On the validity of several tests for assessing waterholding capacity of fresh pork after refrigerated storage.

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INTRODUCTION: The waterholding capacity of meat is an important quality attribute. For the consumer it is important because it affects the appearance before cooking, its behaviour during cooking and its juiciness at the moment of consumption. For the meat industry water-holding capacity is important because it affects, in the form of drip losses, the final weight of the product.

A general hypothesis for the loss of water from meat is that it originates from volume changes of the myofibril (Offer and Knight, 1989). Shrinkage of myofibrils from volume changes of the myofibril (Offer and Knight, 1989). Shrinkage of myofibrils leads to a greater proportion of the so-called free water which is potentially lost from the meat.

The rate of post mortem pH fall is an important determinant of waterholding capacity. A fast pH decline, induced by various conditions such as stress, electrical stimulation, and high early post mortem muscle temperature (as effected by slow cooling rate), promotes denaturation of sarcoplasmic proteins. Furthermore, a fast pH decline will increase the tendency of actomyosin to contract as it forms (Bendall, 1960) expressing fluid to extracellular spaces (Penny, 1977). If the temperature in the muscle is reduced quickly during post mortem glycolysis, sarcomere shortening and loss of WHC may ensue (Honikel et al., 1986).

Different methods are available to estimate/predict the WHC of meat (Kauffman et al., 1986; Honikel, 1987). The most relevant to the fresh meat industry is the measurement of drip loss during storage. However, for prediction of WHC and for scientific purposes this method has important limitations: it does not give information on the mechanism responsible for the observed drip loss, and drip loss is influenced by conditions such as how the meat is packaged, by the size and shape of the meat and by the method of stacking and handling (Offer and Knight, 1989). To elucidate the mechanisms responsible for effects of any treatment on the WHC of meat, additional tests are necessary.

The present study is concerned with the effect of refrigerated storage on the WHC of semi-hot boned, cold boned and PSE porcine longissimus muscle. Several tests for WHC were performed and their value for predicting WHC was evaluated.

MATERIALS and METHODS: Based on pH 45 min post mortem (pH_{45}) between the 3rd and 4th lumbar vertebra, 18 "normal" pig carcasses ($pH_{45}>6.2$) and 20 possible PSE pig carcasses ($pH_{45}<6.0$) were selected. All these carcasses were conveyed through a blast-chilling tunnel at -25°C for 45 min. After an equilibration period of 3 h at 2±2°C, the longissimus muscle of one side of each of the "normal" carcasses was semi-hot boned (SHB). The remaining sides from the "normal" carcasses and the 20 possible PSE carcasses were chilled overnight at 2±2°C. Based on the visual assessment and fibre optic probe (FOP) value (>50) at 1 day post mortem, 12 of the 20 carcasses with $pH_{45}<6.0$ were identified as being PSE. The loins from these and from the chilled sides of the normal carcasses were cold boned (CB). After deboning, all loins were weighed, vacuum packaged and stored at 1±1°C. At 1, 7 and 13 days post mortem 6 loins of each group (SHB, PSE and CB) were unpacked and WHC was assessed.

The muscle pH was measured with a portable pH meter, type CG818 (Schott Geräte, GmbH D6238, Hofheim, FR Germany) equipped with a combined (glass, reference) electrode type N 48 A (Schott Geräte, GmbH D6238, Hofheim, FR Germany).

The FOP-value, indicating light scatter of the muscle (MacDougall and Jones, 1975) was assessed with the Fibre Optic Meat Probe (TBL Fibre Optics Group Ltd, Torbay Works, Leeds LS10 IAT, England).

Drip losses were assessed by weighing samples before and after storage, whereafter the following tests of WHC were performed:

1. "Honikel's-method": a sample of 100-125 g was cut from the loin. This sample was hung from a hook and enclosed in a plastic bag filled with air. There was no contact between meat and bag and no evaporation occurred. After 2 days of storage at 1±1°C the weight loss was assessed (Honikel, 1987).
2. Swelling test as described by Hart (1962): cubes of 1 cm^2 and 0.5 cm thick (0.7-1.0 g) were cut, weighed and soaked in 20 ml of a 0.2M Na_2HPO_4/0.1M citrate buffer of pH 3.2, 4.2, 4.6 and 5.8. After 24 h at 20°C the cubes were taken out, blotted dry and weighed. The % of swelling was calculated as % increase/decrease of the initial weight.
3. Kauffman's filterpaper method (Kauffman et al., 1986).
4. F.O.P. value (vide infra)
5. Transmission value: according to the procedure described by Hart (1962)

Statistical significance of differences between groups was tested with the Student t-test ($p<0.05$).

RESULTS: Results on pH and temperature measurements at 45 min post mortem and before boning are presented in Table 1. At both 45 min and 24 h post mortem, the pH of the "normal" carcasses was significantly higher than that of the "PSE" carcasses. At 24 h post mortem the difference was small, however. At the time of boning the pH and temperature of the SHB loins was lower than 6.0, indicating that rigor-onset had started.

Table 1 pH and temperature (T) of "normal" [semi-hot boned (SHB) or cold boned (CB)] and PSE pig carcasses at 45 min post mortem, and before boning (≈4 h post mortem or ±24 h post mortem) (n=20)

	normal					
	SHB		CB		PSE	
	pH	T	pH	T	pH	T
45 min post mortem	6.44	40.0	6.44	40.0	5.72	41.4
Before boning	5.90	15.2	5.55	2.5	5.42	2.5

SHB = semi-hot boned; CB = cold boned.

Table 2 includes the results on different indicators of WHC and protein denaturation. Semi-hot and cold boned meat did not differ with regard to any of these characteristics. PSE meat yielded significantly higher drip losses, FOP values, transmission values and weights of absorbed fluid in the filterpaper method. PSE and normal meat gave similar values in Honikel's method. Refrigerated storage seemed to affect the values of drip losses, Honikel's method and the filterpaper method. With longer storage, drip losses increased, and the values obtained with Honikel's method and filterpaper method decreased. After storage the measurements on PSE and normal meat, obtained with the filterpaper method, were similar.

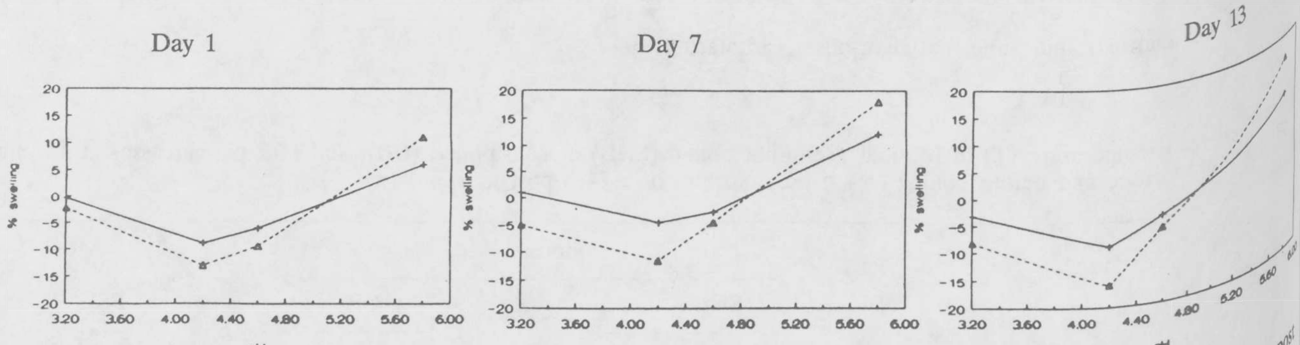
Table 2 Water-holding capacity and degree of protein denaturation of normal [semi-hot (SHB), cold boned (CB)], and PSE pork after refrigerated storage at 0-2°C (n=6 for each group)

	Days post mortem								
	1			7			13		
	normal			normal			normal		
Parameters	SHB	CB	PSE	SHB	CB	PSE	SHB	CB	PSE
Drip losses (%)	0.54	0.35	0.66	1.15[a*]	1.27[a]	3.79[b]	1.25[a]	1.77[a]	4.03[b]
Kauffman's filterpaper method (mg)	49[a]	54[a]	111[b]	29	27	30	68	61	60
Honikel's method (%)	5.2	5.8	6.6	4.5	4.0	3.4	2.8	1.6	1.8
FOP-value	38[a]	39[a]	68[b]	51[a]	49[a]	73[b]	42[a]	43[a]	94[b]
Transmission value (%)	29[a]	33[a]	67[b]	25[a]	23[a]	48[b]	44[a]	45[a]	75[b]

* In rows, within sampling day, figures with different superscripts differ significantly (Student t-test, $p<0.05$).

In Fig. 1 the % of swelling at different pH's, for normal and PSE meat, are presented. Compared to PSE meat, the swelling % of normal normal meat was lower at pH 3.2, 4.0 and 4.6, and higher at pH 5.8. These differences were not affected by storage period. There was a large variation in swelling %, and differences were not significant.

Fig. 1 The % of swelling of normal (Δ) and PSE (+) pork at pH 3.2, 4.2, 4.6 and 5.8 assessed as described by Hart (1962) (n=6) (day 1, 7, 13)



DISCUSSION: In semi-hot boning, carcasses are blast-chilled before boning. At the time of boning, i.e. about 4 h post mortem, the muscle pH is already low. Therefore, differences in temperature and pH-decline of semi-hot boned and cold boned pork and hence differences in WHC, may be expected to be small. Indeed, values for all parameters of WHC and protein denaturation were similar for the semi-hot and cold boned loins.

PSE meat is characterized by a fast pH-decline at a relative high temperature. Ultimate pH is generally not affected. In the present experiment ultimate pH of PSE meat was significantly lower than that of the normal meat, however. This may have been affected by the selection procedure. The high drip losses, fluid absorbance with filterpaper, and FOP- and transmission values also indicate that we selected relatively extreme cases of PSE. Surprisingly, with Honikel's method it was impossible to identify PSE and normal meat. At present we do not have a conclusive explanation for this unexpected observation. However, the fact that the meat had been vacuum packaged may have been an interfering factor.

The drip losses in Honikel's method are affected by storage period. When meat is stored before sampling, drip losses as assessed by this method are lower. Measurement of drip of retail cuts derived from stored meat is thus an unreliable indicator for PSE quality; one of the few remaining criteria for the consumer is colour evaluation.

As suggested by Kauffman et al. (1986), the filter paper method was only valid when used at 1 day post mortem.

Hart (1962) investigated the swelling op PSE vs. normal pork when soaked in buffers of pH's ranging from 3.0 to 6.0. We assessed swelling only at the pH values at which, according to Hart (1962), differences were to be expected. At all three sampling moments, swelling behaviour was similar; at low pH higher swelling % for PSE meat and at high pH higher swelling % for normal meat.

Irrespective of the storage period transmission- and FOP values were higher in PSE than in normal meat. These results substantiate that these parameters can be used as valuable predictors for WHC. The assessments of swelling and transmission values are time consuming and thus not attractive for quality control purposes. Measurement of FOP value is a relatively easy and straightforward procedure and it would appear that FOP values are useful for predicting WHC. One should realize, however, that selection of the carcasses used in this experiment was based on pH and FOP value. Firstly, based on visual evaluation, only 8 of the 20 carcasses with high FOP value were classified as non-PSE. Secondly, carcasses with a low pH and FOP, or high pH and FOP, were not included. Before advocating the FOP measurement one should investigate the WHC of the latter two groups.

CONCLUSIONS: Semi-hot and cold boned meat had a similar WHC.

Honikel's method does not seem a valid method to identify PSE meat after it has been vacuum packaged.

The FOP value is, irrespective of storage period, higher in PSE meat than in normal meat. Before accepting the FOP value as valid indicator of WHC, the WHC of meat with low FOP and pH and meat with high FOP and pH has to be investigated. It is conceivable that the FOP value in combination with visual evaluation will be useful.

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