Supplementary Information

Influence of Simulated Gastrointestinal Digestion on Phenolic Composition, Bioaccessibility, and Antioxidant Properties of Commercial Wild Rice

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Figure S1. Principal component analysis (PCA) score plot with 95% confidence ellipses for wild rice samples by processing and digestion phase.

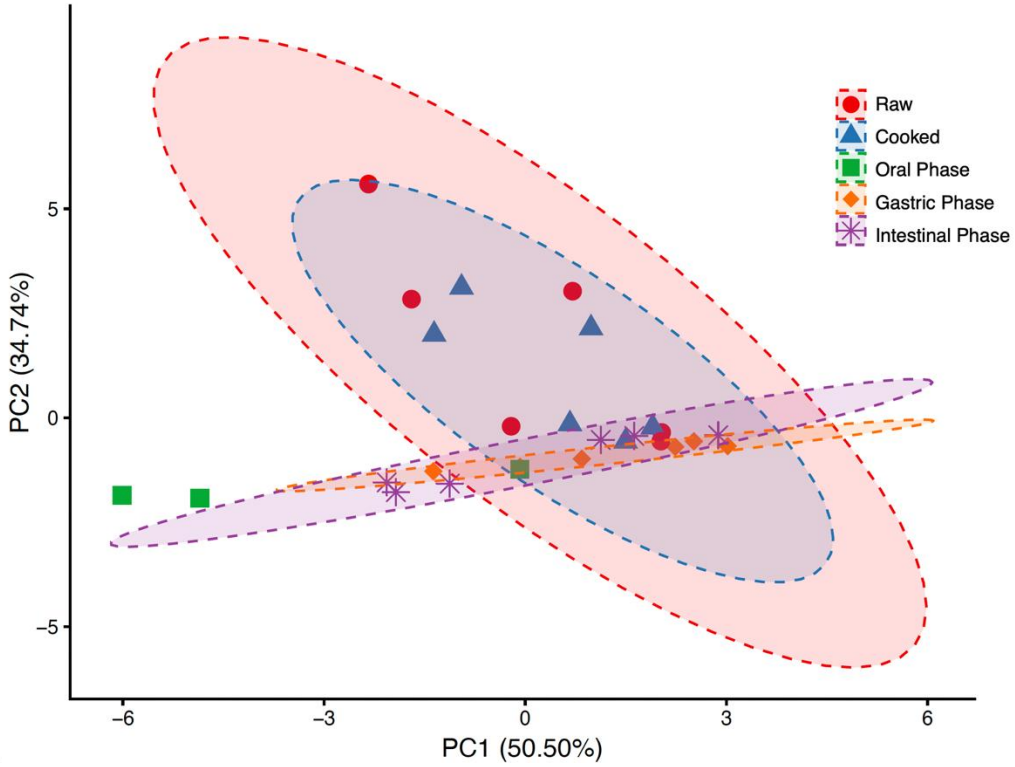

Table S1. PCA Sample Scores

Sample	PC1	PC2	Label
EG_Raw_Free	-2.33636161	5.593642999	Raw
EG_Raw_Bound	-0.209952729	-0.203869497	Raw
EG_Cooked_Free	-0.949411476	3.121395002	Cooked
EG_Cooked_Bound	0.666800457	-0.148639292	Cooked
EG_Oral_Bound	-4.850769266	-1.926659059	Oral
EG_Gastric_Free	2.237037309	-0.695945274	Gastric
EG_Gastric_Bound	-0.076574816	-1.174562315	Gastric
EG_Intestinal_Free	1.126837682	-0.529624743	Intestinal
EG_Intestinal_Bound	-1.928662878	-1.779663255	Intestinal
SY_Raw_Free	0.706531017	3.029554733	Raw
SY_Raw_Bound	2.034591705	-0.351006691	Raw
SY_Cooked_Free	0.981330163	2.147258571	Cooked
SY_Cooked_Bound	1.901155945	-0.226561476	Cooked
SY_Oral_Bound	-0.079834012	-1.230833364	Oral
SY_Gastric_Free	3.019684127	-0.678158373	Gastric
SY_Gastric_Bound	0.844338122	-0.982172156	Gastric
SY_Intestinal_Free	2.878120826	-0.417201694	Intestinal
SY_Intestinal_Bound	-1.125367907	-1.575367294	Intestinal
FL_Raw_Free	-1.695524666	2.839110597	Raw
FL_Raw_Bound	2.021644295	-0.560242644	Raw
FL_Cooked_Free	-1.358450783	1.993719006	Cooked
FL_Cooked_Bound	1.497252942	-0.56537307	Cooked
FL_Oral_Bound	-6.012321904	-1.855647911	Oral
FL_Gastric_Free	2.515211365	-0.562563239	Gastric
FL_Gastric_Bound	-1.369750647	-1.280248005	Gastric
FL_Intestinal_Free	1.626687466	-0.434559408	Intestinal
FL_Intestinal_Bound	-2.064240726	-1.54578215	Intestinal

Principal component scores (PC1 and PC2) for each wild rice (WR) sample, with sample labels indicating variety, state, and fraction.

Table S2. PCA Variable Loadings

Variable	PC1	PC2
DPPH	-0.112477325	0.939179288
ABTS	-0.169245592	0.962970337
TPC	-0.727922954	0.618699361
Ferulic acid	-0.5759522	-0.51915108
Gallic acid	-0.312349292	0.877086977
Sinapic acid	-0.842552484	-0.376477213
Vanillic acid	-0.927210821	-0.242666632
p-coumaric	-0.950186314	-0.001078487
p-Hydroxybenzoic acid	-0.894411202	0.032006212
Caffeic acid	-0.881298813	-0.203482208

Loadings represent the correlation coefficients between each measured variable and the principal components PC1 and PC2.

Table S3. Contribution of Variables to Principal Components

Contribution of Variables	PC1	PC2
DPPH	0.002505387	0.25390185
ABTS	0.005672568	0.266928331
TPC	0.10493389	0.110186449
Ferulic acid	0.065692808	0.077581179
Gallic acid	0.01932084	0.221439033
Sinapic acid	0.140584962	0.040798692
Vanillic acid	0.170255804	0.016950752
p-coumaric	0.178797929	3.3481E-07
p-Hydroxybenzoic acid	0.158423426	0.000294875
Caffeic acid	0.153812387	0.011918504

Contribution values indicate the proportion of each variable's influence on the variance explained by PC1 and PC2.

Table S4. PERMANOVA results for statistical validation of group separation in PCA space.

Source	Df	Sum Sq	R^2	F	P (perm)
State/Digestion phase	4	94.096	0.425	4.06	0.003**
Residual	22	127.518	0.575		
Total	26	221.613	1.000		

*Df = degrees of freedom; Sum Sq = sum of squares; R^2 = proportion of total variance explained; F = pseudo-F by permutation; P (perm) = permutation p-value (999 permutations). PERMANOVA results based on testing for group separation by processing/digestion phase (Label: Raw, Cooked, Oral, Gastric, Intestinal). Significance codes: ***p < 0.001; **p < 0.01; *p < 0.05.

Table S5. Normality Tests for Phenolic compounds, TPC, and Antioxidant Activities

Shapiro-Wilk test	DPPH	ABTS	TPC	Ferulic acid	Gallic acid	Sinapic acid	Vanillic acid	p-coumaric	p-Hydroxybenzoic acid	Caffeic acid
W	0.89	0.88	0.98	0.93	0.94	0.83	0.83	0.9	0.92	0.86
P value	0.149	0.116	0.9842	0.4037	0.5058	0.0332	0.0313	0.197	0.3961	0.0872
Passed normality test (alpha=0.05)?	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
P value summary	ns	ns	ns	ns	ns	*	*	ns	ns	ns

Anderson-Darling test	DPPH	ABTS	TPC	Ferulic acid	Gallic acid	Sinapic acid	Vanillic acid	p-coumaric	p-Hydroxybenzoic acid	Caffeic acid
A2	0.51	0.55	0.18	0.34	0.31	0.76	0.82	0.47	0.36	0.61
P value	0.1483	0.1176	0.8828	0.4262	0.4955	0.0307	0.0217	0.1895	0.373	0.0829
Passed normality test (alpha=0.05)?	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
P value summary	ns	ns	ns	ns	ns	*	*	ns	ns	ns

ns, not significant ($p \geq 0.05$); *, $p < 0.05$. W, Shapiro–Wilk test statistic; A2, Anderson–Darling test statistic. Normality was assessed using the Shapiro–Wilk and Anderson-Darling tests ($\alpha = 0.05$). Variables with $p \geq 0.05$ are considered to have passed the normality test, indicating no significant deviation from normality; $p < 0.05$ indicates failure of the normality test.

Table S6. Pearson Correlation Coefficients Among Phenolic Compounds, TPC, and Antioxidant Activities

Pair	r	Raw p-value	FDR-adjusted p-value	Significance
DPPH vs ABTS	0.98	2.49×10^{-19}	1.12×10^{-17}	***
DPPH vs TPC	0.64	2.90×10^{-4}	0.0087	*
DPPH vs Ferulic acid	-0.37	0.0592	0.11	
DPPH vs Gallic acid	0.75	6.41×10^{-6}	0.00029	***
DPPH vs Sinapic acid	-0.21	0.2979	0.38	
DPPH vs Vanillic acid	-0.13	0.518	0.65	
DPPH vs p-coumaric	0.12	0.5562	0.63	
DPPH vs p-Hydroxybenzoic acid	0.07	0.7256	0.81	
DPPH vs Caffeic acid	-0.09	0.6439	0.79	
ABTS vs TPC	0.72	2.32×10^{-5}	0.00074	***
ABTS vs Ferulic acid	-0.33	0.0943	0.17	
ABTS vs Gallic acid	0.84	5.08×10^{-8}	0.0000023	***
ABTS vs Sinapic acid	-0.21	0.3031	0.37	
ABTS vs Vanillic acid	-0.06	0.7571	0.82	
ABTS vs p-coumaric	0.16	0.4178	0.51	
ABTS vs p-Hydroxybenzoic acid	0.13	0.5192	0.62	
ABTS vs Caffeic acid	-0.07	0.734	0.81	
TPC vs Ferulic acid	0.19	0.3392	0.42	
TPC vs Gallic acid	0.79	1.16×10^{-6}	0.000036	***
TPC vs Sinapic acid	0.38	0.0519	0.1	
TPC vs Vanillic acid	0.55	0.00326	0.029	*
TPC vs p-coumaric	0.64	0.00037	0.0091	*
TPC vs p-Hydroxybenzoic acid	0.59	0.00108	0.022	*
TPC vs Caffeic acid	0.50	0.00826	0.049	*
Ferulic acid vs Gallic acid	-0.28	0.1509	0.24	
Ferulic acid vs Sinapic acid	0.61	0.0008	0.022	*
Ferulic acid vs Vanillic acid	0.76	4.31×10^{-6}	0.00014	***
Ferulic acid vs p-coumaric	0.52	0.00511	0.039	*
Ferulic acid vs p-Hydroxybenzoic acid	0.32	0.1084	0.17	
Ferulic acid vs Caffeic acid	0.44	0.0232	0.055	
Gallic acid vs Sinapic acid	-0.13	0.5024	0.65	
Gallic acid vs Vanillic acid	0.10	0.624	0.73	
Gallic acid vs p-coumaric	0.29	0.1453	0.23	
Gallic acid vs p-Hydroxybenzoic acid	0.36	0.0681	0.13	
Gallic acid vs Caffeic acid	0.07	0.737	0.81	
Sinapic acid vs Vanillic acid	0.80	6.87×10^{-7}	0.000023	***
Sinapic acid vs p-coumaric	0.80	5.88×10^{-7}	0.000022	***

Sinapic acid vs p-Hydroxybenzoic acid	0.74	1.00×10^{-5}	0.00028	***
Sinapic acid vs Caffeic acid	0.83	1.08×10^{7}	0.0000049	***
Vanillic acid vs p-coumaric	0.86	9.92×10^{-9}	0.00000044	***
Vanillic acid vs p-Hydroxybenzoic acid	0.76	3.36×10^{6}	0.00012	***
Vanillic acid vs Caffeic acid	0.84	3.23×10^{-8}	0.0000016	***
p-coumaric vs p-Hydroxybenzoic acid	0.87	3.79×10^{-9}	0.00000017	***
p-coumaric vs Caffeic acid	0.80	5.15×10^{-7}	0.000018	***
p-Hydroxybenzoic acid vs Caffeic acid	0.80	5.07×10^{-7}	0.000019	***

Pearson correlation coefficients (r), raw p-values, and Benjamini–Hochberg FDR-adjusted p-values are shown for each pairwise comparison. Significance is indicated as follows: $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***), based on FDR-adjusted p-values.