SDU

# POPULAR SCIENTIFIC ABSTRACT


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## High-accuracy prediction of meat expiration dates by overcoming non-linearity barriers for microcantilever biosensors.


In Denmark, there is an annual waste of 137,500 tons of meat and fish products, with approximately 43,000 tons being discarded due to overly cautious expiration date estimations. Additionally, the production of 1 kg of meat or fish has a significant global warming potential of 3-29 kg CO2 per kg, resulting in roughly 650,000 tons of CO2 emissions. To address this pressing issue, we propose the development of a Piezoelectrically Driven Microcantilever (PD-MC)-based sensor that enables highly accurate on-site assessment of meat and fish freshness levels. This innovation will allow for more precise prediction of expiration dates, potentially reducing CO2 emissions and waste.

In this context, the objective of this project is to design and develop a microcantilever-based biosensor enabling precise measurements of low levels of cadaverine, a proven indicator of meat and fish spoilage levels, and use it to predict meat expiration dates. Very small differences in cadaverine levels at an early deterioration stage translates into large differences with respect to the expiration date. Therefore, it is a strict requirement that the biosensor enables high-accuracy measurements of +/- 10% at low levels of cadaverine, down to 10µg per kg of meat. To achieve this, we must overcome current state-of-the-art barriers; that PD-MCs exhibit non-linear responses and that mathematical response processing models for non- linearity compensation are lacking.

In this regard, this study presents a novel combination of two PD-MC models that address the inherent and adsorption-dependent non-linearities resulting from the complex dynamics of the functional layer. The research reveals that at low concentrations of cadaverine, the interactions between the analyte and binder dominate the damping effects, resulting in an increase in resonance frequency. The response model that considers the adsorption-dependent dynamics of the functional layer successfully predicts these low concentration levels. Conversely, at high concentrations of cadaverine, the damping effects induced by adsorption-induced mass loading leads to a reduction in resonance frequency, and this can be estimated using the response model derived from the parameterized response following exposure of the PD-MC to known cadaverine concentrations. The advantage of the parameterized response model is its ability to account for non-quantifiable non-linearities.

An amalgamation of the developed response models tailored to specific directions of frequency changes has made it possible to accurately quantify Cadaverine, vis-à-vis the number of storage days, with a trend comparable to that of LC-MS/MS. As a result, the Cadaverine sensor with the proposed response models can be applied across multiple levels of the food supply chain with great confidence.