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Junior Scientists Tandems
Final Report

Name of student: Hessede Gbahoungbola
German Research Institution (GRI): Justus Liebig University Giessen
Supervisor at German Research Institution (IARC): Prof. Dr. Michael Frei
National University (Country): University of Abomey-Calavi
Supervisor at National University: Prof. Waliou Hounkpatin
International Agricultural Research Center (Country): Alliance Bioversity & CIAT
Supervisor at IARC: Dr. Sam Bodjrenou
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Title: Improving the nutritional and sanitary quality of neglected under-utilized species by- products along the value chain in sub-Saharan Africa: Case study of *Vitex doniana* and *Irvingia gabonensis* in Benin

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Summary

As part of my PhD research, I completed a six-month internship at Justus Liebig University Giessen in Germany, thanks to support from the ATSAF scholarship. The main goal was to analyze the nutritional value of neglected and underutilized plant species (NUS) collected in Benin. A total of 61 samples were studied, including leaves, seeds, and roots from various species, with a special focus on *Vitex doniana* and *Irvingia gabonensis*, collected along their value chains. In the laboratory, I helped prepare and analyze these samples to better understand their content in important nutrients like iron, calcium, and zinc, as well as other natural compounds. I also participated in a small experiment to compare the growth and nutrient content of *Basella alba* plants grown in different types of soil. This internship allowed me to gain new scientific and practical skills, work in a modern research environment, and connect with experienced researchers. The data collected will play a key role in my doctoral work. More broadly, the results will help promote the use of NUS in Benin as a way to improve nutrition, support local food systems, and encourage more sustainable farming practices.

Introduction

Neglected and underutilized species (NUS) are plant species that are well adapted to local environments and hold significant cultural and traditional value, yet remain largely underexploited by modern agriculture and overlooked by research and conservation efforts (Dansi et al., 2012). These species are typically excluded from the category of major crops and are predominantly cultivated by smallholder farmers. They are often nutrient-dense, resilient to climate variability, and highly adaptable to local agroecological conditions (Li et al., 2020). The valorization of NUS is critical in addressing global food insecurity, particularly malnutrition, which remains a pressing challenge in many low- and middle-income countries (LMICs) (Ojuederie et al., 2024). Nutrient-rich, climate-resilient, economically viable, and locally available NUS offer significant potential to enhance both dietary and agricultural diversification (Li et al., 2020). Uncovering and harnessing the hidden potential of these species is therefore essential for building more sustainable and resilient food systems. In Africa, and particularly in Benin, a wide range of NUS exist (Dansi et al., 2012). However, the lack of comprehensive data on their nutritional composition and sanitary quality—especially regarding their by-products—poses a major barrier to their promotion and wider adoption (Adjatin et al., 2013). This knowledge gap highlights the need for targeted research initiatives.

In response to this need, I conducted a research mission in Germany aimed at analyzing prioritized NUS, selected based on their nutritional potential, cultural relevance, and local availability. The primary objective of this internship was to carry out detailed micronutrient analyses of these species, thereby contributing to the scientific evidence required for their valorization and integration into sustainable food systems.

1- General Information

My internship journey began with the acceptance of my application by ATSAF in September. Following this confirmation, I began the necessary preparations, including visa processing and other travel arrangements. I arrived in Germany on January 8th, 2025, during the winter season. This marked the beginning of a six-month internship experience filled with work, learning, and the discovery of new people and environments. The winter period, which extended from January to March and into the beginning of April, was particularly challenging for me, especially in January, as I was not accustomed to such cold weather. However, I adapted to the conditions with time.The internship took place at Justus Liebig University Giessen, a prominent public research university located in Giessen, Hesse, Germany. I was hosted by the Crop Production and Yield Physiology Laboratory. This internship was part of a broader research collaboration involving the Alliance of Bioversity International and CIAT, specifically within the framework of the HealthyDiet4Africa (HD4A) Project. This initiative aims to explore the potential of food system diversification as a pathway to combat malnutrition and enhance food and nutrition security across African countries. My academic supervisor in Germany was Professor Michael Frei, who provided expert guidance throughout my stay.

2- Objectives of the Mission

The primary objective of my mission was to carry out laboratory analyses using advanced equipment available at the University of Giessen. The facilities offered state-of-the-art technologies for nutritional assessment, which were instrumental for the research.

Specifically, the goal was to conduct the nutritional characterization of selected neglected plant species collected as part of the research project. This included detailed biochemical analyses focusing on micronutrient content—such as calcium, iron, and zinc—as well as vitamin profiling. These analyses are essential for assessing the nutritional potential of underutilized species and contribute to ongoing efforts to promote their integration into food systems to enhance dietary diversity and combat micronutrient deficiencies.

3- Activities Carried Out

3-1- Sample Preparation and Reception

A total of 40 neglected and underutilized species (NUS) were collected for analysis. These samples included various plant parts such as leaves, seeds, and roots. In addition, two species—Vitex doniana and Irvingia gabonensis—were specifically selected for value chain analysis. These were collected at different stages along the supply chain, from harvest to market, to assess the impact of post-harvest handling and commercialization on their nutritional composition. Irvingia gabonensis samples were obtained in the form of dried kernels and powder, while Vitex doniana samples included both fresh and precooked leaves. To ensure representativeness and reproducibility, samples were collected from three different individuals for each product form, resulting in 21 additional samples. Altogether, 61 plant samples were transported from Benin to the laboratory in Germany.

To preserve their nutritional integrity, all samples underwent a lyophilization (freeze-drying) process prior to transport. This step was critical for maintaining the stability of sensitive compounds. The lyophilized samples were securely packaged and transported by air to the Crop Production and Yield Physiology Laboratory at Justus Liebig University Giessen.

3-2- Analyses Conducted

Upon arrival, the plant samples were ground into fine powder using a laboratory mill, facilitating homogenization and ensuring reliable analytical results. The powdered samples were then divided into small glass vials for subsequent analyses. Prior to this, however, the samples were split into two portions: one designated for micronutrient analysis and the other for vitamin analysis. The vitamin samples were sent to a specialized partner laboratory, while the micronutrient samples remained at the University of Giessen for in-house analysis.

Four main analytical assessments were conducted:

- Carbon and Nitrogen Analysis – This was performed using the Micro-Elementary Analysator UNICUBE, which provides precise elemental composition of plant tissues.
- Micronutrient Profiling – Major and trace elements including calcium (Ca), iron (Fe), magnesium (Mg), sodium (Na), manganese (Mn), phosphorus (P), boron (B), zinc (Zn), copper (Cu), and potassium (K) were analyzed using a microwave digestion system (Microwave digestion device – Microwave 5000, Anton Paar).
- Phytate Analysis – Phytate content, which can affect mineral bioavailability, was quantified using a microplate reader based on the methodology of Vaintraub and Lapteva (Vaintraub & Lapteva, 1988).
- Total Phenolic Content – Phenolic compounds, which contribute to antioxidant properties, were measured using the microplate method according to Ainsworth and Gillespie (Ainsworth & Gillespie, 2007).

In parallel with the laboratory analyses, an experimental trial was initiated to assess the drought resistance of three NUS species: *Trichosanthes cucumerina*, *Basella alba*, and *Stenostylis stenocarpa*. Unfortunately, only *Basella alba* and *Stenostylis stenocarpa* showed any germination. However, due to the low germination rate (4 plants for *Stenostylis* and 6 for *Basella*), it was not possible to conduct the planned drought resistance trial, which required a minimum of 8 plants per species.

Nevertheless, preliminary nutritional analysis of *Basella alba* samples, conducted prior to my arrival, revealed a high iron content. Based on these findings, the research focus shifted to comparing the micronutrient content of *Basella alba* leaves grown in two different soil types: ferrallitic and organic soils. This alternative experiment aimed to understand the influence of soil composition on the nutritional value of the species.

3-3- Challenges Encountered and Solutions Provided

Fortunately, I did not encounter any significant challenges during my stay. I was privileged to work alongside an exceptional team of laboratory technicians who provided constant support and guidance. Their expertise and collaborative spirit contributed immensely to the smooth execution of all planned activities.

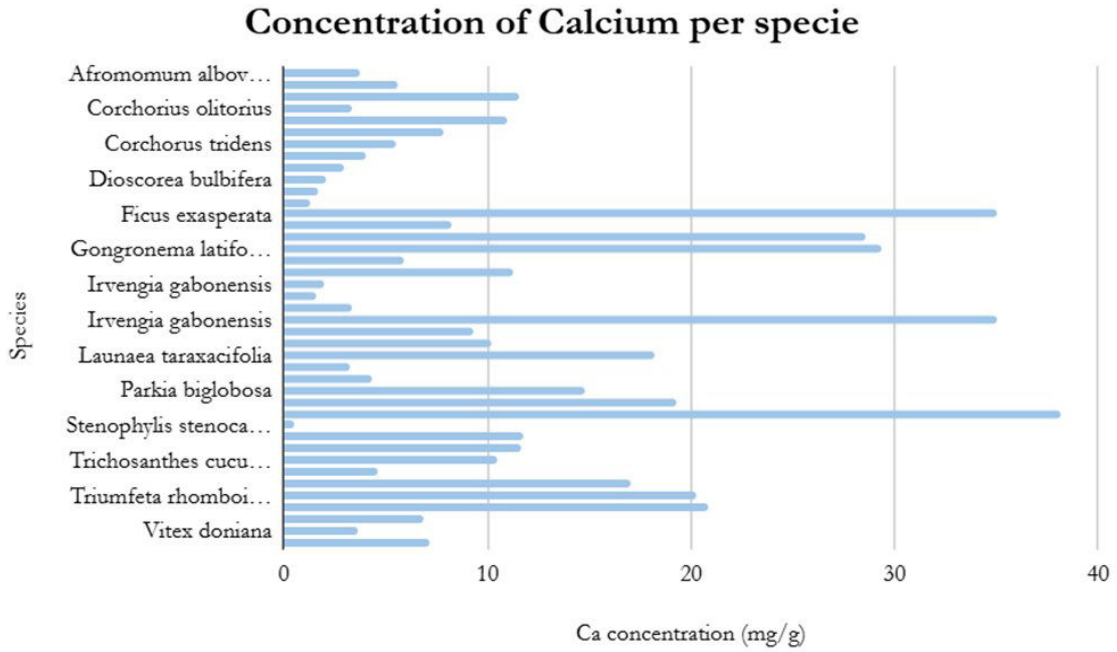
4- Results

Micronutrient content

The analysis revealed results for 10 micronutrients. To keep this report concise, we will present only two of them:

- Calcium

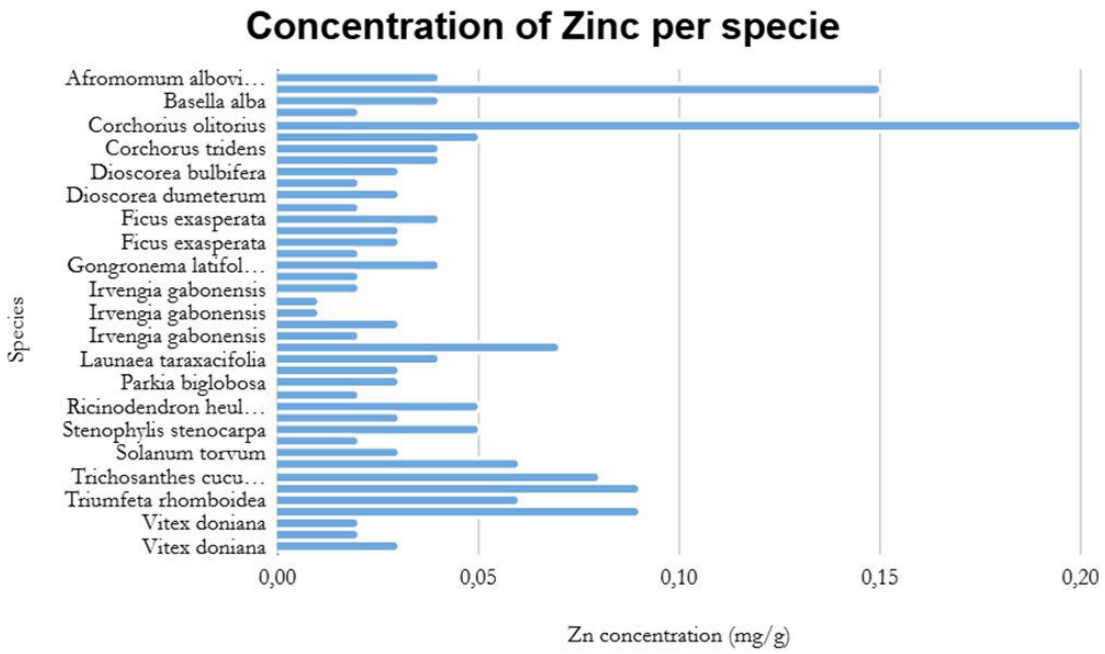
According to the graph, species such as *Irvingia gabonensis*, *Ficus exasperata* (sandpaper fig), and *Ricinodendron heudelotii* exhibit the highest calcium concentrations, making them valuable sources for enhancing bone health and preventing calcium deficiency in local diets (Graph 1).



Graph 1: Calcium content of NUS species

- Zinc

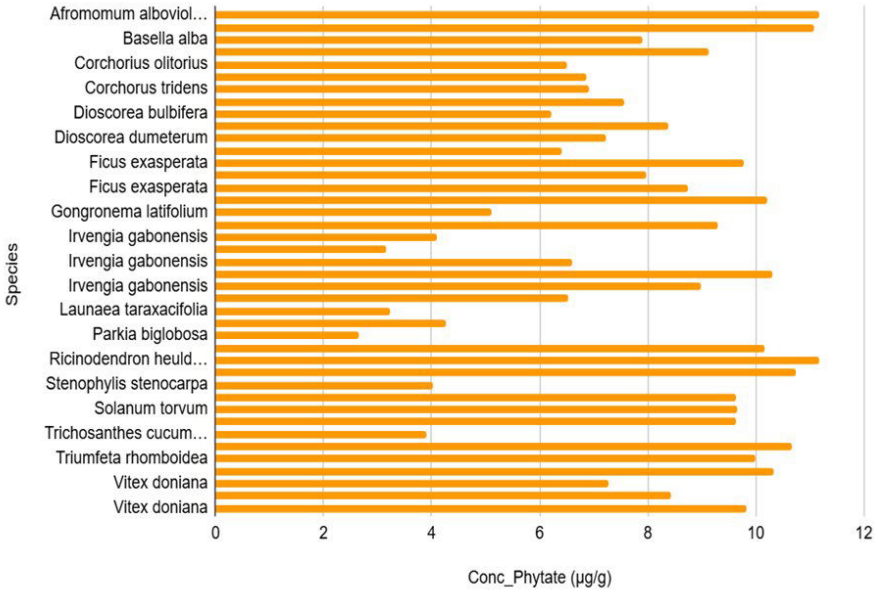
Basella alba and *Corchorus olitorius* had the highest zinc concentrations, underscoring their potential as important dietary sources for addressing zinc deficiency (Graph 2).



Graph 2: Zinc content of NUS species

- Phytates

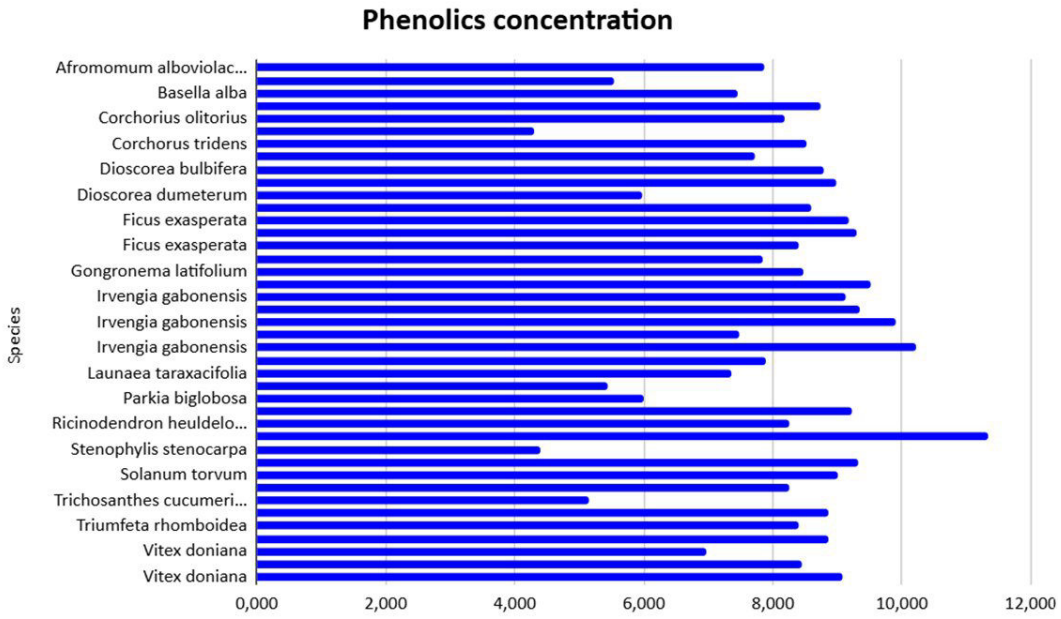
Some species, such as *Aframomum alboviolaceum* (Tondolo), *Ricinodendron heudelotii*, and *Irvingia gabonensis*, exhibited high phytate levels (>10 µg/g), which may hinder mineral absorption. In contrast, *Parkia biglobosa* (African locust bean) and *Launaea taraxacifolia* (African lettuce) had lower phytate contents (below 5 µg/g), making them more favorable for mineral bioavailability. These differences highlight the importance of applying appropriate food processing methods such as cooking or fermentation to reduce phytate levels and improve nutritional outcomes.



Graph 3: Phytates content of NUS species

- Phenolics

Ricinodendron heudelotii (African oil-nut tree), *Irvingia gabonensis* (Bush mango), and *Vitex doniana* (Black plum) had the highest phenolic concentrations, indicating strong antioxidant potential. In contrast, species like *Corchorus olitorius* (Jute mallow) and *Stenophyllis stenocarpa* (African yam bean) showed lower levels, suggesting a more moderate antioxidant contribution. These findings support the inclusion of antioxidant-rich species in sustainable diets to promote public health.



Graph 4: Phenolics content of NUS species

In addition to the laboratory work, I compiled a nutritional composition table for selected neglected species under the HD4A project. This table was developed using data from scientific literature and food composition databases from West Africa, including Nigeria, and other relevant sources.
The database is available here:
http://www.hd4a.eu/Deliverable_D8_Nutrient_composition_database_HD4A2025.xlsx

5- Summary of Mission Contributions

During this internship, I gained valuable scientific and technical skills, particularly in advanced nutritional analysis methods and the use of specialized laboratory equipment. This experience deepened my understanding of the nutritional value of neglected and underutilized species (NUS) and enhanced my ability to conduct high-quality laboratory research. Professionally, the mission allowed me to expand my academic network and engage with international researchers, opening new opportunities for collaboration in the fields of food security and sustainable agriculture. The results and competencies developed during this mission will directly benefit my doctoral research. The data collected will enrich

my dissertation, while the methodologies learned will be applied in future studies, especially for value chain and environmental impact analysis of NUS in Benin.

6- Next Steps in Research

The next phase of the research will focus on the statistical processing and interpretation of the nutritional data generated during the internship. This will contribute to scientific publications aimed at highlighting the nutritional potential of neglected and underutilized species (NUS).

- **Potential Impact for Benin and NUS Valorization**

This research provides scientific evidence of the nutritional value of neglected and underutilized species (NUS), supporting their integration into food and nutrition policies in Benin to combat malnutrition. It also highlights their potential to strengthen local food systems, improve dietary diversity, and promote sustainable agriculture adapted to local environmental conditions.

7- Conclusion

Overall, the internship at Justus Liebig University Giessen was a highly enriching experience, both scientifically and professionally. It provided an excellent opportunity to strengthen my technical skills, broaden my research perspective, and contribute valuable data to my doctoral project. I am fully satisfied with the outcomes achieved, as the objectives initially set nutritional characterization of neglected species, laboratory skill development, and international collaboration—were successfully met. This mission has not only advanced my research but also reinforced my commitment to promoting underutilized species for improved food and nutrition security in Benin and beyond.

8- Acknowledgments

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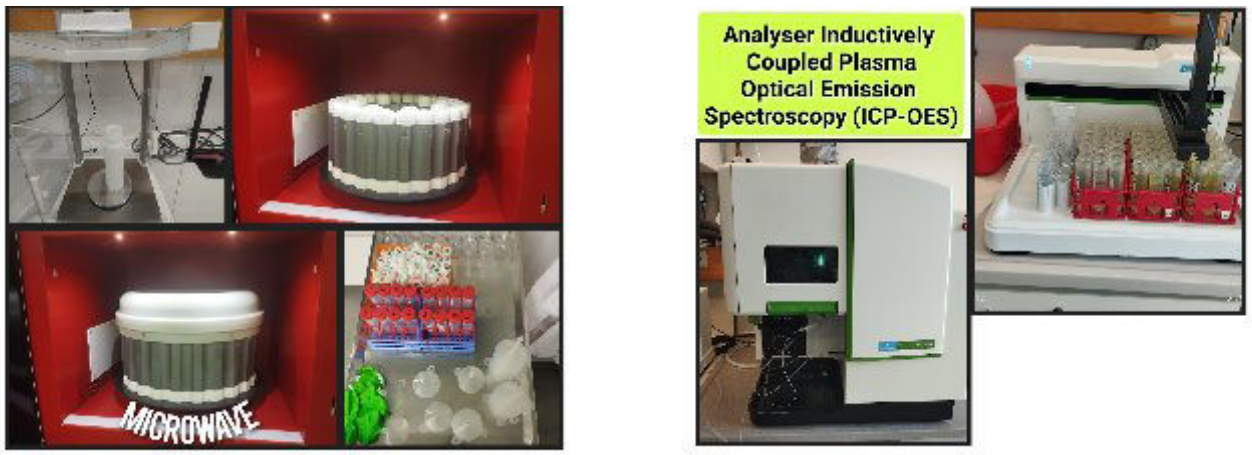
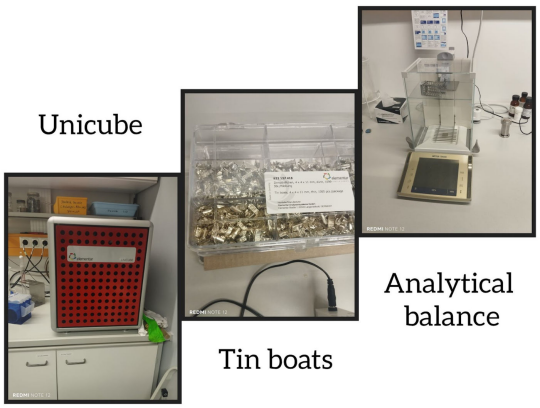
Annexes

Picture 1:**On the left:** seeds of the selected species used for the experiment; **on the right:** *Basella alba* plants grown on two different soil types as part of a comparative study (Own picture)

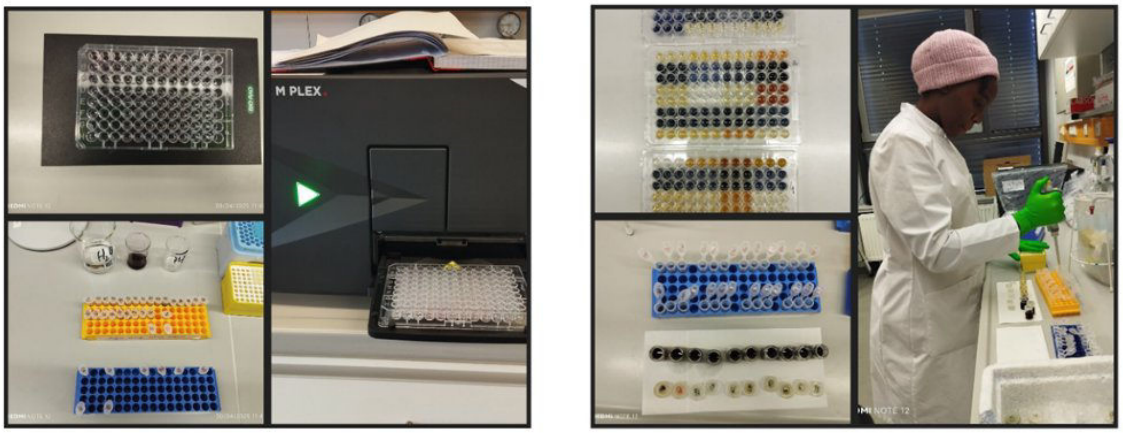
Picture 2: Ground samples prepared for analysis (right) and samples undergoing drying in the oven (left)



Picture 3 : Samples undergoing micronutrient for micronutient analysis



Picture 4 : Sample undergoing Unicube analysis



Picture 5: Samples undergoing Microplate reader analysis (Phytate on the right side and phenolics on the left side)