Supplementary materials

Material and methods

Lupulone and xanthohumol were sourced from Sigma-Aldrich in Poznan, Poland. Merck, Darmstadt, Germany, supplied trifluoroacetic acid and high-performance liquid chromatography (HPLC)- grade methanol. Ultra-pure water was generated using a Direct-Q 3 UV water purification system (Millipore, Molsheim, France; model Exil SA 67120). Additional reagents, including 5,5′-dithiobis-(2-nitrobenzoic acid), 2,2-diphenyl-1-picrylhydrazyl (DPPH), iron(III) chloride hexahydrate, 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), neocuproine, 2,4,6-tris(2-pyridyl)-s-triazine, trolox, galantamine, azelaic acid, acetylcholinesterase (AChE) from *Electrophorus electricus*, butyrylcholinesterase (BuChE) from equine serum, acetylcholine iodide (ATCI), butyrylcholine iodide (BTCI), Trizma® hydrochloride and Trizma® base, were obtained from Sigma-Aldrich, Schnelldorf, Germany. Avantor Performance Materials in Gliwice, Poland, provided sodium chloride. Ammonium acetate and methanol were purchased from Chempur, Piekary Śląskie, Poland, while POCH, Gliwice, Poland, supplied cupric chloride dihydrate, 99.5% acetic acid, 96% ethanol, and sodium acetate trihydrate.

Plant Material and Cultivation Conditions

Soil preparation, fertilisation, and protection against pests and diseases were carried out in accordance with integrated plant protection guidelines. The hops were grown at a spacing of 1.5 by 3.0 meters on a trellis system 7 meters high. The cultivation site has an average annual temperature of 8.9°C and an average yearly rainfall of 592 mm, based on data from the past 30 years. Hop cones were harvested at full technological maturity (BBCH 89) between late August and early September 2021 from the upper parts of the plants at approximately 5 meters in height. Cones were collected from three randomly selected plants per variety, combined into a composite sample, and air-dried at room temperature. The hop varieties Blisk, Nugget, Bačka, and Saphir were chosen to represent both bitter and aromatic types of diverse origins, highlighting their global relevance and chemical diversity. These cultivars were grown under standardised field conditions in Poland to ensure comparability of their bioactive properties and suitability for sustainable applications.

Table S1. Results of the GC-MS analysis of hop leaf extracts

Peak RT (min)		Compound name	Classification	Formula	Quantity (%)				m/z
					Blisk	Nugget	Bačka	Saphir	
7.636		1-Dodecanol, 3,7,11-trimethyl-	Alcohol	$C_{15}H_{32}O$	**0.8**				55; 56; 57; 58; 60; 70; 98
9.750		2-Propyl-tetrahydropyran-3-ol	Alcohol	$C_8H_{16}O_2$			**11.9**	1.9	55; 55; 58; 101; 144; 207
9.806		4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	Lactone / Pyrone	$C_6H_8O_4$			**13.8**		55; 58; 72; 101; 144
9.860		Cyclohexanecarboxylic acid, 2-hydroxy-, ethyl ester	Ester	$C_9H_{16}O_3$	**24.5**				55; 58; 73; 101; 144
11.263		7-epi-cis-sesquisabinene hydrate	Terpenoid Alcohol	$C_{15}H_{26}O$				**2.2**	55; 58; 91; 119; 120
11.527		9-Hexadecenoic acid	Fatty Acid	$C_{16}H_{30}O_2$				**6.6**	53; 55; 69; 97; 126
11.570		6-Acetyl-ß-d-mannose	Sugar Derivative / Ketone	$C_8H_{14}O_7$				**8.5**	55; 56; 58; 97; 126
12.072		5-Octadecenal	Aldehyde	$C_{18}H_{34}O$			**2.1**		55; 57; 58; 69; 97
12.207	12.422	Ascaridole epoxide	Peroxide / Ether	$C_{10}H_{16}O_3$	**26.4**	5.9	13.4	19.3	77; 97; 126; 135; 150
13.105	13.109	2H-Indeno[1,2-b]furan-2-one, 3,3a,4,5,6,7,8,8b-octahydro-8,8-dimethyl	Lactone	$C_{13}H_{18}O_2$	**5.7**		4.2		55; 91; 97; 149; 191
13.476		9,10-Secocholesta-5,7,10(19)-triene-3,24,25-triol, (3ß,5Z,7E)-	Secosteroid	$C_{27}H_{44}O_3$		**2.5**			55; 58; 59; 77; 129; 173
13.574	13.594	3,3,7-Trimethyl-1-methylsulfanyl-2-aza-spiro[4.5]deca-1,6,9-trien-8-one	Spiro Compound / Sulfur-Nitrogen	$C_{13}H_{17}NOS$		**5.6**		3.2	55; 58; 77; 120; 162
14.507		Benz[e]azulene-3,8-dione, 5-[(acetyloxy)methyl]-3a,4,6a,7,9,10,10a,10b-octahydro-3a,10a-dihydroxy-2,10-dimethyl-, (3aa,6aa,10ß,10aß,10bß)-(+)-	Polycyclic Ketone	$C_{19}H_{24}O_6$		**5.5**			55; 56; 58; 59; 81

14.604		Dodecanoic acid, 3-hydroxy-	Hydroxy Fatty Acid	$C_{12}H_{24}O_3$				**4.9**	57; 58; 69; 77; 173
14.722		Oleic Acid	Fatty Acid	$C_{18}H_{34}O_2$				**4.6**	55; 57; 60; 69; 73
14.822		9-Octadecen-12-ynoic acid, methyl ester	Fatty Acid Ester	$C_{19}H_{32}O_2$		**6.2**			55; 57; 58; 59; 69
14.959		ß-Hydroxydodecanoic acid	Hydroxy Fatty Acid	$C_{12}H_{24}O_3$			**2.7**		55; 57; 59; 60; 73
15.356	15.363	9-Octadecenoic acid, (2-phenyl-1,3-dioxolan-4-yl)methyl ester, cis-	Fatty Acid Ester	$C_{28}H_{44}O_4$			**23.6**	17.8	57; 58; 59; 60; 73; 77; 127
15.419	16.612	10-Heptadecen-8-ynoic acid, methyl ester, (E)-	Fatty Acid Ester	$C_{18}H_{30}O_2$	14.7	**36.0**	15.0	3.0	54; 57; 58; 70; 77
15.919		Z-5-Methyl-6-heneicosen-11-one	Ketone	$C_{22}H_{42}O$		**7.0**			55; 57; 58; 59; 71
16.939		2,6,10-Dodecatrienoic acid, 3,7,11-trimethyl-, methyl ester	Terpenoid Ester	$C_{16}H_{26}O_2$				**10.2**	55; 56; 57; 58; 70
18.238		Benz[e]azulene-3,8-dione, 3a,4,6a 7,9,10,10a,10b-octahydro-3a,10a-dihydroxy-5-(hydroxymethyl)-7-(1-hydroxy-1-methylethyl)-2,10-dimethyl-, [3aR-(3aa,6aa,7a,10ß,10aß,10bß)]-	Polycyclic Ketone	$C_{20}H_{28}O_6$		**1.5**			55; 56; 57; 59; 69
18.113	18.408	1-Heptatriacotanol	Long Chain Alcohol	$C_{37}H_{76}O$	**7.8**	6.1	4.3	1.4	53; 55; 57; 69; 124
19.471		Dasycarpidan-1-methanol, acetate (ester)	Indole Alkaloid / Ester	$C_{20}H_{26}N_2O_2$				**4.5**	55; 60; 69; 73; 129
19.675		Cholesta-5,7,9(11)-trien-3-ol acetate	Steroid Ester	$C_{29}H_{44}O_2$		**7.6**			55; 57; 58; 59; 69
20.266		Gibberellic acid	Diterpenoid Acid	$C_{19}H_{22}O_6$				**2.9**	55; 77; 103; 121; 207
21.406	22.305	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	Aromatic Aldehyde / Terpenoid	$C_{23}H_{32}O$			4.3	**4.7**	55; 57; 58; 59; 207
22.935	22.942	Lupulon	Prenylated Phenol / Terpenoid	$C_{26}H_{38}O_4$	**9.4**	3.5	2.5	2.8	117; 129; 207; 347; 362

23.070		Benz[e]azulene-3,8-dione, 5-[(acetyloxy)methyl]-3a,4,6a,7,9,10,10a,10b-octahydro-3a,10a-dihydroxy-2,10-dimethyl-, (3aa,6aa,10ß,10aß,10bß)-(+)-	Polycyclic Ketone	$C_{19}H_{24}O_6$	**7.3**				55; 58; 59; 72; 207
23.077	23.213	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	Aromatic Aldehyde / Terpenoid	$C_{23}H_{32}O$	3.3	**12.6**			55; 59; 69; 71; 207
24.322	24.332	(22S)-21-Acetoxy-6a,11ß-dihydroxy-16a,17a-propylmethylenedioxypregna-1,4-diene-3,20-dione	Steroid Derivative	$C_{27}H_{36}O_8$			**2.2**	1.5	55; 57; 59; 149; 207

Table S2. Results of the GC-MS analysis of hop cone extracts

Peak RT (min)		**Compound name**	**Classification**	**Formula**	**Quantity (%)**				**m/z**
					Blisk	**Nugget**	**Bačka**	**Saphir**	
5.143		2,6-Nonadienal, (E,Z)-	Aldehyde	$C_9H_{14}O$	**3.0**				53; 55; 60; 69; 70
6.290		2-Cyclohexen-1-ol, 1-methyl-	Alcohol	$C_7H_{12}O$			**6.9**		54; 58; 59; 69; 97
7.626		2-Pentenoic acid, 2-methyl-, (E)-	Unsaturated Carboxylic Acid	$C_6H_{10}O_2$		**1.7**			53; 58; 67; 68; 69;
9.750	9.758	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	Lactone / Pyrone	$C_6H_8O_4$			**19.2**	5.0	55; 72; 73; 101; 144
10.838	11.036	3-Nonanol	Alcohol	$C_9H_{20}O$	18.3	7.4	23.3	**38.1**	58; 59; 71; 97; 102
13.457		Caryophyllene	Sesquiterpene (Hydrocarbon)	$C_{15}H_{24}$		**0.4**			55; 57; 58; 59; 91
15.802	15.836	[1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	Ester / Bicyclic Fatty Acid	$C_{21}H_{38}O_2$		0.4		**2.1**	55; 58; 59; 69; 70
16.308		5,8,11,14-Eicosatetraenoic acid, methyl ester, (all-Z)-	Polyunsaturated Fatty Acid Ester	$C_{21}H_{34}O_2$		**0.6**			57; 59; 67; 69; 79

17.617	17.798	24,25-Dihydroxycholecalciferol	Secosteroid / Vitamin D Derivative	$C_{27}H_{44}O_3$			**4.2**	2.8	53; 55; 59; 69; 110
18.378		2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	Aromatic Aldehyde / Terpenoid	$C_{23}H_{32}O$			**2.7**		55; 58; 59; 69; 124
18.406	19.083	Cholesta-5,7,9(11)-trien-3-ol acetate	Steroid Ester	$C_{29}H_{44}O_2$		1.3		**2.3**	53; 55; 57; 59; 69
19.414		Estra-1,3,5(10)-trien-17ß-ol	Steroid / Estrogen Derivative	$C_{18}H_{24}O$		**1.1**			55; 57; 59; 69; 73
19.656		1-Heptatriacotanol	Long Chain Alcohol	$C_{37}H_{76}O$		**2.0**			55; 57; 59; 69; 85; 95; 184; 191
20.760		2,5-Cyclohexadiene-1,4-dione, 2,5-bis(1,1-dimethylpropyl)-	Quinone Derivative	$C_{16}H_{24}O_2$		**2.9**			57; 59; 69; 191; 233
21.681	21.693	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	Aromatic Aldehyde / Terpenoid	$C_{23}H_{32}O$		0.3	**1.3**		55; 59; 69; 69; 207
23.045	24.149	Lupulon	Prenylated Phenol / Terpenoid	$C_{26}H_{38}O_4$	46.2	**77.9**	37.5	46.0	69; 233; 263; 275; 331
23.110	25.098	4H-Cyclopropa[5',6']benz[1',2':7,8]azuleno[5,6-b]oxiren-4-one, 8-(acetyloxy)-1,1a,1b,1c,2a,3,3a,6a,6b,7,8,8a-dodecahydro-3a,6b,8a-trihydroxy-2a-(hydroxymethyl)-1,1,5,7-tetramethyl-, (1aa,1bß,1cß,2aß,3aß,6aa,6ba,7a,8ß,8aa)-	Polycyclic Terpenoid / Oxygenated Derivative	$C_{22}H_{30}O_8$	1.7	2.6		**3.6**	55; 57; 59; 69; 207
25.337		3-Desoxo-3,16-dihydroxy-12-desoxyphorbol 3,13,16,20-tetraacetate	Phorbol Ester / Diterpenoid	$C_{28}H_{38}O_{10}$	**11.3**				69; 73; 96; 207; 208
25.437		3-[3-(1,5-Dimethylhexyl)-7-(2-hydroxy-1-methylethyl)-3a,6,9b-trimethyl-2,3,3a,4,5,6,7,8,9,9b-decahydro-1H-	Steroid-like Terpenoid Ester	$C_{31}H_{54}O_3$	**4.9**				53; 55; 57; 59; 69; 207; 208

		cyclopenta[a]naphthalen-6-yl]propanoic acid, methyl ester							
25.560		7,8-Epoxylanostan-11-ol, 3-acetoxy-	Epoxy Steroid / Triterpenoid	$C_{32}H_{54}O_4$		**1.4**			55; 59; 67; 69; 207
25.703		3-Isopropyl-6a,10b-dimethyl-8-(2-oxo-2-phenyl-ethyl)-dodecahydro-benzo[f]chromen-7-one	Flavonoid / Oxygenated Terpenoid	$C_{26}H_{36}O_3$	**14.6**				69; 133; 207; 208; 281