

Table S3. Correlation analysis between microbiota, metabolites, and phenotypic traits

Omics_1	Omics_2	Correlation	P-Value
3-aminobenzamide	2,4-Dihydroxy Benzoic Acid	-0860557769	0000326983
Creatinine	2,4-Dihydroxy Benzoic Acid	-0749155076	0005041181
Creatinine	3-aminobenzamide	0765802966	000368698
Creatinine	Alloprevotella	-0810991683	0001369962
	Christensenellaceae_R-		
Creatinine	7_group	0772001698	0003260885
Creatinine	Claudin-1	0646250533	0023173494
Creatinine	Claudin-4	0630488325	0027955557
Hispidol	2,4-Dihydroxy Benzoic Acid	-0690481188	0012926703
Hispidol	3-aminobenzamide	0712875173	000926089
Hispidol	Creatinine	0748607707	0005091292
Hispidol	Alloprevotella	-0706293706	0010245194
Hispidol	Claudin-1	0763293772	0003870969
Hispidol	Claudin-4	0678483353	0015283555
N-Acetyl-5-Hydroxytryptamine	2,4-Dihydroxy Benzoic Acid	-0735269157	0006432813
N-Acetyl-5-Hydroxytryptamine	3-aminobenzamide	0839774418	0000631345
N-Acetyl-5-Hydroxytryptamine	Creatinine	0709617723	0009738809
N-Acetyl-5-Hydroxytryptamine	Goblet cell numbers	0793681654	0002058049
N-Acetyl-5-Hydroxytryptamine	Butyric acid	072027972	0008239769
N-Acetyl-5-Hydroxytryptamine	Claudin-1	0805698982	0001557938
N-Acetyl-5-Hydroxytryptamine	Claudin-4	0862239261	0000308649
N-Acetyl-5-Hydroxytryptamine	MUC2	0749158702	000504085
N-Acetyl-5-Hydroxytryptamine	IL-10	0706753493	0010174007
N-Methyl- α -aminoisobutyric acid	2,4-Dihydroxy Benzoic Acid	087250996	0000213327
N-Methyl- α -aminoisobutyric acid	3-aminobenzamide	-0860557769	0000326983
N-Methyl- α -aminoisobutyric acid	Creatinine	-0749155076	0005041181
N-Methyl- α -aminoisobutyric acid	Hispidol	-0802451111	0001682711
	N-Acetyl-5-		
N-Methyl- α -aminoisobutyric acid	Hydroxytryptamine	-0809915772	0001406681
N-Methyl- α -aminoisobutyric acid	Alloprevotella	0765127803	0003735819
N-Methyl- α -aminoisobutyric acid	Goblet cell numbers	-0662708662	0018845753
N-Methyl- α -aminoisobutyric acid	IgM+ cells density	-0612102243	0034389274
N-Methyl- α -aminoisobutyric acid	Claudin-1	-0890217498	0000104172
N-Methyl- α -aminoisobutyric acid	Claudin-4	-0920394363	220019E-05
N-Methyl- α -aminoisobutyric acid	MUC1	-0709156312	0009807961
N-Methyl- α -aminoisobutyric acid	MUC2	-0890217498	0000104172
N-Methyl- α -aminoisobutyric acid	IL-1 β	0739333176	0005998881
N-Methyl- α -aminoisobutyric acid	IL-6	0739333176	0005998881
N-Methyl- α -aminoisobutyric acid	IL-10	-0739333176	0005998881
Ureidoisobutyric Acid	2,4-Dihydroxy Benzoic Acid	0737051793	0006239666
Ureidoisobutyric Acid	3-aminobenzamide	-0860557769	0000326983
Ureidoisobutyric Acid	Creatinine	-0749155076	0005041181
Ureidoisobutyric Acid	Hispidol	-0936815018	712897E-06

Ureidoisobutyric Acid	N-Acetyl-5-Hydroxytryptamine	-0705410511	0010382974
Ureidoisobutyric Acid	N-Methyl- α -aminoisobutyric acid	0856573705	000037381
Ureidoisobutyric Acid	Alloprevotella	0675551865	0015904516
Ureidoisobutyric Acid	Christensenellaceae_R-7_group	-060090525	003879039
Ureidoisobutyric Acid	Prevotella_9	064942555	0022287393
Ureidoisobutyric Acid	Negativibacillus	-0735269157	0006432813
Ureidoisobutyric Acid	Odoribacter	0748470735	0005103891
Ureidoisobutyric Acid	Butyric acid	-0705410511	0010382974
Ureidoisobutyric Acid	Claudin-1	-090530593	510576E-05
Ureidoisobutyric Acid	Claudin-4	-0814775337	000124665
Ureidoisobutyric Acid	MUC1	-0814775337	000124665
Ureidoisobutyric Acid	MUC2	-090530593	510576E-05
Ureidoisobutyric Acid	TNF- α	0724244744	00077289
Ureidoisobutyric Acid	TLR-4	0724244744	00077289
Ureidoisobutyric Acid	IL-1 β	0724244744	00077289
Ureidoisobutyric Acid	IL-6	0724244744	00077289
Ureidoisobutyric Acid	IL-10	-0724244744	00077289
Ureidoisobutyric Acid	PIGR	-0724244744	00077289
Alloprevotella	2,4-Dihydroxy Benzoic Acid	0817380434	0001166845
Alloprevotella	3-aminobenzamide	-0615834573	0033005195
Christensenellaceae_R-7_group	2,4-Dihydroxy Benzoic Acid	-0727804496	0007290796
Christensenellaceae_R-7_group	3-aminobenzamide	0668087204	0017569373
Christensenellaceae_R-7_group	Alloprevotella	-0811188811	0001363315
Prevotella_9	3-aminobenzamide	-0634496227	0026677648
Prevotella_9	Creatinine	-0608243762	0035863294
Prevotella_9	N-Methyl- α -aminoisobutyric acid	0671819535	0016721729
Prevotella_9	Alloprevotella	0643356643	0024003191
Prevotella_9	Negativibacillus	-0629370629	0028319671
Prevotella_9	Claudin-1	-0692618423	0012536906
Negativibacillus	2,4-Dihydroxy Benzoic Acid	-089949171	680903E-05
Negativibacillus	3-aminobenzamide	0921885695	200681E-05
Negativibacillus	Creatinine	0662829741	0018816295
Negativibacillus	N-Acetyl-5-Hydroxytryptamine	072027972	0008239769
Negativibacillus	N-Methyl- α -aminoisobutyric acid	-075019848	000494669
Negativibacillus	Alloprevotella	-0664335664	0018452718
Negativibacillus	Christensenellaceae_R-7_group	079020979	0002223135
Negativibacillus	Goblet cell numbers	0768989336	000346299
Negativibacillus	Butyric acid	0608391608	0035805997
Negativibacillus	Claudin-1	0735023632	0006459763
Negativibacillus	Claudin-4	0749158702	000504085

Negativibacillus	MUC1	0819834052	0001095334
Negativibacillus	MUC2	0650213213	0022071442
Negativibacillus	IL-1 β	-0805698982	0001557938
Negativibacillus	IL-6	-0791563912	0002157587
Negativibacillus	IL-10	0918779541	242584E-05
Odoribacter	2,4-Dihydroxy Benzoic Acid	0915641864	291625E-05
Odoribacter	3-aminobenzamide	-0801661549	0001714169
Odoribacter	Creatinine	-0650916663	0021879871
Odoribacter	Hispidol	-0669145084	0017325991
Odoribacter	N-Acetyl-5-Hydroxytryptamine	-0629992978	0028116508
Odoribacter	N-Methyl- α -aminoisobutyric acid	0763668111	0003843087
Odoribacter	Alloprevotella	0761686425	0003992433
Odoribacter	Christensenellaceae_R-7_group	-0758127143	000427167
Odoribacter	Negativibacillus	-0900498437	648609E-05
Odoribacter	Goblet cell numbers	-0721752599	0008047137
Odoribacter	Butyric acid	-0697619343	0011658884
Odoribacter	Claudin-1	-0676276494	0015749326
Odoribacter	Claudin-4	-0791387387	0002166047
Odoribacter	MUC1	-0935276002	801941E-06
Odoribacter	MUC2	-0762609664	0003922318
Odoribacter	IL-1 β	0791387387	0002166047
Odoribacter	IL-6	0877720556	0000174739
Odoribacter	IL-10	-0964053726	444961E-07
Goblet cell numbers	2,4-Dihydroxy Benzoic Acid	-0771904976	0003267232
Goblet cell numbers	3-aminobenzamide	0726720294	0007422206
Goblet cell numbers	Creatinine	0700169074	0011229204
Goblet cell numbers	Alloprevotella	-0716077225	0008808368
Goblet cell numbers	Christensenellaceae_R-7_group	082542892	0000944898
Goblet cell numbers	Butyric acid	0663165115	0018734875
Goblet cell numbers	Claudin-4	0663102658	0018750019
IgM+ cells density	2,4-Dihydroxy Benzoic Acid	-0634496227	0026677648
Propionic acid	2,4-Dihydroxy Benzoic Acid	-0671819535	0016721729
Propionic acid	N-Acetyl-5-Hydroxytryptamine	0629370629	0028319671
Propionic acid	N-Methyl- α -aminoisobutyric acid	-0627031566	0029092727
Propionic acid	Odoribacter	-0622874413	0030504011
Propionic acid	Claudin-1	0636078143	002618508
Propionic acid	Claudin-4	0650213213	0022071442
Propionic acid	IL-10	0664348283	0018449693
Propionic acid	PIGR	0664348283	0018449693
Butyric acid	3-aminobenzamide	0683016527	0014358724

ZO-1	2,4-Dihydroxy Benzoic Acid	-0724244744	00077289
ZO-1	3-aminobenzamide	0799686905	0001794818
ZO-1	Creatinine	0693537157	0012372047
ZO-1	Hispidol	0848104191	0000490618
	N-Acetyl-5-		
ZO-1	Hydroxytryptamine	0650213213	0022071442
	N-Methyl- α -		
ZO-1	aminoisobutyric acid	-0784598473	0002511128
ZO-1	Ureidoisobutyric Acid	-090530593	510576E-05
ZO-1	Alloprevotella	-0607808004	0036032552
ZO-1	Negativibacillus	0720888563	0008159727
ZO-1	Odoribacter	-0834553971	0000734282
ZO-1	Butyric acid	0777428842	0002919536
ZO-1	Claudin-1	0771428571	0003298628
ZO-1	Claudin-4	0771428571	0003298628
ZO-1	MUC1	0942857143	435756E-06
ZO-1	MUC2	0942857143	435756E-06
ZO-1	TNF- α	-0714285714	0009059463
ZO-1	TLR-4	-0714285714	0009059463
ZO-1	IL-1 β	-0657142857	0020236689
ZO-1	IL-6	-0771428571	0003298628
ZO-1	IL-10	0771428571	0003298628
ZO-1	PIGR	0657142857	0020236689
Claudin-1	2,4-Dihydroxy Benzoic Acid	-0724244744	00077289
Claudin-1	3-aminobenzamide	0844952202	0000540655
Claudin-1	Alloprevotella	-0607808004	0036032552
Claudin-4	2,4-Dihydroxy Benzoic Acid	-0814775337	000124665
Claudin-4	3-aminobenzamide	0829863769	0000837415
Claudin-4	Alloprevotella	-0678483353	0015283555
Claudin-4	Butyric acid	0706753493	0010174007
Claudin-4	Claudin-1	0885714286	0000126369
MUC1	2,4-Dihydroxy Benzoic Acid	-0814775337	000124665
MUC1	3-aminobenzamide	0799686905	0001794818
MUC1	Creatinine	0693537157	0012372047
MUC1	Hispidol	0763293772	0003870969
MUC1	Alloprevotella	-0650213213	0022071442
	Christensenellaceae_R-		
MUC1	7_group	0692618423	0012536906
MUC1	Goblet cell numbers	0606061569	0036716631
MUC1	Butyric acid	0763293772	0003870969
MUC1	Claudin-1	0657142857	0020236689
MUC1	Claudin-4	0714285714	0009059463
MUC1	IL-1 β	-0771428571	0003298628
MUC1	IL-6	-0885714286	0000126369
MUC1	IL-10	0885714286	0000126369

MUC2	2,4-Dihydroxy Benzoic Acid	-0724244744	00077289
MUC2	3-aminobenzamide	0799686905	0001794818
MUC2	Creatinine	0693537157	0012372047
MUC2	Hispidol	0848104191	0000490618
MUC2	Alloprevotella	-0636078143	002618508
MUC2	Butyric acid	0777428842	0002919536
MUC2	Claudin-1	0828571429	0000867706
MUC2	Claudin-4	0885714286	0000126369
MUC2	MUC1	0828571429	0000867706
MUC2	IL-6	-0714285714	0009059463
MUC2	IL-10	0714285714	0009059463
TNF- α	2,4-Dihydroxy Benzoic Acid	090530593	510576E-05
TNF- α	3-aminobenzamide	-0784598473	0002511128
TNF- α	Creatinine	-0772348198	0003238227
TNF- α	Hispidol	-0763293772	0003870969
TNF- α	N-Acetyl-5-Hydroxytryptamine	-0650213213	0022071442
TNF- α	N-Methyl- α -aminoisobutyric acid	0844952202	0000540655
TNF- α	Alloprevotella	0777428842	0002919536
TNF- α	Negativibacillus	-0720888563	0008159727
TNF- α	Odoribacter	0805776248	0001555059
TNF- α	Goblet cell numbers	-0620321841	0031394583
TNF- α	IgM+ cells density	-0749158702	000504085
TNF- α	Butyric acid	-0636078143	002618508
TNF- α	Claudin-4	-0771428571	0003298628
TNF- α	MUC1	-0771428571	0003298628
TNF- α	MUC2	-0771428571	0003298628
TNF- α	TLR-4	1	132832E-79
TNF- α	IL-1 β	0885714286	0000126369
TNF- α	IL-6	0942857143	435756E-06
TNF- α	IL-10	-0771428571	0003298628
TNF- α	PIGR	-0714285714	0009059463
TLR-4	2,4-Dihydroxy Benzoic Acid	090530593	510576E-05
TLR-4	3-aminobenzamide	-0784598473	0002511128
TLR-4	Creatinine	-0772348198	0003238227
TLR-4	Hispidol	-0763293772	0003870969
TLR-4	N-Acetyl-5-Hydroxytryptamine	-0650213213	0022071442
TLR-4	N-Methyl- α -aminoisobutyric acid	0844952202	0000540655
TLR-4	Alloprevotella	0777428842	0002919536
TLR-4	Negativibacillus	-0720888563	0008159727
TLR-4	Odoribacter	0805776248	0001555059
TLR-4	Goblet cell numbers	-0620321841	0031394583
TLR-4	IgM+ cells density	-0749158702	000504085
TLR-4	Butyric acid	-0636078143	002618508

TLR-4	Claudin-4	-0771428571	0003298628
TLR-4	MUC1	-0771428571	0003298628
TLR-4	MUC2	-0771428571	0003298628
TLR-4	IL-1 β	0885714286	0000126369
TLR-4	IL-6	0942857143	435756E-06
TLR-4	IL-10	-0771428571	0003298628
TLR-4	PIGR	-0714285714	0009059463
IL-1 β	2,4-Dihydroxy Benzoic Acid	090530593	510576E-05
IL-1 β	3-aminobenzamide	-0799686905	0001794818
IL-1 β	Creatinine	-0788110406	0002327756
IL-1 β	Hispidol	-0763293772	0003870969
IL-1 β	Alloprevotella	0749158702	000504085
	Christensenellaceae_R-		
IL-1 β	7_group	-0720888563	0008159727
IL-1 β	IgM+ cells density	-0735023632	0006459763
IL-1 β	IL-10	-0771428571	0003298628
IL-6	2,4-Dihydroxy Benzoic Acid	090530593	510576E-05
IL-6	3-aminobenzamide	-0784598473	0002511128
IL-6	Creatinine	-0772348198	0003238227
IL-6	Hispidol	-0763293772	0003870969
IL-6	Alloprevotella	0749158702	000504085
	Christensenellaceae_R-		
IL-6	7_group	-0706753493	0010174007
IL-6	Goblet cell numbers	-0613191705	003398105
IL-6	IgM+ cells density	-0720888563	0008159727
IL-6	Butyric acid	-0636078143	002618508
IL-6	Claudin-4	-0657142857	0020236689
IL-6	IL-1 β	0942857143	435756E-06
IL-6	IL-10	-0828571429	0000867706
IL-10	2,4-Dihydroxy Benzoic Acid	-090530593	510576E-05
IL-10	3-aminobenzamide	0829863769	0000837415
IL-10	Creatinine	0630488325	0027955557
IL-10	Alloprevotella	-0692618423	0012536906
	Christensenellaceae_R-		
IL-10	7_group	0720888563	0008159727
IL-10	Goblet cell numbers	071301361	0009240974
IL-10	Butyric acid	0692618423	0012536906
IL-10	Claudin-1	0714285714	0009059463
IL-10	Claudin-4	0828571429	0000867706
PIGR	2,4-Dihydroxy Benzoic Acid	-090530593	510576E-05
PIGR	3-aminobenzamide	0844952202	0000540655
PIGR	Creatinine	0646250533	0023173494
	N-Acetyl-5-		
PIGR	Hydroxytryptamine	0692618423	0012536906
	N-Methyl- α -		
PIGR	aminoisobutyric acid	-0739333176	0005998881

PIGR	Alloprevotella	-0692618423	0012536906
	Christensenellaceae_R-		
PIGR	7_group	0735023632	0006459763
PIGR	Negativibacillus	093291461	955438E-06
PIGR	Odoribacter	-0877720556	0000174739
PIGR	Goblet cell numbers	0698753338	0011466304
PIGR	Claudin-1	0771428571	0003298628
PIGR	Claudin-4	0771428571	0003298628
PIGR	MUC1	0771428571	0003298628
PIGR	IL-1 β	-0828571429	0000867706
PIGR	IL-6	-0771428571	0003298628
PIGR	IL-10	0942857143	435756E-06

Note: Correlation analysis was performed using Spearman's correlation coefficient to assess associations between variables. Positive values indicate positive correlations, whereas negative values indicate negative correlations. The correlation coefficient represents the strength of the association.