



Session	Emerging Innovative Technologies: Novel Fermentation and Downstream Processing Innovations
Title	Advancing Fermentation Monitoring through Online Raman Spectroscopy
Company	Wageningen Food & Biobased Research
Speaker	Martijn Bekker
Keywords feedstock (max 2)	Fermentation
Keywords technology (max 2)	Raman spectroscopy
Keywords End-Product (max 2)	Protein, Probiotics
Abstract:	
Accurate and timely process monitoring is critical for modern industrial fermentation, ensuring consistent quality, lower costs, and faster development. Conventional strategies rely on inline sensors and offline analytics, which, while reliable, offer limited data density and often fail to provide real-time insights for process control. Raman spectroscopy is an attractive Process Analytical Technology (PAT), delivering non-invasive, reagent-free, multi-parameter measurements directly in the bioreactor. By capturing molecular vibrations, Raman spectra can reveal substrates, products, and biomass simultaneously. However, challenges such as overlapping spectra, fluorescence interference, and the need for advanced chemometrics have hindered its adoption. Our work advances Raman-based monitoring by combining spectroscopy with multivariate modeling. Using modern preprocessing, dimensionality reduction, and regression, we extract quantitative data from complex spectra. High-frequency measurements reveal dynamic trends missed by intermittent sampling. A case study in <i>Pichia pastoris</i> fermentations for recombinant enzyme production shows Raman-derived methanol measurements rivaling dedicated sensors, enabling potential feedback control. The results highlight Raman's ability to support advanced control strategies. While demonstrated in <i>P. pastoris</i>, the approach is broadly applicable, positioning Raman spectroscopy as a versatile PAT for next-generation smart bioprocesses. Acknowledgement: This research is performed within a public private partnership which is partly funded by the Topsector Agrifood.	