USE OF LIGHT BASED METHODS AS PREDICTION TOOL FOR THE QUALITY OF FRESH PORK FOR COOKED HAM PRODUCTION

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Abstract – The use of light based methods, in particular Near Infrared Spectroscopy (NIRS) and 'Capteur Gras/Maigre' (CGM) technology, to predict more accurately the quality of fresh pork for the production of cooked ham was investigated. A total of 55 hams was selected based on pH at 30 minutes post mortem. Traditional meat quality measurements as well as NIR and CGM measurements were performed on the fresh hams. The hams were prepared to cooked hams in a pilot plant after which they were sliced and visually scored according to whether destructured zones were present or not. It was aimed to classify the fresh hams into normal or inferior quality using the light based techniques. A 62.5% correct classification after cross-validation was obtained with NIRS for inferior quality hams, which is similar as obtained by using a combination of electrical conductivity (PQM) and L* color value measurements. However, further improvement is needed to develop a more robust classification tool.

Key Words – Pig, Destructured zones, PSE

I. INTRODUCTION

During the production of cooked ham, texture defects are often noticed [1, 2, 3]. Characteristics of the final product are not only determined by the used process conditions, but also by the technological properties of the raw material. Destructured zones in the cooked ham are estimated to be present in up to 20% of the cooked hams [4]. These destructured zones are described as 'soft zones, having an abnormal pale color, with a high loss of moisture' [5] and are more frequently observed when high quality cooked hams are produced, i.e. with a minimum of added technological aids during the process. Structural defects on the cooked ham are often correlated with lower yields, slicing problems and higher moisture loss. Concerning biochemical properties, Laville et al. [6] concluded that destructured zones show strong similarity to those of pale, soft and exudative (PSE) meat. Both defects are characterized by a higher protein denaturation in the fresh meat, occurring due to a rapid glycolysis and slow temperature decrease post mortem. Laville et al. [7] reported that most destructured zones are observed in the core of the ham at the level of *Semimembranosus* (SM), *Adductor* (AD) and *Biceps femoris* (BF) muscles. As those muscles are situated in the depth of the ham, they are not visible during visual control of the fresh ham. Therefore, fast and objective measurements at the sensitive places in the core of the ham are needed to give more information on the technological quality of the fresh ham, and thus to predict its suitability for producing high quality cooked ham. Previous studies showed the potential of NIRS to categorize meat and meat products based on quality [8]. Geesink et al. [9] indicated that NIRS could be used for the classification of pork according to water holding capacity. García-

Rey et al. [10] reported that NIRS has been able to classify hams according to texture/color. Olsen et al. [11] showed the potential of the CGM grading system to classify pig carcasses by measuring reflection intensity, while inserting the probe through the backfat of the carcass. The aim of this study was to evaluate the use of light based methods, in particular NIRS and CGM technology, as classification tools in order to classify fresh hams into different classes of quality, predicting the quality of the fresh hams for cooked ham production more accurately.

II. MATERIALS AND METHODS

Sample collection and measurements

A total of 55 fresh hams was selected at 3 different slaughterhouses based on pH and temperature values measured 30 minutes post mortem in the SM muscle. As Balac et al. [12] reported that the prevalence of destructured zones is positively correlated to a low pH_{30min}, some fresh hams with a pH_{30min} lower than 5.8 were selected to increase the probability of hams with inferior meat quality. After selection, the fresh hams were transported to the laboratory and further stored at 4°C. The ultimate pH (Hanna HI99163, Hanna Instruments, Temse, Belgium) and PQM (PQM-I/KOMBI, Intek Klassifizier-ungstechnik, Aibach, Germany) were measured 24 hours after slaughter on the raw, intact hams, in particular at the transition zone between SM and AD muscle as well as on the BF muscle. After deboning the hams, the same conventional measurements, i.e. pH and PQM, were performed on the different muscles. Using a HunterLab colorimeter (MiniScan XE, Hunter Associates Laboratory, Reston, VA, USA), CIE $L^*a^*b^*$ color values were determined. Drip loss was analyzed using the Honikel [13] method. NIR spectra were acquired using an Antaris II Analyzer (Thermo Fisher Scientific, Erembodegem, Belgium) equipped with a fiber optics probe over the range 4000-12000 cm^{-1}. Spectra were recorded performing 128 scans with a resolution of 16 cm^{-1}. On the intact hams, 2 types of NIR measurements were carried out 1) on the surface of the BF muscle, 2) at the transition zone between SM and AD muscle where an incision was made to collect the NIR spectrum at 8 cm of depth. On the deboned hams, NIR spectra on both BF muscle and transition between SM and AD were recorded at the surface. Reflection profiles were collected at 800 nm using the CGM grading system (Sydel, France). Afterwards, hams were prepared to high quality cooked hams (with a minimum of additives) in a controlled pilot plant. Cooking loss was determined based on the percentage of weight loss. After 10 days, cooked hams were sliced and visually classified into two different classes of quality, i.e. 1) normal quality (= absence of destructured zones), 2) inferior quality (= presence of destructured zones). Figure 1 shows an example of both normal and inferior quality hams, visually classified by the researchers.

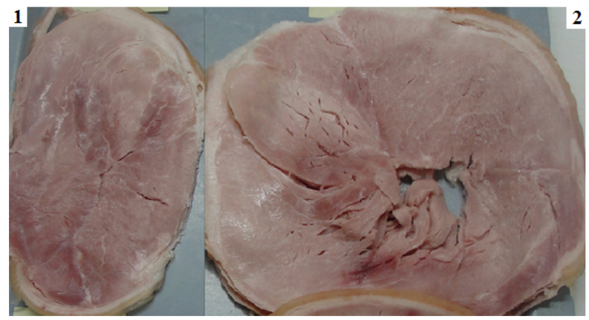

Figure 1. Normal (1) and inferior (2) quality hams

Data analysis

To test the significance of differences between normal and inferior quality hams, data were subjected to an unpaired *t*-test using SPSS Statistics (IBM, version 20). Discriminant analysis (SPSS Statistics, IBM, version 20) was performed in order to investigate the use of 1) the conventional methods, 2) the light based techniques, to classify the fresh hams according to the visual score that was given to the cooked hams after slicing. For the NIR spectral data, factor analysis was first performed to reduce the absorbance data at different wavenumbers into fewer number of factors which were used for further discriminant analysis.

III. RESULTS AND DISCUSSION

After slicing, 39 hams of the original 55 were visually classified into normal quality hams; 16 hams showed presence of destructured zones. Results of meat quality parameters, measured on the intact and deboned fresh hams, of both normal and inferior classified cooked hams are shown in Table 1.

Table 1. Mean and standard deviation (SD) of the meat quality parameters, measured on the intact and deboned hams, of both normal (n=39) and inferior (n=16) cooked hams

Intact		Normal		Inferior		
	Muscle	Mean	SD	Mean	SD	P
pH 30 min p.m.	SM	6.04	0.33	5.69	0.21	<0.001
pH 24h p.m.	SM/AD	5.58	0.14	5.54	0.12	0.340
PQM 24h p.m.	SM/AD	11.38	2.92	10.60	3.04	0.380
Deboned						
pH 24h p.m.	SM/AD	5.57	0.15	5.51	0.19	0.240
pH 24h p.m.	BF	5.68	0.20	5.58	0.12	0.070
PQM 24h p.m.	SM/AD	12.13	2.74	10.63	2.59	0.070
PQM 24h p.m.	BF	12.17	2.70	10.40	2.41	0.030
L^* 24h p.m.	SM/AD	55.55	5.29	62.48	3.58	<0.001
L^* 24h p.m.	BF	47.88	6.12	54.83	5.92	<0.001
a^* 24h p.m.	SM/AD	10.46	1.64	10.56	3.56	0.880
a^* 24h p.m.	BF	11.92	2.07	11.64	3.02	0.700
b^* 24h p.m.	SM/AD	14.91	5.95	19.19	1.91	<0.01
b^* 24h p.m.	BF	13.40	5.95	18.35	1.68	<0.01

Cooked hams exhibiting inferior quality had significantly lower pH_{30min} and significantly higher L^*_{24h} and b^*_{24h} values than cooked hams with normal quality. Concerning the technological quality parameters, cooked hams with inferior quality had significantly higher cooking losses than hams with normal quality (Table 2).

Table 2. Mean and standard deviation (SD) of percentage drip loss and cooking loss of normal and inferior cooked hams

%	Normal			Inferior			
	n	Mean	SD	n	Mean	SD	P
Drip loss*	37	1.05	0.99	10	1.61	1.36	0.150
Cooking loss	39	5.29	1.22	16	6.91	1.14	<0.001

* analyzed on the fresh hams

Figure 2 shows an example of the first derivative NIR spectra, collected on the BP muscle of the fresh ham after deboning, for both normal and inferior classified cooked hams. Systematic shifts in spectral data were observed around 7200 and 5300 cm^{-1}. Since those spectral regions include protein absorption bands [14], sarcoplasmic and myofibrillar protein solubility will be determined in the near future as possible indicator for the occurrence of destructured zones in cooked hams. Previous studies already reported the coherence between destructured zones and a higher protein denaturation [6, 15].

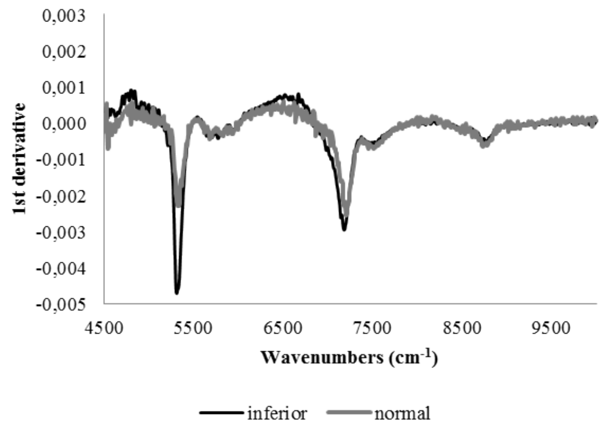

Figure 2. Example of NIR spectra measured on fresh hams showing 1) normal and 2) inferior quality

Both conventional and NIR/CGM data were used to classify the raw hams according to the visual score that was given after slicing. Classification results after cross-validation, based on the measurements carried out 1) on the raw, intact hams and 2) after deboning, for both normal and inferior classified hams are shown in Table 3.

Table 3. Percentage correct classification after cross-validation for both normal (n=39) and inferior (n=16) classified hams

Intact	Muscle	Normal	Inferior	Total
pH 30 min p.m.	SM	89.7	43.8	76.4
NIR spectra	BF	87.2	43.8	74.5
CGM	AD	89.7	43.8	76.4
Deboned				
PQM 24h p.m. (1)	BF	94.9	0.00	67.3
L^* 24h p.m. (2)	SM/AD	87.2	50.0	76.4
L^* 24h p.m.	BF	87.2	50.0	76.4
b^* 24h p.m.	SM/AD	100	6.30	72.7
b^* 24h p.m.	BF	97.4	12.5	72.7
(1) + (2)		89.7	62.5	81.8
NIR spectra	BF	87.2	62.5	80.0

The best light based classification was obtained by measuring NIR spectra on the BF muscle after deboning. Factor analysis followed by discriminant analysis resulted in 87.2% and 62.5% correct classification after cross-validation for normal and inferior hams, respectively, which is approximately equal to the classification obtained by combination of the PQM_{24h} + L^*_{24h}, i.e. 89.7% and 62.5% for normal and inferior hams, respectively. Based on the CGM data, 43.8% of the inferior hams could be classified correctly after cross-validation when measuring on the AD muscle of the intact ham which is similar to the classification obtained by measuring 1) pH_{30min} on the SM muscle and 2) NIR spectra on the BF muscle. Based on cooking losses, 89.7% and 50% of normal and inferior hams, respectively, could be classified correctly after cross-validation.

IV. CONCLUSION

The obtained classification results based on NIR and CGM data are promising. However, further improvement needs to be done so that more inferior hams could be classified correctly and a more robust classification tool can be obtained.

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