PREDICTION OF SHELF-LIFE OF COOKED, SLICED, VACUUM-PACKED HAM

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INTRODUCTION

The Danish authorities require that prepacked meat products are declared with a minimum shelf-life. Sliced, vacuum-packed ham is normally declared a shelf-life of 4-6 weeks at a maximum temperature of 5°C. Previous studies determined by laboratory test have demonstrated a disagreement between the declared and the actual shelf-life (Bøgh-Sørensen et al., 1986).

At the Danish Meat Products Laboratory the shelf-life is tested by organoleptical testing and by microbiological and chemical analyses. Such evaluations normally take 3-5 weeks. Both for the meat producing companies and for the authorities checking the shelf-life, it would be advantageous if the shelf-life could be predicted as soon as possible after production.

The main purpose of this experiment was to establish a correlation between different microbiological and for chemical parameters and the organoleptically evaluated shelf-life of cooked, sliced, vacuum-packed ham stored at 5°C. It was investigated whether it could be possible to establish a mathematical model for prediction of the shelf-life on the basis of significant parameters. Similar investigations have been performed on e.g. chilled fish by Jørgensen et al., 1988.

MATERIALS & METHODS

Product, packaging and storage

Seventeen canned, pasteurized (centre temperature minimum 68.9°C) hams (21 lbs), with max 200 ppm ingoing sodium nitrite were supplied by different meat processing plants. After slicing (16 x 10 x 0.16 cm) at the laboratory, the slices were randomly packed (two or three slices per pouch) using a packaging material with an oxygen transmission rate of <10 cc/m^2/24 hr/atm. The packages were stored in a dark cold-storage room at 1-5 °C for a maximum of 6 weeks.

Sensory evaluation

The vacuum-packed hams were tested every week by a 6 member panel with regard to taste, odour and appearance, using a +5/-5 hedonic scale where +5 = ideal and -5 = very bad. The score -1 was considered as the acceptability limit, and the shelf-life was calculated based on this criterion.

Bacteriological analysis

The bacteriological quality in 2-3 packs per ham was determined immediately after slicing and subsequently after 4, 6, 8, 11, 13, 20, 27, 34 and 41 days of storage by the Spiral Plating Technique, SPT (Liberski, 1986), using the selective plating media described in table 1, after appropriate serial dilutions. In addition, the total count was determined by the Direct Epiflourescense Filter Technic, DEFT, as described by Pettipher et al, 1980, and by Liberski, 1989.

Chemical analysis

Salt content (potentiometric titration with $AgNO_3$) and dry matter were determined once, whereas the pH was measured with the same frequency as the bacteriological analyses.

Statistical analysis

Stepwise linear regression analyses were used for determining the parameters, which significantly influenced the shelf-life. A t-test and linear regression analysis were used for determining the correlation between the two microbiological methods (DEFT and SPT).

TABLE 1. Bacteriological analysis: Media and incubation conditions.

Microflora	Medium	Time (h)	Temperature (°C)
Total count	Tomato agar (TMA)	48	25
Lactic acid bacteria	Man-Rogosa-Sharpe agar (MRS)	48	25
Brochothrix thermosphacta	Streptomycin-thalliumacetate-actidion agar (STAA)	48	22

RESULTS AND DISCUSSION

Prediction of shelf-life

For evaluating the effect on shelf-life, the following parameters have been included in the stepwise linear regression analysis.

Chemical parameters:

- salt in water
- pH (initial and at time of rejection)

Microbiological parameters:

- Total count by DEFT and SPT (initial and at time for acceptability limit)
- Specific bacteria (lactic acid bacteria and Brochothrix thermosphacta at time of rejection)

Number of days for:

- total count (DEFT and SPT) = log 7.5. (Stationary phase occurs at that time).
- DEFT total count reaches SPT total count (= "lag phase").

The analyses showed that only salt in water and the "lag phase" influenced the shelf-life significantly, and based on this, the following predictive mathematical model was established:

$$\text{Shelf life} = -27.34 + 9.16 \times \text{salt/water} + 1.39 \times \text{"lag phase"}$$

Using this model, the shelf-life could be predicted within the first week for 9 hams and within 2 weeks for 8 hams. According to Bøgh-Sørensen and Qvist, 1987, this period would probably be halved at a higher storage temperature, e.g. 10-15°C. The mean difference between organoleptically determined and mathematically calculated shelf-life was 2.2 days.

Some of the results are presented in the following illustrations (figures 1a, 1b, 1c) and it is obvious that the figures verify the model. Comparison of the figures 1a and 1c shows that the "lag phase" influence the shelf-life, figures 1b and 1c demonstrate the effect of salt in water, and figures 1a and 1b show that both "lag phase" and salt in water are necessary for prediction of shelf-life.

In this study, the "lag phase" is defined as days until DEFT total count is equal to SPT total count. The "lag phase" expresses the resuscitation phase of stressed bacteria. It is very important to emphasize that the resuscitation rate depends on degree of damage of the individual bacteria cells, and that it takes place gradually. In many cases the initial bacterial counts of heat-treated meat products determined by manual plating are <100 cfu/g, but after a few days it can rise to e.g. 1 mill. cfu/g. It is probably a consequence of regeneration of stressed bacteria, which are present in large numbers at the time of packaging, but these bacteria need some time for resuscitation. A more severe heat-treatment could probably kill most bacteria, but this would negatively influence the product quality.

Fig. 1a:

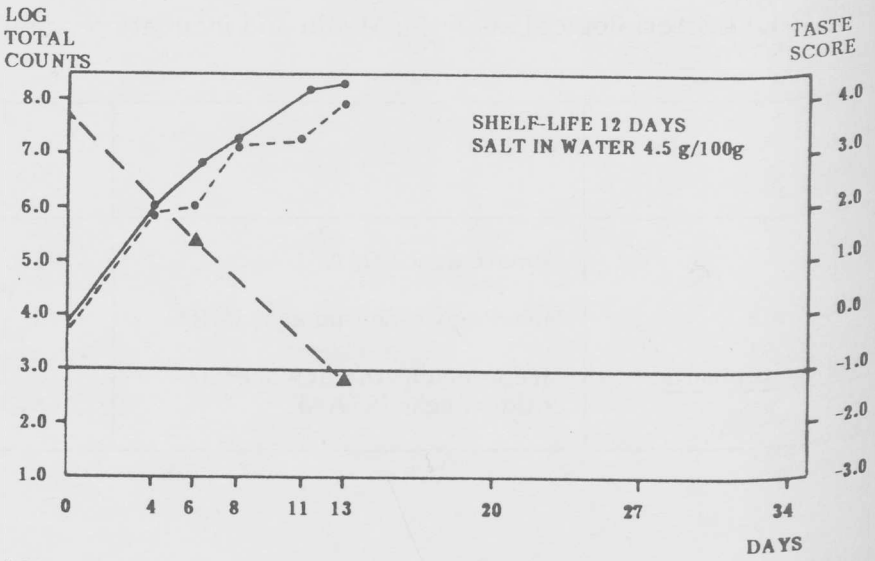


Fig. 1b:

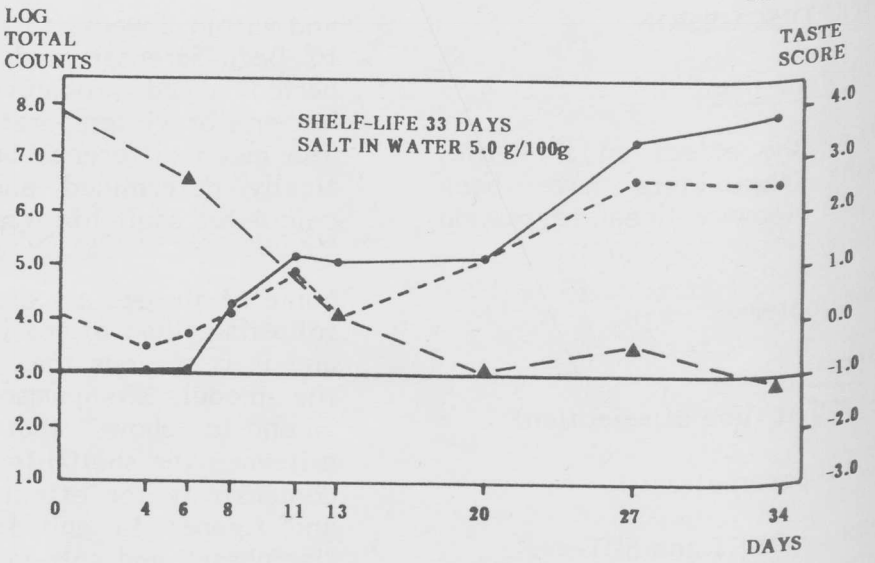
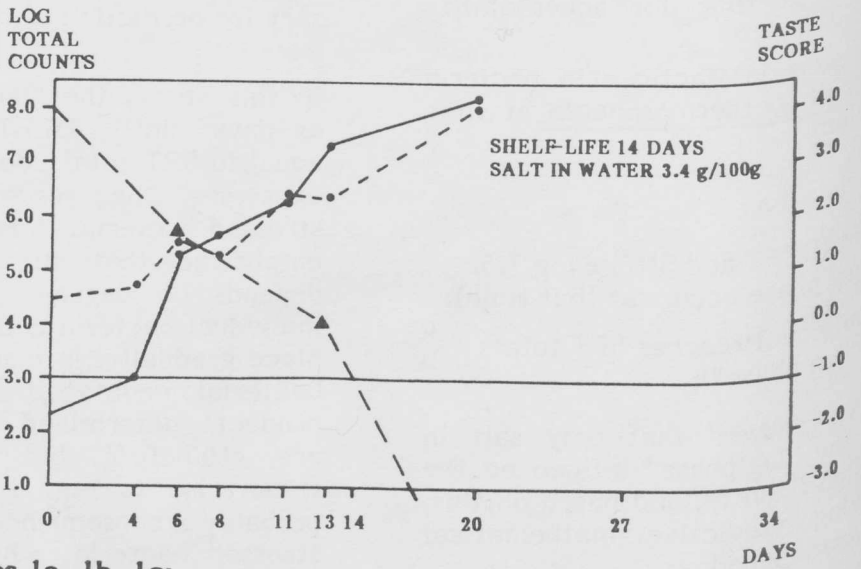


Fig. 1c:



Figures 1a, 1b, 1c:

Microflora and taste score during chill storage (max. 5°C) of cured, sliced, vacuum-packed ham.

●——● total counts, estimated by SPT
●- - - - -● total counts, estimated by DEFT
▲— — — —▲ taste score, +5/-5 hedonic scale, -1 = acceptability limit

In agreement with other investigations (Silla & Simonsen, 1985; Qvist & Fallesen, 1978) this experiment did not demonstrate any significant effect of the initial total count. In most hams the initial counts determined by DEFT are higher than the SPT total counts. The explanation for this phenomenon is that DEFT counts include both viable as well as non-viable gram-positive microorganisms (Liberski, 1989), whereas SPT results only discover the viable ones.

According to microbiological criteria in Sweden, delicatessen are rejected when cfu $>10^8$/g, whereas Denmark do not have such criteria (Simonsen et al., 1988). In this study, neither days until total counts (DEFT or SPT) reach log 7.5 nor total counts (DEFT or SPT) at the time, when the acceptability limit is passed, influence the storage life significantly.

The specific organisms (lactic acid bacteria and Brochothrix thermosphacta) at the time when the acceptability limit is passed did not influence the shelf-life significantly (results not presented). In all hams tested, the count of Brochothrix thermosphacta was very low (90% <log 5), whereas the lactic acid bacteria were the dominating flora in all hams, and they formed the majority of total counts during storage.

Of the chemical parameters only salt in water affected the shelf-life significantly. Salt (3.4 to 5.0 g/100 g water) did not affect the growth of lactic acid bacteria, but some observations indicate that the metabolic activity of these bacteria were reduced with increasing concentration of salt. Therefore, salt in water formed part of the model.

The initial mean pH was 6.4, whereas the mean pH at time of rejection was 6.0. The explanation for the rather constant pH during storage could be the buffering substances (polyphosphate) added to the product. The results are in agreement with other studies (Silla and Simonsen, 1985), which neither demonstrated any correlation between the storage life and the pH of sliced, vacuum-packed meat products.

Comparison of microbiological methods

The total counts, estimated by DEFT and SPT respectively, were compared, and the results are shown in figure 2. The correlation coefficient was r = 0.94, indicating a good agreement between the two methods.

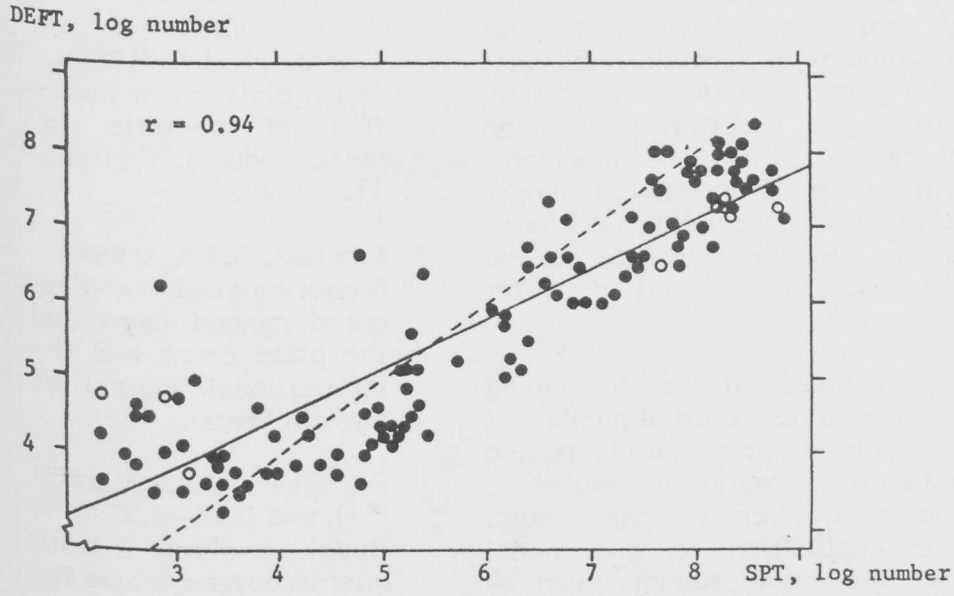


Fig. 2: Regression line for total counts, estimated by DEFT and SPT, respectively.

y = total counts, estimated by the DEFT
x = total counts, estimated by the SPT
• one obeservation, o two observations
——— regression line y = 1.86 + 0.66 x
- - - - - the line y = x (100% agreement)

A t-test shows, however, as it may also be seen from figure 2, that there is not a good agreement between the two methods at low counts (beginning of storage) and at very high counts (after 20 days of storage).

As mentioned earlier, the DEFT-counts include both viable and non-viable bacteria, whereas the SPT-countsinclude viable bacteria only. Sliced, vacuum-packed ham is a heat-treated product, and the majority of the initial microflora in the raw ham is inactivated by the heat-treatment. Therefore, at very low counts, the DEFT-counts are significantly higher than the SPT-counts (Jakobsen and Qvist, 1984). Unfortunately, there is no explanation for the significantly higher SPT-counts at very high counts. In the intervening storage period, there is an agreement between the results of the two methods.

CONCLUSION

The main conclusion of this experiment is that a mathematical model based on the two parameters: Salt in water and "lag phase" can be used for prediction of shelf-life of cured, cooked, sliced, vacuum-packed ham. For the producers, optimal control of salt addition is of great importance, and it is recommended that salt in water content be >4.0. In addition, good manufacturing practices and a high quality of raw materials are important, as this will ensure a relatively longer "lag phase", and the longer the "lag phase" is, the longer will the shelf-life of the product be, especially if salt in water content is above 4.0.

It has to be pointed out that the model has only been tried on a limited number of samples of one kind of meat products, and therefore further research is needed to extend the application of the model. Finally, the application of this model implies that the meat products must be kept at the low temperature (max. 5°C) during storage.

It is of a great importance for development and evaluation of microbiology to prove that microbiological rapid methods can be used advantageously in connection with predictive microbiology and also in connection with HACCP principles. In this way, it will be possible to use the microbiological results during processing, instead of after the products are sold and may be consumed.

REFERENCES

Bøgh-Sørensen, L., Højmark Jensen, J. Jul, M. and Zeuthen, P. (1986): Konserveringsteknik (in Danish), Vol. 1 and 2, 2nd edition, DSR, Copenhagen

Bøgh-Sørensen, L., Qvist, S. (1987): Accelereret holdbarhedsprøvning (in Danish) Report No. 43.34. Landbrugsministeriets Slagteri- og Konserveslaboratorium, Copenhagen.

Jakobsen, M. and Qvist, S. (1984): Direkte Epi-fluorescens Filter Teknik (DEFT) som hurtigmetode til mikrobiologisk analyse af kødprodukter (in Danish). Dansk Veterinær Tidsskrift, 67 (16), 802-811.

Jørgensen, B.R., Gibson, D.M. and Huss, H.H. (1988): Microbiological quality and shelf life prediction of chilled fish. International Journal of Food Microbiolgy, 6 (4), 295-307.

Liberski, D.J.A. (1986): Spiral plate count method for determination of bacteria in chilled, cured meat products. Fleischwirtschaft, 66 (7), 1125-1127.

Liberski, D.J.A. (1989): Bacteriological examinations of chilled cured canned hams and shoulders using the plate count and the DEFT-methods. International Journal of Food Microbiology (in Press).

Pettipher, G.L., Mansell, R., McKinnon, C.H. and Cousins, C.M. (1980): Rapid membran filtration-epifluorescent microscopy technique for direct enumeration of bacteria in raw milk. Applied and Environmental Microbiology, 39 (2), 423-429.

Qvist, S. and Fallesen, K.B. (1978): Begyndelseskimtallet og dets sammensætnings betydning for slicede, vakuumpakkede charcuterivarers holdbarhed (in

Danish). Dansk Veterinær Tidsskrift. 61 (10), 497-501.

Silla, H. and Simonsen, B. (1985): Shelf-life of cured, cooked and sliced meat products. I. Influence of composition, vacuumpackaging and modified atmospheres. Fleischwirtschaft, 65 (2), 181-183.

Simonsen, B., Hirn, J., Salminen, K., Georgsson, F., Bø, G., Framstad, K. and Florin, S.Q., eds. (1988): Mikrobiologiske retningslinjer for næringsmidler i Norden (in Norwegian and Finnish). Permanente Nordiske Udvalg for Næringsmiddelspørgsmål (PNUN). Nordisk Ministerråd. ISBN, København.