THE OCCURRENCE OF ECDYSTEROIDS AND ECDYSTEROID-RELATED COMPOUNDS IN EDIBLE MUSHROOM SPECIES

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The list of edible fungi is based on information from Wikipedia (Edible mushroom) with additional species added. The presence of ecdysteroids or ecdysteroid-related compounds in the fruiting bodies of these species was identified from the review of Kovganko (1999) and additional literature searches.

Important notice:

This database has been designed as a tool to help the scientific community in research on ecdysteroids. The authors wish it to be an evolving system and would encourage other researchers to submit new data, additional publications, proposals for modifications or comments to the authors for inclusion. All new material will be referenced to its contributor.

Please notify Laurie Dinan (dinanlaurence@gmail.com) of any errors or additional literature sources.

Latin Name	Family	Common Name	Category	Ecdysteroids and Ecdysteroid-related Compounds	Reference & Method
Agaricus arvensis	Agariaceae	Horse mushroom	Edible wild species	nt	
Agaricus blazei (A. subrufescens)	Agariaceae	Almond mushroom, himematsutake	Commercially cultivated	cerevisterol (2.3mg from 5kg fw), 3β,5α-dihydroxy-6β-methoxyergosta-7,22-diene (3.4mg), 3β,5α,,6β,9α-tetrahydroxyergosta-7,22-diene (6.3mg), 3β,5α,9α-trihydroxyergosta-7,22-diene-6-one (5.7mg)	Kawagishi et al. (1988); isolation and spectroscopic identification
Agaricus bisporus	Agariaceae	Common mushroom	Commercially cultivated	Chestnut: 0.32µg 20E eq./g dw	Findeisen (2004); EIA of ecdysteroids (DBL-2 antiserum)
				White 1: 20.1 20E eq. µg/g dw	
				White 2: 95.2 20E eq. µg/g dw	
				-	Biophytis (unpublished); HPLC-MS/MS for 20E
Agaricus silvaticus	Agariaceae	Pinewood mushroom	Edible wild species	nt	
Amanita caesarea	Amanitaceae	Caesar's mushroom	Edible wild species	nt	
Amanita fulva	Amanitaceae	Tawny grisette	Edible only after cooking	nt	
Amanita muscaria	Amanitaceae	Fly agaric	Edible only after cooking	-	Dinan (unpublished); RIA for ecdysteroids (DBL1 antiserum)
Amanita	Amanitaceae	Blusher	Edible only	-	Dinan

rubescens			after cooking		(unpublished); RIA for ecdysteroids (DBL1 antiserum)
Armillaria mellea	Physalacriacea	Honey fungus	Edible wild species	nt	
Auricularia auricular-judae	Auriculariaceae	Jew's ear, jelly ear mushroom	Commerically cultivated	nt	
Auricularia polytricha	Auriculariaceae	Cloud-ear fungus	Commercially harvested from the wild	nt	
Boletus aereus	Boletaceae	Dark cep, bronze bolete	Commercially harvested from the wild	nt	
Boletus badius	Boletaceae	Bay bolete	Edible wild species	nt	
Boletus edulis	Boletaceae	Edible boletus	Commercially harvested from the wild	-	Dinan (unpublished); RIA for ecdysteroids (DBL1 antiserum)
Calocybe gambosa	Lyophyllaceae	St. George's mushroom	Edible wild species	nt	
Calvatia cyathiformis	Lycoperdaceae	Purple-spored puffball	Edible wild species	calvasterone ([6,6'*R*]-biergosta-4,4',7,7',22,22'-hexaene-3,3'-dione	Kawahara et al. (1993); isolation and spectroscopic identification
				cyathisterone (ergosta-7,22-diene-3,6-dione; 30mg from 4kg fw)), cyathisterol (8β-hydroxyergost-4,6,22-trien-3-one; 80mg), ergosta-4,7,22-triene-3,6-dione (300mg), ergosta-4,6,8(14),22-tetraen-3-one (200mg)	Kawahara et al. (1994); isolation and spectroscopic identification
				calvasterol A (14α-	Kawahara

				hydroxyergosta-4,7,9,22-teraen-3,6-dione; 10mg from 4kg fw), calvasterol B (9α,14α-dihydroxyergosta-4,7,22-trien-3,6-dione; 15mg from 4kg fw),	et al. (1995); isolation and spectroscopic identification
Calvatia gigantea	Lycoperdaceae	Giant puffball	Edible wild species	nt	
Calvatia utriformis (Lycoperdon utriforme, Handkea utriformis)	Lycoperdaceae		Edible wild species	nt	
Cantharellus cibarius	Cantherellaceae	Golden chanterelle	Commercially harvested from the wild	nt	
Cantharellus tubaeformis (Craterellus tubaeformis)	Cantherellaceae	Funnel chanterelle, yellow-foot	Commercially harvested from the wild	nt	
Chroogomphus rutilus	Gomphidiaceae	Pine-spikes, spike-caps, brown slimecap, copper spike	Edible wild species	nt	
Clavariaceae spp.	Clavariaceae	Coral fungi	Edible wild species	nt	
Clavulinaceae spp.	Clavulinaceae	Coral fungi	Edible wild species	nt	
Clitocybe nuda (Lepista nuda)	Tricholomataceae	Wood blewit	Commercially harvested from the wild/ Commerically cultivated/ Edible only after cooking	nt	
Coprinopsis atramentaria	Psathyrellaceae	Common ink cap	Must not be consumed with alcohol	nt	
Coprinus comatus	Agaricaceae	Shaggy inkcap	Edible wild species/Only young fruiting bodies are edible	nt	
Cortinarius caperatus	Cortinariaceae	Gypsy mushroom	Commercially harvested	nt	

			from the wild		
Cortinarius variicolor	Cortinariaceae	Schleierling	Edible wild species	nt	
Craterellus cornucopioides	Cantherellaceae	Horn of plenty, trompette de la morte	Commercially harvested from the wild	nt	
Cyclocybe aegerita	undefined	Pioppino, poplar mushroom	Commercially cultivated	nt	
Cyttaria espinosae	Cyttariaceae	Digüeñe	Edible wild species	nt	
Flammulina velutipes	Physalacriaceae	Enoki mushroom, velvet shank, winter fungus	Commercially cultivated	5α,8α-epidioxy-(24*S*)-ergost-6-en-3β-ol (0.9mg from 4.1kg fw), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6α,9α-tetrol (0.2mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β-triol (0.5mg), (24*S*)-ergost-7-ene-3β,5α,6β-triol (0.2mg)	Yaoita et al. (1998); isolation and spectroscopic identification
Fistulina hepatica	Fistulinaceae	Beefsteak polypore, ox tongue	Edible wild species	nt	
Ganoderma lucidum	Ganodermataceae	Lingzhi	Commercially exploited for nutritional and dietary products	ergosta-4,7,22-triene-3,6-dione (314mg from 5.32kg fw)	Hirotani et al. (1987); isolation and spectroscopic identification
				6α-hydroxyergosta-4,7,22-trien-3-one, 6β-hydroxyergosta-4,7,22-trien-3-one	Nishitoba et al. (1988); isolation and spectroscopic identification
Grifola frondosa	Meripilaceae	Maitake, hen-of-the-woods	Commercially harvested from the wild	(22*E*,24*R*)-ergosta-7,9(11),22-triene-3β,5α,6β-triol (2.7mg from 20kg fw), (22*E*,24*R*)-	Ishizuka et al. (1997); isolation and spectroscop

				ergosta-7,9(11),22-triene-3β,5α,6α-triol (1.5mg), 3β,5α-dihydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (1.1mg), 3β,5α,9α-trihydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (4.3mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6α-triol (1.0mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β-triol (8.2mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β,9α-tetrol (4.7mg)	ic identification
Gyromitra esculenta	Discinaceae	False morel	Commercially harvested from the wild/ Edible only after cooking	nt	
Hericium erinaceus	Hericiaceae	Lion's mane, monkey head	Commercially cultivated/ Commercially harvested from the wild/Used as food additive	cerevisterol (73mg from 3.8kg dw), cerevisterol-3-glucoside (29mg), 3β,5α,9α-trihydroxyergosta-7,22-dien-6-one (32mg)	Takaishi et al. (1991); isolation and spectroscopic identification
Hydnum repandum	Hydnaceae	Hedgehog mushroom	Commercially harvested from the wild	nt	
Hygrophorus chrysodon	Hygrophoraceae	Gold-flecked woodwax	Edible wild species	nt	
Hypsizygus tesselatus (H. marmoreus)	Tricholomataceae	Beech mushroom	Commercially cultivated/Edible only after cooking	5α,9α-epidioxy-3β-hydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (8.4mg from 4.3kg fw), 5α,9α-epidioxy-3β-hydroxy-(24*S*)-ergost-7-en-6-one	Yaoita et al. (1998); isolation and spectroscopic identification

				(4.2mg), 3β,5α,9α-trihydroxy-(24*S*)-ergost-7-en-6-one (1.0mg), 3β,5α,9α,14α-tetrahydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (1.4mg), 3β,5α,9α-trihydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (3.6mg), (24*S*)-ergost-7-ene-3β,5α,6β-triol (12.8mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β-triol (38mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6α,9α-tetrol (1.4mg), ergosta-7,24(28)-diene-3β,5α,6β-triol (0.3mg)	
Kalaharituber pfeilii	Pezizaceae	Kalahari truffle	Edible wild species	nt	
Lactarius deliciosus	Russulaceae	Saffron milk-cap	Commercially harvested from the wild	nt	
Lactarius determinus	Russulaceae	Orange milk-cap	Edible wild species	nt	
Lactarius salmonicolor	Russulaceae		Edible wild species/Edible after cooking or pickling	nt	
Lactarius subdulcis	Russulaceae	Mild milk-cap	Edible wild species/Edible after cooking or pickling	nt	
Lactarius volemus (Lactefluus volemus)	Russulaceae	Weeping milk-cap	Edible wild species/Edible after cooking or pickling	nt	
Laetiporus sulphureus	Polyporaceae	Sulphur shelf, chicken mushroom	Edible wild species	nt	
Leccinum	Boletaceae	Red-capped	Edible wild	nt	

aurantiacum		scaber stalk	species		
Leccinum scabrum	Boletaceae	Birch bolete	Edible wild species	nt	
Leccinum versipelle	Boletaceae	Orange birch bolete	Edible wild species	nt	
Lentinula edodes (Lentinus edodes)	Marasmiaceae	Shiitake mushroom	Commercially cultivated	3β,5α,9α-trihydroxy-(22*E*,24*R*)-23-methylergosta-7,22-dien-6-one (0.5mg from 4.7kg fw), 3β,5α,9α-trihydroxy-(24*S*)-ergost-7-en-6-one (0.9mg), 3β,5α,9α,14α-tetrahydroxy-22*E*,24*R*)-ergosta-7,22-dien-6-one (1.0mg), 3β,5α,9α-trihydroxy-(22*E*,24*R*)-ergosta-7,22,-dien-6-one (17.1mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6α,9α-tetrol (1.3mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6a-triol (0.6mg), (22*E*,24*R*)-ergosta-7,9(11),22-triene-3β,5α,6α-triol (0.6mg),(22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β-triol (3.3mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β,9α-tetrol (6.2mg)	Yaoita et al. (1998); isolation and spectroscopic identification
Lepista saeva (L. personata, Tricholoma personatum)	Tricholomataceae	Field blewit, blue-leg	Edible only after cooking	nt	
Macrolepiota procera	Agaricaceae	Parasol mushroom	Edible wild species	nt	
Marasmius oreades	Marasmiaceae	Fairy ring mushroom,	Edible wild species	nt	

		Scotch bonnet			
Morchella conica var. deliciosa	Morchellaceae	Black morel	Commercially harvested from the wild /Edible only after cooking	nt	
Morchella esculenta var. rotunda	Morchellaceae	Common morel, true morel	Commercially harvested from the wild /Edible only after cooking	nt	
Pholiota microspora (P. nameko)	Strophariaceae	Nameko, butterscotch mushroom	Usually eaten cooked	3β,5α,9α-trihydroxy-(24*S*)-ergost-7-en-6-one (1.0mg from 3.0kg fw), 4 (0.7mg), 3β,5α,9α-trihydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (3.0mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6α,9α-tetrol (0.6mg), (24*S*)-ergost-7-ene-3β,5α,6β-triol (0.2mg)	Yaoita et al. (1998); isolation and spectroscopic identification
Pleurotus ostreatus	Pleurotaceae	Oyster mushroom	Commercially cultivated/ Commercially harvested from the wild	5α,9α-epidioxy-3β-hydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (1.9mg from 2.7kg fw), 3β,5α,9α-trihydroxy-(24*S*)-ergost-7-en-6-one (0.6mg), 3β,5α,9α,14α-tetrahydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (0.4mg), 3β,5α,9α-trihydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (3.5mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6α,9α-tetrol (0.4mg), 3β,5α-	Yaoita et al. (1998); isolation and spectroscopic identification

				dihydroxy-(22*E*,24*R*)-ergosta-7,22-dien-6-one (0.2mg), (22*E*,24*R*)-ergosta-7,22-diene-3β,5α,6β-triol (13.4mg), (24*S*)-ergost-7-ene-3β,5α,6β-triol (0.2mg)	
				0.07 µg 20E eq./g dw	Findeisen (2004); EIA of ecdysteroids (DBL-2 antiserum)
Polyporus mylittae (Laccocephalum mylittae)	Polyporaceae	Native bread, blackfellow's bread	Edible wild species	nt	
Polyporus squamosus	Polyporaceae	Dryad's saddle, pheasant's back mushroom	Edible wild species	nt	
Polyporus umbellatus	Polyporaceae	Lumpy bracket, umbrella polypore	Only young fruiting bodies are edible	polyporusterones A (300mg from 100kg dw), B (300mg), C (26mg), D (8mg), E (22mg), F (10mg) and G (10mg)	Ohsawa et al. (1992); isolation and spectroscopic identification
				(20*S*,22*R*,24*R*)-16,22-epoxy-3β,14α,23β,25-tetrahydroxyergost-7-en-6-one (4mg from 39.2kg dw), (23*R*,24*R*,25*R*)-23,26-epoxy-3β,14α,21α,22α-tetrahydroxyergost-7-en-6-one (8mg)	Zhou et al. (2007); isolation and spectroscopic identification
				Polyporoids A	Sun &

				(2mg from 1kg dw), B (7mg) and C (3mg), polyporusterones A (10mg), B (14mg), C (18mg) and G (3mg), ergosta-7,22-diene-3β,5α,6β-triol (3mg)	Yasukawa (2008); isolation and spectroscopic identification
				(22*E*,24*R*)-ergosta-6-en-3β,5α,6β-triol (0 – 0.040mg/g dw), (22*E*,24*R*)-ergosta-6,22-dien-3β,5α,6β-triol (0 – 0.073mg/g dw), polyporusterone F (trace – 0.087mg/g dw)	Zhao et al. (2009); HPLC-MS
Ramariaceae spp.	Ramariaceae	Coral fungi	Edible wild species	nt	
Rhizopogon luteolus	Rhizopogonaceae		Edible wild species	nt	
Russula laeta (R. borealis)	Russulaceae		Edible wild species	nt	
Sparassis crispa	Sparassidaceae	Cauliflower mushroom	Edible wild species	nt	
Stropharia rugosoannulata	Strophariaceae	White cap mushroom, burgundy mushroom	Commercially cultivated	nt	
Suillus bovinus	Suillaceae	Jersey cow mushroom, bovine bolete	Edible wild species	nt	
Suillus granulatus	Suillaceae	Weeping bolete	Edible wild species	nt	
Suillus luteus	Suillaceae	Slippery Jack, sticky bun	Edible wild species	nt	
Suillus tomentosus	Suillaceae	Poorman's slippery Jack	Edible wild species	nt	
Tapinella atrotomentosa (Paxillus atrotomentosa)	Tapinellaceae	Velvet roll-rim, velvet-footed pax	Only young fruiting bodies are edible	paxillosterone (356mg from 6.65kg fw), paxillosterone 20,22-p-hydroxybenzylidene acetal (5.5mg), atrotosterones A	Vokac et al. (1998); isolation and spectroscopic identification

				(41mg), B (3.9mg) &C (5.5mg), 25-hydroxyatotosterones A (11.9mg) & B (4.2mg), 20-hydroxyecdysone (41mg)	
Tremella fuciformis	Tremellaceae	Snow fungus	Commercially cultivated	nt	
Tricholoma matsutake	Tricholomataceae	Matsutake	Commercially harvested from the wild	nt	
Tricholoma terreum	Tricholomataceae	Grey knight	Edible wild species	nt	
Tuber aestivum	Tuberaceae	Black summer truffle	Commercially harvested from the wild	nt	
Tuber borchii	Tuberaceae	Whitish truffle	Commercially harvested from the wild	nt	
Tuber brumale	Tuberaceae	Winter truffle, Muscat truffle	Commercially harvested from the wild	nt	
Tuber indicum	Tuberaceae	Chinese black truffle	Commercially harvested from the wild	nt	
Tuber macrosporum	Tuberaceae	Smooth black truffle	Commercially harvested from the wild	nt	
Tuber mesentericum	Tuberaceae	Bagnoli truffle	Commercially harvested from the wild	nt	
Verpa bohemica	Morchellaceae	Early morel, wrinkled thimble-cap	Sometimes toxic	nt	
Volvariella volvaceae	Pluteaceae	Straw mushroom	Commercially cultivated	nt	

nt: not tested

-: negative

References

Findeisen E (2004) Ecdysteroide in der menschlichen Nahrung. Ph D Thesis, University of Marburg, FRG, pp 69

Hirotani M, Asaka I, Ino C, Furuya T, Shiro M (1987) Ganoderic acid derivatives and ergosta-4,7,22-triene-3,6-dione from *Ganoderma lucidum*. Phytochemistry 26: 2797-2803

Ishizuka T, Yaoita Y, Kikuchi M (1997) Sterol constituents from the fruit bodies of *Grifola frondosa* (Fr.) S.F. Gray. Chemical and Pharmaceutical Bulletin 45: 1756-1760

Kawagishi H, Katsumi R, Sazawa T, Mizuno T, Hagiwara T, Nakamura T (1988) Cytotoxic steroids from the mushroom Agaricus blazei. Phytochemistry 27: 2777-2779

Kawahara N, Sekita S, Satake M (1993) A novel dimeric steroid, calvasterone, from the fungus *Calvatia cyathiformis*. Chemical and Pharmaceutical Bulletin 41: 1318-1320

Kawahara N, Sekita S, Satake M (1994) Steroids from *Calvatia cyathiformis*. Phytochemistry 37: 213-215

Kawahara N, Sekita S, Satake M (1995) Two steroids from *Calvatia cyathiformis*. Phytochemistry 38: 947-950

Kovganko NV (1999) Ecdysteroids and related compounds in fungi. Chemistry of Natural Compounds 35: 597-611

Nishitoba T, Sato H, Oda K, Sakamura S (1988) Novel triterpenoids and a steroid from the fungus *Ganoderma lucidum*. Agricultural and Biological Chemistry 52: 211-216

Ohsawa T, Yukawa M, Takao C, Murayama M, Bando H (1992) Studies on constituents of fruit body of *Polyporus umbellatus* and their cytotoxic activity. Chemistry and Pharmaceutical Bulletin 40: 143-147

Sun Y, Yasukawa K (2008) New anti-inflammatory ergostane-type ecdysteroids from the sclerotium of *Polyporus umbellatus*. Bioorganic & Medicinal Chemistry Letters (doi: 10.1016/j.bmcl.2008.04.008)

Takaishi Y, Uda M, Ohashi T, Nakano K, Murakami K, Tomimatsu T (1991) Glycosides of ergosterol derivatives from *Hericum erinacens* [sic]. Phytochemistry 30: 4117-4120

Vokáč K, Buděšínsky M, Harmatha J, Píš J (1998) New ergostane type ecdysteroids from fungi. Ecdysteroid constituents of mushroom *Paxillus atrotomentosus*. Tetrahedron 54: 1657-1666

Yaoita Y, Amemiya K, Ohnuma H, Furumura K, Masaki A, Matsuki T, Kikuchi M (1998) Sterol constituents from five edible mushrooms. Chemical and Pharmaceutical Bulletin 46: 944-950

Zhao Y-Y, Cheng X-L, Zhang Y, Zhao Y, Lin R-C, Sun W-J (2009) Simultaneous determination of eight major steroids from Polyporus umbellatus by high-performance liquid chromatography coupled with mass spectrometry detections. Biomedical Chromatography (doi: 10.1002/bmc.1277)

Zhou W-W, Lin W-H, Guo S-X (2007) Two new polyporusterones isolated from the sclerotia of *Polyporus umbellatus*. Chemical and Pharmaceutical Bulletin 55: 1148-1150