Potential for assessing the pregnancy status of dairy cows by mid-infrared analysis of milk

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Context of an European project

OptiMIR

17 European partners → Common database
Milk recording organizations, research centers, milk analysis laboratory

“New tools for a more sustainable dairy sector”

Based on mid-infrared spectral information from milk

✓ Fertility
✓ Feeding
✓ Health
✓ Rejection of pollutants
✓ Milk quality

www.optimir.eu
Use of MIR spectrum of milk from milk recording programs

- Fat
- Protein
- Lactose
- Urea
- Fatty acids
- Minerals
- Lactoferrin
- ...

Example of a MIR spectrum of milk
Provide a signal of the pregnancy status from the MIR milk spectrum

Why a pregnancy diagnosis?

Does the observed MIR spectrum belong to a pregnant cow or not?
Remove all factors influencing the shape of the spectra and not due to the pregnancy

**Observed spectrum** = Milk sample on which we want to test the pregnancy

**Expected open spectrum** = The expected spectrum for the same day in milk if the animal was open
Remove all factors influencing the shape of the spectra and not due to the pregnancy

Residual spectrum =

Observed spectrum – Expected open spectrum

Residual spectra are used to perform discrimination between two groups of classification (Pregnant cow and non-pregnant cow)
Model the expected open spectra

Dataset from Walloon Breeding Association (AWE, Belgium)

348,191 observations (spectra)
2 years of records
49,849 cows from 920 herds

Mixed model using fixed effects (parity, breed, ...) and random effects (animal, ...)

Data from open observations

159,844 observations (spectra)
from known open cows
Construct a predictive equation to assign a new observation as coming from a pregnant or open cow

Perform the residual spectra of the whole dataset

Residual = Observed - Expected

The discriminant analysis was used with 2 groups of classification (Open vs Pregnant) and with residual spectral point as predictors

Training dataset
75% of lactations randomly selected
From 20 to 120 days after an insemination
Same proportion of pregnant and open observations
7,524 observations (residual spectra)

Testing dataset
25% of lactation
From 20 to 120 days after an insemination
24,278 observations
Good results of classification compared to classical pregnancy diagnosis

Error rate of classification on the testing dataset was 6.4% with a specificity of 95.3% and a sensibility of 93.5%

<table>
<thead>
<tr>
<th>Days after insemination</th>
<th>N Open</th>
<th>N Pregnant</th>
<th>Error rates</th>
<th>Specificity</th>
<th>Sensibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 – 30</td>
<td>592 (22.2%)</td>
<td>2,071 (77.8%)</td>
<td>3.2%</td>
<td>96.8%</td>
<td>82.2%</td>
</tr>
<tr>
<td>31 – 40</td>
<td>489 (18.9%)</td>
<td>2,093 (81.1%)</td>
<td>10.5%</td>
<td>93.1%</td>
<td>88.7%</td>
</tr>
<tr>
<td>41 – 50</td>
<td>154 (6.8%)</td>
<td>2,126 (93.2%)</td>
<td>8.8%</td>
<td>96.1%</td>
<td>90.8%</td>
</tr>
</tbody>
</table>

Specificity is defined as the ability of the equation to predict correctly open cows among all observations belonging to open cows.

Sensibility is defined as the ability of the equation to predict correctly pregnant cows among all observations belonging to pregnant cows.
How the tool will concretely work on field conditions, a suggestion

Cow pregnancy status uncertain, this cow should be tested by a vet

Cow status considered as pregnant

Observed - Expected = Residual
Just a little part of MIR opportunities and OptiMIR project

Adapted to the scheme of a milk recording program but may be adjusted

Off-farm tool
On-farm tool
...

Example of the pregnancy diagnosis but may be adjusted to give information on other animal status

Metabolic disorders
Udder health
Energy balance
...

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