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Some Data about the Relation between pH-, Temperature-, and Rigorvalues 40 minutes Post Mortem and the Meat Quality of Pigs.

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SOME DATA ABOUT THE RELATION BETWEEN pH-, TEMPERATURE- AND RIGORVALUES 40 MINUTES POST MORTEM AND THE MEAT QUALITY OF PIGS.

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1. Introduction.

The problem of the so-called pale and exudative meat of pigs has been studied in many countries. The combination of high temperature and low pH in the post mortem pig muscle seems to produce irreversible changes in the properties of the muscle proteins. These changes have an adverse influence on the quality of fresh meat and meat products.

Less attention has been paid to the problem of the wearied pigs, which produce dark meat with a high ultimate pH value. However, our previous investigations (VAN LOGTESTIJN 1965) have shown that, whilst up to 20 % of about 2 000 investigated Dutch pigs (mainly Dutch Landrace) showed more or less severe symptoms of meat degeneration (="Pale, Soft and Exudative Muscle", "Watery Pork" etc.) in one or more muscles, up to 6 % of the pigs were slaughtered in such a condition, that ultimate pH values higher than 6.4 could be measured.

More recent investigations have shown that a severe stress on pigs leads very rapidly not only to the wellknown situation in which meat degeneration may develop, moreover in some cases to a variation of this situation, characterized by high body temperature and very rapid removal of muscle glycogen. Although it is known that long and wearing transports may cause this fatigue situation, we found manytimes high ultimate pH values in pigs transported within one or two hours over a short distance.

For the production of high quality pork meat it is important to decrease the variation in organoleptic properties, cooking- and roasting-losses, keepability and technological properties of meat, destined for direct consumption or meat products.

A reduction of the variation in the meat quality of pigs could be achieved by two ways:

a. by measures concerning the living animal (i.e. selection, adaptation

of the fodder regimen especially during the last two days before slaughtering, use of pharmaca, transport-methods and -planning, handling before slaughter);

b. selection of slaughtered pigs on the basis of meat quality in regard of their destination and an adequate handling.(cooling etc.)

At present it is impossible to deliver pigs for slaughtering in the desired conditions. Therefore it is important to have good methods for rapid and reliable selection of slaughtered pigs. Untill now it usually seemed impossible to make this selection in practice. The main reasons for this were apparently the lack of reliable and convictive arguments for the economic need of this selection, less reliable selection methods and the fear for stagnation in the processing line.

In our opinion it is useful to classify the slaughtered pigs in not more than three catogories:

type 1 - pigs with insufficient glycolysis, dark meat with a too high ultimate pH.

type 2 - pigs with a "normal" meat quality. It should be stated, that it is difficult at this moment to define this quality, because of the gradual transition in the frequency distribution of meat quality parameters in the pig population.

type 3 - pigs with meat degeneration.

In our opinion the best moment for a selection of the pigs is 30 - 45 minutes post mortem, at which time the carcasses are at or near the end of the slaughter line, because at that moment:

a. The selection would cause the least stagnation and could easily be fitted in the slaughter line. Furtheron it is usually then easier to direct the carcasses into the different lines through a factory, than it would be at a later moment.

b. four selection criteria could be used.

- the pH value;
- the rigor mortis, which can be measured by a very rapid and simple method;
- the meat temperature;

- the colour of the surface of some superfical muscles. Especially a pale colour of the M. semimembranaceus and the M. gluteus and in a less degree of the M. adductor may be an indication for the development of meat degeneration.

In a later stage most of these criteria are less or not at all usable. The variation in the pattern of the temperature, the rigor and the pH is greatest in the first post mortem period.

In another paper we have already given some data about relations between temperature-, pH- and rigor-values, measured in pigs 40 minutes post mortem.(SYBESMA and VAN LOOTESTIJN 1966)

In this paper we intend to give some data about the relations between these three parameters and meat quality in Dutch Landrace (D.L.) pigs. We hope to make clear that at that moment, i.e. 40 minutes post mortem, there is a possibility for a reliable selection of slaughtered pigs on the basis of some important properties of the meat.

2. Material and Methods.

The pH-, rigor- and temperature-values were measured in different groups of Dutch Landrace pigs, slaughtered under commercial conditions.

The readings were taken at different times post mortem.

After a 24 hours of cooling samples (a pork chop of the last lumbar vertebra = 100 - 150 gr. of meat) were taken from the loin, either from all pigs or from a number of selected pigs. These samples were taken to the laboratory, where the meat quality was assessed by visual judgement and measuring of pH-, transmission- and Fahellpho-value.

- pH measuring - At different times post mortem the pH was measured in one or more of the four following muscles: M. adductor, M. semimembranaceus, M. gluteus and M. longissimus dorsi,

by using a Philips portable pH meter (type PR 9401) and Electrofact spear electrodes. The instrument was verified against two buffers (pH 4.00 and 7.00) before each set of readings and was checked at intervals against buffer pH 7.00 during use.

- Rigor measuring - The rigor value of the different muscles was measured on the M. semimembranaceus with the rigor meter described by SYBESMA (1966).

Readings between 0 and 16 made it possible to distinguish easily and rather objective between different phases of rigor.

- Temperature measuring - The meat temperature was measured with the Ellab meter, described in the other paper.(SYBESMA and VAN LOGTESTIJN, 1966)
- Transmission value - The transmission value was measured according to the method, described by HART (1961).
- Fahellpho value - The Fahellpho value was determined with a Fahellpho meter described by LOHSE, PFAU and SCHRÖDER (1965).
- Visual judgment - The visual judgment of the lean meat was based on colour, softness and exudation. Scores from 1 - 4 were given.

Furtheron the pH-, rigor- and temperature-values, measured 40 minutes post mortem will be called: pH_{40}, R_{40}, and T_{40}. Any other time of measuring post mortem will be indicated in a corresponding way. Sometimes an abbreviation of the name of the muscle is added.

3. Choice of the muscle to be examined 40 minutes post mortem.

In most cases the pH_{40}, R_{40} and T_{40} can only be measured either in the M. adductor, in the M. semimembranaceus or in a tri-angular part of the M. gluteus, because at that time the carcasses are divided in two halfs only.

We found no differences in the temperature pattern of these muscles. The part of the M. gluteus is not suited for measurings as it is rather small, not easy to be reached and causing too much risk for damage to the electrodes.

Also the M. adductor is less suited as it is covered with a fascia in 50 % of the cases, can be reached less easily and the pH fall in that muscle is less rapid.

The M. semimembranaceus gives a better and more reliable indication of the type 1 and 3 pH pattern. This may be demonstrated with the following data, obtained from 309 pigs:

From 76 of these 309 pigs with $R_{40} \geq 8$ and $pH_{40\ add} \leq 6.0$ the pH_{40} semim. was on the average 0.18 lower than pH_{40} add.

From 50 pigs with $R_{40} \geq 8$ and pH_{40} add. ≥ 6.5 the pH_{40} semim. was on the average 0.12 lower than pH_{40} add.

From this considerations and data we concluded that for the measuring of pH_{40}, R_{40} and T_{40} values the M. semimembranaceus is the most obvious muscle.

4. The relation between pH value, rigor value and meat temperature 40 minutes post mortem and some factors of meat quality.

4.1 The pH_{40} value as a selection criterion.

Since we know that the development of meat degeneration is accompanied by a rapid onset of acid rigor at a relatively high temperature, it is clear that the pH value on a certain moment after the death of the animal will give reliable information about the chance that this meat defect will really occur.

During the last years many data about pH measurings have been published in different countries. For information about this point we may refer to the review articles of BENDALL and LAWRIE (1963), GOUTEFONGEA (1963), BRISKEY (1964) and to BENDALL, CUTHBERTSON and GATHERUM (1965), VAN LOGTESTIJN (1965), MC LOUGHLIN (1965), RAHELIC and REDE(1965) and TAYLOR (1965). Especially Danish workers have gathered many useful data about their pigs. Yet, there is no agreement about the question if the measuring of the pH_{40} or the pH_{120} alone can give a definite indication. In our opinion it is better to select not only on the pH value, but on a combined measurement of pH value and either rigor value or meat temperature.

Of course this combined measuring is necessary, when we want to select at this moment not only the type 3 pigs (meat degeneration) but also the type 1 (fatigued) pigs. As explained in the introduction we believe that in most cases the measuring at the end of the processing line must be preferred. However it should be stated that the pH_{40} in pigs is closely related with the pH value measured at a later stage.

At an investigation of about 200 D.L. pigs we found the following correlations:

pH_{40} x pH_{210} $r = 0.72^{**}$

pH_{40} x $pH_{24\ h}$ $r = 0.52^{**}$

pH_{210} x $pH_{24\ h}$ $r = 0.64^{**}$

pH_{360} x $pH_{24\ h}$ $r = 0.85^{**}$ $P < 0.05$

From these data it appears that the pH_{210} or pH_{360} values give a better indication of the $pH_{ult.}$ than the pH_{40} values. This is in agreement with SAYRE and BRISKEY (1963), BRISKEY and SAYRE (1964) and VETTERLEIN and KIDNEY (1965). The correlation between pH_{40} and $pH_{24\ h}$ is still rather high. This may be explained by the fact that rather a great part of these pigs belonged to the types 1 and 3. In both cases there is a (very) rapid pH fall, in the first case to a high $pH_{ult.}$ in the second case to a low $pH_{ult.}$. These data confirm that measuring of the pH_{40} value is a good but not sufficient method for the detection of type 3 pigs.

For a more reliable detection of type 3 pigs and for the detection of type 1 pigs we need another criterion to be combined with the pH_{40} value.

4.2 The R_{40} value as a selection criterion.

SYBESMA (1966) showed that a correlation exists between the R_{40} and the pH_{40} values in the M. semimembranaceus ($r = -0.40^{**}$, $P < 0.01$, $n = 93$) It is clear that this correlation coëfficient could be much higher, if it would be determined within groups of exclusively type 1 and 3 pigs, i.e. with alkaline and acid rigor. This is demonstrated in our other paper (SYBESMA and VAN LOGTESTIJN, 1966). 20 pH_{40} values < 6.0 were accompanied by $R \geq 10$ in 16 cases.

At a more recent investigation we found that 23 $pH_{40} \geq 6.50$ and $R \geq 10$ resulted 18 times in $pH_{ult.} \geq 6.4$ (the average $pH_{ult.}$ of the 23 cases was 6.47)

Results of other recent investigations are given in table 1 (page 7).

Table 1: Some data about the relation between pH-, temperature- and rigor-values 40 minutes post mortem and the meat quality of pigs.

	R_{40} semim.	≧ 10			> 5 ≤10	≦ 5
	pH_{40} class.	≧ 6.5	< 6.5 ≧ 6.0	< 6.0	≧ 6.0 < 6.5	≧ 6.0
	N.	6	12	14	9	6
M.semimembr.	pH_{40}	6.73	6.16	5.65	6.24	6.62
	$pH_{24\ h.}$	6.41	5.80	5.68	5.65	5.78
	pH_{40}-$pH_{24h.}$	+0.32	+0.36	-0.03	+0.59	+0.84
	T_{40}	40.8	41.1	41.8	40.5	40.4
M.gluteus	pH_{40}	6.56	6.19	5.68	6.19	6.39
	$pH_{24h.}$	6.33	5.86	5.68	5.81	5.85
	pH_{40}-$pH_{24h.}$	+0.23	+0.33	0.00	+0.38	+0.54
M.long.dorsi	$pH_{48h.}$	6.10	5.86	5.87	5.86	5.87
	Visual judgement	1.17	2.08	3.14	1.89	1.67
	Transm. value	13	39	77	32	19
	Fahellpho value	37	55	62	48	52

From these data it becomes clear that the combined measurement of pH_{40} + R_{40} gives a good indication of meat properties and in other words a possibility of a reliable selection of type 1 and 3 pigs. The difference in meat quality between the type 1 and 3 was significant. (Analyses of variance: F for visual judgement, transmission value and Fahellpho value resp. 13.14, 15.37 and 10.00; Test of Tuckey: D resp. 1.15, 35.1 and 15.9; $P < 0.05$).

4.3 The T_{40} value as a selection criterion.

From table 6 in the other paper it appears that the average meat temperature in the pigs of type 1 and 3 is higher than in the pigs of type 2. The results of recent investigation confirm this fact. In table 2 results are given of measurings of pH_{40}, T_{40} and R_{40} in 245 D.L. pigs.

Table 2: Some data about the relation between meat temperature and pH_{40} + $Rigor_{40}$ values in the M. semimembranaceus of pigs.

pH_{40} →	≤ 6.3	> 6.3	-	-	> 6.5	< 6.0	
T_{40} ↓ R_{40} →	-	-	≥ 8	< 8	≥ 10	≥ 10	N
≥ 42	3	1	3	1	-	3	4
< 42 > 41	39	11	36	14	10	12	50
≤ 41 > 40	48	89	42	95	5	5	137
≤ 40	9	45	5	49	1	-	54
N	99	146	86	159	16	20	245
Average	40.9	40.3	41.0	40.3	41.0	41.4	40.5
T-test	*(P < 0.01)		*(P < 0.001)			N.S.	

From this table we may conclude:

a. Pigs with a high R_{40} values have a significantly higher T_{40} than those with low R_{40}.

b. Although the differences in meat temperature between the types 1 and 3 pigs are not significant, there is a tendency that the type 3 pigs have on the average a somewhat higher meat temperature.

From other investigations we can give the following data on the relation between T_{40} and other parameters, measured in the same muscle:

	r	n
T_{40} add. x T_{40} L.D.	0.72*	48
" x "	0.65*	45
" x pH_{40} add.	-0.35*	91
" x "	-0.08	142

		r	n	
T_{40} add.	x pH_{24} h add.	0.09	47	
"	x "	0.22	142	
"	x Transm. Value L.D.	0.44	45	
"	x "	0.36	89	
"	x "	-0.15	142	$P < 0.05$

From table 2 and the preceding data we may conclude that:

a. there is apparently a high correlation between T_{40} values in different muscles.

b. there is no or very low correlation between $T_{40\ add.}$ and pH_{40} in the whole group. But this is clear if we imagine, that a high T_{40} generally accompanies a rapid pH decrease, leading to a very high or to a very low $pH_{ult.}$. However, the correlation in the type 3 pigs is much better than in the type 1.

c. It is remarkable that, although most cases of meat degeneration occur in pigs with high T_{40} (generally > 41.0°C), sometimes the T_{40} is much lower , in some cases even lower than 40.0°C. Obviously meat degeneration is caused by a complex of causes, from which a high meat temperature generally is one, but not always the most important.

d. There is a rather low correlation between the T_{40} and the transmission value.

5. Conclusions.

The classification of slaughtered pigs in three types of meat quality (1= dark + high $pH_{ult.}$, 2= normal and 3= degenerated meat) is possible by measuring the pH-, rigor- and temperature-values in the M. semimembranaceus. The most obvious time, at which these measuring could be done is at the end of the slaughter line, i.e. approximately 40 minutes post mortem.

Measuring of pH_{40} alone gives a rather good indication of the development of type 3 meat , but not of type 1 meat.

Measuring of the R_{40} or T_{40} values gives a good indication of type 1 and 3 pigs, but it is not sufficient.

A combined measuring of pH_{40} and R_{40} gives the best results. This combination gives a rapid and reliable indication of both type 1 and 3 pigs.

Untill now we got good results with the following criteria:

type 1: $pH_{40} \geq 6.5$ and $R_{40} \geq 10$

type 3: $pH_{40} < 6.0$ and $R_{40} > 10$

type 2: the other pigs.

Zusammenfassung.

Es wurde versucht Kriterien zu finden, die es ermöglichen, geschlachtete Schweine schnell, einfach und doch zuverlässig einzustufen auf Grund der Unterschiede in Fleischqualität.

Es wird poniert, dass eine Einteilung in nur drei Qualitätsklassen zweckmässig ist und für die Praxis ausreicht:,

Typ 1: dunkles Fleisch, mit hohen pH-Endwerten von ermüdeten Schweinen, mit schnellem Eintritt des Rigor mortis (alkalischer Rigor)

Typ 2: "normales"Fleisch.

Typ 3: degeneriertes (blasses, schlaffes und wässriges) Fleisch von Schweinen mit hohen Körpertemperaturen und ebenfalls mit schnellem Eintreten des Rigor mortis (saurer Rigor)

Der Wert als Klassifiezierungskriterium des pH-, des Rigor- oder des Temperaturwertes, 40 minuten nach dem Tode des Schweines in einem Muskel gemessen, wurde geprüft.

Die kombinierte Messung des pH_{40} und $Rigor_{40}$ erwies sich als die brauchbarste und zuverlässigste Indikation für die Entwicklung des Fleisches in Typ 1 oder Typ 3.

Verschiedene Argumente (oberflächliche Lage, besserer Indikator als der M. adduktor oder der M. gluteus) liessen den M. semimembranaceus als den geeignetsten Muskel für die verschiedenen Messungen erscheinen.

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