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# Prediction of PSE-like zones, ultimate pH and cooking yield by computer image analysis of deboned hams

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## Introduction and objectives

Bone-in hams can be selected according to their ultimate pH level for the needs of the cooked ham sector, but the sorting of hams with a pH-meter become more difficult on deboned hams. On the other hand, a lot of new muscle areas are available on deboned hams to perform meat quality measurements, and the PSE-like zones are observable. Vision systems (using cameras) are more and more popular in the meat industry. This technique allows the measurement of multiples areas of the meat and can potentially be more robust than any operator based technique. The objective of the study is to design and to calibrate a vision system dedicated to the online prediction of the meat quality of deboned, defatted and trimmed hams. The meat quality parameters selected to develop prediction algorithms are: PSE-like zones, ultimate pH, cooking yield and slicing defects.

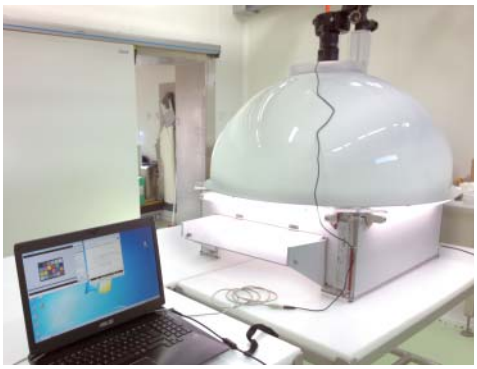

*Figure 1: the vision system*

*Figure 2: raw (top) and linearized (bottom) image of deboned ham*

## Materials and methods

- Vision system : a 70 cm square Lighting box (4 fluorescent D50 tubes), a light collector and a camera (Nikon 7100D + Nikon AF-S 24-70 lens). Camera settings: 5.6 aperture, 640 iso sensitivity, 1:125 shutter speed.
- n=59 deboned hams collection (uniform pH distribution) for the prediction of ultimate pH, cooking yield and slicing yield.
- n=110 deboned hams collection (uniform PSE-like zone class distribution) for the prediction of PSE-like zones (4 grades: 1=no defect, 4=deep defect).
- Image linearization and RGB to L*a*b polynomial conversion performed with ImageJ software and colorchecker digital SG chart (140 color tiles).
- 4 ROI (region of interest) determined on *Semimembranosus* (ROI_2_SM, ROI_15_SM) and *Biceps Femoris* (ROI_2_BF, ROI_10_BF).

## Results

- Best fitting model for RGB to L*a*b* conversion: $\Delta E_{cal.}$= 2,8.
- The prediction of the presence (1+2 class)/absence (3+4 class) of PSE-like zone is better with data from ROI_2_SM (a 2 cm wide circle from internal surface of the *Semimembranosus*): 95 % of correct classification.
- The vision system can predict ultimate pH and cooking yield (r=0,79 and 0,66) but errors are too high for individual prediction (rmsec=0,13 and 4,1).
- The relationship for ultimate pH and cooking yield are similar to what can be observed with the L* of *Semimembranosus* measured with a colorimeter (r=0,63 and 0,78, respectively).

| | pH24 | L* | a* | b* | cooking yield (%) | slices ok (%) | paste-like slices (%) | cohesion defect slices (%) |
|---|---|---|---|---|---|---|---|---|
| n= | 110 | | | | 59 | | | |
| m | 5.69 | 60 | 11 | 11 | 86.0 | 41.6 | 22.2 | 42.6 |
| sd | 0.21 | 6.2 | 2.6 | 2.5 | 5.2 | 37.8 | 20.7 | 40.5 |

*Table 1: calibration samples data set characteristics*

| Ultimate pH prediction model | $R^2c$ | rmsec |
|---|---|---|
| L*a*b*roi_2_sm | 0.56 | 0.14 |
| L*a*b*roi_15_sm | 0.52 | 0.15 |
| L*a*b*roi_2_bf | 0.46 | 0.16 |
| L*a*b*roi_10_bf | 0.41 | 0.16 |
| L*a*b*roi_2_sm + $(L^*)^2$ $(a^*)^2$ $(b^*)^2$ roi_2_sm | 0.63 | 0.13 |

*Table 2: prediction of pH24 according to colorimetric data obtained with the camera (n=110)*

| Cooking yield prediction model | $R^2c$ | rmsec |
|---|---|---|
| L*a*b* roi_2_sm | 0.36 | 4.3 |
| L*a*b* roi_15_sm | 0.43 | 4.1 |
| L*a*b* roi_2_bf | 0.37 | 4.2 |
| L*a*b* roi_10_bf | 0.27 | 4.6 |

*Table 3: prediction of cooking yield according to colorimetric data obtained with the camera (n=59)*

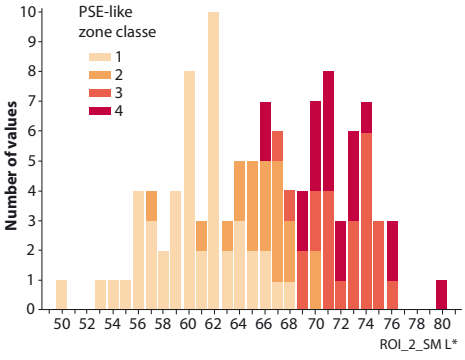


*Figure 3: distribution of the subjective grading of PSE-like zones for calibration data set according to ROI_2_SM L* (n=110)*

*Figure 4: ROI_2_SM, a 2 cm wide circle on the internal surface of the Semimembranosus muscle*

| Model | Overall correct classification (%) | Correct classification for 1+2 grade (%) | Correct classification for 3+4 grade (%) |
|---|---|---|---|
| L*a*b*roi_2_sm | 95 (104/110) | 95 (63/66) | 93 (41/44) |
| L*a*b*roi_2_bf | 90 (99/110) | 91 (60/66) | 89 (39/44) |
| L*a*b*roi_2_sm +L*a*b*roi_2_bf | 93 (102/110) | 94 (62/66) | 91 (40/44) |

*Table 4: PSE-like zone (absence(1+2)/presence(3+4)) prediction results for logistic regression of ROI_2_SM and ROI_2_BF colorimetric data obtained with the camera (n=110)*

## Conclusions

The vision system developed in the present study and its calibrations showed very promising results especially for PSE-like zone prediction (5% of false classification). Designed for deboned-hams measurements, the system allows predictions in motion, and does not require operator. Software design work is still needed to perform automatic ROI detection and calibrations, but pork meat industry expectations are strong on automation of meat quality sorting.