Selected properties of powders with linseed oil and its ethyl esters

D. Ogrodowska, M. Tańska, P. Banaszczyk, I. Z. Konopka, S. Czaplicki, W. Brandt

Department of Food Plant Chemistry and Processing, Faculty of Food Sciences
University of Warmia and Mazury, Plac Cieszyński 1, 10-718, Olsztyn, Poland

BACKGROUND AND AIM

Linseed is one of the richest and easily available sources of α-linolenic acid, which is the most important plant-based essential n-3 polyunsaturated fatty acid (PUFA) with many health benefits. Unfortunately, this valuable fatty acid can be easily oxidized through auto-oxidation, photooxidation, or enzyme-catalysed reactions. Encapsulation can protect PUFAs against oxidation by shielding them against oxygen and also hiding any unwanted flavours from the raw material.

The aim of this study was to compare selected physical and chemical properties of prepared emulsions and encapsulated powders containing linseed oil and its ethyl esters prepared with the use of the most popular coating materials, such as whey protein concentrate, Arabic gum, and maltodextrin.

MATERIALS AND METHODS

Linseed oil (L) was from Olejarnia Świecie" (Świecie nad Osą, Poland), while linseed oil ethyl esters (E) were prepared in the laboratory. The emulsions were composed of 10% L or E + 7.5% maltodextrin (M) + 7.5% whey protein concentrate (W) or Arabic gum (G) + 75% water. The powders were prepared by spray- (SD, a pilot plant spray dryer, A/S Niro Atomizer, Copenhagen, Denmark) and freeze-drying (FD, Cryolizer Freeze Dryer type B-64, New Brunswick Scientific Co., Inc., NJ, USA) methods. Comparison was done based on emulsions (morphology, particle size distribution, stability) and powders (morphology, physicochemical properties, oxidative stability and fatty acid composition) properties. The method used were presented in details in the work of Damerau et al. (2022).

Damerau, A., Ogrodowska, D., Banaszczyk, P., Dajnowiec, F., Tańska, M., & Linderborg, K. M. (2022). Baltic herring (Clupea harengus membras) oil encapsulation by spray drying using a rice and whey protein blend as a coating material. Journal of Food Engineering, 314, 110769, https://doi.org/10.1016/j.jfoodeng.2021.110769

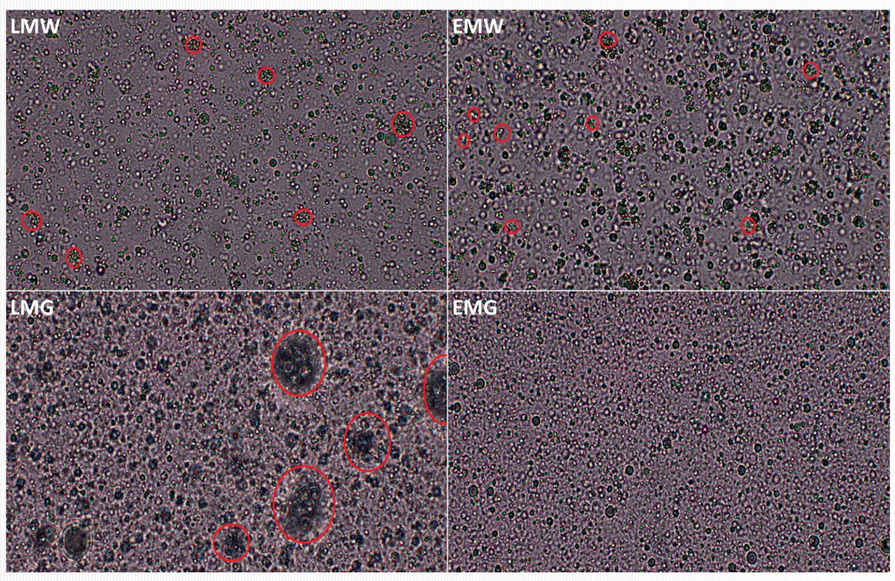

Fig. 2. Optical Microscope images of emulsions (red loop – agglomerates).

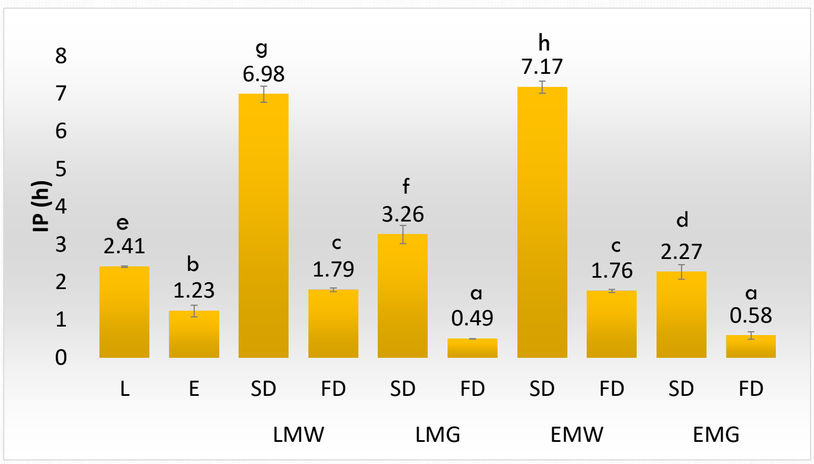

Fig. 3. Induction period (IP) of L, E and powders.

Different letters indicate statistically significant differences (p≤0.05).

Fig. 1. Particle size distribution of emulsions.

Table 1. Physicochemical properties of powders.

Powder	LMW		LMG		EMW		EMG	
Method	SD	FD	SD	FD	SD	FD	SD	FD
MC (%)	2.51 ± 0.01^{a}	3.57 ± 0.08^{d}	2.84 ± 0.46^{b}	2.99 ± 0.07^{bc}	3.09 ± 0.01^{bc}	12.5 ± 0.39^{f}	3.24 ± 0.04^{c}	7.12 ± 0.30^{e}
D3,2 (μm)	24.2 ± 0.44^{b}	n.d.	22.62 ± 0.14^{a}	n.d.	23.17 ± 1.66^{a}	n.d.	23.35 ± 0.35^{ab}	n.d.
D4,3 (μm)	34.46 ± 5.30^{b}	n.d.	37.35 ± 0.87^{b}	n.d	28.33 ± 0.04^{a}	n.d.	47.35 ± 7.88^{c}	n.d.
Span (-)	1.57 ± 0.23^{b}	n.d.	1.90 ± 0.08^{c}	n.d.	1.34 ± 0.00^{a}	n.d.	1.99 ± 0.16^{c}	n.d.
SSA (m^2/g)	0.25 ± 0.01^{a}	n.d.	0.27 ± 0.00^{c}	n.d.	0.25 ± 0.00^{b}	n.d.	0.26 ± 0.00^{b}	n.d.
SOC (%)	8.44 ± 1.66^{de}	11.48 ± 1.32^{f}	8.78 ± 0.47^{e}	4.42 ± 0.10^{a}	7.67 ± 0.05^{cd}	10.95 ± 0.01^{f}	6.78 ± 0.40^{c}	5.52 ± 0.12^{b}
EE (%)	78.9 ± 1.23^{e}	71.31 ± 1.17^{a}	78.06 ± 0.54^{d}	88.94 ± 0.34^{i}	80.83 ± 0.02^{f}	72.63 ± 0.02^{b}	83.06 ± 0.01^{g}	86.2 ± 0.16^{h}
TOC (%)	20.7 ± 0.17^{c}	32.56 ± 0.43^{f}	22.62 ± 0.03^{d}	11.88 ± 0.51^{a}	33.25 ± 0.11^{g}	31.00 ± 0.02^{e}	32.07 ± 1.21^{f}	14.57 ± 0.08^{b}
C14:0	0.04 ± 0.00^{ab}	0.34 ± 0.00^{c}	0.06 ± 0.00^{ab}	0.00 ± 0.00^{a}	0.35 ± 0.00^{c}	0.11 ± 0.00^{b}	0.44 ± 0.04^{d}	0.00 ± 0.00^{a}
C16:0	6.02 ± 0.05^{b}	6.59 ± 0.12^{c}	5.93 ± 0.00^{b}	5.96 ± 0.01^{b}	6.69 ± 0.02^{c}	4.98 ± 0.38^{a}	7.09 ± 0.08^{d}	5.01 ± 0.02^{a}
C18:0	2.99 ± 0.00^{c}	3.20 ± 0.03^{d}	2.96 ± 0.01^{c}	3.01 ± 0.02^{c}	3.30 ± 0.05^{d}	2.45 ± 0.21^{b}	3.34 ± 0.04^{d}	2.15 ± 0.20^{a}
C18:1	21.9 ± 0.01^{b}	23.83 ± 0.24^{c}	21.49 ± 0.02^{a}	23.60 ± 0.12^{c}	21.82 ± 0.24^{b}	24.8 ± 0.17^{e}	21.63 ± 0.03^{ab}	24.35 ± 0.18^{d}
C18:2	15.7 ± 0.05^{f}	14.70 ± 0.01^{a}	16.02 ± 0.03^{g}	14.92 ± 0.04^{b}	15.64 ± 0.03^{e}	14.93 ± 0.03^{b}	15.55 ± 0.02^{d}	15.16 ± 0.03^{c}
C18:3	53.35 ± 0.03^{e}	51.34 ± 0.15^{a}	53.54 ± 0.00^{e}	52.51 ± 0.19^{cd}	52.20 ± 0.30^{bc}	52.73 ± 0.55^{d}	51.95 ± 0.11^{b}	53.33 ± 0.08^{e}

Means within a lines with different letters are significantly different ($p < 0.05$). MC – moisture content; D3,2 - Sauter mean diameter, D4,3 – De Brouckere mean diameter, SSA – specific surface area, SOC – surface oil content, EE – encapsulation efficiency , TOC – total oil content

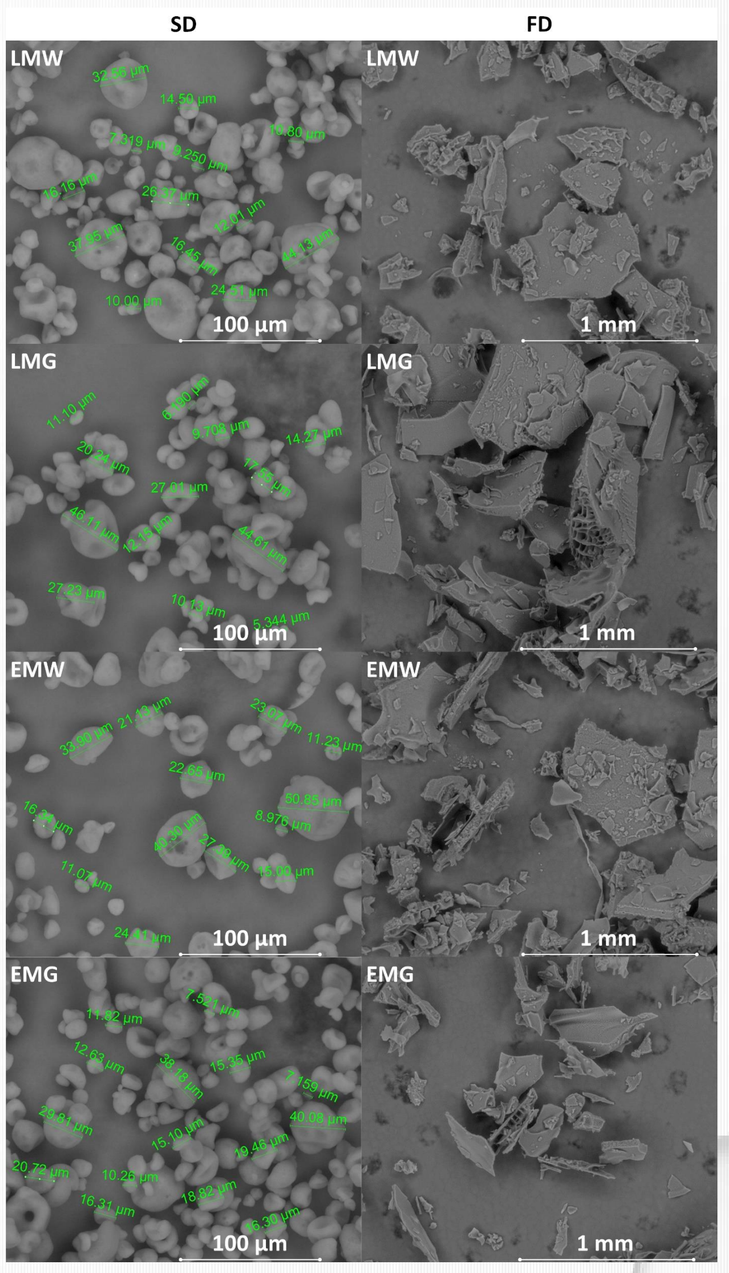

Fig. 4. Scanning Electron Microscope images of powders (SD 400x, FD 50x).

CONCLUSIONS

1) The MG emulsions were characterized by a monomodal distribution of particles, while the distributions of MW emulsions were bimodal (Fig. 1). The image of the LMG reveals the presence of agglomerates in the microstructure of the emulsion composed of several drops of the oil phase of relatively large size (Fig. 2).
2) The turbidimetric analysis showed that the emulsions with W had lower stability compared to the emulsions with G. The determination of powder solubility proved that a precipitate was formed only in preparations containing W, for both FD- and SD-dried samples (data not shown).
3) FD powders with MW had a much higher SOC compared to powders with MG, while SOC for SD powders was not dependent on the coating ingredients (Table 1). Regardless of the drying method used and the emulsion composition, no significant effect on the fatty acid composition was observed (Table 1).
4) SD powders had greater oxidative stability compared to FD powders. Only SD powders showed higher stability compared to LO and LE (Fig. 3).
5) The particles of SD powders are characterized by a spherical shape, while the FD powders have particles similar to flakes (Fig. 4).