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Some observations on the pH in carcasses.

Drs. J.W. Baretta
Stichting Slagersproefstation,
Utrecht-Holland

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As the pH is regarded as an important indicator which can tell us quite a lot about the condition of the animal before slaughter, it seems reasonable to give here a few thoughts of this pH and to mention also some problems concerned with this phenomenon.
I am not going to stress here again that it is necessary for the development of our international scientific cooperation that we use the same method(s) of pH measurement.
I just mention the difficulties in interpretation which arise when one is reading, but especially speaking on pH measurements and one does not know exactly which method the discussionpartner used. And that this is very important becomes evident if you know that there are not only big differences in findings between the methods, but also between different muscles, even between different parts of a muscle.
The electronic determination that makes use of a potentiometer (glasselectrodes) seems to give the most exact results.
The nitrazin yellow indicator test (S c h ʊ n b e r g 1941) can be useful in routine inspection by meat inspectors in certain cases.
The potentiometer is used in three ways:
a. Direct in the muscles by using needle electrodes;
b. In minced meat;
c. In meat extract.
Which way has to be chosen depends on the kind of work that is involved and the facts that are to be obtained.
For to-days discussion we shall keep in mind that the findings in the same animal, even in the same muscle, differ from the method of pH measurement (and alas not only from that!).

That the obtained data differ from the ways of measurement, is quite obvious when we realise that the pH is affected, even heavily affected, by the buffering-capacity of the muscle tissue. In minced meat for example the cells are partly destroyed and that involves the amount of substances that form the buffering-system. Mutatis mutandis goes the same for meat extract. The concentration of both buffering substances and lactid acid are lower than in the original meat.

That I took the liberty to mention these facts which are of course well-known to all of you, finds its origin in the observation that in spite of these well-known facts there is quite a lot of confusion in the international literature on this point.

And if we in this meeting should come to the agreement that the pH can be useful as a help to estimate carcass-, c.q. preslaughtering conditions, we have to know of what we are talking regarding pH.

And now the problem I should like to have discussed here.

As a rule we agree that the drop in pH in the muscular tissue after death is primarily caused by a continuous enzymatic breakdown of glycogen. This breakdown results in an accumulation of lactid acid.

In the living muscles the lactid acid content is only about 0.05%, whereas in muscles 24 hours after death 0.5 - 1.0% may be found.

But if one should say there is a direct correlation between the amount of lactid acid and the pH, one should make a mistake, at least in my opinion. And I have some very good reasons to say so.

Before mentioning the experimental data on which this opinion is built, I like to explain why I deny a direct correlation between pH and lactic acid.

In meatinspection and meatresearch-circles you can often hear the remark: The pH is high (too high), so there is too less lactic acid, so there was too less glycogen in the muscles (c.q. carcass), so the animal was not properly rested before killing.

Or some people even say: It must have been exhausted. This is a conclusion that goes too far in its simplicity. Following the fundamental and very good work of B a t e - S m i t h, we started in our institute to measure the lactid acid content and the pH of meat. The measuring of lactic acid was done according to the method of L o n g, as it was published in the Biochemical Journal no. 40 - 1946. The pH was measured by potentiometer (radiometer 23) in the muscle, in the minced muscle (30 gr. minced meat, grinded in 10 ml fresh water during 5 min.) and in the extract (1 gr. minced meat brought together with 5 ml fresh water in an Erlemeyer during 15 min. under constant stirring the extraction takes place.). Afterwards the solution is filtered and in the filtrate the pH is measured. The following values were found:

muscle	minced	extract	lactic acid
5.60	5.60	5.70	0.87
5.70	5.70	5.75	0.76
5.60	5.60	5.70	0.85
5.80	5.80	5.90	0.72
5.65	5.65	5.65	0.81
5.50	5.50	5.55	0.93
5.70	5.70	5.75	0.76
5.72	5.75	5.75	0.73
5.80	5.80	5.85	0.70
5.80	5.82	5.90	0.73
5.65	5.65	5.70	0.83
5.72	5.75	5.75	0.79

The meat examined in this experiment was meat from healthy, properly rested cattle, taken at random at the slaughterhouse. In accordance to this were the findings of my colleague Dr. S c h o o n, who found the following values in slaughtered cows, which were not healthy in one way or another. (The values are mediums of different measurements.).

Percentage glycogen as found by Dr. Schoon (Holland):

	immediately after slaughter	24 hours after slaughter	percentage of glycogen	breakdown pH
Cows healthy	0.5907%	0.1975%	0.3832%	0.9
cows with bone fract.	0.5218%	0.1404%	0.3814%	0.7
cows with bronchopneumonia	0.0366%	0.0275%	0.0091%	-.-
cows with metritis	0.1107%	0.0059%	0.1128%	0.1
cows with perivaginitis	0.389 %	0.066 %	0.323 %	0.25

From these values you can also not find a correlation between the percentage of broken-down glycogen and the decrease in pH. B a t e - S m i t h tried to get an impression about the prekilling condition of animals by measuring the lactic acid and the pH. He proposed that o,1% lactic acid should cause a decrease in pH of 2/9. So he figured out a value he called "Basic pH".
As is shown in the next table, this figuring gives a certain compensation for the differences between the lactic acid content and the pH, but not enough to make the pH, or even the basic pH an absolute measure for determinating the preslaughtering condition.

animal condition	lactid acid	pH	pH 20/9 x % lactic acid	"Basaal" pH
exhausted	0.19	7.15	0.42	7.57
exhausted	0.36	6.91	0.80	7.71
fatigued	0.42	6.64	0.93	7.57
fatigued	0.46	6.49	0.02	7.51
fatigued	0.51	6.32	1.13	7.55
light exertion	0.68	5.93	1.51	7.44
control	0.72	5.89	1.60	7.49
control	0.92	5.60	2.04	7.64
control	0.94	5.52	2.09	7.61

My view on this problem is that there is one factor that influences the breakdown of glycogen in such a way that more knowledge about this factor is necessary before we can use the pH (with a certain correction) as a good measurement for preslaughtering condition.
The factor I mean here is the influence of the adenosine triphosphate on the breakdown of the glycogen.
This breakdown, that chemically spoken, needs only the reaction from glycogen with water, is in reality much more complicated. Enzymatic systems are playing an important roll and the process starts when free phosphate combines glycogen and gives hexosemonophosphate.
We know from the work and publications of L u n d s g a a r d, L o h m a n and M e i j e r h o f, H a m m and others, that adenosine triphosphate (A.T.P.) is an important and intermedium reaction in the process.
Regarding the fact that the known and unknown enzymatic processes in an animal either during live or after death, are very far influenced by the condition of the animal, it is clear that more fundamental knowledge about those processes is necessary to obtain a better insight in the pH value as an indicator for the condition of the slaughtered animal, c.q. carcass.
Summarizing we may say that in explaining the processes that cause the contraction, the rigor mortis in the muscles, that besides the breakdown of glycogen in lactic acid the phosphorylisation should also get more attention, because this process is probably more a bottleneck in the lactic acid formation than the glycogen content alone.
For fundamental work on preslaughtering conditions, the measuring of lactic acid in the blood may prove to be very useful, because during exercise or exhaustion the lactic acid passes almost immediately from the cells into the blood.