## EFFECTS OF THE PROCESSING TECHNOLOGY ON THE QUALITY PARAMETERS OF COOKED HAM

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SUMMARY: The purpose of the experiments was, to change an approved manufacturing process in such manner, that it will be possible to reduce the mean salt content in the finished product from 2.2 % to 1.8 %, an desirable low salt concentration. The mean yield shall be about 100 %. Besides salt, no additives with a positive influence on the water binding capacity of meat, for instance phosphates, shall be used. By otherwise unchanged technology a reduction of the salt concentration by lowering the brine concentration resulted, as expected in a district lowering of the yield. By a changed tumbling process, that means a prolongation of the active tumbling time about 50 % from 10.7 h to 15.9 h in combination with a changed temperature schedule during the tumbling process and the extensive removal of the connective tissue from the inside of the muscles (layer or surface of contact) topside and silverside, it was possible to produce cooked ham with a salt content of 1.85 % and a middle yield of 100 %. With the earlier technology it was possible to get a middle gain of 104 % with a salt concentration of 2.2 %. Another purpose was to find causal reasons for deviations within one charge. A dominant influence has the pH-value of the fresh ham. With higher pH-values of the ham the yield increases, and the number of hams with pores, the dimension and number of holes and the amount of weep deminished.

INTRODUCTION: In cooked cured products the condition of the raw material has a decisive influence on quality, as there is little comminution or mixing of the material during manufacture. In most cases whole pieces of muscle are used. Cooked cured products are expected to be juicy and of an attractive colour and to have a reasonable shelf live. Cavitis, holes, rents and pores are not wanted, the holding togehter of the slices, also after thin slicing, shall be warranted. The purpose of the experiments was, to change an approved manufacturing process in such manner, that it will be possible to reduce the mean salt content in the finished product from 2.2 % to 1.8 %, a desirable low salt concentration. The mean yield shall be about 100 %. Besides salt, no additives with a positive influence on the water binding capacity of meat, for instance phosphates, shall be used.

MATERIALS AND METHODS: Basic material for the 8 tests were 20 hams taken one or two days after slaughter. These hams were deboned, derinded and defatted. As far as it was possible by the initial weight the hams were trimmed to a constant fresh weight of 3.300 kg. For the tests 5 and 6 the hams were completely defleeced with a machine type ASE 553 (firm Weber Maschinenbau GmbH, Breidenbach, FRG). At the test 7 and 8 only the inside of the hams were defleeced. Before further processing pH-values and conductivity values were measured (pH-meter Portames 653, firm Knick, Berlin, in connection with a probe N 5800 A, firm Schott, Hofheim, conductivity meter type LF 191 with F-electrode of the firm Wissenschaftliche Werkstätten, Weilheim). After that the brine was pumped into the hams with a multi-needle injector (FMG 26/52, of the firm Scheid-System-Technic, Überherrn). Table 1 shows the test variables as amount of injection and brine composition. The tumbling took place in a cooling tumbler 250 MC (firm Scheid-System-Technic) using a beating weight of polyethylene of the following measures: length appr. 270 mm, diameter 160 mm, weight appr. 2.900 kg. Tumbling conditions were carried out under high constant vacuum > 95 %. The exact tumbling conditions of the various batches are listed in table 1. After tumbling the hams were placed in ham boilers lined with foil (type 715, firm Adelmann, Kehl). The ham boilers were de-aerated in a vacuum apparatus, sst Ham-o-vac SV 35 (firm Scheid-System-Technic) for 70 s under high vacuum. After that the lids of the ham boilers were placed and pressed until the springs were totally under tension. The boiling took place in a steam cooking chamber at a constant temperature of 62°C. While cooking thermocouples which were placed in the center of 3 hams, delivered date to a small computer, type Epson HX 20 with corresponding software (firm Scheid-System-Technic) for calculation of $Fc_{70°C}$.

Table 1: Test conditions of batches 1 - 8

| Test | Brine composition NS % | Ascorbate % | Quantity of Injection % | Total distance of tumbling km Drum circumference x RpM x time | |
|---|---|---|---|---|---|
| 1 | 14.4 | 0.20 | 20 | 17.3 | interval tumbling |
| 2 | 10.9 | 0.20 | 20 | 17.3 | interval tumbling |
| 3* | 10.9 | 0.23 | 20 | 26.4 | interval tumbling |
| 4* | 13.8 | 0.20 | 15 | 26.4 | interval tumbling |
| **+5* | 10.9 | 0.20 | 18 | 26.4 | continuous tumbling |
| ** 6* | 10.9 | 0.20 | 18 | 26.4 | interval tumbling |
| ***7* | 10.2 | 0.20 | 19 | 26.4 | continuous tumbling |
| ***8* | 10.2 | 0.20 | 19 | 26.4 | continuous tumbling |

* variable conducting of temperature
** meat was completely defleeced
*** meat was partly defleeced
\+ 10 hams of batch 5 were boiled immediately after tumbling, 10 hours boiled after a curing time of 10 hours

When the ham with the slowest F-value-increase reached a Fc-value of 27, the boiling was stopped and the hams were placed in a chilling room of +2°C. The additional heating effect during the chilling time was also calculated as F-value and added to the F-value of the boiling time. Thus F-values between F 36-38 were reached in one batch at the ham with the most unfavorable course of temperature.

After complete chilling overnight the hams were taken out of the ham boilers and the weight was recorded. Than the hams were cut in the middle and evaluated according a scheme due to their small and large holes as well as exudation of juice. Randomly checked was also the holding-together of thin slices of the ham. Furthermore, total analyses of all hams as well as sodium chloride and phosphate determination, color and consistency measurements were carried out.

RESULTS AND DISCUSSIONS: The first test is representing the standard procedure at which the results were measured of the further changes of process within the series. Results see table 2.

**Table 2:** Results of physical-chemical investigations

| Test | Yield % | Protein % | FEIFFA* % | Water/Protein % | Sodium Chloride % | Abrasion material % |
|---|---|---|---|---|---|---|
| 1 | 103.9 | 19.4 | 19.8 | 3.9 | 2.2 | 2.8 |
| 2 | 97.7 | 20.3 | 20.4 | 3.8 | 2.2 | 5.4 |
| 3 | 105.3 | 19.2 | 19.9 | 3.9 | 2.0 | 1.1 |
| 4 | 100.9 | 20.0 | 20.4 | 3.8 | 2.0 | 0.8 |
| 5 | 97.9 | 20.0 | 20.4 | 3.8 | 1.8 | 4.3 |
| 6 | 101.2 | 19.4 | 20.1 | 3.8 | 1.9 | 1.5 |
| 7 | 100.4 | 19.3 | 20.1 | 3.8 | 1.9 | 2.3 |
| 8 | 99.4 | 19.9 | 20.5 | 3.8 | 1.8 | 1.2 |

* FEIFFA = Meat protein in the fat-free substance

In the second test the salt concentration of the brine was decreased from 14.4 to 10.9 %. This led to an increase of the abrasion material from 2.8 to 5.4 % and to a decrease of the yield from 103.9 to 97.7 %. The salt content of the ham, however, did not decrease as expected but was in average 2.2 % in the same level as in the first test. This is attributed to the fact that the loss of boiling juice had a lower salt concentration than the hams.

In the third test the tumbling program was changed, brine concentration remained as in the second test. The active tumbling time, respectively the active tumbling distance was increased in the interval program of approximately 50 %, i. e. from 10.7 to 15.9 hours resp. 17.3 to 26.4 km. At the same time the temperature of the tumbling drum was pre-chilled to -12°C. In the other tests the pre-chilled drum had -5°C. The combination of these two measures led to an increase of the yield of 105.3 % and to reduction of the abrasion material of 1.1 %. The medium content of sodium chloride could be reduced to 2 % in the batch.

In batch 4 the nitrite curing salt content in the brine was increased from 10.9 to 13.7 %, but the quantity of injection reduced from 20 to 15 %, tumbling program remained as in batch 3. This change effected a reduction of the yield to 100.9 %. The sodium chloride of the final product did not change and the abrasion material of 0.8 % was slightly better as in the third batch.

Based on these results the batch 5 was treated again with a 10.9 % brine and the quantity of injection was 18 %. The hams were almost completely defleeced by machine and continuously tumbled for 15.9 hours. Than the batch was divided, the one half was immediately placed into the ham boilers and cooked, the other half of the hams was stored 24 hours in a chilling room for dry-curing at +2°C than put in ham boilers and cooked. The medium yield of this batch was 97.9 %. Whereby those hams which were immediately cooked reached a yield of 95.3 %, the others which were cooked 24 hours later reached a yield of 98.8 %. The salt content was 1.8 % and the abrasion material 4.3 %. This relatively high proportion of abrasion material was mainly caused by the complete defleecing of the hams. The rough surface of the ham, not protected by the connective tissue has reacted more sensible on the mechanical treatment.

The hams of test 6 were again completely defleeced and pumped with 18 % of a reduced brine of 10.9 % curing salt in order to reduce the salt content further. Tumbling was carried out as in test 4 with a total tumbling time of 26 hours (total distance 26.4 km) and an active tumbling time of 15.9 hours. Compared with test 5 it was again possible to reach a higher yield of 101.2 % and to reduce the abrasion material to 1.5 %. The medium salt content of the final product was 1.9 %.

In the batches 7 and 8 the salt content of the brine was again slightly reduced to 10.2 %. Furthermore only the inner surface of the hams were defleeced (inside of M. adductor and M. semi membranosus) and 15.9 hours, respectively 26.4 hours continuously tumbled. Thereby the yields amounted to 100.4 and 99.4 % and the abrasion material was reduced to 2.3 resp. 1.2 %. The medium salt content in the final product was 1.9 and 1.8 %.

The number of hams which had one or more holes increased by the reduction of salt from test 1 to test 4. Holes appeared mainly in the connective tissue between the individual muscles. A similar positive distribution as in test 1 could be reached by defleecing the hams and prolonging the tumbling times of batches 5 - 8. The percental proportion of hams with large, medium and small holes increased also in test 4. Consequently dropped the proportion of hams evaluated "no holes". Beginning with test 5 the number of hams evaluated "no holes" increased again. The proportion of hams with medium and large holes decreased. The distribution could be compared with that of test 1. Furthermore, the defleecing of the inner surface effected positively the holding-together of thin slices of ham.

The number of hams showing exudated juice after cutting could be reduced clearly compared with test 1 so that the quality was improved.

The proportion of hams with pores was distinctly under 25 %. The number of hams with pores in the tests 7 and 8 were in the same dimensions than in the first test.

The question in test 5 was which influence had the dry-curing after tumbling. The immediately boiled hams reached a yield of 95.3 % while the dry-cured hams reached 98.8 %. The total batch reached a medium yield of 97.9 %. However, sensory scores were unfavorable for the dry-cured hams. 60 % of the hams immediately cooked after tumbling showed no exudated juice and 40 % only small amounts of exudated juice. However, 50 % of the dry-cured hams showed no exudated juice, 35 % small amounts of juice and 15 % moderate exudated juice. Among the not dry-cured hams no one was evaluated porous, those hams dry-cured for 24 hours were evaluated as 80 % not porous and 20 % slightly porous. The dry-curing of the hams has the following influence concerning the size of the holes. The not dry-cured hams had holes in 50 % of the products, each one hole, the other 50 % of the hams had no holes. Those hams 24 hours dry-cured were 40 % without holes, 20 % had one hole and 40 % several holes of which all were evaluated as small holes.

Superimposed was the influence of the variable test parameter by the influence of the pH-values, although this connection is not obvious, looking at the ordered test results, e.g. there is no clear influence by the medium pH-values of the individual hams concerning the yield in the individual tests.

Arranging the yields according the pH-values placed in 0.2 pH-units of all 160 hams of the test series there is a clear connection visible between the yield and the pH-value. The medium yield increases from 99.3 to 108.3 % (-0.7 until 8.3 %) at a distribution of the pH-value in the M. biceps femoris from 5.4 to 6.7 units. This is similar evaluating the pH-values of the M. semimembranosus. The yield increases in the pH-area of 5.4 until 6.7 from 98.2 to 108.5 % (-1.8 until 8.5 %). This connection is in conformity with other investigations (JACQUET u. SELLIER, 1973, REICHERT, 1985).

Less known is that also quality parameter depend distinctly from the pH-value. The evaluation "no holes" increases with climbing pH-values. The number of hams with one hole remains the same, the number of hams with several holes drops in the pH-area of 5.4 - 6.3. At the evaluation of the size of the holes the number of small holes varies almost independently from the pH-value and is in tendency only decreasing. The number of medium and large holes drops with increasing pH-value. In the pH-value area between 5.4 and 6.1 is the number of hams evaluated "slightly porous" decreasing, in the pH-area 6.2 - 6.7 no small pores were found. With increasing pH-value decreased the undesired exudated juice after cutting the ham. The evaluation "strongly exudated juice" was given only for a few hams of pH-value 5.6 - 5.7. The increasing pH-value led also in the M. semimembranosus to similar decrease of exudated juice. Hams with higher pH-values were more tender, i.e. the measured values with the penetrometer were higher. This result reflects that not only the pH-value alone is causing that, but especially the mentioned higher yields of those hams with high pH-value.

The clear positive influence of the salt between 1.3 until 2.2 % salt content in the final product can be confirmed. Higher salt concentrations showed in opposition to other investigations no clear effect. A salt concentration of 1.7 until 1.8 % is sufficient for moderate yield of 100 % at the applied technology. Increasing the salt concentration of about 0.4 % to 2.1 until 2.2 % makes it possible to increase the yield of up to 2.2 %. The salt concentration in the final product has no visible effect on the quantity of abrasion material during tumbling.

CONCLUSIONS: The reduction of the salt content by decreasing the salt concentration of the brine without changing the process technology led as expected to a clear decrease of the yield. Reproducible cooked hams with a medium salt content of 1.85 % and a moderate yield of 100 % can be produced by changing the processing of tumbling, i.e. a prolonged active tumbling time of 50 % from 10.7 hours to 15.9 hours, resp. a prolonged tumbling distance from 17.3 to 26.9 km in connection with an altered temperature process at tumbling and by defleecing the connective tissue of the inner sides of M. semimembranosus and M. biceps femoris. At the initial processing 104 % yield with a salt content of 2.2 % was reached. Aim of the evaluation of the total results was also to find the reasons for the width of deviations within a batch. A dominating influence had the pH-value of the raw hams. Hams with increasing pH-value proved to have not only a better yield, but also the number of hams with porous consistency or holes dropped as well as the exudated juice decreased. Based on the results of the evaluation one should not use raw hams for processing with pH-values of < 5.8. The optimum figures are pH-values of 5.8 until 6.4.

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