Effects of Raising Altitude on the Fatty Acid Composition, Aroma Pattern, Color, and Oxidative Stability of *M. Longissimus* from Hanwoo Steers

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**Abstract**

This study was carried out to investigate the fatty acid composition, aroma pattern, color, and oxidative stability of *M. longissimus* from 28-mon-old Hanwoo steers with different raising altitude (100, 200, 300, 400, 700, and 800 m above sea level). The samples were stored at 2±0.2°C for 9 d. Meat from 700 and 800 m had lower palmitic acid, saturated fatty acids and higher oleic acid, monounsaturated fatty acids (MUFA) than that from 100 m (p<0.05). There was no positive discrimination of the aroma pattern of meat among all groups. There were no significant difference in TBARS values of beef among all groups at 6 and 9 d of storage. At 9 d of storage, meat from 700 m showed the highest MetMb concentration and the lowest a* value among all groups. However, the differences in Mb concentration and color among groups were not linear to the difference in raising altitude. Consequently, the difference in raising altitude at 100-800 m affected the fatty acid composition of meat from Hanwoo steers; the higher the raising altitude, the higher the MUFA concentration. The difference in fatty acid composition among them didn’t affect the aroma pattern and oxidative stability.

**Key words**: raising altitude, fatty acid, aroma pattern, oxidative stability, Hanwoo

**Introduction**

The houses of cattle in Korean Peninsula area are widely varies in altitude due to nearly 70% of this peninsula is covered by mountains and hills (Asian Info, 2000). There are four primary atmospheric changes associated with altitude: 1) decreasing total atmospheric pressure and partial pressure of all atmospheric gases; 2) reduction of atmospheric temperature, with implications for ambient humidity; 3) increasing radiation under a cloudless sky; and 4) a higher fraction of UV-B radiation at any given total solar radiation (Korner, 2007). The higher altitude, the lower atmospheric pressure, so that the partial pressure of oxygen is also lower (Schmidt-Nielsen, 1990). Hyun *et al.* (2006) stated that lower oxygen saturation in atmosphere at higher altitude improves cardiopulmonary function and oxygen utilization of cattle. In addition, cold environment at high altitude can minimize risks from infectious diseases mediated by insects and stress from environment. It might be hypothesized that raising altitude will affect meat quality of cattle. In case of study on lamb meat quality, Ådnøy *et al.* (2005) found that there were small but significant differences in chemical content and sensory quality of meat from high altitude (sea level above 1000 m) compared to low altitude. However, there is limited information related to the effects of raising altitude on beef quality.

Recent concerns about human well-being have affected the beef production system. Human well-being requires quality foods, which include beef. Among other nutrients, fat content and fatty acid composition are important factors determine the quality of beef. Wood *et al.* (2008) stated that fat and fatty acids, whether in adipose tissue or muscle, contribute importantly to various aspects of meat quality and are central to the nutritional value of meat. Furthermore, Wood *et al.* (2003) stated that interest in meat fatty acid composition stems mainly from the need to find ways to produce healthier meat, i.e. with a higher ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids and a more favorable balance between n-6 and n-3 PUFA. However, Scollan *et al.* (2006) stated that the lacks of meat with higher n-3 PUFA are associated with sensory attributes and color stability. As the content of n-3 PUFA in the meat are increased, sensory attributes such as ‘grassy’, ‘greasy’, and ‘fishy’ score may be increased and color stability may be reduced. In addition, meat with higher PUFA is more susceptible to lipid oxidation.

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Faustman (1994) stated that the double bonds located within PUFA are sites of chemical reactivity. Oxygen may react with these sites to form peroxides and the formation of lipid breakdown products leads to development of undesirable flavors and odors.

Lipid and heme pigment oxidations are the primaries cause of quality loss in meat during storage. Lipid oxidation over time has adverse effects on color, odor, flavor, and healthiness of meat products (Monahan, 2000). Myoglobin (Mb) is the primary pigment responsible for the color of meat and the brown color created by changes due to oxidation of the iron in the heme moiety of Mb, and conversion of oxymyoglobin (OxyMb) to metmyoglobin (MetMb) is considered undesirable by most consumers (Smith et al., 2000). There is a significant positive correlation between lipid oxidation and MetMb. Bekhit and Faustman (2005) described that lipid peroxidation increases the percentage of MetMb in meat and, in turn, oxidation of Mb could be generating free radicals that promote lipid oxidation and leads to meat discoloration. Locker (1989) stated that in meat where rancidity is producing peroxides in the fat, the Mb becomes vulnerable to oxidation, even where oxygen is freely available. The surfaces turn brown, and then green brown, as oxidation proceeds further.

Therefore, this study was carried out to investigate the fatty acid composition, aroma pattern, color, and oxidative stability of *M. longissimus* from Hanwoo steers with different raising altitude.

### Materials and Methods

#### Experimental design and meat sample preparation

One hundred and eight heads of 22-mon-old Hanwoo steers were randomly divided into six groups (n=12 heads/group) of raising altitude, i.e. 100, 200, 300, 400, 700, and 800 m above sea level. Cattle were finished for 6 mon prior to slaughter indoor and fed with concentrate at least 10 kg/head/d and rice straw up to 1.5 kg/head/d. The nutrient composition of feedstuffs is presented in Table 1. At 48 h post-slaughter chilling, the *M. longissimus* at the 12-13th thoracic vertebra from each carcass were collected for meat quality analysis. Each sample was cut into 1.5 cm of thickness, individually packaged in a low density polyethylene zipper bag (Cleanwrap Co., Ltd., Korea), and stored at 2±0.2°C for 9 d.

#### Intramuscular fat content

The intramuscular fat content was determined using a Soxhlet as described by AOAC (1995) method.

### Fatty acid composition

Total lipids were extracted as described by Folch *et al.* (1957) and converted to fatty acid methyl esters as described by AOAC (1995). Fatty acid methyl esters were measured using a gas chromatography (Agilent 6890N, Agilent Technologies, USA) equipped with a flame ionization detector (FID) and HP-Innowax fused silica capillary column (30 m length × 0.32 mm id × 0.25 µm film thickness, J & W Scientific, USA). Injector and FID temperatures were 220 and 275°C, respectively. The carrier gas was helium at the constant flow mode (1 mL/min) and the split ratio was 10:1. The initial oven temperature of 150°C was held for 1 min. After that, the oven temperature was increased to 200°C at 15°C/min, increased to 250°C at 3°C/min, and held for 5 min at that temperature.

### Aroma pattern analysis

The aroma pattern was analyzed as described by Hariom *et al.* (2006). An electronic nose (FOX 3000, Alpha MOS, France) equipped with 12 metal oxide sensors was used. One gram of chopped meat was placed into a 10 mL headspace vial, tightly capped with a PTFE/rubber septum and alumina cap, and loaded into the automatic sampler tray. The vial was incubated at 40°C and agitation speed 500 rpm for 180 sec to allow the volatilization of flavor components into the headspace. Two and half millimeter of the sample headspace was extracted by the automatic sampler (HS 100, Alpha MOS, France) syringe at 45°C and flow-injected into the carrier gas flow (synthetic air mixture). The acquisition time was 180 s.

### Lipid oxidation measurement

The lipid oxidation was measured by 2-thiobarbituric acid reactive substances (TBARS) method as described by Sinnhuber and Yu (1977). Zero point four gram of chopped meat was mixed with 3 drops of antioxidant solution, 3 mL of TBA solution, and 17 mL of trichloroacetic acid-HCl solution. Zero point four millimeter of deionized water was used as the blank. The mixture was then heated in the water bath (OB-25E, Jeio Tech Co., Korea) at 98°C for 30 min and then cooled in the tap water for 10 min. Five millimeter of the color solution was transferred into test tube, added with 3 mL of chloroform, and centrifuged (GS-6R Centrifuge, Beckman Instruments Inc., USA) at 3,000 rpm for 15 min. A part of the aqueous clear color solution was then transferred into a cuvet for absorbance measurement at 532 nm using the