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# CHARACTERISTICS OF PIG CARCASES AT THE SLAUGHTER-LINE AND FRESH HAM MUSCLE IN RELATION TO PROPERTIES OF CANNED HAM.

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## Introduction

The biochemical processes in muscle tissue just after slaughtering of the pig are of great influence on fresh meat quality. Especially the decrease in muscle pH, related with the rate of glycolysis, and the moment of onset of rigor mortis are important to the development of pale, exudative muscle (Briskey et al. 1).
According to Sybesma and Van Logtestijn 2) a rapid fall in pH and an early onset of rigor is accompanied by high muscle temperatures. Their principles can be used to sort out carcases at the slaughter-line that show a strong tendency to develop poor meat quality.
As in our factory pale exudative pork is rather frequently encountered and as may be expected that finished products, in particular cooked canned hams, have a poor quality when prepared from this type of meat, it was investigated to what extent slaughter-line characteristics and fresh meat properties were related to the quality of canned hams.

## Classification of pig carcases at the slaughter-line.

All animals were Dutch Landrace pigs and followed the normal slaughter procedure of our factory i.e.: carbon dioxide stunning, bleeding, vertical scalding, dehairing, singeing, black-scraping, veterinary inspection ,splitting of the back bone and cooling.

For pH determinations the E.I.L. model 30C portable pH-meter with spear point dual electrodes type SDSN 33/C was used. The state of rigor was measured with the Sybesma rigor meter, obtainable from the Instituut voor Veeteeltkundig Onderzoek, "Schoonoord", Zeist, The Netherlands. Temperature readings were carried out with bimetal clinical thermomethers, type Cary, ex Eisenhut, Basel, Switzerland. The measurements were taken from ham muscle (M. semimembranaceus) in both carcase halves.

To characterize pig carcases the classification system of Sybesma and Van Logtestijn, bases on data obtained 40 minutes after death, was used. Owing to slaughter-line conditions measurements could not be made sooner than 45 to 50 minutes post mortem in our factory.

Results and discussion of measurements at the slaughter-line.

Before starting experiments in which meat quality was involved, knowledge about the distribution of Hartog's pigs over the groups of the Sybesma classification system was necessary.
The pH and rigor value of the M. semimembranaceus in both hams of 225 pigs in a first series and of 106 animals in a second one were determined; in the first series also temperatures were read. The results are given in per cent in table 1, together with the distribution found by Sybesma on 320 carcases 2).

Table 1. (see next page.)

From the total number of hams (exp. 1) approximately one out of five has a hightemperature, but in group III-3, that is supposed to contain the pigs with the strongest tendency to develop pale exudative meat, this is one out of two.
In the second experiment a strong shift to lower pH values and a moderate one to a more complete state of rigor can be observed. Possibly other conditions during transport or slaughter are the cause.

In comparison with the data from Sybesma and Van Logtestijn the distribution of data over the various classes in general is shifted to a lower $pH_1$ and a higher rigor value. It is probable that this is caused by taking the measurements 5 to 10 minutes later after bleeding.

A comparison of the data from left(L) and right (R) side hams is interesting:

Table 2

(see next page.)

Table 1

| | 1 $pH_1 \geqslant 6.5$ | | | 2 $6.5 > pH \geqslant 6.0$ | | | 3 $pH_1 < 6.0$ | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S.,V.L. | exp.1. | exp.2 | S.,V.L. | exp.1. | exp.2. | S.,V.L. | exp.1. | exp.2. | S.,V.L. | exp.1. | exp.2 |
| I pre-rigor | 16.8 (2.5) | 4.9 (0.0) | 1.0 | 20.0 (4.4) | 10.6 (0.5) | 9.9 | 2.2 (0.6) | 0.9 (0.0) | 1.9 | 39.0 (7.5) | 16.4 (0.5) | 12.8 |
| II onset of rigor | 4.1 (1.3) | 5.9 (0.7) | 1.0 | 19.4 (5.9) | 29.3 (3.6) | 17.0 | 4.0 (3.4) | 8.0 (2.5) | 22.6 | 27.5 (10.6) | 43.2 (6.8) | 40.6 |
| III advanced rigor | 4.1 (2.8) | 1.8 (0.2) | 1.3 | 17.2 (10.6) | 24.6 (6.5) | 10.4 | 12.2 (10.3) | 14.0 (7.2) | 34.9 | 33.5 (23.7) | 40.4 (13.9) | 46.6 |
| total | 25.0 (6.6) | 12.6 (0.9) | 3.3 | 56.6 (20.9) | 64.5 (10.6) | 37.3 | 18.4 (14.3) | 22.9 (9.7) | 59.4 | 100.0 (41.8) | 100.0 (21.2) | 100.0 |

*)in brackets: percentage of total number of hams with temperature 41.0°C.

TABLE 2

| | Experiment 1 | | | Experiment 2 | | |
|---|---|---|---|---|---|---|
| | L. | R | significance of difference between L. and R. | L | R | significance of difference between L. and R. |
| average $pH_1$ | 6.11 | 6.19 | $P < 0.001$ | 5.85 | 5.90 | $P < 0.001$ |
| " rigor value | 8.7 | 8.1 | $P < 0.001$ | 9.7 | 8.4 | $P < 0.0001$ |
| " temp. °C | 40.4 | 40.2 | $P > 0.05$ | | | |

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In the first experiment the $pH_1$ of the L hams is significantly lower, the rigor value significantly higher than those of the R hams.
Under normal production conditions approximately 2/3 of the pigs is hung by their right side hindleg after stunning. Therefore the second experiment was carried out in which all pigs were hung by that leg.
In exp. 1 71.5% of the L muscles have a lower $pH_1$ than the R muscles; in exp. 2 this figure is 73.0% . The difference in percentage is not significant and it seems therefore that the $pH_1$ in the M. semimembranaceus is not influenced by the change in hanging procedure. Why $pH_1$ in the L muscle is significantly lower than in the R is not known.
The rigor value of L muscles is higher than in the corresponding R muscle in 69% in exp. 1 and in 85% in exp. 2. The difference is significant at the 0.01 level. Stretching of the muscle by the weight of the pig presumably retards onset of rigor.
The fact that in our factory vertical scalding is used, during which the pig is hanging by one leg, certainly plays a role. Experiments in which the pigs are hung by left leg are not yet carried out.

<u>Relation of $pH_1$, rigor value, quality score and waterbinding capacity on one hand and cooking loss and other quality characteristics of canned hams on the other.</u>

Three series of experiments were carried out in which were determined:
$pH_1$ and rigor value as described above;
visual judgement of ham meat approximately 24 hours after slaughter by five experienced persons according to the following scale:

1 = pale, exudative
2 = rather pale and moist
3 = normal
4 = red
5 = dark-red and dry

waterbinding capacity. The method is derived from that of Wierbicki c.s. 3). Carefully defatted and trimmed meat is ground in a kitchen grinder ( 3 millimeter holes); 60 grams of meat and 180 ml water is homogenized with an Ultra Turrax (Janke & Kunkel K.G., Staufen, Germany; type of head TP 45/2 G) during 20 seconds at an voltage of 125. After that the mixture is placed 15 minutes under refrigeration. 50 Grams of the mixture is centrifuged for 10 minutes at 760 g; the supernatant is weighed and the amount of bound water is expressed in per cent of the original meat present in the mixture.

cooking loss and other quality characteristics of canned hams.

The hams were derinded, defatted, deboned and stitch-pumped by an Anco multi-needle injector with polyphosphate containing brine (0.5% polyphosphate on meat). After tank brining and draining the hams were cooked in rectangular cans during 5 hours at 74°C in water.
After a storage period of at least one week under refrigeration the amount of cooked out jelly was determined; a number of hams was sliced on a slicing machine to judge colour, coherence and moistness of the slices.

To avoid day effects in the results as much as possible not more than 6 pigs per day were selected to make canned hams from. In the first series the $pH_1$ and rigor values used for classifying the carcases were the same as Sybesma's; in the last series the limits of the classes were changed to obtain a more balanced distribution in the following way:

| | | | |
|---|---|---|---|
| Class | I-1 Sybesma | rigor value $\leq 5$ | $pH_1$ $\geq 6,5$. |
| | I-1 Hartog | " " $< 6$ | $\geq 6.3$ |
| | I-3 Sybesma | " " $\leq 5$ | $< 6.0$ |
| | I-3 Hartog | did not occur in exp.3 | |
| | III-1 Sybesma | did not occur in exp.4 | |
| | III-1 Hartog | " " $\geq 11$ | $\geq 6.3$ |
| | III-3 Sybesma | " " $\geq 10$ | $< 6.0$ |
| | III-3 Hartog | " " $\geq 11$ | $< 5.7$ |

The results are given in table 3.
(see next page.)

Table 3

| | | Class I-1S exp. 3 | Class I-1 H exp. 4 | Class I -3S exp.3 | Class III-1H[x] exp. 4 | Class III-3S exp.3 | Class III-3H exp.4 |
|---|---|---|---|---|---|---|---|
| Number of pigs | | 18 | 50 | 24 | 12 | 102 | 52 |
| $pH_{24hrs.}$ M.semimembr. | average value | 5.83 | 6.08 | 5.84 | 6.70 | 6.05 | 6.13 |
| | highest " | 6.4 | 6.8 | 6.5 | 6.9 | 6.6 | 6.6 |
| | lowest " | 5.6 | 5.5 | 5.4 | 6.4 | 5.5 | 5.7 |
| | stand.dev. | 0.18 | 0.29 | 0.33 | 0.16 | 0.28 | 0.29 |
| Colour score | average value | 2.8 | 2.5 | 2.2 | 4.5 | 2.0 | 1.6 |
| | highest " | 4.6 | 3.8 | 3.4 | 5.0 | 4.6 | 3.3 |
| | lowest " | 1.3 | 1.0 | 1.0 | 3.2 | 1.0 | 1.0 |
| | stand.dev. | 1.0 | 0.7 | 0.7 | 0.6 | 1.0 | 0.6 |
| Waterbinding capacity | average value | 18 | 47 | 24 | 130 | 33 | 35 |
| | highest " | 31 | 124 | 48 | 191 | 103 | 81 |
| | lowest " | 3 | 15 | 9 | 61 | 1 | 6 |
| | stand.dev. | 7 | 25 | 12 | 42 | 25 | 20 |
| Cooking loss | number of hams | 15 | 51 | 15 | 11 | 89 | 52 |
| | average value | 6.8 | 6.2 | 6.6 | 5.7 | 7.9 | 9.0 |
| | highest " | 8.0 | 7.9 | 9.1 | 6.8 | 12.6 | 14.3 |
| | lowest " | 6.0 | 2.9 | 5.0 | 4.5 | 4.4 | 5.1 |
| | stand. dev. | 0.6 | 1.0 | 1.4 | 0.8 | 1.8 | 2.2 |

[x]) In experiment 3 carcass class III-I, in exp. 4 1-3 did not occur.





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It can be seen from the table that changing the class limits indeed results in a better selection of carcase-halves in relation to the cooking loss of canned hams. This leads us to the first conclusion that application of the principles of Sybesma and Van Logtestijn may need adaptation to the specific conditions prevailing in a factory like ours. The second conclusion is, that carcases with a low $pH_1$ and a high rigor value in the M.semimembranaceus approximately 45 minutes post mortem as a group are less suitable for the manufacturing of cooked hams.

The correlations between the properties determined are given in table 4.

Table 4

| | rigor value | $pH_1$ | $pH_{24\ hrs}$ | colour score | waterb. cap. | cooking. loss |
|---|---|---|---|---|---|---|
| rigor value | - | | | | | |
| $pH_1$ | $-0.68^{+++}$ | - | | | | |
| $pH_{24hrs}$ | $-0.27^{+}$ | 0.08 | - | | | |
| colour score | - 0,17 | $0.52^{+++}$ | $0.42^{+++}$ | - | | |
| waterbind.cap. | - 0.02 | $0.27^{+++}$ | $0.69^{+++}$ | $0.53^{+++}$ | - | |
| cooking loss | $0.50^{+++}$ | $-0.63^{+++}$ | $-0.27^{+++}$ | $-0.49^{+++}$ | $-0.43^{+++}$ | - |

\+ significant at the 0.05 level
++ " " " 0.01 level
+++ " " " 0.001 "

However, correlations with cooking loss are significant at the 0.001 level, this does not mean that each ham from carcases out of the III-3 class will have a high cooking loss; in experiment 4 for instance the distribution was as follows:

| 5.0 - 6.9% | 7.0-8.9% | 9.0 - 10.9% | 11.0 - 12.9% | > 12.9% |
|---|---|---|---|---|
| 7 | 23 | 14 | 4 | 4 |

Neither may be concluded that the occurrence of pale watery meat is restricted to carcases from class III-3, nor that this type of meat judged 24 hours after slaughter, always gives rise to a finished product of poor quality. To illustrate this the data of 8 cooked canned hams (from a group of 32) with no quality defects on slicing are given in table 5.

Table 5

| Class | temperature 45 min. | $pH_{24\ hrs.}$ | water-binding capacity (%) | fresh meat quality score 24 hrs. | cooking loss(%) |
|---|---|---|---|---|---|
| I-1 | 40.0 | 5.70 | 17 | 1.4 | 6.0 |
| | 40.7 | 5.70 | 21 | 2.8 | 6.5 |
| I-3 | 40.0 | 5.95 | 27 | 2.4 | 5.9 |
| III-3 | 40.2 | 6.14 | 40 | 3.8 | 5.4 |
| | 40.3 | 6.00 | 22 | 2.0 | 5.6 |
| | 40.5 | 6.12 | 34 | 3.0 | 6.5 |
| | 39.8 | 6.60 | 30 | 1.0 | 7.5 |
| | 40.8 | 6.27 | 54 | 2.4 | 7.8 |

This means that from pigs belonging to class III-3 a good quality canned ham may result and that even a ham with a fresh meat quality score as low as 1.0 (pale and exudative) may come out good in the end. The remaining 24 canned hams showed one or more quality deviations; 13 belonged to class III-3. From these 13 hams 5 had a fresh meat quality score of 1.4 or below; none was pale after curing and cooking!.
In the other two classes 4 hams had a score of 1.8 or less; all these four, however, yielded a pale finished product.
Wetness of cooked ham slices is a frequent occurring quality deviation; from the 24 hams not qualified as good 22 were moist; all cooked hams from the 13 pigs in class III-3 showed this wetness.

## Discussion

Improvement of the technology of ham manufacturing (trimming, brining, curing) has given rise to a considerably more constant canned ham quality in recent years. Despite that ham to ham variation is present to an undesirable extent even to-day. The investigations described in this report are aimed at selection of carcases at the slaughter-line or of fresh hams in order to further improve the quality of the finished product. It proved to be possible, making use of the principles of Sybesma and Van Logtestijn, to sort out those carcases that give rise to a considerable higher average cooking loss in canned hams.

Also the characteristics of ham muscle 24 hours after slaughter are significantly correlated with cooking loss, the best criterion in this respect being the visually determined score of meat quality, a combination of light reflection, wetness and texture. But, the criteria used only indicate average tendencies; it is not yet possible to predict the properties of the finished product from carcase or fresh meat data with accuracy. In this respect carcase data gave somewhat better correlations. This is remarkable in so far as fresh meat is the starting material in the manufacturing process. This means that the methods used to characterize fresh meat quality are not accurate enough or that they measure properties that are not representative.
Of course, the manufacturing process has a strong influence on final quality and it cannot be denied that standardization of the curing process is far from simple.

Many experiments in our factory in which left side hams were subdued to an other curing and/or pasteurization process than the corresponding right side hams, however, showed that the rank order in cooking losses within the series are to a great extent determined also by the properties of the pig. This, together with the fact that the characteristics of only one ham muscle 40 minutes post mortem show reasonable correlations with finished product quality, makes research into more accurate or more representative methods promising.
When these methods, that must be applicable under production conditions, make it possible to separate carcases or fresh meat with inferior properties from meat that is good for specified purposes, the manufacturer is left with the problems what to do with carcases or meat that is not up to standard.

Improvement of conditions during transport of the pigs, lairing in the factory stables and the slaughtering process along the lines described in literature may enhance the average level of meat quality. Measurements on carcases at the slaughter-line may be very useful to control the effects obtained.

All measures taken in factory practice, however useful they are, seem

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only to suppress symptons that find their cause in the physiology of the pig and its genetics.
Research into the biochemistry of muscle tissue and its variability (Briskey et al.) 1) or research into the prevention of stimulation of muscle ante mortem (Bendall) 4) will bring the problem of meat quality variation much closer to its solution.

OSS, 6.7.1967
LAB JLe/BR.

References

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Summary

To characterize pigs at the slaughter-line the classification method of Sybesma and Van Logtestijn, making use of pH and rigor value in ham muscle, has been applied. In two series of 225 and 106 animals respectively a shift to lower pH and higher rigor value, when compared with the data of Sybesma and Van Logtestijn, was found, probably due to the fact that measurements were taken five to ten minutes later, owing to conditions of slaughter in our factory.
A significantly lower rigor value was found in the leg by which the pig was hung after stunning (vertical scalding).
In the following experiments groups of carcases were selected from which cooked hams were manufactured. The pH and water-binding capacity were determined and a visual judgement of meat quality was made the day after slaughter.
In the canned, cooked hams the amount of jelly and other quality characteristics were determined.
Adaptation of Sybesma and Van Logtestijn's limits of the carcase classes to conditions in our factory gave rise to a better selection.
It is not yet possible, however, to predict from carcase measurements or fresh meat properties, as carried out in this investigation, the quality of the finished product with accuracy.

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