

Promotors

Prof. Dr. Yvan Vander Heyden

Analytical Chemistry, Applied Chemometrics and Molecular Modelling, VUB

Prof. Dr. Abdelaziz Bouklouze

Laboratory of Pharmacology and Toxicology, Faculty of Medicine and Pharmacy, University of Mohammed V, Rabat, Morocco

Chair

Prof. Dr. Pieter Cornu

Research Group Clinical Pharmacology and Clinical Pharmacy, VUB

Board of examiners

Prof. Dr. Serge Rudaz

Institute of Pharmaceutical Sciences of Western Switzerland, School of Pharmaceutical Sciences, University of Geneva, Switzerland

Prof. Dr. Eric Ziemons

Laboratory of Pharmaceutical Analytical Chemistry University of Liege, Belgium

Prof. Dr. Debby Mangelings

Analytical Chemistry, Applied Chemometrics and Molecular Modelling, VUB

Prof. Dr. Gamze Ates

Neuro-Aging & Viro-Immunotherapy Research Group, Center for Neurosciences, VUB

INVITATION to the Public defence of

Meryeme El Maouardi

To obtain the academic degree of

'DOCTOR OF PHARMACEUTICAL SCIENCES'

Quality control and adulteration evaluation of Moroccan Argan oils. Vibrational spectroscopy in tandem with chemometric approaches

The public defence will take place on

Thursday, 4 September 2025 at 5 p.m.

In Auditorium Piet Brouwer

VUB Health Campus

Faculty of Medicine and Pharmacy, Laarbeeklaan 103, 1090 Brussels

and can be followed online, accessible through the following link:

https://gf.vub.ac.be/redirects/PhD_defense_Meryeme_El_Maouardi.php

Summary of the dissertation

Argan oil is a luxurious Moroccan product known for its health and cosmetic benefits. However, its high cost and limited production make it a target for adulteration with cheaper oils, which poses a risk to its quality and authenticity. To address this issue, this research explores spectroscopic techniques, such as Near-infrared (NIR), Mid-infrared (MIR), and Raman spectroscopy, in combination with mathematical data analysis methods to ensure the quality, authenticity, and traceability of Argan oil. A first study aimed to build mathematical models to classify Argan oil according to its geographical origin. NIR and MIR spectra were acquired, pretreated, and analyzed using Principal Component Analysis. Furthermore, two classification methods, Partial Least Squares Discriminant Analysis (PLS-DA) and Soft Independent Modelling of Class Analogy (SIMCA), were performed and successfully distinguished oils by region with high accuracy. A second study focused on developing classification and regression models, using NIR and MIR spectra, to detect and quantify adulteration of Argan oil with cheaper oils. Spectra were analyzed with PLS-DA to identify the type of adulterant, then with PLS Regression to quantify the level of adulteration. The developed models demonstrated excellent performance in identifying and quantifying adulterants. A final study compared three Raman spectrophotometers (two portable and one benchtop) for adulteration detection. The spectra were again subjected to PLS-DA and PLSR. All instruments performed effectively, particularly the portable devices are useful for on-site testing. This highlights the potential of Raman spectroscopy as a powerful tool for real-world applications. In conclusion, this research validates the importance of the mathematical treatment of spectra as an effective tool to verify Argan oil's authenticity. The methods can help regulators, producers, and consumers ensuring product integrity and preserving the value of this precious Moroccan product.

Curriculum Vitae

Meryeme El Maouardi was born in Morocco on 20th July 1996. She always has been fascinated how science can solve real-world problems. Meryeme completed an undergraduate degree in Biology in 2016 and a master's degree in Quality Control of Drugs at the Faculty of Pharmacy, University Mohammed V, in Rabat, Morocco, in 2018. She obtained the highest grades and ranked first in her master's class of 2018 – an achievement that confirmed her passion for research and set the stage for her doctoral studies.

In 2018, Meryeme started her PhD adventure under the guidance of Professor Abdelaziz Bouklouze at her home university in Rabat. Her research potential was recognized in 2021 when she received a VLIR-UOS TEAM project Research & Development scholarship (Belgium-Morocco), bringing her to the Vrije Universiteit Brussel in Belgium. There, she worked under the supervision of Professor Yvan Vander Heyden to develop rapid and accurate methods using spectroscopic fingerprinting techniques and data analysis (chemometrics) for the geographical traceability and quality control of Argan oil.

Her PhD journey includes a rewarding year as a part-time teaching assistant at Université Libre de Bruxelles, where she gained experience in academic supervision, and an intensive 3-month research period at the Walloon Agricultural Research Centre, mastering advanced Raman spectroscopy. Additionally, her work resulted in publishing 5 peer-reviewed papers (3 as first author) and presenting her findings at 7 national and international conferences.

What drives Meryeme is the knowledge that her work protects both consumers and honest producers in the Argan oil market. Beyond the lab, she enjoys mentoring younger students and exploring how to communicate science effectively to broader audiences. As she defends her thesis today, she carries with her the support of her mentors, colleagues, and family, and the valuable lesson that scientific breakthroughs come through equal parts of curiosity, perseverance, and collaboration.