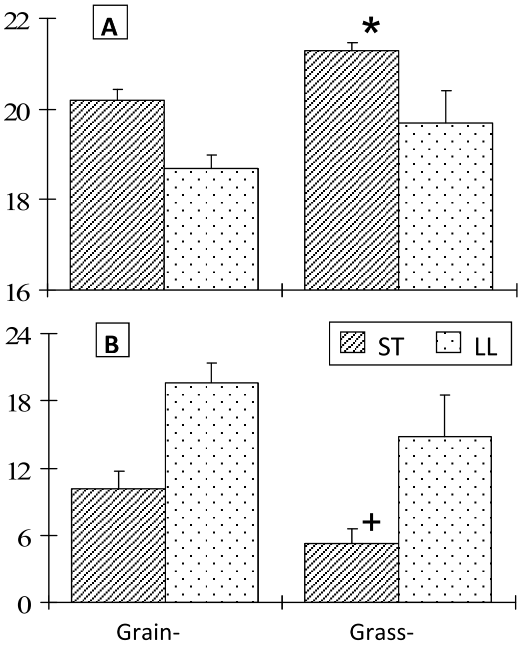

Figure 1.Effect of grass-fed on the nutrient elements in the *M. semitendinosus* (ST) and *M. longissimus lumborum* (LL) of cattle. Crude protein, % (A) and extract lipid, % (B) in ST and LL muscles of grass-fed and grain-fed cattle were analyzed. Data represent means ± SEM. * signifies that means differ significantly between grass-fed and grain-fed cattle in same muscle (P<0.05). +, P<0.10.

However, crude protein in ST muscle was significantly higher in the grass-fed group than in the grain-fed group. We also analyzed extract lipids in muscle; they were higher in the grain-fed group than in the grass-fed group, but not significantly (Fig. 1B). Results of the present study confirm reports of French et al. (2000) and Srinivasan et al. (1998): muscle lipid contents of grass-fed and grain-fed cattle were not different. Drip loss in ST muscle was significantly lower for the grass-fed group (2.26¡Ó0.4) than for the grain-fed group (4.55¡Ó0.9), although that in LL muscle was not significantly different between groups. Corresponding with our results, lower drip loss has been reported for meat from grass-fed (French et al., 2000) and pasture-fed (Muramoto et al., 2005) cattle than from concentrate-fed cattle. Moreover, regarding water-holding capacity, cooking loss in muscle was lower in concentrate-fed cattle than in grazed cattle (Dufrasne et al., 1995). However, cooking loss showed the same tendency as that of drip loss. Several reports describe no difference between concentrate-fed cattle and forage-fed (Mandell et al., 1998) or grass-fed (French et al., 2000) cattle. Contrasting to previous reports, cooking loss in ST muscle for 2 days after slaughter was not different between groups, but that for 30 days after slaughter was significantly lower in the grass-fed group than in the grain-fed group (Fig. 2A).

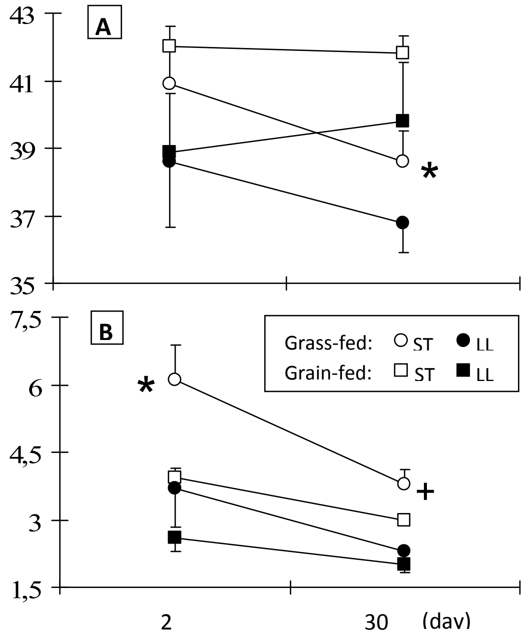

Figure 2.Effect of grass-feeding on cooking loss and Warner-Bratzler shear force in the *M. semitendinosus* (ST) and *M. longissimus lumborum* (LL) of cattle.

Cooking loss, % (A) and Warner–Bratzler shear force, kg (B) in ST and LL muscles before and after aging of grass-fed and grain-fed cattle were analyzed.

Data represent means ± SEM. * signifies that means differ significantly between grass-fed and grain-fed cattle in same muscle (P<0.05). +, P<0.10.

Although cooking loss in muscle showed no constant response from previous reports in roughage-fed cattle, losses of both drip loss and cooking loss shown in this study suggest that the water-holding capacity might be improved in cattle by feeding of a large amount of grass hay. The Warner-Bratzler shear force in ST muscle for 2 days after slaughter was significantly higher for the grass-fed group than for the grain-fed group (p<0.05). Furthermore, at 30 days after slaughter a similar tendency was found (Fig. 2B). The shear force of muscle of the concentrate-fed cattle was lower than that of the forage-fed (Schroeder et al., 1980) and pasture-fed (Muramoto et al., 2005) cattle. In general, muscle of cattle that had been fed large amounts of roughage has higher shear force than that of concentrate-fed cattle. Regarding factors that influence shear force, Nishimura et al. (1999) reported that shear force is high in muscle whose crude fat content is low; that inverse phenomenon was confirmed in different muscles. In the present study, the difference in the shear force before and after aging muscle between the groups probably resulted from the difference in extract lipid contents in those muscles. Table 2 presents fatty acid compositions of ST and LL muscle of the grass-fed and grain-fed cattle. Fatty acids in ST and LL muscles of grass-fed cattle exhibited significantly higher proportions of C15:0, C17:0 and C18:0 than those of grain-fed cattle, indicating the same tendency as that reported by Srinivasan et al. (1998) and Muramoto et al. (2005). Fatty acids in LL muscle of grass-fed cattle in this study were significantly lower proportions of C14:1 and C18:1 than those of grain-fed cattle. These results resemble those reported by Srinivasan et al. (1998) and Muramoto et al. (2005), although percentages of C18:1 in muscle showed no difference between grain-fed and forage-fed cattle (Mandell et al., 1998). Although the content of C18:3n-3 in LL muscle was not detected in concentrate-fed cattle, this fatty acid was detected in grass-fed cattle (Table 2). Furthermore, ST muscle of grass-fed cattle included significantly higher contents of C18:3n-3 than that of grain-fed cattle, as reported by Marner et al. (1984), Mandell et al. (1998), and Muramoto et al. (2005). Therefore, the higher rate of C18:3n-3 observed in grass-fed cattle might improve the n-6/n-3 ratio.

IV. CONCLUSION

Drip loss and cooking loss data presented herein suggest that the water-holding capacity of beef might be improved by feeding of large amounts of grass hay to cattle.

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