Classification of Mozzarella cheese samples by near infrared spectroscopy

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Introduction

Mozzarella cheese is produced by stretching cheese curd. "Mozzarella di Bufala Campana" is one of the most famous Italian cheeses that has a protected designated of origin (PDO), and is made from water buffalo (*Bubalus bubalis* L.) milk. In 2010 over 36 million kilograms of cheese were produced and the revenue was about 306 million Euro. Most of the product is consumed in Italy and about 20% is exported.[1]

The addition of cow (*Bos taurus* L.) milk to buffalo milk in mozzarella preparation is forbidden by the documents that regulate the Mozzarella di Bufala Campana production[2] so any trace of cow milk in the product should be considered fraudulent. The official method for detecting cow milk in cheese is based on isoelectric focusing (IEF),[3] whereas the characteristics of stretched cheese are usually evaluated by Enzyme-linked immunosorbent assay (ELISA),[4] High-performance liquid chromatography (HPLC) [5] and DNA based methods.[6,7]

The aim of this work was to first test the suitability of NIR spectroscopy for discriminating mozzarella (from buffalo milk) from cheeses prepared using the milk of other species. Our second aim was to verify whether NIR spectroscopy could be used to differentiate cheeses made from mixed milk sources.

Materials and Methods

Samples

Fifty one mozzarella cheese samples produced from different milks and from different cheese factories were purchased at a local market, including 34 from cow milk, 12 from water buffalo milk and 1 from goat (*Capra hircus* L.) milk. The remaining 4 mozzarella cheese samples were produced at the Fodder and Dairy Productions Research Centre (Lodi, Italy) pilot plant using buffalo milk with a cow milk content of 1, 3, 5 and 15%.

Near infrared spectroscopy

Samples were grated and measured over the 10000 to 4000 cm^{-1} range with a spectral resolution of 8 cm^{-1} using a NIR-Flex 500 FT-NIR spectrometer (BUCHI, Assago, Milan, Italy). Samples were put in Petri dishes and measured in reflectance mode. Spectra were collated from 64 scans, and four replicates for each sample were performed.

Data analysis

Partial least squares discriminant analysis (PLS-DA) was calculated on autoscaled spectra, and used to build a cheese classification (PLS Toolbox version 4.0.2; Eigenvector Research Inc. Wenalchee, WA, USA). A model was developed using all the spectra recorded from the water buffalo and cow mozzarella cheeses, which were considered two different classes. Cross validation was performed by leaving out the spectra of a single sample each time. The model was then applied to the averaged spectra of all mozzarella cheese samples.

Results and Discussion

The sample spectra featured water absorption bands and peaks at 5780 cm^{-1} and 5660 cm^{-1}, corresponding to the first overtones of the symmetric and asymmetric CH_2 stretching, and due to the significant fat content in Mozzarella cheese, i.e. about 17% for cow milk mozzarella and 25% for water buffalo mozzarella (Figure 1).

Reference paper as:
S. Barzaghi, L. Passolungo, K. Cremonesi and B.M. Donida (2012).Classification of Mozzarella cheese samples by near infrared spectroscopy, in: Proceedings of the 15th International Conference on NearInfrared Spectroscopy,
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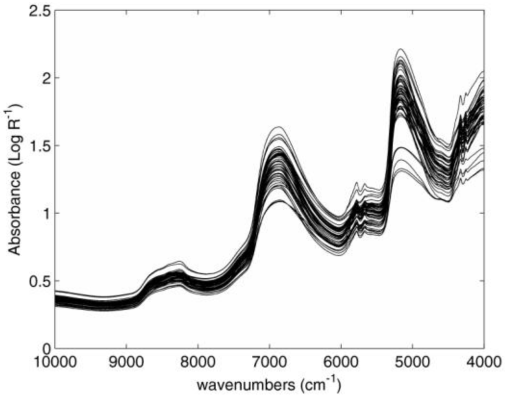

Figure 1. Mozzarella cheese spectra

PLS-DA was used to discriminate the different mozzarella cheeses. The model was built considering just two classes, cow milk and water buffalo milk, because of the low number of samples of cheese obtained from mixed milks. With 5 latent variables (LV) the percentage of variation captured by the regression model was 99.73% for the spectra and 67.40% for the classes. The root mean squared error of calibration (RMSEC) was 0.25. In order to determine the performance of the model, the Receiver Operating Characteristics Curve (ROC) and the threshold plots for the water buffalo mozzarella were examined (Figures 2a and 2b).

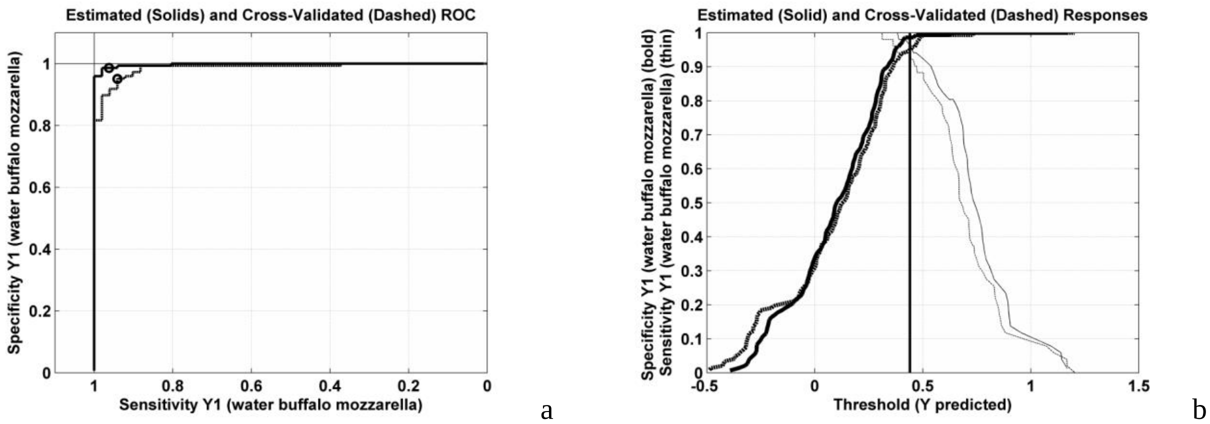

Figure 2. ROC (a) and threshold (b) plots of the calculated model

A good PLS-DA model was obtained. The specificity of the model (i.e. number of samples predicted as not in the class divided by the actual number not in the class) in calibration was 0.986 and in cross validation was 0.952. The sensitivity (i.e. number of samples predicted as water buffalo divided by the number actually in that class) was 0.961 in calibration and 0.941 in cross validation (Figure 2a). The threshold plot (Figure 2b) also indicated the effectiveness of the classification model: the sensitivity and specificity lines determined the threshold value, where the calibration and the cross validation data intersected at 1.

The PLS-DA model was tested on all the samples, including the cheeses obtained from milk which is neither from buffalo nor cow (Figure 3). All the water buffalo mozzarella (triangles) and cow mozzarella (squares) were correctly predicted.

The goat milk cheese sample was identified as not ascribable to “Mozzarella di Bufala Campana” class. Conversely, samples made by using cow and water buffalo milk mixtures (circles) were classified as genuine “Mozzarella di Bufala” samples.

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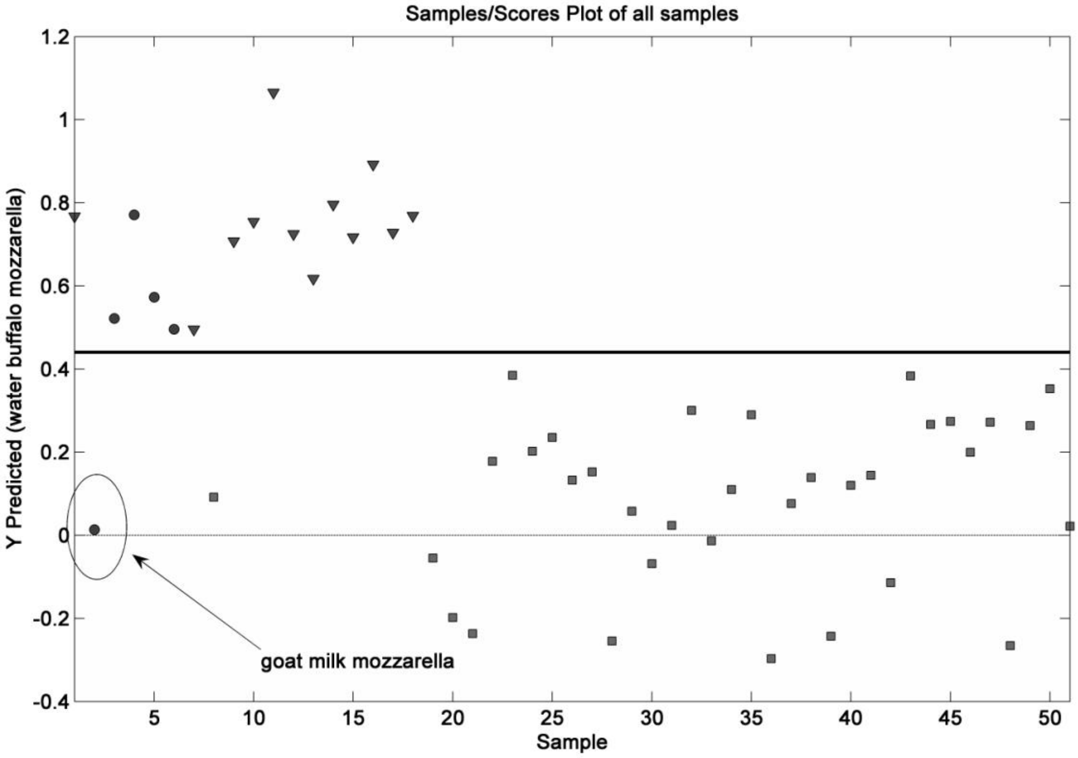

Figure 3. Model Prediction plot for water buffalo mozzarella class**.** Bold line is the threshold line.

Conclusion

This preliminary study presented the possibility of using NIR as a tool for classifying stretched cheese by milk source. Confirmation of the obtained results could be made by increasing the number of samples. Moreover, in order to identify milk mixtures a new model could be made considering this kind of sample as a new class.

Acknowledgements

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