HDN-006

Spreadable fat products from milk fat, blended and plant-based sources: a comparative study of nutritional properties and *in vitro* digestibility

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Abstract

This study investigated the digestibility of three commercial spreads, **milk fat spread** (60% fat, Montfleuri butter, Elvire, France), **blended fat spread** (53% fat, St Hubert L'Original®), and **vegetable fat spread** (53% fat, St Hubert Oméga 3®, palm oil-free, France), using **the *in vitro* INFOGEST 2.0 protocol**. Prior to digestion, spreads were characterized in term of thermal properties, lipid classes, triacylglycerol composition and fatty acid profiles. MFS showed the highest hardness and solid fat content, while vegetable fat spread was softest. BFS exhibited greater thermal and oxidative stability, and both blended fat spread and vegetable fat spread had higher unsaturated fatty acids with lower atherogenic and thrombogenic indices than milk fat spread. *In vitro* digestion revealed fastest gastric lipolysis for vegetable fat spread, after 90 min, lipolysis converged across samples. These results highlight how fat composition affects stability, nutritional quality and triacylglycerol hydrolysis kinetics.

Materials & Methods

Fatty acid profiles were determined by GC-FID after esterification following Ackman (1998). Fatty acid compositions were used to calculate different indices.

- Atherogenic (IA) and thrombogenic (IT) indices (Gerlei *et al.*, 2024)
- Hypocholesterolemic/hypercholesterolemic (HH) ratio and the health-promoting index (HPI) index (Chen and Liu, 2020)
- Oxidisability (OI) and peroxidisability (PI) indices (Bielecka *et al.*, 2023)
- Spreadability (SI) index (Grille *et al.*, 2024)

Triacylglycerols profiles were analyzed by RP-HPLC with a C18 column (150×4.6 mm, 5 µm). Samples in 5% chloroform were separated with acetone/acetonitrile (50:50, v/v) at 30 °C, 1.2 mL/min for 60 min. TAGs were identified by equivalent carbon number (ECN) and quantified using commercial standards (OOO, SSS, POP, SOS, POS) (Gerlei *et al.*, 2024).

Lipids were extracted with chloroform/methanol (2:1, 1 mM BHT) and stored at −20 °C.

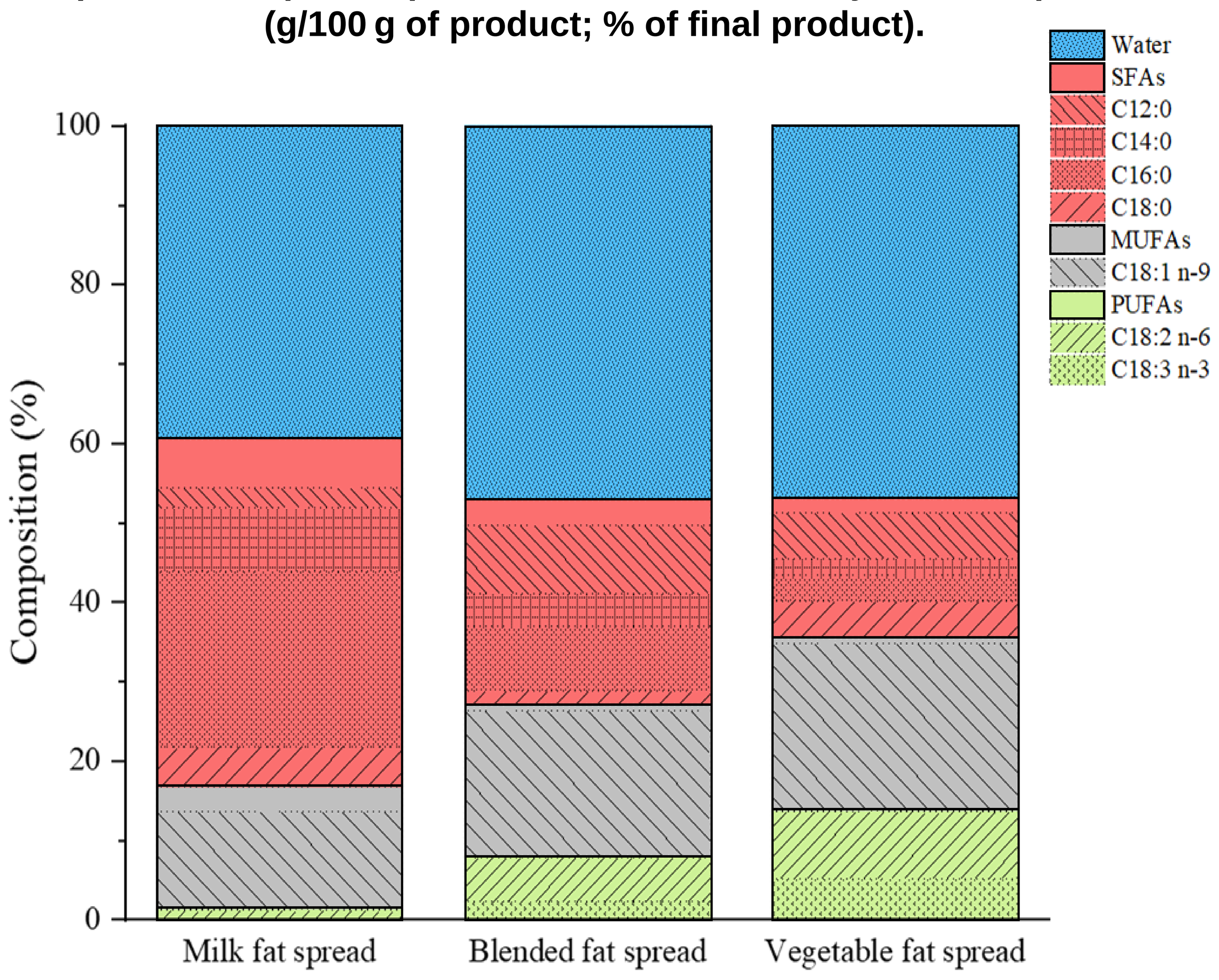
Neutral lipids (TAG, DAG, MAG, FFA) were separated by TLC and quantified by TLC-FID (Iatroscan MK-5) using hexane/diethyl ether/formic acid and calibrated with standards (n=3).

Thermal behavior and solid fat content (SFC) were analyzed by DSC using a non-isothermal protocol (heating/cooling rate 5 °C/min). Oxidative stability was assessed via oxidation induction time (OIT, 5 °C/min to 150 °C under N_2) and oxidation induction temperature (OIT*, 5 °C/min to 250 °C under O_2).

Two-step in vitro digestion (modified INFOGEST 2.0) was performed at 37 °C: gastric phase at pH 5.5 with rabbit gastric extract (60 U/mL lipase, 2000 U/mL pepsin, 30 min) and intestinal phase at pH 6.25 with pancreatic extract/bile salts (2000 U/mL pancreatic lipase, 10 mM bile salts, 0.6 mM $CaCl_2$, 60 min) (Amara *et al.*, 2024).

Results

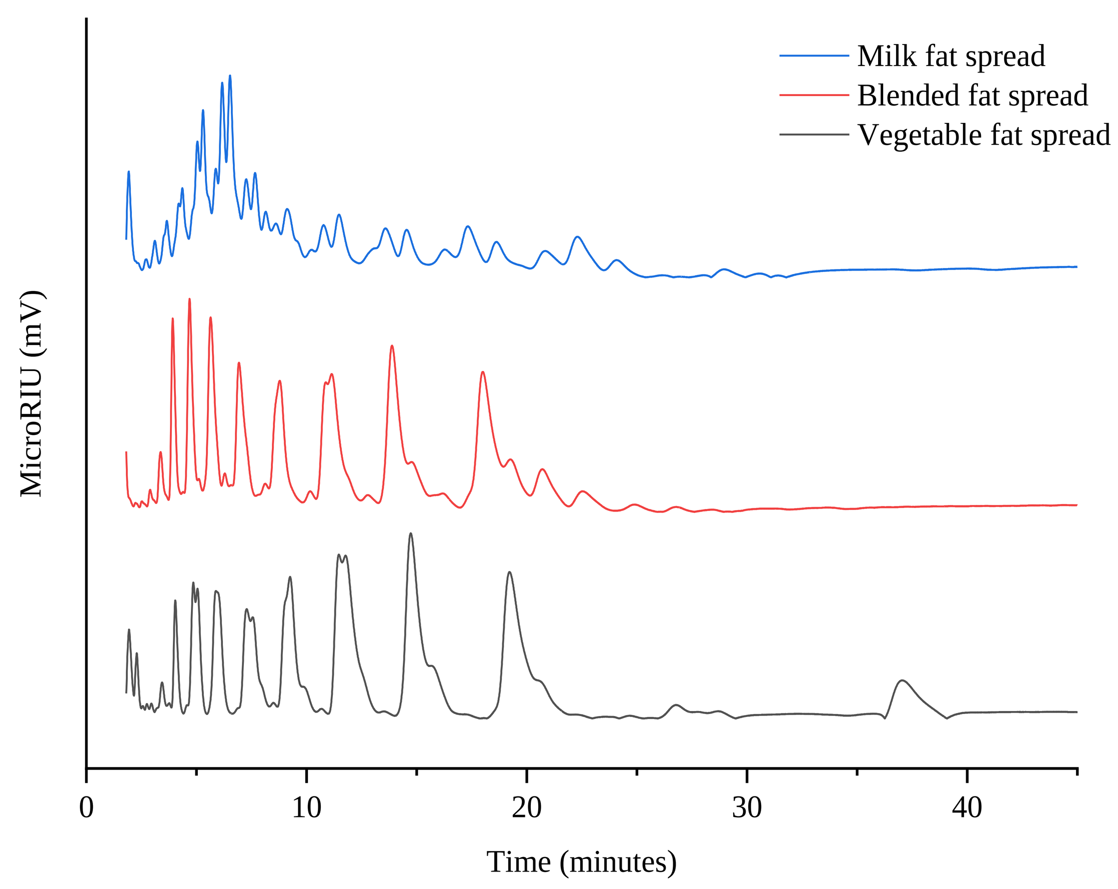
Proportion of aqueous phase, fat content and fatty acid composition (g/100 g of product; % of final product).



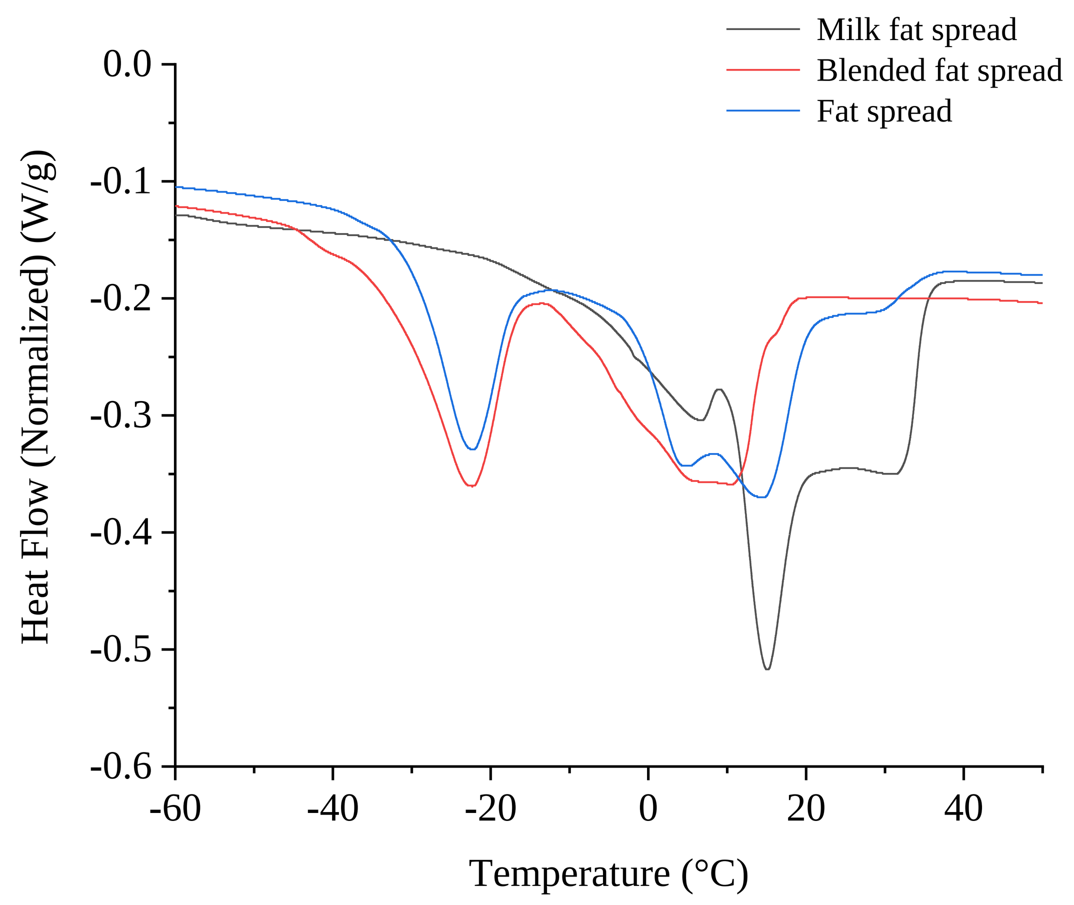
Fatty acid compositions of fat spreads

Fatty acids (%)	Milk fat spread	Blended fat spread	Vegetable fat spread
C12:0	4.10 ± 0.25	16.24 ± 0.43	10.76 ± 0.41
C14:0	13.32 ± 0.34	7.50 ± 0.14	4.13 ± 0.11
C16:0	36.89 ± 0.33	15.54 ± 0.43	6.00 ± 0.04
C18:0	8.22 ± 0.37	3.07 ± 0.07	8.55 ± 0.17
Total SFAs	**74.09**	**48.71**	**32.97**
C18:1 n-9 cis	20.26 ± 0.71	34.57 ± 0.66	39.59 ± 0.66
Total MUFAs	**25.57**	**36.23**	**41.13**
C18:2 n-6 (9c,11c)	1.71 ± 0.03	10.49 ± 0.19	15.79 ± 0.17
C18:3 n-3 cis	0.33 ± 0.02	4.30 ± 0.06	9.89 ± 0.11
Total PUFAs	**2.45**	**15.06**	**26.11**
AI	3.37	1.20	0.49
TI	3.82	0.70	0.31
HH	0.43	1.29	3.19
HPI	0.30	0.83	2.02
OI	0.03	0.20	0.36
PI	4.21	21.08	38.36
SI	1.74	0.44	0.15

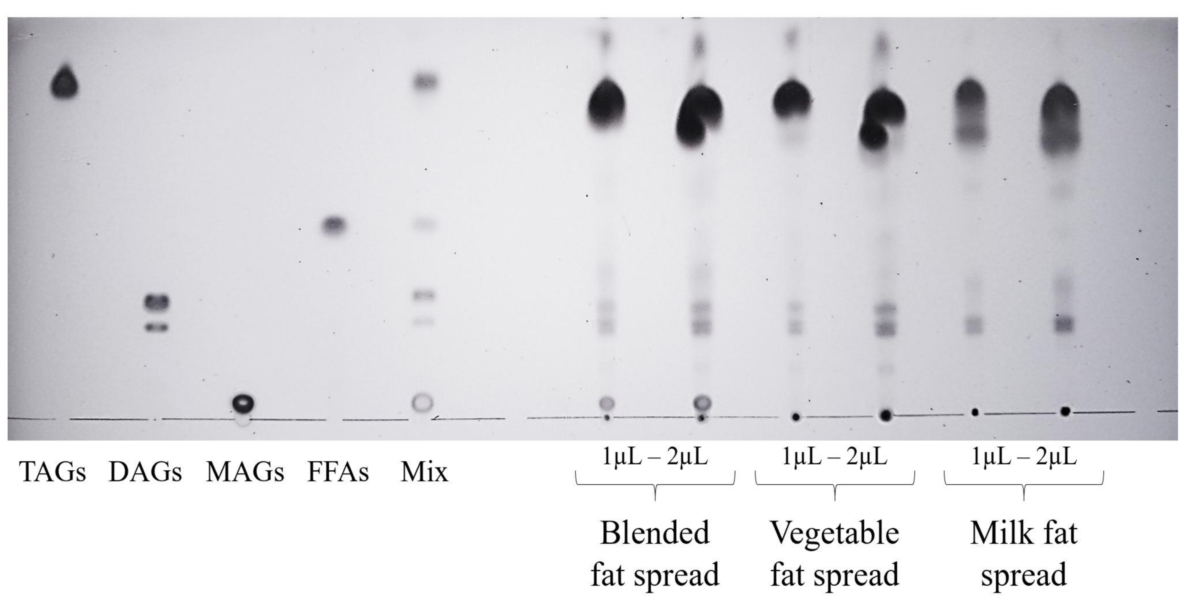
Triacylglycerol profiles by RP-HPLC-RI of fat spreads



DSC melting profiles of fat spreads



TLC analysis of neutral lipids in fat spreads



Solid Fat Content of fat spreads

SFC (%)	10 °C	20 °C	35 °C
Milk fat spread	70.68 ± 0.60	34.38 ± 0.81	0.22 ± 0.11
Blended fat spread	33.58 ± 0.34	9.04 ± 0.26	0.22 ± 0.11
Vegetable fat spread	14.53 ± 0.33	1.62 ± 0.15	0.01 ± 0.00

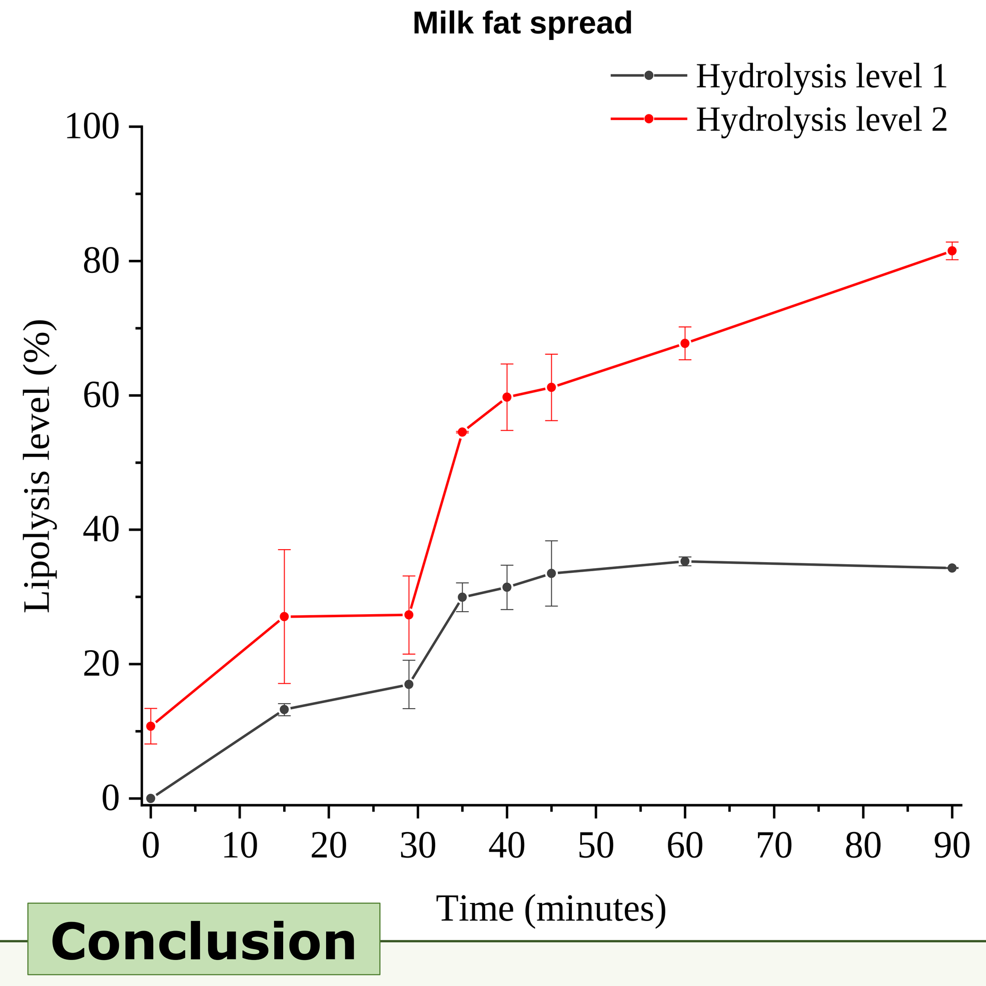
Oxidation induction time and temperature of fat spreads

Oxidation parameters	OIT (min)	OIT* (°C)
Milk fat spread	20.89 ± 3.61	125.61 ± 0.01
Blended fat spread	37.03 ± 1.70	161.01 ± 0.12
Vegetable fat spread	20.07 ± 1.80	136.21 ± 0.01

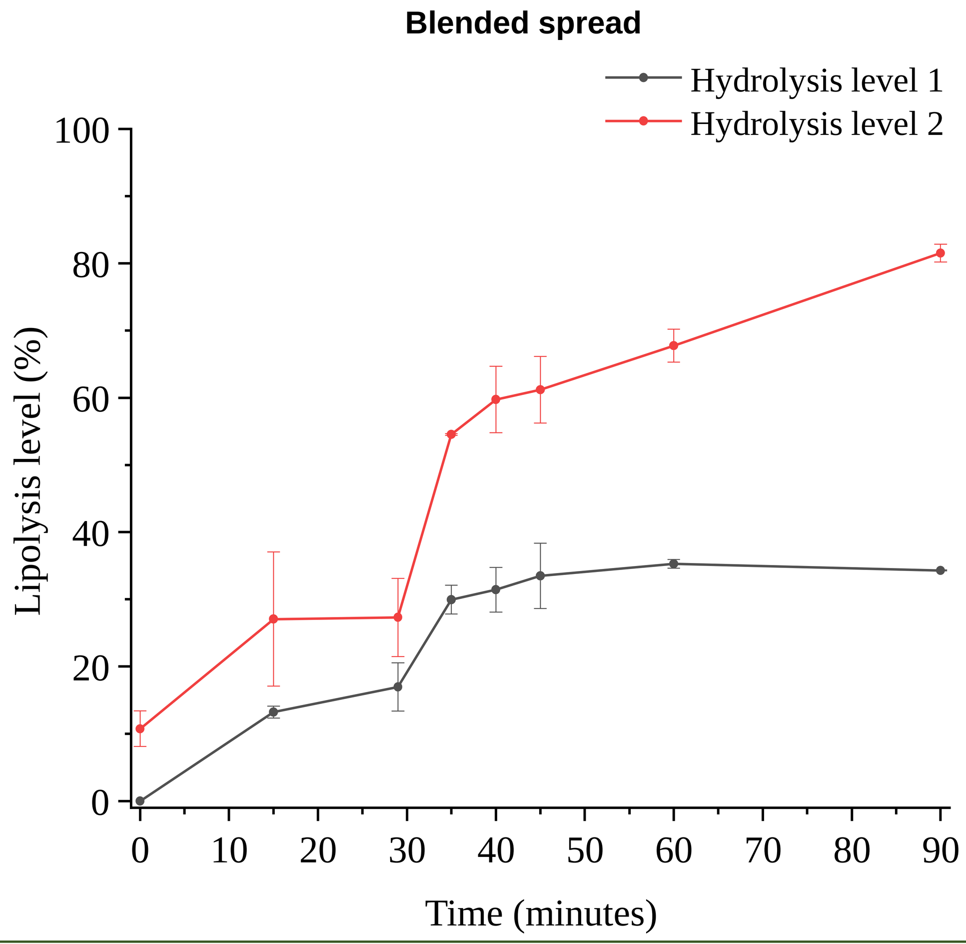
Evolution of lipolysis levels during *in vitro* digestion of fat spreads

Hydrolysis level 1 as % FFA of total TAG fatty acids; Hydrolysis level 2 as % MAG + FFA of total TAG fatty acids, both quantified by TLC-FID.

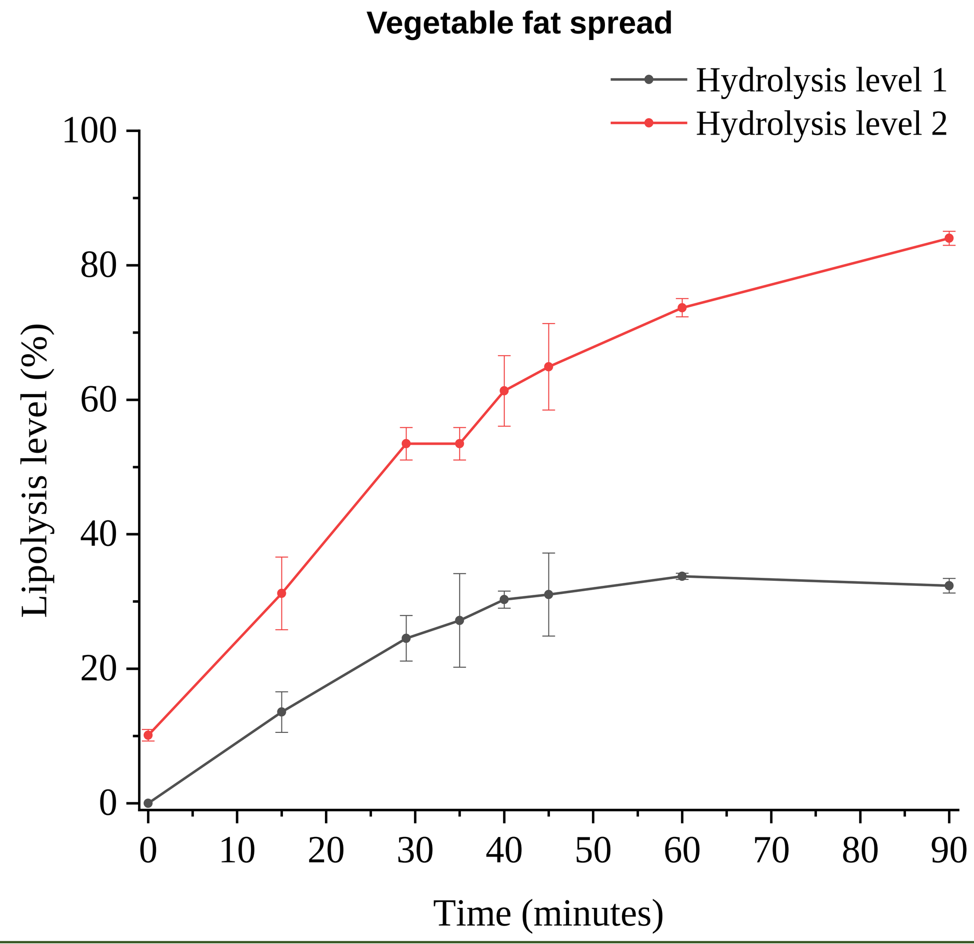
Milk fat spread



Blended spread



Vegetable fat spread



Conclusion

The milk fat spread, blended fat spread and vegetable fat spread differ in lipid composition and nutritional indices. The vegetable and blended fat spreads are richer in unsaturated and essential fatty acids, while the milk fat spread is higher in saturated fats. Nutritional indices (AI, TI, HPI, HHI) confirm the nutritional advantage of the vegetable fat spread, while OI and PI do not align with oxidation parameters (OIT and OIT) from DSC, which do not fully reflect the fat phase composition, including lecithin and minor components with antioxidant properties. *In vitro* digestion shows faster gastric lipolysis for the vegetable fat spread, slower for the blended and milk fat spreads, with near-complete TAG hydrolysis after 90 minutes. These findings demonstrate that lipid composition and formulation strongly influence nutritional quality and early digestion kinetics.

References

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