PE8.19 Predicting the shelf-life of fresh pork and beef 177.00

Lene Meinert (1) lme@danishmeat.dk, Anette G. Kock (1), Jesper Blom-Hanssen (1), Camilla Bejerholm (1), Niels T. Madsen (1) Hardy Christensen (1)
(1)Danish Meat Research Institute

Abstract—predicting the shelf-life of chill-stored fresh meat is important in order to ensure good eating quality at the use-by date and to ensure optimal and flexible retail distribution. General models describing both the growth of psychrotrophic microorganisms and shelf-life (raw meat odour) were generated based on data from shelf-life studies. The models were validated using shelf-life studies with various cuts collected at different commercial plants. The newly developed models are very useful for predicting the shelf-life of chill-stored fresh meat both for research purposes and for daily use in the meat industry. The models can be used, for example, for commutating the improvement of shelf-life along the distribution chain, for determining and documenting realistic use-by dates and for developing new packing concepts.

Index Terms— beef, mathematical modeling, pork, prediction, shelf-life.

I. INTRODUCTION

The increased demand for chill-stored fresh meat with a long shelf-life poses a huge challenge to the meat industry. The quality of chill-stored fresh meat may be affected by, for example, spoilage by microorganisms, lipid and protein oxidation and colour change. Correct declaration of the use-by date for fresh meat in the retail sector is essential in order to: 1) ensure optimal raw meat quality at the use-by date and thereby optimal eating quality perceived by the consumers and 2) ensure optimal use and distribution of the meat. The Nordic meat industry has requested a tool that can be used for the optimal declaration of the use-by date for chill-stored fresh meat. The objective of this work was to investigate whether the shelf-life of fresh meat could be predicted based on the colony count of preferably one microbiological parameter at the time of packing in combination with the selected packing method(s) and storage temperature(s).

II. MATERIALS AND METHODS

General set-up for the shelf-life studies For all the shelf-life studies, various cuts were collected at different commercial slaughterhouses or packing plants just prior to packing. The meat was either packed directly at the plant before transport or transported to the Danish Meat Research Institute (DMRI) and then packed. All the meat was stored at DMRI under controlled and standardised conditions until complete spoilage. During the test period, individual packs (samples) were randomly selected for microbiological evaluation and various organoleptic properties. Five samples were analysed each time, and analyses were conducted continuously (between 7 and 18 times) during each study. The data for beef comprise cuts from commercial cutting plants in Denmark and Sweden, one packing method (vacuum pack) and storage temperatures ranging between -0.3 °C and 14.4 °C (set temperature). The data for pork comprise cuts with and without rind from commercial cutting plants in Germany, Sweden and Denmark, two packing methods (vacuum pack and aerobic storage) and storage temperatures ranging between -1.2 °C and 4.7 °C (set temperature). Furthermore, studies have been carried out with pork, in which the storage temperature was varied during storage in order to investigate whether changes from "high" to "low" temperatures and changes from "low" to "high" temperatures resulted in the same shelf-life. Microbiological and sensory analysis Uniquely, all analyses (microbiological and sensory) were conducted on the same individual sample and could thus be directly linked to the development of spoilage. The order of analysis was 1) raw meat odour and general appearance, 2) psychrotrophic colony count [1] and 3) descriptive sensory evaluation of cooked meat [2]. Raw meat odour was evaluated by at least 3 experienced persons from DMRI. The odour was characterised using the following scale: 2: fresh; 4: slightly diverging but acceptable; 6: diverging to an unacceptable degree; 8: putrid/rotten. Sensory descriptive analysis was conducted at selected times during a given shelf-life study. Nine trained assessors, all tested and trained according to ISO 3972 and ISO 8586-1, performed the evaluation. The meat was cooked in roasting bags in the oven in order to avoid masking of shelf-life-related traits by, for example, fried meat flavour. At the start of each session, the assessors were given a "fresh" pork sample (frozen when fresh) in order to keep the freshness in mind, since the studies lasted for several weeks and in some cases months. Data analysis Fitting of both the microbiological growth curves and the sensory evaluation of the raw meat odour was performed using nonlinear regression (proc nlin) [3] with three different growth models: a logistic model, an exponential model and the Baranyi and Roberts model. The models were compared by the error between fitted and observed values (RMSE) and the ability to generate various parameters (e.g. ìmax) that could be fitted to the temperature by either a linear or exponential curve. The RMSE values in both the Baranyi and Roberts model and the logistic model were comparable. However, the Baranyi and Roberts model was chosen (Figure 1). ---

$$\ln(N) = \ln(N_\infty) - \ln\left(\left(\frac{N_\infty - N_0}{N_0}\right)e^{-\mu_{\max}\cdot A(t)}\right)$$

$$A(t) = t + \frac{1}{\mu_{\max}}\ln\left(e^{-h_0} + \left(1 - e^{-h_0}\right)e^{-\mu_{\max}\cdot t}\right)$$

Figure 1. The Baranyi and Roberts model [4] The parameter h0, which corresponds to the lag phase, was independent of temperature and packing method, but the lag phase for development of odour showed dependency on the initial psychrotrophic colony count. Growth curves from different studies were compared using the MicroFit v1.0 software developed by the Institute of Food Research.

III. RESULTS AND DISCUSSION

This work was initiated by the Nordic meat industry's demand for a tool for declaring an optimal use-by date for various cuts, packed aerobically or in vacuum and stored at different temperatures. The models are based on data from the analyses of more than 1500 pork cuts and 850 beef cuts, randomly collected over time at commercial plants in three countries. The inclusion of natural variation seen in "real life" is essential for the robustness and applicability of the models. The growth of psychrotrophs was independent of the surface type (rind/meat for pork) and origin of the meat (cuts, plant and country). Furthermore, changes from "high" to "low" temperatures and changes from "low" to "high" temperatures resulted in the same shelf-life. These findings made it possible to generate a model describing the growth of psychrotrophs in which the input was limited to a psychrotrophic colony count at start, storage temperature(s) and packing method (s). The development in raw meat odour and phychrotrophic growth follows the same pattern in both pork and beef, whereas parameters characterising the growth and development of spoilage differ. The development in raw meat odour and phychrotrophic growth in beef during storage is shown in Figure 2. The first organoleptic parameter to change during storage was raw meat odour. Parallel to modelling psychrotrophic growth, this finding made it possible to model shelf-life based on changes in raw meat odour. It was not possible to establish a direct connection between psychrotrophic count and raw meat odour at all times during the storage period. This was most likely due to the fact that the decay of meat is a combination of bacteriological activity and activity of intrinsic enzymes. A decrease in storage temperature (e.g. supercooling) will result in an increase in the importance of intrinsic enzymes compared with microbiological growth in relation to shelf-life.

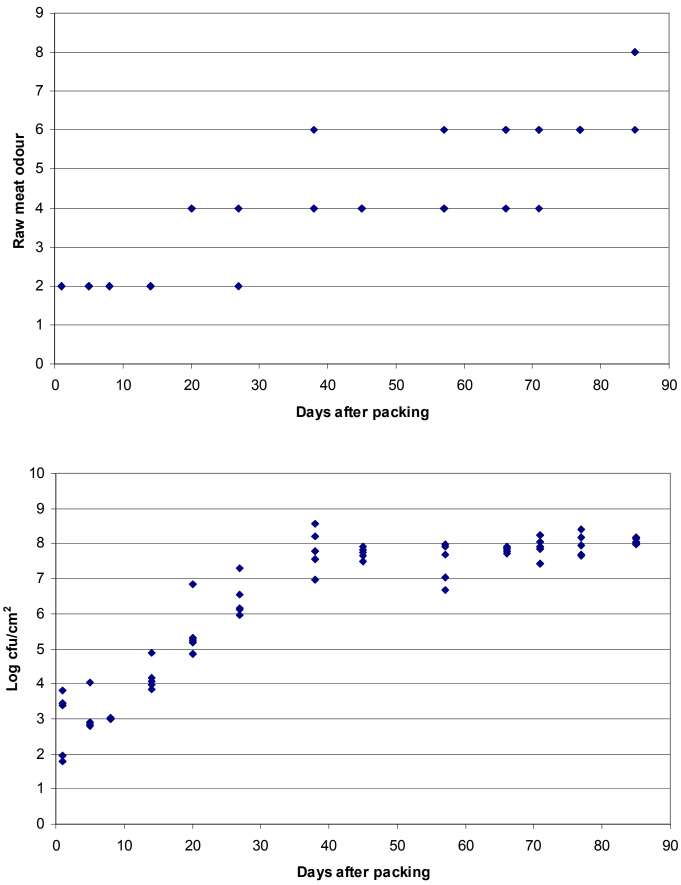

Figure 2

Figure 2. Data from a study using vacuum-packed beef cuts stored at 2.1 °C for 85 days. Growth of psychrotrophs is shown along with development in raw meat odour (2: fresh; 4: slightly diverging but acceptable; 6: diverging to an unacceptable degree; 8: putrid/rotten). One point may represent up to 5 samples/packs. As can be seen from Figure 2, the average value for raw meat odour follows a curve similar to the growth curve. The psychrotrophic colony count at the time of packing was used to model the length of the lag phase. Large natural variations were seen when modelling changes in raw meat odour. These variations occurred even though the studies were standardised and controlled in relation to a number of factors (time of slaughter, cuts, packaging, storage temperature, etc.). Many cuts (e.g. 100 loins in a single study) were used in each study to ensure the inclusion of natural variation. Therefore, the variations express reality and reflect what is seen in the retail sector, and cannot be related to single factors such as pH, which has been investigated (data not shown), cross-breed, rearing, feed, commercial plant, etc. The selection of different cuts from different commercial plants was conducted in order to include as much natural variation as possible. Raw meat odour is a valid indicator of shelf-life. The use of raw meat odour as a universal indicator of shelf-life was evaluated by a sensory study on sterile, “fat-free” and vacuum-packed pork loins stored at -1 °C. This set-up excluded microbiological activity and lipid oxidation, resulting in no apparent tainted odour, even after 11 weeks at -1 °C. However, considerable changes in flavour (bitter/old) of the cooked loins coincided with the shelf-life predicted by the model. These results proved the applicability of raw meat odour as an indicator of shelf-life, even in special set-ups. The work of validating and extending the model is ongoing and will include several temperatures, cuts (also minced meat) and packing methods (including MAP).

IV. CONCLUSION

Models for predicting shelf-life and the growth of psychrotrophs have been generated based on data from the analyses of a vast number of cuts collected at commercial plants. The models contain the natural variation seen in the industry, which underlines the robustness and applicability of the models. The models provide the user with the possibility to combine different storage conditions (packaging and temperature) and predict the shelf-life under specific storage conditions.

ACKNOWLEDGEMENT

This work was funded by the Danish Pig Levy Fund and Nortura, Norway. Kim Keller Rasmussen, Dezone, is thanked for excellent technical assistance with the models.

REFERENCES

[1] Nordic Committee on Food Analysis. (2006). AEROBIC MICROORGANISMS. Determination in foods at 30 °C, 20 °C or 6.5 °C. No 86, 4th ed. 2006.

[2] Meinert, L, Tikk, K., Tikk, M., Brockhoff, B. B., Bredie, W. L. P., Bjergegaard, C. & Aaslyng, M. D. (2009). Flavour development in pork. Influence of flavour precursor concentrations in longissimus dorsi from pigs with different raw meat qualities. Meat Science (81), 255-262

[3] SAS 9.1.3 Service Pack 4, Proc Nlin. SAS Institute Inc., Cary, NC, USA

[4] Baranyi, J & Roberts, T. A. (1994). A dynamic approach to predicting bacterial growth in food. International Journal of Food Microbiology, (23), 277-294.