THE PHYTOCHEMISTRY OF MEDICINAL PLANTS USED BY NATIVE AMERICANS

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Contents

Summary

In this work, a total of 21 plants used by Native American (North America, north of Mexico) peoples in traditional medicine have been summarized. For each plant in this chapter, the ethnobotanical uses of the plant are described, the known phytochemical constituents of the plant are presented, and the known biological activities of plant extracts, essential oils, and isolated phytochemicals are summarized.

1. Introduction

By Native American, we restrict our focus to the native peoples of the United States and Canada. The native peoples of Mexico, Central and South America also have a rich ethnobotanical heritage and a greater botanical diversity. There is a large amount of information due to the botanical diversity of North America, the number of Native American tribes, and the numerous maladies that plant-based medicines were used to treat. This chapter is not intended to be a comprehensive review; there are too many plants native to North America that have been used in the traditional medicines of Native American peoples. Furthermore, many of the plants used ethnobotanically have not been phytochemically characterized. However, this chapter is intended to give an overview of the plant families used by Native Americans as well as a selection of biologically active phytochemical constituents. Table 1 shows the plants considered in this chapter with their photos. Table 2 provide information on their geographic distribution and traditional uses of the plants.

S. No.	Name of the plant (Genus, species)	Family	Photo
1	*Abies balsamea*	Pinaceae	 Branches and cones of *Abies balsamea* (Shutterstock image 1857715300, Nature Clickz/Shutterstock.com).
2	*Achillea millefolium*	Asteraceae	 *Achillea millefolium* (Shutterstock image 147382595, Madlen/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
3	*Amelanchier alnifolia*	Rosaceae	 Leaves and fruits of *Amelanchier alnifolia* (Shutterstock image 167453810, Pi-Lens/Shutterstock.com).
4	*Artemisia ludoviciana*	Asteraceae	 Leaves of *Artemisia ludoviciana* (Shutterstock image 1520222453, Nikoletta Lia Muhari/Shutterstock.com).
5	*Artemisia tridentata*	Asteraceae	 *Artemisia tridentata* (Shutterstock image 661175461, Kathryn Roach/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
6	*Asarum canadense*	Aristolochiaceae	 *Asarum canadense* leaves (Shutterstock image 681292204, K Steve Cope/Shutterstock.com).
7	*Betula papyrifera*	Betulaceae	 Bark and leaves of *Betula papyrifera* (Shutterstock image 1284280132, Danita Delimont/Shutterstock.com).
8	*Eupatorium perfoliatum*	Asteraceae	 *Eupatorium perfoliatum* (Shutterstock image 1777823753, Randy Imanuel/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
9	*Hamamelis virginiana*	Hamamelidaceae	 *Hamamelis virginiana* (Shutterstock image 1611605965, Simona Pavan/Shutterstock.com).
10	*Heracleum maximum*	Apiaceae	 *Heracleum maximum* (Shutterstock image 1270595911, Gerry Bishop/Shutterstock.com).
11	*Humulus lupulus*	Cannabaceae	 Female inflorescences of *Humulus lupulus* (Shutterstock image 116378674, Ursa Major/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
12	*Juniperus communis*	Cupressaceae	 *Juniperus communis* twigs and "berries" (Shutterstock image 1122101687, Adam Radosavljevic/Shutterstock.com).
13	*Juniperus virginiana*	Cupressaceae	 Twigs and "berries" of *Juniperus virginiana* (Shutterstock image 1753402826, Dina Rogatnyjh/Shutterstock.com).
14	*Lomatium dissectum*	Apiaceae	 *Lomatium dissectum* (Shutterstock image 267347003, Randy Bjorklund/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
15	*Mentha canadensis*	Lamiaceae	 *Mentha canadensis* (Shutterstock image 1521735602, Zulashai/Shutterstock.com).
16	*Oplopanax horridus*	Araliaceae	 *Oplopanax horridus* (Shutterstock image 39573769, Steve Estvanik/Shutterstock.com).
17	*Populus balsamifera*	Salicaceae	 Leaves of *Populus balsamifera* (Shutterstock image 1058368001, Viktor Loki/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
18	*Pseudotsuga menziesii*	Pinaceae	 *Pseudotsuga menziesii* (Shutterstock image 1628561809, LFRabanedo/Shutterstock.com).
19	*Sanguinaria canadensis*	Papaveraceae	 Leaf and flower of *Sanguinaria canadensis* (Shutterstock image 1397449319, Dan4Earch/Shutterstock.com).
20	*Sassafras albidum*	Lauraceae	 Leaves of *Sassafras albidum* (Shutterstock image 322881053, Kathy Clark/Shutterstock.com).

S. No.	Name of the plant (Genus, species)	Family	Photo
21	*Thuja plicata*	Cupressaceae	 *Thuja plicata* (Shutterstock image 389641798, Steve Estvanik/Shutterstock.com).

Table 1. The medicinal plants used by Native Americans that are considered in this chapter

Volatile constituents of the medicinal and aromatic plants have generally been obtained as essential oils by hydrodistillation and identified by gas chromatography – mass spectrometry (GC-MS). The non-volatile components have generally been isolated from solvent extracts of the plant materials followed by chromatographic separation and identified by spectrometric methods, usually by nuclear magnetic resonance (NMR) spectrometry.

Biological activities of plant extracts and phytochemicals are often expressed in terms of minimum inhibitory concentrations (MIC) or as median inhibitory concentrations (IC_{50}). There is no general consensus regarding bioactivity breakdowns of plant extracts and phytochemicals with respect to concentrations, but many researchers have considered the following for antimicrobial MIC values: "good activity" have MIC values less than 100 μg/mL, "moderate activity" have MIC values from 100 to 500 μg/mL, "weak activity" have MIC values from 500 to 1000 μg/mL, and if the MIC is greater than 1000 μg/mL, the extract/compound is considered to be "inactive". Likewise, for cytotoxicity assays, extracts and essential oils are considered "active" for IC_{50} values below 100 μg/mL, and for pure compounds, IC_{50} values below 15 μM are considered "active".

2. *Abies balsamea* (L.) Mill. (balsam fir), Pinaceae

The oleoresin of *A. balsamea* is composed of non-volatile diterpenoids, triterpenoids, and tetraterpenoids, and a distillable essential oil. The non-volatile components of *A. balsamea* oleoresin consist chiefly of diterpenoid acids abietic acid, neoabietic acid, palustric acid, isopimaric acid, dehydroabietic acid, laevopimaric acid, sandarocopimaric acid, and 15-hydroxydehydroabietic acid; the neutral diterpenoids (*Z*)-abienol, neoabienol, abiesanordine C, methyl 13-oxo-podocarp-8(14)-en-15-oate,

methyl 15-hydroxydehydroabietate, (12*E*)-8-hydroxy-15-nor-12-labden-14-al, and 8-hydroxy-14, 15-dinor-11-labden-13-one (Figure 1).

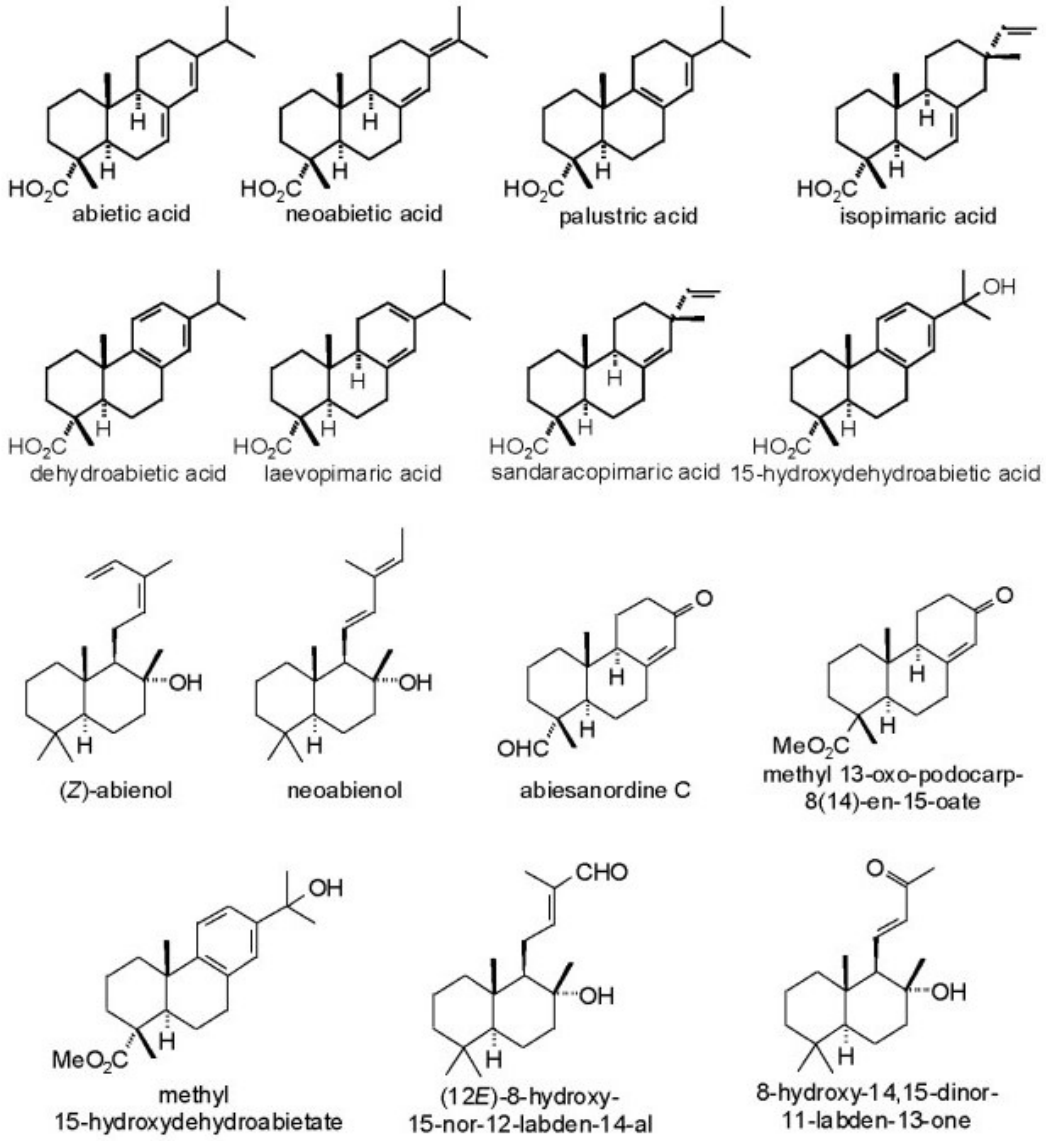
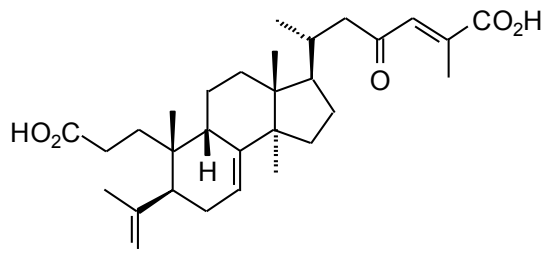
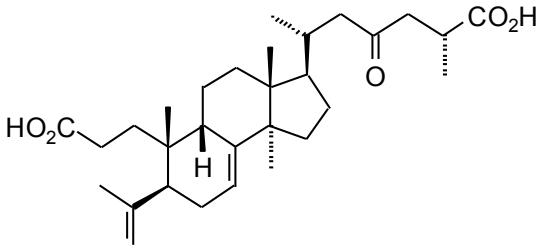


Figure 1. Diterpenoid components of *Abies balsamea* oleoresin.

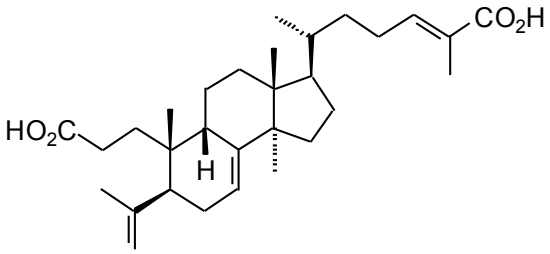
Triterpenoid components of *A. balsamea* oleoresin include (24*E*)-23-oxo-3,4-*seco*-9β*H*-lanosta-4(28),7,24-triene-3,26-dioic acid, (25*R*)-3,4-*seco*-9β*H*-lanosta-4(28),7-diene-3,26-dioic acid, (24*E*)-3,4-*seco*-9β*H*-lanosta-4(28),7,24-triene-3,26-dioic acid, (24*E*)-23-oxo-3,4-*seco*-9β*H*-lanosta-4(28),6,8(14),24-tetraen-3,26-dioic acid, (22*Z*)-3,4-*seco*-9β*H*-lanosta-4(28),7,22,24-tetraen-23,26-olid-3-oic acid, abiesolidic acid, (23*R*,25*R*)-3,4-*seco*-17,14-*friedo*-9β*H*-lanosta-4(28),6,8(14)-trien-26,23-olid-3-oic acid, firmanoic acid, awashishinic acid, 3α-hydroxy-23-oxocycloart-25(27)-en-26-oic acid, abiesonic acid, and abiesonic acid 3-methyl ester (Figure 2.01, 2.02). Abiesonic acid and 3α-hydroxy-23-oxocycloart-25(27)-en-26-oic acid showed weak antibacterial activity against *Staphylococcus aureus*, which may account for the effectiveness of *A. balsamea* oleoresin to treat skin infections and wounds.



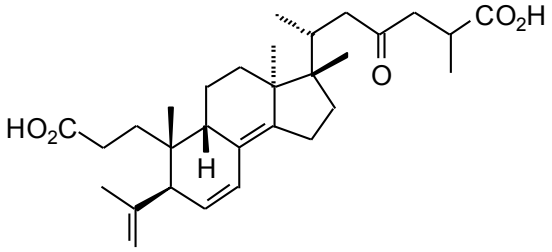
(24*E*)-23-oxo-3,4-*seco*-9β*H*-lanosta-4(28),7,24-triene-3,26-dioic acid



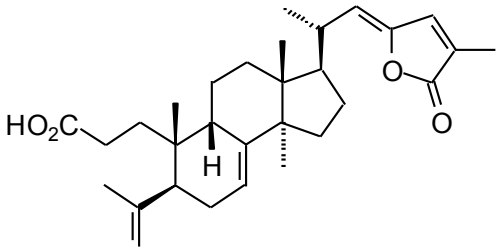
(25*R*)-3,4-*seco*-9β*H*-lanosta-4(28),7-diene-3,26-dioic acid



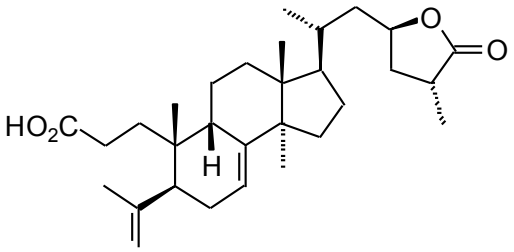
(24*E*)-3,4-*seco*-9β*H*-lanosta-4(28),7,24-triene-3,26-dioic acid



(24*E*)-23-oxo-3,4-*seco*-9β*H*-lanosta-4(28),6,8(14),24-tetraen-3,26-dioic acid

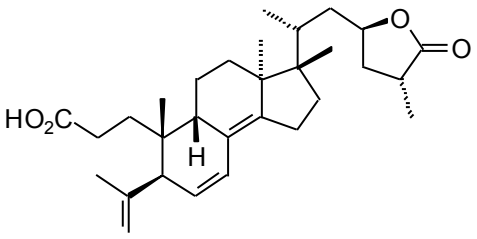


(22*Z*)-3,4-*seco*-9β*H*-lanosta-4(28),7,22,24-tetraen-23,26-olid-3-oic acid

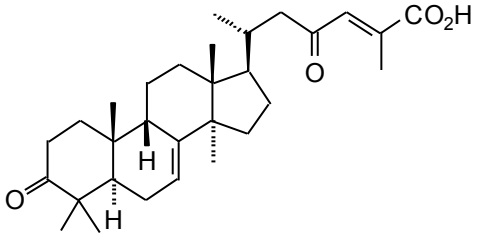


abiesolidic acid

Figure 2.01 Triterpenoid components of *Abies balsamea* oleoresin.



(23*R*,25*R*)-3,4-*seco*-17,14-*friedo*-9β*H*-lanosta-4(28),6,8(14)-trien-26,23-olid-3-oic acid



firmanoic acid

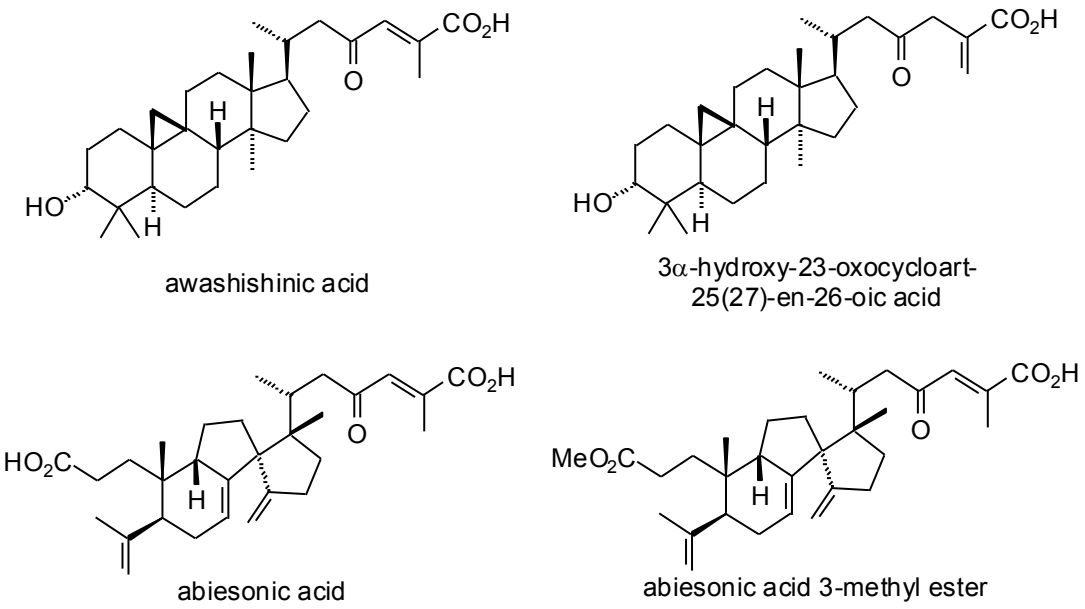


Figure 2.02 Triterpenoid components of *Abies balsamea* oleoresin.

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Biographical Sketch

Will Setzer was born in Los Angeles, California. He received the B.S. degree in Chemistry from Harvey Mudd College, Claremont, California, in 1973, and the Ph.D. in Organic Chemistry from the University of Arizona, Tucson, in 1981 under the direction of Professor Richard S. Glass. He was a Postdoctoral Associate in the laboratory of Wesley G. Bentrude at the University of Utah, Salt Lake City, and an Alexander von Humboldt Research Fellow, Universität Erlangen-Nürnberg, with Prof. Dr. Paul von Ragué Schleyer. Will started his academic career at the University of Alabama in Huntsville as Assistant Professor of Organic Chemistry in 1985. He is currently Professor Emeritus of Chemistry. Although he has always had a casual interest in plants, ethnobotany, and herbal medicines, Will's research in natural products started in 1990 after a trip to the Monteverde Cloud Forest Preserve in Costa Rica. In addition to Costa Rica, Will's bioprospecting trips have taken him and his students to north Queensland, Australia, and the Bahamas, and he has formed several fruitful collaborations with groups in Brazil, Cuba, central Asia, the Middle East, Nigeria, Zimbabwe, and South Africa. His research interests are in natural products drug discovery, essential oils, chemical ecology, and molecular modeling.