E EFFECTS OF PELVIC SUSPENSION AND LIMB-WEIGHTING ON THE SENSORY AND PROCESSING PROPERTIES F VARIOUS PORCINE MUSCLES

ANS J.M. SMULDERS*, RIËTTE L.J.M. VAN LAACK*, SEÁN C. METRUSTY** and LIA T.T. JENNISSEN***

Department of the Science of Food of Animal Origin, Faculty of Veterinary Medicine, Utrecht University, The Netherlands

Department of Food Manufacture and Distribution, Manchester Polytechnic, Manchester, United Kingdom

Boekos Pork Processors, Boekel, The Netherlands

tract

n experiments one side of 15 (experiment 1) and 24 (experiment 2) pig carcasses was suspended from the hip bones at the end of the slaughterline. ip-suspended carcass sides weights of 20 kg (experiments 1 and 2) and 10 kg (experiment 1) were hung from their hind- and fore-limbs, respectively. r overnight chilling weights were removed and Mm. triceps brachii, longissimus lumborum (experiment 1) and semimembranosus/semitendinosus periments 1 and 2) were excised. Colour, drip and cooking losses, shear force values and panel tenderness scores were assessed. In experiment 2 membranosus/semitendinosus muscles were processed into cooked hams and the processing properties assessed. With the exception of the triceps chii, stretched muscles had lower drip and cooking losses, reduced shear force values and markedly higher panel tenderness ratings. Cooked hams de from stretched muscles took up > 2% more brine, lost 2% less weight during cooking and had > 3% more yield.

oduction

ish and British studies have demonstrated that increased toughness in pork may be the result of the introduction of easingly faster chilling rates, promoting cold shortening and/or cold toughening (Taylor, 1990). Still, rapid chilling is sidered attractive because carcass weight losses are reduced and a higher carcass turn-over can be achieved. Hence, thods allowing rapid chilling of pig carcasses without detrimental effects on tenderness are currently considered for adoption the pig meat industry. Although electrical stimulation has been suggested as a possible means to eliminate toughness nsfield et al., 1991), our own studies (van Laack and Smulders, 1989) indicate that this option is less useful under Dutch umstances. In addition, the pig meat industry is concerned because this treatment may induce a pale colour and reduced er-holding properties.

Carcass suspension, reported many years ago to be effective for improving tenderness in beef (Herring et al., 1965; Weniger al., 1968; Hostetler et al., 1970) and lamb (Bouton and Harris, 1972; Bouton et al., 1973; Abban et al., 1973), was more ently suggested as an effective means to improve pork tenderness (Møller and Vestergaard, 1986; Møller et al., 1987), ssibly in combination with electrical stimulation (Dransfield et al., 1991). By suspending carcasses from the hip some of the mmercially more important muscles are stretched, thus preventing these muscles from excessive shortening when the rigor nts sets in. Provided the degree of muscle stretch is sufficient this may be expected to be accompanied by more tender ef. As, theoretically, stretching of muscle may also facilitate myosin extractability, processing properties could also be affected pelvic suspension.

The purpose of the present study was to determine the degree to which stretching by pelvic suspension and by hanging ights from the limbs would increase the tenderness of various commercially important muscles. In addition, a pilot-experiment as conducted to see if stretched muscle might improve the processing properties of muscles suitable for cooked ham oduction.

terials and Methods

e first experiment involved a total of 15 Large White/Landrace crossbred pig carcasses, selected at the end of the aughterline (ca. 40 min post mortem) on the basis of their loin pH being >6.0. At ca 45 min. post mortem one carcass side as suspended from the hip-bone while in hip-suspended sides 20 and 10 kg bars were hung from fore- and hind-limb, spectively. Initially, all carcass sides were chilled rapidly (0.5 h at -30°C at air velocities of 5 m/s). Subsequently, they were ored overnight (ca 14 h) at 2 $\pm$ 2°C, whereafter the weights were removed from the limbs. At 20 h post mortem the carcasses ere deboned. Mm. triceps brachii, longissimus lumborum and semimembranosus were reserved for physical-chemical easurements. M. semitendinosus was used in a paired comparison test by a 20 member experienced taste-panel.

After sampling for physical-chemical measurements on day 1 muscles were vacuum packaged and stored at 2 $\pm$ 2°C. At

day 6 muscles were sampled again. The following measurements were done: a) pH and temperature measurements (as day 1), b) Minolta L^*, a^* and b^*-values of longissimus and semimembranosus muscles at day 1, c) drip loss % during vacuum storage (all muscles), d) cooking loss % after heating to a core temperature of 70°C in a waterbath of 75°C (all muscles), e) sarcomere lengths at day 1 (all muscles), f) Warner-Bratzler shear force values (at day 1 and 6; all muscles), and finally g) panel preference testing with an experienced taste panel (M. semitendinosus).

In a second experiment (24 carcasses) the same procedure was followed, with the exception that no weights were hung from the forelimb and only effects on Mm. semimembranosus and semitendinosus were measured. Twelve carcasses were used for monitoring the effects on fresh meat on days 1 and 6, the remaining 12 carcasses were reserved for assessing effects on processing properties of cooked hams. To this end semimembranosus and semitendinosus muscles were deboned at 2 h post mortem, injected with 20% brine. Before massaging drained brine was added to a small tumbler (Belam DK 81, Uden, Netherlands), which was filled to ca. 50% of its capacity. Tumbling period was 20 h [10 min working time (5 min rotation to the left, 5 min rotation to the right), 50 min pause]. To enable identification of individual muscles these were labelled and placed in elastic cooking nets. Brine uptake, cooking loss and yield were assessed by re-weighing.

Data were analysed statistically with the Student t-test (paired where appropriate). Significance of difference in taste panel paired comparisons was assessed using the tables of Kahan et al. (1973).

Results and Discussion

At the end of the slaughter line (T1), after 1.5 h initial rapid chilling (T2) and at 20 h post mortem (T3) the following average core-temperatures were measured in Mm. triceps brachii, longissimus and semimembranosus, respectively: 40.0, 38.7 and 40.1°C (T1), 28.1, 18.1 and 28.6°C (T2) and 1.9, 1.3 and 3.1°C (T3). At T1, pH values ranged from 6.2 to 6.7. Due to a defective pH probe no measurements were done after this time.

Table 1 includes the combined effects of pelvic suspension and limb-weighting on major sensory meat quality characteristics

Table 1 The effects of pelvic suspension and limb-weighting on physical-chemical and sensory properties of porcine M. triceps brachii (TB), longissimus lumborum (LL), semimembranosus (SM) and semitendinosus (ST); (Exp. 1; $n = 12$)

Property	Pelvic suspension				Control				P-levels of significance		
	TB	LL	SM	ST	TB	LL	SM	ST	TB	LL	SM
Sarcomere length (μm)	2.4	2.2[a]	2.4[a@]	-	2.2	1.7[b]	1.8[b]	-	NS	$p<.001$	$p<.001$
Minolta colour score											NS
L^*value	-	53.1	46.9	-	-	53.6	48.0	-	-	NS	NS
a^*value	-	13.6	15.8	-	-	13.8	15.2	-	-	NS	NS
b^*value	-	6.3	5.5	-	-	6.0	5.4	-	-	NS	$p<.05$
Drip loss % (Day6-Day1)	1.3	1.5[a]	2.0[a]	-	1.2	2.7[b]	3.0[b]	-	NS	$p<.025$	NS
Cooking loss % Day 1	18.4	14.6[a]	17.6	-	16.6	17.7[b]	16.8	-	NS	$p<.05$	NS
Day 6	18.4	18.7	21.9	-	19.2	19.1	21.7	-	NS	NS	
Shear force (kg/cm^2)											
Day 1	4.6	3.8[a]	4.1[a]	-	4.8	4.7[b]	5.4[b]	-	NS	$p<.025$	$p<.001$
Day 6	3.9	3.5[a]	3.6[a]	-	3.8	4.0[b]	4.2[b]	-	NS	$p<.025$	$p<.01$
Panel preference (Day 6)	-	-	-	66.7[a]	-	-	-	0[b]	-	-	26.7% $p<.01$ 40.0% $p<.05$

@ = Figures with different superscripts differ significantly
- = Not determined

e four muscles investigated in the first experiment.

s a result of pelvic suspension and limb-weighting the longissimus and semimembranosus muscles were markedly ched, viz. (on the basis of a 2.0-2.2 μm rest length) approximately 9-10% and 18-20%, respectively; counterpart control cles shortened 14-15% and 9-10% during rigor. Despite the 20 kg weights, treated triceps muscles were similar in length e controls. Probably the anatomical configuration of this muscle prevents effective stretching by the described method. our of the longissimus and semimembranosus muscles were not affected by the treatment.

rip losses were reduced by more than 1 % in longissimus and semimembranosus muscles. Again, drip losses in the M. ps brachii were unaffected by the treatment. At day 1 cooking losses of stretched longissimus samples were significantly er than controls. In semimebranosus and triceps brachii muscles this was not observed. At day 6 cooking losses were er in all muscles.

With the exception of the triceps brachii muscles, pelvic suspension and limb-weighting resulted in a very significant reduction hear force at day 1. Although after one week of ageing these differences had become slightly smaller, they remained very ificant. The relevance of these tenderness improvements for the consumer is nicely illustrated by the panel preference data. out of 15 paired comparisons (66.7%) indicated a strong preference for stretched muscle. In the remaining 5 comparisons panel scores were similar.

In the second experiment average pH values of the semimembranosus muscle were 6.5, 6.3 and 5.8 at T1, T2 and T3, pectively. One of the carcasses destined for cooked ham production exhibited a pH <5.9 and was excluded from further ing. In Table 2 the effects of pelvic suspension and limb-weighting on physical-chemical properties of semimembranosus sensory properties of semitendinosus are presented.

e results indicate that marked stretching had been achieved. The effects of the treatment were even more marked: at 27 to stretch, drip losses were 67%, cooking losses around 85% (days 1 and 6) and shear forces 63 (day 1) and 80% (day 6) e values found for controls. Taste panelist almost unanimously considered stretched muscle markedly more tender.

ble 2. The effects of pelvic suspension and limb-weighting on the physical-chemical and sensory properties of porcine M. semimembranosus (SM) and semitendinosus (ST) muscle (Experiment 2; n=12)

perty	Pelvic suspension		Control		P-level of significance
	SM	ST	SM	ST	SM/ST
rcomere length (μm)	2.6[a@]	-	1.8[b]	-	p<.01
p loss % (Day 6 - Day 1)	3.9[a]	-	5.8[b]	-	p<.01
ooking loss % Day1	17.6[a]	-	21.0[b]	-	p<.01
Day 6	19.7[a]	-	23.2[b]	-	p<.01
ear force (kg/cm^2) Day 1	3.7[a]	-	5.9[b]	-	p<.01
Day 6	3.6[a]	-	4.5[b]	-	p<.01
nel preference (%)	-	83.3[a]	-	0[b]	41.6% p<.01
					41.7% p<.05

ures with different superscript differ significantly
not determined

Table 3 is an account of the processing properties of stretched vs. control semimembranosus/semitendinosus muscle. While al raw muscle weights were similar, stretched muscles took up 2.4% more brine, lost approximately 2% less weight during oking, which resulted in 3.2% more yield. In overviewing these results (particularly the relatively low final yields), one must ose that the 'netting' procedure, necessary to study the behaviour of individual muscles, has undoubtedly hampered ssaging during tumbling. Clearly, the bruising effect and hence myosin extraction on the exposed surface was probably much re pronounced than was the case for surfaces 'shielded off' by the netting procedure.

Differences in chemical composition between treated and and control muscles were negligible. Sarcomere lengths, assessed samples from the cured and cooked product) were significantly different. The effects on shear force were marginal.

Table 3 The effects of pelvic suspension and limb-weighting on the processing properties and chemical composition of pork M. semimembranosus muscle (Experiment 2; n=12)

Properties	Pelvic suspension	Control	P-level of significance
Raw muscle weight (kg)	3.57	3.48	NS
Brine uptake (% of initial weight)	13.57[a@]	11.84[b]	$p<.025$
Cooking loss (% of cured weight)	11.93[a]	13.96[b]	$p<.025$
Cooking yield (cooked- : raw weight)	99.5[a]	96.3[b]	$p<.005$
pH	6.18	6.15	NS
Moisture %	69.16	68.84	NS
Protein %	19.22	19.60	NS
Fat %	9.05	8.68	NS
Salt %	1.48	1.44	NS
Moisture : Protein ratio	3.61	3.52	NS
Sarcomere length (μm)	2.06[a]	1.54[b]	$p<.001$
Shear force (kg/cm^2)	1.52	1.67	$p<.10$

@ = Figures with different superscript differ significantly

Conclusions

Pelvic suspension, possibly enhanced by limb-weighting, affects pork quality significantly. Not only are tenderness and water holding of fresh meat substantially improved, the enhanced processing properties make this technique most promising for meat products manufacture. For these reasons the meat industry seems well-advised to seriously consider adopting this procedure.

Acknowledgement

Mr. Seán Metrusty's cooperation was made possible by a COMETT B_a student exchange grant, issued through the kind mediation of CONTACT LET Manchester, England

References

Abban, A.R., Stouffer, J.R. and Westervelt, R.G., 1975. Pre-rigor mechanical tensioning of lamb carcasses to improve tenderness. J. Food Sci. 40: 1

Bouton, P.E. and Harris P.V., 1972. The effect of some post-slaughter treatments on mechanical properties of bovine and ovine muscles. J.Food Sci. 37: 539

Bouton, P.E., Harris, P.V., Shorthose, W.R and Baxter, R.I., 1973. A comparison of the effects of aging, conditioning and skeletal restraint on the tenderness of mutton. J. Food Sci. 38: 932

Dransfield. E., Ledwith, M.J. and Taylor, A.A., 1991. Effect of electrical stimulation, hip suspension and ageing on quality of chilled pig meat. Meat Sci. 29: 129

Herring, H.K., Cassens, R.G. and Briskey, E.J., 1965. Further studies on bovine muscle tenderness as influenced by carcass position, sarcomere length and fiber diameter. J. Food Sci. 30: 1049

Hostetler, R.L., Landmann, W.A., Link, B.A. and Fitzhugh, H.A., 1970. Influence of carcass position during rigor mortis on tenderness of beef muscles: comparison of two methods. J. Anim. Sci. 31: 47

Kahan, G., Cooper, D., Papavasiliou, A. and Kramer, A., 1971. Expanded tables for determining significance for ranked data. Food Technol., May, 65

Laack, H.L.J.M. van, and Smulders, F.J.M., 1989. The effect of electrical stimulation, time of boning and high temperature conditioning on sensory quality traits of porcine longissimus muscle. Meat Sci. 25: 113

Møller, A.J. and Vestergaard, T. 1986. Effects of altered carcass suspension during rigor mortis on tenderness of pork loin. Meat Sci. 18: 77

Møller, A.J., Kirkegaard, E. and Vestergaard, T. 1987. Tenderness of pork muscles as influenced by chilling rate and altered carcass suspension. Meat Sci. 21: 275

Taylor, A.A., 1990. Developments in fresh meat technology. Proc. 36th Int. Congr. Meat Sci. and Technol., Havana, Cuba, p. 346

Weniger, J.H., Steinhauf, D. and Muftic, A., 1968. Postmortale Veränderungen von Merkmalen der Beschaffenheit unter dem Einfluss von Muskelstrecku und Lagerdauer. Fleischwirtsch. 48, 8: 1058