

## Supplementary Information

**Table S1.** Plasma concentrations of all the anionic compounds detected in this experiment. The data were expressed as means  $\pm$  SD. S, Sham; C, Control; K, AST-120 (Kremezin®). P values from Tukey's test were shown for the compounds which were significant by ANOVA with Benjamini-Hochberg correction.

Compound name	Sham ( $\mu$ M) (n=3)	Control ( $\mu$ M) (n=13)	AST-120 ( $\mu$ M) (n=11)	P value (Tukey's multiple comparison procedure)		
				S vs C	S vs K	C vs K
Butanoate	20.00 $\pm$ 5.29	8.18 $\pm$ 2.21	7.33 $\pm$ 1.71	<0.0001	<0.0001	0.6783
4-Pyridoxate	0.23 $\pm$ 0.08	0.87 $\pm$ 0.46	0.17 $\pm$ 0.07	0.0149	0.9571	<0.0001
o-Hydroxybenzoate	3.90 $\pm$ 2.46	7.60 $\pm$ 3.06	2.77 $\pm$ 1.00	0.0562	0.7474	0.0001
4-Oxopentanoate	2.53 $\pm$ 0.40	4.56 $\pm$ 0.76	3.20 $\pm$ 1.03	0.0034	0.4731	0.0021
Allantoate	4.47 $\pm$ 0.29	14.92 $\pm$ 3.55	12.08 $\pm$ 4.19	0.0005	0.0111	0.1661
Citrate	69.33 $\pm$ 24.01	238.46 $\pm$ 67.15	211.64 $\pm$ 52.60	0.0004	0.003	0.515
cis-Aconitate	3.70 $\pm$ 1.31	11.97 $\pm$ 3.20	13.04 $\pm$ 3.66	0.0018	0.0006	0.712
Malonate	4.43 $\pm$ 1.21	6.70 $\pm$ 1.07	7.41 $\pm$ 0.99	0.0069	0.0006	0.2454
Hippurate	16.33 $\pm$ 5.03	41.46 $\pm$ 20.64	16.55 $\pm$ 5.53	0.0403	0.9997	0.0014
Isocitrate	3.27 $\pm$ 0.78	11.87 $\pm$ 3.32	10.44 $\pm$ 3.57	0.0012	0.0075	0.5474
N-Acetylneuraminate	4.03 $\pm$ 0.40	5.78 $\pm$ 1.04	4.58 $\pm$ 0.90	0.0208	0.6503	0.0127
N-Acetylaspartate	0.63 $\pm$ 0.29	2.36 $\pm$ 0.77	2.12 $\pm$ 0.73	0.003	0.012	0.6964
Indoxyl sulfate	7.57 $\pm$ 4.50	25.18 $\pm$ 19.13	5.72 $\pm$ 4.75	0.1403	0.9774	0.0063
Glutarate	10.57 $\pm$ 1.69	26.77 $\pm$ 6.87	26.45 $\pm$ 9.38	0.0092	0.012	0.9946
Saccharate	0.78 $\pm$ 0.00	2.10 $\pm$ 0.74	2.39 $\pm$ 0.85	0.0303	0.0086	0.6204
Isethionate	2.63 $\pm$ 0.25	4.64 $\pm$ 1.82	6.53 $\pm$ 2.47	0.2979	0.0202	0.0839
Homovanillate	2.10 $\pm$ 0.30	6.57 $\pm$ 2.65	5.70 $\pm$ 1.80	0.0112	0.0489	0.6069
Glucuronate+Galacturonate	3.63 $\pm$ 0.85	14.28 $\pm$ 7.09	10.14 $\pm$ 4.17			
3-Phenylpropionate	7.17 $\pm$ 1.80	9.92 $\pm$ 2.26	11.25 $\pm$ 2.19			
Cholate	4.23 $\pm$ 3.44	10.10 $\pm$ 4.91	4.92 $\pm$ 4.99			
5-Oxoproline	40.67 $\pm$ 7.64	53.38 $\pm$ 10.51	46.27 $\pm$ 5.20			
Asp	6.00 $\pm$ 0.35	12.35 $\pm$ 5.06	9.16 $\pm$ 3.12			
Phenaceturate	1.30 $\pm$ 0.00	4.72 $\pm$ 4.32	1.64 $\pm$ 0.69			
2-Hydroxyisobutyrate	6.53 $\pm$ 1.55	14.92 $\pm$ 5.83	13.87 $\pm$ 4.18			
Azelate	0.87 $\pm$ 0.07	1.22 $\pm$ 0.33	0.97 $\pm$ 0.20			
Pantothenate	2.20 $\pm$ 0.20	3.54 $\pm$ 1.10	2.76 $\pm$ 0.83			
2-Hydroxy-4-methylpentanoate	0.56 $\pm$ 0.00	2.84 $\pm$ 2.29	3.71 $\pm$ 1.94			
Malate	16.67 $\pm$ 5.86	29.92 $\pm$ 9.66	28.55 $\pm$ 8.72			
N-Acetylglutamate	0.43 $\pm$ 0.00	0.75 $\pm$ 0.25	0.67 $\pm$ 0.21			
Glucuronate	8.40 $\pm$ 2.29	16.54 $\pm$ 5.01	16.85 $\pm$ 7.32			
2-Oxoisopentanoate	14.67 $\pm$ 1.53	10.05 $\pm$ 4.00	10.24 $\pm$ 2.41			
Pimelate	0.93 $\pm$ 0.04	1.78 $\pm$ 0.59	1.70 $\pm$ 0.64			
Benzoate	54.67 $\pm$ 19.66	38.85 $\pm$ 9.86	41.45 $\pm$ 11.99			
Fumarate	3.50 $\pm$ 1.05	6.02 $\pm$ 2.16	5.63 $\pm$ 1.75			
3-Hydroxybutyrate	242.00 $\pm$ 23.52	318.00 $\pm$ 116.97	250.00 $\pm$ 51.66			
Threonate	14.67 $\pm$ 1.15	13.31 $\pm$ 1.97	15.54 $\pm$ 3.58			
2-Hydroxybutyrate	8.13 $\pm$ 2.53	5.16 $\pm$ 1.18	6.98 $\pm$ 4.05			
3-Phenylactate	1.70 $\pm$ 0.00	5.05 $\pm$ 4.20	3.22 $\pm$ 1.37			
2-Hydroxypentanoate	18.67 $\pm$ 4.16	41.62 $\pm$ 22.44	43.36 $\pm$ 18.63			
Glycerate	29.33 $\pm$ 11.55	42.00 $\pm$ 12.75	37.91 $\pm$ 7.80			
Hexanoate	3.20 $\pm$ 0.53	3.05 $\pm$ 0.76	2.66 $\pm$ 0.46			
Ru5P	1.20 $\pm$ 0.00	2.40 $\pm$ 1.78	1.66 $\pm$ 0.83			
Glycerophosphate	1.60 $\pm$ 0.00	2.35 $\pm$ 0.69	2.69 $\pm$ 1.38			
3-Methylbutanoate	5.67 $\pm$ 0.98	5.38 $\pm$ 0.44	5.21 $\pm$ 0.22			
Adipate	1.13 $\pm$ 0.15	1.54 $\pm$ 0.47	1.49 $\pm$ 0.41			
Laurate	5.37 $\pm$ 0.81	6.44 $\pm$ 1.43	5.97 $\pm$ 1.23			
Succinate	16.33 $\pm$ 4.51	18.85 $\pm$ 4.95	19.64 $\pm$ 3.64			
Pelargonate	2.93 $\pm$ 0.21	3.29 $\pm$ 0.58	3.14 $\pm$ 0.51			
Cysteine S-sulfate	2.07 $\pm$ 0.25	3.16 $\pm$ 2.25	2.49 $\pm$ 1.44			
4-Methyl-2-oxopentanoate	34.00 $\pm$ 6.08	25.69 $\pm$ 16.12	25.45 $\pm$ 7.05			
2-Oxoglutarate	26.33 $\pm$ 8.14	35.92 $\pm$ 19.68	31.91 $\pm$ 8.90			
Glycolate	28.00 $\pm$ 1.73	27.54 $\pm$ 2.54	25.82 $\pm$ 6.65			
Octanoate	1.83 $\pm$ 0.51	2.05 $\pm$ 0.52	1.90 $\pm$ 0.31			
Citraconate	0.22 $\pm$ 0.00	0.26 $\pm$ 0.10	0.33 $\pm$ 0.30			
Sebacate	0.23 $\pm$ 0.05	0.26 $\pm$ 0.07	0.26 $\pm$ 0.05			
trans-Aconitate	2.86 $\pm$ 2.98	2.59 $\pm$ 1.34	3.06 $\pm$ 1.23			
4-Acetylbutyrate	0.90 $\pm$ 0.87	1.26 $\pm$ 0.82	1.27 $\pm$ 0.70			
Lactate	2632.33 $\pm$ 639.88	2864.15 $\pm$ 1463.17	2526.82 $\pm$ 535.87			
Citramalate	0.62 $\pm$ 0.28	0.59 $\pm$ 0.25	0.67 $\pm$ 0.33			
Propionate	14.33 $\pm$ 10.10	13.73 $\pm$ 5.34	12.80 $\pm$ 5.67			
Pyruvate	99.00 $\pm$ 26.15	107.54 $\pm$ 67.44	103.27 $\pm$ 30.30			

**Table S2.** Plasma concentrations of all the cationic compounds detected in this experiment. The data were expressed as means  $\pm$  SD. S, Sham; C, Control; K, AST-120 (Kremezin®). P values from Tukey's test were shown for the compounds which were significant by ANOVA with Benjamini-Hochberg correction.

Compound name	Sham ( $\mu$ M) (n=3)		Control ( $\mu$ M) (n=13)		AST-120 ( $\mu$ M) (n=11)		P value (Tukey's multiple comparison procedure)		
	Mean	SD	Mean	SD	Mean	SD	S vs C	S vs K	C vs K
Gly	202.33	± 23.63	317.08	± 50.97	248.73	± 27.08	0.0005	0.2068	0.0011
Allantoin	141.33	± 44.16	426.54	± 101.43	316.55	± 83.39	0.0001	0.0176	0.0179
N,N-Dimethylglycine	7.20	± 0.17	16.54	± 3.04	15.45	± 3.08	0.0001	0.0007	0.6436
Trp	94.00	± 12.49	53.92	± 11.87	74.91	± 17.44	0.0007	0.1286	0.0047
Cytosine	0.69	± 0.09	2.17	± 1.15	0.63	± 0.22	0.0259	0.9927	0.0004
gamma-Guanidinobutyrate	0.90	± 0.21	2.95	± 1.02	1.75	± 0.51	0.0015	0.2563	0.0033
Trimethylamine N-oxide	4.77	± 1.37	12.11	± 5.33	19.82	± 7.05	0.1507	0.0019	0.0109
5-Methylcytosine	0.23	± 0.00	0.40	± 0.15	0.23	± 0.00	0.0373	1	0.0011
Gln	478.33	± 57.50	536.08	± 49.51	460.55	± 29.34	0.1131	0.8034	0.0007
Glycerophosphorylcholine	13.33	± 0.58	16.23	± 2.49	11.96	± 2.56	0.1697	0.6649	0.0007
Hydroxyproline	31.33	± 2.89	49.23	± 6.13	45.27	± 7.28	0.0006	0.0078	0.3092
N-gamma-Ethylglutamine	2.93	± 0.50	5.33	± 1.19	4.20	± 0.79	0.0026	0.1443	0.0271
1-Methylnicotinamide	0.45	± 0.08	0.42	± 0.24	0.15	± 0.02	0.9691	0.036	0.0022
Creatine	163.00	± 47.15	142.00	± 46.51	90.09	± 15.69	0.6541	0.0156	0.0061
Homoarginine ; N6,N6,N6-Trimethyllysine	1.20	± 0.10	2.64	± 0.58	3.03	± 0.91	0.012	0.0018	0.3955
Citrulline	57.67	± 18.15	176.15	± 40.80	169.55	± 59.99	0.0024	0.0046	0.9412
Nicotinamide	1.35	± 0.53	1.53	± 0.37	0.99	± 0.25	0.6886	0.2646	0.0022
SDMA	0.46	± 0.08	0.80	± 0.12	0.82	± 0.19	0.004	0.003	0.9565
ADMA	0.18	± 0.01	0.44	± 0.07	0.45	± 0.16	0.005	0.0042	0.978
Anthranilate	0.17	± 0.00	4.15	± 3.54	0.50	± 1.09	0.0627	0.9793	0.0061
Ala	331.00	± 43.31	499.54	± 75.89	462.45	± 70.42	0.0032	0.0245	0.4268
gamma-Butyrobetaine	2.03	± 0.40	1.83	± 0.43	1.41	± 0.19	0.6436	0.0298	0.0189
Dihydroouracil	368.33	± 16.17	765.23	± 338.80	417.73	± 194.78	0.0766	0.9577	0.0121
Imidazole-4-acetate	1.70	± 0.17	3.89	± 1.80	2.39	± 0.44	0.0382	0.6986	0.0254
GABA	1.07	± 0.14	0.81	± 0.13	0.71	± 0.21	0.0515	0.0081	0.3724
Creatinine	25.00	± 1.73	74.31	± 20.74	73.09	± 30.70	0.0124	0.0167	0.992
Glu	74.33	± 7.64	108.31	± 20.86	84.45	± 24.09	0.0539	0.7535	0.0322
Asn	41.33	± 6.43	51.31	± 8.13	43.00	± 5.88	0.0947	0.9317	0.0236
Thr	196.00	± 47.15	262.15	± 45.14	222.36	± 30.38			
Spermidine	0.10	± 0.00	0.28	± 0.15	0.16	± 0.07			
5-Methyl-2'-deoxycytidine	0.87	± 0.14	1.23	± 0.23	1.14	± 0.13			
3-Methylhistidine	19.33	± 3.21	42.69	± 6.34	45.27	± 19.81			
1-Methyladenosine	0.27	± 0.10	0.16	± 0.07	0.15	± 0.05			
alpha-Aminoadipate	1.43	± 0.15	2.37	± 0.56	2.26	± 0.49			
Pipecolate	3.23	± 1.10	11.92	± 2.94	13.54	± 8.00			
Pro	187.00	± 38.57	236.15	± 37.96	241.91	± 21.09			
4-(beta-Acetylaminoethyl)imidazole	0.22	± 0.12	0.18	± 0.09	0.12	± 0.05			
N-Acetylglucosamine	4.77	± 0.15	6.72	± 1.13	6.08	± 1.52			
Glucosamine	0.61	± 0.04	0.59	± 0.18	0.41	± 0.24			
Taurine	145.00	± 57.58	276.69	± 88.64	248.82	± 87.64			
Lys	343.00	± 38.31	466.92	± 101.17	457.64	± 64.52			
Tyramine	0.20	± 0.08	0.43	± 0.18	0.44	± 0.17			
Asp	7.50	± 1.00	14.35	± 4.92	12.01	± 5.34			
Triethanolamine	1.97	± 0.29	3.88	± 1.30	3.92	± 1.75			
Gly-Leu	0.40	± 0.00	0.73	± 0.31	0.59	± 0.23			
Putrescine(1,4-Butanediamine)	0.68	± 0.07	0.58	± 0.21	0.48	± 0.11			
Glutathione(ox); Glutathione(ox) divalent	0.55	± 0.00	1.34	± 0.88	0.91	± 0.59			
5-Hydroxylysine	1.47	± 0.15	1.65	± 0.62	2.04	± 0.55			
Cystathionine	1.20	± 0.00	1.86	± 0.55	1.72	± 0.58			
Sarcosine	6.17	± 0.90	7.95	± 1.87	8.07	± 1.26			
o-Acetylcarnitine	8.13	± 1.35	8.74	± 2.59	7.03	± 1.91			
Cytidine	3.13	± 0.68	3.88	± 1.03	3.29	± 0.80			
Betonicine	0.37	± 0.09	0.56	± 0.18	0.49	± 0.16			
Phe	58.67	± 4.04	63.77	± 10.69	68.00	± 6.74			
Guanidoacetate	5.47	± 0.95	5.68	± 1.33	4.88	± 0.85			
beta-Ala	3.27	± 0.31	2.91	± 0.45	2.75	± 0.49			
7-Methylguanine	0.17	± 0.00	0.28	± 0.11	0.26	± 0.10			
Hypotaurine	3.80	± 0.72	3.75	± 0.88	3.28	± 0.49			
N-epsilon-Acetyllysine	0.79	± 0.13	1.02	± 0.31	1.04	± 0.13			
Ectoine	1.50	± 0.40	4.55	± 3.77	4.09	± 1.49			
Azetidine-2-carboxylate	0.61	± 0.00	0.85	± 0.25	0.86	± 0.26			
Kynurenine	1.30	± 0.20	1.64	± 0.35	1.66	± 0.39			
Arg	137.00	± 23.64	275.85	± 164.02	255.09	± 119.46			
Ser	163.00	± 30.32	183.23	± 32.17	164.82	± 34.44			
Guanidinosuccinate	0.39	± 0.23	0.54	± 0.23	0.71	± 0.56			
Ornithine	52.00	± 21.93	75.54	± 17.28	71.55	± 36.26			
Anserine	1.62	± 0.96	1.08	± 0.78	1.77	± 1.81			
2'-Deoxycytidine	23.33	± 4.04	20.69	± 3.66	20.55	± 3.01			
Carnitine	64.33	± 8.39	56.00	± 12.48	59.73	± 10.18			
Betaine	144.00	± 44.54	124.46	± 23.10	134.82	± 29.16			
Met	48.33	± 5.51	59.85	± 21.20	63.27	± 16.86			
Val	167.67	± 23.44	153.69	± 22.79	163.64	± 27.19			
Leu	136.00	± 20.88	133.00	± 33.29	147.18	± 29.31			
Carnosine; Carnosine divalent	0.36	± 0.06	0.37	± 0.17	0.44	± 0.22			
Methionine sulfoxide	7.23	± 1.42	8.03	± 1.87	7.51	± 0.81			
Uridine	16.00	± 0.00	22.46	± 11.00	23.36	± 12.32			
His	64.33	± 5.51	69.92	± 10.28	68.36	± 8.04			
Urocanate	0.99	± 0.53	2.11	± 2.00	4.96	± 12.01			
2AB; 2-Aminobutyrate	4.97	± 0.61	4.90	± 1.02	4.59	± 0.75			
Thiamine	8.23	± 1.53	9.77	± 4.36	8.63	± 2.92			
Cysteine-glutathione disulphide	0.89	± 0.28	1.40	± 1.12	1.22	± 0.92			
5-Oxoproline	27.00	± 1.73	33.85	± 8.21	31.55	± 19.79			
Tyr	40.67	± 4.04	46.15	± 13.92	45.09	± 9.21			
Histamine	0.28	± 0.10	0.35	± 0.30	0.30	± 0.10			
Ile	68.33	± 9.50	67.54	± 11.84	69.45	± 13.44			