MEAT QUALITY CHARACTERISTICS OF HIGHLTY MARBLED BEEF IMPORTED TO KOREA WITH REFERENCE TO HANWOO

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Background

It has been shown that intramuscular fat improves eating quality upon 15% in its extractable level (Thompson, 2001), and explains approximately 10-15% of variations in palatability (Dikeman, 1987). However, underlying mechanisms by which the fat improve palatability have been controversial. Miller et al. (1994) postulated that intramuscular fat acts as lubricant in chewing action, and reduces the relative number of muscle fibers within a certain amount of meat. On the other hand, Rymill et al. (1997) demonstrated that intramuscular fat indirectly improved eating quality through its effect on the prevention of over-cooking (e.g., burning), and raised a fundamental question whether the fat content is a direct cause of improved palatability in highly marbled meat. Similarly, Thompson (2001) believed that intramuscular fat increases consumer satisfaction by stimulating salivary gland, which consequently brings into being high juiciness in mouth feeling.

Our previous survey indicated that Korean consumer preferred highly marbled meat (Cho et al., 1999), and that was associated with more favorable palatability (Park et al., 2000). The latter study, using 229 Hanwoo *m. longissimus* with a large range of intramuscular fat content, demonstrated that meat containing high intramuscular fat received significantly higher sensory scores in tenderness, juiciness and flavor intensity. For the reason, Korean beef industry has made a long-term effort to improve the degree of marbling. On the other hand, highly marbled foreign product has been imported; while a total of imported beef took approximately 66% share in Korean beef market in 2003 (Korean Ministry of Agriculture and Forest, 2003).

Objectives

To evaluate objective and subjective meat quality traits for highly marbled imported beef *longissimus* muscle in comparison with Hanwoo beef.

Materials and methods

Sampling and treatment: A total of eight imported and seven Hanwoo *longissimus* muscles (visually from the 6th thoracic vertebrae to the last lumbar vertebrae) were purchased from HaNaRo Nong-Hyup Mart in Seoul. Breed, feeding regime and day of ageing were identified on the basis of labels on the whole cut box, as well as data from importing company. The imported products comprised four Wagyu (grain feeding for 450 days and aged for 31 days) and four Angus (grain feeding for 150 days and aged for 71 days). Seven Hanwoo samples were composed of four carcass quality grade (QG) 1 and three QG 3. As the domestic meat samples were collected following day of slaughter, the samples were aged at 1°C for 14 days.

Quality determination: WB-shear force was measured on cooked steaks (2.54 cm thick) in a pre-heated water bath for 60 min until the core temperature reached 70º and then cooled in running water (ca. 18ºC) for 30 min to reach a core temperature below 30ºC. Eight cores of 1.27-cm diameter were made for each sample, and peak force was determined using a V-shaped shear blade with a cross-head speed of 400 mm/min (Wheeler et al., 2000). Cooking loss was calculated as percent of weight changes during cooking for WB-shear force measurement. Non-trained eight panelists evaluated sensory characteristics of tenderness, juiciness and flavor intensity on a six-point scale. The panelists were asked to score from one (1) for extremely dislike to six for extremely like. Thin slice samples (ca. 4mm in thickness, and 50 x 70 mm in size) were cooked by placing on the tin plate (ca. 245-255°C) with turning at the first pooling of liquid on the surface of the strip, or at the start of shrinkage. The cooked strip was immediately served to each panelist for evaluation. Intramuscular fat content was determined by a microwave-solvent extraction method described by AOAC (2000). Fatty acid composition was determined by the Folch solvent extraction method (Folch et al., 1957), according to the method described by Chae et al. (2002). Least square means were estimated using

a general liner model (SAS, 1997), and difference in objective and subjective meat quality traits between the four groups of meat were evaluated by a pair-different test at 0.05 %.

Results and discussion

By definition, sensory characteristics of cooked meat is an overall mouth feel perceived by interactions between multi–parameters including deformation and breakdown during a consecutive action of chewing, and stimulation of salivary gland (Jowitt, 1974). This can be explained by the so-called 'hole effect', by which the sensory panelists tended to perceive higher juiciness and flavor intensity with tender meat and, *vice versa* (Shorthose and Harris, 1991). For the reason, the effect of individual sensory trait such as tenderness, juiciness and flavor on consumer acceptability cannot be considered separately. In other words, toughness of fiber component, intramuscular fat content and water-holding capacity simultaneously influence overall eating quality and consumer satisfaction.

Given the facts, the current result cannot be a direct indication of meat quality associated with either breed or origin of products because ageing time considerably varied from 14 to 71 days (Table 1), but that mirrors its quality *per se* on the market. The current analysis showed that the imported Wagyu after 450 days of grain feeding had a 22 % of intramuscular fat content in *longissimus* muscle (Table 1). Based on our unpublished data, that was a considerably higher percentage than that for average Hanwoo QG 1^{+}. On the other hand, the grain-fed Angus for 150 days had a significantly ($P<0.05$) lower intramuscular fat than Hanwoo QG 1, but greatly ($P<0.05$) higher than Hanwoo QG 3. This implies that the production strategy for highly marbled Hanwoo can be no longer sole solution for Korean beef industry. At the first glance, there was no difference in WB-shear force and sensory characteristics between Hanwoo QG 1 and 3, and between Wagyu and Angus. However, the imported products showed a significantly ($P<0.05$) lower WB-shear force than Hanwoo. This was likely attributed to the considerably longer ageing period, and was rather anticipatable. It is general consensus that difference in meat quality is largely equalized by approximately 14 days of chiller ageing (Hwang et al., 2003), and the changes take place at a relatively slower rate with extended ageing time (Lee and Lee, 1998). On the other hand, the instrument measurement was not reflected on sensory characteristics whereby sensory tenderness and juiciness did not differ between the domestic and foreign products.

Sole difference between Hanwoo and imported meats was observed in flavor intensity in that Hanwoo received significantly ($P<0.05$) desirable scores. It has been shown that chiller ageing at 1°C significantly increased 'off-odour' after approximately 35-60 days, depending on initial quality (Lee and Lee, 1998). However, it was unsure that the result was associated with differences in breed (Raes et al., 2003), feeding regime (Wood et al., 2003), ageing period (Lee and Lee, 1998), or interactions. Nevertheless, the result was an indication of superior eating quality of Hanwoo to the imported beef. An early study (Kim et al., 1999) showed that Hanwoo *longissimus* muscle was more acceptable than imported one when the Hanwoo meat contained significantly higher intramuscular fat. In addition to the study, the current result demonstrated that imported meat was less acceptable for Korean consumers, in spite of higher marbling than Hanwoo.

As Hanwoo QG 1 showed a significantly ($P<0.05$) less cooking loss than Hanwoo QG 3, more favorable sensory traits were somehow expected. However, difference was undetectable. Park et al. (2000) indicated that high intramuscular fat improved tenderness, juiciness and flavor when that was evaluated the following day after slaughter. The current result, on the other hand, indicated that the carcass quality grade had no detectable effect on sensory characteristics as well as objective texture measurement, when meats were aged for 14 days at 1°C.

Apart from nutritional aspect, composition of fatty acids is a decisive component in meat quality due largely to their variations in melting points and oxidation capacity which has significant effects on palatability and flavor development during cooking (Wood et al., 2003). Numerous studies (e.g., Raes et al., 2003; Laborde et al., 2001) have demonstrated that fatty acid composition affected sensory characteristics. Table 2 presents differences in the fatty acids between the meat quality groups, and their relations to tenderness, flavor and juiciness. Significant difference in individual fatty acid between the groups varied. The result was rather expected as fatty acid compositions were significantly affected by breed, carcass quality, and chiller ageing, and these were in a similar trend with previous studies (Laborde et al., 2001; Insausti et al., 2004; Wood et al., 2003). The current manuscript was not intended to discuss details about these effects on fatty acid composition. However, it was particular noticeable that the level of total n-3 PUFA was significantly ($P<0.05$) lower in Hanwoo QG 1, while C18:0 were significantly ($P<0.05$) lower in both the QGs 1 and 3 than these for the rest meats. Even though sensory tenderness and juiciness did not differ between imported

and Hanwoo beef, C20:4n-6 had a significant relationship with juiciness, while C18:1n-9, C20:3n-6 and C20:4n-6 were significantly ($P<0.05$) correlated with tenderness. In addition, flavor intensity was significantly correlated to C18:0 ($P<0.05$) and C19:1n-7 ($P<0.0$). The result indicated that fatty acids were associated with eating quality through their effects on various sensory characteristics.

Conclusions

Chilled beef with a high degree of marbling has been imported, and currently takes a large share in beef market. This was somehow perturbing to Korean beef industry because highly marbled Hanwoo meat has been considered as a sturdy characteristic versus imported beef. The current study demonstrated that Korean consumers found more favorable flavor intensity in Hanwoo beef in spite of lower marbling score and higher WB-shear force. However, it was unsure whether the result was related to difference in breed, feeding regime and/or ageing time. The result coincided with difference in fatty acids such as C18:0.

References

AOAC. 2000. AOAC official method 185.15: Fat (crude) in meat and poultry products- Rapid microwave-solvent extraction method. AOAC international, MD. USA.

Chae, H. S., S. H. Cho, B. Y. Park, Y. M. Yoo, J. H. Kim, C. N. Ahn, J. M. Lee, Y. K. Kim and Y. I. Choi. 2002. Changes of the fatty acids, amino acids and collagen contents in domestic broiler chickens of different marketing standard. Kor. J. Food Sci. Ani. Resour. 22:1-7.

Cho, S. H., J. M. Lee, J. H. Kim, B. Y. Park, Y.M. Yoo and Y. K. Kim. 1999. Survey of consumer perception and demand on beef market. Kor. J. Food Sci. Ani. Resour. 19:352-360.

Dikeman, M. E. 1987. Fat reduction in animals and the effects on palatability and consume acceptance of meat products. In: Congress of 40th Recip. Meat Conf., Chicago, USA, pp. 93-107.

Folch, J. M., M. Lee and G. H. Soloan-Stanley. 1957. A simple method for the isolation and purification of total lipids from animals tissues. J. Biol. Chemim. 226:505-509.

Hwang, I.H., C. E. Devine and D. L. Hopkins. 2003. The biochemical and physical effects of electrical stimulation on beef and sheep meat tenderness. Meat Sci. 65:677-691.

Insausti, K., M. J. Beriain, M. J. Alzueta, T. R. Carr and A. Purroy. 2004. Lipid composition of the intramuscular fat of beef from Spanish cattle breeds stored under modified atmosphere. Meat Sci. 66:639-646.

Jowitt, R. 1974. Psychorheology-Its foundations and current outlook. J. Texture stud. 8:229-240.

Kim, I. S., S. O. Lee, S. N. Kang, J. S. Byun and M. Lee. 1999. The hysicochemical, microbial and sensory characteristics of Han-Woo and imported chilled beef loins. Kor. J. Food Sci. Ani. Resour. 4:331-338.

Korean Department of Agriculture and Forestry. 2003. Major statistics trend in Agriculture Products. Korean Department of Agriculture, Seoul, Korea.

Laborde, F. L., I. B. Mandell, J. J. Tosh, J. W. Wilton and J. G. Buchanan-Smith. 2001. Breed effects on growth performance, carcass characteristics, fatty acid composition, and palatability attributes in finishing steers. J. Ani. Sci. 79:355-356.

Lee, K. T. and K. J. Lee. 1998. Quality changes of vacuum packaged Hanwoo beef during cold storage. J. Ani. Sci. Tech. (Kor). 40:651-660.

Miller, R. K. 1994. Quality characteristics. In Muscle Foods; Meat Poultry and Seafood Technology. eds. Kinsman, D. A., A. W. Kotula and B. C. Breidenstein. New York, Chapman and Hall.

Park, B. Y., S. H. Cho, Y. M. Yoo, J. H. Kim, J. M. Lee, S. K. Joung and Y. K. Kim. 2000. Effect of intramuscular fat contents on the physicochemical properties of beef longissimus dorsi from Hanwoo. J. Ani. Sci. Tech. (Kor.). 42:189-194.

Raes, K., A. Balcaen, P. Dirinck, A. De Winne, E. Claeys, D. Demeyer and S. De Smet. 2003. Meat quality, fatty acid composition and flavour analysis in Belgian retail beef, Meat Sci. 65:1237-1246.

Rymill, S. R., J. M. Thompson and D. M. Ferguson. 1997. The effect of intramuscular fat percentage on the sensory evaluation of beef cooked by different methods to two degrees of doneness. In: Congress of 43rd Int. Cong. Meat Sci. Tech., Auckland, New Zealand, pp. 212-213.

SAS. 1997. Applied statistics and the SAS programming language. SAS Institute INC, Cary, NC, USA.

Shorthose, W. R. and P .V. Harris. 1990. Effect of animal age on the tenderness of selected beef muscles. J. Food Sci. 55:1-8.

Thompson, J. 2001. The relationship between marbling and sensory traits. In: Proc. Marbling Symposium, Coffs Harbour, Australia, pp. 30-35.

Wheeler, T. L., S. D. Shackelford and M. Koohmaraie. 2000. Relationship of beef longissimus tenderness classes to tenderness of gluteus medius, semimembranosus, and biceps femoris. J. Ani. Sci. 78:2856-2861.

Wood, J. D., R. I. Richardson, G. R. Nute, A. V. Fisher, M. M. Campo, E. Kasapidou, P. R. Sheard and M. Enser. 2003. Effects of fatty acids on meat quality: a review. Meat Sci. 66:21-32.

Table 1. Least square means and significant difference in objective and subjective meat quality traits between various carcass quality of domestic and imported beef

	Hanwoo beef		Imported beef		Av. SE$^{\Sigma}$
Carcass quality $^{\Omega}$	QG 1	QG 3	Wagyu	Angus	
Day of ageing	14	14	31	71	
Intramuscular fat (%)	12.8^{a}	4.4^{b}	21.9^{c}	7.9^{d}	0.74
Shear force (kg)	4.1^{a}	3.7^{a}	2.4^{b}	2.4^{b}	0.41
Cooking loss (%)	19.6^{a}	25.7^{b}	20.2^{a}	24.8^{b}	0.19
Juiciness $^{\Psi}$	4.5^{a}	4.1^{a}	4.6^{a}	4.4^{a}	0.28
Tenderness $^{\Psi}$	4.8^{a}	4.5^{a}	5.3^{a}	5.3^{a}	0.31
Flavor intensity $^{\Psi}$	4.9^{a}	4.9^{a}	4.0^{b}	4.1^{b}	0.22

$^{\Sigma}$ Average standard error, numerous/denominator degree of freedom: 1/14.
$^{\Omega}$ QG 1 and QG 3: Carcass quality grade 1 and 3, respectively, Wagyu and Angus were fed in a grain feeding regime for 450 and 15 days, respectively.
$^{\Psi}$ 6: Extremely like, 1: Extremely dislike.

Table 2. Least square means and significant difference in fatty acids between various carcass quality of domestic and imported beef, and simple correlation coefficient between fatty acid and sensory characteristics

	Hanwoo beef		Imported beef		Av. SE$^{\Sigma}$
Carcass quality $^{\Omega}$	QG 1	QG 3	Wagyu	Angus	
C18:0 (stearic)	11.5^{a}	13.7^{b}	14.3^{c}	16.2^{c}	0.66
C18:1n-7 (vaccenic)	0.07^{a}	0.04^{a}	0.17^{a}	0.08^{a}	0.05
C18:1n-9 (oleic)	42.3^{a}	46.7^{a}	47.2^{a}	44.1^{a}	3.95
C20:3n-6 (Dihomo-γ-linolenic)	0.18^{a}	0.11^{ab}	0.04^{b}	0.14^{a}	0.03
C20:4n-6 (arachidonic)	0.31^{a}	0.46^{a}	0.16^{b}	0.32^{a}	0.05
Total n-3 PUFA	0.21^{a}	0.17^{b}	0.16^{b}	0.43^{b}	1.02

	Simple correlation coefficient (n=17)					
	C18:0	C18: 1n-7	C18: 1n-9	C20: 3n-6	C20: 4n-6	n3
Flavor intensity	-0.59*	-0.48†	-0.03	0.21	0.31	-0.30
Juiciness	-0.12	-0.35	0.36	-0.38	-0.61*	-0.18
Tenderness	0.18	-0.14	0.56*	-0.53*	-0.69*	0.10

$^{\Sigma}$ Average standard error, numerous/denominator degree of freedom: 1/14.
$^{\Omega}$ QG 1 and QG 3: Carcass quality grade 1 and 3, respectively, Wagyu and Angus were fed in a grain feeding regime for 450 and 15 days, respectively.
† P<0.1, *P<0.05.