TEXTURAL ATTRIBUTES OF M. *LONGISSIMUS LUMBORUM* OF BEEF RELATED TO IMF CONTENT AND COLLAGEN CHARACTERISTICS

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Abstract – The purpose of this study was to evaluate the interrelationship between texture properties, intramuscular fat (IMF) content and collagen content of Hanwoo steer (n=20). The texture properties were evaluated on *longissimus lumborum* muscles using different tests WBSF, texture profile analysis (TPA) and tensile testing. Aging resulted in decrease WBSF, hardness and all tensile testing parameters (P<0.001). The hardness and tensile strain at break and extension at break (P<0.05) for grade 1+ group was less than grades 1 and 2. Total collagen correlated (P<0.05) with WBSF (r=0.29) tensile strain and energy at break (r=0.31, r=0.34) and chewiness (r=0.20). Soluble collagen negatively correlated (P<0.05) with tensile strain, hardness and gumminess (r=-0.21). IMF content negatively correlated (P<0.05) with collagen (r=-0.44), WBSF (r=-0.20), maximum force (r=-0.31), hardness (r=-0.33), and chewiness (r=-0.56). Collagen contents and collagen types did not influenced by quality grade and by aging. The results indicate that an aging apparently had more influences on WBSF and tensile testing than on TPA measurement. The variations in TPA could be mostly attributed to IMF content.

Key Words – WBSF, tensile test, TPA, collagen, intramuscular fat.

I. INTRODUCTION

The type and amount of basic meat structural components, i.e. collagen and interrelations between chemical constituents, i.e. proteins and fat content is mainly responsible for meat texture attributes [1, 2]. Among the widely used instrumental devices evaluate textural attributes is the WBSF, TPA and tensile testing [3]. The WBSF measure the forces necessary to cut a sample of tissue while tensile test evaluate the rheological behavior and measure the forces for complete rupture. TPA consists in a double-axial compression of the sample without breaking it, and simulated the conditions that the meat is subjected to mastication in the mouth [2, 3].
Thus aim of this study were to (a) instrumentally evaluate the texture properties of LL muscles, using different tests (WBSF, TPA and tensile testing), (b) to evaluate the influence of postmortem aging, IMF content and collagen characteristics of Hanwoo beef on the instrumental texture of beef.

II. MATERIALS AND METHODS

The strip loins *(Longissimus lumborum)* obtained from Hanwoo steers (n=20) slaughtered at the age of 28 mon. The muscles aged at 4^0C for 3 and 14d.

2.1 Texture measurements; The 300g steaks were placed in plastic bags and heated in a water bath until the core temperature had reached 70°C and then cooled in running tap water for 30 min. Then excess moisture was removed and storage at 4°C overnight. All textural measurements were done on an Instron Universal Testing Machine (Model 3342, USA) using shearing, stretching and compression devices.

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.

2.2 Total and heat soluble collagen contents were determined using modified colorimetric method of [4].

2.3. Extraction of collagen was performed by using modified methods of Sato et al., (1986)

2.4. SDS-PAGE analysis was performed by the method of [5] with slight modification, using 6% separating gel and 4% stacking gel.

2.5. Data were analyzed using the GLM procedure and Duncan's multiple range test of SAS Version 9.3 (SAS Institute, Cary, NC, USA).

III. RESULTS AND DISCUSSION

Table 1. The WBSF and tensile testing of *longissimus lumborum muscle* from Hanwoo steers as affected by postmortem aging and quality grade

Traits	Aging		SEM	Quality grade			SEM	F value	
	3d	14d		1+	1	2		Aging	Q/grade
Total collagen, g/100g	0.25	0.3	0.02	0.24	0.31	0.29	0.02	1.2	2.0
Insoluble collagen, g/100g	0.11	0.14	0.01	0.11	0.14	0.13	0.02	1.1	0.6
Collagen solubility, g/100g	0.14	0.16	0.02	0.13	0.17	0.17	0.01	1.0	1.2
Type I collagen, band area percent	11.4	12.4	0.02	11.9	11.9	11.8	0.13	2.1	1.6
Type III collagen	2.42	2.17	0.01	2.29	2.30	2.31	0.03	0.7	1.0
Ratio of collagen (I/III)	4.71	5.72	0.02	5.24	5.20	5.18	0.13	0.2	1.0
WBSF, N	34.3^{a}	22.6^{b}	15.3	33.2	33.5	36.8	0.38	29.7^{***}	0.3
Tensile testing, (N)	23.6^{a}	9.7^{b}	1.07	15.2	16.6	18.5	0.22	93.6^{***}	0.4
Tensile strain, (%)	158.8^{a}	73.1^{b}	8.59	106.2	116.0	126.8	14.5	51.1^{***}	0.4
Tensile extension, (mm)	16.2^{a}	7.4^{b}	0.89	10.8	11.82	13.01	1.48	49.1^{***}	0.4
Load at break, (N)	2.05^{a}	1.37^{b}	0.29	2.15	1.47	1.66	0.03	2.97*	1.1
Tensile strain at break, (%)	381.4^{a}	288.4^{b}	13.3	300.7^{b}	362.1^{a}	331.4^{ab}	17.9	25.1^{***}	2.3^{*}
Tensile extension at break, (mm)	38.8^{a}	29.4^{b}	1.40	30.6	36.9	34.0	1.86	23.0^{***}	2.3
Hardness, N	38.2^{a}	31.9^{b}	0.12	32.0^{b}	33.8^{b}	39.3^{a}	1.45	9.6^{***}	4.2^{*}
Springiness, mm	0.92	0.92	0.07	1.12	0.88	0.82	0.07	-	3.2
Cohesiveness, ratio	0.02	0.02	0.01	0.03	0.02	0.01	0.01	-	1.3
Gumminess, N	0.19	0.49	0.19	0.18^{b}	0.29^{a}	0.1^{b}	0.02	0.6	2.7^{*}
Chewiness, N*mm	0.11	0.13	0.03	0.10	0.08	0.10	0.03	0.3	2.4
								df1/39	df 2/38

$^{a-b,}$ means within each row with different superscripts are significantly different, *** P<0.001, ** P<0.01, * P<0.05

Table 2. Pearson correlation coefficients among IMF, collagen characteristics and textural parameters

	Total collagen	Insoluble collagen	Soluble collagen	Type I collagen	Type III collagen	Ratio (I/III	IMF
Total collagen	1	0.55^{***}	0.47^{**}	0.02	0.03	0.05	-0.44^{*}
Insoluble collagen	0.55^{***}	1	-0.48^{**}	0.01	0.05	-0.03	-0.24
Soluble collagen	0.47^{**}	-0.48^{**}	1	0.02	-0.08	0.07	-0.12
WBSF	0.29^{*}	0.29^{*}	0.01	0.21^{*}	0.12	-0.23	-0.20
Tensile, maximum force	0.18	0.09	-0.10	-0.06	-0.01	-0.04	-0.31^{*}
Tensile strain at maximum force	0.31*	0.04	-0.27*	-0.01	-0.03	0.01	-0.19
Force at break	0.1	0.22	0.14	-0.16	-0.20^{*}	0.09	0.24
Strain energy at break	0.34*	-0.1	-0.25	0.12	-0.17	0.19	-0.15
Hardness	0.13	0.14	-0.28^{*}	0.01	-0.05	0.04	-0.33^{*}
Springiness	-0.11	-0.1	0.01	0.14	-0.32^{*}	0.32^{*}	0.43^{*}
Cohesiveness	-0.09	-0.14	0.06	0.02	-0.35^{*}	0.25	0.60^{**}
Gummines	-0.09	0.11	-0.21	0.04	-0.15	0.13	-0.21
Chewiness	0.20^{*}	0.08	0.13	0.24	-0.33^{*}	0.40^{*}	-0.56^{*}

*** P<0.001, ** P<0.01, * P<0.05

With aging WBSF was decreased by 30% in the samples (P<0.001). However quality grade did not result in changes in shear force (Table 1). The decrease in WBSF value resulting from postmortem aging is associated with an increase in tenderness, due to structural integrity of myofibril changes that closely linked to Ca^{++} dependent protease activity [6]. The WBSF values related more closely to the myofibrillar component of toughness than to the connective tissue component [7].

The TPA values were not affected by postmortem aging, except hardness. In comparison with 3d aged muscles, lower hardness values were determined in muscles after 14d. The decrease of hardness subjected to aging was found its reflection in lower values of the WBSF in 14d aged muscles. Quality grade 2 group had greater (P<0.05) hardness compared to both 1+ and 1 groups. It was probably connected with different content of IMF between quality grade groups. It is generally accepted that an increased level of IMF has a positive influence on the texture of meat [1].

The maximum force and breaking force decreased during 14 d. Aging also resulted in decrease other tensile testing parameters such as tensile strain and extension at break (P<0.001). This is in agreement with previous study of Lu et al., [8]. Relative to quality grade effect, the tensile strain at break and extension at break P<0.001) for grade 1+ group was less than grades 1 and 2. Other parameters were not significantly but slightly increased as decreased quality grade levels. This may be due to the fact that muscles from quality grade group 1+ had more IMF (P<0.05) and less collagen content than those 1 and 2 groups, in the present study.

Total collagen correlated (P<0.05) with texture parameters WBSF (r=0.29), tensile strain and energy at break (r=0.31, r=0.34), and chewiness (r=0.20). Soluble collagen negatively low correlated (P<0.05) with tensile strain (r=-0.27), hardness (r=-0.28), gumminess (r=-0.21). While low correlations were between collagen characteristics and texture of cooked meat and low but significant correlation existed between WBSF and collagen solubility [9].

IMF content negatively (P<0.05) correlated with total collagen (r=-0.44), insoluble collagen (r=-0.24), WBSF (r=-0.20), tensile maximum force (r=-0.31), hardness (r=-0.33), and chewiness (r=-0.56) and positively correlated with springiness and cohesiveness. Similar results were found in previous the studies where IMF content correlated negatively to SF of cooked meat and content instrumental and sensory tenderness [9].

Collagen contents and collagen types in LL muscles did not influenced by quality grade and by aging (Table 1). Present results may support previous findings indicated that structural weakening of IMCT were minimal until 10d postmortem and collagen fibrils and fibres from endomysial and perimysial sheets became dissociated after 14 d [10, 1] total and insoluble collagen of beef from the three marbling groups were not significantly different (p>0.05) when expressed on a dry or wet basis, while the quantity of total collagen, expressed on a nonfat basis, increased as the marbling score increased, this may indicate that IMF content minimize the differences in collagen content between marbling groups [10].

IV CONCLUSION

The parameters measured by three different methods indicate that an aging apparently had more influences on WB shear measurements and tensile test than on TPA measurement. This result might have been influenced by the protein degradation and collagen in connective tissue network that had been weakened during aging. The variations in TPA parameters could be mostly attributed to IMF content.

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