

Effects of Intramuscular Fat on the Sensory Characteristics of *M. longissimus dorsi* in Japanese Black Steers as Judged by a Trained Analytical Panel

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ABSTRACT : The effects of intramuscular fat on the sensory characteristics of *M. longissimus dorsi* in Japanese Black steers were investigated by a trained analytical panel (average 13.4 panelists). Five sets (10 head) of artificial identical twins were divided into 2 groups, high level of intramuscular fat group (HG) which utilized the fattening method of increasing intramuscular fat and low level of intramuscular fat group (LG) which did not use the above method. Regarding *M. longissimus dorsi* which was produced for use in the sensory evaluation, crude fat contents of HG and LG was 25.8% and 23.2% respectively ($p < 0.05$). Warner-Bratzler shear force, water holding capacity, cooking loss and fatty acid composition of HG and LG were similar between the two groups. *M. Longissimus dorsi* taken from HG and LG were tested for their sensory characteristics by a trained panel. HG was given higher points for juiciness than LG ($p < 0.05$). There were no significant differences for tenderness and flavor between the two groups. Overall acceptability which synthesized each of the sensory characteristics of HG and LG were 5.04 and 4.69 points respectively ($p = 0.05$). These results suggested that juiciness increased with the increase of intramuscular fat, and this raised the overall acceptability of *M. longissimus dorsi*. (**Key Words :** Intramuscular Fat, Sensory Evaluation, Japanese Black Steers, Juiciness)

INTRODUCTION

Concerns about the safety and quality of food are becoming important, above all, palatability has recently become important in Japan. This is the case with meat, whose production and approach to distribution are becoming increasingly responsive to these concerns in Japan. The acceptability and palatability of meat are affected by various factors like the texture, the smell, the taste and so on (JMISC, 2005).

Japanese Black cattle is characterized by an ability to deposit a large amount of intramuscular fat (Zembayashi et al., 1988; Xie et al., 1996). *M. longissimus dorsi* in Japanese Black cattle is neither small nor large and is capable of containing more than 30% of intramuscular fat. Intramuscular fat is important because it is one of the main

factors used to determine the beef quality grade (JMGA, 1988; USDA, 1989).

The relationship between intramuscular fat and the acceptability of beef was studied by using sensory evaluation with regards to the degree of intramuscular fat and fatty acid composition. In a study on the relationship between fatty acid composition and sensory evaluation, Dryden and Marchello (1970) reported that there is a significant correlation relationship between oleic acid and flavor score. Also, Westerling and Hedrick (1979) reported that high levels of total unsaturated fatty acids and oleic acid correspond with high flavor scores. Furthermore, there is a significant relationship between fatty acid composition and the melting point of fat (Mitsunashi et al., 1988; Enser and Wood, 1993). In these studies, it is thought that there is a relationship between fatty acids composition, the melting point of fat and the sensory characteristics. Regarding the relationship between intramuscular fat and sensory evaluation, Tatum et al. (1982) and Platter et al. (2003) reported that intramuscular fat has a low, but positive relationship to the palatability trait of beef. On the other hand, intramuscular fat doesn't affect sensory

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Received July 13, 2006; Accepted October 9, 2006

characteristics (Tatum et al., 1980; French et al., 2001), the increase in intramuscular fat is not always directionally consistent with palatability. Under these circumstances, the effects of sensory characteristics on intramuscular fat were not reported in Japanese Black cattle, which are characterized by an ability to deposit a large amount of intramuscular fat.

The objectives of the present study were to determine the effects of intramuscular fat on the sensory characteristics of *M. longissimus dorsi* by increasing the amount of intramuscular fat in one of a pair of identical twins of Japanese Black steers.

MATERIALS AND METHODS

Sample preparation

Five sets (10 head) of artificial identical twins were divided into 2 groups, a high level of intramuscular fat group (HG) and a low level of intramuscular fat group (LG). HG was fattened using the method (Oka et al., 1998a, 1998b; Nade et al., 2003) which controlled vitamin A in the diet to increase intramuscular fat. The fattening period was from 7 to 24 months of age. The samples for this study were excised in blocks of *M. longissimus dorsi* on the 7-10th thoracic vertebrae. *M. longissimus dorsi* on the 7-8th thoracic vertebrae was analyzed to determine its moisture content, crude fat content (as ether extract), crude protein content, cooking loss, Warner-Bratzler shear force, water holding capacity and fatty acid composition. *M. longissimus dorsi* on the 9-10th thoracic vertebrae were aged at post-mortem for 9 days at 2°C. Aged muscles were frozen at -30°C and stored until the sensory test.

Physico-chemical analyses

Moisture content was determined using duplicate samples which were dried for 24 h at 105°C. The weight differences between the samples were calculated before and after drying. Crude fat content was calculated by measuring the weight of intramuscular fat that was extracted by diethyl ether using a Soxhlet extractor for 16 h. The samples used were already analyzed for moisture. Crude protein content was determined by the Kjeldahl method using the nitrogen distillation titration device (2400 Kjeltac Auto Sampler System, FOSS, Hillerod, Denmark).

Cooking loss was calculated as; cooking loss
= [(raw weight approximately 50 g (A)
-cooked weight at 70°C for 1 h)/(A)]×100

Warner-Bratzler shear force (WBSF) was analyzed using samples of at least 4 cakes of muscles that had already been analyzed for cooking loss and were cut (vertical cross section 1×1 cm²) parallel to the long axis of

the muscle fibers (SALTAR, Zenken, Tokyo, Japan). Water holding capacity (WHC) was analyzed by following the Wierbiki and Deatherage (1958) method. Approximately 500 mg triplicate samples of muscle were placed in a filter-press device and compressed at 35 kgf/cm² for 1 min.

In fatty acid composition, intramuscular fat was extracted by means of a modification of the Folch et al. (1957) method using chloroform/methanol (2/1; v/v). Fatty acids were determined as methyl esters with a gas chromatograph (Detector FID, model GC380, GL Science, Tokyo, Japan) using a capillary column CP-Sil 88 W-cot 0.25 mm×50 M (GL Science, Tokyo, Japan).

Sensory evaluation

Sensory characteristics were evaluated by an inhouse trained analytical panel of 7-16 panelists (average 13.4 panelists) who passed the discrimination test of basic taste and hardness (JMISC, 2005). The panel training method was to practice evaluating beef by evaluating beef under the direction of the panel leader. A scoring method of eight scales (AMSA, 1995) was used for the sensory evaluation. Sensory evaluation was conducted 5 times for each pair of twins. Aged muscles were thawed at 2°C a day prior to cooking. The muscles were roasted at 165°C in a drying oven to an internal temperature of 70°C, cut to size (1×1×2 cm³) the samples were kept and served at 60°C. The panelists were asked to assess the following attributes:

Juiciness

(scale 1-8: 1 = extremely dry, 8 = extremely juicy)

Tenderness

(scale 1-8: 1 = extremely tough, 8 = extremely tender)

Flavor

(scale 1-8: 1 = extremely bland, 8 = extremely intense)

Overall acceptability

(scale 1-8: 1 = not acceptable, 8 = extremely acceptable)

Juiciness and tenderness were defined as the feeling from the first moment of the sample which was tasted to the last swallow. Flavor was defined as the feeling of retronasal aroma and the taste through the oral cavity. Overall acceptability was defined as a general feeling on the basis of each attribute.

Sensory evaluation was conducted under red light in order to eliminate the influence of the appearance.

Statistical analysis

Since we investigated sensory characteristics using *M. longissimus dorsi* from five sets of artificial identical twins we could regard the two steers of a set as the same animal

Table 1. Beef marbling score and physico-chemical analysis of *M. longissimus dorsi*

	HG	LG	Significance
BMS No. ¹	3.6±0.2 ²	2.8±0.2	*
Moisture (%)	56.4±1.7	58.1±2.3	*
Crude fat (%)	25.8±2.3	23.2±3.1	*
Crude protein (%)	17.1±0.7	18.3±0.8	**
Cooking loss (%)	23.6±1.2	26.1±1.1	NS
WBSF ³ (newtons)	16.3±2.3	17.6±3.7	NS
WHC ⁴ (%)	75.6±0.5	75.0±1.4	NS

¹ Beef marbling score as graded by Japan Meat Grading Association.

² Means±standard error.

³ Warner-Bratzler shear force.

⁴ Water holding capacity.

** p<0.01, * p<0.05, NS: Not significant.

(Nade et al., 2003), data were analyzed using two-sided paired *t* test, with p<0.05 denoting the level of significance.

RESULTS AND DISCUSSION

The physico-chemical analyses and the degree of intramuscular fat of *M. longissimus dorsi* in Japanese Black steers which was produced for use in the sensory evaluation are shown in Table 1. BMS No., which was graded by Japan Meat Grading Association, of HG was higher than that of LG (p<0.05). Regarding the physico-chemical analyses of *M. longissimus dorsi*, moisture contents of HG and LG were 56.4% and 58.1% respectively, crude protein contents were 17.1% and 18.3% respectively, which showed significant differences (p<0.05, 0.01). Crude fat contents of HG and LG were 25.8% and 23.2% respectively, which showed a significant difference (p<0.05). Crude fat contents of all samples of HG were higher than that of LG. Physical traits of cooking loss, WBSF and WHC did not show any significant differences between the two groups.

Fatty acid composition of *M. longissimus dorsi* in Japanese Black steers which was produced for use in the sensory evaluation is shown in Table 2. None of the proportions of saturated fatty acid (myristic, palmitic and stearic acid) showed any significant differences between the two groups. The proportions of oleic acid, which makes up the greatest proportion in unsaturated fatty acid, in *M. longissimus dorsi* was 48.1% and 46.9% for HG and LG respectively, which did not show a significant difference between the two groups. The proportions of other unsaturated fatty acids did not show any significant differences between the two groups as well. Furthermore, US/S of the two groups did not show a significant difference.

The beef samples utilized for this study were produced using the fattening method which increases the degree of intramuscular fat by controlling the amount of vitamin A in the diet (Oka et al., 1998a, 1998b; Nade et al., 2003) in one of a pair of identical twins. Production of beef samples with

Table 2. Fatty acid composition of *M. longissimus dorsi*

	HG	LG	Significance
C14:0 myristic (%)	2.9±0.2 ¹	3.0±0.2	NS
C14:1 myristoleic (%)	1.1±0.2	1.0±0.1	NS
C16:0 palmitic (%)	27.0±0.6	28.5±0.6	NS
C16:1 palmitoleic (%)	4.3±0.8	3.8±0.3	NS
C18:0 stearic (%)	10.4±1.3	10.6±0.6	NS
C18:1 oleic (%)	48.1±0.5	46.9±1.0	NS
C18:2 linoleic (%)	3.0±0.2	3.1±0.3	NS
US/S ²	1.4±0.1	1.3±0.1	NS

¹ Means±standard error.

² Total unsaturated fatty acid per total saturated fatty acid.

NS: Not significant.

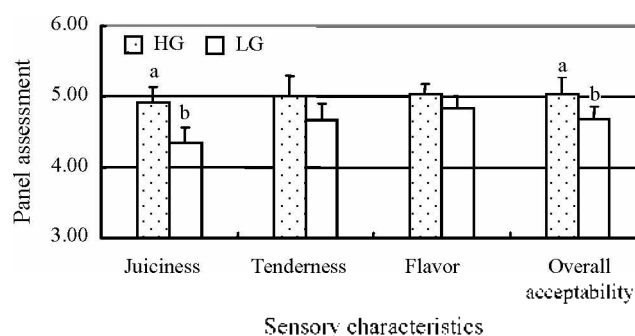


Figure 1. Sensory characteristics of *M. longissimus dorsi*. Values are expressed as means±standard error. ^{a, b} Statistically significant difference for juiciness between the two groups (p<0.05), Statistically significant difference for overall acceptability between the two groups (p = 0.05).

different degrees of intramuscular fat with animals that have the same genes was possible using this method.

Generally, the contents of intramuscular fat and moisture are inversely related (Mitsumoto et al., 1986; Kim and Lee, 2003; Watanabe et al., 2004). The relationship of the chemical composition of the sample was the same in this study as well. Moreover, crude protein content of HG was lower than that of LG in this study.

Fatty acid composition of bovine tissues is affected by factors such as sex (Waldman et al., 1968; Clemens et al., 1973), sire (Inoue et al., 2002; Oka et al., 2002), age (Lengyel et al., 2003) and diet (Melton et al., 1982; Mandell et al., 1998). Also, Nade et al. (2004) already reported that vitamin A in the diet has no effect on the fatty acid composition of *M. longissimus dorsi*. Since this study was executed by using animals who had identical genes and management, as well as fattening methods which do not influence the fatty acid composition of beef, it was thought that there was no significant difference in the fatty acid composition of the two groups.

The sensory characteristics of *M. longissimus dorsi* are shown in Figure 1. Juiciness of HG and LG were 4.92 and 4.35 points respectively, which showed a significant difference (p<0.05). Tenderness and flavor did not show

any significant differences between the two groups. Overall acceptability, which synthesized each of the sensory characteristics, was higher for HG than LG ($p = 0.05$, 5.04 and 4.69 points respectively).

Sensory characteristics of beef are generally influenced by physico-chemical composition such as intramuscular fat (Tatum et al., 1982; Platter et al., 2003), fatty acid composition (Westerling et al., 1979; Melton et al., 1982; Mandell et al., 1998), WBSF (Boleman et al., 1997; Nishimura et al., 1999; Caine et al., 2003), tenderness measured by Tensipresser (Yanagihara et al., 1995). Regarding the juiciness of meat, juiciness is affected by physical traits of cooking loss and compressing meat juicy (Jost et al., 1983; Matsubara et al., 1998; Huff-Lonergan et al., 2002). As a result of the sensory evaluation on *M. longissimus dorsi*, which had no significant differences in WBSF, cooking loss, WHC and fatty acid composition, and which had only a significant difference in intramuscular fat, it is indicated that intramuscular fat considerably affects juiciness and overall acceptability.

The melting point of fat has a correlation relationship with fatty acid composition (Mitsuhashi et al., 1988; Enser et al., 1993). For this report, each sample had no significant difference in fatty acid composition, therefore in this study there might be no significant difference in the melting point of fat between the two groups. The melting points of subcutaneous and intermuscular fat of Japanese black steers fattened until 25.8 months of age that are similar to the animals used in this study are considerably low temperatures, 25.9 and 31.9°C respectively (Mitsuhashi et al., 1988). It was assumed that juiciness was affected by the spreading of intramuscular fat which melted within the mouth by increasing the intramuscular fat in *M. longissimus dorsi*.

Regarding the tenderness of beef, generally, WBSF was widely used as an index of tenderness of beef (Nishimura et al., 1999). It was thought that tenderness did not show any difference between the two groups because there was no significant difference in WBSF in this study.

According to previous studies comparing fatty acid composition and sensory evaluation, the content of oleic acid contained in intramuscular fat in *M. longissimus dorsi* has a correlation with flavor (Dryden et al., 1970). Also Westerling et al. (1979) reported that flavor scores are negatively associated with total saturated fatty acids and positively associated with total unsaturated acids due mainly to the high levels of oleic acid. And, it is thought that there was an important relationship between fatty acid composition and flavor (Melton et al., 1982; Mandell et al., 1998). The sensory evaluation results from samples which had similar fatty acid composition between the two groups showed that the amount of intramuscular fat did not clearly have an influence on flavor.

Kim and Lee (2003) reported intramuscular fat is an important factor in determining juiciness in Hanwoo (Korean native cattle) beef. Japanese Black beef was similar to Hanwoo beef in this respect. The enrichment of juiciness resulted from the increase of intramuscular fat this improved the overall acceptability. Consequently, it was shown that intramuscular fat is an important factor in determining overall acceptability.

Recently, in efforts to improve beef cattle in Japan, not only meat yield but also meat quality is important, above all, palatability has become important. It is obvious that a relationship between intramuscular fat and palatability in Japanese black beef exists. We think that we need to investigate the factors which affect the sensory characteristics of beef in the future to improve palatability. Furthermore, it is expected that the factors relevant to sensory characteristics will be utilized as indices of future breeding improvement in choosing breeding stock and beef evaluation in accordance with consumer needs with the aim of increasing beef consumption.

ACKNOWLEDGEMENTS

We would like to thank the staff at the National Livestock Breeding Center technical department who gave us a great deal of cooperation in this study. This study was partly executed by Research project (1674) for utilizing advanced technologies in agriculture, forestry and fisheries.

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