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An attempt to predict pork drip loss from pH and colour measurements or near infrared spectra using artificial neural networks

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ABSTRACT

The ability to predict meat drip loss by using either near infrared spectra (*SPECTRA*) or different meat quality (*MQ*) measurements, such as pH_{24}, Minolta L^*, a^*, b^*, along with different chemometric approach, was investigated. Back propagation (BP) and counter propagation (CP) artificial neural networks (ANN) were used and compared to PLS (partial least squares) regression. Prediction models were created either by using *MQ* measurements or by using NIR spectral data as independent predictive variables. The analysis consisted of 312 samples of *longissimus dorsi* muscle. Data were split into training and test set using *2D* Kohonen map. The error of drip loss prediction was similar for ANN (2.2–2.6%) and PLS models (2.2–2.5%) and it was higher for *SPECTRA* (2.5–2.6%) than for *MQ* (2.2–2.3%) based models. Nevertheless, the *SPECTRA* based models gave reasonable prediction errors and due to their simplicity of data acquisition represent an acceptable alternative to classical meat quality based models.

1. Introduction

The water-holding capacity is a major pig meat technological property. In practice many methods are used to asses this quality, like drip loss, filter paper test, cooking loss or centrifugal force method (Allison, Ritter, & Doumit, 2002; Bertram et al., 2003; Forrest et al., 2000; Honikel, 1987; Lundström & Malmfors, 1985; Merour, Riendeau, Maignel, Rivest, & Vautier, 2007; Otto, Roehe, Looft, Thoelking, & Kalm, 2004; Otto et al., 2006; Penny, 1975; Trout, 1988), which are not always well correlated. Although the methods for the assessment of water-holding capacity are rather simple they remain time-consuming and destructive and thus impractical for the industrial use. Water-holding capacity is often indirectly estimated by means of different measurements such as meat colour or pH value; however these measurements explain only a part of the variation (Allison et al., 2002; Huff-Lonergan et al., 2002). Lately, there is a growing interest for spectroscopic methods e.g. NIR (near infrared) spectroscopy or Hennesy grading probe. Such approach has many advantages over the existing methods since it provides cheap and rapid determination of many parameters simultaneously (Monin, 1998). The literature data on the ability of NIR spectroscopy for meat chemical composition is abundant, while for the water-holding capacity prediction the reports are not as numerous (Brøndum et al., 2000; Čandek-Potokar, Prevolnik, & Škrlep, 2006; Geesink et al., 2003; Meulemans, Dotreppe, Leroy, Istase, & Clinquart, 2003). The results of the mentioned studies are quite variable and indicate that the ability of NIR spectroscopy to predict water-holding capacity is limited. It may be speculated, that the use of alternative chemometric approach might improve the prediction. Artificial neural networks (ANN) are a modern research tool that is nowadays applicable in different fields including agriculture and food-processing (Brodnjak-Voncina, Cencic-Kodba, & Novic, 2005; Lozano, Novič, Rius, & Zupan, 1995; Zupan, Novič, Li, & Gasteiger, 1994). The method has numerous advantages over the standard regression methods like handling with highly correlated variables and non-linear measurements and has the potential for the classification (Zupan, Novič, & Ruisanchez, 1997).

The aim of the current study was thus firstly to reassess the aptitude of NIR spectroscopy for meat drip loss prediction and secondly to check if an alternative chemometric approach, i.e., the application of artificial neural networks (ANN), could improve the ability to predict meat drip loss.

2. Materials and methods

2.1. Data

2.1.1. Material and measurements

The study comprises 312 pig *longissimus dorsi* muscle samples. For all samples different meat quality (*MQ*) measurements were

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performed. In order to obtain a wide range of studied meat quality parameters (pH, *CIE* L^*, a^*, b^*, drip loss) muscle samples were collected from several slaughter batches, in two abattoirs which slaughter pigs of different genotypes. The *CIE* L^*, a^*, b^* and pH measurements were taken in the abattoir a day after the slaughter on the cross-section of *longissimus dorsi* muscle (cut at the level of last rib). Colour measurements (*CIE* L^*, a^*, b^*) were taken in triplicate on a freshly-cut surface using Minolta Chroma Meter CR-300 (Minolta Co. Ldt, Osaka, Japan) with an 11 mm diameter aperture, D_{65} illuminant, calibrated against white tile. Muscle ultimate pH (pH_{24}) was determined in two replicates in the central area of the *longissimus dorsi* muscle using an MP120 Mettler Toledo pH meter (Mettler-Toledo, GmbH; 8603 Schwarzenbach, Switzerland). The water-holding capacity of meat was assessed using EZ drip loss method which was performed as described by Christensen (2003). Shortly, two cylindrical pieces with a diameter of 2.5 cm were weighted, placed in plastic sealable cups (Sarstedt AG & Co. meat extract collector) and stored at 4 °C for 48 h, when the meat pieces were reweighed. Drip loss was expressed as a percentage of initial sample weight. Basic statistics for meat quality traits pH_{24}, *CIE* L^*, a^*, b^* and drip loss after 48 h were calculated using the UNIVARIATE procedure and correlation coefficients among meat quality traits using CORR procedure (SAS, 2002).

2.1.2. NIR spectroscopy analysis

For NIR spectroscopy, the samples of *longissimus dorsi* muscle were taken at the level of 2nd lumbar vertebra, i.e., neighbouring the location where meat quality measurements were made and were stored at 4 °C until scanning. Scanning of the samples was performed in the laboratory 48 h after slaughter. For practical reasons (same sample set used for intramuscular fat determination/prediction) we decided to work with minced samples, since our previous results (Čandek-Potokar, Prevolnik, & Škrlep, 2006) as well as other reports (Andersen, Borggaard, Rasmussen, & Houmøller, 1999) demonstrate similar prediction results for intact and minced meat in case of drip loss or pH, respectively. Samples were first homogenized in a domestic blender for at least 30 s in order to obtain a homogenous mixture, then placed into a quartz cup (47×57 mm^2) and covered with a paper disc. Scans (*SPECTRA*) were taken over the wavelength range 400 to 2500 nm using the laboratory spectrophotometer NIR Systems model 6500 (Silver Springs, MD, USA). For each sample one scan was recorded. Reflectance data were collected as log 1/*R*.

2.1.3. Data pre-processing

The pre-processing of meat quality data (*MQ*) included normalization in a continuous space, given as $x_{NEW} = (x_{OLD} - \overline{x})/s$, where $\overline{x}$ and s stand for mean and standard deviation, respectively. Firstly, the whole set of samples was normalized. After the splitting of the samples into the training and test set, the normalization was repeated on both sets using the same normalisation parameters (mean and standard deviation of the training set). In case of *SPECTRA* the absorbance values (log 1/*R*), represented as 1036 data points, were compressed (PL1 option of WinISI II – an algorithm

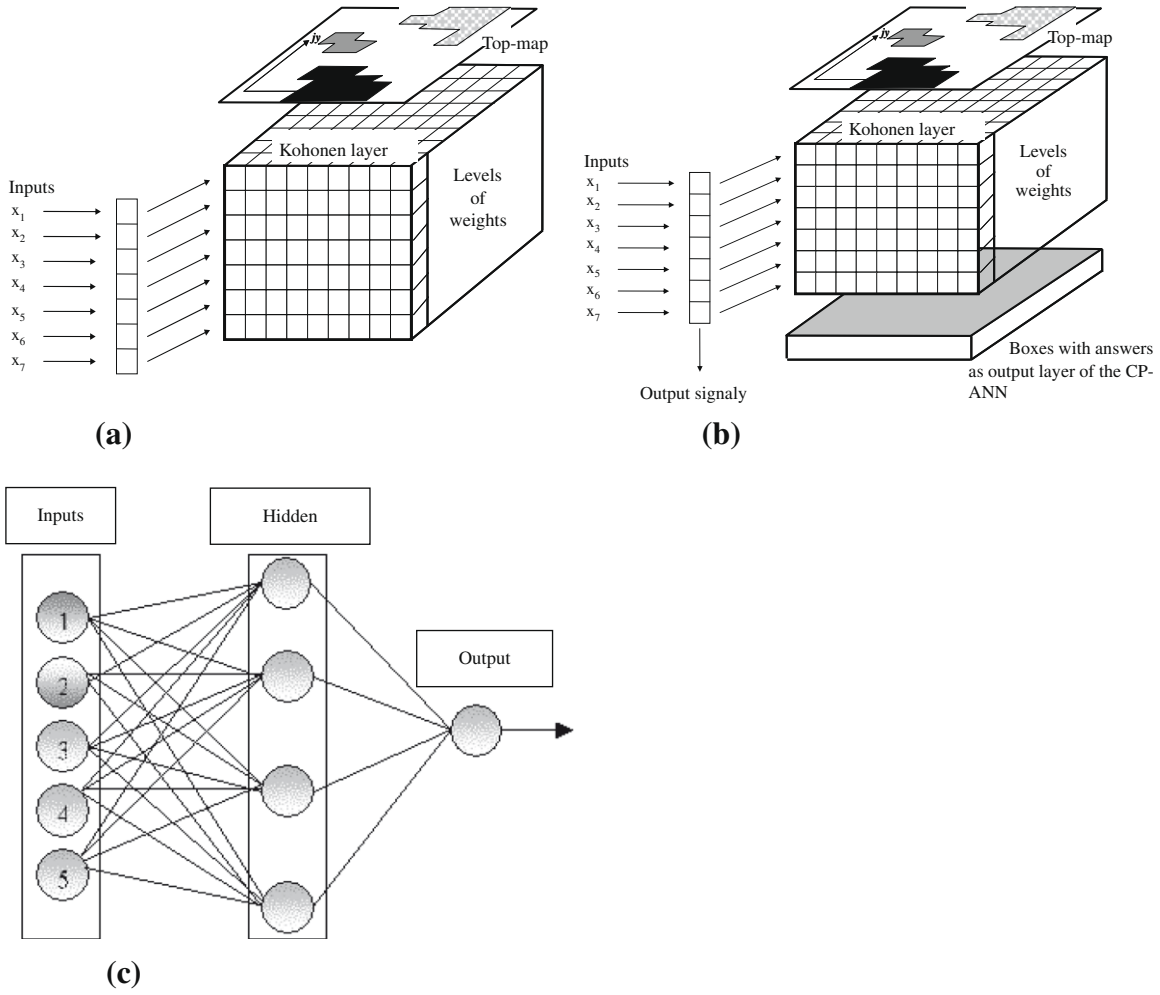

Fig. 1. The structure of the (a) Kohonen ANN, (b) CP-ANN and (c) BP-ANN.