Comparison of Volodkevich and Modified Warner-Bratzler Shear Devices Measuring Differences in Myofibrillar and Connective Tissue Components of Beef Texture

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Keywords: Beef, Texture measurement, muscles, ageing

Background and Objective: Mechanical texture measurements are in common use to evaluate effects of production and processing treatments on meat properties, to predict sensory tenderness, and to serve as a control parameter in quality assurance and certified programmes. A wide range of different methods to study fundamental structure of meat are described and are useful for specific or general purposes. When standard values for a generally acceptable tenderness are given and when comparison of results between laboratories or countries is desired, well defined and standardised reference methods are required. One of the reference methods recommended by Chrystall et al. (1994) refers to the probably most often used Warner-Bratzler shear test but with a modified blade.
In this work we compared an 'original' Warner-Bratzler shear device (Instron Ltd) with two modifications of this device and the Volodkevich bite test in order to evaluate how these methods differentiate between the major texture compounds in beef - the myofibrils and the connective tissue - and how they correlate with sensory perception.

Material and Methods: M. longissimus dorsi (LD) and M. semitendinosus (ST) samples from 22 crossbred bulls were aged for both for 4 and for 14 days at 2 °C to achieve variation in myofibrillar texture. The two different muscles accounted for variation in connective tissue properties. The amount of collagen was 2.12 ±0.28 and 3.66 ±0.40 g/100 g dry matter in LD and ST, respectively. Heat-solubility of collagen was lower in ST compared to LD (12.9 ±1.9 % vs. 14.1 ±1.8 %). For mechanical texture measurements, 2.5 cm slices were vacuum-sealed in PE-bags and cooked for 1 h at 72 °C in a water bath.
The four mechanical devices compared are to be described as follows:

WBCOMMON – a 1.2 mm thick blade with semicircular edges and a 60° triangular hole running through a 2 mm slot. This was the 'original' Warner Bratzler device delivered from Instron Ltd (Buckinghamshire, England).
WBRECT. – a blade with the same measures as WBCOMMON but with a rectangular 1x1 cm hole, similar to the device recommended by Christall et al. (1994).
WBBROAD – a 3 mm thick blade with a 1x1 cm square edged, rectangular hole running through a 3.8 mm slot, blade and slot having the same dimension as used in the Kramer shear cell (Instron Ltd.).
VOLODKEVICH – two blunt wedge-shaped edges (corresponding to 2 cm long horizontal cylinders of 2 mm radius) compressing and cutting the sample according to the Volodkevich bite test.

All devices were mounted to an Instron testing machine 4301. Blade and slot of the (modified) Warner-Bratzler devices were attached inverted compared to the original apparatus, therefore, working in compression. Crosshead speed was set to 200 mm/min for all devices. 1.27 cm cores (WBCOMMON) and 1 x 1 cm strips (all other methods) were taken parallel to fibre orientation from the cooked slices when they had cooled to room temperature. As previous findings in the same material indicated a systematic variation of texture properties over the cross-section of LD (Scheeder et al., 1995), three sections of equal texture properties were identified and one sample for each method was taken from each of the three sections to avoid a confounding between sampling position and method. Therefore, three replications were done per individual slice and method. Respective cores and strips were cut perpendicular to fibres and maximum force (peak force) and overall energy required were recorded for each sample.
For sensory analysis, 2.5 cm slices were microwave cooked in a dish with pre-heated water to an internal temperature of 72 °C. 2 x 2 cm cubes were served to six trained panellists who scored initial firmness, tenderness, and sustainable toughness on a 5-point scale (1 = very soft, tough or low, respectively; 5 = very firm, tender or high, respectively).
Statistical analysis was conducted using GLM-procedure of SAS (Vers. 6.04) with muscle, ageing and breed as fixed effects and all interactions included in the model. Panellists were additionally included as fixed effect, analysing sensory data.

Results and Discussion: The results given in table 1 show that peak force as well as energy of all mechanical methods discriminated between muscles and between ageing groups at a highly significant level. Therefore, sensory perception was well reflected. In terms of peak force which is the most common - and often the only recorded - parameter, the conventional method WBCOMMON achieved the highest F-values. Compared to sensory analysis, all Warner Bratzler derived methods discriminated ageing effect stronger than the effect of muscle resp. connective tissue. In all these methods, energy showed a response closely correlated with peak force. In contrast, VOLODKEVICH-peak force discriminated ageing groups very well while VOLODKEVICH-energy differentiated best between muscles. This might be very useful when causal effects on meat tenderness are to be evaluated, e.g. to separate effect of animal age and effects of technological factors like cooling rate.
Regarding the level of the response, WBCOMMON showed the lowest values for peak force, despite the fact that the cross-section of the cores was about 0.267 cm^2 larger than that of the strips. This controversial finding might be explained by the more deforming cutting action of the triangular blade meeting the round core. The level of energy required was very similar for WBCOMMON and WBRECT.. Due to the thickness of the WBBROAD blade, the cutting occurred at two locations (Voisey, 1976) resulting in higher peak force and energy compared to WBCOMMON and WBRECT..
The completely different mode of working of VOLODKEVICH resulted in the highest peak force and the lowest energy values of all methods compared. VOLODKEVICH-energy was the only of the recorded mechanical parameters giving higher values for ST/14-d compared to LD/4-d.

whereas in all other cases ST/14-d showed similar or even slightly lower values than LD/4-d. This signifies the predominant effect of connective tissue on this parameter.

Tab. 1: Texture Properties of Young Bulls M. Semitendinosus and M. Longissimus Dorsi Aged 4 and 14 Days as Measured with Various Mechanical Devices and Sensory Analysis

Muscle	ST		LD		Standard	F-value* for the effect	
Ageing [d p.m.]	4	14	4	14	error	muscle	ageing
Peak force [N]							
WBCOMMON	67.9	49.4	54.4	37.1	3.33	14.9	28.8
WBRECT.	71.5	53.4	56.6	42.8	3.55	12.9	20.2
WBBROAD	98.8	70.8	77.7	54.7	5.11	13.3	24.5
VOLODKEVICH	136.2	91.0	109.2	66.7	8.28	9.6	28.0
Energy [mJ]							
WBCOMMON	700	532	531	411	32.2	20.2	20.0
WBRECT.	712	507	533	434	28.2	20.1	29.2
WBBROAD	1011	744	743	586	45.5	22.1	21.7
VOLODKEVICH	400	312	267	211	14.6	68.8	21.6
Sensory traits							
Initial firmness	3.7	3.1	2.9	2.7	0.09	37.5	16.0
Tenderness	2.2	3.0	3.1	3.5	0.08	78.3	51.4
Sustainable toughness	3.4	2.7	2.6	2.3	0.09	45.3	25.4

* $p < 0.01$ corresponding to $F > 6.95$ for mechanical measures and $F > 6.69$ for sensory analysis

A specific relation of the initial impression of firmness to myofibrillar component and of the sustainable toughness to connective tissue was not found in this investigation to the expected extend. Overall tenderness discriminated both - muscle as well as ageing groups - as the best of all sensory texture parameters.
Overall correlation of all mechanical measures with sensory texture scores were high (Tab. 2), indicating that all mechanical methods used were giving a good index of meat tenderness. Nevertheless, it has to be considered that overall variability of the material used was also high.

Tab. 2: Correlations Between Mechanical Texture Measures and Sensory Judgement

	Peak force [N]				Energy [mJ]			
	WBCOMMON	WBRECT.	WBBROAD	VOLODKEVICH	WBCOMMON	WBRECT.	WBBROAD	VOLODKEVICH
Initial firmness	0.70	0.71	0.68	0.70	0.70	0.74	0.68	0.61
Tenderness	-0.83	-0.84	-0.84	-0.82	-0.84	-0.86	-0.84	-0.75
Sustainable toughness	0.81	0.84	0.82	0.82	0.82	0.85	0.83	0.73

All correlations were significant at $p < 0.001$

Conclusions: The results indicate that all compared devices gave a good estimate for meat tenderness. In discriminating between muscles or between ageing groups, the conventional Warner-Bratzler blade with a triangular hole performed slightly better than the modifications with quadratic holes. In comparison with sensory perception, all Warner-Bratzler derived devices were somewhat more sensitive to differences in ageing dependent myofibrillar toughness than to connective tissue component of meat texture. The Volodkevich bite test gave the best response on connective tissue toughness when using energy as a parameter.
As results of all methods correlated well with sensory tenderness, factors like ease of handling and reproducible sampling as well as fabrication of the instruments should be predominantly taken into account when developing a reference method or giving recommendations.

Pertinent Literature:

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