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The potential of milk MIR spectra to certify milk geographic origin

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Context

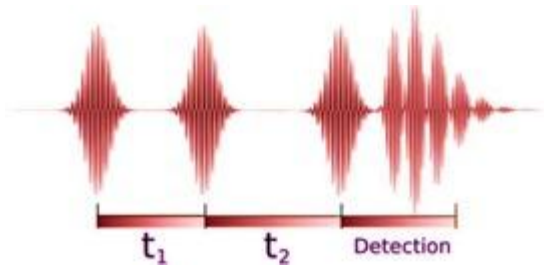
OptiMIR Project:

⇒ 17 European partners ➔ Common database

⇒ Milk recording organizations, research centres, milk analysis laboratory

"*New tools for a more sustainable dairy sector*"

⇒ Based on mid-infrared spectral information from milk:



1. Fertility
2. Feeding
3. Health
4. Rejection of pollutants
5. Milk quality

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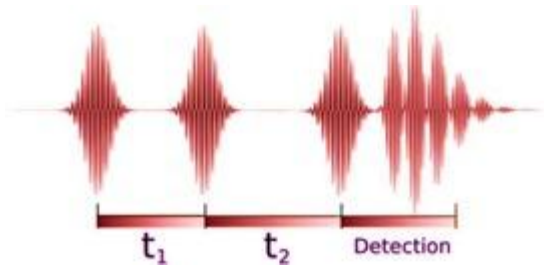

1. Fertility
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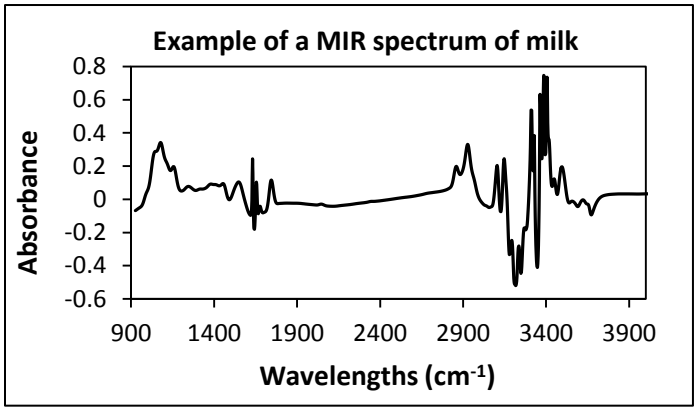
Milk quality

Milk recording

Mid-Infrared Spectroscopy (MIR)



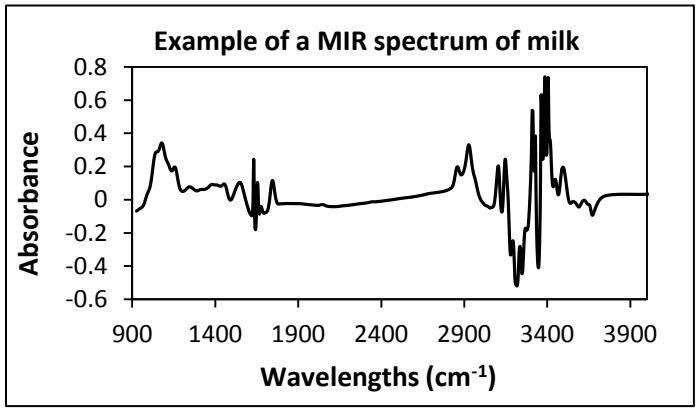
Major components:
Fat, protein, lactose, urea

Fine milk composition:
Fatty acids, minerals, lactoferrin…

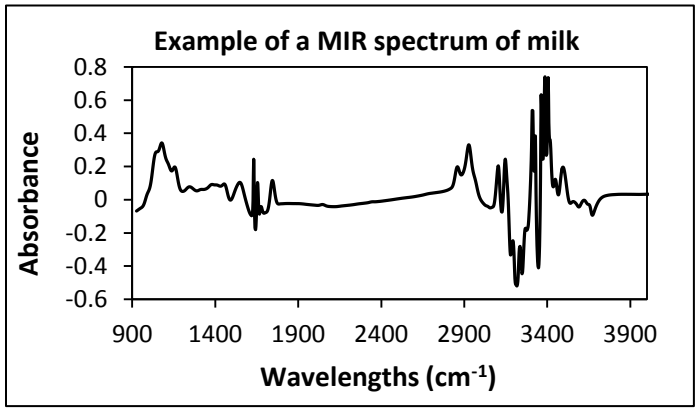
Milk quality ⇔ "TERRITORY"

This work: feasibility study

⇒ Inside PDO "Beurre d'Ardenne"- *origin appellation of traditional products in Walloina, Belgium*



Is it possible to detect the geographic origin of milk?



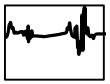
Aims of the study

1. to develop discrimination function based on raw milk spectra between the Ardenne and rest of Wallonia

2. to characterize the differences expressed by the spectra

3. based on both sub-aims to develop "opportunities" for a potential tool and the context of its application

Material

 Spectral data from OpiMIR data base from 2007 to 2012:

1. 400.000 ➡ Ardenne region
2. 1.800.000 ➡ all Wallonia except Ardenne region

 Edits:

- ✓ only official AM/PM supervised test-day milk records
- ✓ 1st lactation
- ✓ important breeds (HOL, DP-BB)
- ✓ herds present over at least years: 2009-2010-2011

  with at least 10 test-day records every year
- ✓ 311 wavelengths variable

Method Development

The linear discriminant algorithm (LDA)

calculated as the squared Mahalanobis distance from a spectrum (observation vector x) to group j (mean vector $\mathcal{L}_j$) is given by:

$$D_j^2=(x-\mathcal{L}_j)' \, COV_j^{-1} \, (x-\mathcal{L}_j)$$

where:

- ☞ D_j^2 squared Mahalanobis distance from group **j**
- ☞ j subscript to distinguish groups: **Ardenne**, **rest of Wallonia**
- ☞ x observation vector (311 wavelengths=variables)*
- ☞ $\mathcal{L}_j$ vector containing variable means of the group **j**
- ☞ COV_j covariance matrix between variables within group **j**

*could be the raw spectra (311 wavelengths) or the residual effects (311 residual wavelengths).

Results based on raw spectra

For 542,733 observations:

Ardenne: 96,499

Rest of Wallonia: 446,234

LDA classification for Ardenne and rest of Wallonia

	Ardenne	Rest of Wallonia
Raw spectra	57.1	58.0

Results based on raw spectra

For 542,733 observations:

Ardenne: 96,499

Rest of Wallonia: 446,234

LDA classification for Ardenne and rest of Wallonia

	Ardenne	Rest of Wallonia
Raw spectra of DP-BB breed	73.1	90.7
Raw spectra of HOL breed	71.8	45.0

Modeling spectra

To adjust for breeds, months, years and days in milk (DIM) effects the following model was used:

$$y = X\beta + Z\gamma + \varepsilon$$

- β: Fixed effects
  - Breed
  - DIM
  - DIM²
- γ: Random effects
  - Year x Month of recording
  - Breed x Year x Month of recording
- ε: Residual effect $\Rightarrow$ input for discriminant function

Results based on residual spectra

For 542,733 observations:

Ardenne: 96,499

Rest of Wallonia: 446,234

LDA classification for Ardenne and rest of Wallonia

	Ardenne	Rest of Wallonia
Residual spectra	94.0	12.7

Results

LDA classification for Ardenne region

Type of observations	Ardenne
Raw spectra	57.1
Raw spectra of DP-BB breed	73.1
Raw spectra of HOL breed	71.8
Residual spectra	94.0
Residual spectra of DP-BB breed	82.7
Residual spectra of HOL breed	83.2

Conclusions

Application of **discriminant analysis** across all residual spectra (542,733 spectra):

⇒ can give producers from **Ardenne** directly information if the **milk which they produce is "like" milk expected**

⇒ **Help them Respect the *origin appellation of traditional products* ⟹ "Beurre d'Ardenne"**

Conclusions

⇒ The characterization of the differences expressed by the spectra could not be processed according to results obtained.

⇒ Therefore some accuracy improvement of discrimination function for Ardenne region have to be made or others approaches could be tried for a better classification.

Conclusions

However the opportunity of this application can be:

- ⇒ to develop a tool based on MIR spectral database
- ⇒ to use simple function for spectral information (analogue to calibration)
- ⇒ therefore methodology can be easily transferable to each partner of OptiMIR project

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Service Public Wallonia SPW-DGO3
Walloon Breeding Association (AWE asbl)
Milk Committee of Battice
National Fund for Scientific Research

Thank you for your attention!

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