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EFFECTS OF SOME POST-SLAUGHTER TREATMENTS ON THE MECHANICAL PROPERTIES OF MEAT

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Over the years, ideas as to which components of meat are responsible for toughness have changed. Connective tissue was once thought to be of prime importance (Ramsbottom & Strandine 1945, 1948). Later, particularly during the 1960's when it was shown that fibrillar shortening increased toughness (Locker 1960, Marsh and Leet 1966, Herring et al. 1965a, 1965b, 1967, Davey et al. 1967) the importance of fibrillar proteins was emphasised. Changes in numerous animal and treatment variables will influence the relative contributions to toughness of these two classes of proteins, and ways of estimating any changes in their relative contributions are sought-after. To this end a number of different mechanical measurements has been made and the effects of cooking temperature and time, and of post-slaughter treatments such as ageing and stretching muscles on these measurements have been examined. Stretching was achieved by changing the normal method of carcase suspension.

Experimental:

Tenderness measurements were made using two instruments, a Warner-Bratzler shear apparatus and an Instron Universal Testing Machine.

Warner-Bratzler (WB) shear values were determined with the cutting blade of the instrument perpendicular to muscle fibre direction, on samples with a rectangular cross-section of 1.5 x 0.67 cms.

Both the compressive and tensile testing modes of the Instron Universal Testing Machine were used. From the compression measurements indices of the cohesiveness and chewiness of the sample were obtained as follows: The work required to insert a 0.63 cm diameter plunger 0.8 cm into a sample 1 cm thick was measured twice in the same place. The ratio of the work required for the second compression to the work required for the first compression was taken as an index of cohesiveness. The product of cohesiveness and the work required for the first insertion was taken as an index of chewiness.

Tensile strength measurements were made with the muscle fibres lying both in and at right angles to the direction of tension. The values obtained are referred to as fibre strength and fibre adhesion values respectively. For both measurements strips of 1.5 x 0.67 cm cross-section were cut and these were used without further modification for fibre adhesion measurements where the fibres were perpendicular to the two faces of greatest area. For fibre strength measurements, the strips were cut to a dumb-bell shape with cross-sectional area in the middle region of 0.44 sq. cm. Without this modification these samples, when stressed, frequently yielded at the clamping jaws of the machine.

Samples, usually of 200 gms, were cooked in their own juice in polyethylene bags in a temperature-controlled water bath. The high speed centrifugation method of Akroyd reported by Bouton et al. (1971) was used to estimate expressible juice. Samples to be aged were sealed in flexible film pouches and held at 0° - 1°C for 2 and 4 weeks.

RESULTS AND DISCUSSICN

Effect of cooking temperature and time:

The observed effects of heat are commonly interpreted in terms of a softening of connective tissue as a result of the conversion of collagen to gelatin and toughening of myofibrillar proteins as they shrink and coagulate.

Table 1 shows the effect on some mechanical parameters of various combinations of temperature and time of cooking. There were no large differences between samples cooked for times between 0.5 and 4 hours, and none of the changes were significant for the young animals.

TABLE 1

Effect on chewiness and WB* shear values of cooking veal and beef (deep pectoral muscle) for various times and at various temperatures

Animal Age	Cooking Temp. (0°C)	Mechanical Parameter	Cooking time in hours				
			0	½	1	2	4
Veal	50	Chewiness	2.14^{a}	3.61^{b}	3.96^{b}	3.73^{b}	-
		WB Shear	41.0^{a}	49.0^{a}	46.3^{a}	42.5^{a}	-
Veal	60	Chewiness	2.51^{a}	0.89^{b}	0.94^{b}	0.98^{b}	-
		WB Shear	43.2^{a}	20.9^{b}	20.7^{b}	20.5^{b}	-
Veal	70	Chewiness	2.23^{a}	1.62^{b}	1.64^{b}	1.65^{b}	-
		WB Shear	36.4^{a}	18.4^{b}	18.6^{b}	18.9^{b}	-
2-3 year	50	Chewiness	1.61^{a}	2.32^{b}	2.48^{b}	3.06^{c}	3.37^{c}
		WB Shear	29.8^{a}	30.2^{a}	28.9^{a}	39.0^{b}	36.3^{b}
2-3 year	60	Chewiness	1.61^{a}	2.28^{b}	2.43^{b}	2.52^{b}	2.02^{b}
		WB Shear	29.8^{a}	27.4^{a}	25.5^{a}	28.7^{a}	25.3^{a}

a, b, c - Change of superscript indicates the difference between values is significant.

WB* - Warner-Bratzler.

From Table 2 it is seen that at 70°C a cooking time of more than 8 hours was required before large changes were produced in chewiness, fibre adhesion of WB shear values.

TABLE 2

Effects of cooking beef biceps femoris muscle for times up to 16 hours at 70°C on chewiness, adhesion and WB shear values

Mechanical Parameter	Cooking time in hours				
	1	2	3	8	16
Chewiness	2.50^{a}	2.55^{a}	2.03^{b}	1.95^{b}	1.28^{c}
Fibre adhesion	1.14^{a}	0.84^{a}	0.95^{a}	0.89^{a}	0.48^{b}
WB Shear	35.1^{a}	35.8^{a}	37.6^{a}	32.7^{a}	27.1^{b}

a, b, c - Change of superscript indicates the difference between values is significant.

Therefore at cooking temperatures up to 70°C differences in heating-up time as a result of small variations in sample shape will have little effect on these values. The effects produced by cooking samples at 90°C were much more dependent on cooking time, as is shown in Fig. 1.

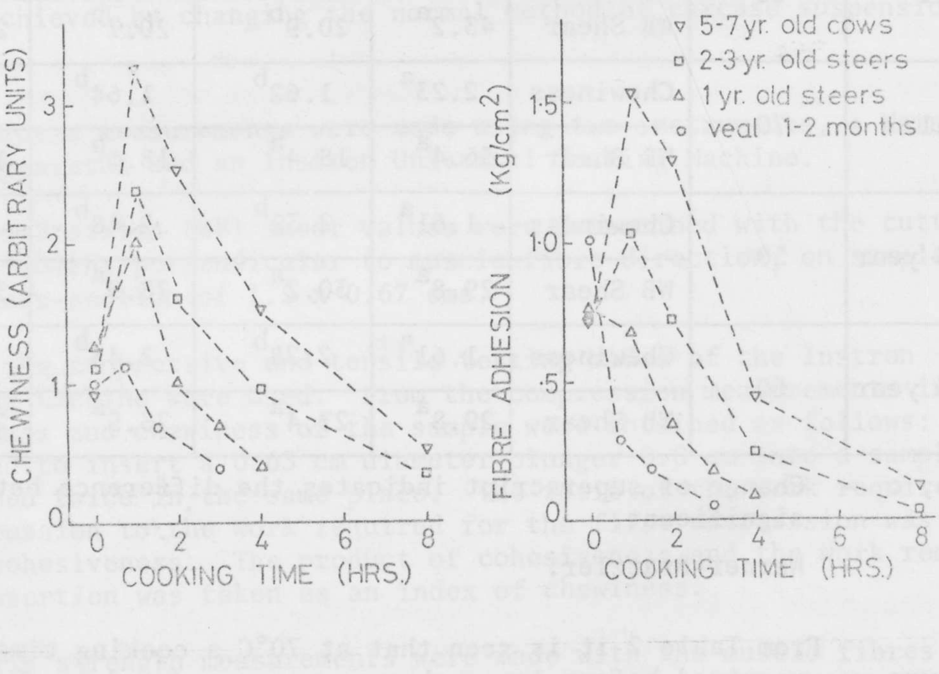

FIG. 1. Effect of cooking at 90°C for various times on chewiness and fibre adhesion values of deep pectoral and biceps femoris muscle samples. (The results for both muscles were similar and have been combined.)

Changes of cooking temperature over the range 40-75°C resulted in large changes in chewiness and fibre adhesion values (Fig. 2), and in cooking loss and the amount of centrifugally expressed juice (Fig. 3).

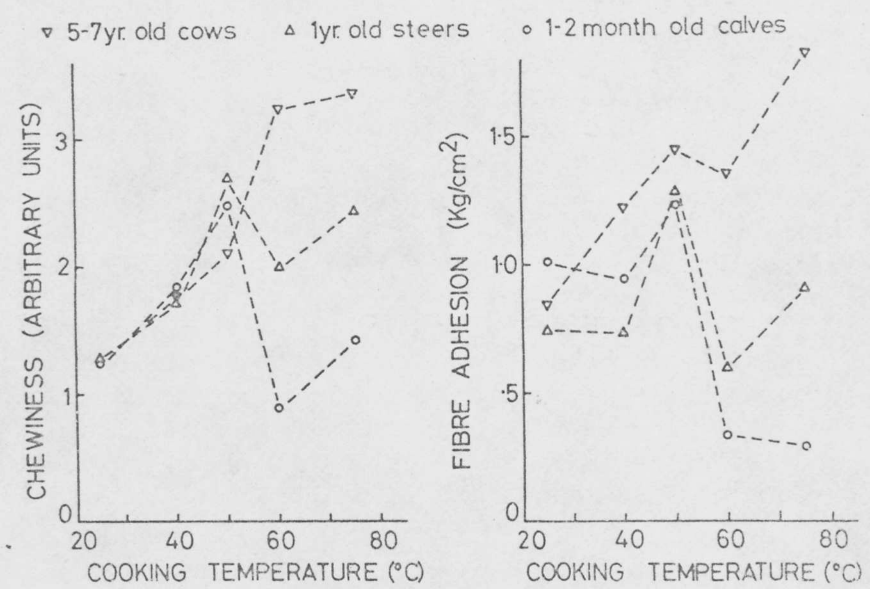

FIG. 2. Effect of cooking deep pectoral and biceps femoris muscle samples from animals of various ages, at 40°, 50°, 60° and 75°C for 1 hour on chewiness and fibre adhesion values. The results for both muscles were similar and have been combined.

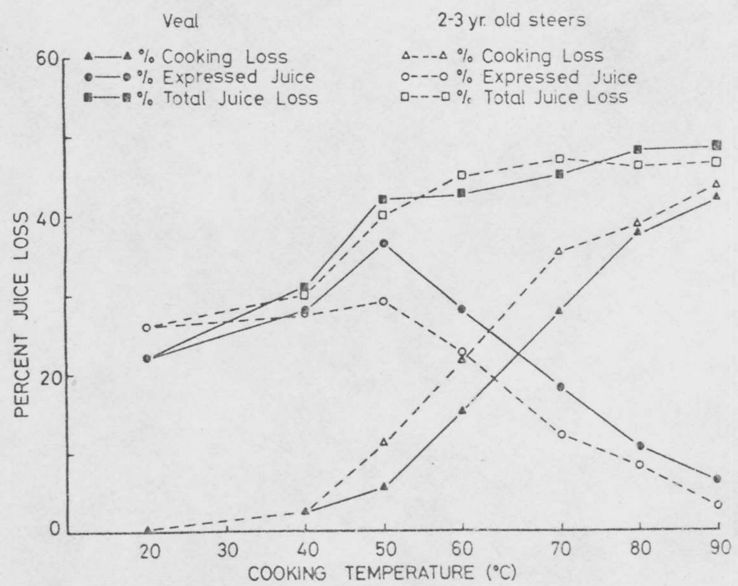

FIG. 3. Changes in % Cooking Loss, % Expressed Juice and % Total Juice Loss for deep pectoral muscles from veal and 2-3 year old steers cooked for an hour at 40°, 50°, 60°, 70°, 80° and 90°C.

Generally, for temperatures up to 50°C, chewiness and fibre adhesion values were greater the higher the cooking temperature. The effects on these values of changing the cooking temperature from 50° to 60° were dependent on animal age. For the younger animals chewiness and fibre adhesion values both decreased significantly, whereas for the 5-7 year old cows chewiness values increased significantly and changes in fibre adhesion values were not significant. These observations are consistent with the observed softening and solubilisation of collagen from young animals that occurs at temperatures near 60°C, and with the greater stability to heat of collagen from older animals (Goll et al. 1964a, 1964b; Hill 1966).

Significant increases in some chewiness and fibre adhesion values when cooking temperature was changed from 60° to 75°C were probably associated with fibrillar shrinkage which has been reported to increase in this temperature range (Giles 1969).

If the presumption is correct that fibre adhesion values were responsive mainly to change in the strength of the connective tissue, then the results of these measurements suggest that connective tissue was effectively strengthened by some heat treatments. It is noted that where cooking losses occur, any increases in fibre adhesion values may be due in part to an increase in the amount of structural material in the test samples.

Post-slaughter treatments:

Post-slaughter treatments studied were ageing and the effect of hanging carcases in different positions until rigor mortis had developed.

Bouton and Harris (unpublished work) found that the longissimus dorsi (LD) muscle tenderises to a much greater extent with ageing than does the semimembranosus (SM) muscle. An experiment using the LD and SM muscles from eight 2-3 year old steers was designed to investigate whether changes in shear and fibre strength values with ageing were related to changes in adhesion between the fibres. The results for samples cooked at 90°C where shortening is expected to be pronounced are shown in Fig. 4 and for samples cooked at 60°C where muscle shortening is slight (Giles 1969) are shown in Fig. 5.

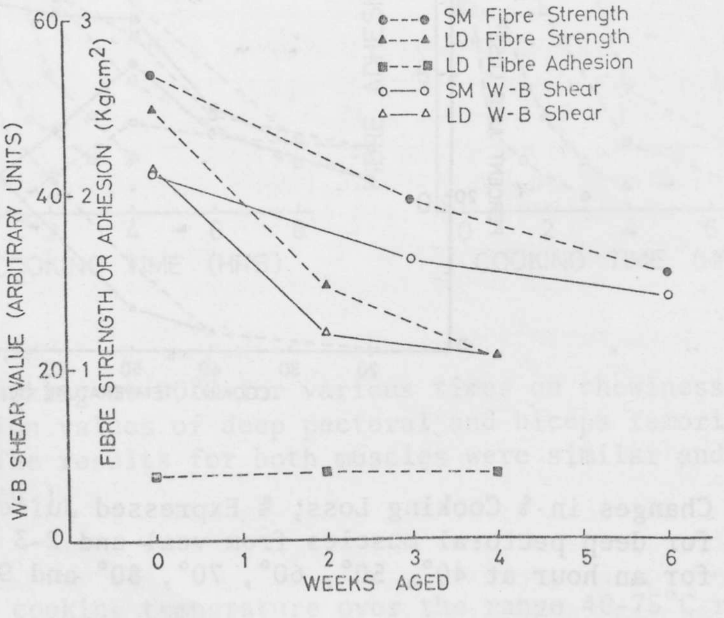

FIG. 4. Changes in fibre strength, fibre adhesion and WB shear values of 2-3 year old beef semimembranosus (SM) and longissimus dorsi (LD) muscle samples aged at 0-1°C for up to 6 weeks and then cooked at 90°C for 90 minutes.

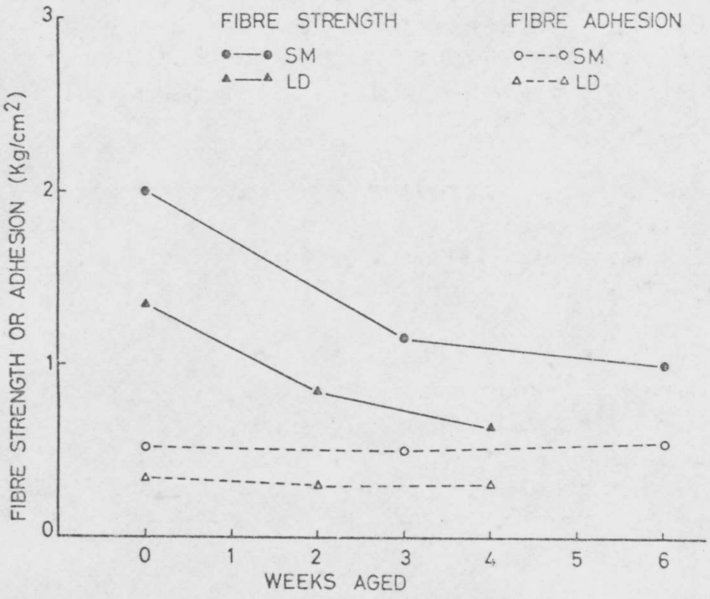

FIG. 5. Changes in fibre strength and fibre adhesion values of samples of semimembranosus (SM) and longissimus dorsi (LD) muscles aged at 0-1°C for up to 6 weeks and then cooked at 60°C for 90 minutes.

These figures show that:

(a) The LD muscle tenderised more rapidly than the SM muscle whether assessed by shear force or fibre strength.

(b) There was no significant change in fibre adhesion values over the full ageing period even though large changes in fibre strength values occurred.

(c) The SM muscle had higher fibre adhesion values than the LD muscle.

(d) The fibre strength was greater in the samples cooked at 90°C than in those cooked at 60°C.

In an experiment combining the effect of hanging position with that of ageing, six 5-7 year old cows and six 2-3 year old steers were used. Following slaughter and dressing, one side of each carcase was hung in the conventional manner from the Achilles tendon while the other side was hung from the obturator foramen (Hostetler et al. 1970a, 1970b), in order to stretch the SM and LD muscles. These muscles were removed from the carcases post rigor and the results of measurements made on them after various periods of ageing can be summarised as follows:

(a) Chewiness values showed highly significant ($P < 0.001$) decreases following either stretching or ageing.

(b) WB Shear measurements showed highly significant ($P < 0.001$) decreases due to ageing or stretching. Ageing effects in the LD muscle were more pronounced than in the SM muscle regardless of whether the muscle was stretched or not - see Fig. 6.

(c) There was no significant change in fibre adhesion values with ageing.

(d) Stretching significantly ($P < 0.001$) decreased fibre adhesion values for both muscles.

(e) The meat from older animals had significantly higher fibre adhesion values and these differences were more pronounced following cooking at the higher temperature.

(f) The SM muscle had higher fibre adhesion values than the LD muscle.

(g) Stretching gave a tenderness equivalent to about 2 weeks of ageing of the muscles from conventionally suspended carcases.

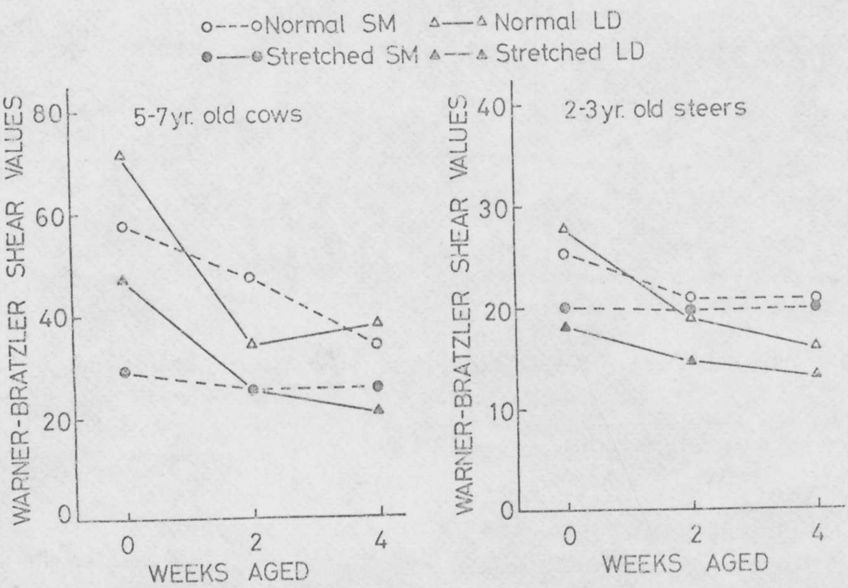

FIG. 6. Comparison of the effects of ageing on WB shear values of longissimus dorsi (LD) and semimembranosus (SM) muscle samples from animals hung from the Achilles tendon and from the obturator foramen (stretched).

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