Near infrared calibration of fatty acids for normal and high oil maize

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Introduction

Parma ham is a typical Italian production made from thighs of heavy pigs (about 160 kg Live weight). Beside the requirements of body weight, Parma ham can be made only from animals raised within a certain geographic area of North-Central Italy, fed with a limited number of feeds (no by product or animal products). All these restriction are intended to produce thighs with characteristics that will guarantee satisfactory curing process and high quality of the end products.

One of the most important characteristics of the thighs is to have a firm fat layer that contains less than 15% of linolenic acid (C18:2). To ensure lower level of unsaturated fatty acids in the final product, the diets fed to pigs in the fattening period must contains less than 2% (DM basis) linoleic. Maize flour represent the major source of unsaturated fatty acids in the diets used for the Italian heavy pigs. For this reason there has been a growing interest of farmers in the determination of total fat content and linoleic acids in maize. This interest has also become a necessity with the introduction of maize hybrids characterized by a content of oil which is almost double the one observed in normal maize. Since high oil content is obtained by topcross impollination, there is a risk that high oil hybrid would increase the oil content of neighbour maize fields.

The objective of this study is to evaluate the performance of a calibration for fatty acids developed with normal maize samples in the prediction of high oil samples before and after updates.

Materials and methods

The calibration of normal maize (NC) samples included 95 samples. Eighty two samples of high oil maize (HO) were divided into 45 samples for calibration updates and 37 for validation set. Sample were ground through a 1mm screen using a cyclone type mill and scanned in small ring cup between 1100 and 2498 nm every 2nm with a Foss NIRSystem 5000. Spectra were recorded as log1/R averaging 32 scans of the sample after 16 scans of the white reference. WinISI 1.5 was used to acquire spectral data and to perform calibration adopting the modified PLS method of ISI. Spectra math treatments included scatter correction (standard normal variate and detrending), first derivative with gaps and smoothing between 4 data point. Calibration was first developed with NC samples only and then added with the 45 HO samples selected for calibration updates. Ether extract (EE) was determined with AOAC[1] procedures and gas chromatography was used in the determination of fatty acids profiles. Fatty acid content are reported as percentage EE.

Results and discussion

As expected the two populations showed a large difference in EE content (Table 1). High oil maize had an average EE content double that of NC (8.48 vs 4.00 % DM). As found in the literature,[2] fatty acids profile showed a slight lower concentration (on the EE basis) of linoleic acids and higher concentration of palmitic and oleic acids for the HO compared to the NC maize.

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Table 1. Ether extract and fatty acid composition on normal maize and high maize

Constituent		Normal	High oil
EE, % DM	Mean	3.82	8.48
	Std deviation	0.34	2.45
C16:0, %EE	Mean	10.39	12.12
	Std deviation	0.98	0.79
C18:1, %EE	Mean	25.15	31.04
	Std deviation	4.20	4.12
C18:2, %EE	Mean	54.80	44.71
	Std deviation	4.47	4.20

Spectral differences reflected differences in composition. Figure 1 shows the average of all of the spectra from NC and HO samples used in this study, which clearly shows that the largest differences between the two population are mainly concentrated between 2200 and 2400 nm typical range of absorption for fats.

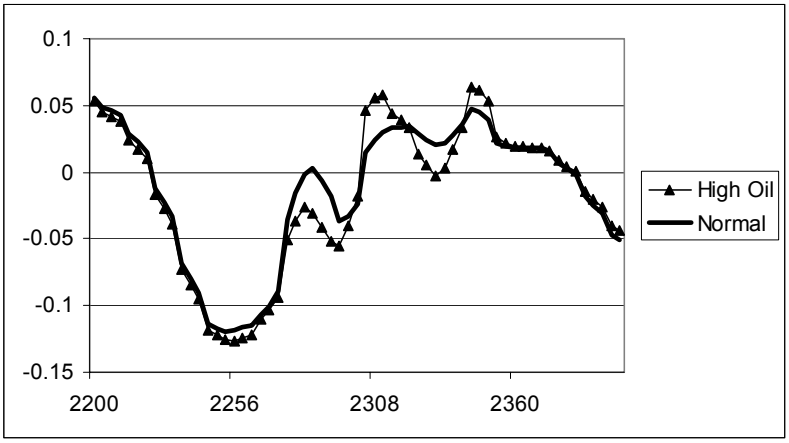

Figure 1. Spectra of high oil and normal maize between 2200 and 2400 nm after Math treatments

Because of the low variability, normal maize calibration for EE had small error of calibration (0.15 % DM) but also low *RSQ* (0.56). For the fatty acids only C18:1 and C18:2 had calibration with *RSQ* greater than 0.70, which indicated the possibility of using the calibration for prediction. Predictions of the validation HO data set using the calibration developed for NC showed large error of prediction (*SEP*) and large biases due to the differences in composition of the two population of maize (Table 2).

Table 2. Prediction performances of HO samples with the calibration developed with NC samples.

	EE	C16:0	C18:1	C18:2
SEP	6.53	3.02	13.67	8.37
Bias	6.25	2.94	-12.22	-7.52
SEPC	1.92	0.70	6.21	3.73
RSQ	0.21	0.09	0.75	0.74

Average GH= 32.25 ; Average NH=26.27

Updating the NC calibration with a small subset of HO samples greatly improved the performances of the calibration (Table 3). Ether extract had a limited *SECV* of 0.41 and *RSQ* of 0.97. For the fatty acids the C18:1 and C18:2 had *SECV* greater than 2 %EE and *RSQ* around 0.80.

Table 3. Performances of calibration after updates.

	Mean	*SD*	*SECV*	1-*VR*
EE, % DM	5.62	2.59	0.41	0.97
C16:0, %EE	11.00	1.27	0.90	0.51
C18:1, %EE	26.86	4.50	2.13	0.82
C18:2, %EE	54.01	4.93	2.15	0.77

The prediction of the validation data set confirmed the good performance of the new updated calibration equation. All the statistical parameters, *SEPC*, *Bias*, Global and Neighbour *H* had a large improvement for all of the constituent, with the only exception of C16:0 (Table 4). It is interesting to notice that the *SEPC* for C18:1 and C18:2 is actually lower than the *SECV* of calibration. Based on these founding a small calibration was developed with the 45 HO samples used for calibration updates which had *SECV* values for C18:1 and C18:2 around 1.5 %EE. It seems therefore that the calibration equations has better performance with HO samples. We must remember that all the fatty acids are expressed as percentage of the total oil content. In this case laboratory errors of fatty acids determination will be enlarged for NC samples simply because they have an EE content about half of HO.

Table 4. Prediction performances of HO samples with the calibration developed with NC samples updated with 45 HO samples

	EE (% DM)	C16:0 (%EE)	C18:1(%EE)	C18:2 (%EE)
SEP	0.65	0.79	1.15	1.58
Bias	0.01	–0.24	–0.15	–0.35
SEPC	0.66	0.77	1.16	1.56
RSQ	0.89	0.01	0.92	0.86

Average Global *H*= 1.04; Average Neighbour *H*=0.30

Conclusions

The population of NC and HO maize samples had large chemical and spectral differences. A calibration equation developed for one type of maize cannot be used for the prediction of the other. Nevertheless, it is possible to build a single calibration equation including both type of maize in the calibration data set.

Prediction performances for the C16:0 were not acceptable for any type of maize. However, it was possible to predict with good accuracy both the total oil content as well as the two major fatty

acids, C18:1 and C18:2. In the future it would be possible to use this calibration to predict oil and C18:2 content, which can be used by swine producers to decide if maize is suitable for the feeding of heavy pigs.

References

1. AOAC, *Association of Official Analytical Chemists*, 15th Edition (1990).
2. Effect of OPTIMUM® High Oil Corn or Added Dietary Fat on Pig Growth Performance and Meat Quality in *http://www.dupontsg.com/technical_information/pork/PorkTrialAFG5002.asp* accessed on 12 may 2003.