RAPID ANALYSIS OF DRIP LOSS IN PORK USING VIS/NIR SPECTROMETRY

K. Fischer*[1], J.P. Lindner[2], P. Freudenreich[1], and M. Judas[1]

[1]*Federal Research Centre for Nutrition and Food, 95326 Kulmbach, Germany*
[2]*Training and Research Centre for Pig Production, 97359 Schwarzenau, Germany*

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Introduction

Weight loss occurring in the course of cooling and storage results directly in monetary loss. Moreover, massive ageing loss appearing in self-service packages may make the product unsightly and keep the consumer from buying the respective piece of meat. With respect to determination of water-holding capacity (WHC) traits there are some direct methods available, such as the EC standard method (bag method) and the EZ-method which were compared by Otto et al. (2004). But both of them provide results only after a measuring period of at least 24 h. Therefore, direct methods are used regularly neither at progeny testing stations nor for the quality evaluation at slaughter plants. Alternatively, the WHC may be estimated by indirect methods connected with the status of PSE and DFD like pH (45 min and 24 h p.m.) or electrical conductivity (24 h p.m.). These techniques, however, are not highly enough related to drip loss to be completely contenting for the use in the market chain. But there are some reports of predicting WHC by means of visible (VIS) and near-infrared (NIR) reflectance spectroscopy (Brondum et al., 2000; Forrest et al., 2000; Geesink et al., 2003; Hoving-Bolink et al., 2005). Due to different equipments, conditions of measurement and breed of the animals investigated, the estimation accuracy was not consistently satisfying. The aim of our study was to contribute parameters of prediction with respect to a whole variety of WHC traits using a powerful broad-spectral device under online conditions.

Material and Methods

A sample of 179 loins (*M. longissimus dorsi*) was selected from different crossbreds as well as pure bred Piétrain and Large White provided by a progeny testing station. In addition to some usual meat quality traits like pH, electrical conductivity, brightness (L*), a variety of criteria concerning water-holding capacity (drip loss, ageing loss, thawing loss, cooking loss) was included at different times after slaughter. All measurements of raw meat fluid loss started at 24 h p.m.. Drip loss was determined using the “bag method” up to 6 days after sampling, and the “EZ method” for a period of only one day. In contrast, “ageing loss” (all superficial connective tissue removed, sample stored in a closed bag in contact with the fluid) was recorded up to 6 days. After a storage time of 6 days a 2.5 cm slice from the ageing loss sample was cut out, deep-frozen and used for the determination of thawing loss and cooking loss (water bath, sample within plastic bag, internal temperature 72 °C).

VIS/NIR measurements were carried out 24 h p.m. with the NIR-System 6500 (Foss, Silversprings, USA). The probe, a remote reflectance sensor head, had the shape of a plain ashlar equipped with a quartz window of 20 cm^2 for emitting light (180° angle) onto the meat surface and receiving the reflected light (45° angle). Within the range from 400 to 2500 nm every 4 nm one reflectance value was recorded. One completed scan took 60 s. For the measurement, the probe was put onto the caudal surface of the drip loss sample (bag method) which was a whole slice of 2.5 cm thickness and cut out at the height of the 14^{th} thoracic vertebra. Data analysis (calibration, cross validation) was performed using WINISI software (1.50; Infrasoft International, Port Matilda, USA).

Results and Discussion

Characterization of the sample. The distribution of the pH values 45 min p.m. reveals that the range below 6.0, which may be regarded as typical for PSE meat, is underrepresented (Table 1). DFD meat on the other hand with pH values 24 h p.m. > 6.0 does not exist in the whole sample at all. Drip loss measured with the EC method (bag method), shows after a period of 1 day a 50^{th} and 99^{th} percentile of 2.7 % and 6.8 %, respectively. This seems low compared to the results of the EZ-method that generated values of 2.9 % and 13.1 %, respectively. The latter method uses only a small piece of muscle tissue (ca. 10 g) with a larger surface in relation to the weight, which promotes the release of fluid. The percentiles of EC drip loss after 6 days are similar to those of the thawing loss. Between these parameters is a negative correlation of about -0.5 (not shown in the table).

Estimation with VIS/NIR. Among the criteria normally used for characterizing the PSE/DFD status, the best calibration with R^2 of 0.94 and a standard error of 0.73 could be calculated for the electrical conductivity 24 h p.m., followed by L^*_{24}, pH_1 and pH_{24} (Table 2). The low R^2 of 0.61 in the case of pH_{24} may be due to the small range of this parameter. Among water-holding capacity traits, the EC drip loss after 1 day is best predicted (R^2 = 0.86, SEC = 0.58). In the course of a longer measuring period, the accuracy of drip loss estimation degrades moderately. As to be expected, the prediction parameters are generally slightly lower for the cross validation. Estimation of ageing loss is not as successful as in the case of drip loss, but the coefficients of determination increase slightly with extended dripping time. The main reason may be that the VIS/NIR measurements were taken only once, and directly upon the slices used for drip loss determination. The ageing loss samples (about

400 g) were cut out in the lumbar region of the loin (all connective tissue removed) and not measured by VIS/NIR. The statistic parameters for the prediction of thawing loss and cooking loss are unfavourable and not appropriate for practical use (Table 2).

Table 1. Distribution of selected meat quality traits in the sample investigated (*M. long. dorsi*, n = 179)

Trait	1. Percentile	25. Percentile	50. Percentile	75. Percentile	99. Percentile
pH 45 min p.m.	5.42	6.06	6.27	6.51	6.73
pH 24 h p.m.	5.27	5.45	5.50	5.56	5.81
EC 24 h p.m.	2.1	3.4	4.7	8.9	12.1
L* 24 h p.m.	42.1	49.6	52.0	54.0	63.0
EZ Drip loss - 1 d (%)	0.2	1.1	2.9	6.4	13.1
EC Drip loss - 1 d (%)	0.5	1.6	2.7	4.0	6.8
Thawing loss (%)	2.4	6.1	7.2	8.2	11.7
Cooking loss (%)	24.9	28.2	29.8	31.0	34.4

Table 2. Range and statistics of estimation for selected meat quality traits with VIS/NIR: coefficients of determination (R^2), standard error of calibration (SEC), and standard error of cross validation (SECV)

Trait	Range	Calibration		Cross validation	
		R^2	SEC	R^2	SECV
pH 45 min p.m. ("pH_1")	5.41 – 6.74	0.89	0.09	0.75	0.14
pH 24 h p.m.	5.25 – 5.88	0.61	0.04	0.58	0.04
EC 24 h p.m.	2.0 – 12.9	0.94	0.73	0.85	1.13
L* 24 h p.m.	40.9 – 63.6	0.91	1.10	0.87	1.31
EZ Drip loss - 1 d (%)	0.2 – 14.2	0.89	1.04	0.84	1.27
EC Drip loss - 1 d (%)	0.3 – 6.8	0.92	0.42	0.86	0.58
EC Drip loss - 2 d (%)	0.8 – 8.6	0.75	0.93	0.73	0.97
EC Drip loss - 3 d (%)	1.3 – 10.9	0.81	0.86	0.76	0.96
EC Drip loss - 6 d (%)	2.0 – 11.6	0.78	0.93	0.67	1.12
Ageing loss - 1 d (%)	0.7 – 12.4	0.61	1.65	0.60	1.66
Ageing loss - 3 d (%)	1.6 – 17.5	0.71	1.60	0.70	1.62
Ageing loss - 6 d (%)	2.2 – 18.9	0.72	1.52	0.72	1.53
Thawing loss (%)	0.3 – 12.0	0.35	0.97	0.33	0.98
Cooking loss (%)	24.7 – 36.5	0.32	1.37	0.27	1.43

Conclusions

Basically, VIS/NIR measurements can be a useful tool for the prediction of drip loss, pH_1, electrical conductivity, colour, and, with reservations, of ageing loss. Thawing and cooking loss cannot be assessed with this technique. The results presented have still to be verified on an independent validation sample, including animals from commercial slaughter plants. Moreover, further investigations should be performed including probes which are not so large and heavy as the one used in our experiment.

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