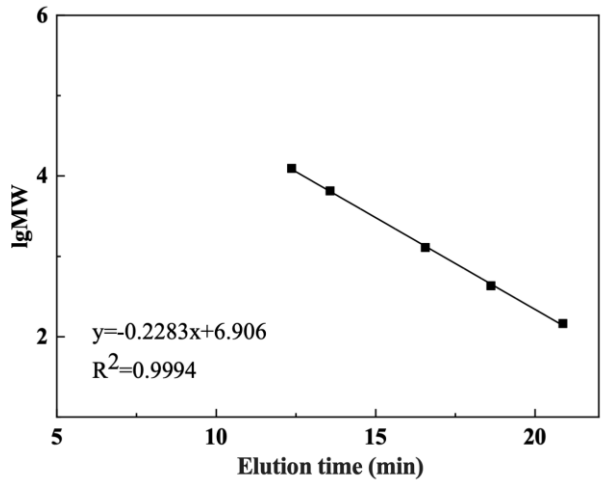
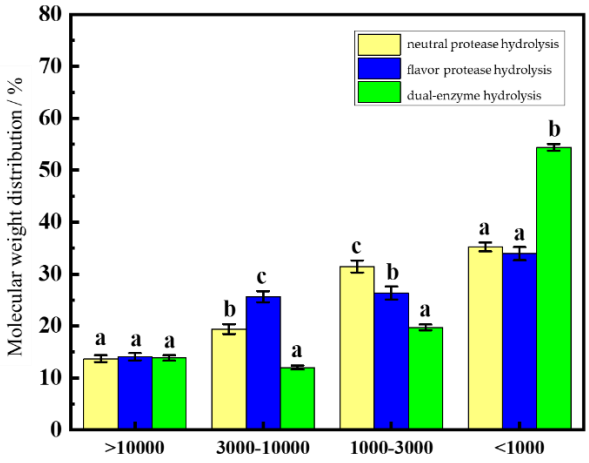



(A)




(B)

**Supplementary Figure S1.** (A) Standard curve for determining the molecular weight distribution of peptides by gel permeation chromatography, (B)The molecular weight distribution of peptides enzymatic hydrolysates after neutral protease, flavor protease, and dual-enzyme hydrolysis. (Lowercase letters in the figure indicate significant differences ($p$<0.05) in the molecular weight of enzymatic hydrolysates from different enzymes.)

**Supplementary Table S1.** Amino Acid Content of High F-Value Oligopeptides

| Amino Acid | Content (mg/mL) | |
|---|---|---|
| | **Before adsorption** | **After adsorption** |
| Essential amino acid | | |
| Thr | 3.633±0.151 | 2.450±0.229 |
| Lys | 1.945±0.218 | 1.760±0.096 |
| Met | 0.344±0.016 | 0.255±0.020 |
| Phe○ | 1.209±0.079* | 0.275±0.007* |
| Ile# | 2.904±0.157 | 2.180±0.256 |
| Leu# | 2.953±0.074 | 2.913±0.085 |
| His | 0.711±0.025 | 0.578±0.040 |
| Tyr○ | 2.498±0.115* | 0.057±0.001* |
| Val# | 2.783±0.136 | 2.652±0.108 |
| Cys | 0.455±0.036 | 0.273±0.052 |
| Non-essential amino acid | | |
| Ser | 1.760±0.020 | 1.100±0.131 |
| Arg | 1.208±0.201 | 1.073±0.079 |
| Asp | 3.425±0.055 | 2.012±0.147 |
| Gly | 1.572±0.024 | 1.346±0.289 |
| Glu | 4.008±0.052 | 3.442±0.222 |
| Ala | 4.113±0.457 | 2.768±0.168 |
| Pro | 1.906±0.277 | 1.241±0.064 |
| Total (Essential + Non-essential) | 37.426±2.093 | 26.375±1.993 |
| Branched-chain amino acids (BCAAs) and aromatic amino acids (AAAs) | | |
| #BCAAs | 8.640±0.367 | 7.745±0.449 |
| ○AAAs | 3.707±0.194 | 0.332±0.008 |

**Supplementary Table S2.** Amino acid sequence of high F-value oligopeptides after activated carbon adsorption

| No. | Sequence | No. | Sequence | No. | Sequence |
|---|---|---|---|---|---|
| 1 | TPEKNFGY | 104 | VPVILVGNK | 206 | DSLDLPH |
| 2 | DPPEQPGKP | 105 | IDLGDIKE | 207 | GLRL |
| 3 | NPPLIPKL | 106 | EELAKTQF | 208 | GIRL |
| 4 | TPPAPPDE | 107 | ADPVRTEP | 209 | GLRI |
| 5 | LPIGHLLSN | 108 | APTEIEK | 210 | TVPPAAVP |
| 6 | SGSSLHIGD | 109 | MDLNTRY | 211 | YPLPGDLKA |
| 7 | GPADVYKY | 110 | EFEAIKT | 212 | GLFEPSH |
| 8 | GTEVAVLGH | 111 | IPDWKP | 213 | VPLLEGKL |
| 9 | DDAPRAVFP | 112 | EDGEKVLE | 214 | ESLREP |
| 10 | APEEHPVL | 113 | DDFKGF | 215 | GEADKGLQF |
| 11 | PAPPPPPPP | 114 | LPIGHLLS | 216 | IPDEIRDS |
| 12 | VPVFINH | 115 | DHIPGSP | 217 | NRVV |
| 13 | GLDFTGVRN | 116 | NELRVAP | 218 | NDKDVPGSP |
| 14 | APSDKVSY | 117 | APSIIPLLQ | 219 | GQKGVLLP |
| 15 | DPLGLPGRP | 118 | VDLEPGTMD | 220 | DGYKW |
| 16 | EAGIKGIFQ | 119 | DDTRIVL | 221 | GQEQKYSQ |
| 17 | DVESLTKF | 120 | EEPPVVE | 222 | DTRF |
| 18 | SDEFVAAMD | 121 | GGDELPPTP | 223 | DELHLN |
| 19 | NPEALMPKS | 122 | ERELPVA | 224 | EAPLNPKAN |
| 20 | DLTSLKAEN | 123 | YGLVIKS | 225 | WPLYK |
| 21 | GDEGRPGP | 124 | EPPVVEV | 226 | TPNLERLA |
| 22 | DESGPSIVH | 125 | GVIHVID | 227 | EGKVIE |
| 23 | DSVIGNADY | 126 | DELMIEK | 228 | RDLTDY |
| 24 | DEGRPGP | 127 | SEFEAIK | 229 | VPLITK |
| 25 | DHTPGDPVP | 128 | DEAKIAL | 230 | QALEKLF |
| 26 | GPPVETPEP | 129 | LPVQLQR | 231 | EQYFKT |
| 27 | DDPSIPKT | 130 | DHDLVLDM | 232 | VPSVLK |
| 28 | LPTIPIHP | 131 | GYALPH | 233 | ELHL |
| 29 | DGQVITIGN | 132 | PVPPPPPP | 234 | AVGMLAGP |
| 30 | GSSLHIGD | 133 | PSIPKT | 235 | LVPR |
| 31 | DLISLVSKT | 134 | GDVNIKPL | 236 | PGKPEF |

| | | | | | |
|---|---|---|---|---|---|
| 32 | TEAPLNPKA | 135 | EQYFKT | 237 | ELFAALQ |
| 33 | ADIAEESLK | 136 | YDPNALR | 238 | EDGELRF |
| 34 | DMKVFSKP | 137 | YPPPLARF | 239 | DLTSLKA |
| 35 | ESLREPSTA | 138 | APGKGILAA | 240 | DGIRY |
| 36 | SPHVAGAAA | 139 | DPPRIDD | 241 | DGLRY |
| 37 | MPGERQY | 140 | RPSVNF | 242 | LPGNKYG |
| 38 | GDLERAYL | 141 | VPISGFHGD | 243 | ELFK |
| 39 | EPPNQSPTE | 142 | DKPDPSY | 244 | DLTSLKAE |
| 40 | APLNPKA | 143 | DGYKWIA | 245 | IPLK |
| 41 | FPEYPKN | 144 | ETLDGLAKT | 246 | LPLK |
| 42 | DEYGKIAG | 145 | TSCSPGGL | 247 | DVRY |
| 43 | ADSKIIPLN | 146 | IDLVEIKT | 248 | DDRAPSPTP |
| 44 | ADGGLIGHL | 147 | GVKAFP | 249 | DHDLVL |
| 45 | DDEFDIKT | 148 | DIPDEIRD | 250 | TPNDIVKG |
| 46 | SDPVAIQQ | 149 | TDYLMK | 251 | APPLKLN |
| 47 | SPVATLISK | 150 | VPFFMR | 252 | TPLHLAA |
| 48 | SEFEAIKT | 151 | APRAVF | 253 | GEDHIPGSP |
| 49 | APLNPKAN | 152 | VPSPKVSD | 254 | APLNPK |
| 50 | GERGPSGP | 153 | LPFEVRQ | 255 | GEAHNVFP |
| 51 | NPYTVKV | 154 | DGLRIDT | 256 | ILSAPR |
| 52 | DEGRPGPT | 155 | EIFIGGR | 257 | EKFPPP |
| 53 | TPDGKPVQP | 156 | QLEKLFE | 258 | LPIGH |
| 54 | DPWGVKV | 157 | NPIWLSPT | 259 | DLWR |
| 55 | STPEKNF | 158 | FPEYPK | 260 | GVHIPT |
| 56 | GVIPDWKP | 159 | APPERP | 261 | EFRQLN |
| 57 | GIHETTYN | 160 | QDFIELLN | 262 | DGPKL |
| 58 | ADQEIPGSP | 161 | VDKAMI | 263 | DGPKI |
| 59 | YDELHLN | 162 | DSINKEF | 264 | LEKLF |
| 60 | ESLREPST | 163 | DPSIPKT | 265 | DSLSILH |
| 61 | SPPEYFA | 164 | LPIGHLL | 266 | MDHDLVL |
| 62 | SYLIGTAKF | 165 | GPLTVLK | 267 | EVLK |
| 63 | DPVLIPKL | 166 | VPSPKVS | 268 | LPGNKY |
| 64 | EWSDRLP | 167 | KTLP | 269 | EDNLTFK |
| 65 | EDHIPGSP | 168 | YDEKFA | 270 | DSLRF |
| 66 | GDLPGKDAP | 169 | ADSLSILH | 271 | EPPIVDVNT |

| | | | | | |
|---|---|---|---|---|---|
| 67 | SPGLKIQP | 170 | IPNNVKT | 272 | QSCSAGLF |
| 68 | VPLPGFDK | 171 | DSLGSHSDP | 273 | APPTMKI |
| 69 | EHLLQGPE | 172 | QGIRGPSGP | 274 | DPKDPL |
| 70 | SEIDLGDIK | 173 | DEPEDPPP | 275 | ELIR |
| 71 | GSQDEPLKL | 174 | EQGPPGEPG | 276 | ELLR |
| 72 | TPEKNF | 175 | PPIICA | 277 | EILR |
| 73 | LPKMGQ | 176 | TPKNLF | 278 | TRLGLGF |
| 74 | VPNFHLP | 177 | AGNDFQLQP | 279 | APALF |
| 75 | APRAVFP | 178 | ERPYYGP | 280 | IPDKI |
| 76 | EGRPGPTGP | 179 | EYFK | 281 | EVDDEGDE |
| 77 | EELGITIGN | 180 | LPIGHL | 282 | LPGYKLPE |
| 78 | EQYFKTT | 181 | DYFHP | 283 | YDMKVF |
| 79 | DGPDKIP | 182 | DKDVPGSP | 284 | SPEIQEKL |
| 80 | PAPPPPPP | 183 | DPQGLPNRP | 285 | GGKFDP |
| 81 | VPNFH | 184 | MPRP | 286 | EKVLE |
| 82 | DEPPIVD | 185 | DLAALEK | 287 | QIDENLR |
| 83 | SSLHIGD | 186 | EPPPSKP | 288 | TVMCCAP |
| 84 | GPGAIIKLN | 187 | KTVI | 289 | VGSFSSPNY |
| 85 | APPTMK | 188 | KTVL | 290 | DDINLH |
| 86 | GDVNIKP | 189 | DSIRPTE | 291 | QETNINNL |
| 87 | EQYFKTT | 190 | SRLF | 292 | EIEYKP |
| 88 | NEPVKQF | 191 | SRIF | 293 | GPQGPPGP |
| 89 | YPLPGDLK | 192 | TVGPGSAAY | 294 | IPRIGS |
| 90 | DEKAIINV | 193 | VPFPRL | 295 | SPYVKL |
| 91 | DDPSIPK | 194 | DHDLVLD | 296 | EPQNPVSL |
| 92 | GTIPEQDP | 195 | PPVSF | 297 | ETRFE |
| 93 | APETVKL | 196 | ENPPVVT | 298 | LPLVKE |
| 94 | DDGIVRY | 197 | TKIP | 299 | DLRF |
| 95 | TPLGLVK | 198 | TPTIEGTFD | 300 | IPVIDK |
| 96 | DSLRFGAS | 199 | DVASTMGAM | 301 | GLVPLDK |
| 97 | GIKGIFQ | 200 | TPKNTP | 302 | QPPTVVP |
| 98 | QDPVERVP | 201 | KDFVVDP | 303 | PHAI |
| 99 | EFPEYPK | 202 | DPSIPK | 304 | ELHIGD |
| 100 | NPITYFG | 203 | DLDIYH | 305 | IPPPPPP |
| 101 | DHLIQLD | 204 | DEPFPPEE | 306 | GLFR |

| | | | | | |
|---|---|---|---|---|---|
| 102 | VPVTVVKE | 205 | GEDTKVV | 307 | GIFR |
| 103 | APHTWTF | | | | |

**Supplementary Table S3.** Effect of HFO on Body Weight of Mice

| Groups | Body Weight (g) | | | |
|---|---|---|---|---|
| | **7d** | **14d** | **21d** | **28d** |
| Blank | 21.18±0.37 | 22.51±0.43 | 23.49±0.36 | 25.52±0.42 |
| Control | 21.23±0.37* | 22.35±0.50* | 23.55±0.42* | 25.45±0.45* |
| HFO-L | 21.28±0.37* | 22.46±0.48* | 23.41±0.44* | 25.44±0.42* |
| HFO-M | 21.24±0.42* | 22.39±0.42* | 23.55±0.38* | 25.60±0.41* |
| HFO-H | 21.25±0.33* | 22.41±0.40* | 23.73±0.39* | 25.23±0.56* |

* No significant difference compared to the control group, $p<0.05$

**Supplementary Table S4.** Effect of HFO on Organ Index of Mice

| Groups | Organ Index (mg/g) | | | | |
|---|---|---|---|---|---|
| | Heart | Liver | Spleen | Lung | Kidney |
| Blank | 5.33±0.83 | 43.40±3.12 | 4.72±0.75 | 35.30±1.47 | 14.66±0.88 |
| Control | 5.38±0.47* | 43.73±2.91* | 4.66±0.74* | 35.26±1.16* | 14.96±1.00* |
| HFO-L | 5.30±0.54* | 42.79±2.87* | 4.27±1.25* | 34.79±1.24* | 14.81±0.86* |
| HFO-M | 5.78±0.61* | 41.20±2.13* | 3.96±0.67* | 35.41±1.19* | 14.89±0.66* |
| HFO-H | 5.52±0.49* | 43.18±2.62* | 4.44±0.70* | 35.68±1.62* | 14.71±0.94* |

* No significant difference compared to the control group, $p<0.05$