Non-destructive detection of cheese and meat quality using a portable fiber optic near infrared instrument

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Introduction

Food quality and safety have become very important issues in recent years, particularly for meat and dairy products. Meats differ in several aspects including sensorial, technological, nutritional and hygienic quality. For example, the most prominent quality defect in pork is pale, soft, exudative (PSE) meat. An additional risk for high-value foods is the possibility of their adulteration with cheaper or inferior substances. Cheese analogues or imitation cheeses, for example, are cheese-like products usually containing non-dairy fats or proteins. Such analogues are traditionally produced by substituting the butter fat present in full fat cheese with an alternative, less expensive, animal or vegetable oil. A common meat adulteration is the sale of frozen-then-thawed meat as fresh.

Regulatory bodies, food producers and consumers increasingly demand rapid, non-destructive methods for assessing food quality and authenticity. Successful applications of NIR spectroscopy for determining chemical composition of cheese and meat, and for providing some sensory characteristics of meat, have previously been reported.[1-5] The capacity for NIR spectroscopy to discriminate and authenticate meat has also been demonstrated.[6-8]

The aim of this work was to assess the feasibility of a portable fiber optic NIR instrument for pork meat and white brine cheese authentication.

Materials and Methods

Samples

Meat samples

Meat was taken from cross-breed pigs. The pH of muscle samples was measured at 45 minutes post-mortem and carcasses were divided into two classes according to pH values – normal meat with pH_{45} values higher than 5.8, and PSE meat with pH_{45} values lower than 5.8. Porcine muscle (*Longissimus thoracis et lumborum*) samples were taken 24 h after slaughter from the 12th to 13th rib and divided into two parts. One part of each sample was scanned immediately, with the remaining part packed in a sealed plastic bag and deep frozen at -32°C for 6 h and stored at -21°C. Samples were thawed after one month storage and measured again.

Bulgarian white brine cheese samples

Bulgarian white brine cheese samples from cow milk were compared with cheese analogues made with vegetable oil from different producers. An additional set of samples from butter and palm oil were also measured.

Near infrared spectroscopy

NIR measurements were performed with a NIRQuest 512 spectrometer (Ocean Optics, Inc., Dunedin, Fl., USA) in the region 900–1700 nm using a reflection fiber optic probe. Two or three measurements collected from different parts of each sample were averaged to minimise effects of structural variation. Spectral data processing was performed with Pirouette Version 2.0 (Infometrics, Inc., Woodinville, WA, USA). Soft independent modeling of class analogy (SIMCA) was implemented to create models of the respective meat and cheese types based on their NIR spectra.

Results and Discussion

Cheese analysis

Second derivative transformation of spectral data was performed and mean spectra of natural white brine cheese, cheese analogues with vegetable fat, butter and palm oil are presented at Figure 1. There were clear differences in the positions and intensities of spectral absorption bands of butter and palm oil. Milk fat and

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palm oil had different fatty acid compositions and contents. The main differences in absorption intensities between palm oil and butter spectra were observed at 928, 1218, 1342, 1535 and 1640 nm; more absorption maxima were observed in palm oil spectra. Differences in absorption maxima of butter and palm oil were found at 1052, 1125, 1168, 1186, 1254, 1400 and 1503 nm. Those differences influenced spectra of natural cheese and cheese analogues with palm oil. The main differences in spectra of natural cheese and cheese analogues were observed at 928, 1026, 1165–1275 and 1585 nm.

Results of SIMCA models for distinguishing between natural white brine cheese and cheese analogues with vegetable oil (based on first derivative spectra transformation) are presented in Table 1.

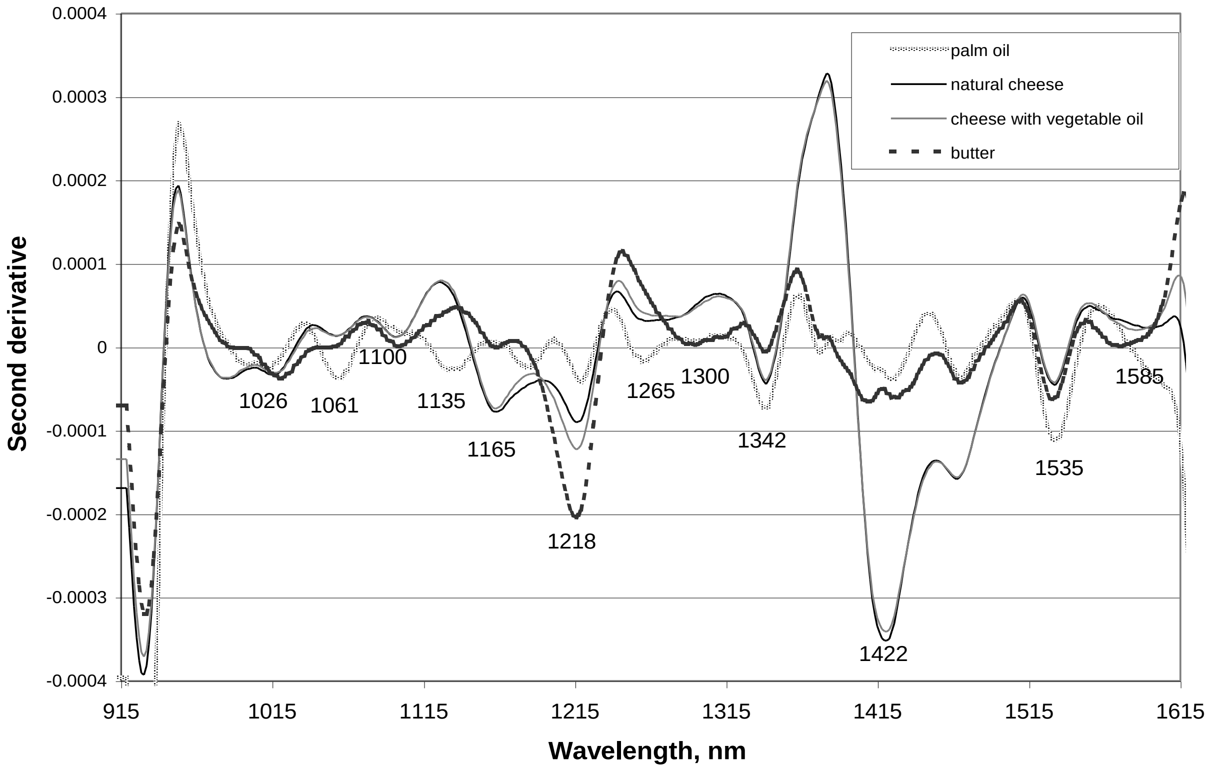

Figure 1. Second derivative average spectra of natural white brine cheese, cheese analogues with vegetable oil, palm oil and butter.

Table 1. SIMCA classification of natural white brine cheese and cheese analogues with vegetable oil.

	Calibration		Validation	
	Natural cheese	Cheese analogues with vegetable oil	Natural Cheese	Cheese analogues with vegetable oil
Natural Cheese	56	4	23	0
Cheese analogues with vegetable oil	1	40	2	29

SIMCA models based on first derivative spectral data transformation correctly classified 95.05% of cheese samples in the calibration dataset and 96.30% of samples in the validation set.

Normal and pale, soft, exudative (PSE) meat

Differences in absorption spectra were observed between normal and PSE meat. Second derivative transformation of spectral data was performed and mean spectra of normal meat samples and PSE meat samples are presented at Figure 2. The main spectral differences were found between 1350 and 1500 nm, and could be associated with water and protein absorption. PSE meat occurs when the pigs suffer acute stress before slaughter. When there are sufficient energy reserves in the muscles, the initial pH can drop very fast post-mortem due to the production of lactic acid. This pH drop causes a denaturation of the myosin and sarcoplasmic proteins and results in pale meat with a low water holding capacity. Other spectral differences were observed at 930, 990, 1024, 1156 and 1530 nm. Results of SIMCA models for distinguishing between normal meat and PSE meat, based on first derivative spectra transformation, are presented in Table 2.

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Correct classification was obtained for 92.30% of samples in the calibration dataset and 84.84% of samples in the validation set.

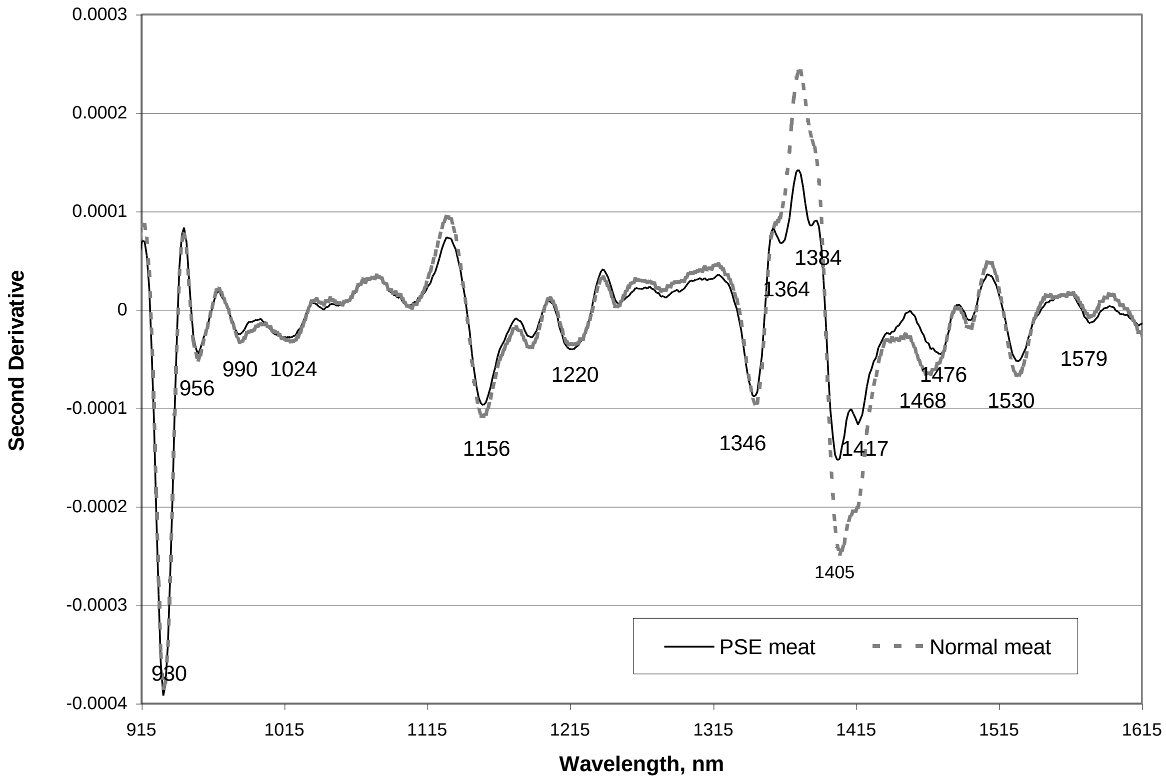

Figure 2. Second derivative average spectra of normal meat and PSE meat.

Table 2. SIMCA classification of normal meat and PSE meat.

	Calibration		Validation		
	Normal meat	PSE meat	Normal meat	PSE meat	Non-classified
Normal meat	35	0	21	6	
PSE meat	8	61	4	34	1

Fresh and frozen-then-thawed meat

Freezing and thawing of meat affects quality. Frozen and thawed pork can have an almost two-fold increase in drip loss compared to non-frozen pork, owing to physical disruptions caused by the formation of ice crystals. Water in the meat is either bound, entrapped or free. Entrapped and free water can be easily converted to ice during freezing, causing significant damage to cell membranes. Differences in meat caused by freezing were observed with near infrared spectra. Second derivative mean spectra of fresh meat samples and frozen–then-thawed meat samples are presented in Figure 3. The main spectral differences were found between 900–1000 nm and 1350–1500 nm, and could be attributed to water absorption. Such differences revealed proportional changes of different forms of water (i.e. bound, entrapped or free) in the meat. Results of SIMCA models for distinguishing between fresh and frozen–then-thawed meat, based on first derivative spectra transformation are presented in Table 3. SIMCA models based on first derivative spectral data transformation correctly classified 100% of meat samples in the calibration dataset and 92.30% of samples in the validation set.

Table 3. SIMCA classification of fresh and frozen–then-thawed meat.

	Calibration		Validation		
	Fresh meat	frozen–then-thawed meat	Fresh meat	frozen–then-thawed meat	Non-classified
Fresh meat	72	0	40	1	
Frozen–then-thawed meat	0	66	4	32	1

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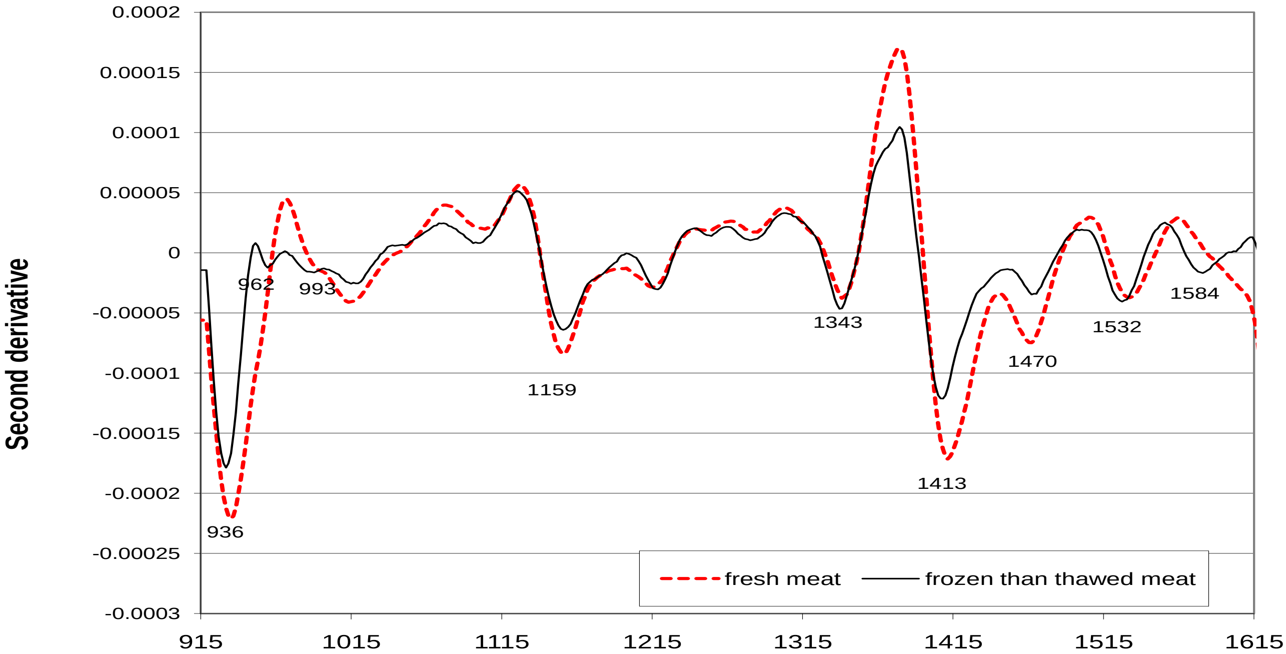

Figure 3. Second derivative average spectra of a fresh and frozen–then-thawed meat.

Conclusion

Differences were observed in NIR spectra of dairy and meat products that differed in authenticity or quality: natural white brine cheese and cheese analogues with vegetable fat; fresh and frozen-then thawed meat; normal and PSE pork meat. Portable fiber optic NIR instrumentation could be used for fast and non-destructive determinations of cheese and meat quality.

Acknowledgements

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