THE RATE OF pH DECLINE AFTER SLAUGHTER IN PIGS OF DIFFERENT AGES. COMPARISON OF TWO METHODS USED FOR MEASURING pH IN MUSCLE.

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INTRODUCTION

The pH-value and other biochemical parameters during the post mortem reaction sequence have been intensively studied in many animal species.

Especially in pigs the rate of pH decline is of great interest because it is a good and the most easily measured indicator of meat quality.

The rate of pH decline can be caused by several factors. I.e. by genetic differences between races, handling of the pigs before slaughter and biochemical differences between muscles.

However, the effect of age on the rate of pH decline has not been studied very much. In this study it was also possible to measure the pH value in an early stage after death, immediately after the exsanguination was over, some 3-4 minutes after sticking.

This study was a part of a larger study concerning the effects of various feeds on the growth of pigs and on the chemical composition of the carcass. The study is to be continued this year.

Fiber type analysis were carried out on the same muscle samples as the pH measurements. The results will be published later.

MATERIALS AND METHODS

In this study pH-measurements were made from 39 Yorkshire-Finnish landrace crossbreed-pigs. The pigs were slaughtered when they reached a predetermined weight.

20 kg 10 pigs
50 kg 10 pigs
80 kg 9 pigs
110 kg 10 pigs

Animals were stunned electrically and exsanguinated in the normal manner.

Measurements were made from two muscles: Musculus longissimus dorsi (LD) and Musculus triceps brachii (TB) at six given times after stunning. Some of the measurements were carried out using two methods for measuring muscle pH.

1) using a spear-tip penentrating electrode (Ross combination electrode, spear-tip, 8163SC, attached to a Knick, Portames 651 pH-meter) (probe electrode technique)

2) removing a small sample (1-2g) from the muscle and homogenizing it immediately in Natriumiodoacetate-Potassiumchloride solution (5mM NaIAcet and 150 mM KCl, 25ml of solution/2g of sample) (Bendall, 1975).
The pH value of the solution was measured within 10 sec at room temperature.

Table 1. presents the measurements made. Measurements using method 1 (spear-tip electrode) were carried out from all animals. In weightgroup 20 kg measurements using method 2 (NaIAcet-solution) were carried out only from four animals.

Table 1. Measurements made

measuring time	LD		TB	
	probe	NaIAcet	probe	NaIAcet
pH0	x	x		
pHkj	x	x	x	x
pH1	x	x	x	x
pH2	x	x	x	x
pH4	x		x	
pH24	x		x	

pH0 : immediately after bleeding, 3-4 minutes after sticking
pHkj: after skalding, 13-19 minutes after sticking
pH1 : one hour after sticking
pH2 : two hours after sticking
pH4 : four hours after sticking
pH24: next morning

The carcasses were moved to a chillingroom immediately after evisceration and sampling about one hour after stunning.

The pH-values of blood and liver were measured for each animal. The pH-value of blood was measured immediately after sticking. The pH-value of liver was measured immediately after evisceration using probe electrode technique.
The L-lactic acid content of blood and the glycogen content of liver were assayed using a Boehring-Mannheim reagent kit based on the entsymatic method.

RESULTS

Tables 2 and 3 show the means and standard deviations of pH-values in different weight-groups. As can be seen from table 2. the means of pH-values obtained using the two different measuring methods differ very little and there was no systematic difference between the methods.

The correlation between the values measured using the two techniques was r=0.840 (230 measurements).

The regression equation is
pHprobe = 0.431 + 0.926pHIacet (R-sq=70.6%)
which gives a difference of 0.05 units at pH 6.5 and 0.013 at pH 6.0 the NaIAcet/KCl method giving higher values.

As can bee seen in Figures 1. and 2. the rate of pH decline was similar in all weightgroups.

pH0 - pHkj (LD)	0.01	units/min
pHkj - pH1 (LD and TB)	0.005	units/min
	0.30	units/h
pH1 - pH2 (LD and TB)	0.004	units/min
	0.24	units/h

As seen in Fig.1 during the first two hours post mortem the pH-values of LD were lower in small animals (20kg, 50kg) than in big ones.

There is, however, no significant difference ($p<0.05$) between the groups, because the ranges of the values were large.

The pH-values of TB (Fig. 2) did not show any marked difference between weightgroups.

pH24 values of LD were significantly higher ($p<0.05$) in weightgroup 20kg than in other groups.

pH24-values of TB had no significant differen-ce, although the pH-value of the 20kg-group was the highest.

Figure 3a-d presents the pH values of LD and TB of different weightgroups versus time. In weightgroups 20kg and 50kg the pH-values of TB were higher (0.1-0.2 units) than those of LD during the whole measuring period (0-24hours). In weightgroup 110kg the pH value of LD was slightly higher (0.05units) than that of TB during the first two hours.

Table 4. presents the means and standard deviations of the pH-values of blood, the L-lactic acid content of blood and the glycogen content of liver in different weightgroups. There was no significant difference between weightgroups in blood pH though the smaller animals tended to have lower blood pH values. The blood L-lactic acid content in groups 20kg and 50kg was significantly higher ($p<0.05$) than in groups 80kg and 110kg.

The glycogen content of liver was significantly higher ($p<0.05$) in weightgroup 20kg than in other groups.

The correlations between blood pH and blood lactic acid content and measurements connected to them were poor.
For example:

blood pH - blood, L-lactic acid	r= -0.387
blood pH - pH0,LD, (probe)	r= 0.471
blood lactic acid - pH0,LD,(probe)	r= 0.54

CONCLUSIONS

The NaIacet-method is expected to give higher pH values than the probe electrode method. Greaser (1986) and Dutson (1983) have summed up the reasons as follows: The alteration of pK values of muscle buffers caused by temperature shift and the lowering of ionic strenght. The effect caused by the change in ionic strenght is compensated by the use of KCl. Homogenisation of the muscle causes the release of CO_2 and as a result the pH rises. These factors results in an alkalinization of 0.2 units at pH 7 and 0.1 units at pH 6.
In the present study this difference was not seen, but both methods gave equivalent results. This is in agreement with the results achieved by Solomon (1987).

Although the means of pH values do not differ from each other there were quite a few cases where the methods gave differing values. One reason was the difficulty in getting stable values using probe electrode technique. After inserting the electrode in the muscle it could take up to one minute before a stable value was obtained. The reading kept decreasing rapidly. This happened at the early stages of the post mortem-reaction sequence (pH0 and pHkj-measurements) but not with all animals.

It is usually assumed that glycolysis is faster and thus also the rate of pH decline greater in white muscles than in dark ones.

The initial pH value of LD (a white muscle) was markedly lower in the two lighter weight-groups (20 kg and 50 kg) than in the heavier ones (Figure 1.) This is not in very good accordance with the change in the fiber type distribution with age. The proportion of white fibers increases with age. In M. longissimus dorsi this change in fiber type distribution can be noticed up to the weight of 50 kg (Ruusunen, 1989).

The rate of pH decline was similar in all weightgroups and in both muscles. A similar result has been achieved by Beecher et al. (1965) who studied porcine semitendinosus and found out that the rate of glycogen depletion as well as pH decline was the same both in the white and dark parts of the muscle.

The initial pH values of both LD and TB were low (Table 2. see weightgroup 110kg, pH0). Similar results have also, however, been obtained by other researchers. Table 5. lists in addition to the results of the present study also some other studies where initial pH values for pig LD muscle have been measured. Considerably low pH values have been measured also in living muscle during exercise (Gadian, 1983).

During the interval 3-17 min after sticking the rate of pH decline in LD was 0.01 pH units/min. Considering this and the low initial pH it seems likely that the pH of the muscle at the time of sticking must have been lower than 7. One must, however, take into consideration that during exsanguination glycolysis and thus also the rate of pH decline may be faster than during the interval 3-17 min.

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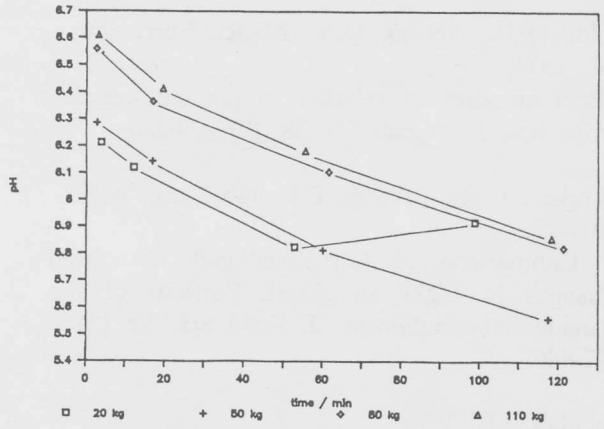


Figure 1. pH values of LD of different weight-groups versus time (measured using probe electrode technique).

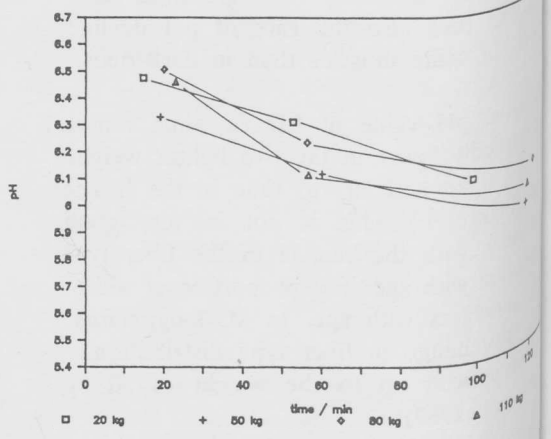
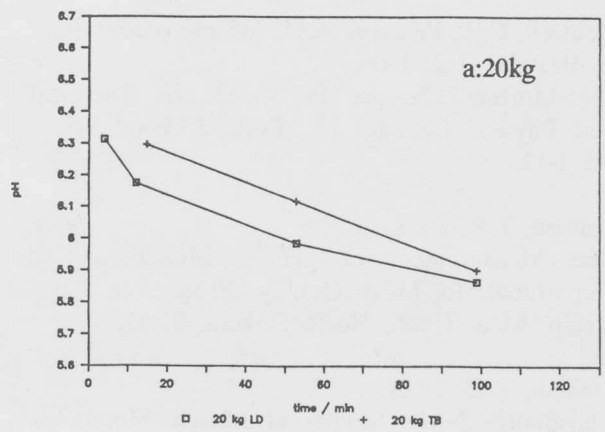
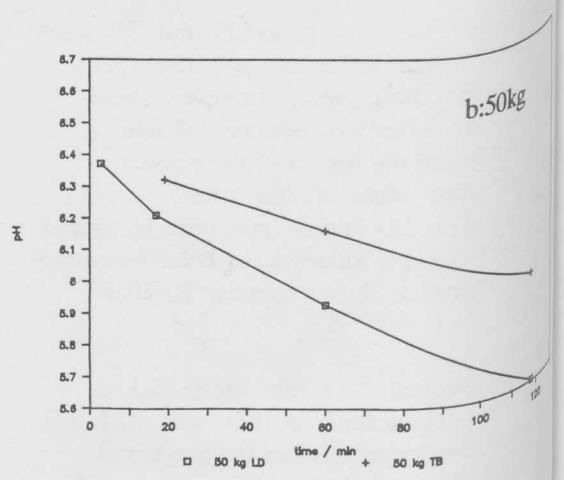
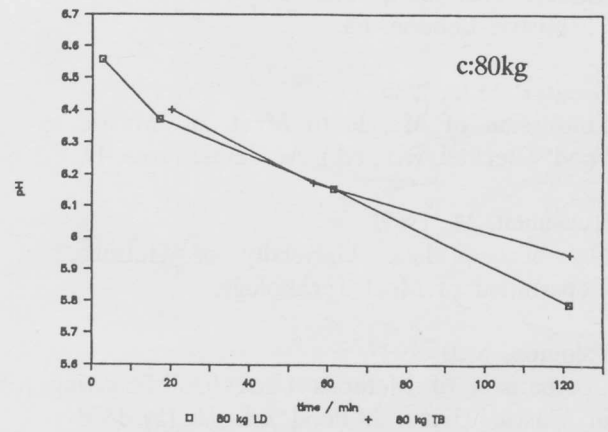


Figure 2. pH values of TB of different weight-groups versus time (measured using probe electrode technique).







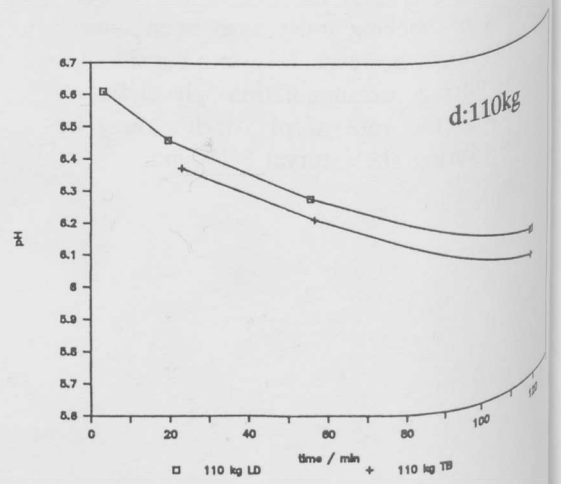


Figure 3a-d. pH values of LD and TB of different weightgroups versus time (measured using NaIAcet-technique).
a: 20kg b: 50kg c: 80kg d: 110kg

Table 2. Means and standard deviations of pH-values (pHO, pHkj, pH1 and pH2) of different weightgroups (measured using Iodoacetate and Probe Electrode Techniques)

		probe		Iacet		corr	
LD	weight-group	mean	stdev	mean	stdev		samples
pH 0	20	6.21	0.288	6.31	-	-	10 (4)
	50	6.28	0.325	6.37	0.199	0.863	10
	80	6.55	0.155	6.55	0.182	0.863	9
	110	6.61	0.186	6.61	0.189	0.868	10
	all	6.48	0.296	6.51	0.212	0.874	
pHkj	20	6.12	0.164	6.17	-	-	10 (4)
	50	6.14	0.239	6.21	0.230	0.788	10
	80	6.36	0.254	6.37	0.206	0.568	9
	110	6.41	0.206	6.46	0.218	0.922	10
	all	6.28	0.251	6.34	0.237	0.803	
pH1	20	5.84	0.145	5.98	-	-	10 (4)
	50	5.81	0.340	5.93	0.410	0.870	10
	80	6.10	0.297	6.15	0.272	0.832	9
	110	6.18	0.317	6.27	0.320	0.857	10
	all	5.98	0.318	6.12	0.361	0.877	
pH2	20	5.91	0.218	5.86	-	-	10 (4)
	50	5.56	0.278	5.60	0.278	0.898	10
	80	5.82	0.402	5.79	0.314	0.936	9
	110	5.86	0.420	6.06	0.393	0.931	10
	all	5.78	0.354	5.82	0.390	0.894	
TB							
pHkj	20	6.47	0.302	6.30	-	-	10 (4)
	50	6.33	0.270	6.32	0.161	0.794	10
	80	6.51	0.148	6.40	0.096	0.633	9
	110	6.46	0.208	6.37	0.178	0.072	10
	all	6.43	0.222	6.36	0.149	0.514	
pH1	20	6.31	0.340	6.12	-	-	10 (4)
	50	6.11	0.204	6.16	0.161	0.820	10
	80	6.23	0.193	6.17	0.133	0.314	9
	110	6.11	0.251	6.21	0.255	0.555	10
	all	6.19	0.260	6.18	0.187	0.541	
pH2	20	6.08	0.317	5.90	-	-	10 (4)
	50	5.92	0.270	5.94	0.206	0.839	10
	80	6.06	0.282	5.94	0.207	0.528	9
	110	5.99	0.241	5.98	0.273	0.370	10
	all	6.01	0.275	5.95	0.224	0.541	

Table 3. Means and standard deviations of pH values (pH4 and pH24) of different weightgroups (measured using probe electrode technique)

	weight-group	LD		TB	
		mean	stdev	mean	stdev
pH4	20	5.87	0.21	5.96	0.26
	50	5.46	0.24	5.66	0.17
	80	5.64	0.33	5.78	0.19
	110	5.59	0.34	5.76	0.16
	all	5.64	0.31	5.79	0.22
pH24	20	5.68	0.05	5.83	0.15
	50	5.45	0.14	5.70	0.08
	80	5.45	0.09	5.66	0.13
	110	5.48	0.07	5.67	0.11
	all	5.52	0.14	5.72	0.13

Table 4. Means and standard deviations of the pH-values of blood, the L-lactic acid content of blood and the glycogen content of liver.

weight-group	blood pH		blood L-lactic acid µmol/l		liver glycogen mg/g	
	mean	stdev	mean	stdev	mean	stdev
20	7.13	0.13	16.5	4.05	39.1	7.49
50	7.08	0.11	15.9	4.99	7.1	6.50
80	7.21	0.14	8.5	5.30	6.0	7.44
110	7.21	0.13	6.5	2.78	10.8	11.06

Table 5. pH0 and pH1 values of pig Longissimus dorsi muscle

	pH0 (min)	'pH1' (min)	storage temp °C	rate of pH decline unit/h[a)]
LD				
York x Finnish lr.				
probe	6.61 (4)	6.18 (56)		0.5
Iacet	6.61 (4)	6.27 (56)		0.4
Addis et al.(1974)				
LD				
probe				
Poland China	6.22 (5)	5.81 (30)		1.0[b)]
Hamp x York	6.63 (5)	6.27 (30)		0.9
Beecher et al.(1965)				
Semitendinosus (light part)				
probe				
Chester White Poland China	6.11	5.73 (60)	37	0.4
Bendall et al.(1979)				
LD				
Iacet/KCl				
Large White	6.86 (10)			
Bodwell et al.(1966)				
LD				
Iacet (without KCl)				
Poland China	6.2 (11.5)	5.5 (116)	37	0.3
Yorkshire	6.7 (-"-)	5.4 (170)	37	0.5

a) calculated from the pH values and times given in the references.

b) animals deliberately stressed before slaughter