Diode-array near infrared analysis of whole and filleted salmon

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Introduction

Fish farming has turned out to be one of Norway's most important export industries. The production of Atlantic salmon has increased from 50,000 tons in 1987 to about 300,000 tons in 1997. At our local research station "Gifa's" the annual production is about 1500 tons.

The chemical composition of farmed Atlantic salmon is one of several factors dependent on the chemical composition of the feed, Table 1.

The continuous changes in feed composition make it necessary to establish simple, rapid and accurate analytical methods.

Use of near infrared (NIR) transmittance on minced samples has been found to be as accurate as the traditional "wet" chemical methods for measurements of water, fat and protein content in the fish.[1] By using the traditional NIR transmittance method, using the Infratec 1225 Food and Feed Analyzer, it is necessary to cut out a piece of the fish and mince it, which is time-consuming and destroys the fish.

In this investigation full scale (400–1700 nm) diode-array reflectance measurement has been made by non-contact illumination on unskinned and on filleted salmon.

Material and methods

Salmon from Gifa's was slaughtered, gutted and stored on ice for three days. After measurement on the whole fish the salmon was filleted for measurement from the flesh side.

The NIR measurements were performed on a Perten DA7000. The fish was placed on the circular glassplate, so the area from the backfin to the gut of the fish was illuminated with white light. The reflected light was analysed by two diode-arrays for simultaneously sensing using the wavelengths from 400–950 and 950–1700 nm, with 5 nm intervals, resulting in a rapid analysis.

The "Norwegian quality cut", corresponding to the flesh from the backfin to the gut was then taken, and minced for corresponding chemical analysis.

Fat, was extracted with ethyl acetate, according to Norwegian standards.[2]

Astaxanthin, was measured after separation of the astaxanthin from the fat in ethyl acetate extract by absorption chromatography on a silicic acid column. After chromatography the solution was evap-

Table 1. Development of fish feed, as % protein and % fat in the feed, from 1975 until today.

	1975	1980	1984	1989	1999
Protein	58	49	45	40	40
Fat	8	15	27	30	38

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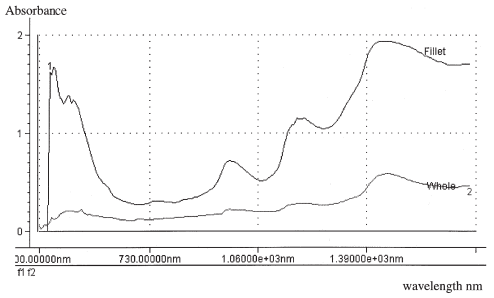

Figure 1. Absorbance spectrum of filleted salmon from the flesh side and of whole salmon.

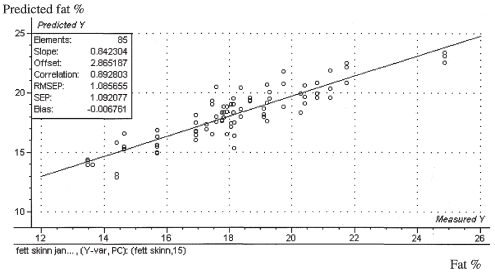

Figure 2. Prediction of fat content in whole, unskinned salmon by using 15 principal components in the wavelength range 990–1700 nm.

orated and the pigment was dissolved in 10 mL hexane and the concentration of astaxanthin was measured in a spectrophotometer at 472 nm.

Partial least square (PLS) regression analysis was used for analysis of the spectral data, with the aid of the "Unscrambler 7.0" program.

Results and discussion

Figure1 shows the spectrum from 400 to 1700 nm for whole salmon and the corresponding spectrum from the flesh side of the fillet.

Calibration of the fat content in whole, unskinned salmon, was optimal in the wavelength range from 990 to 1700 nm and resulted in a correlation of 0.89 and a *SEP* of 1.1% fat (Figure 2). These results indicates that it should be possible for an on-line sorting of salmon, even in the living state, according to the fat content

Measurements of the fillet, from the meat side, were enhanced by using the wavelength range from 500 to 1700 nm, resulting in a correlation of 0.94 and a *SEP* of 0.82% for the analysis of the fat content (Figure 3).

Measurement on the fillet from the flesh side also made it possible to measure the concentration of the pigment astaxanthin in the salmon by using the wavelength range from 430 to 1600 nm, resulting in a correlation of 0.92 and a *SEP* of 0.33 mg astaxanthin kg^{-1} flesh (Figure 4). Earlier attempts for

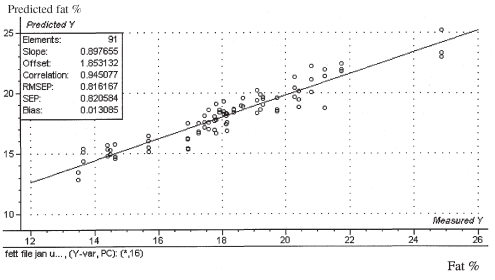

Figure 3. Prediction of the fat content in the fillet from the flesh side by using 15 principal components in the wavelength range 500–1700 nm.

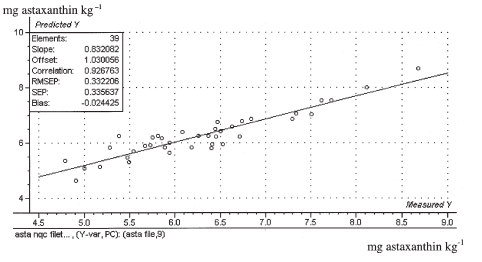

Figure 4. Prediction of the astaxanthin content (mg kg^{-1}) in the fillet from the flesh side by using 9 principal components in the wavelength range 430–1600.

NIR analysis of astaxanthin with other instruments has been unsuccessful. Knowing that the usual chemical analysis of astaxanthin is the most time-consuming and expensive one of the ordinary quality analysis of salmon, make DA-NIR analysis very promising.

Measurements using fibre optics were unsuccessful, probably due to too small fibre compared to the fibre structure in the flesh. It was also found that it was a disadvantage to place the salmon or the fillet in a plastic bag during measurement.

Conclusion

With DA-NIR it is possible to sort or grade whole salmon on-line according to the fat content. Measurement on the fillet has a higher accuracy and also offers a method for on line measurement of the content of astaxanthin in the fillet. Different applications have different optimum wavelengths.

Acknowledgements

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References

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2. Norwegian Standard Association, NS 9401/9402 (1994).