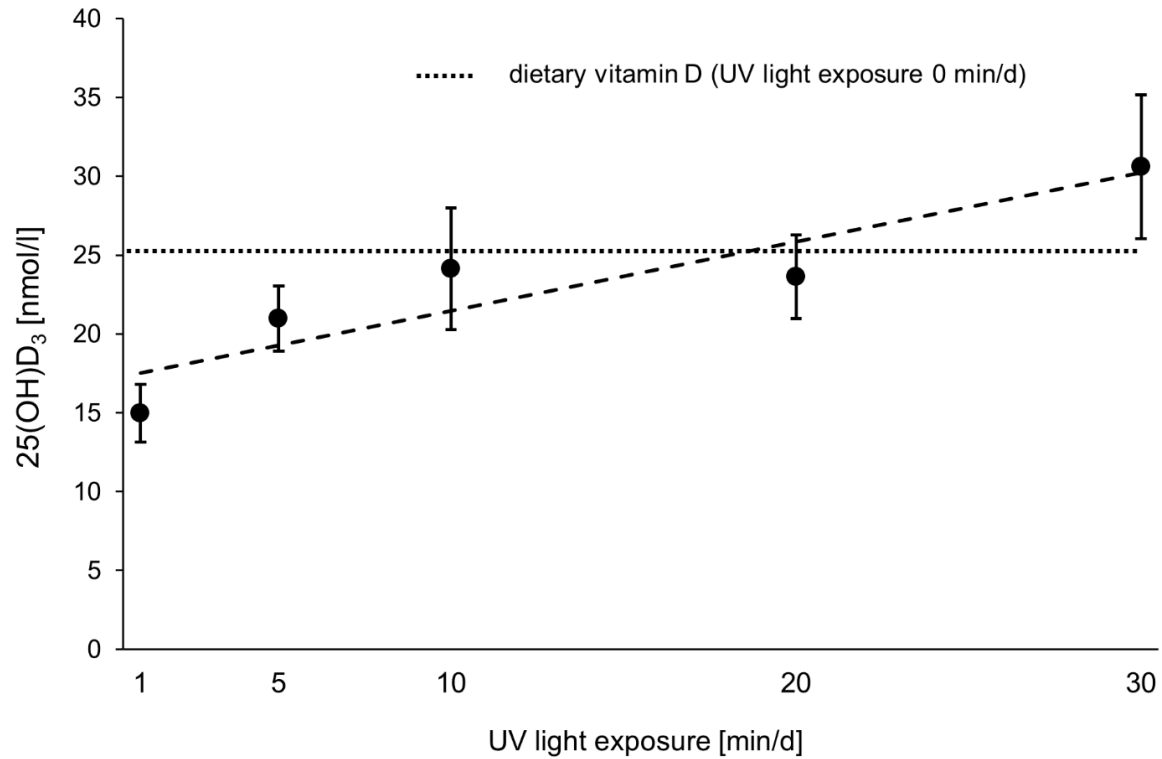
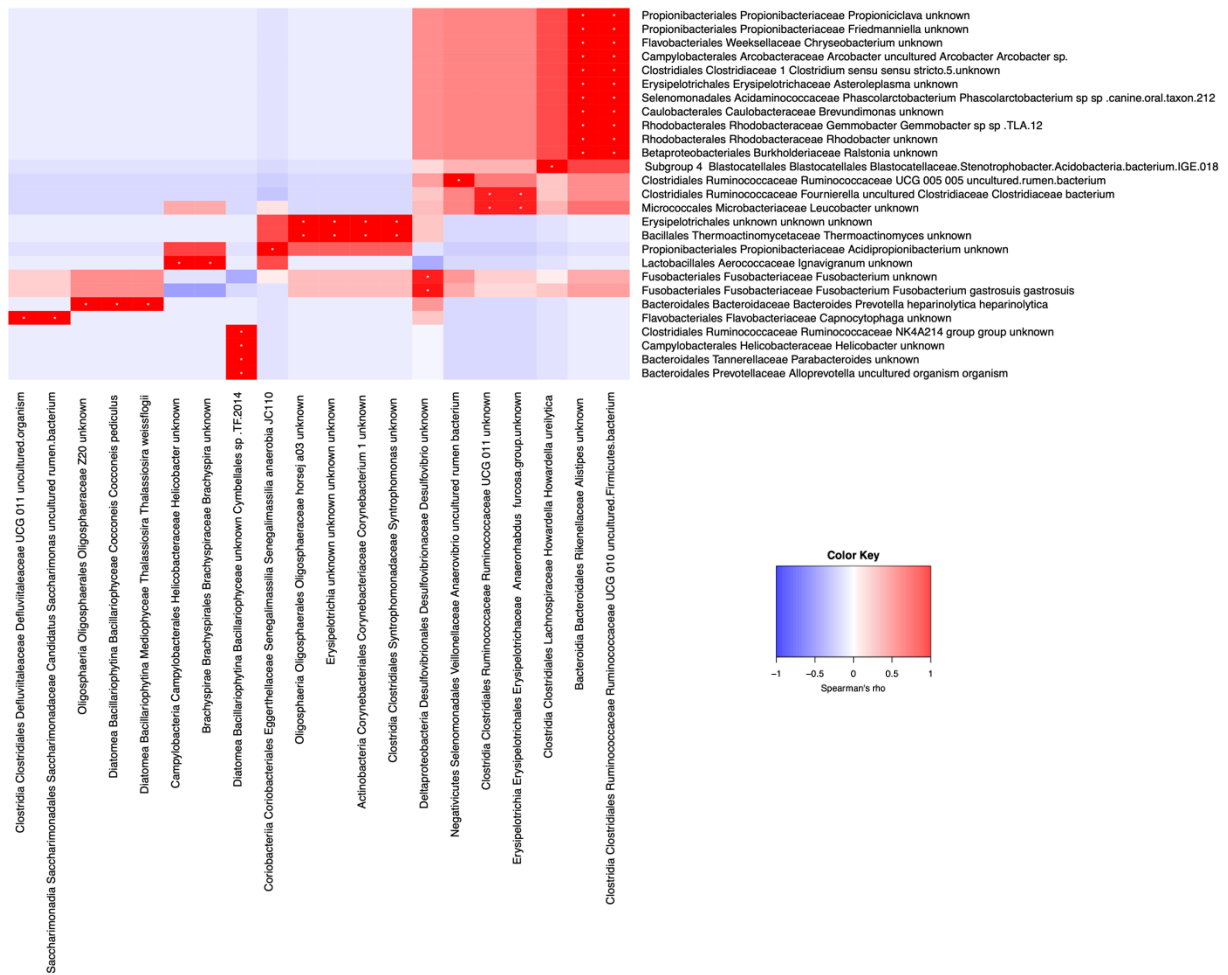


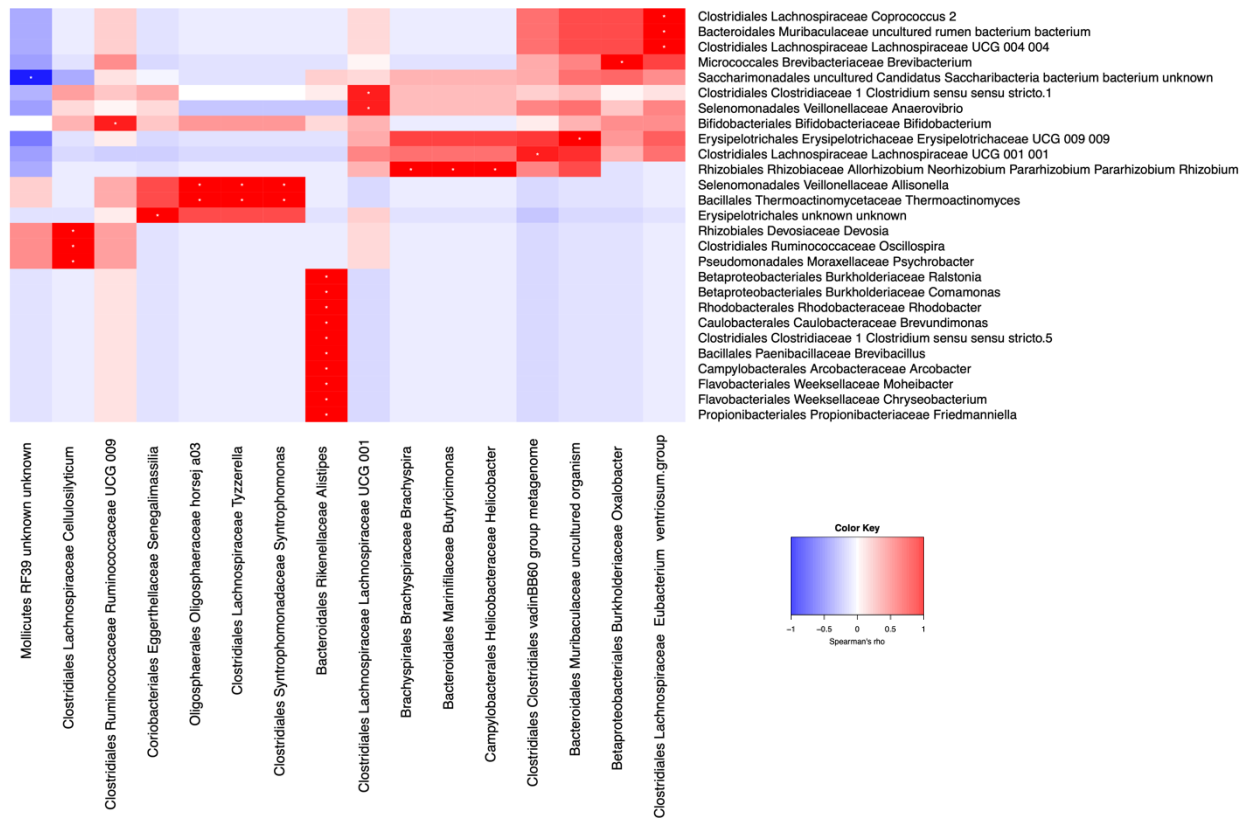
Supplemental figure 1: UV spectrum of the UV lamps. Model: Exo Terra Reptile UVB. The illustration was provided by the manufacturer and has been slightly modified.



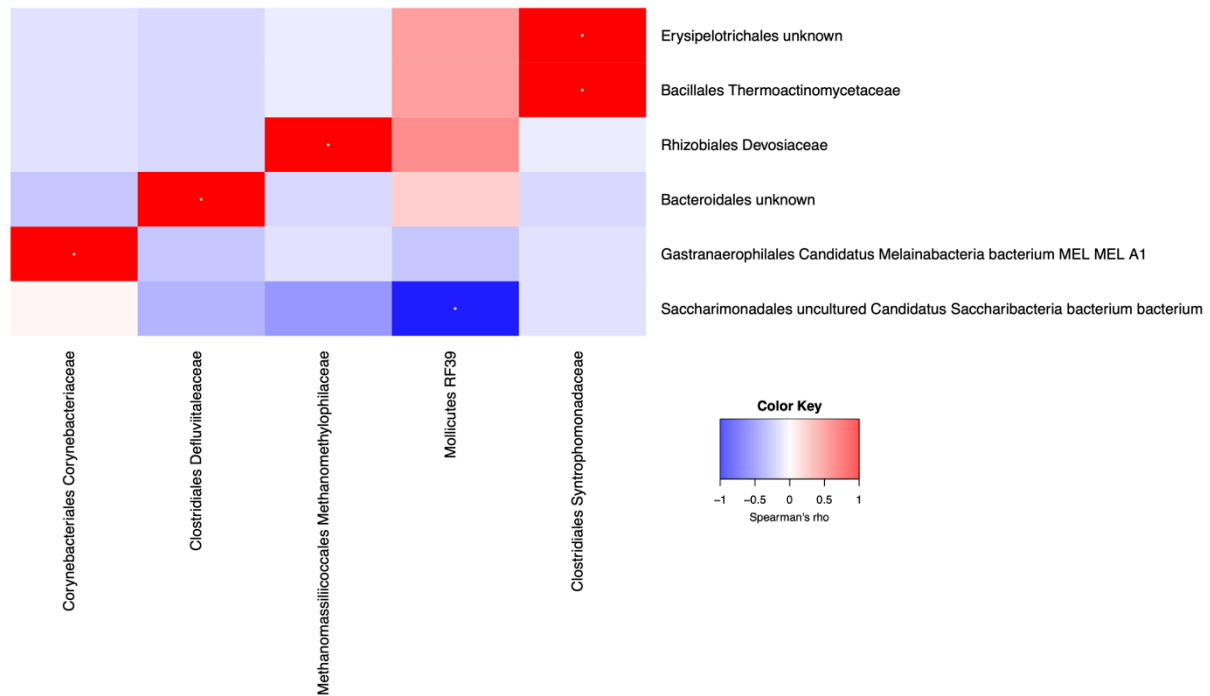
Supplemental figure 2: Intersection between daily UV exposure and dietary vitamin D supply on the basis of plasma 25-hydroxyvitamin D₃ (25(OH)D₃) concentrations in pigs of the pre-study. Pigs exposed to UV light did not receive oral vitamin D. Data are reported as mean values ± standard deviation (averaged over week 1 to 4 from 3 to 4 animals per group). The dotted line represents the mean plasma 25(OH)D₃ concentration of pigs with a dietary vitamin D supply of 20 µg/d.



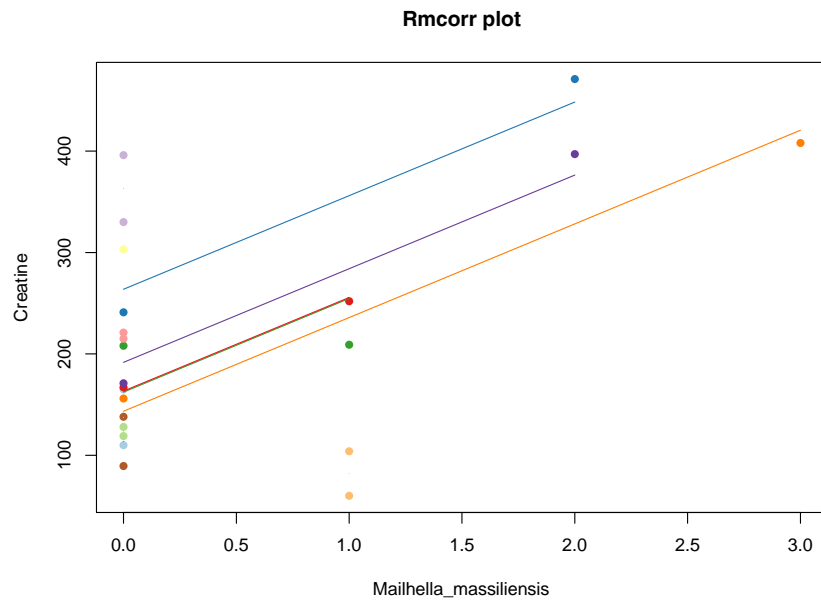
Supplemental figure 3: Heatmap of stool and chyme microbiome correlation at the species level. The x-axis represents stool microbes, and the y-axis represents chyme microbes. Spearman's correlation tests were executed, and the results underwent adjustment for multiple testing using the Benjamini-Hochberg correction. White asterisks denote instances where Spearman's correlation yielded a q-value of less than 0.05, indicating statistical significance.



Supplemental figure 4: Heatmap of stool and chyme microbiome correlation at the genus level. The x-axis represents stool microbes, and the y-axis represents chyme microbes. Spearman's correlation tests were executed, and the results underwent adjustment for multiple testing using the Benjamini-Hochberg correction. White asterisks denote instances where Spearman's correlation yielded a q-value of less than 0.05, indicating statistical significance.



Supplemental figure 5: Heatmap of stool and chyme microbiome correlation at the family level. The x-axis represents stool microbes, and the y-axis represents chyme microbes. Spearman's correlation tests were executed, and the results underwent adjustment for multiple testing using the Benjamini-Hochberg correction. White asterisks denote instances where Spearman's correlation yielded a q-value of less than 0.05, indicating statistical significance.



Supplemental figure 6: Correlation of the plasma creatine level and the stool abundance of *Maihella massiliensis*. The repeated measures correlation analysis was conducted utilizing the Rmcorr package, with subsequent adjustments for multiple testing employing the Benjamini-Hochberg correction. The calculated correlation coefficient was 0.93, while the associated q-value was 0.03. In the scatter plot, subjects are distinguished by distinct colors, and parallel lines have been fitted to the data points representing each subject.

Supplemental table 1: Composition (% of total) of pig feeds.

	Pre-Starter feed	Starter feed
Wheat	38.0	38.0
Barley	17.7	20.6
Corn	8.0	12.0
Soybean meal	22.0	18.0
Wheat bran	3.0	3.0
Whey powder	5.0	2.5
Soybean oil	2.5	2.4
Vitamin D-free premix of vitamins and minerals*	2.0	2.0
Monocalcium phosphate	0.5	0.5
L-lysine HCl	0.56	0.56
DL-methionine	0.22	0.22
L-threonine	0.26	0.26
L-valine	0.17	0.17
L-tryptophan	0.06	0.06

* Basu Mineralfutter GmbH, Bad Sulza, Germany

Supplemental table 2: Plasma concentrations of folic acid metabolites in pigs at baseline (week 0), after two and four weeks of intervention.

	Dietary vitamin D		UV exposure		P values		
	Median	IQR	Median	IQR	Group	Time	Group x time
Folic acid (nmol/l)							
Week 0	2.30	1.60-4.90	2.35	1.71-4.52			
Week 2	4.08	2.38-6.06	4.03	3.18-5.38	Ns	P < 0.001	Ns
Week 4	1.04	0.89-1.64	1.17	1.00-1.99			
5-Methyl-THF (nmol/l)							
Week 0	9.07	5.53-12.3	9.57	6.82-14.1			
Week 2	6.95	5.69-9.78	9.29	5.31-11.3	Ns	Ns	Ns
Week 4	6.43	4.70-11.4	8.35	6.97-13.1			
5-Formyl-THF (nmol/l)¹							
Week 0	0	0-1.39	0	0-1.28	Ns		
Week 2	0	0-0.84	0.58	0-1.76	Ns		
Week 4	0	0-0.94	0.53	0-1.10	Ns		
4-Alfa-hydroxy-5-methyl-THF (nmol/l)							
Week 0	1.57	1.07-2.98	1.32	0.82-1.44			
Week 2	3.35	2.95-3.83	4.01	2.25-5.10	Ns	P < 0.001	Ns
Week 4	1.21	0.64-3.24	0.83	0.55-1.27			
Acetamidobenzoylglutamate (nmol/l)							
Week 0	1.17	0.90-2.36	0.99	0.68-1.35			
Week 2	1.12	0.85-1.42	1.29	0.79-4.40	Ns	Ns	Ns
Week 4	1.60	1.01-2.56	2.22	1.27-3.15			
Para-aminobenzoylglutamate (nmol/l)							
Week 0	1.01	0.76-1.79	1.18	0.50-2.09			
Week 2	1.00	0.22-1.39	1.07	0.46-1.53	Ns	Ns	Ns
Week 4	1.19	0.64-1.92	0.99	0.92-1.39			

Not significant (ns), tetrahydrofolic acid (THF). Data were statistically analysed by the *mixed-model procedure* (n = 8). ¹ Groups were compared for each week by the Mann-Whitney *U* test.

Supplemental table 3: Concentrations of bile acids in feces of pigs at baseline (week 0) and after four weeks of intervention.

	Dietary vitamin D ₃		UV exposure		P values		
	Median	IQR	Median	IQR	Group	Time	Group x time
Lithocholic acid (µg/g dry matter)							
Week 0	1105	632-1433	893	453-1279	Ns	Ns	Ns
Week 4	1321	661-2140	1610	459-2247			
Hyodeoxycholic acid (µg/g dry matter)							
Week 0	432	163-1077	589	200-1485	Ns	Ns	Ns
Week 4	816	212-1784	1510	112-2204			
Isolithocholic acid (µg/g dry matter)							
Week 0	131	67-166	121	45-175	Ns	Ns	Ns
Week 4	184	75-303	232	41-353			
Isolithocholic acid like (µg/g dry matter)							
Week 0	18.7	15.5-31.4	27.9	11.7-35.7	Ns	Ns	Ns
Week 4	25.9	19.6-36.0	24.2	11.1-53.2			

Not significant (ns). Data were statistically analysed by the *mixed-model procedure* (n = 8).

Supplemental table 4: Concentrations of bile acids (mg/ml) in bile of pigs after four weeks of intervention.

	Dietary vitamin D ₃		UV exposure		P value
	Median	Interquartile range	Median	Interquartile range	
Glyco Hyodeoxycholic acid like	22.0	15.4-27.3	20.7	14.3-31.8	ns
Glycochendeoxycholic acid	13.3	12.0-14.8	13.5	10.2-16.1	ns
Glycocholic acid	0.01	0.01-0.04	0.04	0.02-0.06	ns
Glycodeoxycholic acid	0.03	0.02-0.04	0.02	0.02-0.03	ns
Glycolithocholic acid	0.14	0.11-0.17	0.07	0.02-0.11	ns
Glycolithocholic acid-sulfate like	0.07	0.03-0.09	0.09	0.05-0.39	ns
Glycoursodeoxycholic acid	0.16	0.10-0.43	0.11	0.03-0.24	ns
Tauro Hyodeoxycholic acid	4.60	2.84-5.29	3.68	3.03-7.49	ns
Taurochendeoxycholic acid	4.07	3.47-4.58	4.06	3.56-5.30	ns
Tauroursodeoxycholic acid	0.08	0.03-0.13	0.06	0.02-0.09	ns

Not significant (ns). Groups were compared by the Mann-Whitney *U* test (n = 8).

Supplemental table 5: Concentrations of short chain fatty acids in feces of pigs at baseline (week 0) and after four weeks of intervention.

	Dietary vitamin D ₃		UV exposure		Group	P values	
	Median	IQR	Median	IQR		Time	Group x time
Acetic acid (mmol/l)							
Week 0	18.4	17.0-21.8	17.0	15.6-24.5	Ns	Ns	Ns
Week 4	19.0	15.7-22.4	18.2	14.7-21.5			
Propionic acid (mmol/l)							
Week 0	7.20	6.88-11.6	7.65	5.33-8.42	Ns	Ns	Ns
Week 4	8.48	7.84-10.8	9.36	6.85-9.89			
2-methyl-propanoic acid (mmol/l)							
Week 0	0.52	0.33-1.01	0.79	0.57-1.02	Ns	P < 0.05	Ns
Week 4	1.17	0.72-1.20	0.96	0.90-1.13			
Butanoic acid (mmol/l)							
Week 0	4.52	3.61-5.59	3.22	3.01-3.95	Ns	P < 0.05	Ns
Week 4	5.70	4.07-9.08	5.16	3.67-6.01			
3-methyl-butanoic acid (mmol/l)							
Week 0	0.36	0.23-0.90	0.67	0.42-0.86	Ns	P < 0.05	Ns
Week 4	0.94	0.57-1.04	0.84	0.73-0.92			
Pentanoic acid (mmol/l)							
Week 0	1.29	0.91-1.55	0.96	0.76-1.45	Ns	Ns	Ns
Week 4	1.65	1.14-2.06	1.21	1.07-1.58			
Hexanoic acid (mmol/l)							
Week 0	0.07	0.03-0.30	0.13	0.05-0.36	Ns	P < 0.05	Ns
Week 4	0.40	0.17-0.66	0.30	0.17-0.38			
Heptanoic acid (mmol/l)							
Week 0	0.002	0.002-0.05	0.005	0.002-0.06	Ns	P < 0.01	Ns
Week 4	0.04	0.02-0.10	0.05	0.02-0.08			

Short chain fatty acids were analysed in fecal water. Not significant (ns). Data were statistically analysed by the *mixed-model procedure* (n = 8).

Supplemental table 6: Plasma compounds with annotation level 1, 2a or 2b identified by metabolom analysis in pigs after four weeks of intervention.

Compound	Annotation level	Log2 ratio UV/Vit D	P value (t test)
Glycoursodeoxycholic acid	2b	-1.99	0.198
Chenodeoxycholic acid	2a	-1.24	0.037
Glycoursodeoxycholic acid	2b	-1.23	0.163
Docosahexaenoic acid ethyl ester	2b	-1.16	0.051
Hexadecanedioic acid	2b	-1.15	0.073
Docosahexaenoic acid ethyl ester	2b	-1.07	0.036
Bilirubin	2b	-0.94	0.005
Taurochenodeoxycholate	1	-0.90	0.334
Cholic acid	1	-0.85	0.061
3-[4-methyl-1-(2-methylpropanoyl)-3-oxocyclohexyl]butanoic acid	2b	-0.82	0.124
Tetradecanedioic acid	2b	-0.82	0.096
5-hydroxytryptamine (Serotonin)	1	-0.79	0.116
(9Z,12Z)-6,8-Dihydroxy-9,12-octadecadienoic acid	2b	-0.77	0.121
(1S,4R,4aS,8aS)-1,2-Bis(hydroxymethyl)-5,5,8a-trimethyl-1,4,4a,5,6,7,8,8a-octahydro-1,4-naphthalenediol	2b	-0.74	0.165
Guanosine	2a	-0.73	0.092
Glycoursodeoxycholic acid	2b	-0.73	0.343
Hyodeoxycholate	2a	-0.71	0.120
Inosine	2a	-0.67	0.243
9-Nitrooleate	2b	-0.67	0.151
Glycocholic acid	2b	-0.59	0.545
Dodecanedioic acid	2b	-0.57	0.125
N-Acetylglycine	2b	-0.55	0.052
Xanthine	2a	-0.53	0.232
1-Linoleoyl glycerol	2b	-0.51	0.076
1-Methylnicotinamide	2b	-0.49	0.020
γ -Linolenic acid	1	-0.47	0.052

3-Methylcrotonylglycine	2b	-0.40	0.318
2-(hydroxymethyl)butanoic acid	2a	-0.39	0.131
5-Methoxyindole	2b	-0.37	0.467
(+/-)12(13)-DiHOME	2b	-0.32	0.225
L-2-Aminoadipic acid	2b	-0.31	0.453
N-acetylproline	2a	-0.30	0.427
N-Acetylalanine	2b	-0.28	0.167
Indole-3-lactic acid	2b	-0.28	0.546
5-methyl-tryptophan	2a	-0.24	0.467
Leucine	1	-0.23	0.360
(R)-3-Hydroxy myristic acid	2b	-0.23	0.548
Urea	2a	-0.22	0.165
3-tert-Butyladipic acid	2b	-0.21	0.165
16-Hydroxyhexadecanoic acid	2b	-0.21	0.476
Decanophenone	2b	-0.21	0.189
Suberic acid	1	-0.20	0.403
Sorbic acid	2b	-0.20	0.125
OPEO	2b	-0.19	0.734
Arginine	1	-0.19	0.284
2,5-Bis(tert-butylperoxy)2,5-dimethylhexane	2b	-0.19	0.282
PDMP	2b	-0.19	0.085
Docosahexaenoic acid methyl ester	2b	-0.18	0.768
4-Methyl-2-oxovaleric acid (ketoleucine)	2a	-0.17	0.568
(+/-)12(13)-DiHOME	2b	-0.17	0.705
4-Indolecarbaldehyde	2b	-0.16	0.639
2-Amino-4-methylpyrimidine	2b	-0.15	0.231
Dipropyleneglycol dibenzoate	2b	-0.15	0.245
Histidine	1	-0.15	0.232
Phthaldialdehyde	2b	-0.14	0.173
Isoleucine	2a	-0.13	0.272
Linoleic acid	1	-0.13	0.554
N-Benzylformamide	2b	-0.13	0.287
Carnosine	1	-0.12	0.593

N3,N4-Dimethyl-L-arginine	2b	-0.12	0.129
AUDA	2b	-0.11	0.385
Valine	1	-0.10	0.357
Phenylacetyl glycine	2b	-0.09	0.714
Hippuric acid	2b	-0.09	0.736
(+)-ar-Turmerone	2b	-0.08	0.495
2-deoxycytidine	2a	-0.08	0.756
Propionylcarnitine (C3)	1	-0.08	0.734
6-Methylquinoline	2b	-0.08	0.742
trans-D-Allethrin	2b	-0.07	0.561
Lysine	2a	-0.07	0.727
Gluconic acid	2b	-0.07	0.696
Cytidine	2a	-0.07	0.714
Triethyleneglycol diacetate	2b	-0.06	0.575
1,2,3,4-Tetramethyl-1,3-cyclopentadiene	2b	-0.05	0.554
6-Methylindole	2b	-0.05	0.805
methyl-cinnamate	1	-0.04	0.781
Citrulline	1	-0.04	0.757
5-Methoxy-tryptophan	2a	-0.04	0.862
16-Hydroxyhexadecanoic acid	2b	-0.04	0.848
7-Methylguanine	1	-0.03	0.759
Cytosine	2a	-0.03	0.852
Phenylalanine	1	-0.02	0.887
Creatine	1	-0.02	0.935
Ornithine	1	-0.02	0.856
Tryptophan	1	-0.02	0.937
Galactos/glucos-amin	2a	-0.02	0.877
3-phenyllactic acid	1	-0.01	0.976
Beta-alanine	1	-0.01	0.973
Thymine	1	-0.01	0.979
Allantoin	1	0.00	0.985
Pyruvic acid	2a	0.00	0.982
PEG n7	2b	0.00	0.967

3-Methylhistidine	1	0.01	0.946
1H-indene-3-carboxamide	2b	0.01	0.945
Creatinine	2a	0.01	0.863
Nicotine amide	2a	0.01	0.942
5-aminolevulinic acid	1	0.01	0.918
N8-Acetylspermidine	1	0.02	0.944
Choline	1	0.02	0.819
PEG n8	2b	0.03	0.787
5-Fluoro-3,5-AB-PFUPPYCA	2b	0.03	0.860
N6,N6,N6-Trimethyl-L-lysine	2b	0.03	0.782
Caprolactam	2b	0.03	0.892
Hexose1	1	0.04	0.706
Proline	2a	0.04	0.582
Palmitoylcarnintine (C16)	1	0.04	0.892
Tyrosine	1	0.05	0.704
5-hydroxy-4-methoxy-5,6-dihydro-2H-pyran-2-one	2b	0.06	0.618
PEG n10	2b	0.06	0.644
N-Acetyl-ornithine	1	0.06	0.686
Citric acid	2a	0.06	0.592
Prolylleucine	2b	0.06	0.661
Glutamic acid	1	0.06	0.591
Hexose 2	1	0.07	0.729
Glutamine	2a	0.11	0.345
ectoine	2a	0.12	0.344
3-Indoxyl sulphate	2b	0.12	0.769
Hypoxanthine	2a	0.14	0.212
Serine	2a	0.14	0.216
alpha-Ketoglutaric acid	2a	0.14	0.391
4-Oxoproline	2b	0.15	0.154
Taurine	2a	0.15	0.403
Phloroglucinol	2b	0.16	0.283
Alanine	2a	0.17	0.191

Lauro lactam	2b	0.19	0.346
Hypotaurine	2a	0.19	0.360
Betaine	1	0.20	0.095
DL-Stachydrine	2b	0.21	0.286
Trigonelline (N'-methylnicotinate)	1	0.21	0.278
Lactic acid	1	0.22	0.463
cis-Aconitic acid	2a	0.23	0.256
Isocitric acid	1	0.24	0.244
Acetylcholine	1	0.24	0.068
Choline phosphate (PCHO)	1	0.25	0.261
Carnitine	1	0.25	0.071
Protocatechuic acid	1	0.26	0.248
Asparagine	2a	0.26	0.104
Trimethylamine N-Oxide	1	0.29	0.561
Acetylcarnitine (C2)	1	0.29	0.283
Sorbitol/Manitol	2a	0.30	0.215
Threonine	1	0.30	0.078
Aspartic acid	2a	0.32	0.248
Succinic acid	1	0.34	0.262
Diaminopimelic acid	2a	0.37	0.077
2,2'-Methylenebis(4-methyl-6-tert-butylphenol)	2b	0.52	0.010
Spermidine	2a	0.55	0.320
Spermine	2a	0.63	0.230
1-Dodecyl-2-pyrrolidinone	2b	1.34	0.000
4-Methylumbelliferone hydrate	2b	2.62	0.038
Monobutyl phthalate	2b	2.66	0.031
trans-Anethole	2b	2.96	0.000
Hexadecanamide	2b	3.09	0.000
(2E,4E)-N-(2-methylpropyl)deca-2,4-dienamide	2b	3.31	0.000