AN UPDATE ON THE CONSTITUENTS OF POPLAR-TYPE PROPOLIS

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INTRODUCTION

Propolis (bee glue) is a lipophilic resinous material that honeybees (*Apis mellifera* L.) collect from living plants. The compounds identified in propolis originate from three sources: plant exudate collected by bees, substances secreted from bee metabolism (including beeswax), and materials which are introduced during propolis elaboration (such as pollen). In general, the composition of propolis is directly related to that of bud exudates collected by honeybees from various trees (1). It is generally accepted and chemically demonstrated that in temperate zones the bud exudates of species and their hybrids of the genus *Populus* (poplars) are the main source of propolis, notably species of the section *Aigeiros*; the most common species of this section is *P. nigra* L. (black poplar). This 'poplar-type' propolis is found in Europe (with the exception of some Mediterranean countries or parts thereof), North America, New Zealand and temperate regions of Asia (including several regions of China). It is characterized by the predominant presence of phenolics including flavonoid aglycones and aromatic acids and their esters (1,2). Poplar propolis can readily be differentiated from other propolis types such as Brazilian red propolis, which has other plants as source materials (3).

Poplar-type propolis is a complex material which may contain >100 compounds. The main groups of chemicals are: (a) free aromatic (phenolic) acids; (b) esters of these acids; (c) flavonoids (flavones, flavanones, flavonols, dihydroflavonols); (d) chalcones and dihydrochalcones; (e) terpenoids; (f) others (including acyclic hydrocarbons and esters, alcohols, aldehydes, amino acids, aromatic hydrocarbons, fatty acids, ketones, sterols, sugars and sugar alcohols). In 1995, Marcucci reviewed the literature on the chemicals found in poplar-type propolis and summarized and tabulated over 200 known ingredients (4). The purpose of our study was to find additional chemicals identified in poplar-type propolis and to provide an updated list.

MATERIALS AND METHODS

We searched for relevant information on the chemical composition of poplar-type propolis using the search word 'propolis' in PubMed and the journals and books databases of Elsevier Science Direct, American Chemical Society, Taylor & Francis, Thieme, Wiley and SpringerLink. References of relevant articles were searched by hand. We included data only from studies, where we were convinced that the propolis investigated actually was of the poplar-type, excluding any cases where we felt there was uncertainty about the nature of the propolis.

RESULTS

Over 120 additional chemicals identified in poplar-type propolis from various locations, not present in the 1995 survey (4), were found (5-20). All currently known ingredients of this type of propolis are listed in table 1 in chemical categories and tabulated alphabetically with synonyms, CAS numbers and references. They include (in sequence of declining numbers in each category): 44 aromatic acid esters; 42 terpenoids; 37 aromatic acids; 25 aliphatic fatty acids (long-chain) and their esters; 25 aliphatic hydrocarbons and wax esters; 25 amino acids; 22 flavones and flavonols; 17 aliphatic acids (short-chain); 16 glycerol derivatives; 14 flavanones; 13 aldehydes; 12 alcohols; 10 aliphatic acid esters; 9 chalcones; 9 sugars and sugar alcohols; 8 acetophenones and other ketones; 5 dihydrochalcones; 4 steroids and 7 miscellaneous ingredients of poplar-type propolis, a total of 344 chemical constituents.

By excluding data from any article where the poplar origin of the propolis investigated was not certain (to us), as a literature search can never reveal all published data, and as some journals are inaccessible or written in a language unknown to us, it is highly likely that we have missed relevant chemicals. Conversely, we cannot exclude the possibility that some of the chemicals in this list are in fact not constituents of poplar-type propolis but are found in propolis from other plant sources. Additionally, chemicals may have been wrongly identified in certain studies. Therefore, we do not maintain that the list is complete or completely accurate.

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20)

Classes	Synonyms	CAS	REF.
ALIPHATIC HYDROCARBONS AND WAX ESTERS			
Dodecane		112-40-3	8
Dotriacontyl hexadecanoate	Dotriacontanyl palmitate	80252-38-6	4
Dotriacontyl octadecenoate	Octadecenoic acid dotriacontyl ester	130031-86-6	4
Heneicosane		629-94-7	4
Hentriacontane	Untriacontane	630-04-6	4
Heptacosane		593-49-7	4,8
Hexacosane		630-01-3	4
Hexacosyl hexadecanoate	Hexacosyl palmitate; palmitoyl hexacosanol	60007-87-6	4
Hexacosyl octadecenoate	Octadecenoic acid hexacosyl ester	93976-08-0	4
Nonacosane		630-03-5	4
Nonadecane		629-92-5	8
Octacosyl hexadecanoate	Octacosyl palmitate	78509-52-1	4
Octacosyl octadecenoate	Octadecenoic acid octacosyl ester	93976-07-9	4
Pentacosane		629-99-2	4
Squalene		111-02-4	17
Tetracosyl hexadecanoate	Palmitoyltetracosanol; tetracosanol palmitate	42232-35-9	4
Tetracosyl octadecenoate	Octadecenoic acid tetracosyl ester	93976-09-1	4
Tetratriacontyl hexadecanoate	Tetratriacontyl palmitate	84461-48-3	4
Tetratriacontyl octadecenoate	Octadecenoic acid tetratriacontyl ester	130031-85-5	4
Triacontyl hexadecanoate	Myricyl palmitate; triacontanyl palmitate	6027-71-0	4
Triacontyl octadecenoate	Octadecenoic acid triacontyl ester	93976-06-8	4
Tricosane	Triacosane	638-67-5	4
Tridecane		629-50-5	8
Tritriacontane		630-05-7	4
Undecane		1120-21-4	8
ALCOHOLS			
Benzyl alcohol		100-51-6	4
2,3-Butanediol	2,3-Butylene glycol; dimethylethylene glycol	513-85-9	9
Cinnamyl alcohol	Cinnamic alcohol	104-54-1	4
trans-Cinnamyl alcohol	(*E*)-Cinnamic alcohol; (*E*)-cinnamyl alcohol	4407-36-7	10
trans-*p*-Coumaryl alcohol		20649-40-5	10
Isobutyl alcohol	Isobutanol; 2-methyl-1-propanol	78-83-1	4
2-Methyl-2-buten-1-ol		4675-87-0	8
2-Methyl-3-buten-2-ol	Isoprenyl alcohol	115-18-4	8
3-Methyl-2-buten-1-ol	3,3-Dimethylallyl alcohol; prenol; prenyl alcohol	556-82-1	4,10
3-Methyl-3-buten-1-ol	Isoprenol; isopropenylethyl alcohol; methallylcarbinol	763-32-6	10
Phenethyl alcohol	Phenylethyl alcohol	60-12-8	4
1-Tetracosanol	Lignoceryl alcohol; lignocerol; tetracosyl alcohol	506-51-4	10
ALDEHYDES			
Benzaldehyde		100-52-7	4
Cinnamaldehyde	Cinnamal; cinnamic aldehyde	104-55-2	8
Decanal	Decanaldehyde; decyl aldehyde	112-31-2	8
3,4-Dihydroxybenzaldehyde	Protocatechualdehyde; 4-formylcatechol; catechaldehyde	139-85-5	4,10
n-Hexanal	Hexaldehyde; caproic aldehyde	66-25-1	4
Hex-2-enal	2-Hexenaldehyde	505-57-7	12
p-Hydroxybenzaldehyde	4-Formylphenol	123-08-0	4,16
Isovanillin	*p*-Anisaldehyde; isovanillic aldehyde	621-59-0	4
2-Methyl-2-butenal	2-Methylcrotonaldehyde	1115-11-3	8
Nonanal	Nonanaldehyde; nonylaldehyde	124-19-6	8
Octanal	Octyl aldehyde	124-13-0	8

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
Propionaldehyde	Propanal	123-38-6	4
Vanillin	3-Methoxy-4-hydroxybenzaldehyde; vanillaldehyde	121-33-5	4
ALIPHATIC ACIDS (SHORT-CHAIN)			
Acetic acid		64-19-7	4
Angelic acid	(*Z*)-2-Methylcrotonic acid; *cis*-2-Methyl-2-butenoic acid	565-63-9	4
Butanedioic acid	Succinic acid; dihydrofumaric acid	110-15-6	12
Butanoic acid	Butyric acid; ethylacetic acid; propylformic acid	107-92-6	4
Butenoic acid	Crotonic acid; 3-methylacrylic acid	3724-65-0	4
Citric acid		77-92-9	10
2,3-Dihydroxypropanoic acid	Glyceric acid; glyceronic acid; glycerolic acid	473-81-4	9
Fumaric acid	2-(*E*)-Butenedioic acid; allomaleic acid	110-17-8	4
Hydroxyacetic acid	Glycolic acid	79-14-1	9
5-Hydroxyvaleric acid	5-Hydroxypentanoic acid	13392-69-3	9
Isobutyric acid	2-Methylpropanoic acid; dimethylacetic acid; isobutanoic acid	79-31-2	4
Malic acid	Hydroxysuccinic acid; hydroxybutanedioic acid	6915-15-7	9
2-Methylbutanoic acid	Methyl-*n*-butyric acid; α-methylbutyric acid	116-53-0	10
2-Methyl-2-butenoic acid	Methylmethacrylic acid; α-methylcrotonic acid	3201-46-2	11
Methylbutyric acid	Methylbutanoic acid	35915-22-1	4
Methylpentanoic acid	Methylvaleric acid	27936-41-0	10
2,3,4-Trihydroxybutanoic acid	Threonic acid	3909-12-4	10
ALIPHATIC ACID ESTERS (ESTERS OF ALIPHATIC ACIDS)			
Benzyl acetate		140-11-4	4
Ethyl (3*E*)-5-phenyl-3-pente-noate	Ethyl 5-phenyl-*trans*-3-pentenoate		14
Isoamyl acetate	Isopentyl acetate	123-92-2	11
Isobutyl acetate	2-Methylpropyl acetate	110-19-0	4
Isobutyl isobutyrate		97-85-8	10
Isopentenyl acetate	3-Methyl-3-butenyl acetate	5205-07-2	4
3-Methyl-2-butenyl acetate	Dimethylallyl acetate; prenyl acetate	1191-16-8	10
3-Methyl-3-butenyl acetate		5205-07-2	10
2-Methylbutyl acetate		624-41-9	10
3-Methylbutyl butanoate	Isoamyl butanoate; isoamyl butyrate; isopentyl butyrate	106-27-4	10
ALIPHATIC FATTY ACIDS (LONG-CHAIN) AND THEIR ESTERS			
Decanoic acid	*n*-Decylic acid	334-48-5	8
Docosanoic acid	Behenic acid	112-85-6	4
Dodecanoic acid	Lauric acid; dodecylic acid	143-07-7	4
Eicosanoic acid	Arachidic acid; arachic acid	506-30-9	4
Ethyl hexadecanoate	Ethyl palmitate	628-97-7	16
Ethyl linoleate	Ethyl linolate l	544-35-4	16
Ethyl octadecanoate	Ethyl stearate	111-61-5	16
Ethyl (9*Z*)-octadecenoate	Ethyl oleate	111-62-6	16
Ethyl tetradecanoate	Ethyl myristate	124-06-1	16
Hexacosanoic acid	Cerotic acid; ceratinic acid	506-46-7	4
Hexadecanoic acid	Palmitic acid; cetylic acid; *n*-hexadecoic acid	57-10-3	4
Hexadecenoic acid		25447-95-4	10
cis-9-Hexadecenoic acid	Palmitoleic acid; oleopalmitic acid	373-49-9	17
14-Hydroxyhexadecanoic acid	14-Hydroxypalmitic acid	59642-38-5	10
15-Hydroxyhexadecanoic acid	15-Hydroxypalmitic acid	4552-17-4	10
17-Hydroxyoctadecanoic acid	17-DL-Hydroxystearic acid	4552-19-6	10
Nonanoic acid	Pelargonic acid	112-05-0	9
Octacosanoic acid	Montanic acid	506-48-9	4
(*Z,Z*)-9,12-Octadecadienoic acid	Linoleic acid	60-33-3	4
Octadecanoic acid	Stearic acid	57-11-4	4

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
9-Octadecenoic acid	Oleic acid	112-80-1	4
Octanoic acid	Caprylic acid	124-07-2	10
9-Oxo-10(*E*)-12(*Z*)-octadeca-dienoic acid		54232-59-6	18
Tetracosanoic acid	Lignoceric acid	557-59-5	4
Tetradecanoic acid	Myristic acid	544-63-8	4
AMINO ACIDS			
Alanine	DL-Alanine (CAS 302-72-7); L-alanine (CAS 56-41-7)		4
β-Alanine		107-95-9	4
α-Aminobutyric acid		2835-81-6	4
δ-Aminobutyric acid			4
Arginine	DL-Arginine (CAS 7200-25-1); L-arginine (CAS 74-79-3)		4
Aspartic acid	DL-Aspartic acid (CAS 617-45-8); L-aspartic acid (CAS 56-84-8)		4
Cystine	DL-Cystine (CAS 923-32-0); L-cystine (CAS 56-89-3)		4
Glutamic acid	DL-Glutamic acid (CAS 617-65-2); L-glutamic acid (CAS 56-86-0)		4
Glycine		56-40-6	4
Histidine	DL-Histidine (CAS 4998-57-6); L-histidine (CAS 71-00-1)		4
Hydroxyproline	L-Hydroxyproline (CAS 51-35-4)	6912-67-0	4
Isoleucine	DL-Isoleucine (CAS 443-79-8); L-isoleucine (CAS 73-32-5)		4
Leucine	DL-Leucine (CAS 328-39-2); L-leucine (CAS 61-90-5)		4
Lysine	DL-Lysine (CAS 70-54-2); L-lysine (CAS 56-87-1)		4
Methionine	DL-Methionine (CAS 59-51-8); L-methionine (CAS 63-68-3)		4
Ornithine	DL-ornithine (CAS 616-07-9); L-ornithine (CAS 70-26-8)		4
Phenylalanine	DL-Phenylalanine (CAS 150-30-1); L-phenylalanine (CAS 63-91-2)		4
Proline	DL-Proline (CAS 609-36-9); L-proline (CAS 147-85-3)		4
Pyroglutamic acid	DL-Pyroglutamic acid (CAS 149-87-1); L-pyroglutamic acid (CAS 98-79-3)		4
Sarcosine		107-97-1	4
Serine	DL-Serine (CAS 302-84-1); L-serine (CAS 56-45-1)		4
Threonine	DL-Threonine (CAS 80-68-2); L-threonine (CAS 72-19-5)		4
Tryptophan	DL-tryptophan (CAS 54-12-6); L-tryptophan (CAS 73-22-3)		4
Tyrosine	DL-Tyrosine (CAS 556-03-6); L-tyrosine (CAS 60-18-4)		4
Valine	DL-Valine (CAS 516-06-3); L-valine (CAS 72-18-4)		4
AROMATIC ACIDS			
p-Anisic acid	*p*-Methoxybenzoic acid	100-09-4	4
Benzoic acid		65-85-0	4
Caffeic acid	3,4-Dihydroxycinnamic acid	331-39-5	4
trans-Caffeic acid	(*E*)-Caffeic acid; *trans*-3,4-dihydroxycinnamic acid	501-16-6	10
Cinnamic acid		621-82-9	4
cis-Cinnamic acid	(*Z*)-Cinnamic acid; allocinnamic acid; isocinnamic acid	102-94-3	10
trans-Cinnamic acid	(*E*)-Cinnamic acid	140-10-3	10
Cinnamylideneacetic acid	β-Styrylacrylic acid; 5-phenyl-*trans,trans*-2,4-pentadienoic acid	1552-94-9	7
Coumaric acid	Hydroxycinnamic acid	25429-38-3	4
m-Coumaric acid	3-Coumaric acid; 3-hydroxycinnamic acid	588-30-7	4
o-Coumaric acid	2-Coumaric acid; 2-hydroxycinnamic acid	583-17-5	4
p-Coumaric acid	4-Coumaric acid; 4-hydroxycinnamic acid	7400-08-0	4
cis-*p*-Coumaric acid	*cis*-4-Hydroxycinnamic acid; (*Z*)-*p*-coumaric acid	4501-31-9	9,16
trans-*p*-Coumaric acid	*trans*-4-Hydroxycinnamic acid; naringeninic acid; (*E*)-*p*-coumaric acid	501-98-4	9,16
Dihydrocinnamic acid	3-Phenylpropanoic acid; benzenepropionic acid; benzylacetic acid	501-52-0	14
3,4-Dihydroxybenzoic acid	Protocatechuic acid	99-50-3	10
3,4-Dimethoxycinnamic acid	Methylferulic acid; *O,O*-dimethylcaffeic acid; *trans*-: CAS 14737-89-4	2316-26-9	4
3,4-Dimethoxycoumaric acid	3,4-Dimethoxyhydrocinnamic acid	2107-70-2	?
Ferulic acid	3-Methoxy-4-hydroxycinnamic acid	1135-24-6	4
trans-Ferulic acid	*trans*-3-Methoxy-4-hydroxycinnamic acid	537-98-4	10
Gentisic acid	2,5-Dihydroxybenzoic acid; 5-hydroxysalicylic acid	490-79-9	4

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
Hydrocoumaric acid	Melilotic acid; *o*-hydroxyhydrocinnamic acid	495-78-3	10
p-Hydroxybenzoic acid	*p*-Carboxyphenol; *p*-salicylic acid	99-96-7	4
Isoferulic acid	3-Hydroxy-4-methoxycinnamic acid; 4-methoxycaffeic acid	537-73-5	4
trans-Isoferulic acid	*trans*-3-Hydroxy-4-methoxycinnamic acid	25522-33-2	10
p-Methoxycinnamic acid	*O*-methyl-*p*-coumaric acid	830-09-1	4
cis-*p*-Methoxycinnamic acid	(*Z*)-*p*-methoxycinnamic acid; *cis*-4-methoxycinnamic acid	5676-64-2	10
trans-*p*-Methoxycinamic acid	(*E*)-*p*-Methoxycinnamic acid; *trans*-4-methoxycinamic acid	943-89-5	10
4-Methoxyhydrocinnamic acid		1929-29-9	9
2-(2-Methoxyphenyl)propanoic acid		91061-46-0	16
4-Methylmandelic acid		18584-20-8	9
2-Phenyl-2-hydroxyacrylic acid			9
3-Phenyl-3-hydroxypropanoic acid	3-Hydroxy-3-phenylpropionic acid	3480-87-3	16
(3*E*)-5-Phenyl-3-pentenoic acid	5-Phenyl-*trans*-3-pentenoic acid		7,14
Salicylic acid	2-Hydroxybenzoic acid	69-72-7	4
Vanillic acid	3-Methoxy-4-hydroxybenzoic acid	121-4-6	4
Veratric acid	3,4-Dimethoxybenzoic acid; dimethylprotocatechuic acid	93-07-2	4
AROMATIC ACID ESTERS (ESTERS OF AROMATIC ACIDS)			
Benzyl acetate		140-11-4	8
Benzyl benzoate		120-51-4	4
Benzyl caffeate	*trans*-: ref. 10	107843-77-6	4
Benzyl cinnamate	Cinnamein	103-41-3	19
Benzyl coumarate (*cis*-4-)	Benzyl *p*-hydroxycinnamate	27727-38-4	4
Benzyl *trans*-4-coumarate	Benzyl *p*-coumarate	61844-62-0	9
Benzyl 2,3-dihydroxybenzoate		672958-03-1	16
Benzyl-3,4-dimethoxycinnamate		244612-90-6	4
Benzyl ferulate	*trans*- (Benzyl (*E*)-ferulate): ref.10 (CAS 132335-97-8)	87024-37-1	4
Benzyl isoferulate	*trans*-: ref. 10		4
Benzyl 2-methoxybenzoate		75679-47-9	10
Benzyl salicylate		118-58-1	4
Butyl caffeate		22020-28-6	4
Cinnamyl benzoate		5320-75-2	4
Cinnamyl acetate		103-54-8	8
Cinnamyl caffeate	*trans*-: ref. 10	115610-79-2	4
Cinnamyl cinnamate	*trans*-: ((*E*)-Cinnamyl (*E*)-cinnamate): ref. 10 (CAS 40918-97-6)	122-69-0	10
Cinnamyl coumarate	*trans*-*p*-: ((*E*)-Cinnamyl (*E*)-*p*-coumarate): ref. 10 (CAS 115610-30-5)	115610-77-0	4
Cinnamyl ferulate		132160-00-0	9
Cinnamyl isoferulate	*trans*-: ((*E*)-Cinnamyl (*E*)-isoferulate): ref. 10 (CAS 115610-31-6)	115610-78-1	4
Cinnamyl *p*-methoxycinnamate			6
Coniferyl benzoate		4159-29-9	10
Ethyl benzoate		93-89-0	4
Ethyl caffeate		102-37-4	4
Ethyl dihydrocinnamate		2021-28-5	9
Geranyl *trans*-caffeate			10
4-Hydroxybenzyl benzoate	*p*-Hydroxybenzyl benzoate	91998-14-0	10
Methyl benzoate		93-58-3	4
2-Methyl-2-butenyl caffeate	*trans*-: ref. 10		4
3-Methyl-2-butenyl caffeate	Prenyl caffeate; *trans*-: ref. 10	100884-13-7	4
3-Methyl-3-butenyl caffeate	*trans*-: ref. 10		4
2-Methyl-2-butenyl *p*-coumarate			10
3-Methyl-2-butenyl *p*-coumarate	Prenyl coumarate; *cis*-: ref 10; *trans*-: ref. 10		4
3-Methyl-3-butenyl *p*-coumarate	*trans*-: ref. 10		4

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
3-Methyl-2-butenyl ferulate	Prenyl ferulate; *trans*-: ref. 10		4
3-Methyl-3-butenyl ferulate	*trans*-: ref. 10		4
2-Methyl-2-butenyl isoferulate			4
3-Methyl-2-butenyl isoferulate	Prenyl isoferulate	269053-68-1	9
3-Methyl-3-butenyl isoferulate	*trans*-: ref. 10		4
Methyl salicylate	Wintergreen oil	119-36-8	4
Pentenyl caffeate	These are the methyl butenyl caffeates (see there)		4
Pentenyl coumarate	These are the methyl butenyl coumarates (see there)		4
Pentenyl ferulate	These are the methyl butenyl ferulates (see there)		4
Pentyl caffeate			4
β-Phenethyl acetate		103-45-7	8
Phenylethyl caffeate	*trans*-: ref. 10	104594-70-9	4
Phenylethyl *p*-coumarate	Coumaric acid phenethyl ester; *trans*-: ref. 10	133367-29-0	4
Phenylethyl isoferulate			8
CHALCONES [a]			
Alpinetin chalcone	2',4'-Dihydroxy-6'-methoxychalcone; cardamonin	19309-14-9	4
Isosakuranetin chalcone	2',4',6'-Trihydroxy-4-methoxychalcone	137225-57-1	10
Naringenin chalcone	*trans*-2',4,4',6'-Tetrahydroxychalcone; chalconaringenin	25515-46-2	4
Pinobanksin-3-acetate chalcone	2',4',6'-Trihydroxy-β-acetoxychalcone		4
Pinobanksin chalcone	2',4',6',β-Tetrahydroxychalcone		4
Pinocembrin chalcone	2',4',6'-Trihydroxychalcone	82451-30-7	4
Pinostrobin chalcone	2',6'-Dihydroxy-4'-methoxychalcone	18956-15-5	4
Sakuranetin chalcone	2',6',4'-Trihydroxy-4'-methoxychalcone; neosakuranetin	81719-04-2	4
2',6',α-Trihydroxy-4'-methoxychalcone			4
DIHYDROCHALCONES [b]			
2',6'-Dihydroxy-4',4'-dimethoxydihydrochalcone			10,16
2',6'-Dihydroxy-4'-methoxydihydrochalcone			4,16
2',4',6'-Trihydroxydihydrochalcone			4,16
2',4',6'-Trihydroxy-4'-methoxydihydrochalcone			10,16
2',6',4'-Trihydroxy-4'-methoxydihydrochalcone			16
FLAVANONES			
2,5-Dihydroxy-7-methoxyflavanone		35486-66-9	4
Isosakuranetin	5,7-Dihydroxy-4'-methoxyflavanone; naringenin-4'-methyl ether	480-43-3	10
Naringenin	4',5,7-Trihydroxyflavanone	480-41-1	4
Pinobanksin	3,5,7-Trihydroxyflavanone	548-82-3	4
Pinobanksin-3-*O*-acetate	5,7-Dihydroxy-3-ethanoyloxy flavanone; 3-*O*-acetylpinobanksin	52117-69-8	4
Pinobanksin-3-*O*-butyrate	5,7-Dihydroxy-3-butanoyloxy flavanone	126394-71-6	4,9
Pinobanksin-3-*O*-hexanoate	5,7-Dihydroxy-3-hexanoyloxyflavanone	126394-73-8	4
Pinobanksin 3-methyl ether	5,7-Dihydroxy-3-methoxyflavanone; 3-methylpinobanksin	129843-35-2	4
Pinobanksin 7-methyl ether	3,5-Dihydroxy-7-methoxyflavanone; 7-O-Methylpinobanksin; alpinone	480-13-7	6
Pinobanksin-3-*O*-pentanoate	5,7-Dihydroxy-3-pentanoyloxyflavanone	126394-72-7	4
Pinobanksin-3-*O*-propanoate	5,7-Dihydroxy-3-propanoyloxyflavanone; pinobanksin 3-*O*-propionate	126394-70-5	4
Pinocembrin	5,7-Dihydroxyflavanone; dihydrochrysin	480-39-7	4
Pinostrobin	5-Hydroxy-7-methoxyflavanone; 7-methylpinocembrin	480-37-5	4
Sakuranetin	5,4'-Dihydroxy-7-methoxyflavanone; 7-*O*-methylnaringenin	2957-21-3	4
FLAVONES AND FLAVONOLS			
Acacetin	5,7-Dihydroxy-4'-methoxyflavone; 4'-methylapigenin; linarigenin	480-44-4	4
Apigenin	4',5,7-Trihydroxyflavone; apigenol; C.I. natural yellow 1; versulin	520-36-5	4
Chrysin	5,7-Dihydroxyflavone; crysin	480-40-0	4
4,7'-Dimethylkaempferol	3,5-Dihydroxy-7,4'-dimethoxyflavone	15486-33-6	4
3,7-Dimethylquercetin	3,7-Dimethoxy-3',4',5-trihydroxyflavone	2068-02-2	4
5,7-Dimethylquercetin	5,7-Dimethoxy-3,3',4'-trihydroxyflavone		6

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
Fisetin	3,3',4',7-Tetrahydroxyflavone; C.I. 75620; C.I. natural brown 1	528-48-3	4
Galangin	3,5,7-Trihydroxyflavone; norizalpinin	548-83-4	4
Isorhamnetin	3,4',5,7-Tetrahydroxy-3'-methoxyflavone; 3'-methylquercetin; C.I. 75680; isorhamnetol	480-19-3	4
Izalpinin	3,5-Dihydroxy-7-methoxyflavone; 7-methylgalangin; isalpinin	480-14-8	4
Kaempferide	3,5,7-Trihydroxy-4'-methoxyflavone; 4'-methylkaempferol	491-54-3	4
Kaempferol	3,4',5,7-Tetrahydroxyflavone; 3'-deoxyquercetin; C.I. 75640; indigo yellow; rhamnolutein	520-18-3	4
7-Methylapigenin	4',5-Dihydroxy-7-methoxyflavone; genkwanin	437-64-9	4
3-Methylgalangin	5,7-Dihydroxy-3-methoxyflavone	6665-74-3	4
3-Methylkaempferol	5,7,4'-Trihydroxy-3-methoxyflavone; isokaempferide	1592-70-7	4
4'-Methylkaempferol	3,5,7-Trihydroxy-4'-methoxyflavone; 4'-Methoxykaempferol	491-54-3	10
7-Methylkaempferol	3,4',5-Trihydroxy-7-methoxyflavonol; rhamnocitrin; C.I. 75650	569-92-6	4
Pectolinarigenin	5,7-Dihydroxy-4',6-dimethoxyflavone; 6-methoxyacacetin; 6-methoxykaempferide	520-12-7	4
Pilloin	3',5-Dihydroxy-4',7-dimethoxyflavone; persicogein	32174-62-2	13
Quercetin	3,3',4',5,7-Pentahydroxyflavone; 3'-hydroxykaempferol; C.I. 75670; lipoflavin; quercetol	117-39-5	4
Rhamnetin	3,3',4',5-Tetrahydroxy-7-methoxyflavone; 7-methylquercetin; C.I. 75690	90-19-7	4,10
Tectochrysin	5-Hydroxy-7-methoxyflavone; 7-*O*-methylchrysin	520-28-5	4
ACETOPHENONES AND OTHER KETONES			
Acetophenone	1-Phenylethanone; acetylbenzene; methyl phenyl ketone	98-86-2	4
Dihydroxyacetophenone	not further specified		4
Dihydroxymethoxyaceto-phenone	not further specified		
p-Hydroxyacetophenone	4-Acetylphenol; 4-hydroxyphenyl methyl ketone; piceol	99-93-4	10
Methoxyacetophenone	not further specified		20
Methylacetophenone	Methyl tolyl ketone	26444-19-9	4
6-Methyl-5-hepten-2-one	Isoprenylacetone; methylheptenone; prenylacetone; sulcatone	110-93-0	10,12
4-Phenyl-3-buten-2-one	Acetocinnamone	122-57-6	20
GLYCEROL DERIVATIVES			
(+)-2-Acetyl-1-caffeoyl-3-cinnamoylglycerol			5
(−)-2-Acetyl-1-caffeoyl-3-cinnamoylglycerol			5
2-Acetyl-1-caffeoyl-3-coumaroylglycerol			5
2-Acetyl-1-coumaroyl-3-cinnamoylglycerol		1400912-82-4	5
2-Acetyl-1-(*E*)-coumaroyl-3-(*E*)-feruloylglycerol		83028-11-9	15
2-Acetyl-1,3-di[(*E*)-*p*-coumaroyl]glycerol		83058-41-7	15
2-Acetyl-1,3-dicaffeoylglycerol			5
2-Acetyl-1,3-dicinnamylglycerol		1400809-69-9	5
2-Acetyl-1,3-diferuloylglycerol		1400809-68-8	5
2-Acetyl-1-feruloyl-3-caffeoylglycerol			5
(+)-2-Acetyl-1-feruloyl-3-cinnamoylglycerol			5
(−)-2-Acetyl-1-feruloyl-3-cinnamoylglycerol			5
2-Acetyl-1-feruloyl-3-coumaroylglycerol			5
(−)-2-Acetyl-1-(*E*)-feruloyl-3-(3′(ζ),16′)-dihydroxypalmitoylglycerol			5
Glyceryl phosphate	α-Glycerophosphate (CAS 57-03-4); β-glycerophosphate (CAS 17181-54-3)		4
Monoacetyl glycerine	1-Deoxy-D-*threo*-pentulose; 1-deoxy-D-xylulose; D-1-deoxyxylulose	60299-43-6	10
STEROIDS			
Chalinasterol acetate	(3β)-Ergosta-5,24(28)-dien-3-ol, 3-acetate; 24-methylenecholesterol acetate; ostreasterol	13000-50-5	4
β-Dihydrofucosterol acetete	Dihydrofucosterol: CAS 117001-63-5		4

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
Fucosterol acetate	Fucosterol: CAS 17605-67-3		4
Stigmasterol acetate	Stigmasteryl acetate	4651-48-3	4
SUGARS AND SUGAR ALCOHOLS			
D-Fructose		57-48-7	10
DL-Fructose		30237-26-4	10
α-Glucose		492-62-6	4
β-Glucose		492-61-5	4
Glycerol	Glycyl alcohol; glycerin	56-81-5	4
Inositol	Myoinositol	87-89-8	10
Salicin	Salicyl alcohol glucoside; Saligenin β-D-glucopyranoside	138-52-3	10
Sorbitol	D-Glucitol; hexahydric alcohol	50-70-4	10
Sucrose		57-50-10	10
TERPENOIDS			
allo-Aromadendrene		25246-27-9	8
α-Bisabolol		515-69-5	8
β-Bisabolol		15352-77-9	4
Bulnesol		22451-73-6	20
γ-Cadinene		39029-41-9	20
δ-Cadinene		483-76-1	20
T-Cadinol		58580-31-7	8
α-Cadinol		481-4-5	8
δ-Cadinol		19435-97-3	8
α-Calacorene		21391-99-1	8
Calamenene		1406-50-4	20
Caryophyllene		87-44-5	20
Caryophyllene oxide		1139-30-6	8
Cedrol		77-53-2	8
1,8-Cineole	Eucalyptol	470-82-6	8
α-Copaene		3856-25-5	4,20
α-Copaen-11-ol		41370-56-3	8
ar-Curcumene	Curcumene	644-30-4	8
α-Cubebene		17699-14-8	8
Cubenol		21284-22-0	8
β-Cyclocitral		432-25-7	8
Cymene	Cymol	25155-15-1	4
α-Elemene		5951-67-7	20
β-Eudesmol	β-Selinenol	473-15-4	19,20
γ-Eudesmol	Selinenol	1209-71-8	8
Guaiol	Guaiac alcohol	489-86-1	20
α-Humulene		6753-98-6	8
Limonene		138-86-3	4
Linalool		78-70-6	8
cis-Linalool oxide		11063-77-7	8
Linalyl acetate		115-95-7	10
Manoyl oxide		596-84-9	8
Menthol		89-78-1	8
α-Muurolene		10208-80-7	20
γ-Muurolene		30021-74-0	20
trans-Nerolidol		40716-66-3	10
α-Pinene		80-56-8	8
β-Selinene		17066-67-0	20
Terpinen-4-ol		562-74-3	8
Thymol		89-83-8	8
Viridiflorol		552-02-3	8
α-Ylangene		14912-44-8	8

TABLE 1 COMPOUNDS IDENTIFIED IN POPLAR-TYPE PROPOLIS (4,5-20) *(continued)*

Classes	Synonyms	CAS	REF.
MISCELLANEOUS INGREDIENTS OF POPLAR-TYPE PROPOLIS			
N-Carboxypyrrolidine-2-carboxylic acid	N-Carboxypyroglutamic acid		10
Elemicine	5-Allyl-1,2,3-trimethoxybenzene	487-11-6	10
Guaiacol	Methylcatechol; *o*-hydroxyanisol; *o*-methoxyphenol	90-05-1	9
5-Hepten-2-one		6714-00-7	4
Hydroquinone	1,4-Benzenediol; 1,4-dihydroxybenzene	123-31-9	4
Naphthalene	Tar camphor; white tar	91-20-3	4
Styrene	Ethenylbenzene	100-42-5	4

[a] These compounds have been identified only by GC-MS; it is important to note that flavanones can easily turn into chalcones under the conditions of silylation for GC-MS analysis; for this reason their presence in the native propolis is not unambiguous
[b] Dihydrochalcones are considered to be characteristic for bud exudates of poplars of the Section *Tacamahaca* but not of Section *Aigeiros* (16)

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