Improving taste and flavor in dairy products through milk analysis of free fatty by Mid-infrared (MIR) spectrometry

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Introduction

The dairy sector deals with a recurring issue: a **defect of taste appearing** due to degradation of fat, commonly called **lipolysis**.

Lipolysis happens after the milking, through the physical shocks induced by freezing, pumping, transfer and storage of the milk. Physical break of fat globules makes **triglycerides** accessible to **enzymes** and degraded into **free fatty acids (FFA)**.

Among them, the volatile **short chain FFA** lead to **organoleptic issues** through undesired tastes.

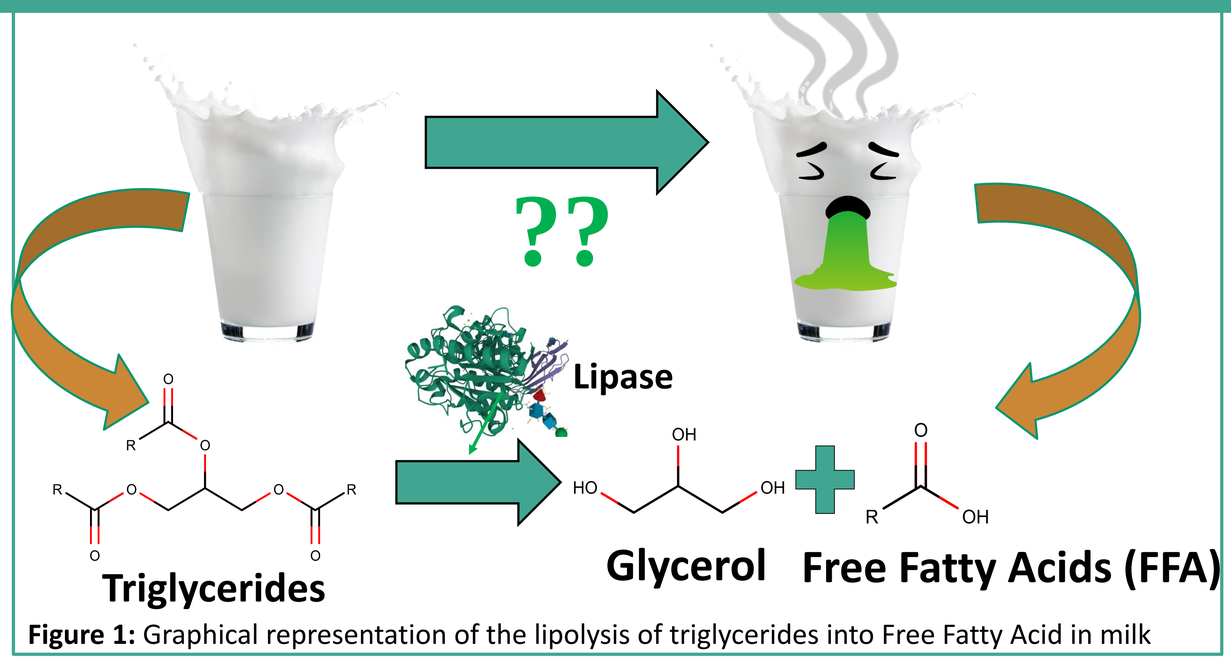

Figure 1: Graphical representation of the lipolysis of triglycerides into Free Fatty Acid in milk

<u>Lipolysis why it's bad ? → Cause bad taste of the milk</u>

Butyric acid (C4:0) → **Rancid taste**

Caproic acid (C6:0)

Caprylic acid (C8:0)

Capric acid (C10:0) → **Rancid taste**

Other FFA (C12:0 → C18:3) → effect on **milk transformation** + Inhibition of **bacteria**

Results

a)Quantification

- **20%** of the samples were above the limit of quantification (LOQ).
- **A protocol for inducing lipolysis** is therefore needed to create models for quantifying FFAs.
- **Homogenisation** of the sample → **strong lipolysis** over time + compatible with Mid infrared spectroscopy.

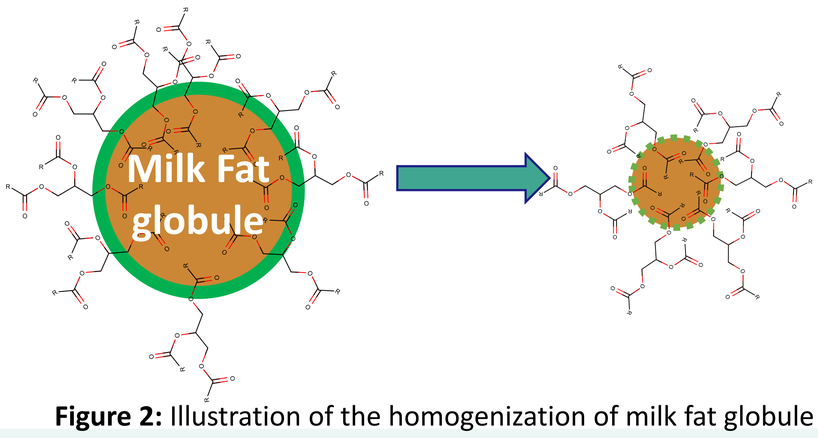

Figure 2: Illustration of the homogenization of milk fat globule

- **Decreasing the diameter of fat globules**
- **Destruction of milk fat membrane**
  → **Triglycerides more available to lipolysis**

b)Modelling

- **792** samples analysed → **GCMS/MS** to obtain the FFA values.
- M**odels were built** for free fatty acid using **several algorithms**: Principal Component Regression (PCR), Partial Least Square regression (PLSr), Elasticnet regression, Kernel Ridge regression (KRR) and Support Vector Machine-Regression (SVM-R)
- A cross validation **10 groups subset** and **random external validation** with **20%** of total sample → evaluate models

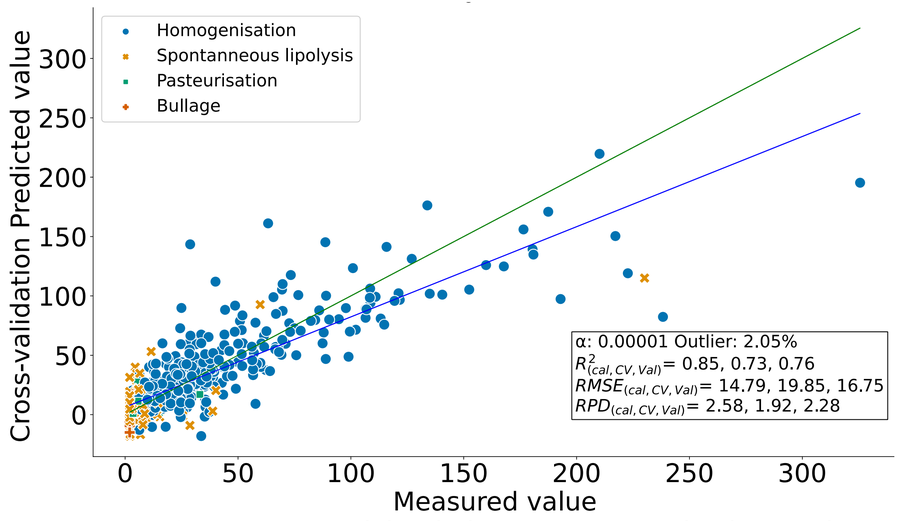

Figure 2: C4 model including spontaneous lipolysis and homogenized sample with kernel Ridge Regression

Table 1: Modelling performances of each Free Fatty acid with the best algorithm based on lowest RMSE from the external validation

FFA	Algo	R^2_{cal}	R^2_{cv}	R^2_{val}	$RMSE_{cal}$	$RMSE_{cv}$	$RMSE_{val}$	RPD_{cal}	RPD_{cv}	RPD_{val}
C4	KRR	0.85	0.73	0.76	14.79	19.85	16.75	2.58	1.92	2.28
C6	ElasticNet	0.77	0.68	0.57	9.74	11.58	12.70	2.10	1.77	1.61
C8	SVM-R	0.85	0.54	0.40	4.95	8.71	9.72	2.61	1.48	1.33
C10	KRR	0.59	0.52	0.38	8.88	9.62	9.15	1.56	1.44	1.51
C12	PCR	0.35	0.31	0.08	6.45	6.65	6.34	1.24	1.21	1.26
C14	KRR	0.52	0.40	0.02	9.91	11.06	11.04	1.44	1.29	1.29
C16	KRR	0.50	0.36	0.20	22.40	25.25	21.82	1.41	1.25	1.45
C18	PLS	0.70	0.59	0.49	11.18	12.99	12.48	1.81	1.56	1.62

Conclusion: This work presents encouraging performances of Free Fatty acid prediction and exhibit the potential to detect specific milk flavor issues.

Acknowledgement:

eip-agri AGRICULTURE & INNOVATION

THE GOVERNMENT OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of Agriculture, Viticulture and Rural Development

Wallonie recherche CRA-W

Walloon Agricultural Research Centre

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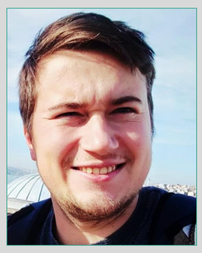

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