Profile of Hanwoo Steer Carcass Characteristics, Meat Quality and Fatty Acid Composition after Feeding Italian Ryegrass Silage

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Abstract

The objective of this work was to evaluate the growth performance, feed intake, slaughter characteristics, meat quantity and quality characteristics of Hanwoo steers fed with Italian ryegrass (IRG) silage (TRT). IRG silage consisted 11.70% protein, 2.84% ether extract, 53.50% dry matter digestibility and 63.34% total digestible nutrients. The daily weight gain and feed conversion ratio of TRT were significantly (p<0.01) higher than that of control diet (CON; fed rice straw) in the whole periods. However, the slaughter weight, dressing percentage, quantity grade and quantity traits (marbling score, meat color, fat color, and quality grade) of either TRT or CON were similar. Meat fed TRT diet showed higher crude fat and lightness (L*) value and lower moisture content and pH value compared with the CON diet (p<0.05). Overall the carcass yield was 12.5% higher than CON diet.

Keywords: Italian ryegrass silage, Hanwoo steers, carcass characteristics, meat quality, fatty acid profiles

Introduction

It is widely recognized that diet plays a major role in modulating the fatty acid composition of cattle (Jensen, 2002), goats (Chilliard et al., 2003) and sheep (Bocquier and Caja, 2001). However, feed costs represent the largest single variable cost in beef production in Korea. Contributing to this situation is high operating costs, where the feed component is the major cost of total cost. The grass is the cheapest source of feed available for beef (and milk) production, which provided that the environment and management permit high yields of high-quality herbage to be utilized (McGee, 2005). Production and efficient utilization of high yields of high nutritive value grass throughout an extended grazing season are critical for cost efficient beef production (O’Riordan et al., 2000). Production of beef cattle fed with grass silage diet supplements containing a high source of protein have been evaluated (Keating et al., 1990; Petit et al., 1994; Steen, 1984; Veira et al., 1988). Grass-feed based production systems are low-input methods that are particularly suitable to meet the demand of meat retailers and consumers for the naturalist and animal-friendly production of beef (Razminowicz et al., 2006). Therefore, in Korea, the combination of roughage and concentration commonly available in the market is used to rear Hanwoo. Especially, the study of manufacturing silage using whole crop barley silage or whole crop rye silage was carried out to expand the usage of roughage (Shinekhuu et al., 2010). Italian ryegrass (Lolium multiflorum Lam.; IRG) is an important crop cultivated for the production of high-quality forage in temperate regions around the world for various purposes. It is a preferred forage crop due to its fast growth, palatability, high forage yield and good nutritional quality. It is utilised as green forage or silage. Fresh as well as dry matter (DM) yield and nutritional quality of IRG vary considerably with varieties, the stages at
which harvested, climatic conditions and agronomic factors. However, the benefits of feeding diet combinations of concentrate and IRG silages from growing period to finishing period of Hanwoo steer have not been evaluated. In order to determine the efficacy of the IRG silage/concentrate feeding system for Hanwoo steer, it was essential to conduct feeding trials to evaluate the IRG silage combined with concentrate system and compare to a traditional rice straw combined with concentrate based system. The objectives of this study were to compare the growth performance, and carcass quality of Hanwoo steer fed IRG silage/concentrate and rice straw/concentrate diet, and meat quantity and quality characteristics.

**Materials and Methods**

**Experimental design and animal management**

This experiment was conducted according to the Hanwoo care and user guidelines of the National Livestock Research Institute of Korea. The calves of Hanwoo steers were obtained upon weaning (body weight of 190.00±26.64 kg and from 120 to 180 d of age) and maintained in the individual feeding barn of the National Institute of Animal Science in Korea and cared according to the Hanwoo guidelines of the National Livestock Research Institute of Korea (MFAFF, 2007). Hanwoo steers (4-6 mon age) were individually penned and fed the experimental diets twice daily at 09:00 AM and 16:00 PM and had free access to mineral blocks. Each treatment was fed to steers via an individual gate feeding system.

Twenty-four Hanwoo steer were used in this experiment that lasted for 739 d (August 2008-September, 2010). Hanwoo steers were randomly allotted to two treatments (three pens per treatment, four Hanwoo steers per pen) and then investigated by stage of each period. Average body weight ± SD at the start of the experiment was 212.40 kg for the control and 167.60 kg for the treatment, respectively. Animals were fed in a semi-covered barn.

### Table 1. Ingredient composition and chemical analysis of the experimental diets

|                        | Growing period | Early fattening period | Middle fattening period | Late fattening period |
|------------------------|----------------|------------------------|-------------------------|-----------------------|
| Corn flake             | 25.00          | 29.00                  | 30.00                   | 35.00                 |
| Barley                 | -              | -                      | -                       | 8.00                  |
| Cottonseed whole       | -              | -                      | -                       | 3.00                  |
| Wheat                  | 18.00          | 18.00                  | 18.00                   | 18.00                 |
| Gluten feed            | 8.00           | 9.58                   | 12.00                   | 3.00                  |
| Rice bran polished     | -              | 1.00                   | 2.36                    | 1.93                  |
| Tapioca residue        | 4.58           | 6.22                   | 5.23                    | 5.23                  |
| Wheat bran             | 11.79          | 12.40                  | 13.81                   | 6.34                  |
| Palm kernal meal       | 8.00           | 5.00                   | 3.00                    | 2.05                  |
| Coconut oil meal       | 3.00           | 2.00                   | 1.00                    | 1.00                  |
| Rapeseed meal          | 5.00           | 3.00                   | 3.00                    | 2.00                  |
| Soybean meal           | 7.39           | 3.28                   | 0.94                    | 2.12                  |
| Distillers dried grains| 2.22           | 3.50                   | 4.00                    | 5.71                  |
| Limestone              | 2.17           | 2.31                   | 1.75                    | 1.64                  |
| Molasses               | 3.00           | 3.00                   | 3.00                    | 3.00                  |
| Salt                   | 0.81           | 0.81                   | 0.69                    | 0.69                  |
| Probiotics             | 0.05           | 0.10                   | 0.10                    | 0.10                  |
| Magnesium oxide        | 0.30           | 0.30                   | 0.30                    | 0.30                  |
| Sodium bicarbonate     | 0.30           | 0.30                   | 0.50                    | 0.50                  |
| Mineral premix         | 0.21           | 0.21                   | 0.21                    | 0.21                  |
| Vitamin premix         | 0.18           | -                      | 0.10                    | 0.18                  |
| Total                  | 100.00         | 100.00                 | 100.00                  | 100.00                |
| Dry matter (%)         | 87.71          | 87.32                  | 87.21                   | 87.06                 |
| Crude protein (% of DM)| 16.00          | 14.00                  | 13.72                   | 12.39                 |
| Acid detergent fiber (% of DM) | 9.37   | 10.05                  | 8.14                    | 8.16                  |
| Neutral detergent fiber (% of DM) | 26.28 | 26.06                  | 24.43                   | 22.67                 |
| TDN                    | 70.17          | 72.07                  | 73.30                   | 75.00                 |

*a*Steers had free access to mineral blocks (Rincal block, Daehan New Pham, Korea; provided following nutrients per kg: I, 150 mg; Mn, 200 mg; S, 4,000 mg; Co, 100 mg; Fe, 2,000 mg; Zn, 100 mg; Ni, 50 mg; Cu, 100 mg; Mg, 3,000 mg; Ca, 2,000 mg; Se, 40 µg; NaCl, 380 g) throughout the experiment.

*b*Provided following nutrients per kg of additive (Grobic-DC, Bayer HealthCare, Germany): Vitamin A, 2,650,000 IU; Vitamin D3, 530,000 IU; Vitamin E, 1,050 IU; Niacin, 10,000 mg; Mn, 4,400 mg; Zn, 4,400 mg; Fe, 13,200 mg; Cu, 2,200 mg; I, 440 mg; Co, 440 mg.
with two pens per treatment. Animals had *ad libitum* access to fresh water. At the end of the feeding trial, all animals were slaughtered at a commercial abattoir (National Agricultural Cooperative Federation, Korea).

The rice straw was purchased from a beef cattle farm and chopped to 4-5 cm lengths. The IRG was grown on a research farm at National Livestock Research Institute of Korea, harvested at heading stage and packed with *Lactobacillus plantarum* in round bale wrapper using the silage wrapping machine, and IRG silage was stored for 90 d. Ingredient composition and chemical analysis of the concentrate diets were showed in Table 1.

*Lactobacillus plantarum* strain procured from Chung-Mi Bio Co., Korea was used for the preparation of silage. All animals were also fed concentrate diets for each growing period. After feeding the roughage or silage, the concentrate was offered each feeding time. The leftover feed is collected every day just before the evening feeding time (17:00) to measure the feed intake. The classification of growing period was divided into initial period for 137 d, first fattening period for 124 d, mid fattening period for 184 days, finish fattening period for 295 d, and a final period of 739 d, respectively, from the beginning of feeding period. Random grab samples of rice straw and IRG silage were taken monthly and were ground through a 1 mm screen for the proximal analysis by the method of AOAC (1995). The chemical composition of rice straw or IRG silage was analyzed.

**Chemical composition analyses**

The dry matter content of the rice straw and IRG silages were determined by freeze-drying for at least 24 h. Crude ash was obtained at 550°C for 5 h. The crude protein, ether extract, and crude ash were determined by AOAC (1995). Digestible energy values were calculated from the total digestible nutrients (TDN) using the factors suggested by the NRC (2001), and the data were subjected to analysis of variance (Snedecor and Cochran, 1968).

**Measurements and analyses**

All the steers were slaughtered for the examination of carcass characteristics. Samples of intramuscular (*M. longissimus dorsi*) (LM) at the 13-14th ribs were taken and ground, and mixed well for fatty acids analysis. Carcasses were weighed immediately post the slaughter process, and then chilled at 4°C for 48 h. The day after slaughtering, the left side of the carcass was ribbed between the last rib and the first lumbar vertebrae to evaluate carcass traits. After 30 min of blooming period, evaluation was performed for quantity grade (5 = grade A to 2 = grade D), marbling score (1 = low fat to 5 = high fat), meat color (1 = very light cherry red to 7 = very dark red), fat color (1 = white to 7 = yellow), texture (1 = very fine to 3 = very coarse), maturity (1 = below 15 mon old to 15-26 mon old = 2), and quality grade (7 = grade 1° to grade 3 = 1) on the basis of Animal Products Grading Service (APGS) manual (2007). Briefly, back fat thickness was determined by measuring, perpendicular to the outside surface, at a point two-thirds of the length of the rib-eye ribbed between the last rib and the first lumbar vertebrae. The area of the rib-eye was determined at the surface of the cut using a standard grid. Ten grams of chopped meat was mixed with 10 mL deionized water. The pH of the slurry was measured using the pH meter (F-12, Horiba, Japan). The cooking loss was performed as described by Kang *et al.* (2010). The sample of cooking loss was then used for the shear force assessment. The sample was cut into 1 cm² cross section with the fiber direction and 1.5 cm in length. The shear force was measured using a texture analyzer (TA-XT2i, Stable Microsystems Ltd., UK) equipped with a 25 kg load cell, a Warner-Bratzler shear blade, and a test speed setting at 2.0 mm/s. Only the maximum force (kg) was taken into account. Part of meat samples were cut into pieces of 2 cm in width, 4 cm in length and 0.5 cm in thickness. In addition, they were roasted using the electronic pan for home use until the internal temperature of 73°C was attained.

**Fatty acid analysis**

The total contents of lipids were extracted from the ground LM. Tissues were homogenized in chloroform/methanol solution (Folch *et al.*, 1957) using a homogeizer (PT-MR3100, Switzerland). The chloroform recovered from the measured aliquots of the extract was evaporated in the dry bath (Type 16500, USA) at 50°C using nitrogen gas. Methylation of the lipids extracted followed the method of Lepage and Roy (1986) prior to injecting into a gas chromatograph (HP 5890 II fixed with a G1513A autosampler, Hewlett-Packard Co.). A fused silica capillary column (100 m × 0.25 mm, i.d. × 0.20 μm thickness, Supelco, SP TM-2560, USA) was used for the fatty acid analyses and ultra-pure helium was used as the carrier gas (flower rate = 1.0 mL/min). The injector and detector temperature was maintained at 250°C. The initial oven temperature was 140°C (held for 30 min), and then increased by 15°C/min to 220°C (held for 40 min).
Statistical analysis
Samples were analyzed in triplicate, and the data were presented as mean ± standard error of the means. The pen was considered as the experimental unit. An analysis of variance was performed on all the variables measured using the general linear model procedure of the SAS statistical package (Statistics Analytical System, USA, 2002). The Duncan’s multiple range tests were used to determine differences between treatment means.

Results and Discussion

Performance and characteristics
The nutrient composition of rice straw and IRG silage are shown in Table 2. Results revealed that the percent of crude protein in IRG silage was significantly higher (11.70%). The other components of IRG silage such as ether extract (2.84%), in vitro dry matter digestibility (IVDMD) (53.50%), total digestible nutrient (TDN) (63.34%), lower dry matter (68.04%), crude ash (12.70%) and neutral detergent fiber (55.32%) were comparatively higher than those of rice straw (p<0.05). The chemical compositions of the silages used are typical of well-preerved, lactate silages (McDonald and Edwards, 1976). The nutrition value of IRG silage in this study was similar to the silage of barley and ryegrass (Kim et al., 2003; McIsacc and Lovering, 1982). Kuneilus and Narasimhalu (1983) and Narasimhalu et al. (1985) also reported that ryegrass harvested annually showed high crude protein (160-190 g kg⁻¹ DM) that results in high quality of forage for ruminants. In this study, Hanwoo steers were fed a diet consisting of 2.41 kg DM rice straw and 7.41 kg DM concentrate for the control group and 4.00 kg DM IRG silage and 6.20 concentrate on treatment group per a day, respectively (See Materials and methods). Tables 3 and 4 show the effects of feeding IRG silage/concentrate diet on growth performance and feed intake of Hanwoo steers while growing, first, middle and finish fattening period. The effects of feeding IRG silage/concentrate on growth performance and feed intake of Hanwoo steers during the whole period are shown in Table 5. In the middle fattening period, the final body weight of the group fed IGR silage/concentrate diet (Treatment) (554.90 kg) were significantly higher than those of the control group (CON), although the initial body weight of CON and IRG groups were 212.40 and 167.60 kg respectively. However, the

Table 2. Nutrient composition of rice straw and Italian ryegrass (IRG) silage (%)

|                      | Rice straw | IRG silage | SEM¹ | Pr > F² |
|----------------------|------------|------------|------|---------|
| Dry matter (DM)      | 90.01      | 68.04      | 4.56 | 0.01    |
| Crude protein (CP)   | 3.62       | 11.70      | 1.01 | 0.01    |
| Ether extract (EE)   | 1.90       | 2.84       | 0.32 | 0.01    |
| Crude ash (CA)       | 32.41      | 12.70      | 1.22 | 0.01    |
| Neutral detergent fiber (NDF) | 80.02   | 55.32      | 2.58 | 0.01    |
| Acid detergent fiber (ADF) | 53.14   | 32.70      | 3.60 | 0.01    |
| In vitro dry matter digestibility (IVDMD) | 51.63 | 53.50 | 0.82 | 0.05 |
| Total digestible nutrient (TDN) | 47.03 | 63.34 | 2.46 | 0.01 |

¹Standard error of the mean. ²Probability levels.

Table 3. Effects of feeding IRG silage/concentrate on growth performance and feed intake of Hanwoo steers during growing and first fattening period

| Items                       | CON¹ | T² | SEM³ | Pr > F⁴ |
|-----------------------------|------|----|------|---------|
| Initial body weight (kg)     | 212.40 | 167.60 | 4.38 | 0.00 |
| Final body weight (kg)       | 305.90 | 314.90 | 13.37 | 0.64 |
| Daily weight gain (kg)⁵      | 0.68 | 1.08 | 0.12 | 0.03 |
| Feed intake (kg)⁶            | 6.61 | 8.50 | 0.30 | 0.01 |
| Concentrate (kg)⁷           | 3.68 | 3.22 | 0.16 | 0.11 |
| Rice straw (kg)⁸            | 2.93 | 0.00 | - | - |
| IRG silage (kg)⁹            | 0.00 | 5.28 | - | - |
| Feed efficiency             | 0.10 | 0.13 | 0.02 | 0.31 |
| Feed conversion ration      | 13.47 | 8.98 | 2.18 | 0.16 |

¹CON: Rice straw+concentrate. ²T: Italian ryegrass silage+concentrate. ³Standard error of the mean. ⁴Probability levels. ⁵Total weight gain and daily weight gain calculated for each animal per a day that it received the test diets. ⁶⁷Feed intake, concentrate, and rice straw/IRG silage calculated for each animal for each period that it received the test diets (kg/head/day, DM basis).
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The daily weight gain of steer fed treatment diet was significantly higher than that of CON diet during the period of growing and middle fattening ($p < 0.05$), whereas no significant difference was found in the period of middle and finish fattening period ($p > 0.05$). As a whole, the daily weight gain of treatment was significantly ($p < 0.01$) higher than that of CON (Table 5). The daily weight gain was higher 57.54%, 31.82%, 18.04%, and 5.10% compared with CON in the growing, first fattening, middle fattening and finish the fattening period, respectively. This result indicated that the increase in daily weight gain of the growing period was relatively higher than those of other periods ($p < 0.05$). In addition, we could suggest that the whole period of the daily weight gain was mainly affected by the growing and middle fattening period in Hanwoo steer (Tables 3 and 4).

The total feed intake of treatment was higher ($p < 0.01$) than that of CON in the growing period, but no significant difference was found in the other periods, which may affect the whole period of total feed intake. During the feed intake of concentrate, treatment was higher than CON in the first or middle fattening period ($p < 0.01$). Therefore, the feed intake of concentrate on treatment showed significantly ($p < 0.01$) higher than that of CON in the whole period. However, in the growing period and final fattening period, there were no significant differences between CON and treatment of the feed intake of concentrate. These results are in agreement with the results of Christensen et al. (1977) and Cho et al. (2009) who reported that the total feed intake was increased and concentrate feed intake was decreased in the group fed barley silage compared with roughage feeding system in cows. No significant differences were observed in feed efficiency and feed conversion ratio between T and CON groups in each period of Hanwoo steer ($p > 0.05$). Thomas et al. (1988) and Baker et al. (1992) reported that diets containing a high proportion of grass silage have sustained lower growth rates and resulted in a greater fat.

| Items | Middle fattening period | Late fattening period |
|-------|-------------------------|-----------------------|
|       | CON¹ | T² | SEM³ | Pr > F⁴ | CON | T | SEM | Pr > F |
| Initial body weight (kg) | 376.30 | 407.70 | 14.85 | 0.15 | 501.00 | 554.90 | 17.25 | 0.04 |
| Final body weight (kg) | 501.00 | 554.90 | 17.25 | 0.04 | 676.10 | 735.40 | 23.46 | 0.09 |
| Daily weight gain (kg)⁵ | 0.68 | 0.80 | 0.05 | 0.08 | 0.59 | 0.61 | 0.03 | 0.72 |
| Feed intake (kg)⁶ | 11.40 | 11.43 | 0.49 | 0.96 | 9.57 | 9.24 | 0.21 | 0.33 |
| Concentrate (kg)⁷ | 8.66 | 6.96 | 0.21 | 0.00 | 8.49 | 7.63 | 0.23 | 0.06 |
| Rice straw (kg)⁸ | 2.73 | 0.00 | 0.00 | 0.00 | 1.60 | - | - | - |
| IRG silage (kg)⁹ | 0.00 | 4.48 | - | - | 1.08 | 0.00 | - | - |
| Feed efficiency | 0.06 | 0.07 | 0.00 | 0.16 | 0.06 | 0.07 | 0.00 | 0.36 |
| Feed conversion ration | 17.36 | 14.80 | 0.97 | 0.08 | 16.28 | 15.89 | 0.99 | 0.78 |

¹CON: Rice straw+concentrate. ²T: Italian ryegrass silage+concentrate. ³Standard error of the mean. ⁴Probability levels. ⁵Total weight gain and daily weight gain calculated for each animal per a day that it received the test diets. ⁶⁷Feed intake, concentrate and rice straw/IRG silage calculated for each animal for each period that it received the test diets (kg/head/day, DM basis).

| Items | Whole period |
|-------|--------------|
|       | CON¹ | T² | SEM³ | Pr > F⁴ |
| Daily weight gain (kg)⁵ | 0.63 | 0.77 | 0.034 | 0.01 |
| Feed intake (kg)⁶ | 9.83 | 10.20 | 0.11 | 0.08 |
| Concentrate (kg)⁷ | 7.42 | 6.20 | 0.09 | 0.00 |
| Rice straw (kg)⁸ | 2.41 | 0.00 | - | - |
| IRG silage (kg)⁹ | 0.00 | 4.00 | - | - |
| Feed efficiency | 0.06 | 0.08 | 0.00 | 0.07 |
| Feed conversion ration | 16.22 | 13.44 | 0.78 | 0.02 |

¹CON: Rice straw+concentrate. ²T: Italian ryegrass silage+concentrate. ³Standard error of the mean. ⁴Probability levels. ⁵Total weight gain and daily weight gain calculated for each animal per a day that it received the test diets. ⁶⁷Feed intake, concentrate and rice straw/IRG silage calculated for each animal for each period that it received the test diets (kg/head/day, DM basis).
deposition in the grain-fed beef when cattle were given high-concentrate diets in the forms of similar amount of energy and protein. However, the feed conversion ratio of treatment was significantly (p<0.05) higher than CON in the whole period.

Carcass characteristics

The effect of IRG silage/concentrate on carcass yield and quality traits of Hanwoo steer is shown in Table 6A. The carcass fed IRG silage/concentrated diet significantly increased back-fat thickness and rib-eye area of Hanwoo steers comparing with the CON diet (p<0.05). However, slaughter weight, dressing percentage, quantity grade and quality grade (marbling score, meat color, fat color, texture, matures, and quality grade) of carcass from Hanwoo steers feeding silage affected the back-fat thickness and rib-eye area in steers. Previous research (Steen, 1995) has reported similar findings but have also reported that the carcass weight of steer significantly reduced when concentrate intake reduced, which is in disagreement with our data.

Meat characteristics

Table 6B shows that the chemical composition and meat qualities of M. longissimus dorsi (LM) of Hanwoo steer fed IRG silage/concentrate. LM from IRG silage/concentrate diet based production systems resulted in lighter (L*) carcasses with higher fat and lower moisture compared to the LM from rice straw/concentrate diet (p<0.05). Similar to the present study, Duckett et al. (1993) found that intramuscular fat content and palatability can be increased by switching from a forage diet to a high concentrate diet 84-196 d prior to slaughter. Furthermore, Schnell et al. (1997) and French et al. (2001) have reported that cattle finished on forage have subcutaneous fat that is more yellow in color compared to cattle finished on grain, which may be a disadvantage for consumer acceptance of forage finished beef. However, the crude protein and ash compositions of meat composition and redness (a*) and yellowness (b*) values of meat surface color between test diets were similar. Vestergaard et al. (2000) mentioned that postmortem glycolysis is converted to lactate and H⁺ resulting in a decrease in pH of the meat, and the glycolysis level at slaughter is inversely related to the ultimate pH. Monin and Sellier (1985) suggested that a high energy diet increased capacity for post-mortem glycolysis, which would lead to an extended pH decline and lower ultimate pH. However, in this study, the LM from IRG silage/concentrate diet had significantly (p<0.05) higher pH value than the LM from rice straw/concentrate diet (CON).

The fatty acid compositions of LM from Hanwoo steer fed IRG silage/concentrate diet is shown in Table 6C. The

| Table 6A. Effects of feeding IRG silage/concentrate on carcass yield and quality traits of Hanwoo steer |
|---------------------------------------------|
| Carcass yield traits                        |
| Back fat thickness (cm)                     | CON  | T  | SEM  | Pr > F |
| 10.50                                        | 14.50 | 1.23| 0.03 |
| Rib-eye area (cm²)                          | 83.00 | 91.10| 2.54 | 0.04 |
| Slaughter weight (kg)                       | 400.60| 429.10| 11.75| 0.10 |
| Dressing percent (%)                        | 65.93 | 63.89| 0.82 | 0.10 |
| Quantity grade                             | 4.20  | 3.90 | 0.19 | 0.28 |
| Quality traits                              |
| Marbling score                             | 4.30  | 4.60 | 0.74 | 0.78 |
| Meat color                                 | 4.80  | 5.00 | 0.21 | 0.50 |
| Fat color                                  | 2.90  | 3.00 | 0.07 | 0.33 |
| Texture                                    | 1.60  | 1.50 | 0.16 | 0.67 |
| Mature                                     | 2.00  | 1.50 | 0.24 | 0.16 |
| Quality grade                              | 3.90  | 4.80 | 0.37 | 0.10 |
| Total Price ($)                             | 6,099,111 | 6,860,567 | 337,726 | 0.15 |

| Table 6B. Chemical composition and meat qualities of M. longissimus dorsi from Hanwoo steer fed IRG silage/concentrate |
|-------------------------------------------------------------|
| Chemical composition                                       |
| Moisture                                                   | CON  | T  | SEM  | Pr > F |
| 68.17                                                      | 63.42 | 1.22 | 0.03 |
| Crude fat                                                  | 11.33 | 17.14 | 1.19 | 0.01 |
| Crude protein                                              | 19.95 | 20.42 | 0.73 | 0.67 |
| Ash                                                        | 0.86  | 0.91 | 0.02 | 0.06 |
| Meat qualities                                             |
| Cooking loss (%)                                           | 24.10 | 23.59 | 1.02 | 0.14 |
| Shear force (kg)                                           | 3.82  | 3.57 | 0.11 | 0.21 |
| Water holding capacity                                     | 55.68 | 55.05 | 1.08 | 0.64 |
| pH                                                         | 5.64  | 5.54 | 0.01 | 0.05 |
| Surface Color                                              |
| L*                                                        | 38.64 | 41.90 | 0.12 | 0.00 |
| a*                                                        | 23.29 | 23.43 | 0.24 | 0.78 |
| b*                                                        | 10.94 | 11.97 | 0.13 | 0.52 |

1: CON: Hanwoo steer fed rice straw+concentrate. 2: T: Hanwoo steer fed Italian ryegrass silage+concentrate. 3: Standard error of the mean. 4: Probability levels. 5: grade A (5 point) ~ grade D (2 point). 6: low fat (1 point) ~ high fat (5 point). 7: very light cherry red (1 point) ~ very dark red (7 point). 8: white (1 point) ~ yellow (7 point). 9: very fine (1 point) ~ very coarse (3 point). 10: below 15 month old (1 point) ~ from 15 to 26 month old (2 point). 11: grade 1’ (7 point) ~ grade 3 (1 point).
fatty acid composition of meat (muscle and adipose tissue) is important for two main reasons: it determines nutritional value and it affects various aspects of meat quality, including shelf life and flavour (Wood et al., 2003). Previous research (Melton et al., 1982; Scollan et al., 2001) has reported similar findings like forage-based beef had higher concentrations of n3 PUFA than concentrate-based beef. However, our results were in disagreement with those studies. No significant differences were found in fatty acid compositions between tested groups (p>0.05). The overall results showed that feeding IRG silage had significant increase crude fat and lightness (L*) and decrease pH and moisture of Hanwoo beef, and the increase of rib-eye area, back fat thickness and slaughter weight of the carcass trait. In addition, feeding IRG silage to Hanwoo steer showed 12.5% higher yield than CON diet in an economic perspective.

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