Electronic Supplementary Information

The methods of STG purification

In brief, 50 mL the crude STG and 50 mL of n-hexane were mixed and passed through the column, and then washed through the column by eluting with 150 mL n-hexane. The order of column loading materials was alumina, silicic acid, diatomaceous earth, activated carbon and silica gel (v/v/v/v/v, 5:2:1:2:5). After, the mixtures were collected by using a vacuum rotary evaporator at 37 ^{o}C. According to the results of HPLC analysis, most of the by-products have been removed, and the purity of TAG content was above 97%. Then, the total TAG composition of purified STG was analyzed by using UPLC-Q-TOF-MS device (according to 2.3.2), and the purity reached 73.92%. According to the total FFA composition of purified STG, MCT/LCT was prepared by using high purity MCT and LCT (w/w, 1:3).

Reference

1. V. Cardenia, T. Waraho, M. T. Rodriguez-Estrada,D. J. Mcclements, E. A. Decker, Antioxidant and pro-oxidant activity behavior of phospholipids in stripped soybean oil-in-water emulsions. *J Am Oil Chem Soc*., 2011, **88**, 1409-1416.

Determination of total FFA composition of lipid digestion products

The total FFA composition of lipid digestion products were determined using previous methods with slight modifications.[1] First, the small intestine digestion products were kept at 100 ^{o}C for 10 min. 2ml of chloroform and 1 mL methyl alcohol solution were added into tubes and vortexed for 5 min. Subsequently, the tubes were centrifuged for 10 min at 4000 rpm, and the organic phase was collected, which was then extracted at 40 ^{o}C using rotary evaporator. The products were isolated using thin-layer chromatography. The developing solvent system consisted of n-hexane, ethyl ether, and acetic acid (50/50/1, v/v/v). One mL of 2,7-dichlorofluorescein ethanol solution was sprayed on the thin layer chromatography plates and measured at a wavelength of 245 nm. Finally, FFA strips were separated and extracted using n-hexane and ethyl ether solution (the ratio of 1:1). The extraction was repeated two times. The tubes were then centrifuged for 1 minute at 10000 rpm. Following that, the supernatant was collected and dried under a nitrogen atmosphere. Two milliliters of n-hexane were added as extracted solvent and vortexed for 3 minutes. After that, 4 mL of NaCl solution was added, followed by collecting the supernatant. Following that, 1 g of anhydrous sodium sulfate was added for removing water. Finally, the tubes were centrifuged for 5 min at 10000 rpm, and the supernatant was absorbed for GC analysis. The detailed GC analysis methodologies were produced based on our previous study.[2]

Reference

1. E. G. Bligh, W. J. Dyer, A rapid method of total lipid extraction and purification, *Can J Physiol Pharm*., **37**(8), 911-917.

2. X. S. Wang, C, Jiang, W. D. Xu, Z. C, Miu, Q. Z. Jin, X. G. Wang, Enzymatic synthesis of structured triacylglycerols rich in 1,3-dioleoyl-2-palmitoylglycerol and 1-oleoyl-2-palmitoyl-3-linoleoylglycerol in a solvent-free system, *LWT-Food Sci Technol.*, 2020, **118**, 108798.
3. Z. Z. Yang, W. H. Jin, X. Y. Cheng, Z. Dong, M. Chang, X. S. Wang, Enzymatic enrichment of n-3 polyunsaturated fatty acid glycerides by selective hydrolysis, *Food Chem*., 2021, **346**, 128743.

The methods of *in vitro* digestion assay

Initial phase: The VitD nanoemulsions were diluted 10 times with 5 mM phosphate buffered saline (pH=7). Gastric phase: Gastric digestion was accomplished by mixing the samples with simulated gastric fluid (SGF) at 1:1 ratio. After adjusting the pH of the resulting mixture to 2.5, the sample was stirred at 37 °C for 120 min. Small intestine phase: 60 mL of gastric phase products were added into a pH-stat automatic device (Hanon, T860) that maintained a constant pH of 7.0 by adding NaOH. Afterwards, 3 mL of simulated intestine fluid, 7 mL of bile salt mixture, and 5 mL of pancreatic lipase were added to the SGF-sample mixture. The final mixture was adjusted to pH 6.9995 to 6.999 (using 0.1 M NaOH) and incubated for 120 min at 37℃. During the 120 min digestion period, the automatic titration unit (Hanon T860, Shandong, China) with a pH-stat programming to keep the pH at 7 was used with NaOH (0.1 M) as the titrant solution for monitoring the FFA release rate.

Reference

1. A. Brodkorb, L. Egger, M. Alminger, P. Alvito, R. Assuncao, S. Ballance, T. Bohn, C. Bourlieu-Lacanal, R. Boutrou, F. Carriere, A. Clemente, M. Corredig, D. Dupont, C. Dufour, C. Edwards, M. Golding, S. Karakaya, B. Kirkhus, S. Le Feunteun, U. Lesmes, A. Macierzanka, A. R. Mackie, C. Martins, S. Marze, D. J. McClements, O. Menard, M. Minekus, R. Portmann, C. N. Santos, I. Souchon, R. P. Singh, G. E. Vegarud, M. S. J. Wickham, W. Weitschies, I. Recio, INFOGEST static in vitro simulation of gastrointestinal food digestion. *Nat Protoc.*, 2019, **14**, 991-1014.

The detailed compositions of different experimental diets

Component	Standard diet based in AIN-93M		VitD deficiency diet based in AIN-93M	
	gm%	kcal%	gm%	kcal%
Protein	14.2	14.7	14.2	14.7
Carbohydrate	73.1	75.9	73.1	75.9
Fat	4.0	9.4	4.0	9.4
Total	-	100.0	-	100.0
kcal/gm	3.85	-	3.85	-
Ingredient				
Casein, 30 Mesh	140	560	140	560
L-Cystine	1.8	7.2	1.8	7.2
Corn Starch	495.692	1983	495.692	1983
Maltodextrin	125	500	125	500
Sucrose	100	400	100	400
Cellulose	50	0	50	0
Soybean Oil	40	360	40	360
Mineral Mix S10022G	35	0	35	0
Vitamin Mix V10037	10	40	-	-
Vitamin Mix V10037(no Vit D)	-	-	10	40
Choline Bitartrate	2.5	0	2.5	0
Total	**1000**	**3850**	**1000**	**3850**

The body weight change during experiments

	1	2	3	4	5	6	7
STG	25.32±0.9 3	25.46±1. 42	25.48 ±1.55	25.40 ±1.69	25.59 ±1.81	25.30± 1.52	25.65±1. 11
MCT/LCT	25.44±0.7 4	25.86±0. 92	25.72 ±0.54	25.48 ±0.48	25.95 ±0.08	25.67± 0.53	25.66±0. 44
STG+VitD	25.65±0.6 0	26.39±0. 52	26.40 ±0.31	26.22 ±0.33	26.47 ±0.43	25.93± 0.34	26.30±0. 48
MCT/LCT+Vit D	25.42±1.4 6	25.49±0. 99	25.67 ±0.98	25.13 ±1.00	25.37 ±0.72	25.34± 1.07	25.34±0. 60

The food consumption (g)

Groups[a]	2nd[b]	4th[c]	7th[d]
STG	50.39 g	46.32 g	57.47 g
MCT/LCT	50.40 g	45.40 g	62.75 g
STG+VitD	53.85 g	47.38 g	56.23 g
MCT/LCT+VitD	52.57 g	50.11 g	58.57 g

a: the mice number in each group is 7

b: 2nd means the food consumption in first two days

c: 4th means the sum of food consumption in third day and forth day

d: 7th means the food consumption in last three days