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Estimating Extractive Content in *Dalbergia latifolia* Wood Using Near-Infrared (NIR) Spectroscopy and Three Solvent Systems

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INTRODUCTION & AIM

Dalbergia latifolia, commonly known as Indian rosewood, is a valuable hardwood species renowned for its aesthetic appeal, strength, and resistance to decay. The extractive content in wood plays a crucial role in its durability, color, and mechanical properties. Traditional wet chemistry methods for estimating extractive content are labor-intensive and time-consuming. Near-Infrared (NIR) spectroscopy, a rapid and non-destructive analytical tool, offers a promising alternative. This study aims to estimate the extractive content in *D. latifolia* using NIR spectroscopy combined with solvent extraction methods.

Objective: To develop a reliable and rapid method for estimating extractive content in *D. latifolia* wood using NIR spectroscopy, complemented by three solvent systems (hotwater, iso-propanol, and hexane) to differentiate between polar, mid-polar, and non-polar extractives.

MATERIALS AND METHOD

Sample collection and preparation:

•Wood samples were collected from different markets in the Bangalore region to account for variability in the extractive content.

•Samples were ground into fine powder to facilitate uniform extraction and spectral analysis.

Solvent extraction:

Solvent systems: Hotwater (polar), Iso-propanol (mid-polar), and Hexane (non-polar).

Extraction was performed following TAPPI methods:

•Hot-water extraction (TAPPI T 207 cm-99)

•Iso-propanol and Hexane extraction (TAPPI T 204 cm-97)

NIR Spectroscopy:

- NIR spectra were acquired using a Bruker FT-NIR (Model MPA) equipped with an integrating sphere.
- Spectral range: 12,500–4000 cm^{-1} with a resolution of 8 cm^{-1}. (specific range selected
- A total of 32 scans were averaged for each sample.
- Key absorbance peaks related to functional groups (O-H, C-H, N-H) were identified.

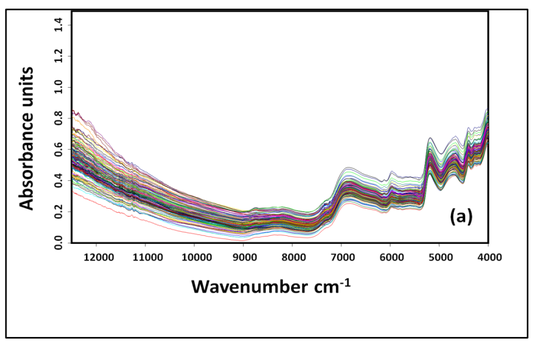


Figure 1. NIR spectra of *D. latifolia* .

Data Analysis:

• Partial Least Squares Regression (PLS-R) models were developed to correlate NIR spectra with the extractive contents obtained from each solvent system.

•The dataset was split into calibration (75%) and validation (25%) sets to assess the model's accuracy.

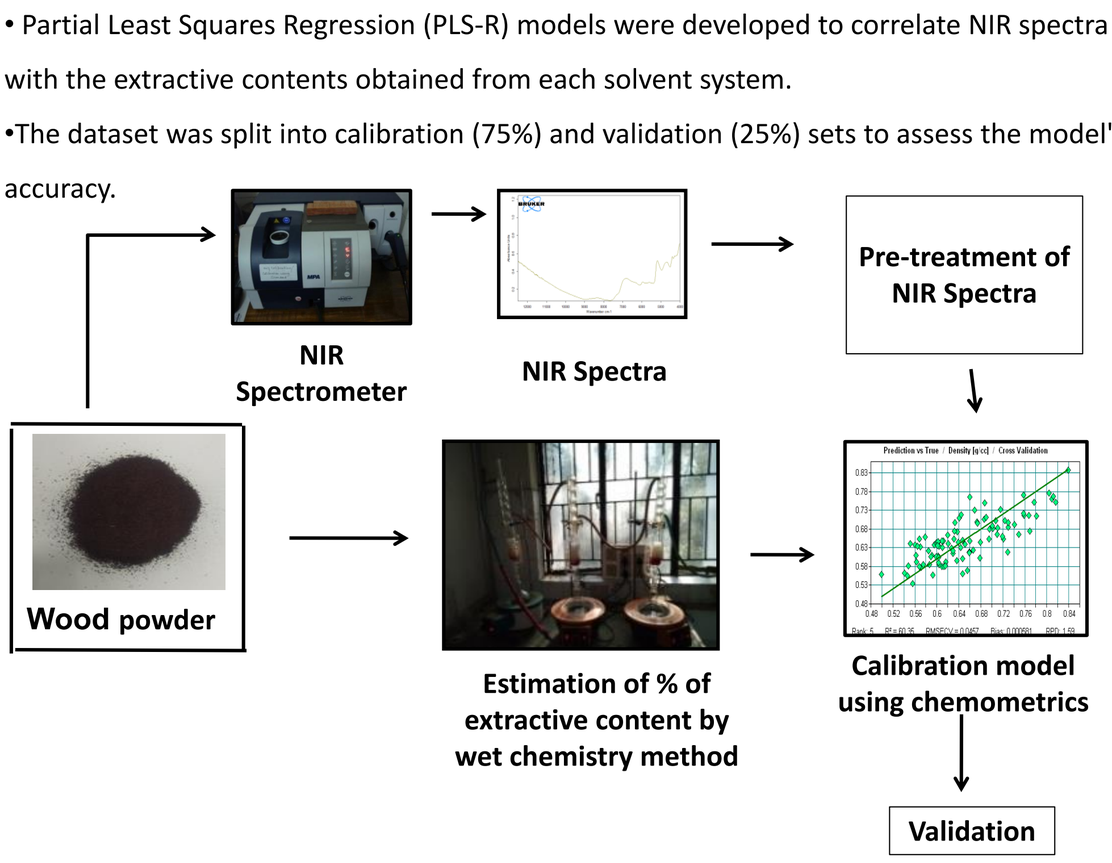


Figure 2. Methodology for estimation of extractive content using NIRS

RESULTS & DISCUSSION

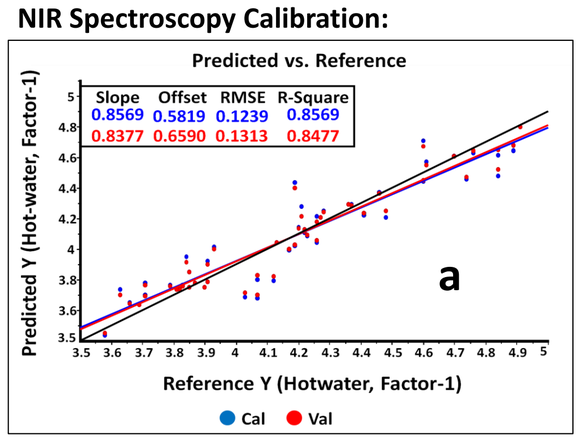
Extractive content by solvent system:

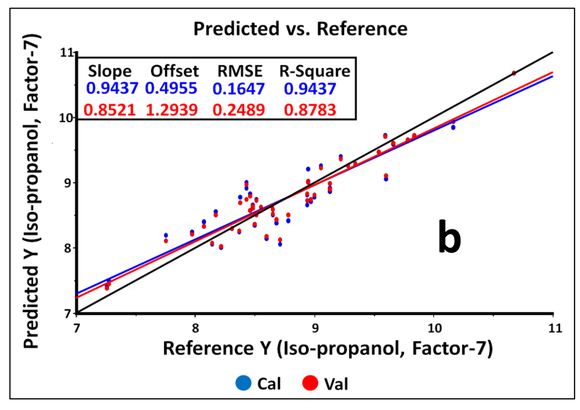
Table 1. Extractives content of *D. latifolia* wood species using three different solvents.

Statistical parameters	Hot-water (%)	Iso-propanol (%)	Hexane (%)
Average (%)	4.09	8.63	1.50
SD (%)	0.34	0.60	0.21
CV (%)	8.20	6.94	13.97
Maximum (%)	5.02	10.10	2.01
Minimum (%)	3.59	7.54	1.01

SD-standard deviation, CV- Coefficient of variation

NIR Spectroscopy Calibration:





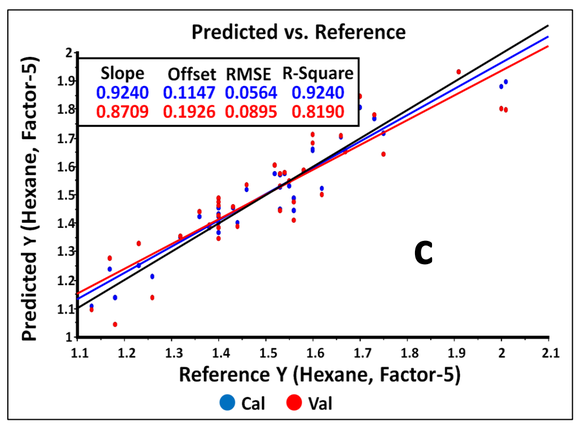


Figure 3: Calibration and Validation results of PLS-R model for (a) Hot-water, (b) Iso-propanol, and (c) hexane extractive content.

Table 2. Extractives content of *D. latifolia* wood species using three different solvents.

Components	Model	Hot-water (%)	Isopropanol (%)	Hexane (%)
LV	-	1	7	5
$R^2_{(CV)}$	Cross-validation (n=50)	0.847	0.878	0.81
$RMSE_{(CV)}$		0.131	0.248	0.089
$RPD_{(CV)}$		2.56	2.41	2.36
$R^2_{(C)}$	Calibration (n=37)	0.856	0.943	0.920
$RMSE_{(C)}$		0.123	0.164	0.056
$RPD_{(C)}$		2.72	3.65	3.75
$R^2_{(P)}$	Validation set (n=13)	0.758	0.71	0.74
$RMSE_{(P)}$		0.165	0.30	0.10
$RPD_{(P)}$		2.03	1.99	2.10

CONCLUSION

NIR spectroscopy, combined with traditional solvent extraction, provides a reliable, rapid, and non-destructive method for estimating extractive content in *D. latifolia wood*. The strong correlation between NIR predictions and solvent extraction results shows that, NIR spectroscopy is a promising tool for assessing non-polar extractives, which influence the wood's durability.

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