Supporting Information

Zinc bioavailability from phytate rich foods and zinc supplements. Modelling the effects of food components with oxygen, nitrogen and sulfur donor ligands

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Figure Captions:

Figure S1 Optimized 1:1 binding structures of zinc/cysteine, zinc/cystine, zinc/N-acetyl-cysteine, zinc/glutathione, zinc/histidine, zinc/N-acetyl-histidine and zinc/carnosine complexes calculated by DFT/B3LYP/6-31G(d, p) and LanL2DZ mixed basis set combined with integral equation formalism polarizable continuum model (IEFPCM).

Figure S2 Isothermal titration calorimetry data of competitive binding of zinc between citrate and cysteine, histidine and BSA, respectively. Observed titration curves of titrating cysteine (A), histidine (B) and BSA (C) to zinc citrate. Integration of the thermogram yielded competitive binding isotherm graphs of cysteine (D), histidine (E) and BSA (F). Red lines represent the model fitting for obtaining the thermodynamic parameters.

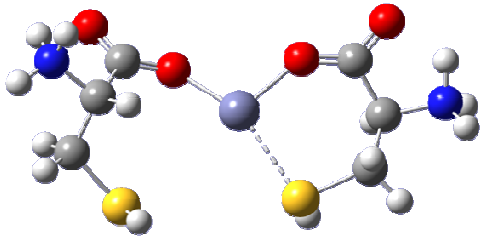
Figure S3 Optimized structures of zinc citrate ternary complexes calculated by DFT/B3LYP/6-31G(d, p) and LanL2DZ mixed basis set combined with integral equation formalism polarizable continuum model (IEFPCM).

Figure S4 Optimized structures of zinc phytate ternary complexes calculated by DFT/B3LYP/6-31G(d, p) and LanL2DZ mixed basis set combined with integral equation formalism polarizable continuum model (IEFPCM).

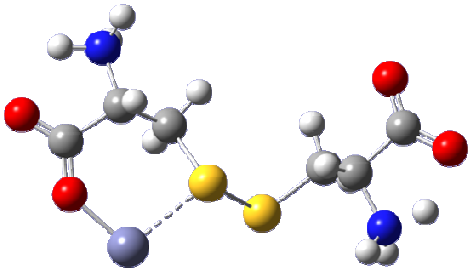
Table S1 Atoms Involved in Zinc Binding, Bond length Between the Binding Atoms and Zinc Ion and Binding Enthalpy of Zinc Complexes at Their Optimized Structures Using DFT/B3LYP/6-31G(d, p) and LanL2DZ Mixed Basis Set. Thermodynamic Parameters (Binding Constant, Stoichiometry, ΔH, ΔS and ΔG) of Zinc Complex Formation at 298 K and Relative Driving Force, ΔGrel, for Forming Zinc Complex.

Ligand	Atoms	Bond length (Å)	$\Delta H_{binding}$ (kJ/mol)	Binding constant	n	ΔH (kJ/mol)	ΔS (J/mol K)	ΔG (kJ/mol)	ΔG_{rel}
Cysteine[1]	Zn_{15}-O_7	1.99	-169.6	6.5×10^4	2.2	-32.9	-18.0	-27.5	1.3
	Zn_{15}-S_{13}	2.60							
	Zn_{15}-O_{23}	1.96							
Cystine[1]	Zn_{27}-O_7	1.88	-183.4	3.1×10^4	1.4	-6.6	63.9	-25.6	1.4
	Zn_{27}-S_{12}	2.44							
N-acetyl-cysteine	Zn_{17}-O_6	1.97	-251.5	$(3.2 \pm 0.2)\times10^3$	0.4 ± 0.02	-32.6 ± 3.0	-42.2	-20	1.9
	Zn_{17}-S_{20}	2.70							
	Zn_{17}-O_{21}	1.97							
Glutathione[1]	Zn_{37}-O_{10}	2.10	-145.3	4.3×10^3	1.1	-16.9	13.0	-20.7	1.1
	Zn_{37}-O_{11}	2.13							
	Zn_{37}-S_{35}	2.61							
Histidine[1]	Zn_{21}-N_8	2.09	-135.3	6.4×10^3	1.6	-21.0	2.5	-21.7	1
	Zn_{21}-O_{18}	1.99							
N-acetyl-histidine	Zn_{25}-N_8	2.06	-204.0	$(3.6 \pm 3.6)\times10^3$	0.6 ± 0.3	-2.0 ± 14.9	61.4	-20.3	1.5
	Zn_{25}-O_{18}	1.95							
Carnosine[2]	Zn_{31}-N_7	2.05	-227.3	7.2×10^3	-	-	-	-	1.7

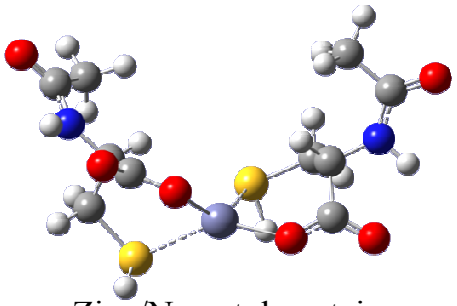
	Zn_{31}-O_{15}	1.94							
Bovine serum albumin[1]	-	-	-	2.3×10^{5}	1.2	-29.5	-15.4	-24.9	-



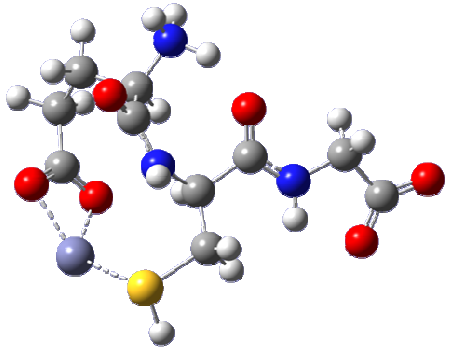
Zinc/Cysteine



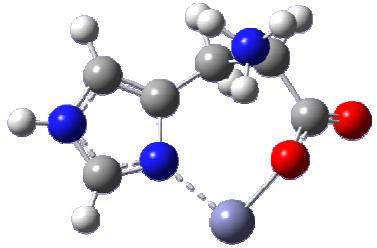
Zinc/Cystine



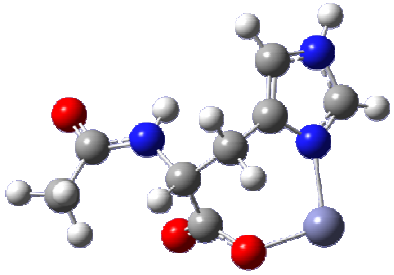
Zinc/N-acetyl-cysteine



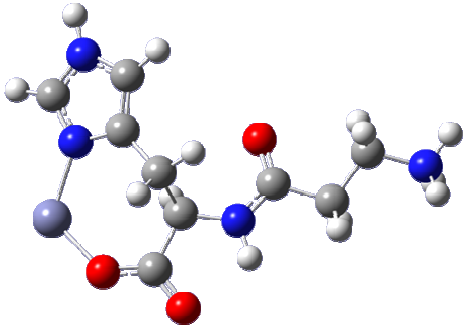
Zinc/Glutathione



Zinc/Histidine



Zinc/N-acetyl-histidine



Zinc/Carnosine

Figure S1

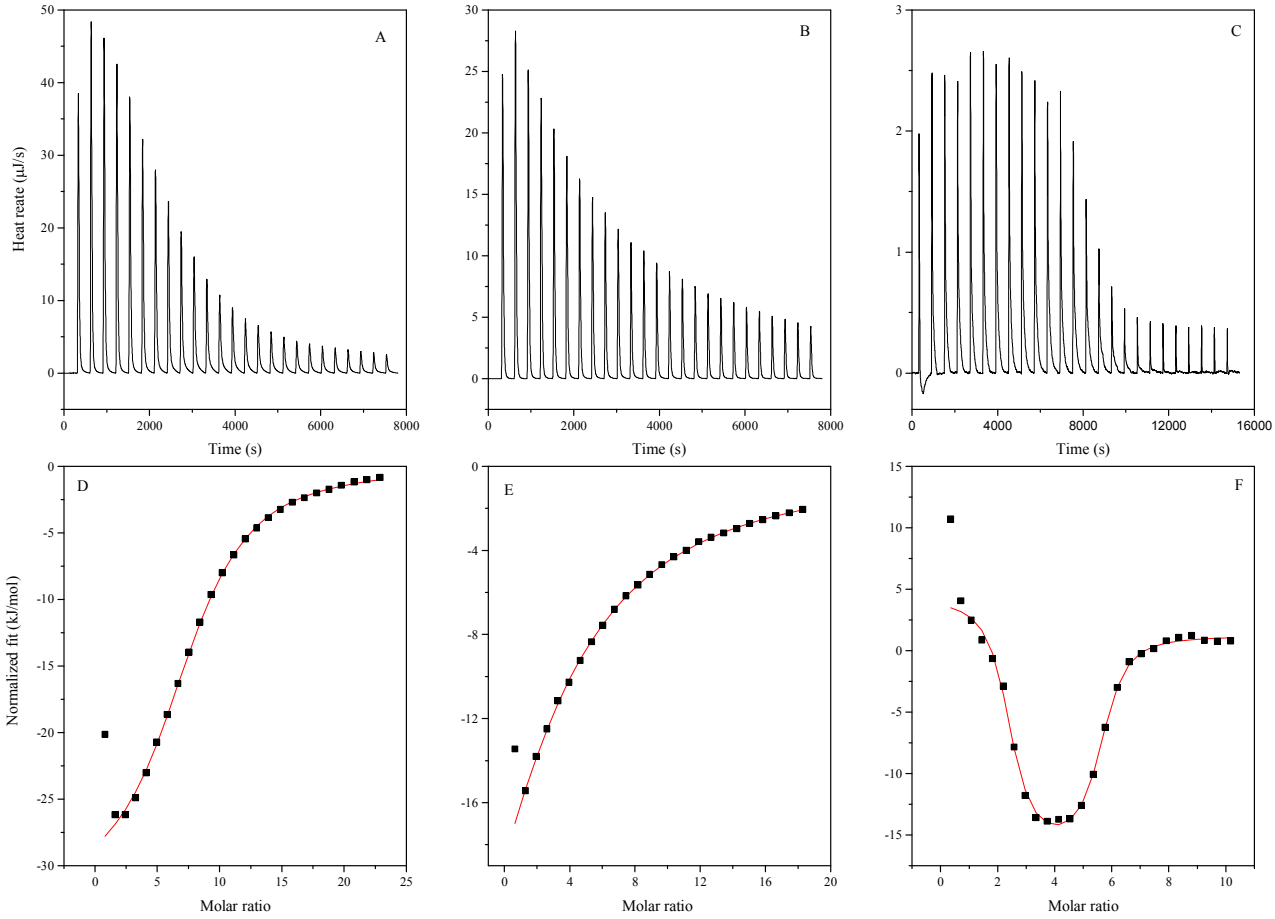
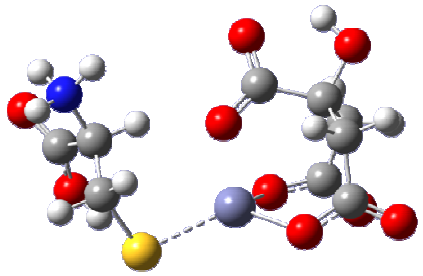
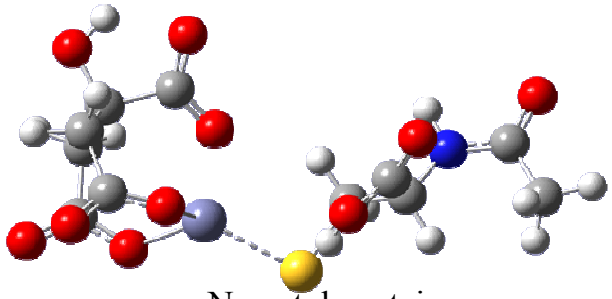

A
B
C
D
E
F
Heat reate (μJ/s)
Time (s)
Time (s)
Time (s)
Normalized fit (kJ/mol)
Molar ratio
Molar ratio
Molar ratio

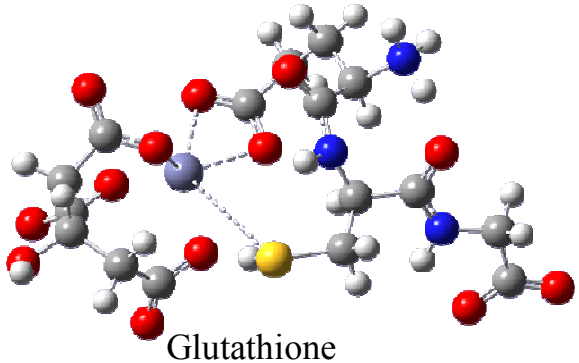
Figure S2



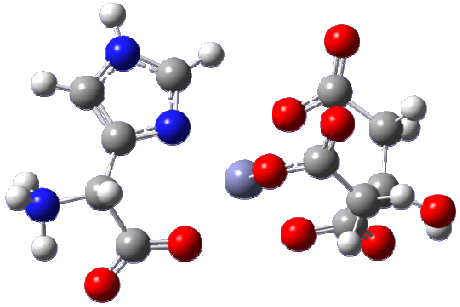
Cysteine



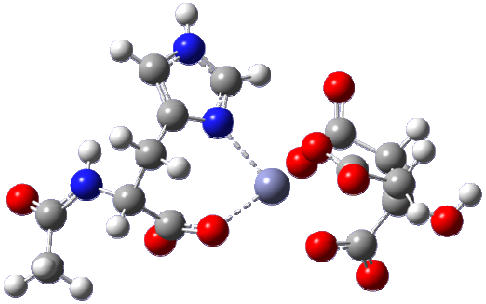
N-acetyl-cysteine



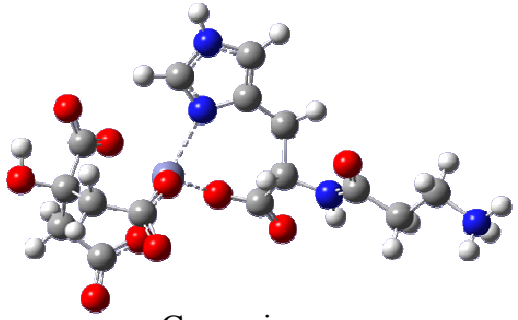
Glutathione



Histidine



N-acetyl-histidine



Carnosine

Figure S3

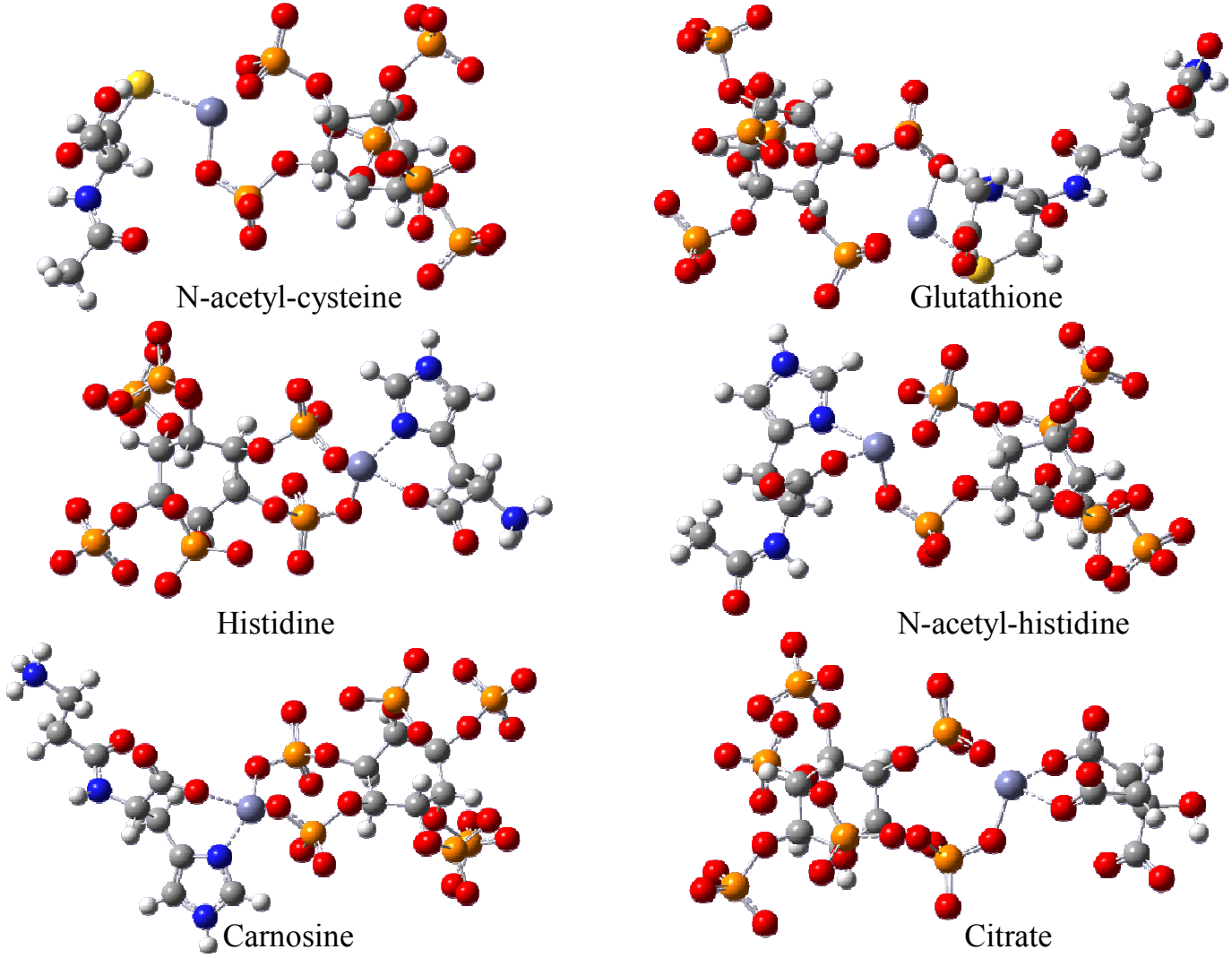

N-acetyl-cysteine
Glutathione
Histidine
N-acetyl-histidine
Carnosine
Citrate

Figure S4

References

(1) Tang, N.; Skibsted, L. H. Zinc bioavailability from whey. Enthalpy-entropy compensation in protein binding. *Food Res. Int.* **2016,** *89*, 749-755.

(2) Agarwal, R. P.; Perrin, D. D. Stability constants of complexes of zinc and cobalt (II) ions with some histidine-containing peptides. *J. Chem. Soc. Dalton Trans.* **1975**, 1045-1048.