Supplementary Table S1. Cell viability of RAW 264.7 macrophages following treatment with *L. japonica* extracts (MTT assay, 200 μg/mL)

Treatment[1)]	Cell viability (%)
LPS[2)] control	98.70 ± 0.46[3)a4)]
Control	97.97 ± 0.65[ab]
Visco	96.47 ± 0.71[b]
W. confusa FO-L5	96.40 ± 0.95[b]
Leu. citreum FO-L9	95.03 ± 1.03[c]
P. acidilactici FO-L10	93.97 ± 1.91[cd]
FO-L5+FO-L10 (FO-MIX)	92.67 ±1.31[d]

[1)]All treatment groups maintained cell viability above 90%, indicating no apparent cytotoxicity at the tested concentrations.
[2)]LPS, lipopolysaccharide from *Escherichia coli* O111:B4 (1 μg/mL).
[3)]Values are expressed as mean ± SD (n = 3).
[4)]Different lowercase letters indicate significant differences among treatments ($p < 0.05$).

Supplementary Table S2. PCA loading matrix of bioactive compounds, enzyme activities, and antioxidant and anti-inflammatory parameters[1)]

Variable	PC1[2)]	PC2[3)]
TPC	0.949	0.197
Phlorotannin	0.965	0.077
AE-FCP[4)]	0.983	0.096
β-Glucosidase	0.976	0.114
Tannase	0.947	0.131
Protease	0.962	−0.112
DPPH	0.971	0.202
ABTS	0.980	0.145
FRAP	0.969	0.194
NO inhibition	0.910	−0.333
IL-6	−0.908	0.374
TNF-α	−0.894	0.410

[1)]PC1 (first principal component) and PC2 (second principal component) were derived from the PCA of 12 standardized variables (n = 18 biological replicates). Loading represents the correlations between the variables and principal components.

[2)]PC1 was the only component that met the Kaiser criterion (eigenvalue ≥ 1.0).

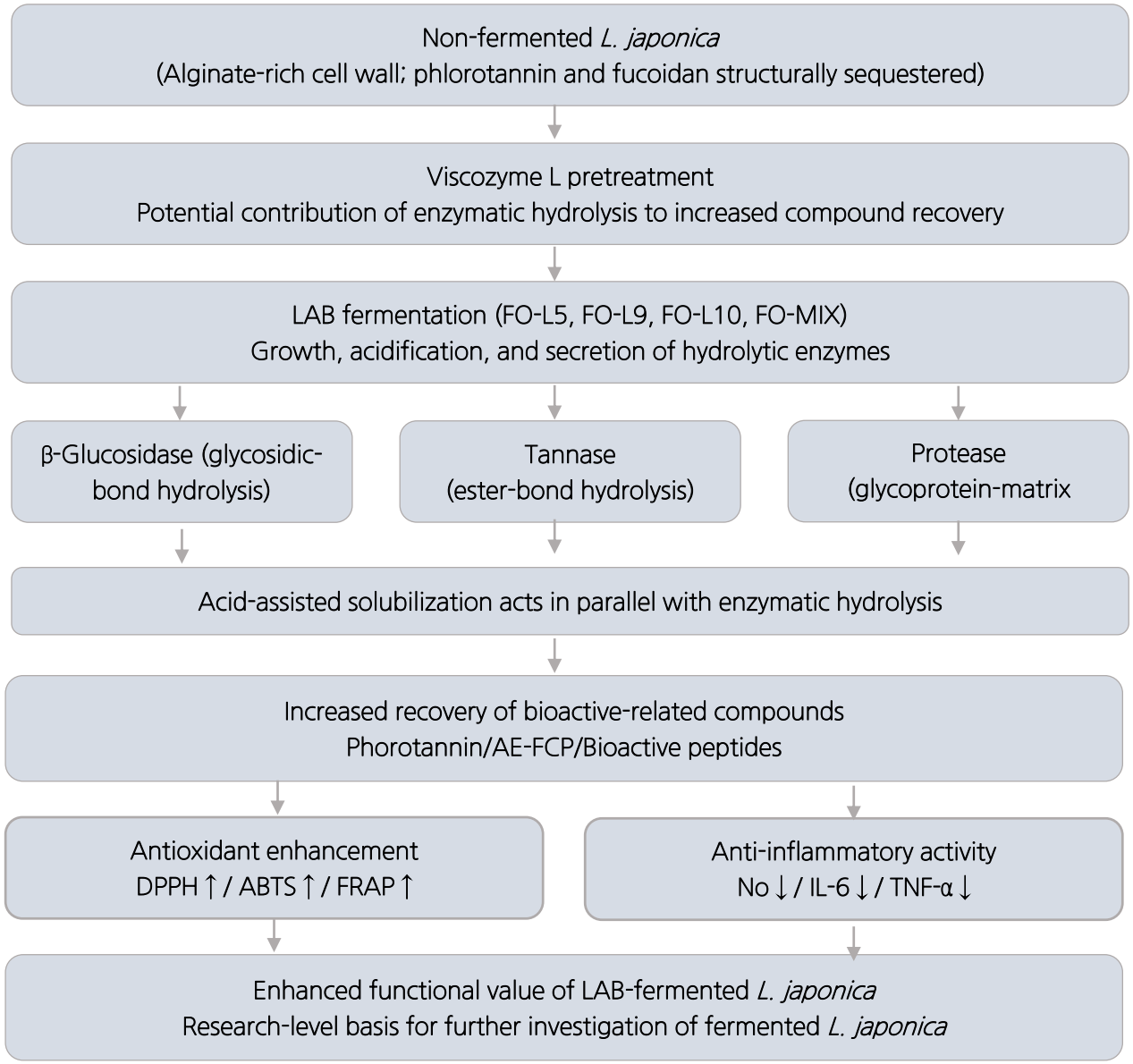
[3)]PC2 was included only for visualization purposes and was not considered for formal interpretation.

[4)]AE-FCP, acid-extractable fucose-containing polysaccharides; values are expressed as L-fucose-equivalent estimates.

Supplementary Table S3. PCA score coordinates of the treatment centroids (n = 18)[1)]

Treatment	PC1	PC2
Control	−4.915	0.209
Visco	−3.372	0.131
W. confusa FO-L5	0.362	−1.492
Leu. citreum FO-L9	1.700	0.656
P. acidilactici FO-L10	1.289	0.586
FO-L5+FO-L10 (FO-MIX)	4.936	−0.091

[1)]Values represent mean PC1 (first principal component) and PC2 (second principal component) scores calculated from three biological replicates per treatment. The treatment centroids correspond to the positions displayed in the PCA biplot (Fig. 2).



Supplementary Fig. S1. Conceptual framework of the fermentation-associated relationships evaluated in this study, including Viscozyme L pretreatment, LAB fermentation, enzymatic activity, bioactive compound-related parameters, antioxidant capacity, and anti-inflammatory responses.