

Table S1. Enzymes for *in silico* proteolysis recorded in the BIOPEP-UWM tool.

No.	Enzyme	No.	Enzyme
11	chymotrypsin	28	thrombin
12	trypsin	29	pancreatic elastase II
13	pepsin (pH 1.3)	30	stem bromelain
14	Proteinase K	31	glutamyl endopeptidase II
15	pancreatic elastase	32	oligopeptidase B
16	prolyl oligopeptidase	33	calpain 2
17	V-8 protease (Glutamyl endopeptidase)	34	glycyl endopeptidase
18	thermolysin	36	oligopeptidase F
19	chymotrypsin	37	proteinase P1 (lactocepin)
20	plasmin	38	Xaa-Pro dipeptidase
21	cathepsin G	39	pepsin (pH > 2)
22	clostripain	40	coccolysin
23	chymase	41	subtilisin
24	papain	42	chymosin
25	ficin	43	ginger protease (zingipain)
26	leukocyte elastase	44	V-8 protease (Glutamyl endopeptidase) (pH = 7.8)
27	metridin		

Table S2. Overview of computational tools utilized in this study.

Category	Name	Website (version)	Description
Software	Modeller	https://salilab.org/modeller/ (v10.1)	Program for homology or comparative modeling of protein three-dimensional structures
	Amber	https://ambermd.org/ (v16)	Program for biomolecular simulation
	Pymol	https://pymol.org/2/ (v2.0)	Molecular visualization system
	Auto Dock Vina	https://vina.scripps.edu/ (v1.5.6)	An open-source program for doing molecular docking
	BIOVIA Discovery Studio	https://www.3ds.com/products-services/biovia/products/molecular-modeling-simulation/biovia-discovery-studio/visualization/ (v2016)	A molecular modeling application for viewing (visualization), sharing and analyzing protein and small molecule data
Database	UniProt	http://www.uniprot.org/	Protein sequence and functional information
	BIOPEP-UWM	https://biochemia.uwm.edu.pl/biopep-uwm/	Bioactive peptide database, in silico hydrolysis program
	PeptideRanker	http://distilldeep.ucd.ie/PeptideRanker/	Evaluation of probability that the peptide will be bioactive
	ToxinPred	http://crdd.osdd.net/raghava/toxinpred/index.html	Toxicity prediction of peptides and design of toxic/non-toxic peptides
	AllerTOP	https://www.ddg-pharmfac.net/AllerTOP/	Allergenicity prediction of peptides
	Innovagen	http://www.innovagen.com/proteomics-tools	Peptide physiochemical property (Mw, PI, solubility...) calculator
	Expasy-protparam	https://web.expasy.org/protparam/	Peptide physiochemical property (Mw, PI, stability...) calculator
	UMPred-FRL	http://pmlabstack.pythonanywhere.com/UMPred-FRL	Screening of candidate peptides with potential umami sensory properties
	Umami_YYDS	http://tastepeptides-meta.com/Umami_YYDS	Umami/bitterness judgment model based on machine learning and chemical descriptors
	Umami-MRNN	https://umami-mrnn.herokuapp.com/	Deep learning-based method to predict umami peptides
	RCSB PDB	https://www.rcsb.org/	Global protein data bank archive of 3D structure data for large biological molecules
	SAVES	https://saves.mbi.ucla.edu/	Structure validation server

Table S3. List of umami peptides reported by August 2023.

Peptide sequence	Length	Taste attributes	Source	Reference (doi)
AD	2	Umami	Synthesized, Chicken enzymatic hydrolysate (CEH)	10.1016/j.biomaterials.2021.121338
AE	2	Umami	Synthesized, CEH	
AF	2	Umami	Chicken soup	
AH	2	Umami	CEH	
AM	2	Umami	CEH	
CE	2	Umami/Sour	MRP of Bovine bone marrow extract	
CM	2	Umami	Shiitake mushroom	
DA	2	Umami	Soy sauce	
DD	2	Umami	Beef Soup	
DE	2	Umami	Beef Soup	
DL	2	Umami	Synthesized	
DR	2	Umami	Soy sauce	
EA	2	Umami	Heated yeast extract (YE)	
ED	2	MSG-like, brothy	Fish protein hydrolysate (FPH), Heated YE, CEH	
EE	2	Umami/brothy/MSG-like	Beef soup, FPH	
EK	2	Umami	Beef soup	
EL	2	Umami	Synthesized, heated YE	
EN	2	Umami	Heated YE	
EP	2	Umami/Astringent	MRP of peanut hydrolysate (PH)	
ES	2	Umami	Heated YE, PMSP, FPH	
ET	2	Umami	PMSP	
EV	2	Umami/Sweet	CEH	
GD	2	Umami	Synthesized	
GE	2	Umami	Synthesized, Spain hams, shiitake mushroom	
HS	2	Umami	CEH	
HV	2	Umami	Heated YE	
KG	2	Umami	Heated YE	
LE	2	Umami	Synthesized	
LV	2	Umami	Heated YE	
NY	2	Umami	Heated YE	
QL	2	Umami	Heated YE	
RL	2	Umami	Synthesized	
TE	2	MSG-like, Umami	FPH, chicken soup	
VD	2	Umami	Synthesized	

VE	2	Umami	Synthesized, CEH
VT	2	Umami	Chicken soup
VV	2	Umami	Heated YE, synthesized
ADA	3	Umami	Synthesized, heated YE
AEA	3	Umami	Synthesized, heated YE, CEH
APA	3	Umami	Heated YE
DAE	3	Umami	Soy sauce
DAG	3	Umami	CEH
DCG	3	Umami	Wheat gluten fermentation broth
DDD	3	Umami	Synthesized
DDE	3	Umami	Synthesized
DED	3	Umami	Synthesized
DEE	3	Umami	Synthesized
DEL	3	Umami	Synthesized
DES	3	MSG-like	FPH
DQR	3	Umami/Sour	PH
EDD	3	Umami	Synthesized
EDE	3	MSG-like	FPH
EDG	3	Umami/Sour	PH
EED	3	Umami	Synthesized
EEE	3	Umami/Salty	Synthesized, wine
EEL	3	Umami	Synthesized
EGF	3	Umami/Kokumi	PH
EGS	3	Brothy/MSG-like	PMSP, FPH
EMH	3	Umami	Heated YE
EPE	3	Umami	Shiitake mushroom
EPQ	3	MSG-like	Deamidated wheat gluten
EQE	3	MSG-like	FPH
ESV	3	Umami	Synthesized
EVC	3	Umami	Soy sauce
GCG	3	Umami	Shiitake mushroom
GDG	3	Umami	Synthesized
GEG	3	Umami	Synthesized
GFP	3	Umami (enhancing)	SPH
GGY	3	Umami	Heated YE
GLE	3	Umami	Soy sauce
LVG	3	Umami	Heated YE
NNP	3	Umami/Sweet	PH
PAA	3	Umami	Heated YE
PET	3	Umami	Heated YE

PGD	3	Umami	Heated YE
PSE	3	Umami	Manchego Cheese
PSG	3	Umami	Heated YE
QPS	3	Umami	Heated YE
RKE	3	Umami	Manchego Cheese
SEE	3	MSG-like	FPH
SFE	3	Umami/Astringent	MRP of PH
TAY	3	Umami (enhancing)	SPH
TGC	3	Umami	Soy sauce
VAV	3	Umami	Heated YE
VDV	3	Umami	Synthesized
VEH	3	Umami	Heated YE
VEV	3	Umami	Synthesized
VGG	3	Umami	Synthesized
VPY	3	Umami (enhancing)	SPH
AAPY	4	Umami (enhancing)	SPH
GGGE	4	Umami	Soy sauce
GGPG	4	Umami	Heated YE
INEL	4	Umami	Manchego Cheese
LEQL	4	Umami	Manchego Cheese
LYER	4	Kokumi/Sweetness/Umami	TOH
NRTF	4	Umami	Synthesized
QEEL	4	Umami	Manchego Cheese
VRSY	4	Kokumi/Sweetness/Umami	TOH
VEAL	4	Umami	Soy sauce
AFDEK	5	Umami (enhancing)	Douchi
CALTP	5	Umami/Kokumi	T. obscurus (100 °C)
EAGIQ	5	Umami	Soy sauce
EEDGK	5	Umami	Synthesized
EQEEL	5	Umami	Manchego Cheese
EQQQQ	5	Umami/Salty	Soy sauce
HCHTN	5	Umami	Synthesized
LPEEV	5	Umami/Sweet	Soy sauce
NGKET	5	Umami	PHH
SAEQK	5	Umami	Manchego Cheese
VVGET	5	Umami	Manchego Cheese
ALPEEV	6	Umami	Soy sauce
CCNKS	6	Umami	Jinhua ham
DFKREP	6	Umami	White Sufu
EFKEYN	6	Umami/Kokumi	T. rubripes (4 °C)

EHAMLN	6	Umami/Kokumi	T. rubripes (4 °C)
ENINEL	6	Umami	Manchego Cheese
GPDPER	6	Umami	Atlantic cod
INKPGL	6	Umami	Atlantic cod
KGRYER	6	Kokumi/Sweet/Umami	TOH
LAPSTM	6	Umami	Beef stir-fried
LSERYP	6	Umami	PHH
NVVGET	6	Umami	Manchego Cheese
PDLPNT	6	Umami	PHH
RPLGNC	6	Umami/Kokumi	T.obscurus (100 °C))
SDSCIR	6	Umami	Atlantic cod
TESSSE	6	Umami/Kokumi	PH
TLRRCM	6	Umami/Kokumi	T. obscurus (4 °C)
AHSVRFY	7	Umami	Parma ham
ASNMSDL	7	Umami (enhancing)	Volvariella volvacea
DREKFDE	7	Umami	White Sufu
HLQLAIR	7	Umami/Kokumi/Sour	T.rubripes (100 °C)
LQPLNAH	7	Umami (enhancing)	Volvariella volvacea
PGGVRNG	7	Umami/Kokumi/Bitter	T. rubripes (4 °C)
PVARMCR	7	Umami/Kokumi	T. obscurus (4 °C)
AQALQAQA	8	Umami/Sweet	Soy sauce
DEDFKREP	8	Umami/Sour	White Sufu
DPLRGGYY	8	Umami/Kokumi/	T. rubripes (100 °C)
ESDVVSDL	8	Umami	BRH
FADNVFAL	8	Umami	Beef stir-fried
FAGDDAPR	8	Umami	Beef stir-fried
GSGVGGAK	8	Umami	BRH
KGDEESLA	8	Delicious taste	Beef brothy
KGSLADEE	8	Umami	Synthesized
PECGLVVG	8	Umami	Beef stir-fried
RPNPFENR	8	Umami	Clam
SLADEEKG	8	Umami	Synthesized
SLAKGDEE	8	Umami	Synthesized
SSRNEQSR	8	Umami	PH
VAPEEHPT	8	Umami	Beef stir-fried
YGGTPPFV	8	Umami/Sweet	T. obscurus (100 °C)
AGLQFPVGR	9	Umami/Kokumi/Bitter	T. rubripes (100 °C)
DVILPVPAF	9	Umami	T. flavidus
DVNNPANQL	9	Umami	SSH

EFEGGSIEH	9	Umami	SSH	
GLLPDGTTPR	9	Umami	Clam	
LLLPGELAK	9	Umami/Sweet	T. rubripes (100 °C)	
SSVGGGSAG	9	Umami	BRH	
STMLESER	9	Umami	Clam	
YKCKDGDRL	9	Kokumi/Umami	T. obscurus hydrolysate	
AGFAGDDAPR	10	Umami/Sweet/Kokumi	T. rubripes (100 °C)	
ANPGPVRDLR	10	Umami	Clam	
DVNNPANQLD	10		Sunflower seed	
GYSFTTTAER	10	Umami/Sweet	T. rubripes (100 °C)	
IGAEVYHNLK	10	Weak umami	T. flavidus	
QVAIAHRDAK	10	Umami	Clam	
AGGGGGGVVAG	11	Umami	BRH	
AMLEQVAMTDK	11	Umami	T. flavidus	
EGSEAPDGSSR	11	Umami	PH	
NNENQLDEYQR	11	Umami	SSH	
VLPTDQNFILR	11	Umami	Clam	
DAGVIAGLNVL	12	Umami/Sweet/Kokumi	T. rubripes (100 °C)	
GGKLVVDGHAIT	12	Umami	T. flavidus	
VTADESQQDVLK	12	Umami	Clam	
RGENSEEEGAIVT	14	Umami/Kokumi	PH	
RGENSEDEQGAIVT	14	Umami/Astringent	MRP of PH	
GENEEEDSGAIVTVK	15	Umami	Tempeh	
TVAGGAWTYNTTSAVTV	18	Umami/Sweet	T. flavidus	
K				
EINEL	5	Umami	Manchego cheese	BIOPEP-UWM database
VG	2	Umami	Synthesized	
DG	2	Umami	Fish protein hydrolysate	
EG	2	Umami	Fish protein hydrolysate	
EDF	3	Umami	Jinhua and Parma hams	
EDV	3	Umami	Jinhua and Parma hams	
EY	2	Umami	Synthesized	
PE	2	Umami enhancing	Jinhua and Parma hams	
PAQ	3	Umami enhancing	Jinhua and Parma hams	
DGG	3	Umami enhancing	Jinhua and Parma hams	
IPIPATKT	8	Umami	Sanhuang chicken hydrolysate	
NP	2	Umami	Synthesized	
LEE	3	Umami	Synthesized	10.1111/1750-3841.13576
EPS	3	MSG-like	Deamidated wheat gluten hydrolysate	
ESLA	4	Sour > astringent > umami >	Synthesized	

EESLA	5	bitter Sour > astringent > umami > bitter	Synthesized	
DEESLA	6	Sour > astringent > umami > sweet > bitter	Synthesized	
WVNEEDHL	8	Sour, astringent, weak sweet	Chicken	10.1111/1541-4337.12916
NSLEGEFKG	9	Sour, astringent, thickness	Chicken	
KDLFDPVIQD	10	Weak sour and astringent	Chicken	
ADGLWL	6	Astringent, umami, sweet, sour, bitter	Sanhuang chicken hydrolysates	
GFLGPQ	6	Astringent, sour, umami, sweet, bitter	Sanhuang chicken hydrolysates	
AGDDAPR	7	Sour, umami	Sanhuang chicken hydrolysates	
IGPGLGR	7	Sour, umami	Sanhuang chicken hydrolysates	
KDGGGGK	7	Umami	Sanhuang chicken hydrolysates	
SEASNNK	7	Sweet, umami	Sanhuang chicken hydrolysates	
HGEDKEGE	8	Sour, umami	Sanhuang chicken hydrolysates	
PGPAGPAGP	9	Astringent, umami	Sanhuang chicken hydrolysates	
GS	2		Porcine bone protein extracts	
KP	2		Porcine bone protein extracts	
PN	2		Porcine bone protein extracts	
SY	2		Porcine bone protein extracts	
APHR	4		Porcine bone protein extracts	
PDKPNT	6		Jinhua ham	
ER	2		Crab sauce	
WF	2		Crab sauce	
DPC	3		Crab sauce	
DVC	3		Crab sauce	
DVD	3		Crab sauce	
DK	2	Umami	Myosin	
EEK	3	Umami	Myosin	
EDQK	4	Umami	Myosin	
SEGGR	5	Umami	Myosin	
QDSIGS	6	Umami	Myosin	
DAPYDYK	7	Outstanding umami, sourness and sweet	Chinese anchovy sauce	
NQEGLFR	7	Umami and bitterness, slightly sourness	Chinese anchovy sauce	
VYETPDR	7	Moderate umami, slightly sourness or bitterness	Chinese anchovy sauce	

EGSTIGLSK	9	Umami, slightly bitterness and sourness	Chinese anchovy sauce
MAASGDVGK	9	Moderate umami and sourness, distinct sweet	Chinese anchovy sauce
TREQMIHER	9	Umami, slightly sourness and bitterness	Chinese anchovy sauce
EATLWDMEEK	10	Outstanding umami and bitterness	Chinese anchovy sauce
LLDAFFFDNK	10	Moderate umami and sweet, slightly sourness	Chinese anchovy sauce
LPLLEEAFLSR	11	Umami, bitterness	Chinese anchovy sauce
MEREQEESTMR	11	Apparent umami	Chinese anchovy sauce
AKLTSLEECQR	12	Outstanding umami, slightly sourness and sweet	Chinese anchovy sauce
NALKSVECYDAR	12	Outstanding umami and sweet	Chinese anchovy sauce
YLASCLSSVKEEK	13	Outstanding umami and sweet	Chinese anchovy sauce
EQLEATVQKLDERS	14	Moderate umami, slightly sweet and bitterness	Chinese anchovy sauce
IMEALAGAGIDPRR	14	Umami, slightly bitterness and sourness	Chinese anchovy sauce
SGVVAAVNDAAKDFHG	16	Apparent sweet, moderate umami, slightly sourness	Chinese anchovy sauce
VLSLNSGTEAVEAAIK	16	Moderate sweet, slightly umami and sourness	Chinese anchovy sauce
APAP	4	Sour, salty	Trachinotus ovatus
ASEFFR	6	Sweet, sour, bitter	Trachinotus ovatus
WDDMEK	6	Umami, sour, salty, kokumi	Trachinotus ovatus
AEASALR	7	Umami, sour	Trachinotus ovatus
LGDVLR	7	Salty, umami, sour	Trachinotus ovatus
SEEK	4	Umami, astringent, bitter	Ruditapes philippinarum
KSAEN	5	Umami, sour, sweet	Ruditapes philippinarum
HNESQN	6	Umami, sour, salty	Ruditapes philippinarum
KEMQKN	6	Umami, sour	Ruditapes philippinarum
KGGGGP	6	Slight umami, sour	Ruditapes philippinarum
TGDPEK	6	Slight umami, sour	Ruditapes philippinarum
TYLPVH	6	Umami, sour, astringent, bitter	Ruditapes philippinarum
AGAGPTP	7	Umami, sour, astringent	Ruditapes philippinarum
PAATIPE	7	Umami, sweet, sour, bitter	Ruditapes philippinarum
RGEPNND	7	Umami, sour, astringent	Ruditapes philippinarum
GRVSNCAA	8	Umami, sweet, astringent	Ruditapes philippinarum

QIEELEGK	8	Umami, astringent	Ruditapes philippinarum	
TDVEQEGD	8	Umami, sour, astringent	Ruditapes philippinarum	
GPAGPAGPR	9	Sweetness, umami	Ruditapes philippinarum	
DALKKK	6	Strong umami, strong sweet	Tilapia lower jaw	
STELFK	6	Strong umami, sweet, salty	Tilapia lower jaw	
VADLMR	6	Strong umami, obvious sweet	Tilapia lower jaw	
FVGLQER	7	Umami, slight sweet and salty	Tilapia lower jaw	
VVLNPVARVE	10	Strong umami, strong sweet	Tilapia lower jaw	
HFR	3	Bitter, astringent flavor, kokumi	Takifugu obscurus	
RPHR	4	Reagent flavor, irritant, bitter, kokumi	Takifugu obscurus	
NSNDN	5	Reagent flavor, the flavor of disinfectant fluid	Takifugu obscurus	
RPWHR	5	Reagent flavor, capsule flavor, irritant, bitter	Takifugu obscurus	
RWDGRG	6	Kokumi	Takifugu obscurus	
NEY	3	Bland, tasteless	Peanut protein	
GGITETW	7	Bland, tasteless	Peanut protein	
RFPHADF	7	Strong bitter, astringent	Peanut protein	
YYGNSA	7	Sour, sweet, astringent	Volvariella volvacea	
VF	2		Shiitake mushroom	
YNEYPLGR	9	Umami, sweet, slight	Leccinum extremiorientale	
FNEIKETST	10	Rich umami, sweet	Leccinum extremiorientale	
DQEDLDESIGVK	13	Umami, sweet, slight sour	Leccinum extremiorientale	
EEEQ	4	Umami, kokumi		10.1016/j.tifs.2019.04.008
GGNP	4	Umami, sweet		
VDR	3	Umami, sour, astringent		
DPQ	3	Umami, astringent		
FT	2	Sour, astringent, umami-enhancing		
FK	2	Slight sweet, umami-enhancing		
SE	2	Umami		
ADE	3	sweet, sour, bitter, umami-enhancing		
AED	3	sour, umami-enhancing		
SPE	3	salt, sour, umami-enhancing		
FSGLDGAK	8	Umami, Sour	porcine bone soup	10.1016/j.foodchem.2022.132870
FSGLDGSK	8	Umami, Sour, Weak Bitter	porcine bone soup	
AL	2		yeast extract	10.1021/acs.jafc.0c02797
AP	2		chicken soup	

AV	2	yeast extract
AY	2	yeast extract
DEEGST	6	Fish protein
DEGD	4	Fish protein
DEGSD	5	Fish protein
DEGSE	5	Fish protein
DESD	4	Fish protein
DESTE	5	Fish protein
DGSE	4	Fish protein
ECG	3	yeast extract
EGA	3	Fish protein
EID	3	Fish protein
EILE	4	Fish protein
ENE	3	fish
EVG	3	beer
FQP	3	peanut protein
GL	2	ham
GY	2	peanut protein
ID	2	Fish protein
IE	2	Fish protein
IEE	3	Fish protein
LA	2	yeast extract
LK	2	yeast extract
LQ	2	yeast extract
LT	2	yeast extract
QEELINEL	8	Raw milk, cheese
SD	2	Fish protein
TF	2	peanut protein
TP	2	peanut protein
YE	2	yeast extract
YKCKDXXLR	9	Takifugu obscurus
SF	2	
LGAGGSLA	8	
KGNEESLA	8	
LDL	3	
DDDD	4	
VEL	3	
KE	2	
KA	2	
HN	2	

UMP-TR dataset

UMP-IND dataset
10.1016/j.foodres.2019.03.001

PT	2		
SG	2		
NT	2		
CV	2		
LP	2		
KV	2		
GQEDYDRLRPL	11		10.1016/j.ultsonch.2022.106206
VVVGTPGRVF	10		
ESPERPFL	8		
HLYHPVPIEE	10		
EGTAG	5	Hypsizygos marmoreus	10.1016/j.foodchem.2022.134163
MTNLLEDLSFR	11		10.1039/D0FO03326J
GFGDSCTPGKNER	13		
YADSNIQINGTDR	13		
AREIALQELGEQAK	14		
IQQDDCK	7		
QAEADMAR	8		
AGFMPLP	7		10.1016/j.foodchem.2021.131996
APYSGY	6		
PPMF	4		
SLSSLMK	7		
VAMNPVDHPH	10		
DEK	3		10.1111/ijfs.15166
EVAEALDAPKTT	12	strong umami and sweet, litter salty and bitter	10.1016/j.foodchem.2022.134137
AVLEEAQKVELK	12	umami, sweet, bitter, salty	
AEDLSTLR	8	strong umami, litter bitter	
KVDVDSLK	8	umami, sweet, bitter, salty	
PPQEAQF	8		10.1016/j.foodchem.2022.134414
AEEHVEAVN	9		
NEFGYSNR	8		
LPLQD	5		
GPSGKLW	7		
DGGRY	6		
GPVGYGYE	8		
GPVGYGYEY	9		
AGPSIVH	7		
LERM	4	Umami, astringent and slight bitter	10.1016/j.foodchem.2022.134562
FGEKL	5	Umami, astringent and salty	

ELLKLH	6	Umami and sour	
LLEEKLK	7	Umami, astringent and slight sweet	
KSQAKEV	7	slight umami, sweet and kokumi	
AQKDEEKME	9	umami , slight salty and sour	
EANK	4		10.1016/j.fshw.2022.07.026
EEAK	4		
EMQK	4		
RD	2	Umami	10.1016/j.foodchem.2022.132175
DGV	3	Umami	
LMSL	4	Umami, bitter, astringen,	10.1016/j.foodchem.2022.133504
EFLKEQF	7	slight umami and sour	
DEELNKL	8	slight umami, bitter, salty and sour	
KALSEELDN	9	umami, slight sweet	
TETKTFTLK	9	umami, slight sweet, sour and bitter	
AAEAKLELLE	10	umami, slight salty and sour	
KETLEQEKSG	10	umami, slight sweet and sour	
TWKE	4	umami, slight sour	
DLRAD	5	umami, kokumi, slight sour	
DDLDR	5	umami, slight sour	
KSLEEA	6	umami, slight sweet and sour	
MQAMKLEK	8	umami, slight sweet	
DQLEKQVK	8	umami, slight sweet	
AKALKEEDL	9	umami, slight sweet and sour	
TGFLPEEYMK	10	slight umami	
AMKLEKENAL	10	umami, slight sweet and sour	
DGF	3	Umami, astringent	10.1016/j.foodchem.2022.133835
HHYE	4	Sour, umami, astringent	
KCGQ	4	Sour, umami, salt, astringent	
EPLCNQ	6		10.1016/j.jfca.2022.104530
SGCVNEL	7		
PHEMQ	5		
SEPSHF	6		
ESCAPQL	7		
HA	2	Umami, bitter	10.1016/j.foodres.2018.11.002
DFE	3	Umami, sour, kokumi,	10.1016/j.foodchem.2022.134583

LREY	4	astrigent	
HEAL	4	Umami, sour and bitter	10.1002/jsfa.12319
LAKVH	5	Umami, salt	
FQKVVA	6	Umami	
HVKELE	6	Umami, sweet and salt	
AEVKKAP	7	Umami, sweet	
EAVEKPQS	8	Umami, sweet	
KALSEEL	7	Umami	
KKMFETES	8	Umami, sour	
EFHNR	5		
DPLKY	5		
TPPKID	6		
EAFRVL	6		
ADSYRLP	7		
IKDPHVD	7		
SLSSLMF	7		
DDF	3		10.1039/D2FO03776A
ADC	3		
GGR	3		
DNW	3		
QDF	3		
IGDM	4		
DCIY	4		
AGCD	4		
QDTW	4		
SGDAW	5		
NDDGW	5		
SDLYVR	6	umami-enhancing	10.3390/molecules27092853
GSAQA	5		10.1007/s00217-022-04061-4
ISKEK	5		
LPKERLYV	8		
VENQQLAL	8		
PKALSAFK	8	slight umami, sour, umami enhancing	10.1021/acs.jafc.2c09178
NKHGSGK	7	strong umami, sour, umami enhancing	
SADETPR	7	umami, sour, sweet, umami enhancing	
EIKKAALDANEK	12	strong umami, sour, umami	

DALAHK	6	enhancing slight umami, sour, umami	
LDDGR	5	enhancing strong umami, sour, umami	
GHENQR	6	enhancing umami, sour, umami	
GLPD	4		10.3390/foods8020043
GHGD	4		
HE	2	Umami, sweet, sour	10.1016/j.biomaterials.2022.121697
HD	2	Umami, sour	
EH	2	Umami, sour	
DH	2	Umami, sweet, sour	
EQ	2	Umami, sour, salt	
DQ	2	Umami, sweet, sour	
DN	2	Umami, sour	
DY	2	Umami, sweet, astringent	
DM	2	Umami, astringent	
DI	2	Umami, sweet, sour	
DV	2	Umami, sweet, sour, astringent	
QE	2	Umami, sweet, sour	
QD	2	Umami, sweet, sour	
NE	2	Umami, sour	
ND	2	Umami, sour	
ALPAEV	6		10.1016/j.foodchem.2022.134812
EQEEK	5		
IQEL	4		
KAPSTM	6		
NGG	3		
PLA	3		
QEEK	4		
QP	2		
SAEQT	5		
SFG	3		
SGLAEGSG	8		
SGSLGGGSG	9		
SSAVK	5		
TPE	3		
VEAGP	5		
VES	3		
VTADESQQDVLV	12		

VYPPFGPL	8		
YIHGGS	6		
ATQ	3	Umami, Sweet	
LPG	3	Umami	
ECH	3	Umami, Sweet	
NQS	3	Umami, Sweet	
GPPDER	6	Umami	
AGPPVGPAG	9		10.1111/ijfs.14655
DAINWTPPGEIAH	13		10.1111/1750-3841.15751
FLGDEETVR	9		
GVDEATHIELTK	13		
PAGPVGPVG	9		
VAPEEHPTL	9		
NALNDITSL	9	umami-enhancing	10.1016/j.foodchem.2022.132455
TFYNELR	7	Weak umami, Weak saltiness	10.1111/ijfs.15883
TLFQPSF	7	Umami, weak saltiness	
LYANNVL	7	Umami	
FAGDDAPRAVFPS	13	Umami, weak saltiness	

Notes: Fish protein hydrolysate (FPH); Chicken enzymatic hydrolysate (CEH); Peanut hydrolysate (PH); Sunflower seeds hydrolysate (SSH); Parma ham hydrolysate (PHH); Brown rice hydrolysate (BRH); *Takifugu obscurus* hydrolysate (TOH); Yeast extract (YE); Silkworm pupa hydrolysate (SPH); Proteinase modified soybean protein (PMSP).

Table S4. The number and frequency (A_{umami} value) of umami peptides theoretically generated from *in silico* proteolysis of porcine type I collagen $\alpha 1$ and $\alpha 2$ chains by different enzymes.

Enzyme combination	pork type I collagen $\alpha 1$ chain		pork type I collagen $\alpha 2$ chain	
	Number of umami peptides	A_{umami} value	Number of umami peptides	A_{umami} value
11	10	0.0068	12	0.0088
12	2	0.0014	0	0.0000
13	5	0.0034	5	0.0037
14	29	0.0198	28	0.0205
15	73	0.0498	54	0.0396
16	3	0.0020	1	0.0007
17	2	0.0014	0	0.0000
18	17	0.0116	25	0.0183
19	37	0.0252	65	0.0476
20	2	0.0014	0	0.0000
21	8	0.0055	9	0.0066
22	1	0.0007	0	0.0000
23	8	0.0055	7	0.0051
24	58	0.0396	61	0.0447
25	55	0.0375	49	0.0359
26	30	0.0205	26	0.0190
27	8	0.0055	7	0.0051
28	0	0.0000	0	0.0000
29	5	0.0034	7	0.0051
30	84	0.0573	70	0.0513
31	0	0.0000	0	0.0000
32	2	0.0014	0	0.0000
33	78	0.0532	69	0.0505
34	31	0.0211	35	0.0256
36	5	0.0034	5	0.0037
37	24	0.0164	20	0.0147
38	6	0.0041	4	0.0029
39	60	0.0409	74	0.0542
40	8	0.0055	14	0.0103
41	10	0.0068	12	0.0088
44	11	0.0075	8	0.0059
11+12	22	0.0150	18	0.0132
11+13	10	0.0068	12	0.0088
11+14	32	0.0218	34	0.0249
11+15	83	0.0566	69	0.0505
11+16	19	0.0130	22	0.0161
11+17	13	0.0089	19	0.0139
11+18	19	0.0130	17	0.0125
11+19	39	0.0266	40	0.0293
11+20	22	0.0150	18	0.0132

11+21	10	0.0068	12	0.0088
11+22	16	0.0109	17	0.0125
11+23	10	0.0068	12	0.0088
11+24	73	0.0498	77	0.0564
11+25	58	0.0396	56	0.0410
11+26	39	0.0266	39	0.0286
11+27	9	0.0061	12	0.0088
11+28	15	0.0102	18	0.0132
11+29	10	0.0068	12	0.0088
11+30	94	0.0641	78	0.0571
11+31	10	0.0068	14	0.0103
11+32	22	0.0150	18	0.0132
11+33	93	0.0634	82	0.0601
11+34	38	0.0259	45	0.0330
11+36	10	0.0068	12	0.0088
11+37	36	0.0246	31	0.0227
11+38	16	0.0109	21	0.0154
11+39	59	0.0402	71	0.0520
11+40	11	0.0075	7	0.0051
11+41	12	0.0082	18	0.0132
11+44	26	0.0177	33	0.0242
12+13	14	0.0095	10	0.0073
12+14	41	0.0280	37	0.0271
12+15	91	0.0621	68	0.0498
12+16	11	0.0075	6	0.0044
12+17	21	0.0143	21	0.0154
12+18	34	0.0232	38	0.0278
12+19	64	0.0437	65	0.0476
12+20	2	0.0014	0	0.0000
12+21	20	0.0136	17	0.0125
12+22	2	0.0014	0	0.0000
12+23	18	0.0123	14	0.0103
12+24	69	0.0471	62	0.0454
12+25	55	0.0375	47	0.0344
12+26	46	0.0314	32	0.0234
12+27	18	0.0123	14	0.0103
12+28	2	0.0014	0	0.0000
12+29	14	0.0095	11	0.0081
12+30	78	0.0532	57	0.0418
12+31	3	0.0020	3	0.0022
12+32	2	0.0014	0	0.0000
12+33	78	0.0532	69	0.0505
12+34	61	0.0416	62	0.0454
12+36	14	0.0095	10	0.0073

12+37	41	0.0280	35	0.0256
12+38	16	0.0109	11	0.0081
12+39	55	0.0375	68	0.0498
12+40	23	0.0157	25	0.0183
12+41	24	0.0164	23	0.0168
12+44	38	0.0259	33	0.0242
13+14	29	0.0198	28	0.0205
13+15	75	0.0512	56	0.0410
13+16	13	0.0089	13	0.0095
13+17	7	0.0048	9	0.0066
13+18	15	0.0102	16	0.0117
13+19	39	0.0266	40	0.0293
13+20	14	0.0095	10	0.0073
13+21	8	0.0055	9	0.0066
13+22	10	0.0068	10	0.0073
13+23	7	0.0048	7	0.0051
13+24	54	0.0368	61	0.0447
13+25	55	0.0375	48	0.0352
13+26	31	0.0211	27	0.0198
13+27	8	0.0055	7	0.0051
13+28	9	0.0061	10	0.0073
13+29	5	0.0034	7	0.0051
13+30	84	0.0573	62	0.0454
13+31	5	0.0034	6	0.0044
13+32	14	0.0095	10	0.0073
13+33	80	0.0546	69	0.0505
13+34	28	0.0191	28	0.0205
13+36	5	0.0034	5	0.0037
13+37	27	0.0184	22	0.0161
13+38	11	0.0075	9	0.0066
13+39	60	0.0409	74	0.0542
13+40	8	0.0055	7	0.0051
13+41	10	0.0068	12	0.0088
13+44	17	0.0116	20	0.0147
14+15	103	0.0703	84	0.0615
14+16	29	0.0198	28	0.0205
14+17	46	0.0314	42	0.0308
14+18	43	0.0293	30	0.0220
14+19	47	0.0321	51	0.0374
14+20	41	0.0280	37	0.0271
14+21	29	0.0198	28	0.0205
14+22	36	0.0246	34	0.0249
14+23	29	0.0198	28	0.0205
14+24	135	0.0921	125	0.0916

14+25	113	0.0771	105	0.0769
14+26	50	0.0341	48	0.0352
14+27	29	0.0198	28	0.0205
14+28	34	0.0232	34	0.0249
14+29	29	0.0198	28	0.0205
14+30	49	0.0334	100	0.0733
14+31	32	0.0218	28	0.0205
14+32	41	0.0280	37	0.0271
14+33	137	0.0935	123	0.0901
14+34	107	0.0730	100	0.0733
14+36	29	0.0198	28	0.0205
14+37	37	0.0252	31	0.0227
14+38	37	0.0252	36	0.0264
14+39	35	0.0239	27	0.0198
14+40	49	0.0334	40	0.0293
14+41	34	0.0232	38	0.0278
14+44	54	0.0368	46	0.0337
15+16	99	0.0675	79	0.0579
15+17	58	0.0396	45	0.0330
15+18	43	0.0293	35	0.0256
15+19	66	0.0450	59	0.0432
15+20	91	0.0621	78	0.0571
15+21	77	0.0525	59	0.0432
15+22	98	0.0668	71	0.0520
15+23	64	0.0437	56	0.0410
15+24	81	0.0553	67	0.0491
15+25	95	0.0648	65	0.0476
15+26	73	0.0498	54	0.0396
15+27	74	0.0505	56	0.0410
15+28	90	0.0614	66	0.0484
15+29	76	0.0518	72	0.0527
15+30	95	0.0648	59	0.0432
15+31	63	0.0430	48	0.0352
15+32	91	0.0621	68	0.0498
15+33	81	0.0553	66	0.0484
15+34	73	0.0498	54	0.0396
15+36	74	0.0505	55	0.0403
15+37	72	0.0491	51	0.0374
15+38	73	0.0498	54	0.0396
15+39	18	0.0123	22	0.0161
15+40	52	0.0355	43	0.0315
15+41	66	0.0450	48	0.0352
15+44	49	0.0334	39	0.0286
16+17	21	0.0143	12	0.0088

16+18	65	0.0443	50	0.0366
16+19	38	0.0259	37	0.0271
16+20	11	0.0075	5	0.0037
16+21	16	0.0109	17	0.0125
16+22	8	0.0055	5	0.0037
16+23	17	0.0116	15	0.0110
16+24	115	0.0784	110	0.0806
16+25	105	0.0716	98	0.0718
16+26	48	0.0327	42	0.0308
16+27	17	0.0116	15	0.0110
16+28	6	0.0041	3	0.0022
16+29	13	0.0089	15	0.0110
16+30	111	0.0757	88	0.0645
16+31	7	0.0048	2	0.0015
16+32	11	0.0075	6	0.0044
16+33	120	0.0819	108	0.0791
16+34	90	0.0614	87	0.0637
16+36	13	0.0089	13	0.0095
16+37	26	0.0177	20	0.0147
16+38	16	0.0109	12	0.0088
16+39	55	0.0375	63	0.0462
16+40	57	0.0389	43	0.0315
16+41	27	0.0184	26	0.0190
16+44	34	0.0232	21	0.0154
17+18	23	0.0157	30	0.0220
17+19	38	0.0259	37	0.0271
17+20	21	0.0143	21	0.0154
17+21	11	0.0075	14	0.0103
17+22	14	0.0095	9	0.0066
17+23	11	0.0075	10	0.0073
17+24	56	0.0382	61	0.0447
17+25	44	0.0300	29	0.0212
17+26	49	0.0334	41	0.0300
17+27	11	0.0075	10	0.0073
17+28	13	0.0089	9	0.0066
17+29	7	0.0048	12	0.0088
17+30	59	0.0402	48	0.0352
17+31	2	0.0014	0	0.0000
17+32	21	0.0143	21	0.0154
17+33	58	0.0396	53	0.0388
17+34	41	0.0280	44	0.0322
17+36	7	0.0048	9	0.0066
17+37	40	0.0273	30	0.0220
17+38	12	0.0082	7	0.0051

17+39	60	0.0409	74	0.0542
17+40	14	0.0095	22	0.0161
17+41	25	0.0171	18	0.0132
17+44	11	0.0075	8	0.0059
18+19	72	0.0491	52	0.0381
18+20	34	0.0232	38	0.0278
18+21	16	0.0109	16	0.0117
18+22	23	0.0157	30	0.0220
18+23	16	0.0109	15	0.0110
18+24	67	0.0457	83	0.0608
18+25	59	0.0402	69	0.0505
18+26	18	0.0123	18	0.0132
18+27	16	0.0109	15	0.0110
18+28	20	0.0136	30	0.0220
18+29	15	0.0102	17	0.0125
18+30	62	0.0423	49	0.0359
18+31	17	0.0116	25	0.0183
18+32	34	0.0232	38	0.0278
18+33	90	0.0614	93	0.0681
18+34	46	0.0314	67	0.0491
18+36	15	0.0102	16	0.0117
18+37	42	0.0286	30	0.0220
18+38	28	0.0191	33	0.0242
18+39	54	0.0368	69	0.0505
18+40	17	0.0116	25	0.0183
18+41	17	0.0116	16	0.0117
18+44	38	0.0259	41	0.0300
19+20	64	0.0437	65	0.0476
19+21	39	0.0266	40	0.0293
19+22	56	0.0382	53	0.0388
19+23	39	0.0266	40	0.0293
19+24	95	0.0648	91	0.0667
19+25	73	0.0498	60	0.0440
19+26	86	0.0587	82	0.0601
19+27	39	0.0266	40	0.0293
19+28	55	0.0375	54	0.0396
19+29	39	0.0266	40	0.0293
19+30	72	0.0491	62	0.0454
19+31	38	0.0259	37	0.0271
19+32	64	0.0437	65	0.0476
19+33	90	0.0614	76	0.0557
19+34	83	0.0566	78	0.0571
19+36	39	0.0266	38	0.0278
19+37	46	0.0314	38	0.0278

19+38	50	0.0341	48	0.0352
19+39	55	0.0375	63	0.0462
19+40	64	0.0437	47	0.0344
19+41	59	0.0402	54	0.0396
19+44	50	0.0341	47	0.0344
20+21	20	0.0136	15	0.0110
20+22	2	0.0014	0	0.0000
20+23	18	0.0123	14	0.0103
20+24	69	0.0471	62	0.0454
20+25	55	0.0375	47	0.0344
20+26	46	0.0314	32	0.0234
20+27	18	0.0123	14	0.0103
20+28	2	0.0014	0	0.0000
20+29	14	0.0095	11	0.0081
20+30	81	0.0553	57	0.0418
20+31	3	0.0020	3	0.0022
20+32	2	0.0014	0	0.0000
20+33	78	0.0532	69	0.0505
20+34	61	0.0416	62	0.0454
20+36	14	0.0095	10	0.0073
20+37	41	0.0280	35	0.0256
20+38	16	0.0109	11	0.0081
20+39	55	0.0375	68	0.0498
20+40	24	0.0164	25	0.0183
20+41	24	0.0164	23	0.0168
20+44	38	0.0259	33	0.0242
21+22	14	0.0095	14	0.0103
21+23	8	0.0055	9	0.0066
21+24	69	0.0471	67	0.0491
21+25	55	0.0375	48	0.0352
21+26	36	0.0246	35	0.0256
21+27	8	0.0055	9	0.0066
21+28	13	0.0089	15	0.0110
21+29	8	0.0055	9	0.0066
21+30	91	0.0621	62	0.0454
21+31	8	0.0055	10	0.0073
21+32	19	0.0130	15	0.0110
21+33	92	0.0628	75	0.0549
21+34	34	0.0232	34	0.0249
21+36	8	0.0055	9	0.0066
21+37	33	0.0225	26	0.0190
21+38	14	0.0095	13	0.0095
21+39	59	0.0402	72	0.0527
21+40	9	0.0061	7	0.0051

21+41	10	0.0068	15	0.0110
21+44	21	0.0143	24	0.0176
22+23	13	0.0089	13	0.0095
22+24	58	0.0396	61	0.0447
22+25	55	0.0375	47	0.0344
22+26	41	0.0280	33	0.0242
22+27	13	0.0089	13	0.0095
22+28	1	0.0007	0	0.0000
22+29	10	0.0068	11	0.0081
22+30	84	0.0573	62	0.0454
22+31	1	0.0007	3	0.0022
22+32	2	0.0014	0	0.0000
22+33	78	0.0532	69	0.0505
22+34	52	0.0355	53	0.0388
22+36	10	0.0068	10	0.0073
22+37	35	0.0239	27	0.0198
22+38	13	0.0089	11	0.0081
22+39	55	0.0375	68	0.0498
22+40	14	0.0095	17	0.0125
22+41	17	0.0116	24	0.0176
22+44	24	0.0164	21	0.0154
23+24	63	0.0430	65	0.0476
23+25	55	0.0375	47	0.0344
23+26	35	0.0239	32	0.0234
23+27	8	0.0055	7	0.0051
23+28	13	0.0089	13	0.0095
23+29	8	0.0055	9	0.0066
23+30	88	0.0600	66	0.0484
23+31	8	0.0055	8	0.0059
23+32	18	0.0123	14	0.0103
23+33	87	0.0593	74	0.0542
23+34	32	0.0218	31	0.0227
23+36	8	0.0055	7	0.0051
23+37	34	0.0232	26	0.0190
23+38	14	0.0095	11	0.0081
23+39	60	0.0409	74	0.0542
23+40	8	0.0055	6	0.0044
23+41	10	0.0068	12	0.0088
23+44	22	0.0150	21	0.0154
24+25	68	0.0464	63	0.0462
24+26	79	0.0539	62	0.0454
24+27	66	0.0450	65	0.0476
24+28	59	0.0402	61	0.0447
24+29	60	0.0409	62	0.0454

24+30	71	0.0484	58	0.0425
24+31	60	0.0409	70	0.0513
24+32	69	0.0471	62	0.0454
24+33	77	0.0525	68	0.0498
24+34	58	0.0396	61	0.0447
24+36	58	0.0396	61	0.0447
24+37	80	0.0546	75	0.0549
24+38	59	0.0402	61	0.0447
24+39	55	0.0375	66	0.0484
24+40	56	0.0382	58	0.0425
24+41	68	0.0464	85	0.0623
24+44	61	0.0416	63	0.0462
25+26	92	0.0628	65	0.0476
25+27	55	0.0375	47	0.0344
25+28	55	0.0375	47	0.0344
25+29	59	0.0402	48	0.0352
25+30	87	0.0593	60	0.0440
25+31	58	0.0396	54	0.0396
25+32	55	0.0375	47	0.0344
25+33	69	0.0471	62	0.0454
25+34	55	0.0375	47	0.0344
25+36	55	0.0375	47	0.0344
25+37	59	0.0402	54	0.0396
25+38	55	0.0375	47	0.0344
25+39	29	0.0198	49	0.0359
25+40	49	0.0334	49	0.0359
25+41	63	0.0430	67	0.0491
25+44	31	0.0211	28	0.0205
26+27	35	0.0239	32	0.0234
26+28	37	0.0252	33	0.0242
26+29	32	0.0218	30	0.0220
26+30	91	0.0621	67	0.0491
26+31	28	0.0191	28	0.0205
26+32	46	0.0314	32	0.0234
26+33	76	0.0518	62	0.0454
26+34	69	0.0471	50	0.0366
26+36	31	0.0211	27	0.0198
26+37	34	0.0232	23	0.0168
26+38	39	0.0266	32	0.0234
26+39	18	0.0123	22	0.0161
26+40	26	0.0177	18	0.0132
26+41	28	0.0191	49	0.0359
26+44	56	0.0382	48	0.0352
27+28	13	0.0089	13	0.0095

27+29	8	0.0055	9	0.0066
27+30	78	0.0532	66	0.0484
27+31	8	0.0055	8	0.0059
27+32	18	0.0123	14	0.0103
27+33	87	0.0593	73	0.0535
27+34	32	0.0218	31	0.0227
27+36	8	0.0055	7	0.0051
27+37	34	0.0232	26	0.0190
27+38	14	0.0095	11	0.0081
27+39	60	0.0409	72	0.0527
27+40	8	0.0055	7	0.0051
27+41	10	0.0068	12	0.0088
27+44	22	0.0150	21	0.0154
28+29	9	0.0061	12	0.0088
28+30	84	0.0573	62	0.0454
28+31	0	0.0000	3	0.0022
28+32	18	0.0123	0	0.0000
28+33	78	0.0532	69	0.0505
28+34	49	0.0334	48	0.0352
28+36	9	0.0061	10	0.0073
28+37	31	0.0211	25	0.0183
28+38	10	0.0068	10	0.0073
28+39	61	0.0416	12	0.0088
28+40	11	0.0075	7	0.0051
28+41	18	0.0123	12	0.0088
28+44	25	0.0171	21	0.0154
29+30	89	0.0607	64	0.0469
29+31	5	0.0034	8	0.0059
29+32	14	0.0095	11	0.0081
29+33	82	0.0559	70	0.0513
29+34	29	0.0198	30	0.0220
29+36	5	0.0034	7	0.0051
29+37	27	0.0184	22	0.0161
29+38	11	0.0075	11	0.0081
29+39	60	0.0409	74	0.0542
29+40	8	0.0055	7	0.0051
29+41	10	0.0068	15	0.0110
29+44	19	0.0130	22	0.0161
30+31	74	0.0505	57	0.0418
30+32	81	0.0553	57	0.0418
30+33	72	0.0491	57	0.0418
30+34	84	0.0573	62	0.0454
30+36	84	0.0573	62	0.0454
30+37	90	0.0614	60	0.0440

30+38	85	0.0580	62	0.0454
30+39	16	0.0109	19	0.0139
30+40	69	0.0471	54	0.0396
30+41	81	0.0553	59	0.0432
30+44	39	0.0266	35	0.0256
31+32	3	0.0020	3	0.0022
31+33	79	0.0539	76	0.0557
31+34	33	0.0225	41	0.0300
31+36	5	0.0034	6	0.0044
31+37	29	0.0198	19	0.0139
31+38	7	0.0048	8	0.0059
31+39	60	0.0409	74	0.0542
31+40	10	0.0068	18	0.0132
31+41	11	0.0075	13	0.0095
31+44	11	0.0075	8	0.0059
32+33	78	0.0532	69	0.0505
32+34	61	0.0416	62	0.0454
32+36	14	0.0095	10	0.0073
32+37	41	0.0280	35	0.0256
32+38	16	0.0109	11	0.0081
32+39	55	0.0375	68	0.0498
32+40	24	0.0164	25	0.0183
32+41	24	0.0164	23	0.0168
32+44	38	0.0259	33	0.0242
33+34	78	0.0532	69	0.0505
33+36	80	0.0546	69	0.0505
33+37	77	0.0525	72	0.0527
33+38	80	0.0546	69	0.0505
33+39	57	0.0389	69	0.0505
33+40	79	0.0539	70	0.0513
33+41	75	0.0512	82	0.0601
33+44	51	0.0348	49	0.0359
34+36	28	0.0191	28	0.0205
34+37	44	0.0300	46	0.0337
34+38	19	0.0130	22	0.0161
34+39	60	0.0409	74	0.0542
34+40	33	0.0225	44	0.0322
34+41	35	0.0239	50	0.0366
34+44	56	0.0382	59	0.0432
36+37	27	0.0184	22	0.0161
36+38	11	0.0075	9	0.0066
36+39	60	0.0409	72	0.0527
36+40	8	0.0055	7	0.0051
36+41	10	0.0068	12	0.0088

36+44	17	0.0116	20	0.0147
37+38	26	0.0177	20	0.0147
37+39	40	0.0273	30	0.0220
37+40	41	0.0280	39	0.0286
37+41	22	0.0150	17	0.0125
37+44	49	0.0334	20	0.0147
38+39	62	0.0423	75	0.0549
38+40	14	0.0095	12	0.0088
38+41	16	0.0109	26	0.0190
38+44	23	0.0157	14	0.0103
39+40	54	0.0368	69	0.0505
39+41	38	0.0259	60	0.0440
39+44	60	0.0409	74	0.0542
40+41	17	0.0116	16	0.0117
40+44	32	0.0218	31	0.0227
41+44	37	0.0252	29	0.0212

Notes: Please refer to Table S1 for the specific names of the enzymes corresponding to each number.

Table S5. Box-Behnken design and experimental results of response surface methodology.

Run	X ₁ (substrate concentration/%)	X ₂ (enzyme-substrate ratio/‰)	X ₃ (time/h)	Y (umami score)	Calculated umami score	Relative error (%)
1	7	3	2	6.22	6.27	0.80
2	9	3	1	5.82	5.85	0.60
3	7	2	3	5.68	5.69	0.26
4	7	3	2	6.23	6.27	0.64
5	9	3	3	5.53	5.51	0.27
6	7	3	2	6.25	6.27	0.32
7	7	2	1	5.46	5.42	0.64
8	5	3	1	5.34	5.35	0.28
9	7	3	2	6.26	6.27	0.16
10	7	4	3	5.54	5.57	0.63
11	9	4	2	5.98	5.96	0.33
12	5	3	3	5.68	5.64	0.62
13	5	2	2	5.58	5.60	0.36
14	5	4	2	5.69	5.69	<0.01
15	9	2	2	5.70	5.70	<0.01
16	7	3	2	6.39	6.27	1.88
17	7	4	1	5.91	5.89	0.25

Table S6. ANOVA for response surface quadratic model: estimated regression model of the relationship between dependent variables and independent variables.

Source	Sum of squares	df	Mean square	F-Value	P-Value	Significant
Model	1.68	9	0.1871	51.17	<0.0001	**
X ₁ -substrate concentration	0.0685	1	0.0685	18.72	0.0035	**
X ₂ -enzyme addition	0.0613	1	0.0613	16.75	0.0046	**
X ₃ -time	0.0012	1	0.0012	0.3418	0.5771	
X ₁ X ₂	0.0072	1	0.0072	1.98	0.2027	
X ₁ X ₃	0.0992	1	0.0992	27.13	0.0012	**
X ₂ X ₃	0.0870	1	0.0870	23.80	0.0018	**
X ₁ ²	0.3633	1	0.3633	99.35	<0.0001	**
X ₂ ²	0.2400	1	0.2400	65.63	<0.0001	**
X ₃ ²	0.6201	1	0.6201	169.55	<0.0001	**
Residual	0.0256	7	0.0037			
Lack of Fit	0.0066	3	0.0022	0.4632	0.7234	
Pure Error	0.0190	4	0.0047			
Cor Total	1.71	16				