

Rapid measurements of fat content in live salmon

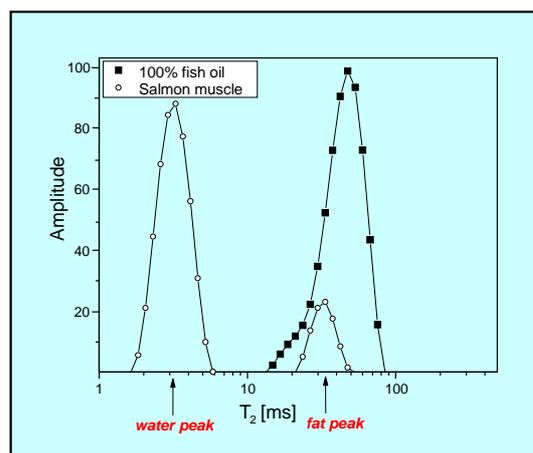
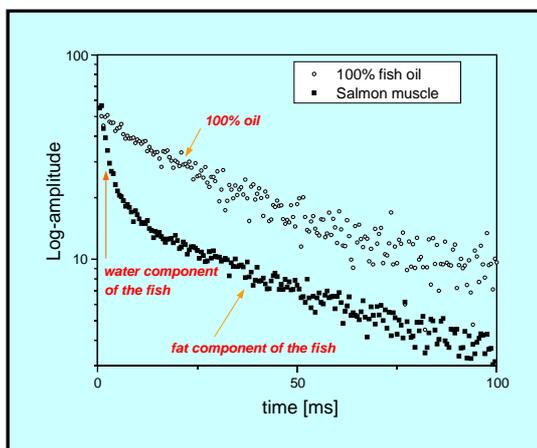
Introduction

Knowledge of the fat content in whole salmon is essential for optimisation of the feeding regimes in fish farming, systematic breeding, meeting the requirements of a particular market and many other applications. The BRUKER Professional MOUSE (Bruker Optik GmbH, Germany) has been used for rapid measurements of the fat content in live and slaughtered salmon. This instrument is a low field mobile NMR analyser for relaxation measurements in the near surface volume of samples unrestricted in size. In the present study we have optimised a CPMG pulse sequence in order to design measurements that separate sufficiently NMR signals of the fat and water components at a short acquisition time (20 sec) and an adequate signal to noise ratio.

BRUKER Professional MOUSE: Principle of the fat content determination

The characteristic NMR relaxation response of fat and water is exploited to quantify the fat component faster and at the same time more accurate. Unlike conventional benchtop NMR instruments, the stationary magnetic field in the measurement volume of the mobile NMR analyser is highly inhomogeneous. The strong magnetic field gradient causes that the self-diffusion of the nuclear spins dominates the observed spin relaxation effects.

The diffusion coefficient of water in salmon ($\sim 1.2 \cdot 10^{-9} \text{ m}^2/\text{s}$) is several times higher than that of fat ($\sim 0.2 \cdot 10^{-9} \text{ m}^2/\text{s}$). This makes the diffusion-dependent, effective relaxation times T_2^* of water and fat differ by an average factor of 12 when observed with the mobile NMR analyser. This substantial contrast makes it possible to quantify the fat component directly from the relaxation curve.

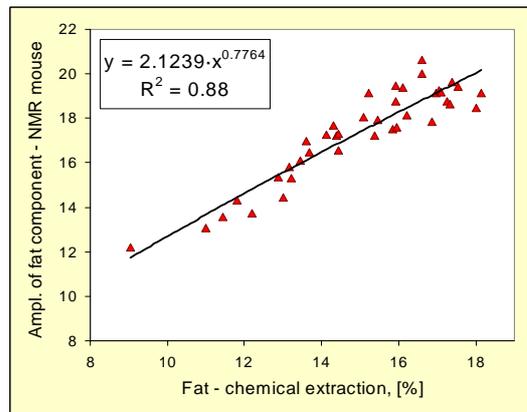


T₂ relaxation curves of pure fish oil and salmon muscle measured with the BRUKER Professional MOUSE. The corresponding relaxation spectrum exhibits two distinct relaxation components of water and fat respectively.

“Field study” - results of the fat measurements in live salmon

The Norwegian Quality Cut (NQC) is a standardised muscle section for fat determination. The NQC of 39 live and anaesthetised salmon was scanned using the mobile NMR analyser. The average amplitudes of the fat component correlated to the results of fat chemical extraction from the whole NQC after slaughtering of the same fishes. The correlation coefficient was $r = 0.88$.

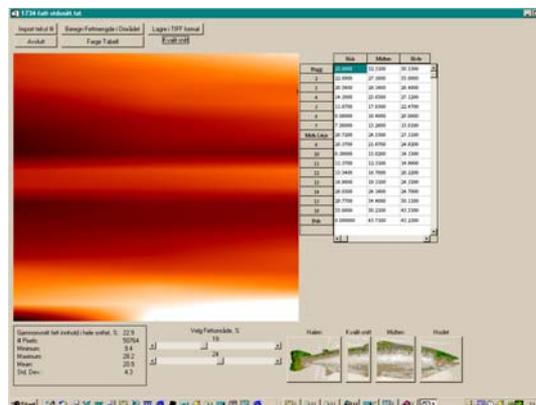
A similar correlation coefficient was found between the fat content determined using a Near Infrared analyser on the same set of salmon.



Correlation between the fat content measured with the BRUKER Professional MOUSE in the NQC of 39 live salmon and fat content measured chemically in the whole NQC after slaughtering of the same fishes

Spatial distribution of fat in the NQC of salmon

Because of its mobility the instrument can be utilised to map the NMR observable parameters over the surface of a salmon sample, thus making it possible to study topographical distributions. To demonstrate this, fat measurements were performed with the mobile NMR analyser in about 50 predefined positions of the NQC. The resultant fat values were visualised as fat distribution images, using specially developed software. The fat images correlated well with expected anatomical distributions of fat in salmon. Fat value in any image pixel as well as in a user-defined Region Of Interest can be directly read out with this technique.



“Fat image” of the Norwegian Quality Cut generated from 50 local fat measurements with BRUKER Professional MOUSE. The software was created using Interactive Data Language (Research Systems Ltd., UK)

Conclusions

⇒ A new method for fat measurements in live and slaughtered fish with BRUKER Professional MOUSE has been developed.

⇒ A significant correlation between the fat content determined with BRUKER Professional MOUSE and the chemical extraction results is found, based on measurements in 39 live salmon.

⇒ Main advantages of the new technique are:

- rapid method with a direct fat content read-out,
 - easy operation,
 - stable and fast calibration,
 - mobility,
 - on-line implementation feasible,
 - maintenance-free hardware,
 - option for spatially resolved fat distribution measurements
- *Amplifier*
 - *Pre-amplifier*
 - *Hand-held magnet*
 - *Laptop with the minispec software*
 - *Calibration fluid (fish oil)*

