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A NEW LIGHT IN HERBARIA
How can NIRS be applied to herbarium specimens for identification?

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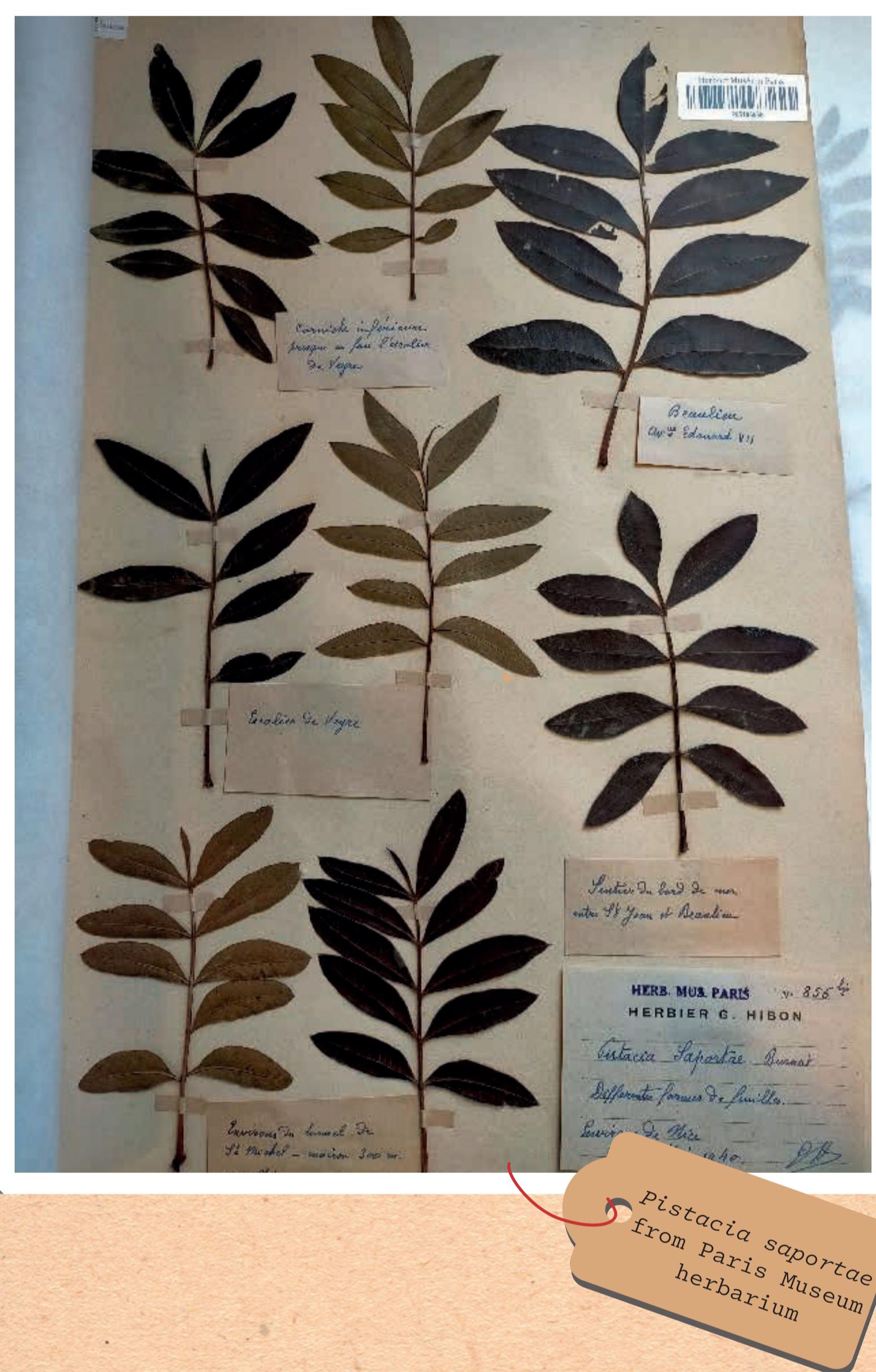
Herbaria preserved hundreds of millions of specimens from all over the world and can date back hundreds of years. Theses collections are remarkable and irreplaceable sources of information about plants, they are a **true library of the world's biodiversity**.

NIRS (Near Infrared Reflectance Spectroscopy) is a well-established indirect measurement method widely used in agronomy for plant constituents. Based on the absorption of light by organic bonds in molecules, **NIRS has great potential for non-destructive, rapid and portable analysis of herbarium specimens.**

Our team is trying to use NIRS on herbarium specimens to **distinguish species from their spectrum**, and perhaps to **identify new specimens from a calibration developed on herbarium samples.**

Pistacia saportae from Paris Museum herbarium

Methods

Materials
• **The 4 Mediterranean species of *Pistacia* :** *P. terebinthus, P. lentiscus, P. vera and P. atlantica* and the **hybrid** *P. saportae* (*P. terebinthus* x *P. lentiscus*).
• **88 herbarium specimens** from the University of Montpellier (MPU) and the Paris Museum (P)
• **36 newly collected specimens** from Southern France at different phenological stages

Measurements
• Directly in herbaria
• ASD Spectrometer with thin probe 6mm diameter.
• Average spectrum of 50 datapoints by specimen (10 spectra on 5 leaves, adaxial)
• Background paper with 100% light absorption

Data treatments
• Use of wavelengths in the NIR region (800-2400nm)
• Spectra pre-processing & dimension reduction by Principal Components Analysis (PCA)
• Discrimination by Factorial Discriminant Analysis (FDA)
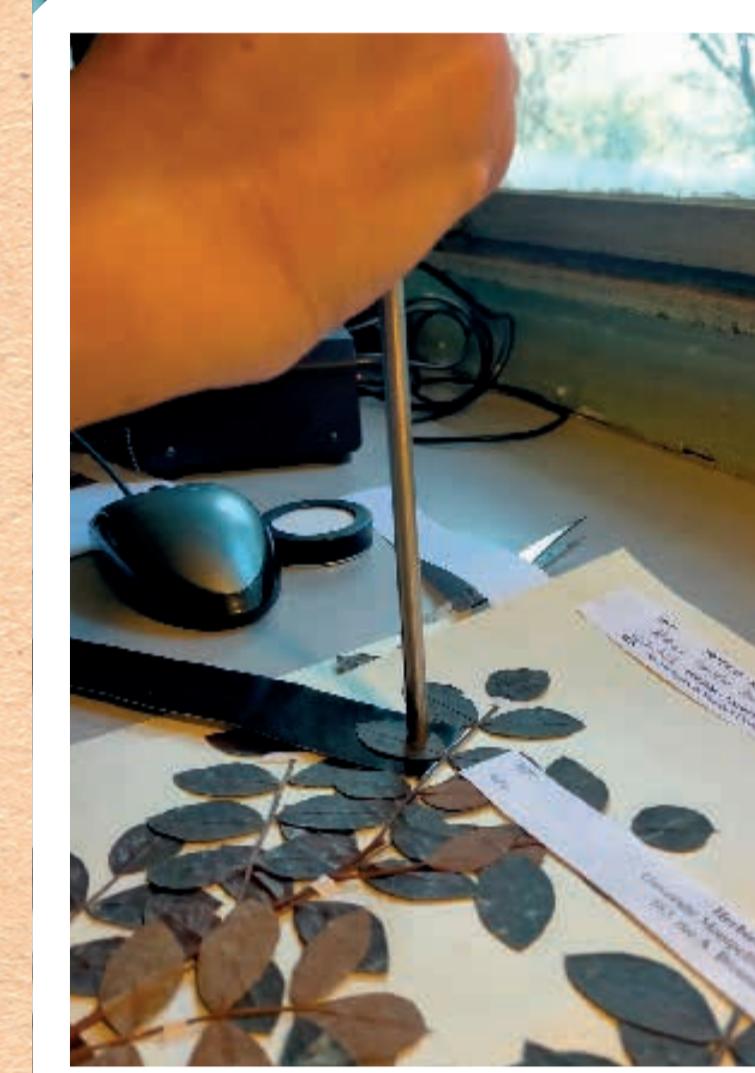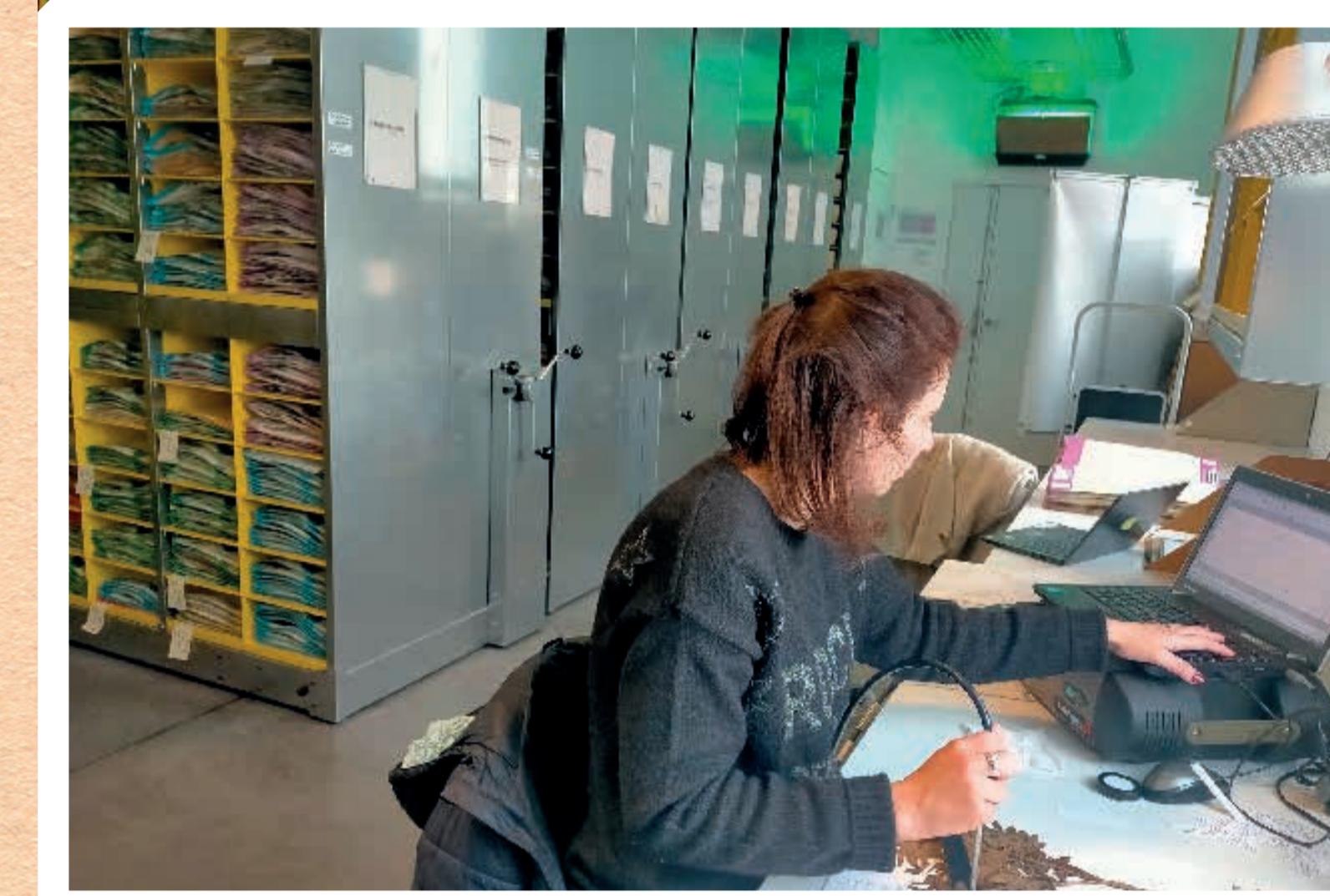
from \ to	P. lentiscus	P. saportae	P. terebinthus	Total	% correct
P. lentiscus	25	6	0	31	81%
P. saportae	4	21	1	26	81%
P. terebinthus	0	4	28	32	88%
Total	29	31	29	89	83%
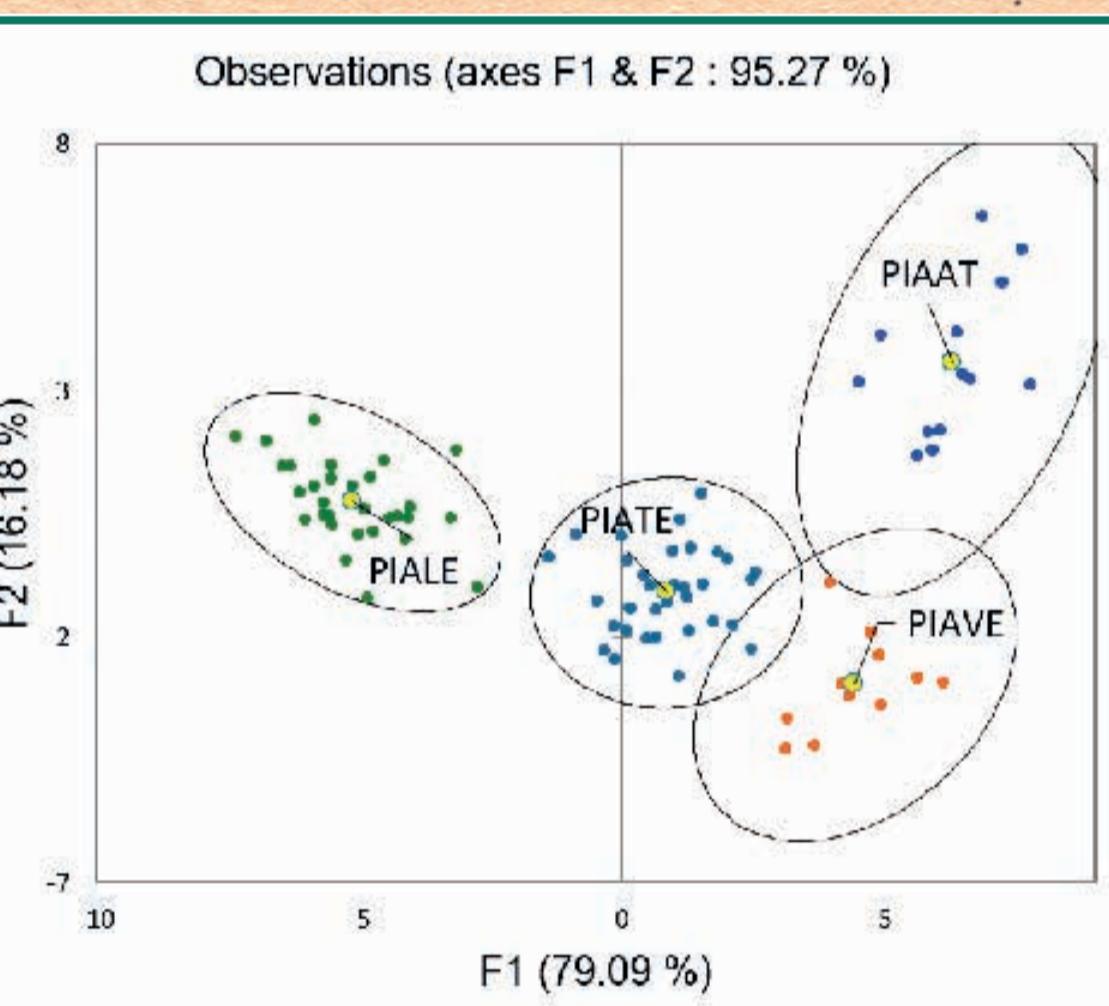
Discrimination of 4 *Pistacia* species by FDA on NIRS spectra

● PIALE *P. lentiscus*
● PIAAT *P. atlantica*
● PIATE *P. terebinthus*
● PIAVE *P. vera*

Results

The **4 species of *Pistacia* were distinguished** on the FDA with a success rate of 98%. The first factorial axis separated *P. lentiscus, P. terebinthus* and *P. vera*, and the second axis separated *P. atlantica* from the other species.

***P. lentiscus* and *P. terebinthus* were completely separated**, while the **hybrid appeared between them** as expected. Some samples were misclassified, as *P. saportae* has a high phenotypic variability. During this study a mis-identified sample from 1864 was spotted by NIRS.

When the **calibration made from herbarium specimens was applied to new samples**, the **classification success** was 68% only, partly due to many non-typical samples in new collections (very young or senescent leaves, etc)

● PIALE *P. lentiscus*
● PIARA *P. saportae*
● PIATE *P. terebinthus*
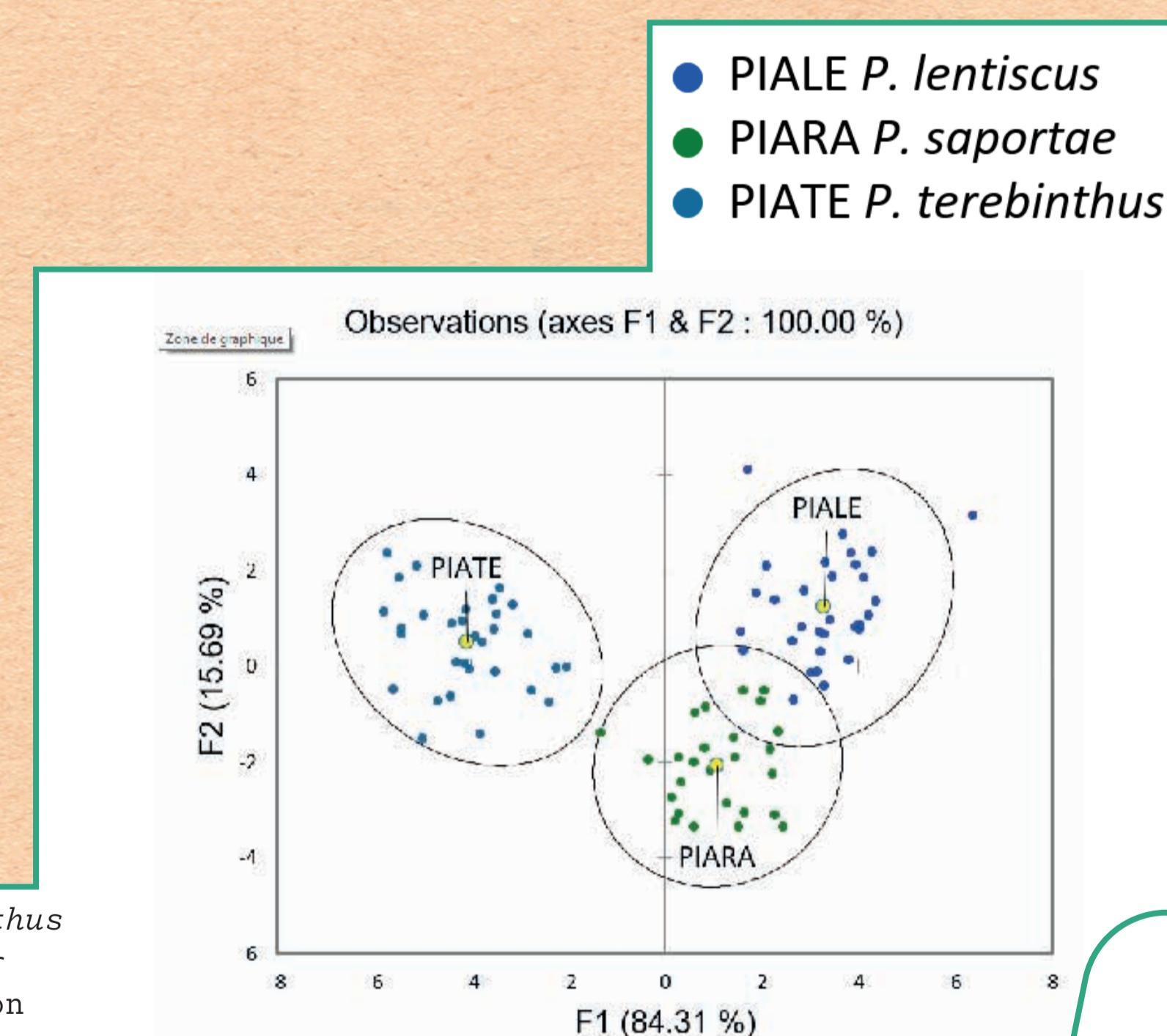
Discrimination of *P. terebinthus* and *P. lentiscus* and their hybrid *P. saportae* by FDA on NIRS spectra

Conclusion and perspectives

NIRS can provides valuable information from herbarium specimens without damages. In the Pistacia example, **species could be well distinguished by their spectrum**. Hybrid spectra are intermediate between those two parent species. **NIRS could account for the taxonomic link and the proximity.** *Pistacia* **new samples could be identified with calibration of old herbarium references.**

Other potential uses of NIRS on herbarium collections are investigated in our team at CIRAD :
• **Predicting samples chemical composition**
• Using **spectra data as functional traits** in addition to morphological traits measurement
• Using **hyperspectral images** for a higher information content
• Identifying **potentially mis-identified** samples
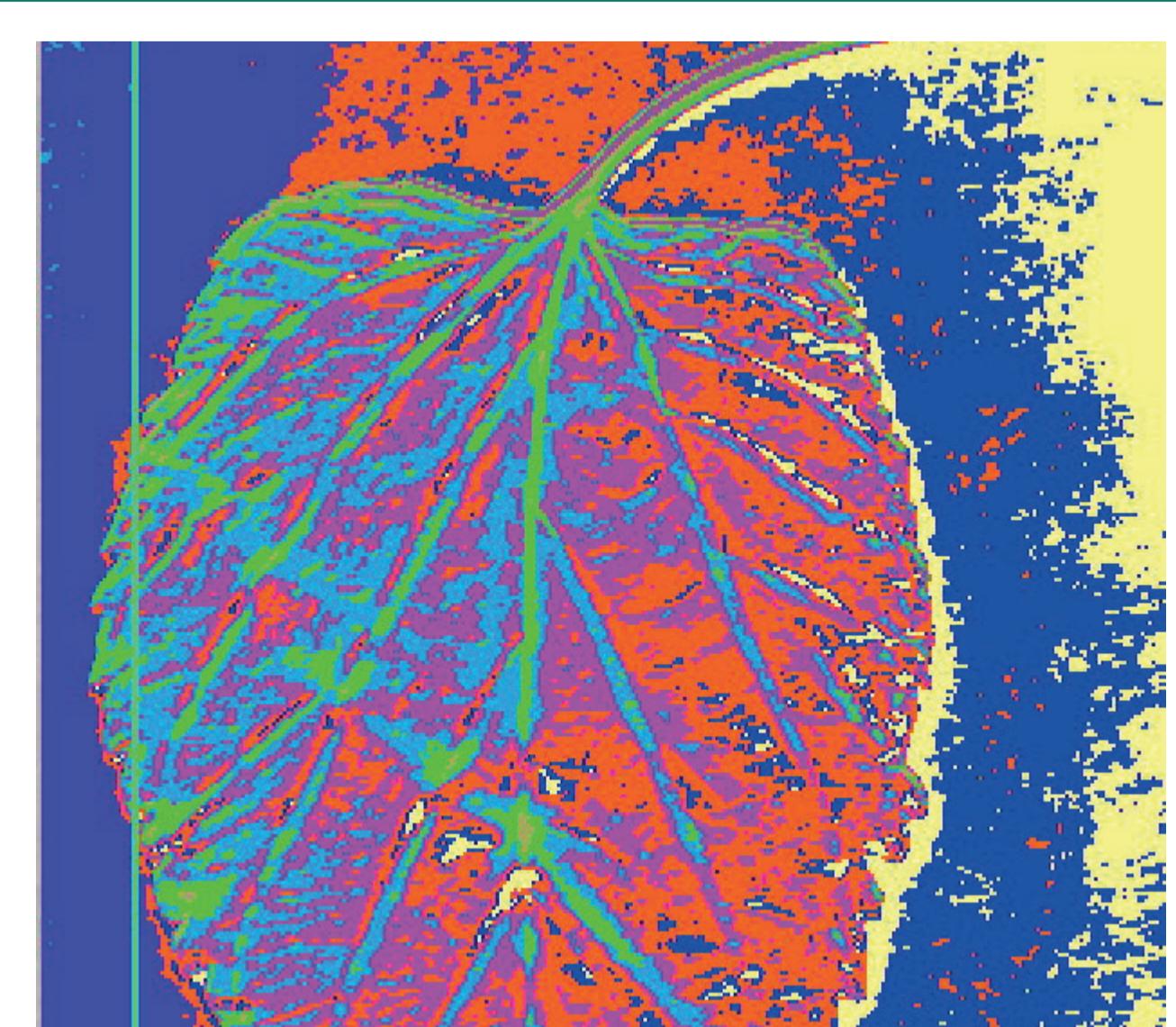
Hyperspectral picture of a Morus alba leaf

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AGRICULTURAL RESEARCH FOR DEVELOPMENT

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