4:13 Some factors affecting the toughness of pork

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Introduction

It is generally believed that pork is tender (Buchter and Zeuthen, 1971). Certainly butchers seldom deliberately age pork to tenderise it. Tough pork does, however, occur and von Mickwitz (1982) has recently drawn attention to the poor palatability of Pale-Soft-Exudative (PSE) pork. Cassens et al. (1975) in a review concluded that it was "difficult to make a generalization about the palatability of PSE meat." Buchter and Zeuthen (1971) considered that the equivocal results that had been obtained regarding the tenderness of PSE pork relative to normal or Dark-Firm-Dry (DFD) pork may have been due to the differential rate of ageing of PSE pork although Fox et al. (1980) found no evidence of such an effect. Topel et al. (1976) suggested that the varied results may have been due to differences in cooking techniques.

An Australian company involved in the production of high quality pork became concerned that some of its product was tough. It was suggested that this may have been due to the greater chronological age of pigs fed restricted rations to ensure lean carcasses. In Australia 95%, or more, of male pigs slaughtered for pork or bacon are intact boars, a situation which does not pertain in many countries, and this could also have affected the texture of the pork.

The present experiment was done to determine the variation in Warner-Bratzler shear force values of the M.longissimus dorsi (LD) of lean pork carcasses of boars and gilts and to determine some of the factors that influenced these values.

Materials and Methods

Fifty nine pigs (Landrace x Large White), 33 gilts and 26 boars, in groups of 20, 20 and 19, from three farms, were slaughtered in one abattoir. The animals ranged in age from 23 to 43 weeks at slaughter. Their mean cold carcass weight was 55.3 kg and their mean subcutaneous fat depth measured over the loin on the hot carcass, with an optical probe, at the P2 site, was 15.0 mm. It was not possible to measure initial LD pH values 45 minutes postmortem. The carcasses were chilled, air temperature 3°C, for 24 hr and then boned. At boning 10 cm long samples were removed from the posterior end of one loin of each carcass, put in polyethylene bags and rapidly frozen to -20°C.

At the laboratory the frozen samples were thawed on wire racks, at 5 to 6°C for 24 hr. Samples of LD, mean weight 112 g, were dissected from the loin samples after the depth of the subcutaneous fat over the LD had been measured. The meat colour of the samples was assessed independently by three observers on a 1 (very pale) to 7 (very dark) structured scale. When the samples had warmed to room temperature (22°C) their ultimate pH was determined directly with a Watson-Victor portable pH meter and a Philips C64/1 combined electrode.

Fig. 1 Relationship between % cooking loss and ultimate pH

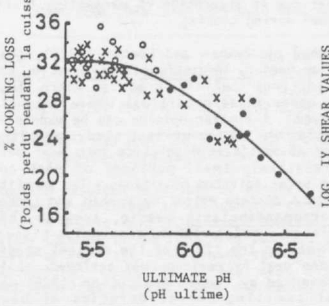
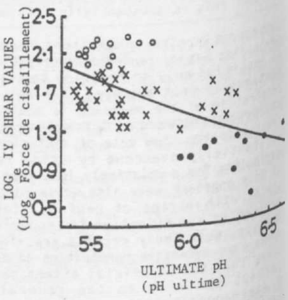


Fig. 2 Relationship between log IY shear force values and ultimate pH



● = IY SHEAR VALUES < 4kg

X = IY SHEAR VALUES 4 - 7.9kg

O = IY SHEAR VALUES > 8kg

Fig. 3 Relationship between IY shear force values and % cooking loss

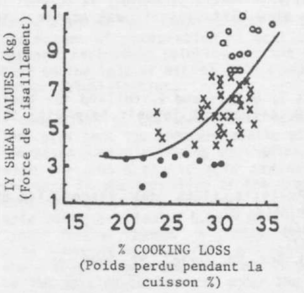
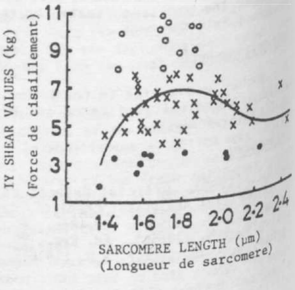


Fig. 4 Relationship between IY shear force values and sarcomere length



Small samples were removed for sarcomere length determinations, using a He-Ne laser (Bouton et al., 1973a), before the samples destined for cooking were weighed and then cooked, wrapped tightly in polyethylene bags, in a water bath at 80°C for 1 hr. After cooking the samples were cooled in cold running water for 30 minutes then patted dry with paper towels and reweighed. The samples were cooled overnight, at 0-1°C. A minimum of five rectangular strips 1 cm² in cross-sectional area with their long edges parallel to the long axis of the muscle fibres were cut from each sample and sheared on a modified Warner-Bratzler shear device (Bouton and Harris, 1972). Initial yield shear force (IY) and peak shear force (PF) were determined from recorded shear force-deformation curves. The significance of sex differences was determined using analysis of variance. Simple correlations between actual and log transformed variables and multiple regressions were also calculated.

Results and Discussion

The effect of animal age on Warner-Bratzler shear force values was evaluated within the one group of 19 pigs with a wide range of ages (25-43 weeks). Although Warner-Bratzler IY and PF values increased with age the correlations ($r = 0.26$ and $r = 0.19$, respectively) were not significant.

LD samples from all boars had significantly ($P<0.02$) lesser mean Warner-Bratzler IY and PF values (5.4 v. 6.7 kg) and (7.2 v. 8.6 kg), greater ($P<0.0002$) LD ultimate pH values (5.95 v. 5.61) and were darker (colour score 3.6 v. 2.8, $P<0.05$) than those from all gilts.

Correlations between some variables and Warner-Bratzler shear values are shown in Table 1; IY values only are given as IY and PF values were closely related ($r = 0.97$). Carcass weight was, as anticipated, significantly correlated with P2 and mean loin fat depth ($r = 0.46$ and 0.29, respectively) but with no other variables in Table 1.

Table 1. Matrix of correlations between some variables and Warner-Bratzler initial yield (IY) shear force values

Variable	Sex[(a)]	LD Ult. pH	Meat Colour Score[(b)]	Cook. Loss (%)	Sarc. Length (µm)	WB IY (kg)
1 Sex[(a)]	1					
2 LD ultimate pH	0.47**	1				
3 Colour Score[(b)]	0.33**	0.78***	1			
4 Cooking Loss (%)	-0.26*	-0.84***	-0.62***	1		
5 Sarcomere Length (µm)	-0.03	-0.24+	-0.17	0.27*	1	
6 WB IY (kg)	-0.31*	-0.60***	-0.40**	-0.62***	-0.04	1

(a) Gilts = 1, Boars = 2
(b) 1 = V.light to 7 = V.dark
Significance:- + P <0.1; * P <0.05; ** P <0.01; *** P <0.001.

The relationship between ultimate pH and cooking loss is shown in Fig.1. This result is similar to those Bouton et al. (1971) obtained for sheep biceps femoris and semimembranosus muscles cooked at 90°C for one hour. In the present case cooking loss was highest and varied little with ultimate pH over the range 5.4 to 5.8 but decreased as the ultimate pH of samples increased above 5.8. The multiple correlation coefficient, R, between ultimate pH, (ultimate pH)^2, and percent cooking loss was 0.89.

Warner-Bratzler IY values transformed to log$_e$ were linearly related to ultimate pH values, $r = 0.67$, (Fig.2). There was a curvilinear relationship between cooking loss and Warner-Bratzler IY values (Fig.3), $R = 0.65$.

IY values were generally low, less than 4 kg, until cooking loss exceeded 27%. They then appeared to increase linearly, from c. 4 kg to c. 11 kg, as cooking loss increased to a maximum; if samples with cooking losses less than 26% were not included in the analysis the slope of the linear regression ($r = 0.5$) indicated that IY values increased by 0.56 kg with each 1% increase in cooking loss above 26%. The simple correlation between sarcomere length and IY shear values was low. The reason for this is apparent in Fig.4. A third order polynomial regression, $R = 0.41$ ($P<0.05$), can be drawn indicating that as sarcomere length (SL) decreased from 2.5 to c. 2.0 µm there was little change in IY shear values. IY values then increased, as sarcomere length decreased, to a maximum at sarcomere lengths c. 1.8 µm and then decreased as sarcomere lengths decreased to c. 1.4. The shape of this curve was not very different from those reported for other species although Bouton et al. (1973b) found for sheep muscles that the greatest values for Warner-Bratzler peak shear forces occurred when sarcomeres were about 1.4 µm long. Cooking loss changed little with sarcomere length except that it decreased as sarcomere lengths decreased from 1.7 to 1.4 µm; the third order polynomial regression coefficient ($R = 0.53$) was significant. This result was unexpected, as Bouton et al. (1976) have shown that the cooking loss of beef increased as sarcomere lengths decreased. Results for the high pH (>5.9) samples were ignored and the relationships between cooking loss and initial yield within groups of the 14 samples with shorter (<1.7 µm) sarcomeres, the 21 samples with intermediate length (1.7-1.99 µm), and the 7 samples with longer (>2 µm) sarcomeres examined. The correlation coefficients and slopes for regressions between cooking loss and IY shear values for the groups with shorter, intermediate, and longer sarcomere lengths were, respectively:- $r = 0.37$ (not significant), $b = -0.41$ kg; $r = 0.60$ ($P<0.05$), $b = 0.72$ kg; $r = 0.73$ ($P<0.06$), $b = 0.37$. The mean cooking losses of these groups were 31.1, 32.0 and 31.2% and the mean IY shear values 6.8, 7.7 and 5.6 kg respectively. IY shear values tended to increase as cooking losses decreased in the group with shorter sarcomeres but increased with increasing cooking loss in the other two groups. The samples with high IY shear values, low cooking losses, and shorter sarcomeres could have lost more drip during the thawing procedure and, therefore, had less to lose during cooking than other samples.

Multiple regression analysis showed that carcass weight, sex, P2 fat depth, colour score, cooking loss and sarcomere length, together, accounted for about 50% of the variation in Warner-Bratzler IY shear force values of all samples ($R = 0.70$). However, cooking loss, ultimate pH, sarcomere length, (sarcomere length)^2 and (sarcomere length)^3, together, accounted for 46% of the variation, with cooking loss and ultimate pH, together, accounting for 40%, and ultimate pH, alone, for 36%.

The relationship between shear force values and cooking loss in this experiment, with frozen and thawed samples, may be causal and pertain to unfrozen pork. These samples were well cooked, 80°C for an hour. In samples cooked less it could be expected that maximum shear force values would be proportionately less. In such a case the range in shear values and the chances of finding statistically significant differences in shear values between samples with low (including PSE samples), normal, and high ultimate pH values would be reduced.

Samples with a high ultimate pH (>5.9) had low shear values regardless of their sarcomere lengths. Most of these samples were from boars. We believe this is due, in part, to the sexually oriented behaviour of some boars in lairage leading to depletion of their muscle glycogen concentrations at slaughter. Samples with Warner-Bratzler IY shear values greater than 8 kg were samples with an ultimate pH less than 5.9 and either had shorter sarcomeres (<1.7 µm) together with a relatively low cooking loss (<32%) or intermediate length sarcomeres (1.7 to 1.99 µm) with a relatively high (>32%) cooking loss.

Conclusions

A considerable proportion of the samples (22%) had high shear values (>8 kg) which would probably be considered tough by consumers. Age at slaughter (range 25-43 weeks) had little influence on shear values. Of the variables studied cooking loss and ultimate pH had the predominant effects on shear values. Generally, low ultimate pH, pale meat, and high cooking losses were associated with high shear values. High pH samples were dark in colour and had low cooking losses and low shear values at all sarcomere lengths. If consumers select paler pork cuts from retail display and cook them well they are tending to select cuts which they will find tough. Pork from boars had lower Warner-Bratzler shear values than pork from gilts largely due to ultimate pH differences between sexes.

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