PREDICTION OF THE TENDERNESS OF COOKED MEAT FROM MEASUREMENTS MADE ON THE RAW MEAT

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SUMMARY

A novel method of predicting the tenderness of cooked meat from measurements on post-rigor raw meat samples is described. Correlations between measurements taken with the device operated on an Instron Universal Testing Machine (RV1) and objective measurement of connective tissue strength of the cooked meat (adhesion and Instron compression values) varied between 0.74 and 0.78; similar correlations using the device in a portable mode (RV4) were less, 0.31 to 0.57 but (RV4) values were well correlated, 0.60 to 0.67, with taste panel tenderness.

INTRODUCTION

Most of the methods used to relate measurements on raw meat to cooked meat tenderness have been penetrometer methods (Hansen 1972; Hinnegardt and Tuomy 1970; Galloway et al., 1973). The correlations between measurements on the raw meat and subjectively assessed tenderness of the cooked meat have ranged from -0.11 to 0.77 (Hansen, 1972, Henrickson et al., 1972; Parrish et al., 1973; Campion et al., 1975). A measurement on raw meat should be sensitive to both myofibrillar and connective tissue toughness. However, effective electrical stimulation minimizes the myofibrillar component of toughness. In stimulated carcasses, toughness is, thus, essentially dependent on the connective tissue contribution and a device that measured this could be expected to predict tenderness with some accuracy.

In this paper measurements of the connective tissue strength of raw meat samples are related to objective measurements, and subjective assessments of the tenderness, of the meat after cooking.

MATERIALS AND METHODS

Raw measurement device:

The principle of the method is illustrated in Figure 1. A 7 cm deep cut was made in post-rigor muscles along the predominant fibre direction using a double edged knife (blade 2.2 cm wide and 0.3 cm thick).Into this cut or slit was inserted 2 parallel blades and the force required to move these 2 blades apart by 2.0 cm was measured.

The method essentially measures the force required to enlarge a standard sized hole in a standard way.

The first device (RV1) was designed for use on an Instron Universal Testing Machine (Type 1122). The RV1 had stainless steel blades which were 1 mm thick, 2 cm wide and 2.5 cm long. The portable version (RV4), which was used on whole muscles, has blades which are 3 mm thick, 2 cm wide and 4.5 cm long. For RV1 the force required to move the blades apart was both generated and measured using the Instron. In the RV4 a combination of hydraulic pressure and springs was used to generate the required force and to measure peak force.

Experimental Material

In experiment 1, RV1 measurements on 8 muscles (*semimembranosus* - SM; *adductor* - A; *biceps femorus* - BF; *semitendinosus* - ST; *vastus lateralis* - VL; *gluteus medius* - GM; *longissmus dorsi* - LD and *psoas major* - PM) were compared with adhesion and WB shear force measurements on raw samples and adhesion, Instron compression (IC) and WB shear force measurements on 250 g samples of these muscles (cooked at 80°C for 1 hr) from 8 animals. In experiment 2, the same 8 muscles from 4 animals were used and RV1 measurements were compared with adhesion and WB shear force measurements on the raw meat and adhesion and WB shear force on pressure-heat treated and control (non pressure treated) samples cooked at 80°C for 1 hr.

In the third experiment RV4 was used on PM, GM and SM muscles of 9 beef animals and results were compared with adhesions, IC, WB shear force and taste panel measurements on the cooked meat.

Cooking method:- 250 g samples were removed from each muscle after RV1 or RV4 measurements had been done. Each sample was placed in a polyethylene bag, fastened with metal clips, cooked for 1 hr totally immersed in a water bath at 80°C (± 0.5°C), and then cooled in cold running water for 30 min. Samples for pressure-heat treatment weighed about 80 g.

Objective and subjective measurements

Ultimate pH values of the raw muscle samples were measured directly at 20°C. All muscles had pH values in the range of 5.6-5.8. The analysis of the WB shear force deformation curves [to derive initial yield (WBIY) and peak force (WBPF) values], Instron compression and adhesion measurements have been described (Bouton

TABLE 1 CORRELATION MATRIX OBTAINED BETWEEN RV1 MEASUREMENTS ON RAW MUSCLE SAMPLES AND ADHESION, WB SHEAR (IN RAW) AND ADHESIONS (Ad) INSTRON COMPRESSION (IC) AND WB SHEAR VALUES OF COOKED (80°C/1 hr) SAMPLES

		1	2	3	4	5	6	7	8
1 RV1	R	1.00	0.60	0.03	0.41	0.78	0.74	0.49	0.66
2 Ad	a	-	1.00	0.09	0.32	0.61	0.59	0.43	0.50
3 WBIY	w	-	-	1.00	0.09	-0.04	-0.04	-0.03	-0.01
4 WBPF		-	-	-	1.00	0.34	0.35	0.02	0.21
5 Ad	C o	-	-	-	-	1.00	0.83	0.61	0.76
6 IC	o	-	-	-	-	-	1.00	0.67	0.84
7 WBIY	k	-	-	-	-	-	-	1.00	0.92
8 WBPF	e d	-	-	-	-	-	-	-	1.00

N = 64

(R values >0.39 significant at P<0.001 level, >0.31 at P<0.01 and >0.24 at P<0.05)

and Harris, 1972; Bouton et al., 1975). The 10 members of the taste panel were all trained. Cooked samples for the taste panel were cut, after overnight storage at 0-1°C, into 13 mm cubes (one face of each cube parallel to meat fibre direction). At each session the panellists tasted 3 samples, SM, GM and PM muscles, from each animal and were asked to rate the samples for tenderness and juiciness on an unstructured scale. The ends of the scale were defined as 1 extremely tender, or extremely juicy, while 25 was extremely tough or extremely dry. The order of sample tasting was randomised.

Pressure-heat treatment

Samples (approx. 80 g) were subjected to a pressure-heat treatment (Ratcliff et al., 1977). After pressure treatment the samples were cooled in cold water for at least 30 min, removed from the vacuum sealed bags and cooked at 80°C for 1 hr as described above. Regression analysis was used to determine linear correlation coefficients between variables.

RESULTS AND DISCUSSION

Experiment 1:

RV1 measurements were related to adhesion and WB shear force measurements in the raw meat and to adhesion, WB shear force and IC measurements in the cooked (Table 1).

Correlations between RV1 and adhesion values of both raw (0.60) and cooked (0.78) samples were highly significant, as was that between RV1 and Instron compression values of cooked samples (0.74). Correlations with WB were not significant for raw WBIY values but were significant ($P < 0.001$) for WBP values of both raw and cooked samples. The RV1 measurements on the raw meat thus related well to objective measurements of the cooked meat tenderness.

Experiment 2:

This was similar to the first experiment but a pressure-heat treatment was also used. Correlations (Table 2) between RV1 and adhesion values obtained for raw, cooked control and cooked pressure-heat treated samples were all highly significant ($P < .001$) at 0.61, 0.63 and 0.68, respectively. None of the correlations with WB shear force were significant, apart from the WBPF values obtained for the pressure-heat treated samples (0.77); here the PxH treatment ensured that the myofibrillar toughness was very low.

The RV1 measurements were, thus, significantly and consistently related to objective measures which reflect connective tissue strength.

Experiment 3:

The portable RV4 device was used on raw SM, GM and PM muscles and the results (Table 3) compared with IC, Ad, WBIY, WBPF and subjective assessments of tenderness on the cooked meat. For PM muscles where there was little variation in tenderness and RV4 measurements did not correlate significantly with either objective or subjective measurements. For the other muscles both individually, and combined, the RV4 measurements correlated well with tenderness measurements on the cooked meat.

CONCLUSION

The results obtained with both RV1 and RV4 indicated a good relationship between raw measurements obtained with them and tenderness of the cooked meat. The main disadvantage of the device is that it will not work on pre-rigor meat.

However, the main purpose of these experiments was to demonstrate whether measurements taken on raw meat with a device which did not operate as a penetrometer were, predictively, correlated to the tenderness of the meat when cooked. These, preliminary, results indicated that the method appeared to give results at least as good as those obtained with plunger type devices.

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TABLE 2 CORRELATION MATRIX BETWEEN RVI MEASUREMENTS, ON RAW MEAT, AND ADHESION (Ad) AND WB PEAK FORCE MEASUREMENTS OF, RAW AND COOKED (80°C/1 hr), CONTROL AND PRESSURE-HEAT TREATED MEAT SAMPLES

		1	2	3	4	5	6	7
1 RV1	R	1.00	0.61	0.34	0.63	-0.03	0.68	-0.77
2 Ad	a	-	1.00	0.56	0.70	0.22	0.67	0.50
3 WBPF	w	-	-	1.00	0.38	-0.05	0.66	0.47
	C							
4 Ad	o	-	-	-	1.00	0.26	0.78	0.62
5 WBPF	o	-	-	-	-	1.00	0.14	-0.08
6 AD*	k	-	-	-	-	-	1.00	0.76
7 WBF*	e	-	-	-	-	-	-	1.00
	d							

*Pressure-heat treated samples

TABLE 3 CORRELATION BETWEEN RV4 MEASUREMENTS ON RAW SM, GM AND PM (n = 26) MUSCLES FROM BEEF ANIMALS OF VARIOUS AGES WITH IC, AD, WBIY, WBPF AND TASTE PANEL (TP) MEASUREMENTS ON THE COOKED MEAT

	MUSCLES				
	SM	GM	PM	SM + GM	SM + GM + PM
TP	0.66***	0.67***	0.13ns	0.70**	0.83***
IC	0.34NS	0.53**	0.15NS	0.56***	0.76***
Ad	0.31NS	0.55**	0.12NS	0.57***	0.75***
WBIY	0.39NS	0.55*	0.03NS	0.49***	0.63***
WBPF	0.32NS	0.67***	0.13NS	0.70***	0.83***
n	26	26	26	52	78

NS - non significant
* P<0.05; ** P<0.01 and *** P<0.001

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