

NICOTIANA TABACUM L.: MORPHOLOGICAL, PHYTOCHEMICAL, AND MICROSCOPIC CHARACTERIZATION OF LEAVES AND STEMS

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Abstract: *Nicotiana tabacum* L., commonly known as cultivated tobacco, is an annual plant widely grown for commercial purposes. This study provides a comprehensive overview of its morphological characteristics, phytochemical composition, and microscopic features of leaves and stems. The plant contains significant levels of nicotine, phenolics, and other bioactive compounds. Microscopic analysis revealed characteristic features such as bicollateral vascular bundles, glandular and non-glandular trichomes, and calcium oxalate crystals (cystoliths). Additionally, post-harvest tobacco leaf residues were analyzed using conventional solvents and Natural Deep Eutectic Solvents (NaDES) to extract bioactive metabolites, highlighting their potential for cosmetic and therapeutic applications. These findings enhance our understanding of *N. tabacum*'s structural and chemical properties and suggest sustainable uses for tobacco biomass.

Keywords: *Nicotiana tabacum*, tobacco, morphology, phytochemicals, alkaloids, microscopic features, leaves, stems

НИКОТИАНА ТАБАКУМ L.: МОРФОЛОГИЧЕСКАЯ, ФИТОХИМИЧЕСКАЯ И МИКРОСКОПИЧЕСКАЯ ХАРАКТЕРИСТИКА ЛИСТЬЕВ И СТЕБЛЕЙ

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Аннотация: *Nicotiana tabacum* L., широко известный как культурный табак, является однолетним растением, широко выращиваемым в коммерческих целях. В данном исследовании представлен всесторонний обзор морфологических характеристик, фитохимического состава и микроскопических особенностей листьев и стеблей. Растение содержит значительные уровни никотина, фенольных соединений и других биологически активных веществ. Микроскопический анализ выявил характерные признаки, такие как биколлатеральные сосудистые пучки, железистые и нежелезистые трихомы, а также кристаллы оксалата кальция (цистолиты). Кроме того, послеуборочные остатки табачных листьев были проанализированы с использованием традиционных растворителей и натуральных глубоких эвтектических растворителей (NaDES) для извлечения биологически активных метаболитов, что подчеркивает их потенциал для косметического и терапевтического применения. Полученные данные расширяют наше понимание структурных и химических свойств *N. tabacum* и предлагают устойчивые способы использования табачной биомассы.

Ключевые слова: *Nicotiana tabacum*, табак, морфология, фитохимические вещества, алкалоиды, микроскопические особенности, листья, стебли

Introduction

Nicotiana tabacum L., a member of the Solanaceae family, is a tropical annual plant widely cultivated worldwide for tobacco production. It reaches heights of 1–3

meters, with large oval, elliptic, or obovate leaves used primarily for cigarette and other tobacco products. *N. tabacum* is believed to be a hybrid of *N. sylvestris*, *N. tomentosiformis*, and possibly *N. otophora*. Tobacco cultivation generates trillions of kilograms of biomass waste annually, negatively impacting the environment. Identifying and utilizing bioactive compounds from tobacco residues offers an opportunity to repurpose this biomass for cosmetic and therapeutic applications.

Materials and Methods

Plant Material

N. tabacum var. Virginia plants were cultivated under controlled conditions. Leaves and stems were collected at various developmental stages for morphological, phytochemical, and microscopic analysis. Post-harvest residues were collected during “topping” and processing operations.

Phytochemical Analysis

Conventional solvents (water, acetone, ethanol) and Natural Deep Eutectic Solvents (NaDES: LAS, FGS, SALA, CU, CAP) were used to extract bioactive compounds from leaf and stem residues. Alkaloid and phenolic content, sugar concentration, and antioxidant activity (ABTS and H₂O₂ scavenging) were measured.

Microscopic Examination

Fresh and dried leaf and stem samples, as well as fine powders, were analyzed using light microscopy. Features examined included epidermal cell shape, stomatal type, vascular bundles, trichomes, mesophyll structure, and presence of calcium oxalate crystals.

Results

Morphological Features

N. tabacum plants grew 1–3 m in height with thick, sparsely branched stems and large leaves up to 50 cm long. Flowers were paniculately arranged and varied in color from white to pink or red. Fruit capsules were narrow, elliptic to ovoid, measuring 1.5–2 cm.

Phytochemical Composition

Nicotine concentration increased with plant maturity, representing 64% in leaves, 18% in stems, 13% in roots, and 5% in flowers. The plant also contained polysaccharides, phenolics (rutin, chlorogenic acid), amino acids (glutamine, asparagine, GABA), pyridine alkaloids, and indole alkaloids (yohimbine, harmaline). Megastigmatrienone was identified as a key aromatic compound responsible for tobacco fragrance and industrial applications.

NaDES extraction yielded higher phenolic content compared to conventional solvents (18.13–21.98 mg AGE/g tobacco powder). CU, FGS, and acetone/ethanol extracts exhibited the highest alkaloid concentrations (6.37–11.23 mg ACE/g tobacco powder). Extracts also showed significant antioxidant activity.

Component / Extract	Leaves	Stems	Roots	Flowers	Notes
Nicotine (%)	64	18	13	5	Increases with plant maturity
Polysaccharides	✓	✓	✓	✓	Present in all plant parts
Phenolics	✓	✓	✓	✓	Includes rutin, chlorogenic acid
Amino acids	✓	✓	✓	✓	Includes glutamine, asparagine, GABA
Pyridine alkaloids	✓	✓	✓	✓	Nicotine 90–95%, nornicotine/anatabine ~2.5%
Indole alkaloids	✓	✓	✓	✓	Includes yohimbine, harmaline
Megastigmatrienone	✓	—	—	—	Key aromatic compound
NaDES Phenolic	18.13–21.98	—	—	—	Higher than

Component / Extract	Leaves	Stems	Roots	Flowers	Notes
Content (mg AGE/g)					conventional solvents
Alkaloid Content (mg ACE/g)	CU: 6.37–11.23	FGS: 6.37–11.23	—	—	CU, FGS, Acetone/Ethanol extracts highest
Antioxidant Activity	✓	✓	✓	✓	Significant in all extracts

Microscopic Features

Leaf and stem tissues displayed bicollateral vascular bundles, 6–9 glandular trichomes, multicellular non-glandular trichomes, and cystoliths. Epidermal cells exhibited sinuous anticlinal walls with anomocytic stomata in leaves. Mature leaves contained abundant cystoliths in the mesophyll. Stem cross-sections showed elongated cortical parenchyma, medullary parenchyma, fibers, and vascular bundles. Powdered samples preserved these characteristics, though epidermal fragments were less frequent.

Discussion

N. tabacum exhibits distinct morphological and microscopic traits characteristic of the Solanaceae family. Its rich phytochemical profile, including alkaloids, phenolics, and aromatic compounds, highlights its potential for industrial, therapeutic, and cosmetic applications. NaDES extraction represents a sustainable approach to recovering bioactive compounds from tobacco residues. Microscopic markers, such as anticlinal epidermal walls, cystolith-containing mesophyll, and vascular bundle patterns, allow reliable identification of tobacco leaf and stem tissues, even in powdered forms.

Conclusion: *Nicotiana tabacum* L. is a structurally and chemically complex plant with high economic importance. Understanding its morphological, phytochemical,

and microscopic characteristics facilitates its sustainable utilization. Extraction of bioactive compounds from post-harvest residues using NaDES offers a promising avenue for environmentally friendly applications in cosmetics and therapy.

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