Research & Development

Factsheet 30

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Innovative sensors to determine fish freshness

Summary

Fish freshness quality is typically determined by sensory assessment, which relies on the use of trained assessors. Commonly used schemes include Torry and the Quality Index Method (QIM). However it is desirable to find an alternative, instrumental method to provide an objective system for determining fish freshness. Ideally any such method should be reliable, rapid, non-destructive and easy to use. A wide number of instrumental techniques have been tested yet few have made it to commercial reality. In this study, several different methods have been used to evaluate cod over time, to assess which has the greatest potential in fish freshness assessment. These included spectroscopy and colour imaging measurement.

What is spectroscopy?

Spectroscopy covers a range of techniques which describe the interaction of electromagnetic radiation with matter. A number of spectroscopic methods have shown promise in determining fish freshness, particularly those in the visible / near infra-red regions.

Visible spectroscopy allows changes in fish appearance to be determined instrumentally whilst near infra-red spectroscopy is used to determine changes in composition. Both types can respond to changes in the physical structure of the samples.

Both are measured by wavelengths in units called nanometers (nm), typically over a waveband between Visible (400-700nm) and NIR (700-2500nm).

The project

Campden BRI was funded by Seafish to evaluate the potential of colour measurements and near infra-red spectroscopy as reliable methods of determining fish freshness. Colour measurements were made with a calibrated colour imaging system. NIR measurements were made with a hyperspectral imaging system, and with a conventional bulk system.

Specific objectives of the project were;

- To develop demonstrated calibrations for fish freshness as determined by storage time (days on ice) using NIR spectroscopy.
- To determine the potential of reliably assessing fish freshness using imaging techniques.

Method

Farmed cod were stored on ice over a period of 17 days. On each day, five cod were selected at random and analysed. The cod were assessed using the Torry schemes for raw and cooked assessment (cooked assessments only up to 9 days on ice).

Whole cod were imaged using a DigiEye imaging system to record the external visual characteristics, and were scanned by a hyperspectral NIR imaging system to analyse the surface properties. The fillets and gills were

removed and subject to the same tests. A portion of each fillet was removed and packed into a rectangular cell for NIR scanning. Gill filaments were packed into a ring cup for scanning.

Whole cod presented for DigiEye scanning

Gills and fillets presented for DigiEye scanning

The data were analysed to measure the average colour of the fillets, gills and pupils of the eyes. Skin pigments were too variable to be relevant indicators.

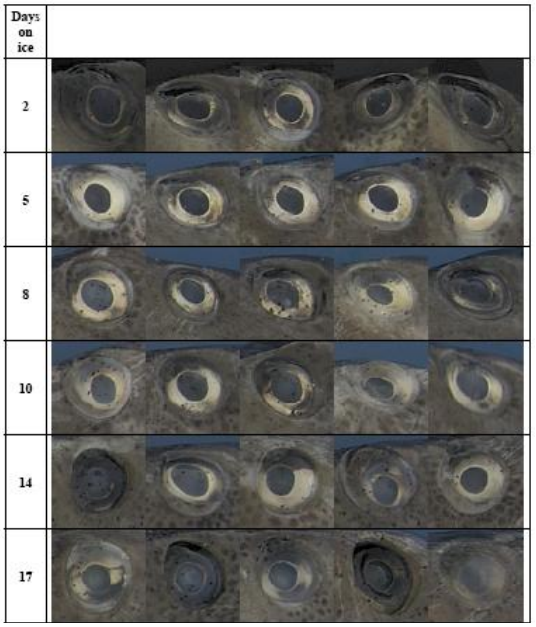
Results & discussion

Results of visual characteristics

The variation in natural pigmentation between different cod was considerable.

The main change in the fish was seen in the eyes. There was an increase in lightness as the colour of the eyes changed rapidly from black to cloudy white over the initial period ofdays 2 to 8.

Eye colour changes with days on ice



The main colour change in fillets during storage was an increase in yellowness. This was detected by changes in the degrees of yellowness on a colour scale measuring blue to yellow variation. This correlated well with days on ice. The thickness of the fillets is an important factor though and needs to be sufficiently thick to not be affected by any background colour.

Gill filaments showed a characteristic change from deep red to a pale yellow colour with time. This was detected by a decrease in redness and an increase in both yellowness and lightness. After analysis, the measurement of the gills was shown as a potential method of measuring the freshness of fish up to day 9 on ice. After this point, changes were less consistent and therefore less useful for predicting storage time.

Results of NIR spectra

The wavelength data (spectra) of the different parts of the fish was analysed relative to days on ice (2 to 17 days). This data was converted into a series of models to assess suitability for correlation with days on ice.

In terms of storage time, for the calculation over the complete spectrum (408-2492nm), the best model was obtained for the gills. This model could correctly predict storage life to +/- 1.88 days. However this was reduced to +/- 1.63 days using a more limited spectral range (408-1440nm).

With fillets, the best model could predict days on ice to +/- 2.28 days over complete spectrum (408-2492nm); this was reduced to +/- 2.12 days using restricted wavelength range (408-1440nm).

Comparing all the results it is considered that they show similar performance of approximately +/- 1.5 to 2 days, corresponding to a difference of 0.5 Torry points. This is an acceptable variation for sensory assessment by a panel of trained assessors.

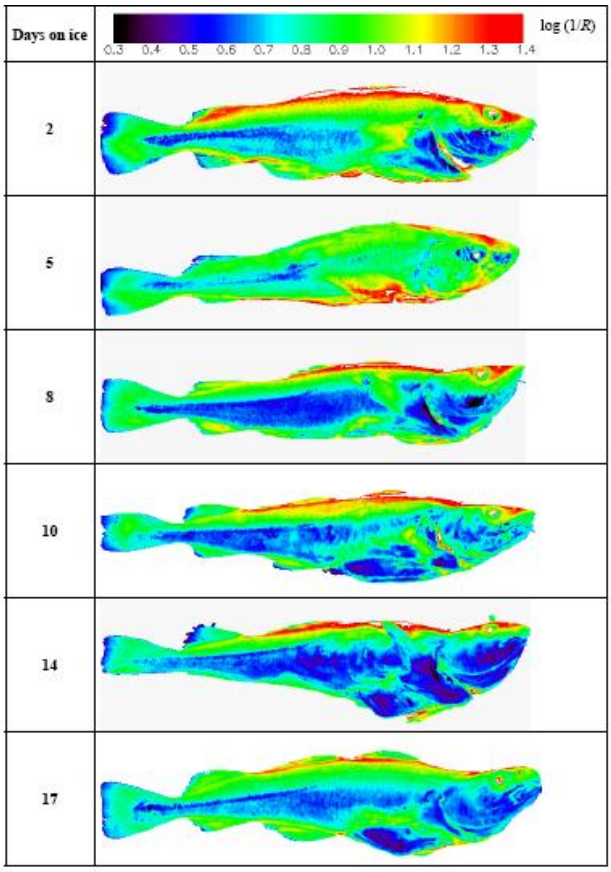
Hyperspectral NIR imaging system

The spectra recorded by this system are collected for each pixel over a range of about 900-2500nm.

In terms of the fillets, the model best correlated with time was the head end of the fillet. This gave a prediction of +/- 1.66 days with days on ice. It appears that this portion of the fillet could be a better indicator of fish freshness than other parts of the fillet.

The spectra of whole cod were collected over a range of wavelengths about 900-2500nm. The mean spectra for the whole fish showed evidence of an increase in reflectance with age. The general trend of an increase in overall reflectance with storage time is clear, signified by a shift towards the blue end of the false colour scale as seen in the following series of images.

NIR false colour images of the whole cod at 1164nm



Overview of results

The following table shows the performance of the best model for each instrument for fillets and gills with time.

	NIR systems 6500	**Hyperspectral NIR imaging**	
	408 – 1440 nm (+/- days on ice)	892 – 2094nm (+/- days on ice)	892 – 2495nm (+/- days on ice)
Whole fillet	Not measured	1.73	Not analyzed
Fillet section	2.12	1.73 – 1.9	1.66
Gills	1.63	Not analyzed	Not analyzed

Conclusions

- Sensory assessment and several instrumental methods were used to assess suitability for freshness evaluation.
- A DigiEye imaging system was used to take calibrated colour images and to make colour measurements of eyes, fillets and gills for cod stored on ice up to 17 days.
- Two NIR systems were also used to make measurements of whole cod, fillets and gill filaments.
- For the colour measurements the results showed potential for use in the determination of fish freshness. An objective measurement of fish freshness can be carried out for eyes and gills.
- NIR measurements of gill filaments and fillets showed better predictions of age than colour measurements. The overall best performance was obtained from the gills. The best model for fillets was obtained from the head end of the fillet.
- The work showed the potential of colour and NIR reflectance measurements for assessing freshness of cod with age, particularly over the earlier storage life of cod (up to about 9 days). This can be a difficult period to assess the freshness quality of fish using analytical means. For example Total Volatile Base Nitrogen (TVBN) is more suited for use after about 10 days.
- Although this study shows the potential for objective instrumental assessment for fish freshness, a significant amount of further work is required to develop robust models and a practical instrument for commercial use. Any such work should be in collaboration with a suitable instrument manufacturer. However it will be some time before a commercially available instrument would be available to market.

Contacts & further information

- Michaela Archer – Seafish – m_archer@seafish.co.uk
- Campden BRI – http://www.campden.co.uk/
- Full details of the project are available in the Seafish Report – *SR610 – Innovative sensors to rapidly and non-destructively determine fish freshness,* Campden BRI, 2009. To download a copy of this report go to the Seafish website - http://www.seafish.org/resources/publications.asp and search for ‘Sensors’ on the publications page.