

Supplementary Information for

Microbial biotransformation of plant-derived metabolites: Mechanisms, Pathways, and Multi-Omics Integration

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Table S1. Hydrolytic activation and deconjugation of major classes in plant-derived metabolites

Classification	Substrate	Key enzyme	Representative microbiota	End-product	Evidence level	Functional shift	Ref.
Flavonoids	Naringin	α -Rhamnosidase	<i>Lactiplantibacillus plantarum</i>	Naringenin	Recombinant enzyme; isolate culture	NA	1,2
	3''-oxo-puerarin	C-deglycosylation enzymes (DgpB-C)	<i>Dorea</i> sp. PUE	Daidzein	Recombinant enzyme	Bioavailability \uparrow	3
	Rutin	β -glucosidase; α -L-rhamnosidase; β -rutinosidase	<i>Bacteroides</i> JY-6; <i>Fusobacterium</i> K-60	Quercetin-3-O- glucoside; quercetin; leucocyanidin	Fecal incubation; recombinant enzyme	Anti-oxidant \uparrow	2,4
	Epimedium B	β -xylosidase Dt-2286	<i>Dictyoglomus turgidum</i>	Baohuoside I; Sagittatoside B;	Recombinant enzyme	Anti-osteoporosis \uparrow	5
	Theasinensins A	Tannase	Human gut microbes	Theasinensins C	Fecal incubation	Bioavailability \uparrow	6
	Mangiferin	C-C glucosyl-cleaving enzyme	<i>Bacillus</i> sp. KM7-1; <i>Bacteroides</i> sp. MANG	Norathyriol	Isolate culture; animal study	Anti-diabetes \uparrow ; anti- cancer \uparrow	7
	Hesperidin	α -L-rhamnosidase; β -glucosidase	<i>Bifidobacterium</i> <i>pseudocatenulatum</i>	Hesperetin	Isolate culture	Anti-inflammatory \uparrow	8,9
	Daidzin	β -glucosidase	<i>Eubacterium ramulus</i> ; <i>Bifidobacterium breve</i>	Daidzein	Isolate culture; animal study	Neuroprotection \uparrow	10,11
	Kaempferol-3-O-sophoroside	β -glucosidase	<i>Lactobacillus paracasei</i>	Kaempferol	Isolate culture; animal study	Anti-aging \uparrow	12
	Epimedin A, B, C	β -glucosidase; α -L-rhamnosidase	<i>Bacteroides thetaiotaomicron</i>	Icariin II; Icariin A, B	Recombinant enzyme; animal study	Anti-osteoporosis \uparrow	13,14,15
	Isorhamnetin-3-O- neohesperidoside	β -glucosidase	<i>Escherichia</i> sp. 23	Isorhamnetin-3-O- glucoside; isorhamnetin	Isolate culture	Anti-inflammation \uparrow	16
	Luteolin 7-O- and 6-C-glucoside	β -glucosidase	<i>Eubacterium cellulosolvans</i>	Luteolin	Recombinant enzyme; gene identification; isolate culture	Bioavailability \uparrow	17,18
	Calycosin-7-O- β -D-glucoside	β -glucosidase	Rat gut microbes	Calycosin	Animal study; fecal incubation	Neuroprotection \uparrow	19
	Wogonoside	β -glucuronidase	Human gut microbes	Wogonin	Fecal incubation	Anti-inflammation \uparrow	20
	Cyanidin 3-glucoside	β -glucosidase	<i>Eubacterium ramulus</i>	Cyanidin	Animal study; fecal incubation	Bioavailability \uparrow	21
	Quercetin 3-O-glucoside; isorhamnetin 3-O-glucoside	β -glucosidase	<i>Bifidobacterium animalis</i> ; <i>Lactocaseibacillus paracasei</i>	Quercetin; isorhamnetin	Recombinant enzyme; isolate culture	Anti-inflammatory \uparrow	22,23
	Baicalin	β -glucuronidase	<i>Escherichia coli</i> ; <i>Lactobacillus brevis</i>	Baicalein; oroxylin A	Recombinant enzyme; fecal incubation	Bioavailability \uparrow	24,25,26
Terpenoids	Ginsenoside Rb1	β -glucosidase	<i>Irpex lacteus</i>	Ginsenoside Rd	Isolate culture; purified enzyme	NA	27
	Compound K	β -glucosidase	<i>Alistipes finegoldii</i> ; <i>Parabacteroides merdae</i>	(20S)-Protopanaxadiol	Isolate culture; fecal incubation	Antidiabetic \uparrow	28
	Ginsenoside Rb1	Type-I ginsenosidase	<i>Cladosporium xylophilum</i>	Ginsenoside F2	Isolate culture: purified enzyme	Bioavailability \uparrow	29
	Notoginsenoside F ₁	Ginsenosidase	<i>Cladosporium xylophilum</i>	Ginsenoside B7	Isolate culture:	NA	29

	Albiflorin	Esterases	<i>Bifidobacterium breve</i> ; <i>Bifidobacterium longum</i>	Benzoic acid	purified enzyme Animal study; fecal incubation; isolate culture	Anti-depression↑	30,31
	Pedunculoside	NA	<i>Bifidobacterium adolescentis</i>	Deglycosylated products	Isolate culture; animal study	Bioavailability↑	32
	Glycyrrhizin	β-glucuronidase	<i>Eubacterium</i> L-8; <i>Bacteroidetes</i> J-37; <i>Streptococcus</i> LJ-22	18β-glycyrrhetic acid	Recombinant enzyme; isolate culture	Anti-allergic↑; anti-tumor↑	33,34
	Geniposide	β-glucosidase; carboxylesterases	<i>Eubacterium</i> sp. A-44	Genipin; geniposidic acid	Animal study; fecal incubation	Anti-hepatitis↑	35,36
	Ardipusillosides I	β-glucosidase; α-L-rhamnosidase	Human gut microbes	Deglycosylated product	Fecal incubation	Bioavailability↑	37
	Mogroside III	NA	Human gut microbes	Mogrol	Fecal incubation	Bioavailability↑	38
	Asiaticoside	Glycoside hydrolases	<i>Aspergillus niger</i>	Corresponding aglycones	Isolate culture	Bioavailability↑	39
Anthraquinones	Sennoside A	β-glucosidase	<i>Bifidobacterium</i> sp. SEN	Sennidin A-8- monoglucoside	Isolate culture; animal study	Purgation↑	40
Lignans	Secoisolariciresinol	NA	<i>Eubacterium</i> sp. ARC-2	Corresponding aglycones	Isolate culture	NA	41,42
Alkaloids	Boldine-9-O-β-D-glucoside	β-glucosidase	<i>Cunninghamella blackesleeana</i>	Boldine	Isolate culture; purified enzyme	Lipophilicity ↑	43
	Diester diterpenoid alkaloids	Carboxylesterases	Human gut microbes	Monoester diterpenoid alkaloids	Recombinant enzyme; isolate culture	Toxicity↓	44
Phenols	Hydroxycinnamic acid glycoside	Feruloyl esterase	<i>Lactiplantibacillus plantarum</i> ; <i>Lactobacillus johnsonii</i>	Hydroxycinnamic acid	Recombinant enzyme; isolate culture	Bioavailability↑	45
	Ellagitannins; gallotannins	Tannase	<i>Lactiplantibacillus plantarum</i>	Ellagic acid; gallic acid	Recombinant enzyme; isolate culture	NA	45,46
	Polyphenolic β-glycoside	Phospho-β-glucosidase	<i>Lactobacillus acidophilus</i> ; <i>Furfurilactobacillus rossiae</i>	Phenolic aglycone	Recombinant enzyme; isolate culture	NA	45,47
	Galloyl esters	Tannase	<i>Lactiplantibacillus plantarum</i>	Gallic acid	Recombinant enzyme; isolate culture	NA	1
	α-Arabinosylated phenolics	α-L-arabinosidase	<i>Lactiplantibacillus plantarum</i>	Phenolic aglycone	Recombinant enzyme; isolate culture	NA	1
	Chlorogenic acid	Hydroxycinnamic acid esterase	<i>Bifidobacterium animalis</i>	Hydroxycinnamic acid	Recombinant enzyme; isolate culture	NA	48
	Amygdalin	β-glucosidase	Rat gut microbes	Mandelonitrile; prunasin	Fecal incubation; animal study	Toxicity↑	49,50
	Ellagitannins	Tannase	<i>Akkermansia muciniphila</i>	Ellagic acid	Recombinant enzyme; isolate culture	Neuroprotection↑	51
	Scopolamine	NA	Rat gut microbes	Scopine	Animal study	NA	52,53
	p-Coumaric acids	Feruloyl esterases	<i>Lactiplantibacillus</i> sp.	Ferulic acid	Recombinant enzyme	Anti-oxidant↑	54
	Gallic tannins	Tannase	<i>Lactiplantibacillus plantarum</i>	Gallic acid	Purified enzyme; isolate culture	Anti-inflammatory↑	55

	Mangiferin	NA	<i>Lachnospiraceae</i> sp. CG19-1	Norathyriol	Isolate culture	NA	56
Steroids	Pulsatilla saponin D	NA	Rat gut microbes	Corresponding deglycosylation products	Animal study	Bioavailability↑	57
Others	Aceteoside	Feruloyl esterase; α -L-rhamnosidase	<i>Alternaria botrytis</i>	Verbasoside; hydroxysalidroside	Purified enzyme; isolate culture	NA	58

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