IN SEARCH OF A SHEAR-TEST CHECK MATERIAL FOR MEAT

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Background: The most widely reported measurement of meat tenderness undoubtedly is Warner-Bratzler (WB) shear force. Shearing a core of meat of a certain diameter using a WB-type blade has resulted in widespread use of the term WB-shear (Voisey, 1975; Harris, 1976). Voisey (1975) discussed the inconsistencies and inappropriate use of this term but conceded its widespread use was here to stay.

Standardization of the meat shear-test should be an obvious requirement; however, until recently it has been neglected by meat scientists. Daily calibration checks and periodic instrument validation will alert users to defects or damage to load cells. Yet, failure to obtain duplicate shear-test results when slightly modified designs of the same test cell were used (Bourne, 1972) or at different test sites using identical test protocol (Wheeler et al., 1995). The pencil eraser material proposed by Wheeler et al. (1995) was tested on an Instron Universal Testing Machine (Instron Corp., Canton, MA) at various crosshead speeds and full scale loads. Mean shear force of erasers was reported to be similar among various WB-shear devices (5.48±.25 kg) but varied from 4.74 to 10.92 kg among four Instrons. Some problems of standardizing instrumental tests are discussed by Bourne (1972), but benefits could be far-reaching in establishing instrument-sensory relationships and in minimizing reliance on panel tests for routine testing.

Texture profile standard rating scales (Ceville and Liska, 1975; Szczesniak et al., 1963) have been shown to have good correlation between the sensory tests and instrumental, i. e. , viscosimeter and texturometer measurements. In the texture profile, commonly used foods are selected for their availability and consistent textural characteristics. Perhaps use of a processed food or other highly controlled, manufactured product could also serve as a standard, or check material, in appraising meat shear-test instruments. Therefore, the objectives of this study were to explore the possibility of using caramels, gums, gelatins, and samples of plastic tubing for a check material, and to demonstrate sources of variation among test cells and instruments that may exist.

Methods. Study I: Two bags of caramels (Kraft, Inc., Glenview, IL) were purchased locally from each of three different stores. Samples were chosen to detect differences in freshness by selecting purchase by dates showing the least (<1 week) and greatest (12 weeks) shelflife remaining. Unwrapped caramels were cored with a 1.19 cm id corer and sheared for peak force ona WB-device (G. & R. Electric Co., Manhattan, KS) anda TextureTest System [Model TMS-90, Food Texture Corporation (FTC), Herndon, VA]. A crosshead speed of 22.86 cm/min was used to match the fixed rate of the WB-shear apparatus, and a minimum of 15 cores were sheared on each instrument. Resulting data were analyzed using the Statistical Analysis System (SAS, 1992) as a 2×2 factorial with two levels of freshness and two instruments. The three stores served as experiment replications.

Study II: Products used for evaluation as a standard check material included: Kraft caramels; 4% (w/w) *k*-carrageenan (Gelcarin GP 911, FMC Corporation, Philadelphia, PA) in 1% (w/v) KCl with or without 3% (w/w) sucrose as a dispersant; 5-, 10- and 30% (w/w) gelatin (USP grade, Fisher Scientific, Pittsburgh, PA); various gelatin/*k*-carrageenan mixtures; *k*-carrageenan/konjac (Nutricol K80V, FMC Corporation, Philadelphia, PA) flour 60/40 mixture; and, several types of tubing. Kappa-carrageenan and gelatin mixtures were mixed in cold water using a vortex mixer then heated to 83 ° C in an ultrasonic cleaner while deaerating. A 1.19 cm id corer was used to remove samples from the gel mixtures prior to shearing. Microbore and small-bore tubing samples were: Silastic® (Dow Corning, Corning, NY); PE-20 and PE-60 polyethylene (Clay Adams, Parsippany, NJ); Tygon® polyvinyl chloride (Thomas Scientific, Swedesboro, NJ); PEEK (polyetheretherketone, Cole Parmer Instrument Co., Niles, IL); and, Teflon® (Zeus Industrial Products, Raritan, NJ). Tubing was cut into 4 cm lengths and sheared on the FTC at 1 cm intervals at crosshead speeds of 15, 20 and 25 cm/min. Five shears for each product by crosshead speed combination were replicated three times. Data were analyzed for each product as a one-way analysis of variance with replication as a block effect.

Study III: In addition, variation among test cells within an instrument was evaluated using a well-used and five new meat test cells obtained from Food Texture Corp. Silastic® tubing was sheared five times with each test cell at crosshead speeds of 20 and 25 cm/min. Each test cell and speed combination was replicated three times. Data were analyzed as a 2×6 factorial (crosshead speeds × test cells) with replication as a block effect. Where differences were detected among blades, the LSD option was used for mean separation (SAS, 1992).

Results and Discussion: Study I: Effect of shelflife on shear force of caramels is presented in Figure 1. Within an instrument, differences ($P<.05$) in shear force were detected. The approximate .7 kg increase in shear force when shelflife decreased from 12 to <1 week for both the FTC and WB-shear system was not unexpected. This supports the need to control the shelflife of any check material selected. For all replications and shelflife, shear force measured with the FTC was consistently .5 to .6 kg higher ($P<.05$) than with the WB-shear device. This difference is explained by the thicker blade of the FTC test cell, 3.175 vs 1.016 mm on the WB-shear (Voisey, 1975).

Study II: Shear force means of various products at different crosshead speeds using the FTC are presented in Table 1. Peak shear force values for caramels having 12 weeks shelflife were not different ($P>.05$) at crosshead speeds of 15, 20 or 25 cm/min. Likewise, shear force of 4% *k*-carrageenan did not change as crosshead speed increased from 15 to 25 cm/min. Other carrageenan/gelatin mixtures had similar shear force values and, thus, are not shown. The *k*-carrageenan/konjac flour mixture shear force at 25 cm/min was 2.9 times that *k*-carrageenan alone showing the synergistic effect of addition of konjac flour on gel strength. This mixture also was difficult to solubilize and deaerate. Consequently, there was material for testing only at 25 cm/min. The advantage of an edible food product as a check material is that it could be used also to train sensory panelists. Texture profie standards are reported to have good correlation with viscometer and texturometer measurements (Szczesniak et al., 1963) and could be a starting point in evaluating materials for the meat shear-test.

For Silastic® and Tygon® brand tubing, shear force increased (P<.05) slightly as crosshead speed increased. Although differences in shear force were detected with increasing crosshead speed with the 1-year old sample of PE-20, PE-60 and Teflon tubing, differences were small and there was no trend in the direction of change. The approximate 1 kg increase in shear force as the age of PE-20 tubing increased from 1 to 4 years illustrates again the effect of age of materials on shear force. Microbore and small bore tubing material have controlled manufacturing specifications, i.e., wall thickness variations less than .03 mm, traceable manufacture date and lot control numbers, making these materials suitable for a check material. Similar evaluations are being conducted using an Instron.

Table 1 - FTC Texture Test System means for peak shear force (kg) of potential check materials at various crosshead speeds

Material[a]	Crosshead speed (cm/min) 15	20	25	SEM[b]
Kraft caramels, 12 weeks shelflife remaining	2.27	2.30	2.39	.066
k-carrageenan, 4% w/w	.76	.78	.73	.027
k -carrageenan/konjac flour, 60/40 ratio	NA[c]	NA	2.14	.133
Silastic® microbore tubing, .76 mm id × 1.65 mm od	2.70^{y}	2.72^{xy}	2.79^{x}	.023
Tygon® PVC tubing, 2.38 mm id × 3.97 mm od	9.05^{z}	9.65^{y}	10.18^{x}	.082
PEEK microbore tubing, .762 mm id × 1.58 mm od	25.77	25.54	24.04	.942
PE-20 polyethylene, .38 mm id × 1.09 mm od, 1 yr old	3.13^{y}	3.23^{x}	3.18^{xy}	.031
PE-20, polyethylene tubing 4 yr old	4.17	4.16	4.16	.079
PE-60 polyethylene tubing, .76 mm id × 1.219 mm od	3.83^{y}	3.95^{x}	3.47^{y}	.039
Teflon microbore tubing, .71 mm id × .7 mm od	3.26^{y}	3.14^{y}	3.24^{xy}	.041

[a] Refer to methods for full product description.
[b] Standard error of mean of five observations at each speed, replicated three times.
[c] Not analyzed (NA) due to insufficient amount of material.
[xyz] Means on a row having different superscripts differ significantly (P<.05).

Study III: Variations among test cells used on the same instrument (FTC) are illustrated in Figure 2. A test cell in use over 5 years and five new test cells were compared. When the same Silastic® tubing sample was sheared on each cell at two crosshead speeds, all except two cells were significantly different (P<.01). No differences were noted due to crosshead speed except for test cells 4 and 5. Shear force values from the well-used cell were approximately twice those from new cells. Voisey (1975) noted the FTC meat-shear cell differs from the WB-shear device in that the blade is thicker and edges are sharper, affecting performance. Another factor that could account for the differences among cells is friction as the blade is pushed through a slot (Voisey, 1975; Bourne, 1972). Similar comparisons are under way for the Instron as it uses blades of the same thickness as the WB-shear or FTC system, and also are pushed through a slot.

Conclusions: While none of the materials tested behaved like meat, i. e., as a viscoelastic body where shear force decreases with increasing shear rate (Lepetit and Sale, 1985), Kraft caramels, some polyethylene tubing and PEEK tubing had consistent shear force values across the range of crosshead speeds used. The low standard errors of the mean for materials tested in this study indicate that any of the materials tested would be as good or better than the eraser material proposed by Wheeler et al. (1995). Wheeler et al. (1995) reported mean ± SD from an Instron (5 cm/min crosshead speed and 0 to 10 kg full scale load) and a WB-shear device of 5.54±.30 and 5.48±.25 kg, respectively. Furthermore, the possibility exists of choosing check materials to represent low, moderate and high shear force values by selecting tubing of different sizes.

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Figure 1. Effect of caramel freshness on peak shear force values

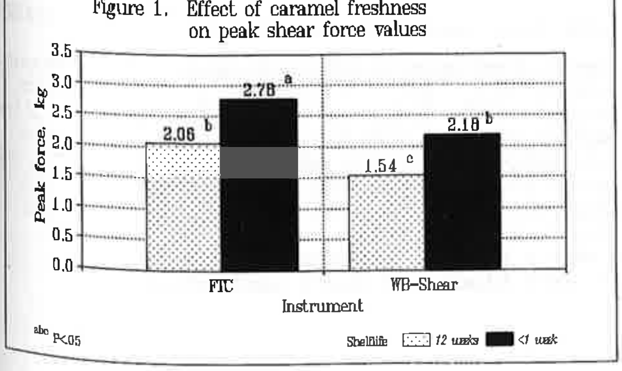

Figure 2. Variation among new vs a well used blade