

SPRINGER BRIEFS IN PLANT SCIENCE

Münir Öztürk · Volkan Altay  
Khalid Rehman Hakeem  
Eren Akçiçek

# Liquorice

## From Botany to Phytochemistry

 Springer

# **SpringerBriefs in Plant Science**

SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic. Typical topics might include:

- A timely report of state-of-the art analytical techniques
- A bridge between new research results, as published in journal articles, and a contextual literature review
- A snapshot of a hot or emerging topic
- An in-depth case study or clinical example
- A presentation of core concepts that students must understand in order to make independent contributions

SpringerBriefs in Plant Sciences showcase emerging theory, original research, review material and practical application in plant genetics and genomics, agronomy, forestry, plant breeding and biotechnology, botany, and related fields, from a global author community. Briefs are characterized by fast, global electronic dissemination, standard publishing contracts, standardized manuscript preparation and formatting guidelines, and expedited production schedules.

More information about this series at <http://www.springer.com/series/10080>

Münir Öztürk · Volkan Altay  
Khalid Rehman Hakeem  
Eren Akçiçek

# Liquorice

From Botany to Phytochemistry

 Springer

Münir Öztürk  
Department of Botany and Center for  
Environmental Studies  
Ege University  
Izmir, Turkey

Khalid Rehman Hakeem  
Department of Biological Sciences  
King Abdulaziz University  
Jeddah, Saudi Arabia

Volkan Altay  
Department of Biology, Faculty of Science  
and Arts  
Mustafa Kemal University  
Hatay, Turkey

Eren Akçiçek  
Department of Gastroenterology, Faculty of  
Medicine  
Ege University  
Izmir, Turkey

ISSN 2192-1229

ISSN 2192-1210 (electronic)

SpringerBriefs in Plant Science

ISBN 978-3-319-74239-7

ISBN 978-3-319-74240-3 (eBook)

<https://doi.org/10.1007/978-3-319-74240-3>

Library of Congress Control Number: 2018930380

© The Author(s) 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

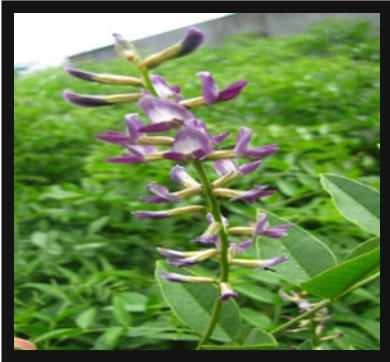
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland



*Glycyrrhiza glabra* (at the top)



*Glycyrrhiza flavescens* ssp. *flavescens*  
(right side)



*Glycyrrhiza glabra* root (in the centre)



*Glycyrrhiza echinata* (lower side)

*Dedicated to*

*Abu Ali Husayn ibn Abd Allah ibn Sina  
(Avicenna)  
(980–1037 CE)*



*An important figure as a physician, astronomer, thinker and writer, accepted as the father of early modern medicine due to the book he wrote “el-Kanun fi’-Tib” or “Canon of Medicine”- incorporates the work of Galen, as well as ancient Ayurvedic, Arabian and Persian texts as*

*well as his own theories of medicine. His influence on the development of medicine across much of the world has been quite significant.*

*(Image from google search—who is Avisena SML 710 × 1024, from Ms. Tel Asiado—a writer, author, content producer—from google search)*



# Preface

According to the famous medicine man “Avicenna,” there are men on our mother earth who have wit but no religion, and the men who have religion but no wit, ecologically speaking all things have causes, knowledge of anything is not complete unless you know its causes as such in medicine we must know the causes of sickness and health. This book deals with the health benefits of liquorice (*Glycyrrhiza*), a widely used plant as herbal medicine and one of the most extensively investigated medicinal plants of the world. The roots and stolons have been used as food, and in traditional the root is well known to the herb dealers as well as traditional medicine men for over 4000 years. It has been used against the treatment of many ailments including the diseases of lung, heart, and kidney; arthritis, eczema, gastric ulcer, low blood pressure, allergies, liver toxicity, and certain microbial infections. The extract of this plant contains sugars, starch, resins, essential oils, tannins, inorganic salts, and low levels of nitrogenous constituents such as proteins, individual amino acids, and nucleic acids. A large number of biologically active compounds have been isolated from *Glycyrrhiza* species, where triterpene saponins and flavonoids are the main constituents.

In this introductory book, we have tried to present a global perspective of liquorice with a detailed historical background and attempt has been made to bridge the gap between botany, ecology, treatment of diseases, molecular and pharmaceutical aspects. Along with the discussions on the recent studies on the phytochemical and pharmacological aspects, some side and toxicity effects have also been evaluated. The information on bioactive components has been presented at length. The book also presents details on the taxonomy of this genus at global level,

as well as its industrial use and economical importance. Some information on its ecology, cultivation, genetics, and biotechnology has also been included. We hope it will prove of great help to the workers involved in the research aspects of liquorice.

Izmir, Turkey  
Hatay, Turkey  
Jeddah, Saudi Arabia  
Izmir, Turkey

Münir Öztürk  
Volkan Altay  
Khalid Rehman Hakeem  
Eren Akçiçek

# Contents

<b>1</b>	<b>Introduction</b> . . . . .	1
	References . . . . .	2
<b>2</b>	<b>Botany</b> . . . . .	5
	2.1 Taxonomy and Morphology . . . . .	5
	2.2 Pollen Studies . . . . .	13
	2.3 Distribution in the World . . . . .	16
	References . . . . .	16
<b>3</b>	<b>Ecology</b> . . . . .	19
	References . . . . .	21
<b>4</b>	<b>Ecophysiological Aspects</b> . . . . .	23
	References . . . . .	29
<b>5</b>	<b>Liquorice–Mycorrhiza Interactions</b> . . . . .	31
	5.1 <i>Glycyrrhiza glabra</i> . . . . .	31
	5.2 <i>Glycyrrhiza uralensis</i> . . . . .	34
	5.2.1 Arbuscular Mycorrhizal Colonization . . . . .	34
	5.2.2 Effects on the Liquorice Development with or Without AM Fungal Inoculation . . . . .	35
	5.2.3 Effects on Root Oxidase Activity and Phosphorus and Potassium Uptake . . . . .	35
	5.2.4 Glycyrrhizin Production . . . . .	36
	References . . . . .	38
<b>6</b>	<b>Molecular Aspects</b> . . . . .	41
	6.1 Cytogenetics . . . . .	41
	6.2 Genetic and Biotechnology . . . . .	41
	References . . . . .	43

<b>7</b>	<b>Pharmacological Activities and Phytochemical Constituents</b> . . . . .	45
7.1	Phytochemistry of Components . . . . .	46
7.1.1	Flavanoids . . . . .	48
7.1.2	Saponins . . . . .	49
7.1.3	Phenolic Compounds . . . . .	49
7.1.4	Coumarins . . . . .	50
7.1.5	Essential Oils and Other Compounds . . . . .	51
7.2	Bioactive Components and Biological Functions . . . . .	53
7.2.1	Glycyrrhizic Acid and 18 $\beta$ -Glycyrrhetic Acid . . . . .	54
7.2.2	Liquiritin, Isoliquiritin, Liquiritigenin, and Isoliquiritigenin . . . . .	57
7.2.3	Dehydroglyasperin C and D . . . . .	59
7.2.4	Glabridin . . . . .	59
7.2.5	Carbenoxolone . . . . .	60
	References . . . . .	61
<b>8</b>	<b>Economic Importance</b> . . . . .	73
8.1	Traditional Uses . . . . .	73
8.2	Industrial Uses . . . . .	74
8.2.1	Liquorice as an Industrial Resource: A Case Study from Japan . . . . .	79
8.3	Other Uses . . . . .	82
8.3.1	Liquorice Drinks . . . . .	82
8.3.2	Meyan Balı (the Succus Liquiritiae) . . . . .	82
8.3.3	Use as Animal Feed . . . . .	84
8.3.4	Use as Dye Plant . . . . .	84
8.3.5	Evaluation of Liquorice Wastes . . . . .	85
8.3.6	Antimicrobial and Antifungal Activity . . . . .	86
8.3.7	Antiviral Activity . . . . .	90
8.3.8	Anti-inflammatory . . . . .	91
8.3.9	Anti-ulcer . . . . .	93
8.3.10	Anti Tumor . . . . .	93
8.3.11	Antioxidant . . . . .	95
8.3.12	Hepatoprotective Activity . . . . .	96
8.3.13	Dermatological Effect . . . . .	97
8.3.14	Antidepressant and Memory-Enhancing Activity . . . . .	97
8.3.15	Immunoregulatory Activity . . . . .	98
8.3.16	Inhibitory Effect on Diabetes . . . . .	99
8.3.17	Adrenal Cortical Hormone-like Function . . . . .	100
8.3.18	Other Effects . . . . .	100
8.3.19	Side Effects and Toxicity . . . . .	102
8.3.20	Other Alternative Uses . . . . .	107
	References . . . . .	108

<b>9 Cultivation</b> .....	127
References .....	131
<b>10 Global Perspectives and Future Approaches</b> .....	133
References .....	134
<b>11 Concluding Remarks and Future Directions of Research</b> .....	135
References .....	137
<b>Index</b> .....	141

# Chapter 1

## Introduction



The genus *Glycyrrhiza* (Liquorice) includes well-known traditional medicinal plants growing in several regions of the world. The stolon and roots of the plants have been used in traditional medicine by humans for over 4000 years and it has been described as “the grandfather of herbs” (Ody 2000). *Glycyrrhiza* genus consists of about 30 taxa, of which only 15 taxa have been studied so far (Blumenthal et al. 2000; Sultana et al. 2010; Chopra et al. 2013; Altay et al. 2016). The plants included in the genus *Glycyrrhiza* are perennial herbs native to the regions in the Mediterranean, central and southern Russia, Asia Minor, and parts of Iran. It is now widely cultivated throughout Europe, the Middle East, and Asia (Blumenthal et al. 2000).

The plant has a long history of medicinal uses in Eurasia. It is believed to be effective in treating peptic ulcer disease, constipation, cough, diabetes, cystitis, tuberculosis, wounds, kidney stones, lung ailments, Addison’s disease, colds, and painful swellings (Varshney et al. 1983; Dafni et al. 1984; Arseculeratne et al. 1985; Fujita et al. 1995; Yarnell 1997; Gray and Flatt 1997; Rajurkar and Pardeshi 1997; Armanini et al. 2002; Chopra et al. 2002; Sharma and Agrawal 2013). It has also been used for its anabolic properties and its capacity to improve male sexual function (Sircar 1984; Nisteswar and Murthy 1989).

The name “*Glycyrrhiza*” comes from Greek words (glukos: sweet, rhiza: root) meaning “sweet root”. Liquorice has a long and honorable history in the service of humanity as it has been used medicinally long before the time of Christ. In the fourth century B.C., the Greek botanist and contemporary of Aristotle, Theophrastus (ca. 370–288/5 B.C.), refers to liquorice as “Scythian root” or “sweet root” in his Enquiry into Plants (Theophrastus 1916). This ancient herbalist was also interested in the history of liquorice and claims that the Scythians, whose civilization was established early in the first millennium B.C., used liquorice and mare’s milk cheese and could subsequently abstain from drinking for 11 or 12 days. He also mentions that liquorice is useful in treating asthma when administered with honey. Roots of this plant have been used in other areas of the ancient world, the Brahmans of India, the Hindus, Greeks, Romans, Babylonians, and Chinese (Chopra and Chopra 1958; Chopra et al. 1958). Nature’s medicine has recorded that the earliest evidence of the use of liquorice goes back to the first syllables of recorded time. It has been mentioned throughout the history and has been included in the records of Pharaohs and Prophets. Generous supplies have been discovered in the Emperor Tut’s grave as well as in other tombs of ancient Egyptian pharaohs; Egyptian hieroglyphics record the use of Liquorice as a popular beverage by

humans in the days when the Bible was still being written (Lucas 1976). During the Middle Ages, early medical practitioners like Ibn Sinna (Avicenna, 980–1037) have written about liquorice in his “Canone” (EMA 2013). He mentions that liquorice is used to treat many illnesses but mainly drunk as a tonic as a remedy for cold and cough. *Glycyrrhiza* is one of the main treatments in the traditional medicine (Davis and Morris 1991). Alexander the Great, the Scythian armies, Roman Emperor Caesar, and even Hindu prophet, Brahma, are on record endorsing the beneficial aspects of liquorice (Oğuz 1987). Warriors used it for its ability to quench thirst while on the March, while others (including Brahma and venerable Chinese Buddhist sages) recognized Liquorice’s valuable healing properties (Rogers 2014). In Chinese medicine, it has been used for over 4.000 years as a tonic to rejuvenate the heart and spleen, and as a treatment for ulcers, cold symptoms, and skin disorders. Chinese prepared it most often as medicinal tea (Fernie 1897). Recently, a sample of historic liquorice from 756 A.D. was analyzed and found to still have active principles (Sigurjonsdottir et al. 1995, 2001).

Pedanius Dioscorides of Anazarba present-day Tarsus in Turkey has given the name “glukurrhiza” for the sweet flavoring root or stem of *Glycyrrhiza glabra*, the first part of the word glukus means “sweet”, and the rhiza means “root”. Chinese too have named it as “gao cao-sweet root”. Generally, three plants are identified under liquorice *G. glabra*, *Glycyrrhiza uralensis*, and *Glycyrrhiza inflata* (Kao et al. 2014).

The commonly known “liquorice” is accepted as *G. glabra*. This “sweet wood” belongs to Fabaceae (Leguminosae) family (Chopra and Chopra 1958). Forever, it has got many vernacular names such as Sa em (Latin America); Réglisse, boisdoux (France); Lakritze, Süsshholz (Germany); Spanish liquorice, Orozuz, Ragaliz (Spain); Lakrids, Lakridsplante (Denmark); Zoethout (Netherlands); Lagritsa-magusjuur (Estonia); Lakritskasvi, Lakritsi (Finland); Glikoriza, (Greece); Édesfa, Igazi édesgyökér (Hungary); Lakkris (Iceland); Liquirizia (Italy); Lakrisrot (Norway); Lukrecja gladka (Poland); Lakrits (Sweden); Lakrichnik, Russian liquorice (Russia); Kan tsau, Gancao (China); Kanzou (Japan); Yashtimadhu, Atimadhuram, Madhuka (India); Arpsous, Arq-sous, Aslussiesa, Asla-soos (Arabic); Shirin bajan, Ausareha mahaka (Persian); Noekiyu (Myanmar); and Susu (Kiswahili) in different regions in the world (Rao 1993; Blumenthal et al. 2000; Chopra et al. 2002; Nomura et al. 2002; Anagha et al. 2012; Damle 2014; Rogers 2014). It is also known as meyan, biyan, boyam, miyan, payan, piyam, tatlı bayram, tatlı biyan, tatlı kök, biyam balı, sus, and süs in different regions of Turkey and other Turkic Republics (Akan and Balos 2008).

## References

- Akan H, Balos M (2008) GAP Bölgesi’nden toplanan meyan kökü (*Glycyrrhiza glabra* L.) taksonunun ihracat durumu, etnobotanik özellikleri ve tıbbi önemi. Fırat Üniversitesi Fen ve Mühendislik Bilimleri Dergisi 20(2):233–241 (In Turkish)
- Altay V, Karahan F, Öztürk M, Hakeem KR, İlhan E, Erayman M (2016) Molecular and ecological investigations on the wild populations of *Glycyrrhiza* L. taxa distributed in the East Mediterranean Area of Turkey. J Plant Res 129(6):1021–1032