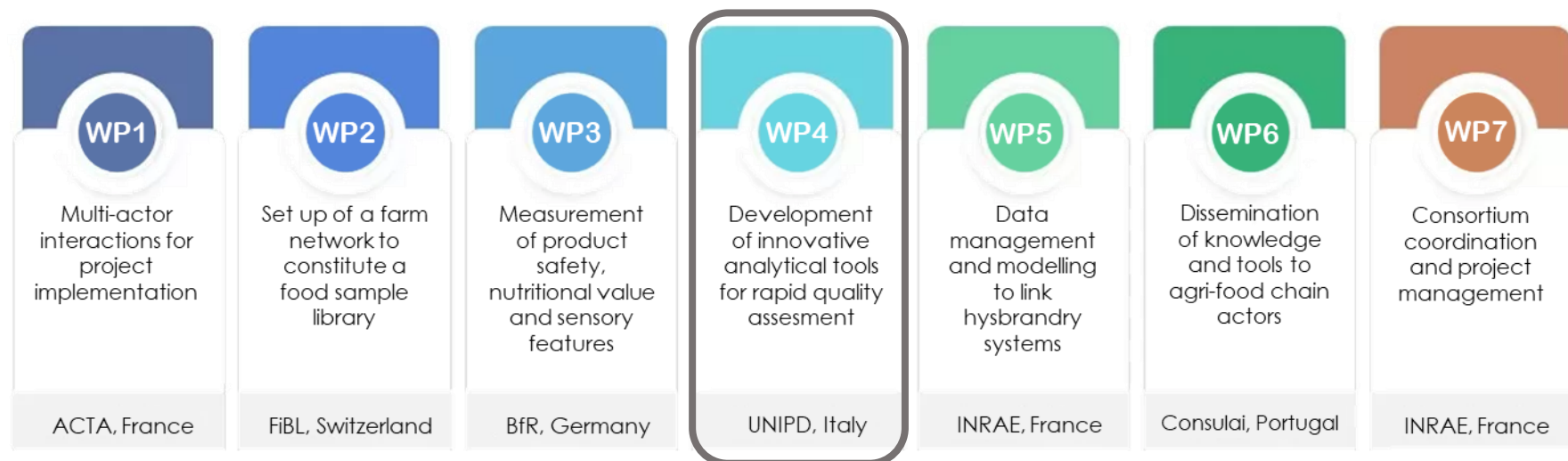


Rapid Infrared Spectroscopy for Assessing Beef Quality and Farming Intensification in Europe

A. Lopez^{1,2}, B. Martin¹, J. F. Hocquette¹, C. Labonne¹, F. Ferlay-Demiaz¹, I. Constant¹, V. M. Moretti², D. Andueza¹

¹ Université Clermont Auvergne, INRAE, Vetagro Sup, UMR Herbivores, Saint-Genès-Champanelle, 63122 Theix, France

² Università Degli Studi di Milano, Department of Veterinary Medicine And Animal Science, Via dell'Università, 6, 26900 Lodi, Italy





State of the art

Beef systems in Europe

from Cozzi et al. (2025) Technical Report: EFSA Supporting publications
Dumont et al. (2017) in Fourrages

INTENSIVE INDOOR SYSTEMS

Feedlot type

in many EU countries

indoor fattening (6-15 months)

kept indoors and
fattened after weaning

1/3 of EU production
rely on high stocking densities
minimal grassland
uniform products at low cost
fattening starts after the weaning phase

PASTURE-BASED SYSTEMS

Mixed crop-livestock

regions with a long grazing season: France, Ireland, less in Austria,
Poland and Germany

Grazing

Indoor

kept on pasture with
supplementary feeding;
housed when necessary

Winter housing

Grazing

Winter housing

Grazing

Indoor

Grassland and pastoral

pastoral regions: France, Ireland, Azores, Germany, Austria and Spain

Grazing all year

with weather protection

greater variability
competition between crops and livestock
improving sustainability through diversified rotations
increased self-sufficiency

quality labels
limited use of land suitable for human-edible crops

+

INTENSIFICATION

-

Beef systems in Europe

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+

INTENSIFICATION

-

HIGH EFFICIENCY (economic performances, increased productivity)

→ BUT ←

criticism for its ethical and environmental impacts:
expanding feed requirements drive land use expansion
across multiple continents
van der Sluis et al. (2016) in Land Use Policy

**DIVERSITY OFFERS CONSUMERS A RANGE OF
OPPORTUNITIES, BUT IT ADDS CONSIDERABLE
COMPLEXITY TO THE SECTOR**

Hocquette et al. (2018) in Asian-Australas J Anim Sci

LOW EFFICIENCY

→ BUT ←

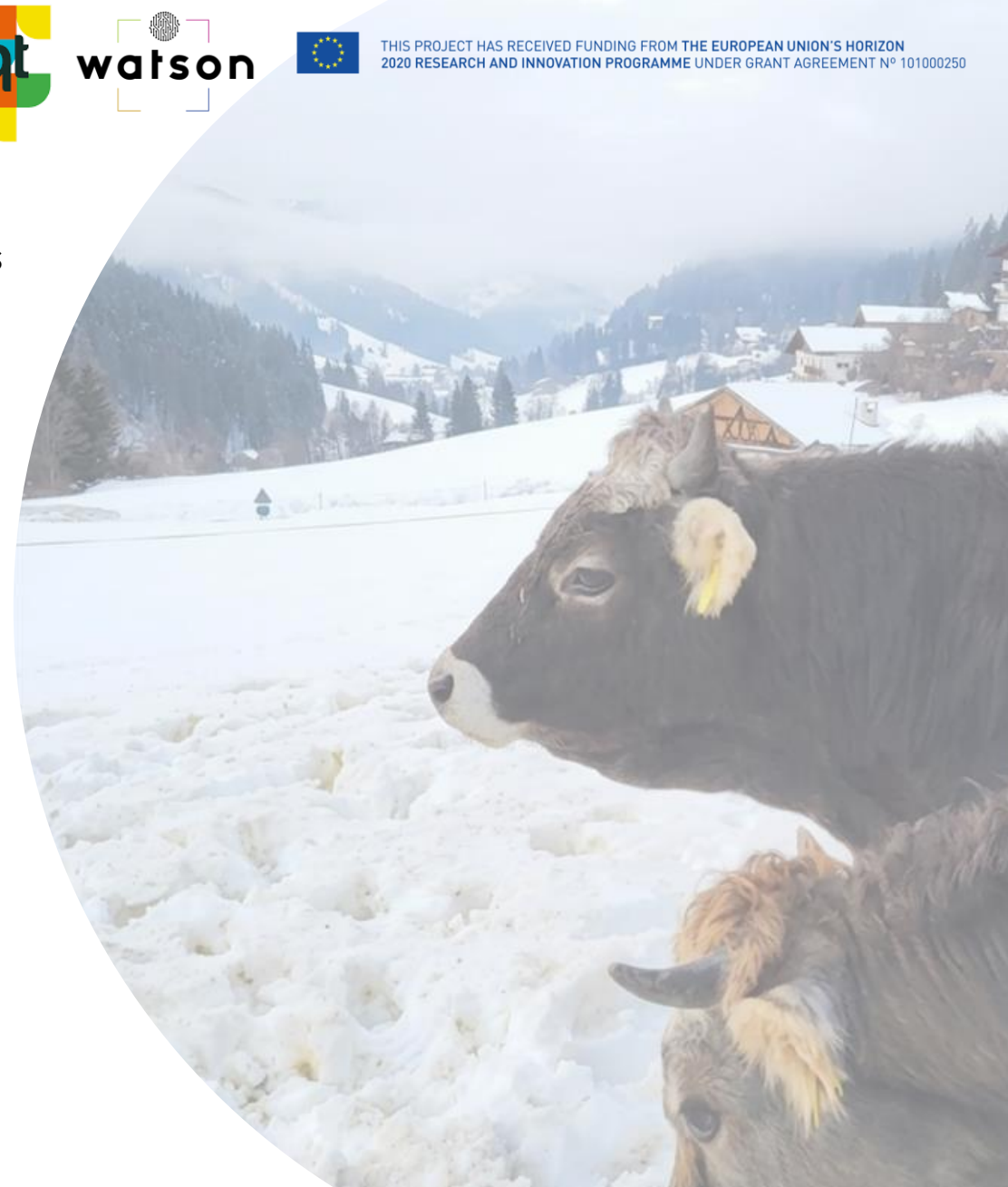
fulfill critical roles in land management and rural vitality

Mountain farming

suffers competitive pressure from intensive lowland farming, where economies of scale drive down costs and standardize supply

In the alpine area, in absence of subsidies, beef farms register negative economic income

from Zanon et al. (2023) in Züchtungskunde



The differential quality and value of mountain- and grasslands- origin products remains largely invisible to supply chain actors

The core challenge

is not productivity
it is **traceability** and **valorisation**

1

How to tell apart **a beef sample from pasture** from one raised in a feedlot...

2

How to detect **biochemical composition** in beef from different livestock systems...



...in a rapid way?



Materials and methods

I. Farms and sampling design

South Wales

65 m asl [5-120]



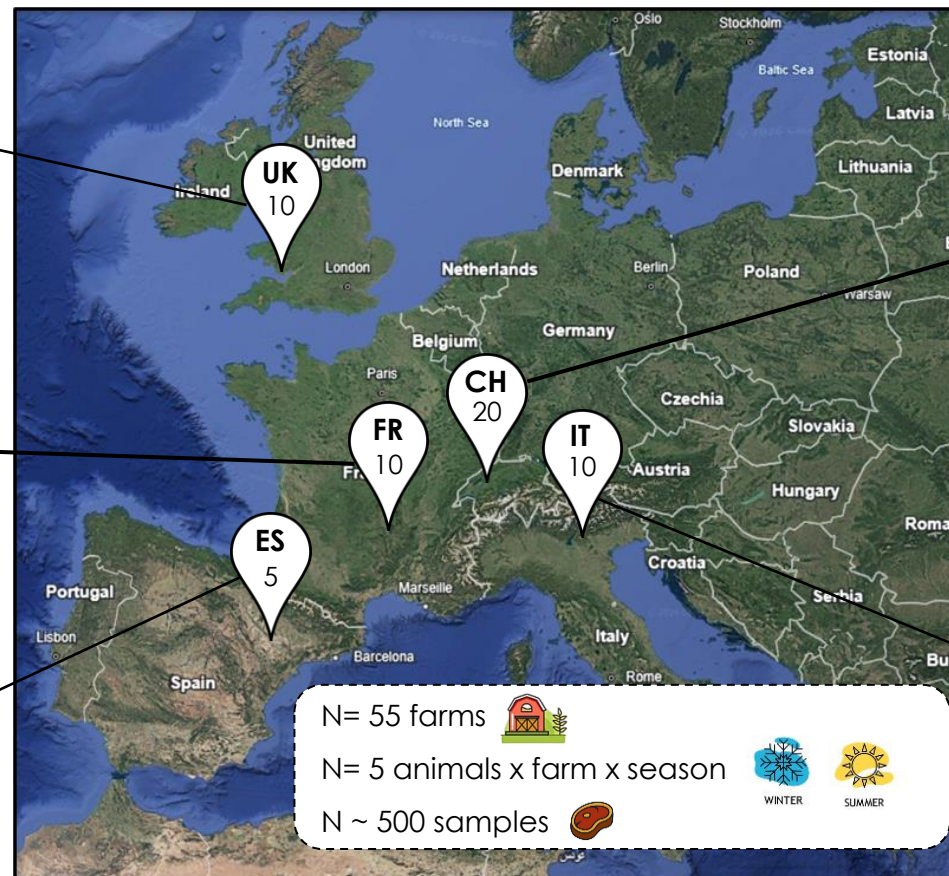
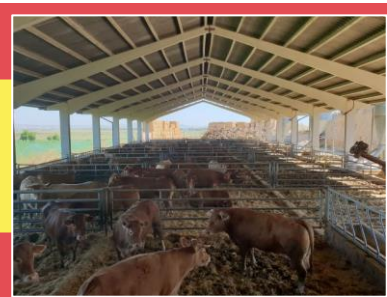
Massif Central

513 m asl [220-820]



Aragón Cataluña

685 m asl [640-700]



Swiss Plateau

580 m asl [410-850]



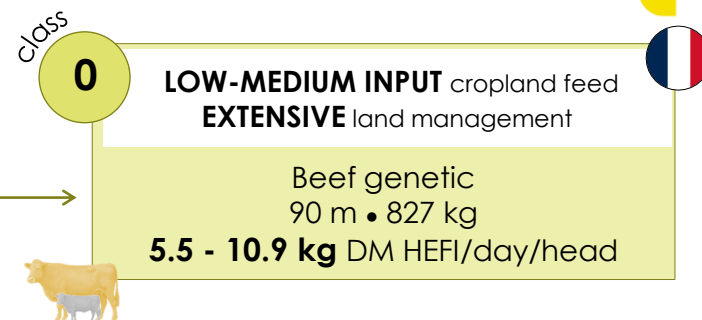
Trento Province Po Valley

55 m asl [10-150]

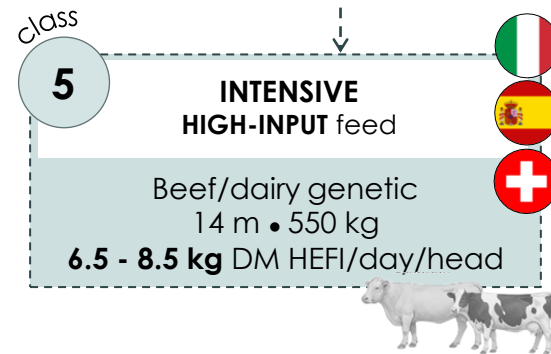
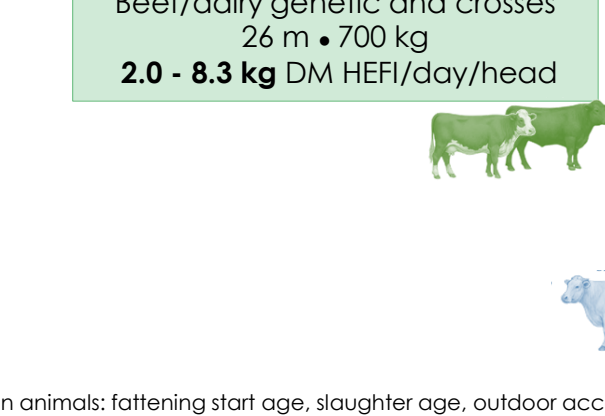
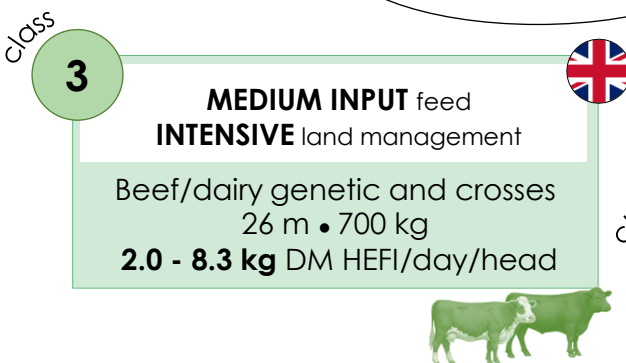


I. Farms and sampling design

Animal age
+
-



FATTENING BEEF FARMS



INTENSIFICATION CLASSES DEFINED BY CLUSTERING BEEF FARMS THROUGH INTENSIFICATION INPUTS VARIABLES*

Bailly-Caumette et al. (2026, submitted) Livestock farming intensification: mitigating or exacerbating feed-food competition? Contrasting results in broiler, dairy and beef productions

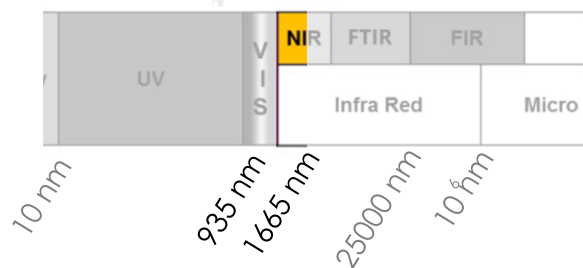
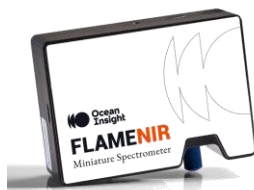
*on animals: fattening start age, slaughter age, outdoor access after weaning, high energy feed inputs (HEFI) – concentrates and maize silage
*on land: fertilisation (kg N/ha), % of mineral fertilisation

Grass-based systems

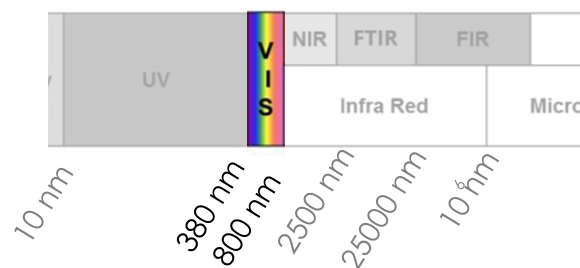
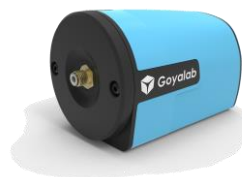
Indoor/intensive systems

II. Spectral devices

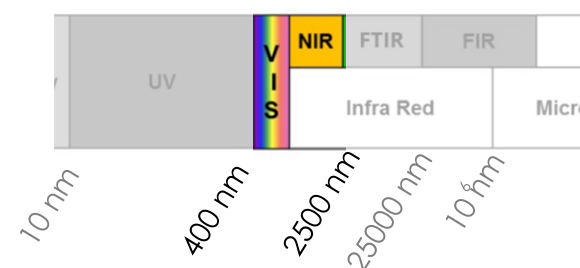
FlameNIR (FN)



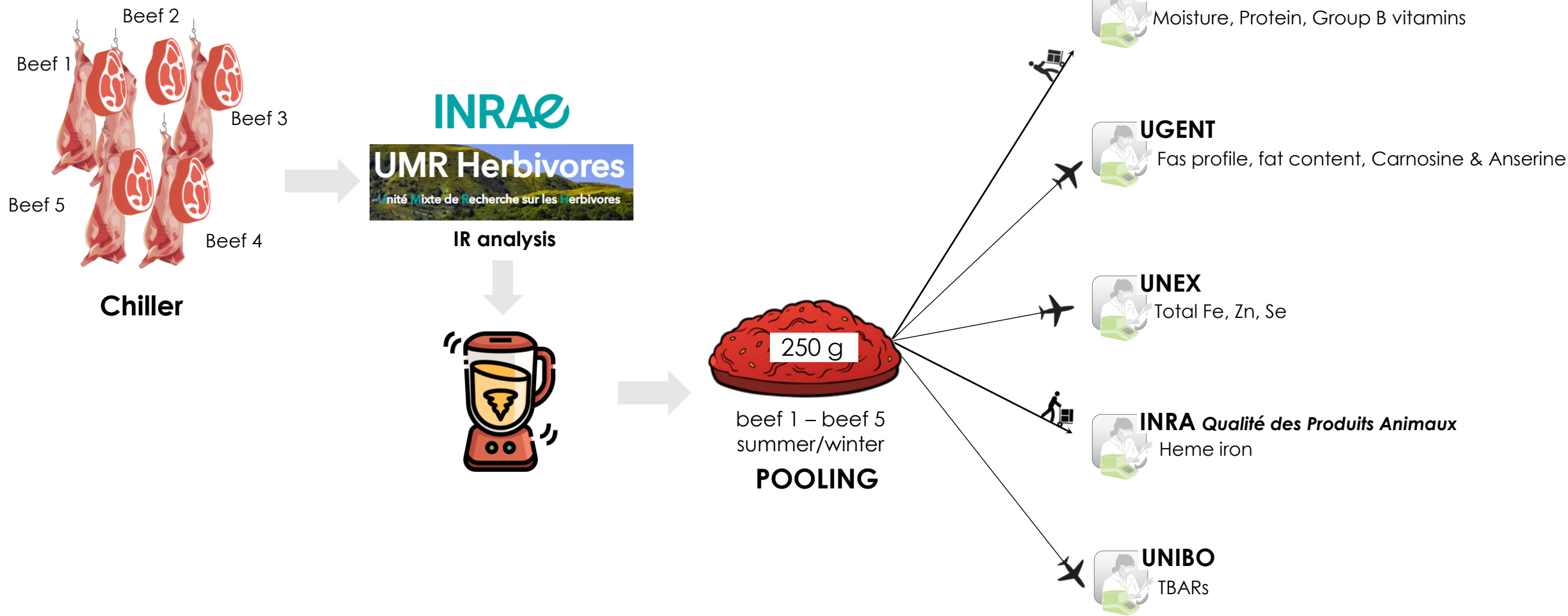
IndiGo (IG)



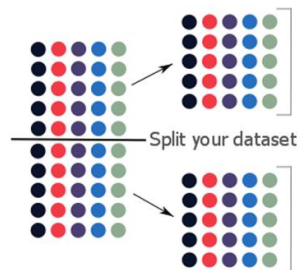
DS2500 (DS)



III. Analytical flow



IV. Data analysis

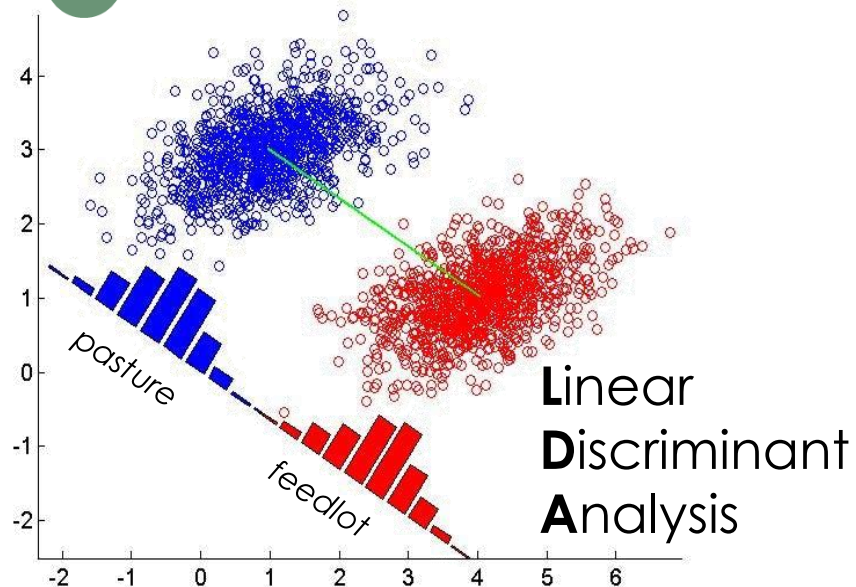


Calibration/Training subset 70%

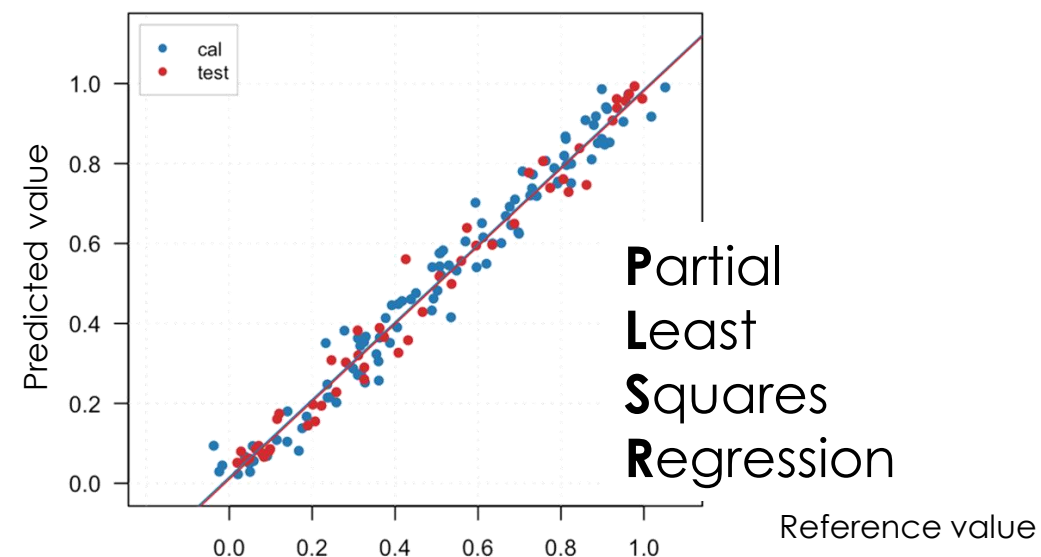
Validation/Test subset 30%

algorithm developed by Kennard & Stone (1969) in Technometrics

1 CLASSIFICATION



2 PREDICTION



Results

TASKS

The spectra

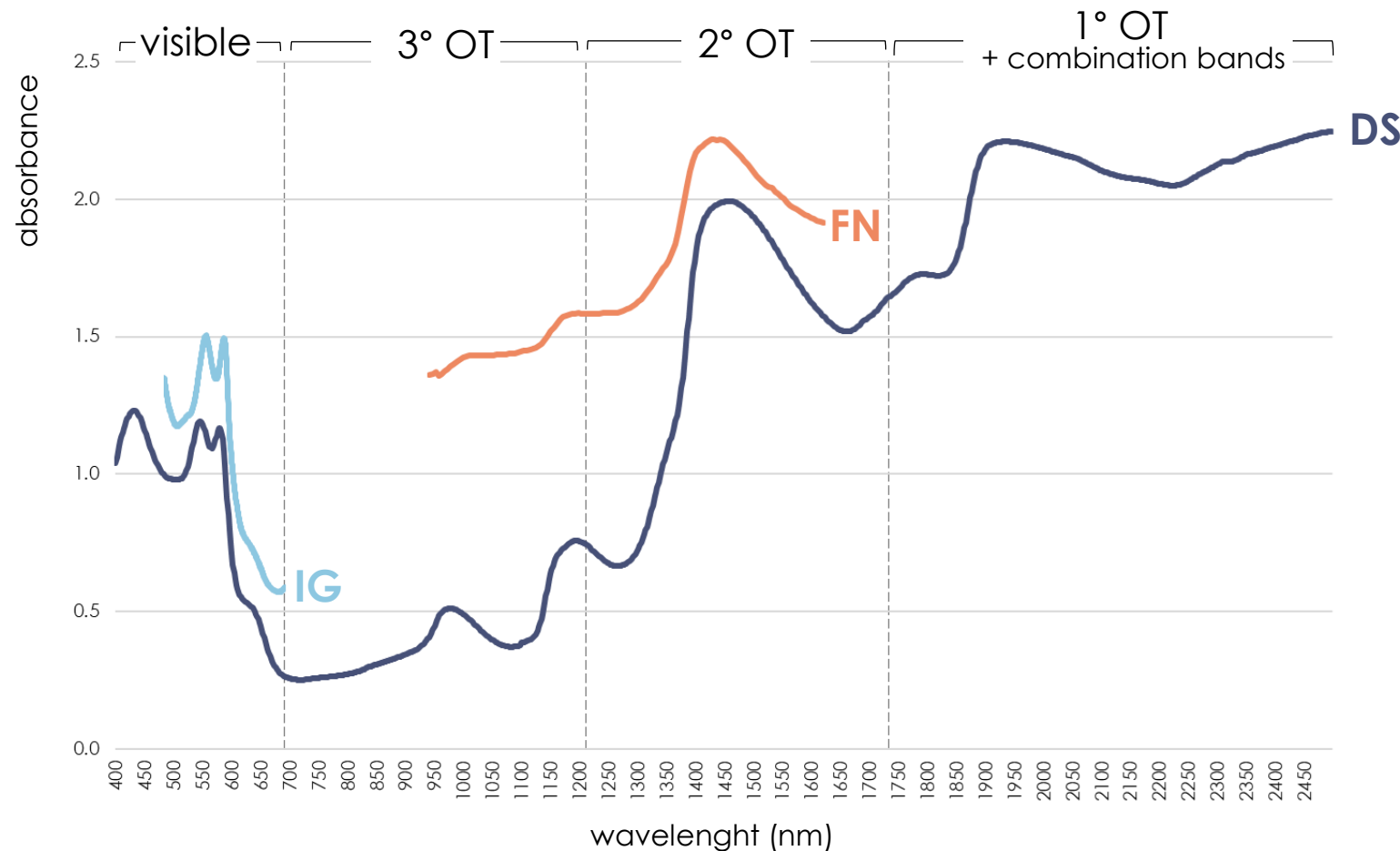
1

&

2

classification

prediction



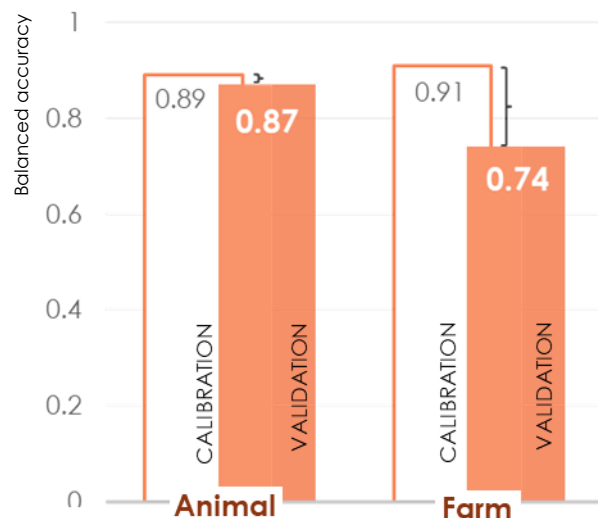
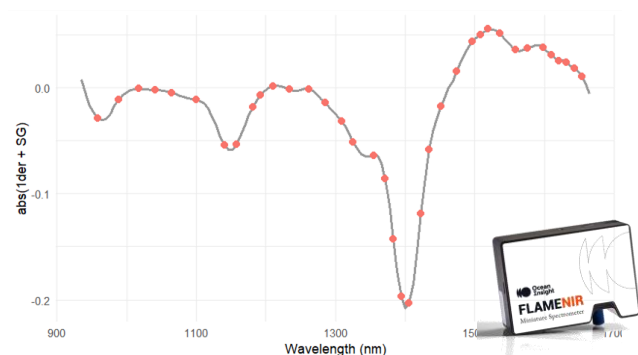
TASK CovSel and Classification accuracy

1

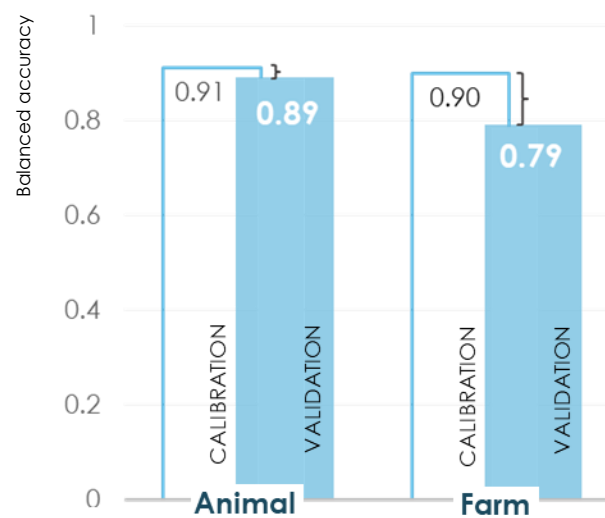
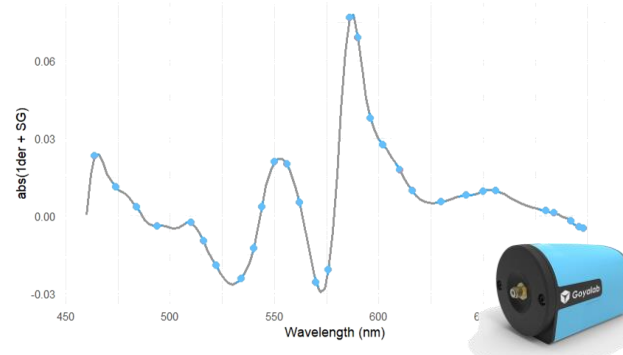
classification

for the three devices using the two validation approaches '**Animal**' (A) & '**Farm**' (F)

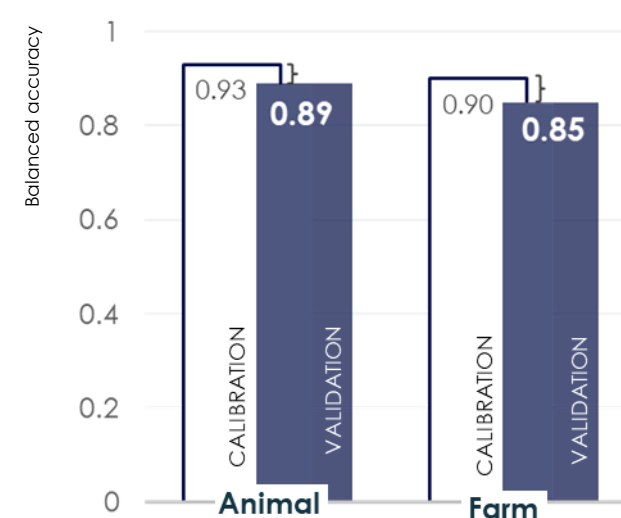
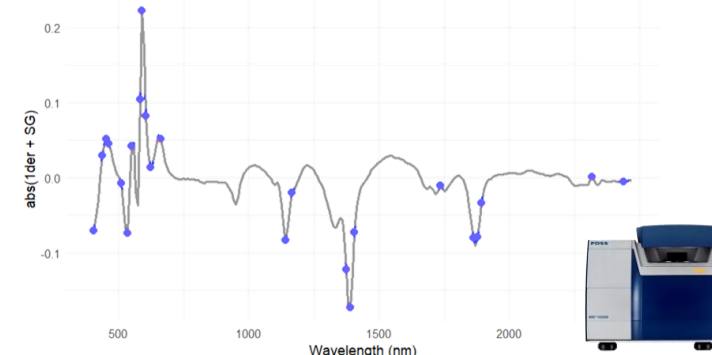
128 wavelengths → 39A/37F CovSel variables



480 wavelengths → 37A/30F CovSel variables



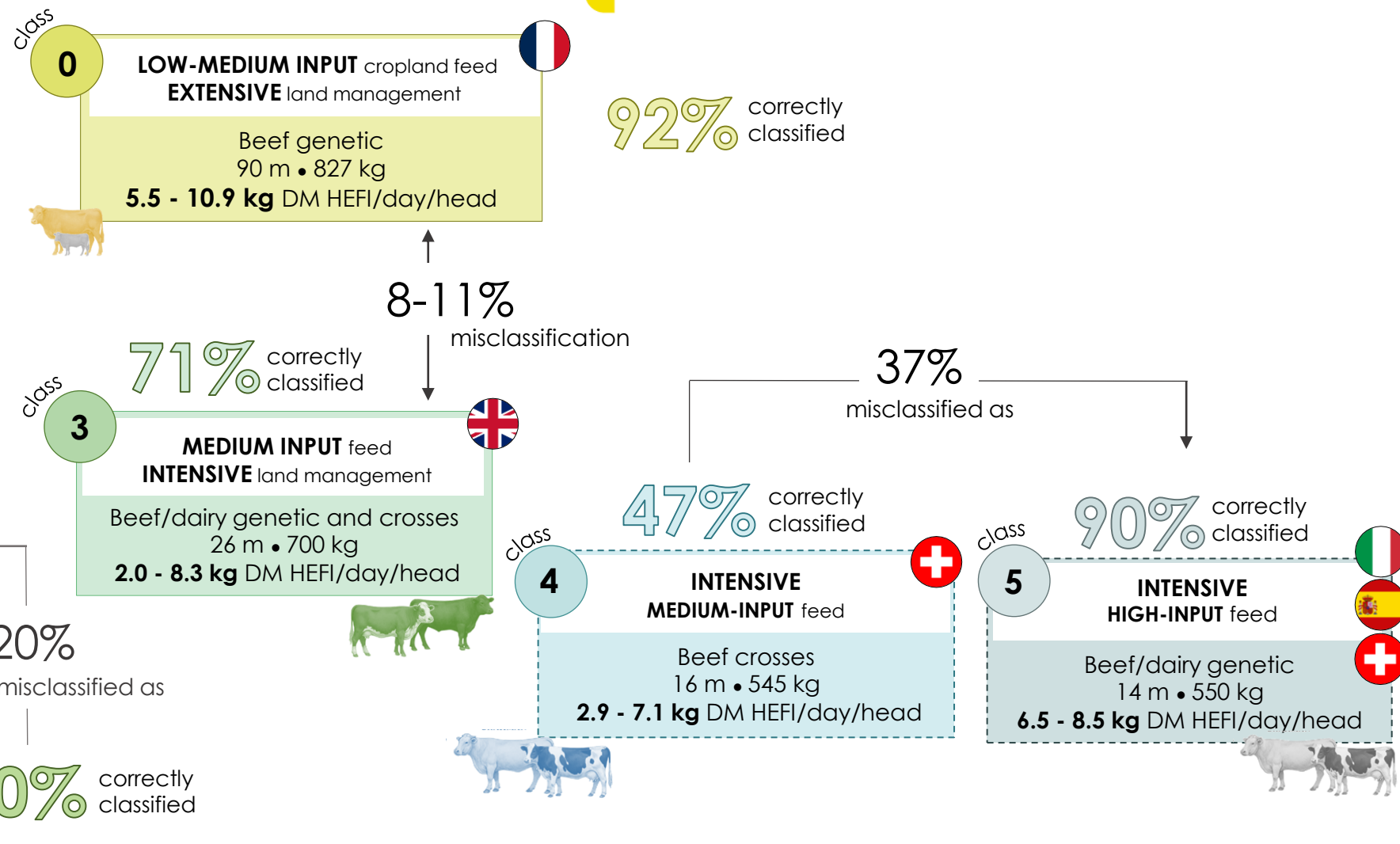
1050 wavelengths → 44A/23F CovSel variables



TASK Classification results

1 based on **benchtop device**
and '**Farm**' validation

classification



Animal age

Grass-based systems

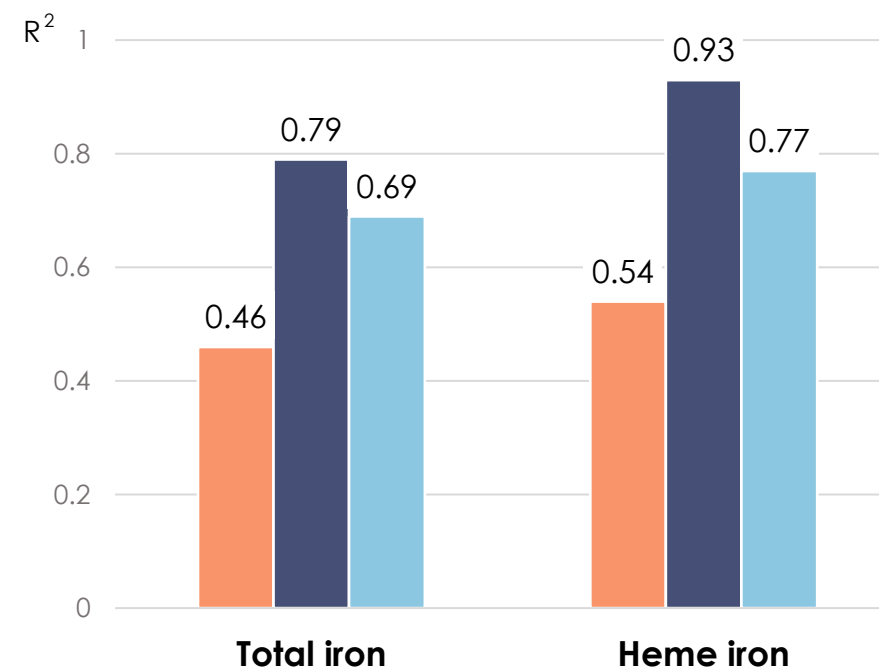
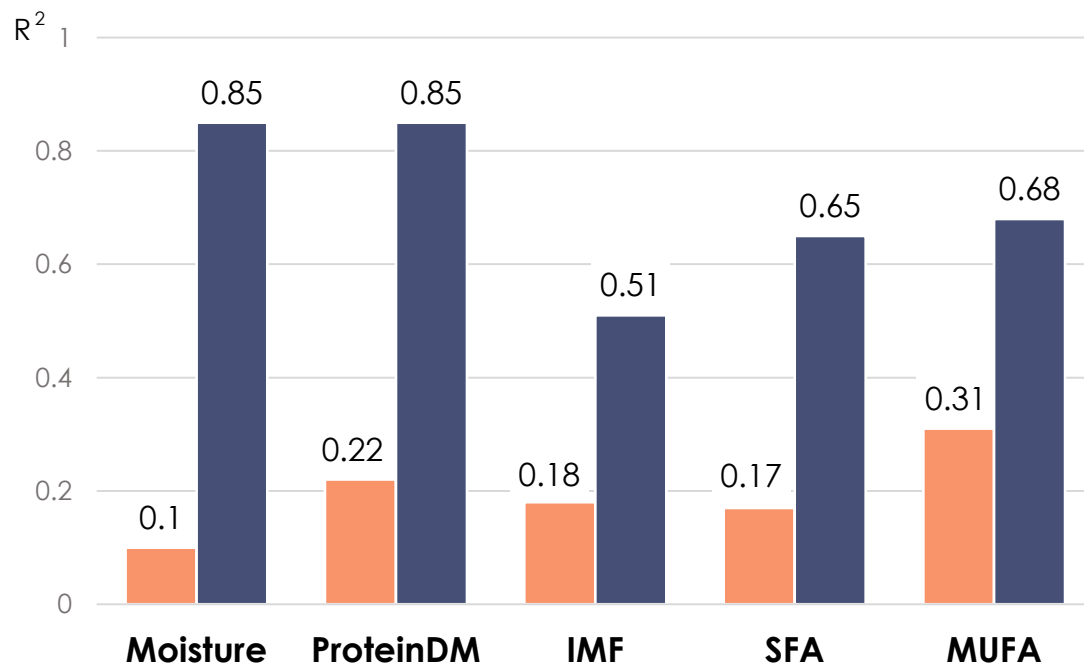
Indoor/intensive systems

TASK Prediction accuracy

2

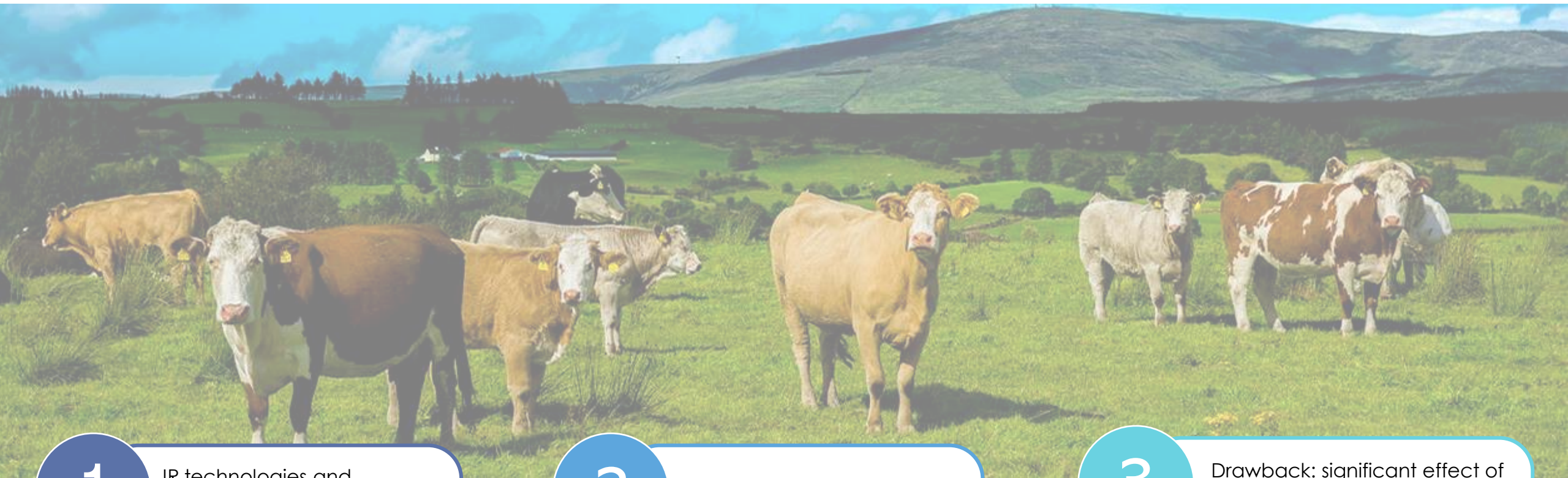
2.1 Comparison among devices and spectral ranges

prediction





Conclusions

**1**

IR technologies and chemometrics can be a promising technique for authentication in the beef sector (++)benchtop device)

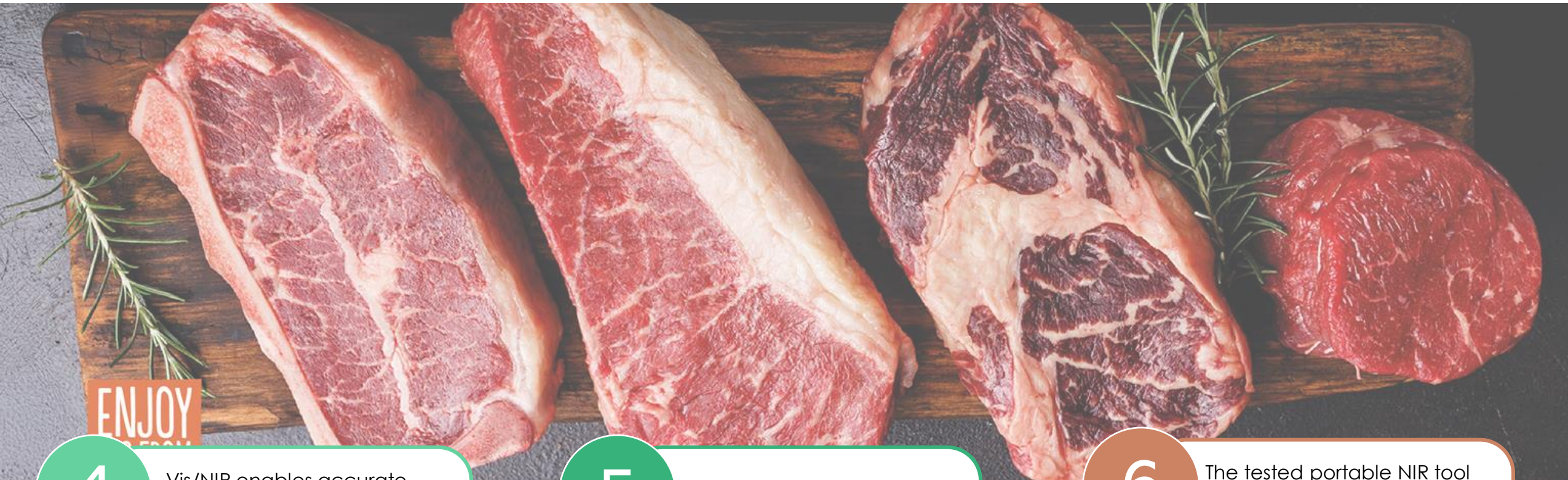
**2**

Different intensification levels (especially extreme contrasts as *feedlots vs pasture*) can be discriminated

**3**

Drawback: significant effect of the sampling design on accuracy → include more farms within the same class and restricted geographical areas





4

Vis/NIR enables accurate prediction for several beef traits (proximate composition, major fatty acids, total and heme iron)

5

Scanning individual samples yields to higher prediction accuracy than scanning pooled samples

6

The tested portable NIR tool needs further optimization to improve prediction of considered biochemical traits in beef prediction



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Video credits: <https://time4europeanbeef.eu/> | Beef from Spain | Funded by the EU



Stefaan De Smet
Aziz Mouhanna



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Francesca Soglia



QUEEN'S
UNIVERSITY
BELFAST

Lynda Perkins
Nigel Scollan



Universitat Autònoma
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