COMPARISON BETWEEN TWO STATISTICAL MODELS FOR PREDICTION OF TURKEY BREAST MUSCLE COLOUR

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INTRODUCTION

In France, turkey breast meat is mainly sold from supermarkets in the form of scallops. A certain percentage of turkey breast meat shows discolouration, which is characterized by fading of the colour from pink to yellow-brown during storage. Consumers prefer a pink colour from an esthetic point of view. Cutting the meat makes changes in meat colour visible, and with the increase of turkey meat production, discolouration of scallops is now considered a major problem

Discolouration of meat causes financial losses. Previous studies showed that discolouration was more evident in M. Pectoralis superficialis which has a low haem pigment concentration. Discolouration seems to be partly caused by oxidation processes. It has been shown that myoglobin oxidation was involved in these processes (Santé et al., 1993). Little research has been done on raw turkey meat. In most cases, the studies were centred on lipid oxidation in minced meat (Kanner et al., 1988). It is important for the turkey industry to be able to detect early abnormal carcasses, in order to use them for different processing schemes. Swatland (1987) developped a technique for measuring the colour of raw and cooked turkey meat but the interpretation of the results remains difficult. The aim of this experiment was to determine which muscle characteristics predict reliably meat discolouration. This paper presents a statistical model to predict turkey breast meat colour.

MATERIALS & METHODS

The experiment was done in duplicate in the same abattoir (Dandy Company, France)

Sample preparation

Sixty-eight male turkeys, 15 weeks-old, were slaughtered at the abattoir and chilled conventionally. The Pectoralis major muscle was removed on the following day. Breast muscles were cut into sections perpendicular to muscle fibers. Scallops, 1.5 cm thick (80-100 cm2 surface area), were cut from each breast muscle and transported to the laboratory while maintained at 4°C.

pH measurements

The pH was measured directly in the M. Pectoralis major at 4 hours and 24 hours post mortem using a Schott Gerate CG 836 pH meter, equipped with a Schott Gerate N48 electrode. Samples of Pectoralis major at 30 min post-mortem were removed and deep frozen in liquid nitrogen before grinding in 5mM iodoacetate solution at the laboratory.

Temperature

Temperature was measured at a depth of 3 cm in the M. Pectoralis major at 1 h, 4 h and 24 h .

Colour measurements

Colour measurements were made at 1 h, 4 h, 24 h, 2 d, 5 d and 12 days post mortem using a Chromameter CR-300 (Minolta). Results were expressed as L* (lightness), a* (redness) and b* (yellowness) in the CIELAB system.
Heam pigment was determined according to Hornsey (1956) at day 2 at the laboratory.

Electrical conductivity

The measurement of electrical conductivity was performed using a MS TESTER. Two electrodes were sunk in the Pectoralis major. A frequency of 15 kHz was applied and dielectric factor loss was measured.

Subjective colour assessment

At 24 hours post mortem, after cutting procedure, the colour Pectoralis major was assessed by an expert of the processing plant using a four points scale: score 1 = pale meat, score 2 = normal , score 3 = dark meat and score 4 = very dark meat.

Statistical analysis

For the statistical treatment, pH, temperature, colour coordinates (L* a* b*), haem pigment and electrical conductivity were choosen as objective variables to explain variation in the subjective colour assessment.

- Canonical discriminant analysis

For a set of observations containing one or more quantitative variables and a classification variable defining groups of observations, canonical discriminant analysis proposes a discriminant criterion to classify each observation into one of the groups. The derived discriminant criterion from this data set can be applied to a second data set during the same execution of canonical discriminant analysis. The data set that the canonical discriminant analysis uses to derive the discriminant criterion is called the training or calibration data set.

Canonical discriminant analysis is a dimension-reduction technique related to principal component analysis and canonical correlation. Given a classification variable and several quantitative variables, canonical discriminant analysis derives canonical variables (linear combinations of the quantitative variables that summarize between-score variation in much the same way that principal components summarize total variation).

Canonical discriminant analysis evaluates the performance of a discriminant criterion by estimating error rates (probabilities of misclassification) in the classification of future observations. These error-rate estimates include error-count estimates and posterior probability error-rate estimates.

- Neural network

The multi-layer perceptron was chosen in this study. A multi-layer perceptron is a whole set of neural cells organized in succesive layers with nonrecurrent oriented connections among themselves. The output layer contains the predicted responses (= the scores) and the input layer contains the parameters that are likely to influence these responses (= pH, L*, a*, b*, ...).

Each neural cell are a single calculation processor which works in two successive steps : the activations originating from preceding cells (Aj) are individually multiplied by a coefficient wij (weight of the connection between neural cells i and j). The sum of all pondered activations is then calculated to obtain the total stimulation of the cell i (Si). With a sigmoidal activation function, , the neural cell then calculates its own activation Ai, such that Ai = F(Si) and transmits it to the next neural cell. Neural cells, whose activation are constantly maintained maximum, are also defined and called biases. The parameters of the model are the coefficients wij. Their identification was carried out using the classical back-propagation algorithm.

RESULTS

Colour

The development of redness, yellowness and lightness are presented in figures 1, 2 and 3. For each score, redness increased until day 2 and then decreased. The decrease was the strongest in muscles from score 1. In general, yellowness increased during storage and did not differ between colour scores. Score 1 showed the highest values of lightness during aging indicating fading of the meat colour.
Myoglobin concentration is presented in figure 4. The lowest and highest myoglobin concentrations were found in score 1 and 4 muscles, respectively, score 2 and 3 muscles having intermediate values.

pH

The development of pH is presented in figure 5. Thirty min post mortem, pH values were higher than 6.00 for all scores. The lowest ultimate pH (5.80) was found in muscles with score 1 and the highest pH (5.95) in muscles with score 4. During the first 30 minutes, there was no difference between the four scores. This result was also found by Van Hoof (1979) in intact breast meat and by Barbut (1993) in chopped breast meat. Van Hoof suggested that the appearant pale colour of poultry meat is associated with low pH-values and that turkey meat is susceptible to a PSE-like condition as described in pork. In pork, the rate of glycolysis is a major determinant in the development of PSE meat while the impact of the ultimate pH is much smaller. The present study found that in turkey breast meat, the rate of glycolysis cannot explain the difference in colour observed after 24 hours, possibly of the high rate of glycolysis in this type of muscle. In contrast, the ultimate pH was the lowest for the score 1 muscles, suggesting that initial energy stores may influence the predisposition for meat discolouration.

Electrical conductivity

The electrical dielectric loss values were comprised between 0.8 and 0.9. No significant differences were found between scores (data not shown).

Canonical discriminant analysis

Results of the canonical discriminant analysis are shown in table I. With 8 variables (L*, a*, b* and pH measured at 30 min and 4 hours post mortem) measured before 24 hours, only 52.9 % of turkey-meat pieces are correctly classified. A better classification can be made with 25 variables (all the varaibles at each time of measure) measured until 12 days : 80,9 % of turkey-meat pieces are well classified. This result is not acceptable for an industrial application which needs an earlier response.

Tabel I:
Row : original group (according to the expert assessment of colour)
Colum : resubstitution group (according to the statistical model)
In bold, samples classified similarly by the expert and the statistical model

Neural network

A three-layer perceptron was chosen in this study : an input layer, an hidden layer and an output layer. The input layer contains eight cells corresponding to the eight variables measured before 24 hours. The hidden layer contains four cells and the output layer also four cells corresponding to tne scores. The results are shown in the table II. 86.8 % of turkey-meat pieces are correctly classified. This result is acceptable for an industrial application. They are explained by the fact that a neural network takes into account non-linearity in the relationship between two variables.

Table II : neural network
Row : original group (according to the expert assessment of colour)
Colum : resubstitution group (according to the statistical model)
In bold, samples classified similarly by the expert and the statistical model

CONCLUSION

The palest meat was characterized by the lowest ultimate pH but did not shown any difference concerning the rate of onset of rigor mortis. Using canonical discriminant analysis, only 52% of breast meat was correctly classified before 24 hours post mortem. This statistical treatment can, therefore, not be used as a predictive model of meat colour. The neural network analysis gave much better results, with 88% of the breast meat correctly classified. This study is part of a larger program which aims to determine threshold values for the relevant variables (L*, a*, b* and pH), in order to be able to detect reliably muscle predisposed to discolouration.

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