TEXTURE AND COLLAGEN CHARACTERISTICS OF MAJOR BEEF MUSCLES.

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BACKGROUND

Collagen, the main component of muscle connective tissue, greatly influences beef toughness. Properties rather than concentration of collagen play an important role in determining meat quality (Bailey and Light, 1989). Collagen concentration does not change significantly during growth until slaughter, but collagen solubility decreases with animal weight and age (Sorensen, 1981; Bailey and Light, 1989). Marsh (1977) gives two major structural reasons for variation in tenderness: collagen (connective tissue) and the contractile status which refers to the decrease in sarcomere length caused by cold shortening. Many authors have tried to clarify the relationship between quantity of collagen and meat hardness, using sensorial and mechanical tests; though it has not been clearly established since inconsistent results have been obtained. The conclusion that can be obtained is that the quantity of collagen influences meat texture, but a direct correlation cannot be settled down; rather other factors such as the solubility of the collagen should also be kept in mind, the distribution of the fibers of collagen and the hardness contributed by the complex myofibrilar and the citoesqueleton.

OBJETIVE

The purpose of this study was to investigate the differences of 14 major beef muscles in their chemical and physical properties, especially the relationship between collagen and tenderness.

METHODS

Meat was obtained of three Swiss Brown steer carcasses. Each muscle was divided in small sections and vacumm-packed. The pH of all muscles was measured using a CRISON model 2001 and pH electrode of three diaphragms, 24 hr postmortem. Hunter CIE L*,a*,b* color values of each muscle were evaluated using a Spectrophotometer MINOLTA model CM-2002. Shear force values were recorded with a Texture analyser model TA-XT2i from STABLE MICRO SYSTEMS. Collagen concentration was determined by the method of Bergman and Loxley (1963) adapted and modified by Bonnet and Kopp (1984), and was expressed as mg per g of muscle. Collagen solubility was determined by the method of Hill, (1966). Differential scanning calorimetry (DSC) was performed using the method previously described by Bonnet and Kopp (1985); thermal curves of collagen were analysed using a calorimeter DUPONT INSTRUMENTS model DSC 10 with Thermal Analyst 2000. Average sarcomere lengths were determined from measurements of 10 randomly selected fibers fragments previously fixed by immersion in glutardialdehyde 2.5 % (v/v), using an immersion objective (X100) and a graduated ocular scale (X10) in a NIKON phase contrast microscope model L-ke. The statistical analysis was perfomed with SPSS (Statistical Package for the Social Sciences) for Windows version 7.5.2s (1989-1997).

RESULTS AND DISCUSSION

The results of W-B shear force are shown in Table 1, where the *Diaphragm* and the *Psoas major* are the muscles that present the lowest hardness ($p < 0.05$) and on the other hand the muscle *Flexor digitorum* shows the higgest. The muscles *Diaphragm* and *Psoas major* present the lower concentration of collagen, which can be related with low hardness (Liu et al.,1996). The *Flexor digitorum* is the muscle with the highest content, which reflects its hardness, and it is located in the 14 rank. Total collagen content was not a good predictor of tenderness. The correlation between collagen content and overall tenderness of all fourteen muscles was 0.35 ($P > 0.01$). As for the content of soluble collagen, *Diaphragm* and *L. thoracis* present the smallest quantity, while the *Flexor digitorum* has the highest content. Low correlations were obtained between soluble collagen and toughness and it was 0.31 ($p > 0.05$).The *Psoas major* and the *L. lumborum* present the longest sarcomeres and lowers respectively. These results are in agreement with the results of Hostetler et al. (1972) for carcasses suspended from the aquiles tendon after slaughter. As a result of DSC assays, *Flexor digitorium* ranked first (lowest denaturalization temperature) and *Diaphragma* 14; the correlation between collagen content and DSC was –0.25. The means of the color characteristics and pH of the carcasses of Swiss brown livestock are given in the table 2, where the lowest pH was for *the Gluteus medius* (5.41), and the highest for the *Sternomandibularis* (5.77) and all were above pH=5.5, except for the first one. This confirms that the pH was inside the normal ranges and therefore it is reflected in the color of the muscles, since all they except for the diaphragm had a brightness (L*), above 40.

CONCLUSION

As it is already known in other beef breeds tender meat is associated with higher concentration of collagen in the muscles, but none of the chemical and physical properties evaluated has strong correlations for all the muscles.

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Table 1.- Rank of fourteen muscles by Warner-Bratzler shear force, total collagen, soluble collagen, sarcomere length and DSC.

Muscle rank	Warner-Bratzler shear force (Kg)	Total Collagen (mg/g wet tissue)	Soluble Collagen (mg/ g wet tissue)	Sarcomere length (μm)	DSC (°C)
1	*Diaphragma* 1.30 **a**	*Psoas major* 0.159 **a**	*Diaphragma* 0.016 **a**	*Psoas major* 3.37 **a**	*Flexor digitorum* 60.31 **a**
2	*Psoas major* 2.18 **a**	*Diaphragma* 0.170 **a**	*L. thoracis* 0.026 **a**	*Sternomandibularis* 2.58 **b**	*Gluteus medius* 60.65 **ab**
3	*L. thoracis* 2.70 **ab**	*L. lumborum* 0.197 **ab**	*Psoas major* 0.044 **a**	*Pectoralis profundus* 2.57 **b**	*Infraespinatus* 60.70 **ab**
4	*L. lumborum* 3.00 **ab**	*L. thoracis* 0.209 **abcd**	*L. lumborum* 0.084 **b**	*Infraespinatus* 2.34 **bc**	*L. lumborum* 60.84 **abc**
5	*Gluteus medius* 3.70 **bc**	*Cuadriceps femoris* 0.242 **abcd**	*Semimembranosus* 0.099 **b**	*Flexor digitorum* 2.29 **bc**	*L. thoracis* 60.86 **abc**
6	*Cuadriceps femoris* 4.03 **cd**	*Gluteus medius* 0.322 **abcde**	*Cuadriceps femoris* 0.106 **b**	*L. thoracis* 1.99 **c**	*Psoas major* 61.01 **abc**
7	*Semitendinosus* 4.32 **de**	*Semitendinosus* 0.335 **bcdef**	*Semitendinosus* 0.169 **b**	*Semitendinosus* 1.97 **c**	*Triceps brachii* 61.09 **abcd**
8	*Semimembranosus* 4.40 **de**	*Semimembranosus* 0.359 **bcde**	*Biceps femoris* 0.186 **bc**	*Triceps brachii* 1.91 **c**	*Semimembranosus* 61.15 **abcd**
9	*Infraespinatus* 4.94 **e**	*Biceps femoris* 0.406 **cdef**	*Infraespinatus* 0.225 **bc**	*Semimembranosus* 1.89 **c**	*Cuadriceps femoris* 61.44 **bcdef**
10	*Biceps femoris* 5.74 **ef**	*Pectoral profundus* 0.407 **def**	*Triceps brachii* 0.237 **c**	*Cuadriceps femoris* 1.88 **c**	*Sternomandibularis* 61.58 **cdef**
11	*Triceps brachii* 5.90 **ef**	*Triceps brachii* 0.477 **ef**	*Pectoralis profundus* 0.294 **cd**	*Diaphragma* 1.76 **d**	*Semitendinosus* 61.89 **def**
12	*Sternomandibularis* 6.41 **f**	*Infraespinatus* 0.526 **e**	*Gluteus medius* 0.301 **cd**	*Biceps femoris* 1.64 **de**	*Biceps femoris* 62.10 **ef**
13	*Pectoralis profundus* 6.47 **fg**	*Sternomandibularis* 0.534 **f**	*Sternomandibularis* 0.340 **d**	*Gluteus medius* 1.47 **e**	*Pectoralis profundus* 62.11 **ef**
14	*Flexor digitorum* 6.83 **g**	*Flexor digitorum* 0.601 **g**	*Flexor digitorum* 0.588 **e**	*L. lumborum* 1.45 **e**	*Diaphragma* 62.39 **f**

[a-g] Means within a column with a common superscript are not significantly different (p<0.05).

Table 2. Color (L* a* b*) and pH of fourteen beef muscles from Swiss brown steers.

Muscle	L*	a*	b*	pH
Diaphragma	38.51 **a** ±2.12	16.80 **e** ±2.75	14.31 **cde** ±1.06	5.69 **def**
Psoas major	45.54 **fg** ±1.33	11.69 **a** ±1.66	14.35 **cde** ±1.34	5.56 **bc**
L. thoracis	42.61 **cd** ±1.76	14.09 **cde** ±1.85	15.11 **efg** ±1.15	5.65 **cdef**
L. lumborum	43.20 **cd** ±2.03	14.22 **bcd** ±1.24	15.14 **e** ±1.03	5.50 **ab**
Gluteus medius	45.48 **fg** ±1.56	15.85 **de** ±1.99	16.63 **fg** ±1.61	5.41 **a**
Cuadriceps femoris	40.29 **b** ±1.20	11.97 **a** ±1.59	12.14 **bc** ±1.67	5.60 **bcde**
Semitendinosus	52.05 **h** ±1.15	12.36 **ab** ±2.09	17.94 **h** ±1.46	5.54 **abc**
Semimembranosus	44.92 **efg** ±2.28	14.01 **bc** ±0.52	15.31 **ef** ±0.74	5.51 **abc**
Infraespinatus	41.83 **c** ±2.52	12.52 **ab** ±2.07	13.20 **bc** ±1.83	5.63 **bcdef**
Biceps femoris	46.26 **g** ±1.62	10.98 **a** ±1.80	14.82 **de** ±0.48	5.55 **abc**
Triceps brachii	44.24 **def** ±1.36	11.61 **a** ±2.77	13.23 **bc** ±2.26	5.52 **abc**
Sternomandibularis	43.56 **d** ±1.49	11.26 **ab** ±1.69	9.97 **a** ±1.88	5.77 **f**
Pectoralis profundus	46.08 **g** ±1.76	16.76 **e** ±1.80	17.21 **gh** ±1.62	5.66 **cdef**
Flexor digitorum	43.57 **de** ±1.15	12.43 **ab** ±2.34	13.61 **bcd** ±2.16	5.7 **ef**

[a-g] Means within a column with a common superscript are not significantly different (p<0.05).