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The use of near-infrared reflectance spectroscopy (NIRS) in the prediction of chemical composition of freeze-dried egg yolk and discrimination between different $n-3$ PUFA feeding sources

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Abstract

The study evaluated near-infrared reflectance spectroscopy (NIRS) to predict the physicochemical composition of freeze-dried egg yolk samples from laying hens fed with four different diets. Beside the control (C), the other three diets were enriched with different sources of $n-3$ polyunsaturated fatty acids (PUFA): marine origin (NF), extruded linseed (EL) and ground linseed (GL). Furthermore, NIRS was used to classify the yolks according to hens' feeding regime. Samples were analyzed chemically and scanned in reflectance mode between 1100 and 2498 nm of the near-infrared region.

Abbreviations: HUFA, highly unsaturated fatty acids; $L^*a^*b^*$, L^* = lightness, a^* = redness, b^* = yellowness; MDA, malondialdehyde; MPLS, modified partial least squares; MSC, multiplicative scatter correction; NIRS, near-infrared reflectance spectroscopy; PCA, principal component analysis; PLS, partial least squares regression; PUFA, polyunsaturated fatty acids; RMS, root mean square; RMSC, root mean square corrected for bias; SEC, standard error of calibration; SECV, standard error of cross-validation; SNV-DT, standard normal variate and detrending; SEP, standard error of prediction; TBARS, thiobarbituric acid-reactive substances; $1-VR$, coefficient of determination of cross validation

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The calibration results for the 365 yolk samples showed that NIRS can be used to predict their chemical composition, but it also highlights some limitation probably related to problems in the reference method. The prediction of PUFA was accurate while the calibration for the major chemical components (protein, lipids and DM) needs to be improved. Partial least squares (PLS) discriminant analysis was developed to differentiate the yolks, which originated from hens fed with the different diets. All the yolks from hens fed the C and the NF diets, and 98.6% of the two linseed diets, were correctly classified. pH, cholesterol and CIE colour parameters were not successfully predicted; the latter because the visible region was not scanned and this suggests that colour attributes cannot be predicted from NIR spectra alone. It was concluded that NIRS could be used both for estimation of chemical composition in nutritional experiments and as a screening analytical control technique for $n-3$ PUFA enriched eggs.

Keywords: NIRS; Laying hen; Egg yolk; Dietary $n-3$ PUFA; Chemical composition

1. Introduction

Ever since Dyerberg et al. (1974) reported a link between dietary $n-3$ fatty acids (FA) consumption and decreased incidence of cardiovascular disease in Eskimos, there has been a growing interest to increase the content of $n-3$ PUFA in foods of animal origin. Enrichment of eggs with $n-3$ FA may be achieved by using different dietary fat sources rich in this specific type of fatty acid. The three main sources of $n-3$ PUFA for poultry are: (1) fish oils, rich in EPA and DHA, (2) linseed and millet which mainly contains a-LNA and (3) marine algae which are rich in DHA. During the last decade the production of eggs with modified composition by the means of dietary treatments is increasing and needs quality and quantity control systems to assure wholesomeness and safety to consumers. As near-infrared reflectance spectroscopy (NIRS) is a rapid, non-consumptive and safe technique that can simultaneously analyze multiple components in organic substances, it could be an advantageous instrument to characterize egg quality in production.

Numerous NIRS applications have been developed in agriculture, food, biomedical, pharmaceutical and chemical industries, and other sectors. Most applications have dealt with the quantitative determination of main components of raw material and ingredients (Osborne et al., 1993a). NIRS is widely applied for quantitative analysis of chemical constituents such as protein content, moisture and fats in cereals, animal feeds, fats, meat and milk, as well as carbohydrates in fruit juices and alcohol in beverages (Burns and Ciurczak, 1992). Applications of NIR for the prediction of functional properties and quality variables in foods have also emerged (Berzaghi et al., 2005; Molette et al., 2001; Windham and Morrison, 1998). Furthermore, discriminant analysis makes it possible to use NIRS for identification and control of sample purity/quality (Berzaghi et al., 2005; Murray et al., 2001; Osborne et al., 1993b).

The objective of this research was to investigate whether the NIRS data could be used to predict the chemical and physical composition of the egg yolk of laying hens. The second objective was to investigate if, by analyzing the eggs by NIRS, it could be possible to use discriminant analysis to distinguish the four different dietary treatments.