EFFECT OF MUSCLE TYPE AND AGING ON TEXTURAL PROPERTIES OF HANWOO BEEF

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Abstract – The texture properties evaluated on ten muscles including, *Psoas major* (PM), *Longissimus thoracis* (LT), *Longissimus lumborum (LL)*, *Gluteus medius* (GM), *Semimembranosus* (SM), *Semitendinosus* (ST), *Biceps femoris* (BF), *Triceps brachii (TB)*, *Supraspinatus* (SS*)*, and *Diaphragm* (DP) from Hanwoo steer (n=20), using different tests Warner Bratzler shear force (WBSF), texture profile analysis (TPA) and tensile testing. At 3d aging PM muscle was the very tender (29.0N) while TB was tougher (56.7N). With 21 d aging WBSF was decreased (P<0.001) by range 1.1 to 45% in the different muscles. Large variations were between WBSF values of LT, LL and DP muscles compare to others SM, PM and BF that may indicate that beef muscles responded differently to postmortem aging. The maximum tensile force of 3 d aged muscles ranged (P<0.001) from 18.5N to 35.8N. The aging significantly (P<0.001) reduced values of the both maximum and breaking force. The hardness (ranged from 28.5 to 70.3N), gumminess, adhesiveness and chewiness were affected by muscle type (P<0.001). The lower hardness (P<0.001) were determined for LT, LL and SM. Springiness was high (P<0.001) for ST and BF muscles, while lower was for PM, LT and DP. The cohesiveness of ST and TB muscles was greater (P<0.05) than other muscles. Variations in texture measurements could be attributed by collagen and fat deposition of the muscles

Key Words –beef, WBSF, tensile test, TPA

I. INTRODUCTION

Retail cuts from the rib and loin have been highly marketable, but those from the chuck and round often suffer because of real or perceived problems with tenderness [1]. The type and amount of basic meat structural components, i.e. collagen and IMF, each with its own particular textural or mechanical properties are mainly responsible for variability texture attributes of different muscles [2, 3]. The WBSF test makes it possible to measure the forces necessary to cut a sample of tissue and SF values relate more closely to the myofibrillar component [4]. The tensile test is best suited for structural investigations and tensile properties are dictated by the collagen content, while the compressive properties are dictated by the intramuscular fat (IMF). Thus aim of this study was to evaluate the influence of muscle type and postmortem aging (21 d) on the instrumental texture parameters of Hanwoo beef.

II. MATERIALS AND METHODS

Hanwoo steers (n=15) were slaughtered at the age of 29 mon. Ten muscles including, *psoas major*, *longissimus thoracis*, *longissimus lumborum gluteus medius*, *semimembranosus*, *semitendinosus*, *biceps femoris*, *triceps brachii*, *supraspinatus* and *diaphragm* obtained at 3 days postmortem. Muscles were trimmed free of subcutaneous and visible connective tissue and aged at 4^0C for 21 days.

Texture measurements; The 300g steaks were placed in plastic bags and heated in a water bath (maintained at 70^oC) until the core temperature had reached 70°C and then cooled in running tap water for 30 min. Then excess moisture was removed and samples kept at 4°C overnight. Then all textural measurements were done on an Instron Universal Testing Machine (Model 3342, USA) using shearing, stretching and compression devices at room temperature. The WBSF evaluated on six pieces core samples with 0.5 inch diameter. Samples were sheared perpendicular to the fiber orientation at a crosshead speed of 400 mm/min, using a 40 kgf load cell. Tensile testing was conducted on six strips cut in a rectangular bar shape with approximately 70 mm long, 10 mm wide and 10 mm thick per sample. The samples were cut parallel to the fibre direction. Stretching was performed at 50 mm/min until the two meat pieces separated. TPA was done on 3 cuts in a rectangular trapezoid shape with shallow end 0.5mm, deep end 1.5mm, 70 mm long and 60 cm wide per sample. Each sample underwent 2 cycles of 60% compression at constant speed 50 mm/min.

III. RESULTS AND DISCUSSION

WBSF measurements; Results indicated (Table 1) that at 3d aging PM muscle was the very tender (29.0N) while TB was tougher (56.7N) than other muscles ($P<0.001$) which had similar ($P\geq0.05$) values ranged from 43.2N to 48.9N. These results are in agreement with the findings of Belew et al. [1] who classified muscles; a "very tender" (<31.4N) was PM, "tender or intermediate" (31.4<45.1N) were LT, LL, SS and ST. Although a study by Shackelford et al., (1995) reported that PM was the very tender, LD, GM and SS were intermediate however SM, BF and ST were tougher than others. Generally, support muscles are tenderer than locomotive muscles [1].

After 21 d of postmortem aging, WBSF value of muscles decreased ($P<0.001$). With aging WBSF was decreased by range 1.1 to 45% in the different muscles. Large variations were between WBSF values of LT, LL and DP muscles compare to SM, PM and BF may indicate that beef muscles respond differently to postmortem aging [5]. The mechanism of tenderization during postmortem aging is the proteolytic degradation of key cytoskeletal proteins by the calpain enzyme system [5]. In postmortem aging of meat, the rate of aging is faster in fast-twitch muscles than in slow-twitch oxidative muscles. The calpain/calpastatin ratio is higher in fast-twitch glycolytic muscles than in slow-switch oxidative muscles, which could partly explain the faster rate of aging in glycolytic muscles [6].

Table 1. The WBSF and tensile testing of Hanwoo beef as affected by muscle type and postmortem aging

Muscles	WBSF, N		Tensile maximum force, N		Tensile strain, %		Tensile extension, mm		Force at break, N	
	3d	21d	3d	21d	3d	21d	3d	21d	3d	21d
Psoas major	29.0^{cX}	26.2^{cY}	18.5^{e}	19.4^{ab}	97.6^{c}	92.3^{bc}	9.97^{c}	9.4^{bc}	0.10^{e}	0.10^{c}
Longissimus thoracis	47.3^{bX}	25.7^{cY}	26.9^{dX}	9.5^{cY}	153.2^{bX}	57.2^{eY}	15.4^{bX}	5.8^{dY}	0.31^{cdX}	0.21^{abY}
Longissimus lumborum	47.1^{bX}	26.8^{bcY}	29.7^{bcX}	9.4^{cY}	182.1^{bX}	59.3^{dY}	18.3^{bX}	5.9^{dY}	0.32^{cdX}	0.21^{abY}
Gluteus medius	48.9^{bX}	32.7^{bY}	28.8^{cdX}	20.0^{abY}	188.0^{bX}	110.7^{bY}	18.9^{bX}	11.2^{bY}	0.19^{d}	0.22^{ab}
Semimembranosus	43.5^{bX}	31.3^{bcY}	29.1^{cdX}	13.7^{bcY}	168.4^{bX}	83.3^{cdY}	16.9^{bX}	8.5^{cY}	0.30^{cdX}	0.14^{bcY}
Biceps femoris	43.3^{b}	42.8^{a}	27.9^{cdX}	17.2^{bY}	158.6^{b}	172.0^{a}	15.9^{b}	17.4^{a}	0.43^{abX}	0.27^{aY}
Diaphragm	43.4^{bX}	29.2^{bcY}	33.9^{abX}	24.7^{aY}	243.8^{aX}	186.6^{aY}	24.6^{aX}	18.9^{aY}	0.26^{c}	0.21^{ab}
Semitendinosus	46.8^{b}		35.8^{a}		194.4^{b}		19.5^{b}		0.34^{bc}	
Supraspinatus	43.1^{b}		29.9^{bc}		171.9^{b}		17.4^{b}		0.20^{d}	
Triceps brachii	56.7^{a}		34.5^{ab}		274.2^{a}		27.9^{a}		0.47^{a}	
SEM	0.21	0.19	0.21	0.21	16.2	8.43	1.63	0.85	0.05	0.03
Muscle df 9/149	11.6***	9.4***	6.2***	6.7***	8.01***	31.7***	8.2***	3.18***	5.4***	3.5**
Aging df 1/254	138.9***		117.7***		67.1***		65.7***		13.2***	
Muscle* Aging 6/254	8.34***		6.4***		6.5***		6.5***		1.6	

$^{a-e,}$ means within each column with different superscripts in muscle type sections are significantly different; df, degrees of freedom;
$^{X, Y}$, means within each row with different superscripts in aging days sections are significantly different, *** $P<0.001$, ** $P<0.01$, $^{*}P<0.05$

The maximum force for the muscles of 3 d aged groups ranged from 18.5N to 35.8N. The aging significantly ($P<0.001$) reduced values of the both maximum and breaking force. Numerous workers have reported that the force at break was 4.5N, 1.5N, 2.5N and 4.6N for cooked BF, LD, SM and ST muscles respectively [7]. The variables of the maximum and breaking force for muscles may be related to the amount of collagen and IMF found in the different types of muscles. Results of WBSF further supported the observation that PM, LT and LL muscles have a lower collagen content, and therefore a higher tenderness, since these muscles failed at a lower applied force than the neck, skirt and round. Furthermore a number of studies demonstrated that the effect of fat and connective tissues on tenderness besides of myofibrillar proteolytic degradation: The development of adipose tissues appears to disorganize the structure of IMCT and contributes to the tenderness during postmortem aging. The adipose tissue deposits between the muscle fiber bundles appeared to partially disrupt the honeycomb structure of the endomysium, the perimysium separated into thinner collagen fibers [2].

The hardness were affected by muscle type and aging ($P<0.001$). The hardness ranged from 28.5 to 70.3N.

Table 2. The texture profile analysis (TPA) of Hanwoo beef as affected by muscle type and postmortem aging

Muscles	Hardness, N		Springiness, mm		Cohesiveness		Gumminess, N		Chewiness, N*mm	
	3d	21d	3d	21d	3d	21d	3d	21d	3d	21d
Psoas major	28.54^{e}	32.36^{d}	0.36^{dY}	0.58^{cX}	0.010^{b}	0.014^{c}	-1.08^{c}	-0.49^{b}	-0. 09^{d}	0. 18^{b}
Longissimus thoracis	46.78^{cdX}	39.72^{cY}	0.68^{bc}	0.72^{bc}	0.013^{b}	0.016^{abc}	-0.69^{c}	-0.49^{b}	0.09^{cd}	0. 21^{b}
Longissimus lumborum	49.43^{bcX}	40.31^{cY}	0.72^{bc}	0.72^{bc}	0.014^{b}	0.016^{abc}	1.96^{b}	-0.19^{b}	0.56^{bcd}	0.51^{b}
Gluteus medius	50.60^{bc}	50.89^{b}	0.81^{bc}	0.82^{b}	0.015^{b}	0.015^{bc}	0.78^{abX}	-0.69^{bY}	1.11^{b}	0.59^{b}
Semimembranosus	61.59^{abX}	56.29^{aY}	0.80^{bc}	0.87^{b}	0.014^{b}	0.021^{ab}	0.29^{b}	0.09^{b}	0.97^{bc}	1.54^{b}
Biceps femoris	59.72^{ab}	61.29^{a}	0.87^{abY}	1.14^{aX}	0.015^{b}	0.022^{a}	0.69^{ab}	1.86^{a}	1.03^{b}	3.15^{a}
Diaphragm	36.28^{de}	35.89^{cd}	0.63^{c}	0.72^{bc}	0.011^{b}	0.013^{c}	0.09^{bX}	-0.78^{bY}	0.37^{bcd}	-0. 01^{b}
Semitendinosus	70.31^{a}		1.01^{a}		0.020^{a}		1.37^{a}		2.23^{a}	
Supraspinatus	48.25^{cd}		0.74^{bc}		0.012^{b}		0.29^{b}		0.65^{bcd}	
Triceps brachii	57.29^{ab}		0.82^{bc}		0.011^{b}		0.29^{b}		0. 94^{bc}	
SEM	0.41	0.20	0.06	0.06	0.001	0.02	0.03	0.04	0.03	0.05
F value										
Muscle df 9/254	7.9***	30.1***	7.7***	6.5***	3.4**	2.6*	6.5***	5.3***	6.01***	4.6***
Aging df 1/254	18.5***		10.9**		3.9		6.8*		3.1	
Muscle*Aging 6/254	1.03		1.4		1.03		3.4**		2.4*	

$^{a-e,}$ means within each column with different superscripts in muscle type sections are significantly different; df, degrees of freedom; $^{X, Y}$, means within each row with different superscripts in aging days sections are significantly different, *** P<0.001, ** P<0.01, *P<0.05

In comparison with 3d aged muscles, lower hardness values (P<0.001) were determined for LT, LL and SM muscles after 21d. The presented hardness values in this study may support to those detected by other authors; hardness was 46.7 N for SM muscles and 71.9 N for QF muscles [8]. It may probably connect with different content of IMF between muscles. It is generally accepted that an increased level of IMF has a positive influence on the texture of meat. At the 3 d, springiness was high (P<0.001) for ST and BF muscles, while lower for PM, LT and DP than others which showed intermediate similar values. Generally the less springiness will exhibit if product is more destroyed. But it is also possible for some products to stick to the retracting probe so in those instances the plots will indicate a greater springiness then proper. Thus muscles such with higher amount of collagen resulted higher springiness values because it is collagen gelatinized during cooking and was stickier. In addition higher amount IMF in LT and DP muscles might be highly related to springiness, Caine et al., [9] documented that and springiness of beef patties has also been reported to decrease as fat content increases.

The cohesiveness of cooked ST and TB muscles (0.02; 0.17) greater (P<0.05) than other muscles which were had similar values. In meats, the obvious way to experience cohesion is the energy or the number of times it takes to break down the product until it is palatable to be swallowed. The product is whose structural integrity withstands compressive or tensile stress. The compression of gumminess, adhesiveness and chewiness values did not differed between aging while, were affected by muscle type (P<0.001) probably because of differences in the contribution of connective tissue and intramuscular fat content. Results are partly in agreement in which harder products appear to also have higher gumminess, adhesiveness and chewiness.

IV. CONCLUSION

The current results indicate that a muscle type effectively influenced on three different methods while an aging apparently had more influences on shear force measurement and tensile test than on texture profile analysis (TPA) measurement. Variations in texture measurements could be attributed by collagen and fat deposition of the muscles, which also varies in the amount and spatial distribution between muscles, reflecting differences in physiological functions.

ACKNOWLEDGEMENTS

This study was supported by Research Program for Agriculture Science and Technology Development (Project No PJ01017003), RDA, Republic of Korea.

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