

**Table S2.** Microencapsulation techniques and properties of encapsulated carotenoids.

| Carotenoid                | Emulsion composition  | Method and conditions   | Wall material  | [EA]                       | Particle size (µm)   | EE (%)  | Storage conditions                                | Carotenoid retention after storage (%)      | Reference |
|---------------------------|---|---|--|----------------------------|--|---|---|---|-----------|
| Astaxanthin               | Flaxseed oil (10%), SC (10%), lactose (10%) and water (70%) | Spray drying at 180 °C  | SC-lactose (1:1)   | NR                         | 6 to 100   | 86.06 ± 1.44  | 26 days at 5, 25 and 40 °C                        | 73.83 (5°C)<br>60.17 (25°C)<br>47.09 (40°C) | [87]      |
| Astaxanthin               | Sunflower oil and EA solution (1:4)                         | Spray drying at 160, 170 and 180 °C   | SCF-WPI (1:1)<br>SCF-SC (1:1)                                      | 30%<br>30%                 | NR<br>NR   | ~ 95.00   | NR  | NR  | [88]      |
| α-carotene and β-carotene | Rapeseed oil (5%), EA (30%) and water (65%)                 | Spray drying at 190 °C  | GA-MD (1:1)  | 30%                        | NR   | 59.40   | 12 weeks at 20°C without access to daylight       | 54.20                                       | [89]      |
| β-carotene                | Oil (10%), EA (25%) and water (65%)                         | Spray drying at 190 °C  | GA-MD-MS (1:1:1)   | 25%                        | NR   | 88.60 ± 0.40  | 64 days at 20°C under daylight                    | 75.70                                       | [90]      |
| β-carotene                | β-carotene (0.05%) and GA solution (99.95%)                 | Spray drying at 170 °C<br>Drum drying at 140 °C<br>Freeze drying                  | MD   | 40%                        | 30 ± 10<br>105 ± 15<br>80 ± 25                                   | 38.00 ± 2.00 <sup>a</sup><br>66.00 ± 2.00 <sup>a</sup><br>50.00 ± 2.00 <sup>a</sup> | 15 weeks at 25, 35 and 45 °C and RH of 11 and 32% | ~ 27.00<br>> 47.00<br>~ 38.00               | [91]      |
| β-carotene                | Dichloromethane (carotenoids) and EA solutions              | Spray drying at 170 °C  | GA   | 20%                        | 10.7 ± 0.2   | 99.00   | NR  | NR  | [92]      |
| Apo-8'-carotenal          |   |   | MD   | 20%                        | 7.1 ± 0.1  | 63.90   |   |   |           |
|                           |   |   | GA   | 20%                        | 9.4 ± 0.1  | 96.60   |   |   |           |
|                           |   |   | MD   | 20%                        | 6.4 ± 0.1  | 75.70   |   |   |           |
|                           |   |   | GA   | 20%                        | 8.9 ± 0.1  | 94.90   |   |   |           |
| Apo-12'-carotenal         |   |   | MD   | 20%                        | 7.4 ± 0.2  | 92.80   |   |   |           |
| β-carotene                | Soya oil (1%), EA solution (99%)                            | Complex coacervation and freeze drying  | CA-GG (1:0.05)<br>CA-GG (1:0.1)<br>CA-GG (1:0.25)<br>CA-GG (1:0.5) | NR<br>NR<br>NR<br>NR       | 170.76 ± 4.87<br>180.43 ± 3.09<br>165.83 ± 5.93<br>176.47 ± 4.65 | 57.05 ± 6.64<br>62.60 ± 3.68<br>63.16 ± 1.04<br>65.95 ± 5.33                        | Intense exposure to UV rays for 5 days            | NR  | [74]      |
| β-carotene and lutein     | Sunflower oil, WPI solution and EA solution                 | Spray drying of SL emulsions at 185 °C<br>Spray drying of LBL emulsions at 185 °C | Trehalose-MD (1:1)<br>Trehalose-MD (1:1) and GA                    | 57.14%<br>57.14% and 2.91% | 92.27 ± 0.64<br>107.30 ± 0.40                                    | NR<br>NR  | 92 days at 25, 45 and 65 °C                       | NR  | [93]      |
|                           | Same composition as SL and LBL emulsions                    | Freeze drying   | Same composition as SL and LBL emulsions                           | -                          | NR   | NR  |   |   |           |
|                           | Banana passion fruit ( <i>Passiflora mollissima</i> )       | -   | Spray drying at 120 °C   | MD                         | 3%   | NR  |   |   |           |

|   |   |  |                                    |                  |              |                           |   |   |       |
|---|---|--|------------------------------------|------------------|--------------|---------------------------|---|---|-------|
| Bixin   | Annatto extract and EA (1:4)                                      | Spray drying at 180 °C                   | GA-MD (1:1)                        | NR               | NR           | 75.69                     | 18 days at 25°C under ligh and dark conditions              | NR  | [95]  |
| Canthaxanthin                                   | Corn oil and EA solution (1:4)                                    | Spray drying at 170 °C                   | SSPS                               | 10%              | 7.94 ± 0.14  | 90.30 ± 0.70              | 16 weeks at 4, 25 and 45 °C under light and dark conditions | 75(D) and 58(L) at 25°C<br>95(D) and 88(L) at 4°C | [96]  |
|   |   |  | GA                                 | 10%              | 9.08 ± 0.07  | 86.90 ± 0.30              |   | 72(D) and 53(L) at 25°C<br>93(D) and 86(L) at 4°C |       |
|   |   |  | MD                                 | 10%              | 10.42 ± 0.14 | 73.50 ± 0.60              |   | 57(D) and 26(L) at 25°C<br>84(D) and 74(L) at 4°C |       |
| Lutein  | Ethanol (lutein 10%), soybean phospholid and EA solution          | Spray drying at 170 °C                   | Gelatin-starch (1:8)               | 1:10             | NR           | 62.00 – 94.40             | 30 days at room temperature under daylight                  | > 32.20   | [97]  |
|   |   | Spray drying at 180 °C                   |                                    | 1:20             | NR           |                           |   |   |       |
|   |   | Spray drying at 190 °C                   |                                    | 1:30             | NR           |                           |   |   |       |
| Lutein and zeaxanthin                           | -   | Inclusion complex                        | Glycyrrhizic acid and AG           | NR               | NR           | NR                        | NR  | NR  | [98]  |
| Lutein from <i>Tagetes erecta</i>               | Sunflower oil, SC, inulin and water                               | Spray-drying at 140, 160 and 180 °C      | Inulin                             | 1:1, 1:2 and 1:3 | NR           | 78.00 – 86.40             | NR  | NR  | [86]  |
| Lycopene  | Acetone (lycopene) and EA solution                                | Spray drying at 170, 180, 190 and 210 °C | Gelatin-sucrose at multiple ratios | NR               | NR           | 12.10 – 82.20             | 4 weeks at 0°C  | NR  | [99]  |
| Lycopene  | Dichloromethane (lycopene) and EA solution                        | Spray-drying at 170 °C                   | GA-sucrose (8:2)                   | 20%              | NR           | 94.00 – 96.00             | NR  | NR  | [100] |
|   | Dichloromethane (lycopene) and β-CD solution with Tween 20 (0.2%) | Inclusion complex and freeze drying      | β-CD                               | 1:4              | NR           | ~ 50.00                   |   |   |       |
| Paprika oleoresin                               | Oleoresin and MS (1:4)  | Spray drying at 180 °C                   | MS                                 | 0.3 g/L          | NR           | NR                        | 35 days at 35°C and aw=0.108, 0.318, 0.515 and 0.743        | NR  | [101] |
| Petals of <i>Tropaeolum majus</i>               | Olive oil (carotenoids), SC, water and EA solution                | Spray-drying at 130 °C                   | MD                                 | 20%              | NR           | 54.82 ± 0.03 <sup>a</sup> | NR  | NR  | [102] |
|   |   |  | GA                                 | 20%              | NR           | 83.76 ± 0.06 <sup>a</sup> |   |   |       |
|   |   | Spray-drying at 150 °C                   | MD                                 | 20%              | NR           | 49.71 ± 0.08 <sup>a</sup> |   |   |       |
|   |   |  | GA                                 | 20%              | NR           | 74.10 ± 0.01 <sup>a</sup> |   |   |       |
|   |   | Spray-drying at 170 °C                   | MD                                 | 20%              | NR           | 45.16 ± 0.02 <sup>a</sup> |   |   |       |
|   |   |  | GA                                 | 20%              | NR           | 68.96 ± 0.02 <sup>a</sup> |   |   |       |
| Probiotic juice rich in lycopene and β-carotene | -   | Spray drying between 120 and 160 °C      | MD                                 | 10 to 15%        | NR           | NR                        | NR  | NR  | [103] |

AG: arabinogalactan. CA: Casein. EA: encapsulating agent. EE: encapsulation efficiency. GA: Arabic gum. GG: Guar gum. LBL: layer-by-layer. MD: maltodextrin. MS: modified starch. NR: not reported. SC: sodium caseinate. SCF: soluble corn fiber. SL: single layer. SSPS: soluble soybean polysaccharide. WPI: Whey protein isolate. β-CD: β-cyclodextrin. <sup>a</sup> Carotenoid retention (%).