nanomaterials

MDPI

Supplementary Materials

# Comparison of Different Protein Emulsifiers on Physicochemical Properties of β-Carotene-Loaded Nanoemulsion: Effect on Formation, Stability, and In Vitro Digestion

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**Table S1.** The mean particle size (nm) in different digestion stage of the PPI-, SPI-, RBPI-, and WPI-stabilized nanoemulsions.

| | PPI-β-ct-NE | SPI-β-ct-NE | RBPI-β-ct-NE | WPI-β-ct-NE |
|---|---|---|---|---|
| Initial | 238.95 ± 1.77 | 251.40 ± 1.13 | 278.40 ± 3.25 | 263.70±3.11 |
| Oral | 444.45 ± 0.64 | 282.40 ± 9.48 | 301.45 ± 5.87 | 281.35 ± 3.61 |
| Gastric | 7528.5 ± 246.78 | 409.05 ± 8.41 | 642.25 ± 12.09 | 284.45 ± 1.06 |
| Small Intestine | 254.8 ± 2.69 | 587.5 ± 30.12 | 876.45 ± 16.33 | 381.6 ± 15.41 |

**Table S2.** The zeta-potential (mV) in different digestion stage of the PPI-, SPI-, RBPI-, and WPI-stabilized nanoemulsions.

| | PPI-β-ct-NE | SPI-β-ct-NE | RBPI-β-ct-NE | WPI-β-ct-NE |
|---|---|---|---|---|
| Initial | –40.13 ± 1.02 | –36.40 ± 0.69 | –28.93 ± 1.16 | –33.10 ± 1.04 |
| Oral | –38.20 ± 1.69 | –35.17 ± 1.55 | –26.27 ± 1.10 | –31.17 ± 0.74 |
| Gastric | –8.04 ± 0.15 | –24.13 ± 1.30 | –15.23 ± 1.72 | –25.57 ± 1.89 |
| Small Intestine | –53.13 ± 0.85 | –38.97 ± 0.55 | –37.30 ± 2.98 | –35.87 ± 0.42 |

**Table S3.** The POV values (mg/kg oil) in different days of the PPI-, SPI-, RBPI-, and WPI-stabilized nanoemulsions.

| POV | PPI-β-ct-NE | SPI-β-ct-NE | RBPI-β-ct-NE | WPI-β-ct-NE | Blank |
|---|---|---|---|---|---|
| Day 0 | 0.358 ± 0.005 | 0.356 ± 0.005 | 0.352 ± 0.002 | 0.356 ± 0.004 | 0.355 ± 0.004 |
| Day 2 | 0.388 ± 0.033 | 0.423 ± 0.016 | 0.443 ± 0.049 | 0.413 ± 0.019 | 0.877 ± 0.025 |
| Day 4 | 0.456 ± 0.028 | 0.551 ± 0.015 | 0.623 ± 0.031 | 0.498 ± 0.023 | 1.454 ± 0.019 |
| Day 6 | 0.479 ± 0.008 | 0.655 ± 0.030 | 0.789 ± 0.021 | 0.632 ± 0.055 | 1.843 ± 0.019 |
| Day 8 | 0.540 ± 0.020 | 0.760 ± 0.013 | 0.974 ± 0.005 | 0.657 ± 0.033 | 2.189 ± 0.029 |
| Day 10 | 0.696 ± 0.017 | 1.012 ± 0.016 | 1.241 ± 0.009 | 0.764 ± 0.011 | 2.412 ± 0.004 |
| Day 12 | 0.742 ± 0.021 | 1.344 ± 0.039 | 1.412 ± 0.011 | 0.846 ± 0.032 | 2.820 ± 0.088 |
| Day 14 | 0.745 ± 0.004 | 1.422 ± 0.070 | 1.487 ± 0.040 | 0.854 ± 0.010 | 3.488 ± 0.144 |

**Table S4.** The TBARS values (mg malondialdehyde/kg oil) in different days of the PPI-, SPI-, RBPI-, and WPI-stabilized nanoemulsions.

| TBARS | PPI-β-ct-NE | SPI-β-ct-NE | RBPI-β-ct-NE | WPI-β-ct-NE | Blank |
|---|---|---|---|---|---|
| Day 0 | 0.851 ± 0.020 | 0.865 ± 0.016 | 0.859 ± 0.012 | 0.862 ± 0.013 | 0.854 ± 0.020 |
| Day 2 | 0.877 ± 0.010 | 1.272 ± 0.015 | 1.306 ± 0.025 | 1.125 ± 0.046 | 2.327 ± 0.099 |
| Day 4 | 0.896 ± 0.015 | 1.794 ± 0.047 | 1.868 ± 0.029 | 1.166 ± 0.040 | 3.481 ± 0.121 |
| Day 6 | 0.972 ± 0.017 | 1.817 ± 0.021 | 1.932 ± 0.031 | 1.249 ± 0.027 | 4.474 ± 0.081 |
| Day 8 | 1.045 ± 0.025 | 1.918 ± 0.015 | 2.167 ± 0.033 | 1.265 ± 0.033 | 4.991 ± 0.116 |
| Day 10 | 1.092 ± 0.029 | 1.979 ± 0.037 | 2.224 ± 0.044 | 1.309 ± 0.049 | 5.904 ± 0.124 |
| Day 12 | 1.105 ± 0.017 | 2.351 ± 0.093 | 2.506 ± 0.030 | 1.327 ± 0.061 | 6.260 ± 0.166 |
| Day 14 | 1.109 ± 0.061 | 2.461 ± 0.079 | 2.859 ± 0.079 | 1.370 ± 0.082 | 7.389 ± 0.141 |

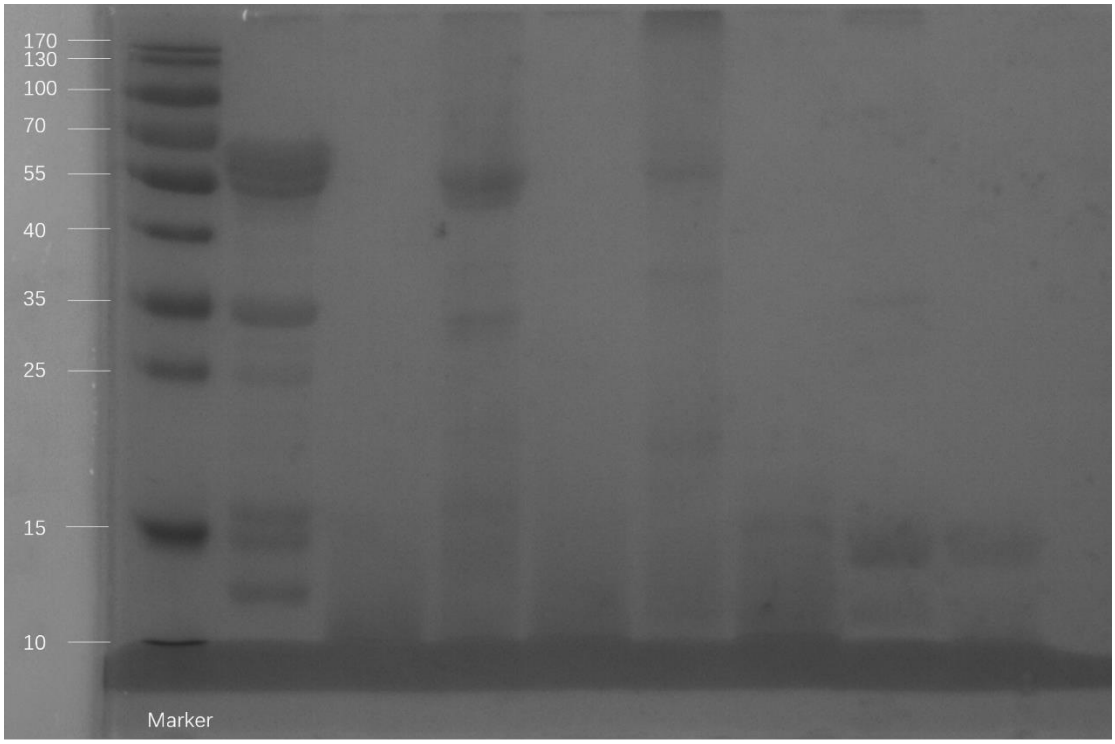
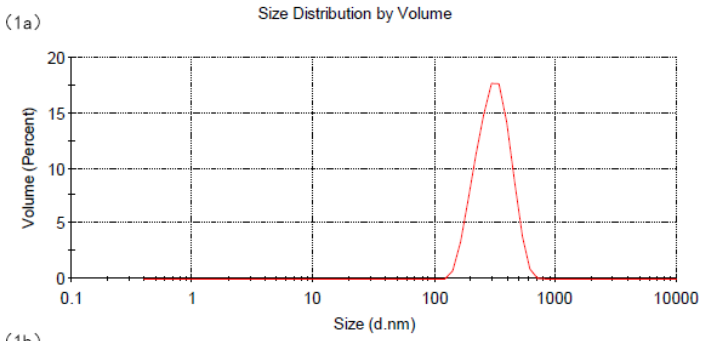



**Figure S1.** Sodium dodecylsulfate polyacrylamide gel electrophoresis (SDS-PAGE) of PPI, SPI, RBPI and WPI after gastric digestionFrom left to right, lane 1 and 2 are initial PPI sample and PPI sample after gastric digestion; lane 3 and 4 are initial SPI sample and SPI sample after gastric digestion; lane 5 and 6 are initial RBPI sample and BPI sample after gastric digestion; lane 7 and 8 are initial WPI sample and WPI sample after gastric digestion.

（1a）


Size Distribution by Volume
Volume (Percent)
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5
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0.1
1
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100
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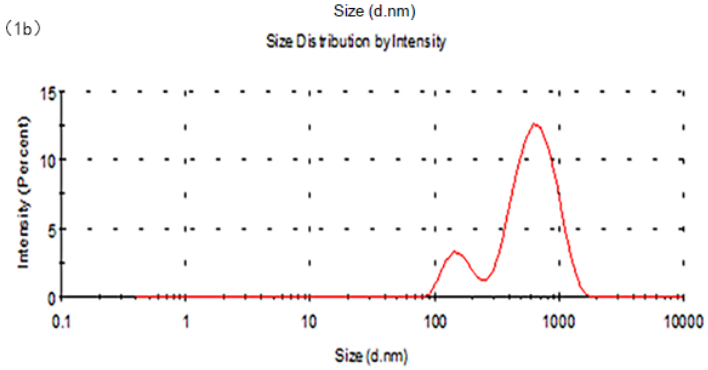
10000
Size (d.nm)

（1b）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Intensity (Percent)
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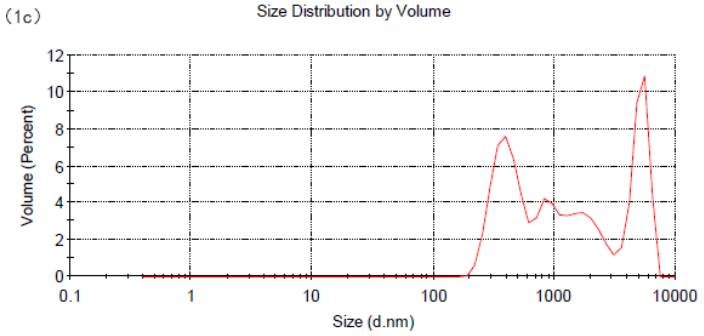
Size (d.nm)

（1c）


Size Distribution by Volume
Volume (Percent)
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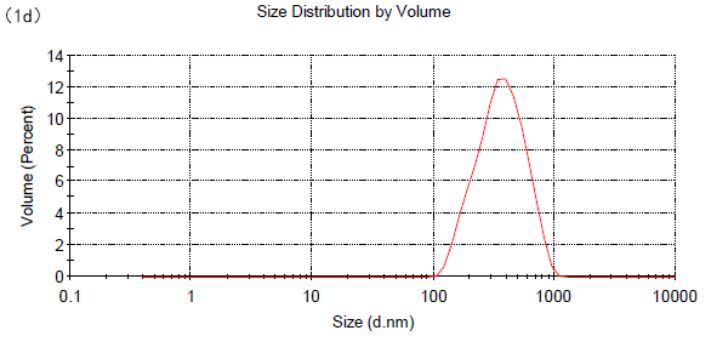
Size (d.nm)

（1d）


Size Distribution by Volume
Volume (Percent)
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1000
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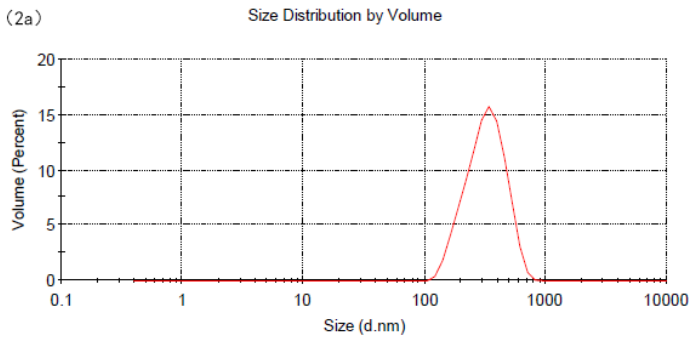
Size (d.nm)

（2a）


Size Distribution by Volume
Volume (Percent)
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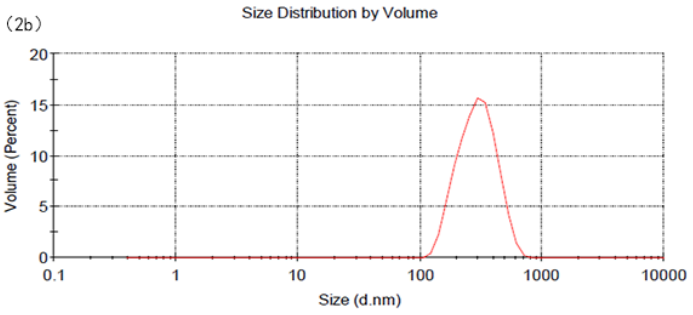
10000
Size (d.nm)

（2b）


Size Distribution by Volume
Volume (Percent)
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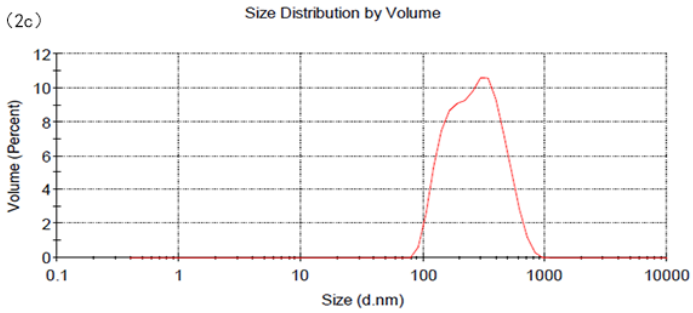
Size (d.nm)

（2c）


Size Distribution by Volume
Volume (Percent)
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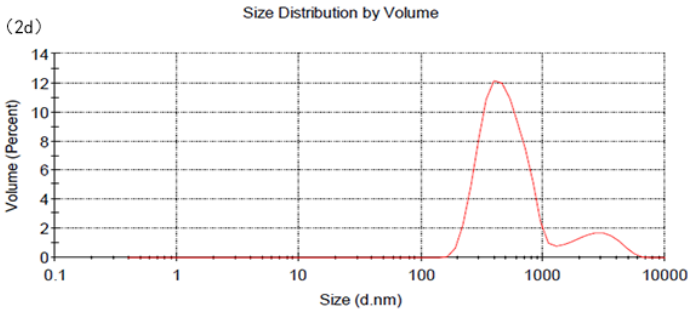
Size (d.nm)

（2d）


Size Distribution by Volume
Volume (Percent)
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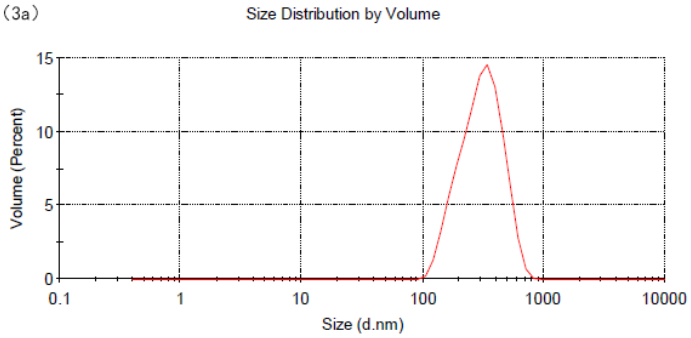
1000
10000
Size (d.nm)

（3a）


Size Distribution by Volume
Volume (Percent)
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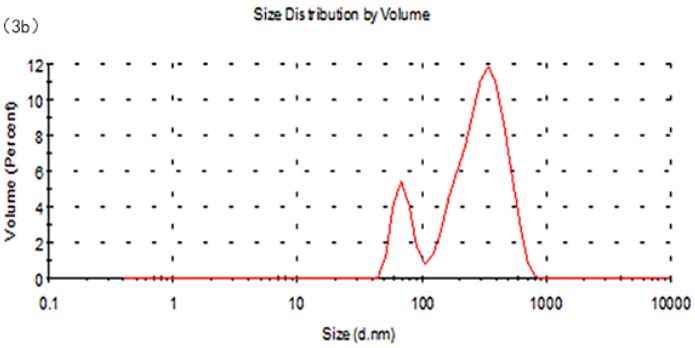
Size (d.nm)

（3b）


Size Distribution by Volume
Volume (Percent)
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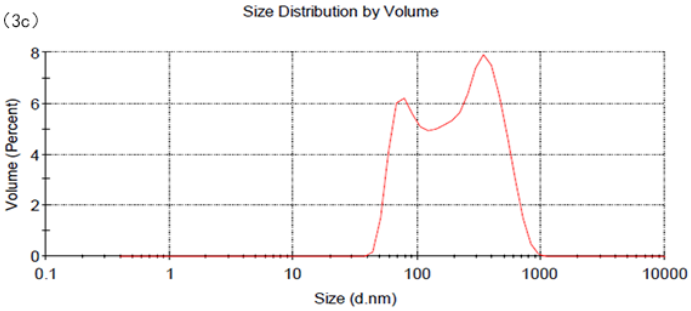
10000
Size (d.nm)

（3c）


Size Distribution by Volume
Volume (Percent)
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4
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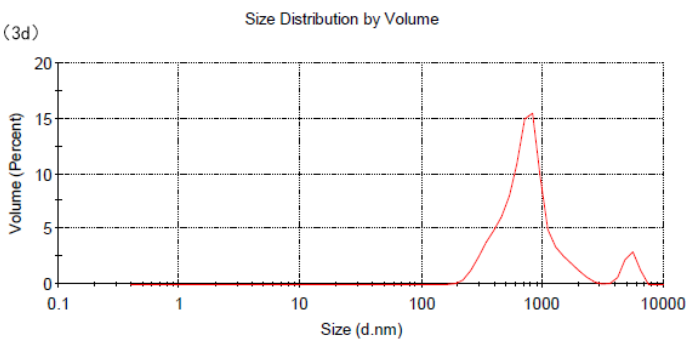
Size (d.nm)

（3d）


Size Distribution by Volume
Volume (Percent)
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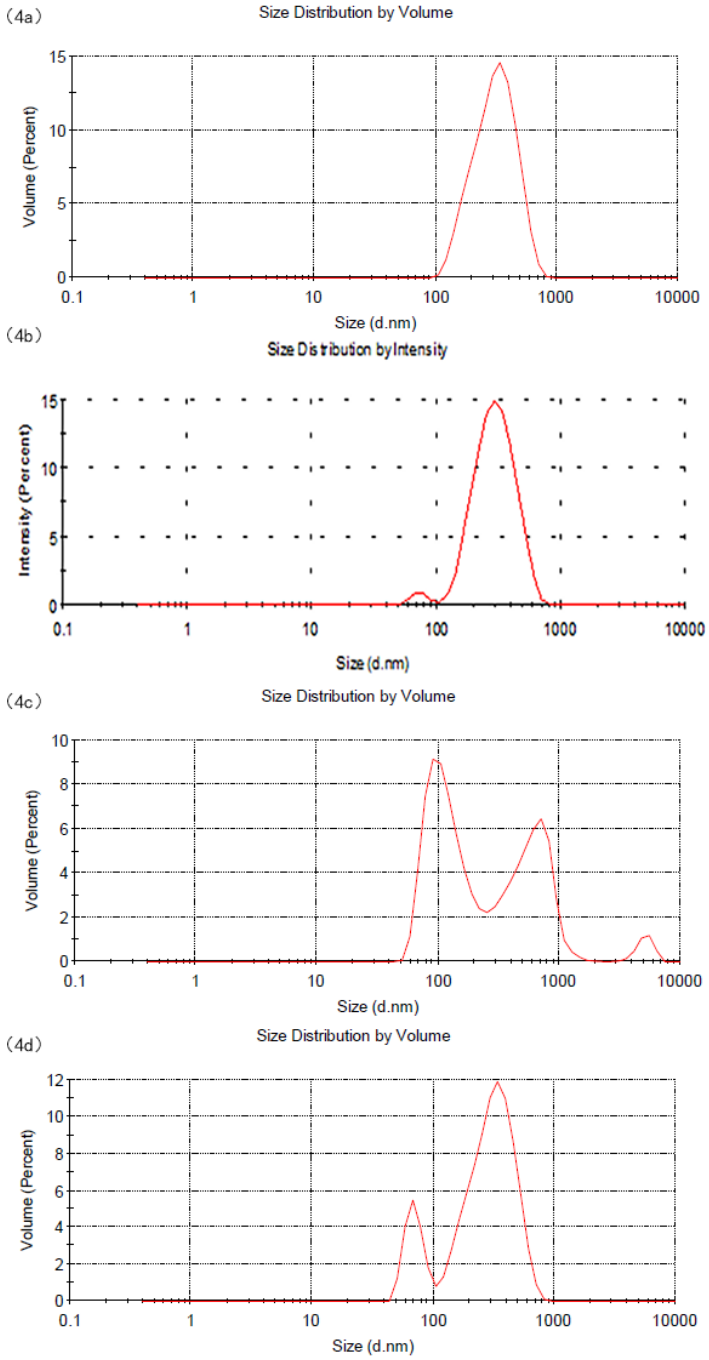


**Figure S2.** The PDI of PPI-, SPI-, RBPI-, and WPI-stabilized nanoemulsions in different digestion phases. **1–4** show the nanostructures of PPI-, SPI-, RBPI- and WPI-stabilized nanoemulsions, respectively. **a–d** show the nanostructures of nanoemulsions in initial, oral, gastric, and small intestine phases, respectively.