Development of a portable MIR instrument for in-farm milk analysis
-
what are the needs and expectations of the dairy sector?

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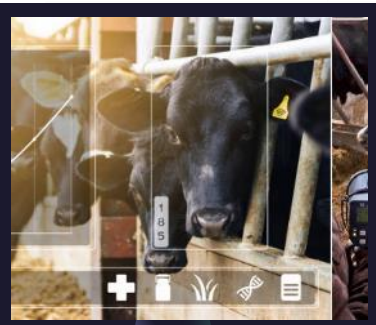


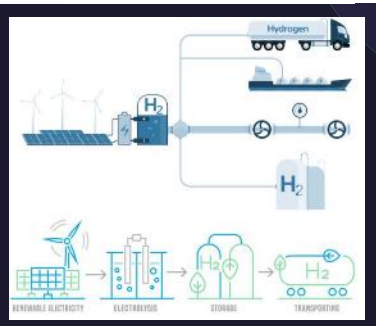
SUSTAINABLE FARMING

Focus will be on cows farming. **BROMEDIR will be used for on-farm, fast analysis of individual cow milk samples** focusing on the nutritional value of milk (measurement of total fat, total protein, carbonydrates-lactose content) and cow's health traits (fatty acids profiling that can indicate physiological imbalance.

MILK ANALYSIS

FUEL QUALITY

Focus will be on both **monitoring of jet fuel quality and control of biodiesel percentage present in car & marine diesel**. Contamination with fatty acid methyl ester (FAME) will be tested for jet fuel and for the second part, biodiesel (FAME) content in car (petroleum) & marine diesel will be tested.



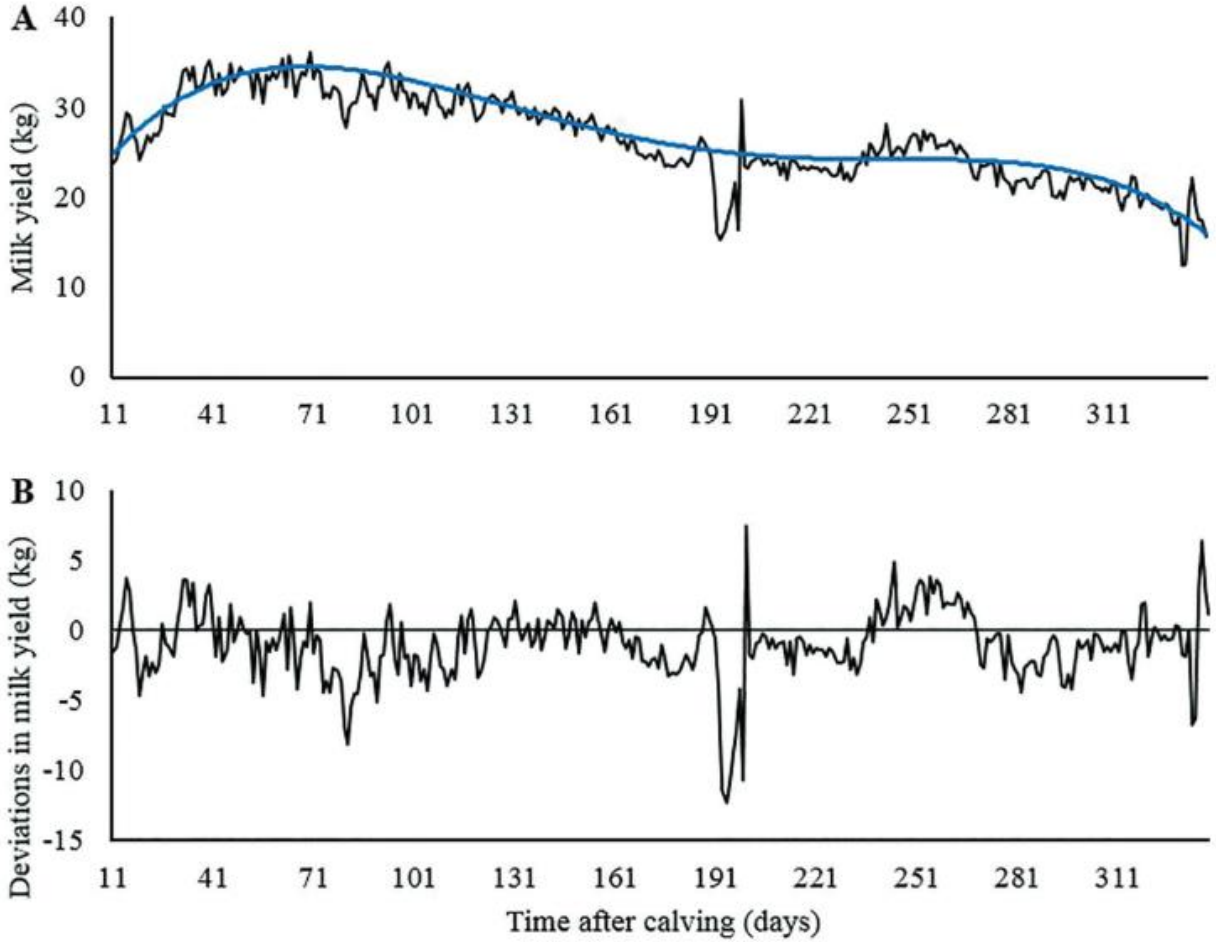
HYDROGEN QUALITY

Trace contamination detection of hydrogen during production & supply to end-customers requires continuous hydrogen measurement a) in feed gas, b) after pre-enrichment, and c) in product gas after electrochemical compression-separation for dynamic process control – as pipeline compositions and supply/demand situations may vary significantly.

Herd monitoring - PLF

- Precision livestock farming
- High frequency of measurement (daily)
- Individual cow level
- Powerful to detect deviations
  - Heat
  - Unknown disturbances (mastitis, heat stress…)
- BUT few phenotypes
  - Milk yield
  - Accelerometers
  - Milk Conductivity
  - …

Poppe et al., 2020



Herd monitoring - MIR

- High number of phenotypes
  - Milk quality (fatty acids, minerals, coegulation properties…)
  - Energy deficit
  - Ketone bodies
  - Mastitis
  - Fertility (ability to conceive…)
  - Environmental footprint (CH4, nitrogen efficiency…)
  - …
- BUT low frequency, every 4 to 6 weeks with DHI

MIR on farm?

- Objective of Bromedir: develop a miniaturized MIR spectrometer for in-farm milk analysis
  - Would enable to predict high number of phenotypes at a high frequency (daily)
  - Extremely powerful tool for rapid and specific detection of troubles

- MIR not existing yet
- NIR systems in farms → less precision and phenotypes compared to MIR

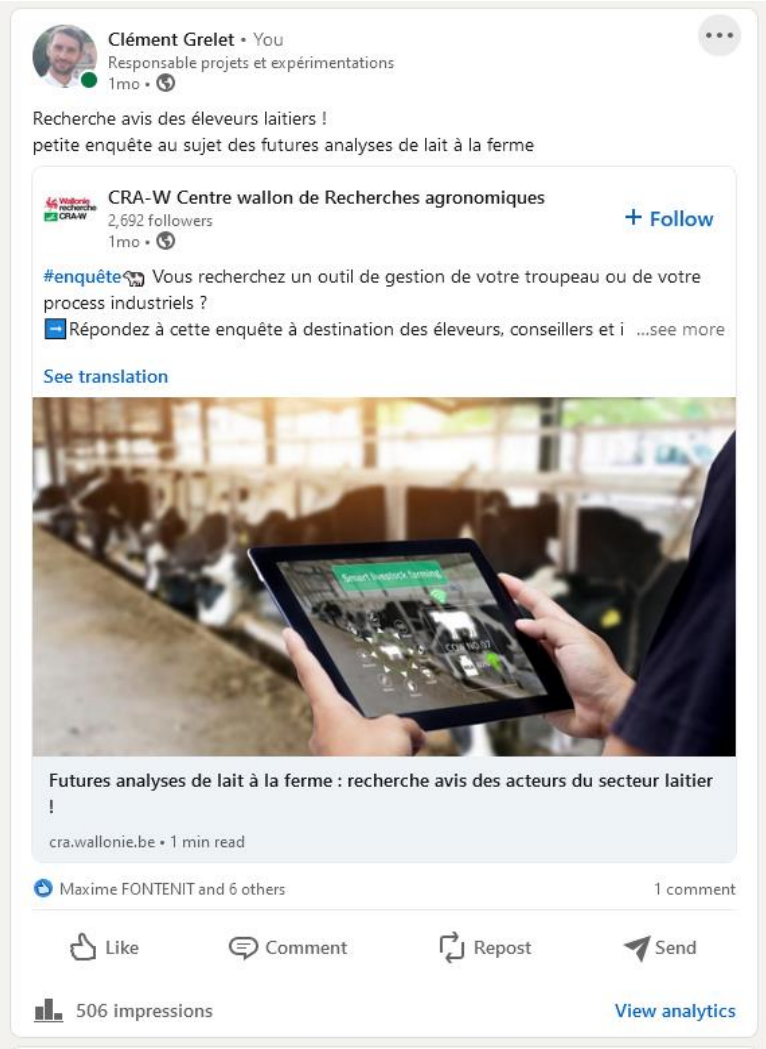
Preliminary step

What are the needs and expectations of dairy sector?

- Which type of instrument?
- For which users?
- And which use?

Survey

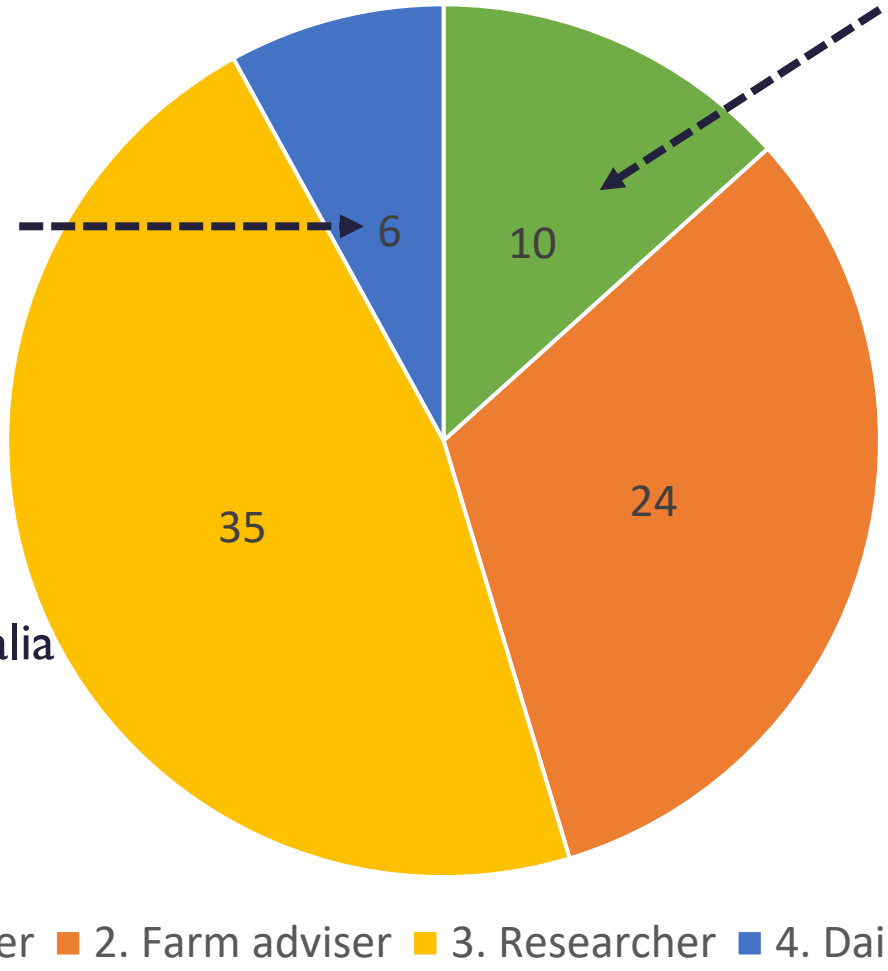
- Performed from 15th February to 15th march
- 4 languages (English, French, German and Greek)
- Addressed to 4 stakeholders groups:
  - Dairy farmers
  - Advisers (milk recording organizations, vets, nutritionists)
  - Livestock researchers
  - Milk industry (factories processing milk products)
- Reached by mails and social media (facebook, agricultural newspapers…)



Who responded?

- 75 persons

Dairy industry
- Belgium, Austria, Cyprus
- >200 persons



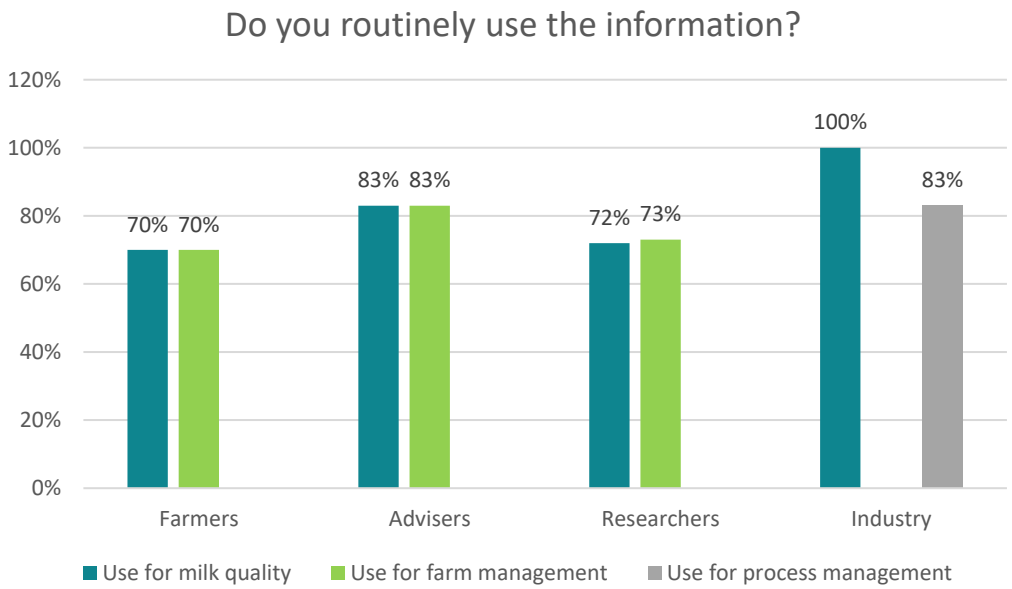
Farmers
- Belgium and France
- Holstein cows
- 50 to 260 cows
- 1 to 5 peoples working
- 40% with AMS

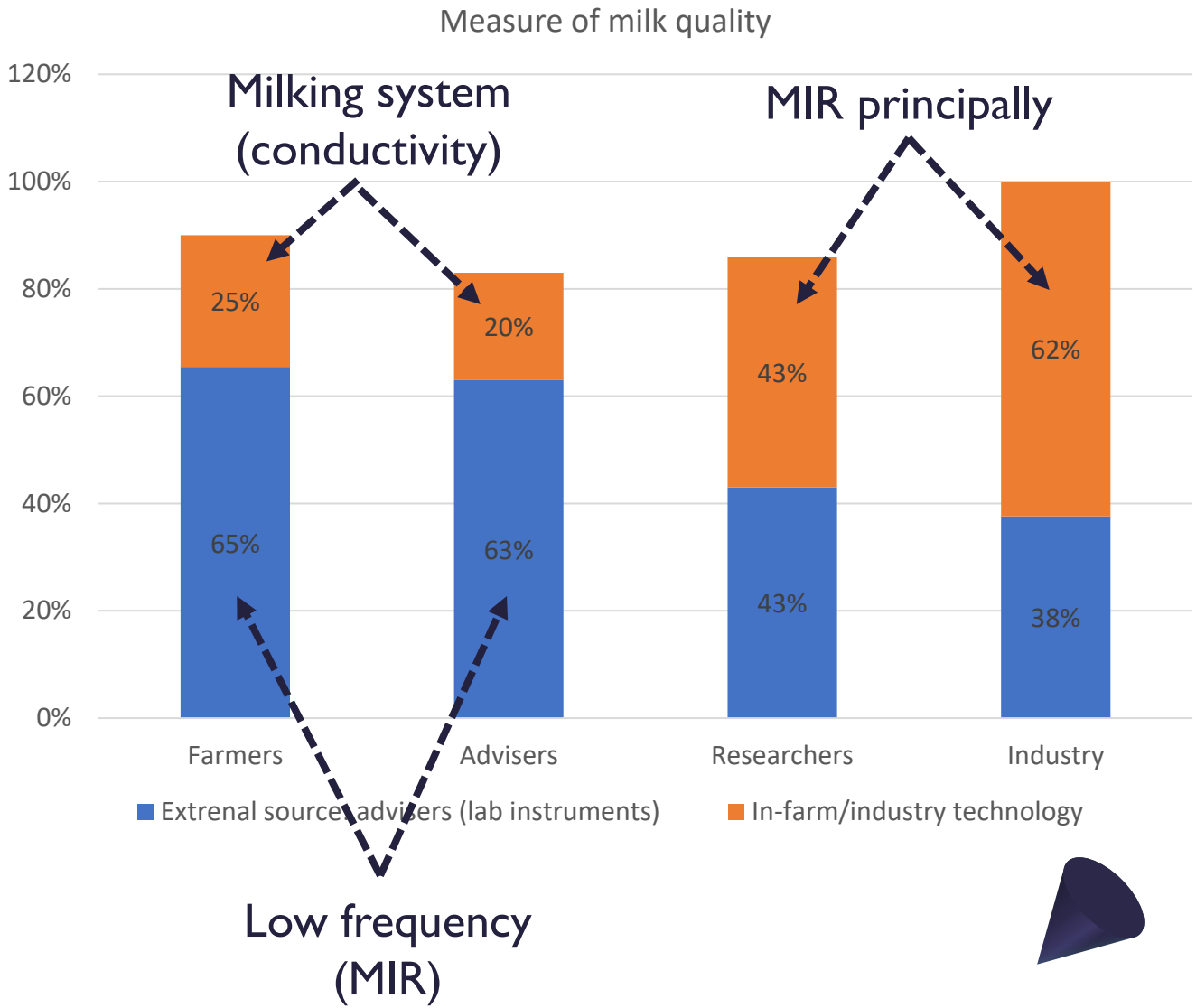
Researchers
- 14 countries (Europe + Canada, Australia and China)
- 29% with AMS
- Breeding, physiology, nutrition, milk analysis, infrared, modelling

Farm advisers
- 7 countries (Europe + USA)
- DHI, vets, feed industry and dairy industry

Information already accessible on milk quality?

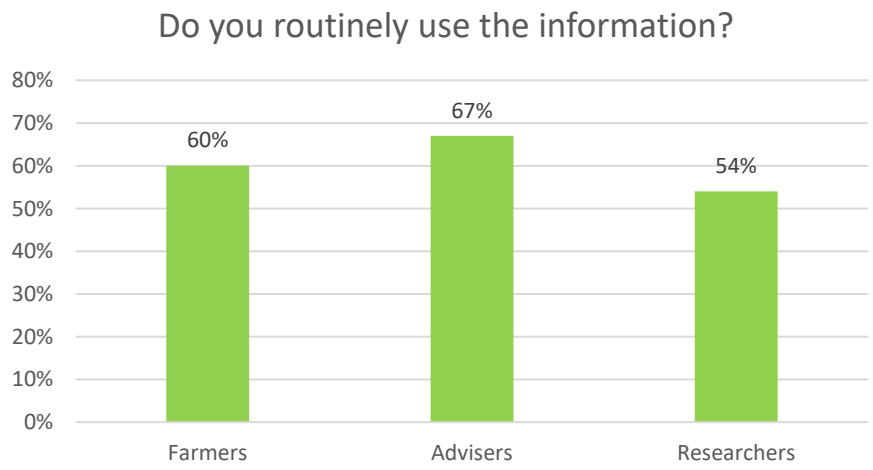
- High access rate to milk quality (83% to 100%)
- Individual and/or tank milk
- Main traits: Fat, proteins, urea, conductivity, SCC (fatty acids also)

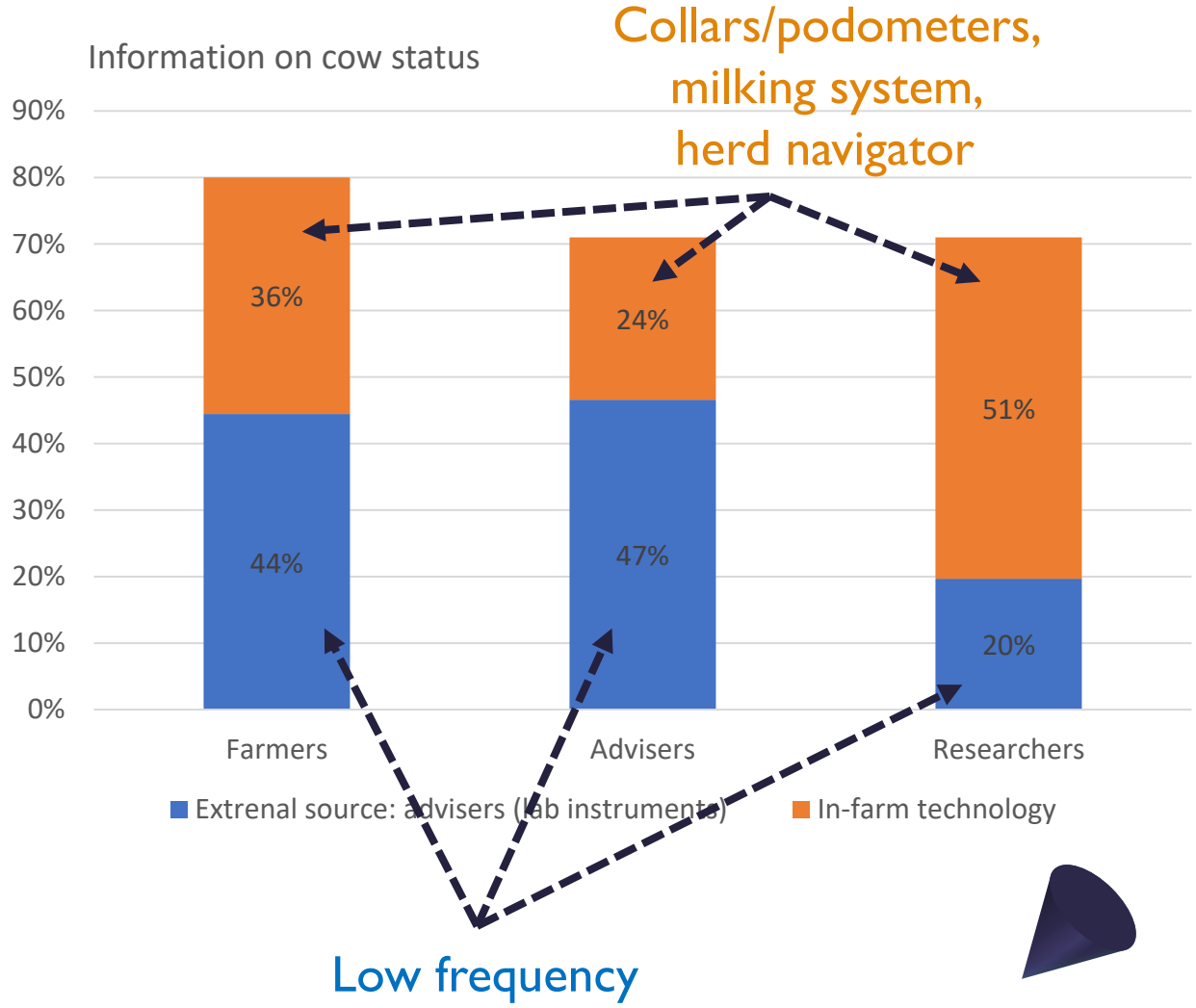




Information already accessible on cow status?

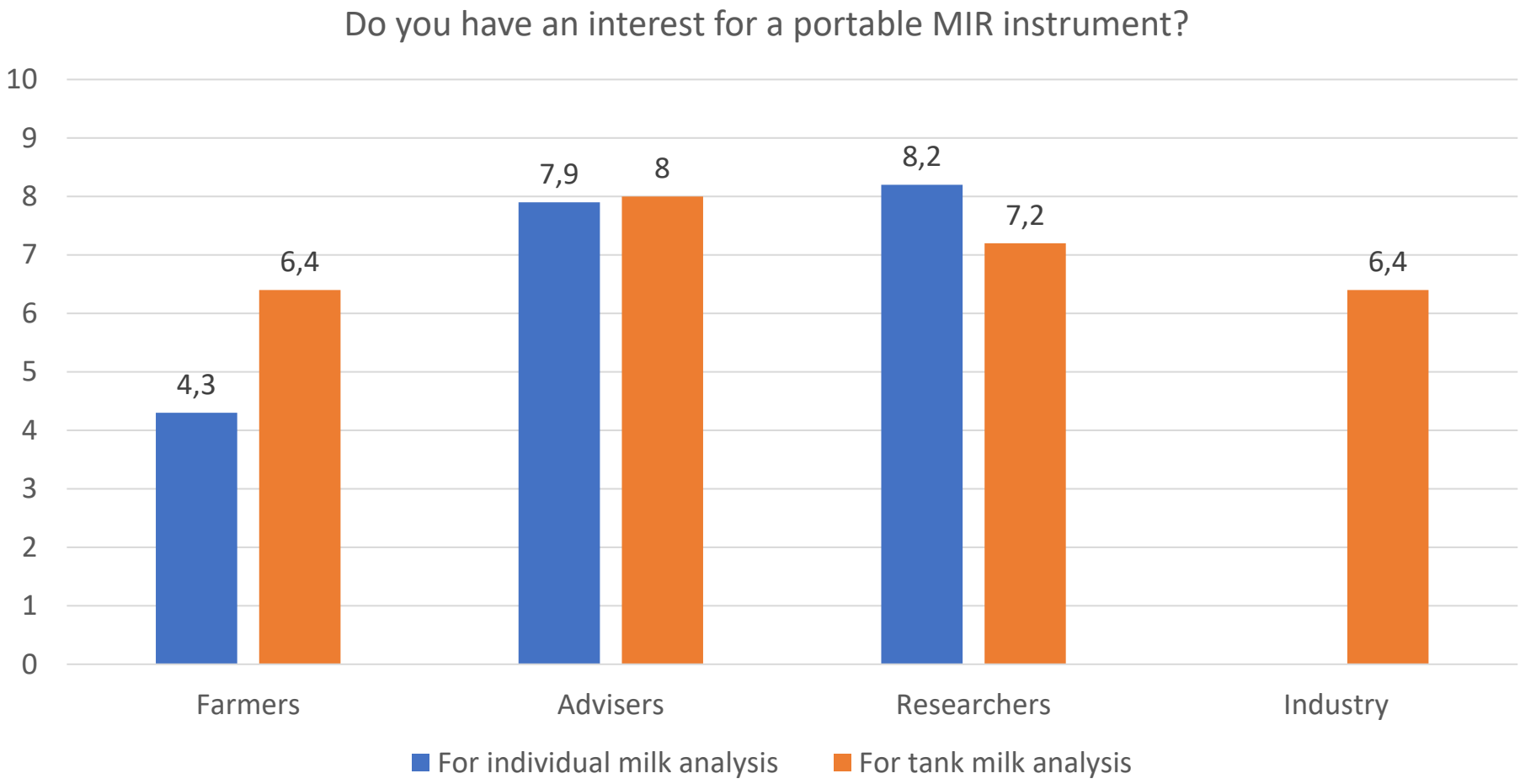
- High access rate to cow status information (71% to 80%)
  - Mastitis
  - Heat detection
  - Rumination
  - Feed efficiency
  - Energy deficit/Ketosis





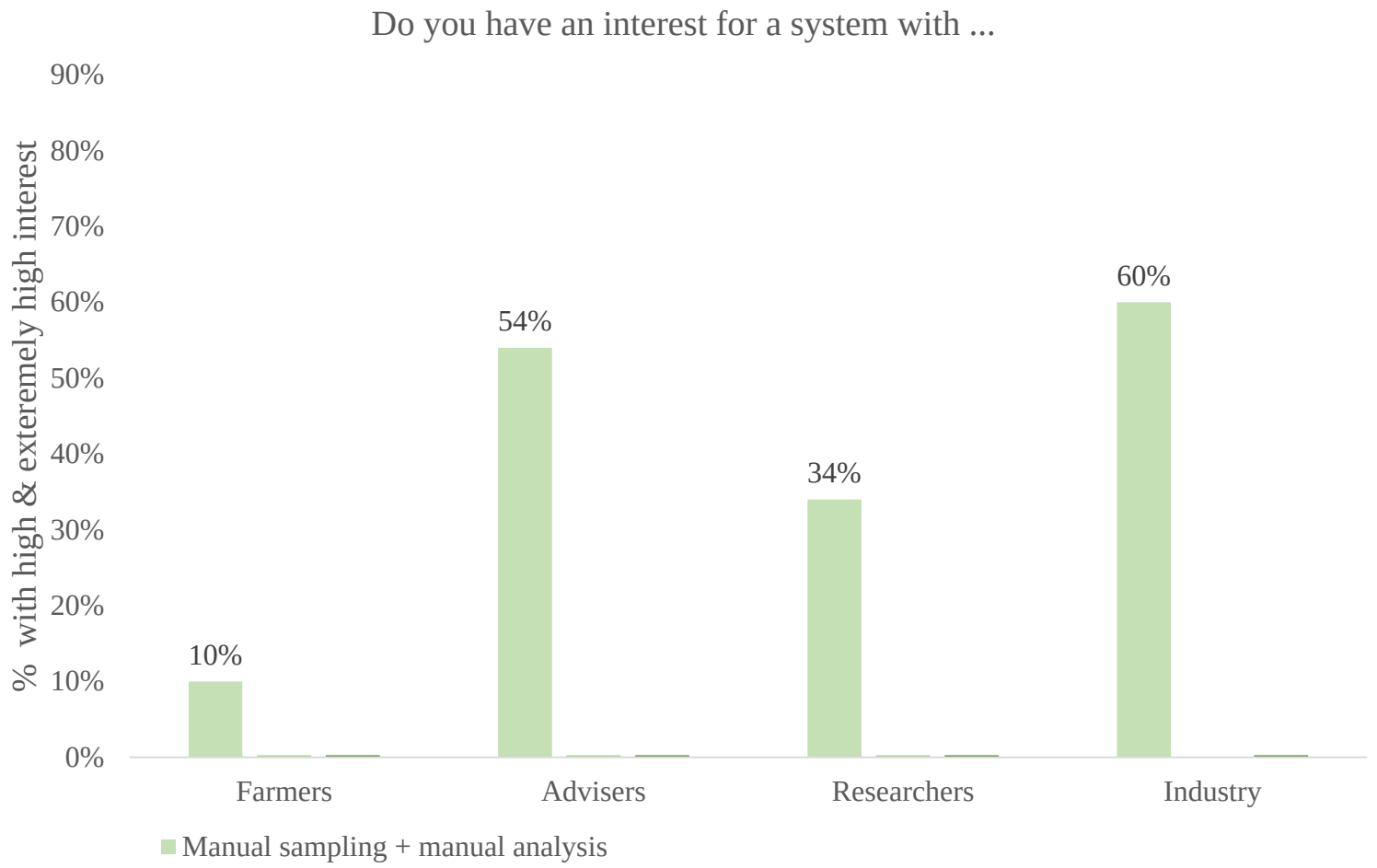
Interest for a portable MIR instrument?

- Interest from the stakeholders (on a scale from 0 to 10) : large differences between groups



Interest for a portable MIR instrument?

- Interest regarding the automation of system …
  - Extremely high interest
  - High interest
  - Limited interest
  - Low interest



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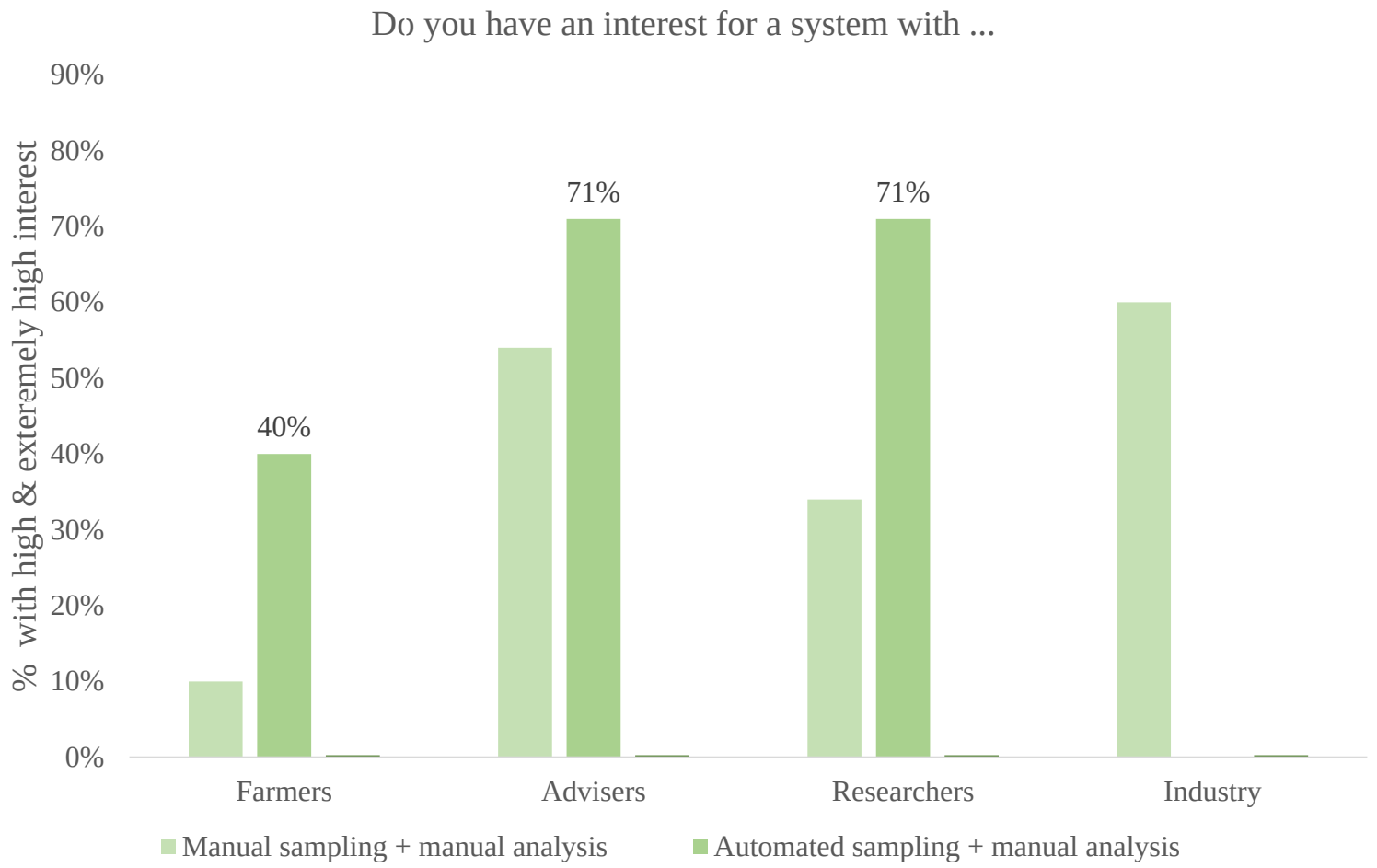

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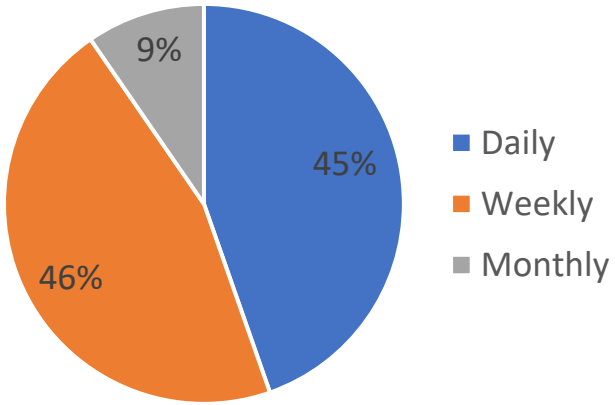
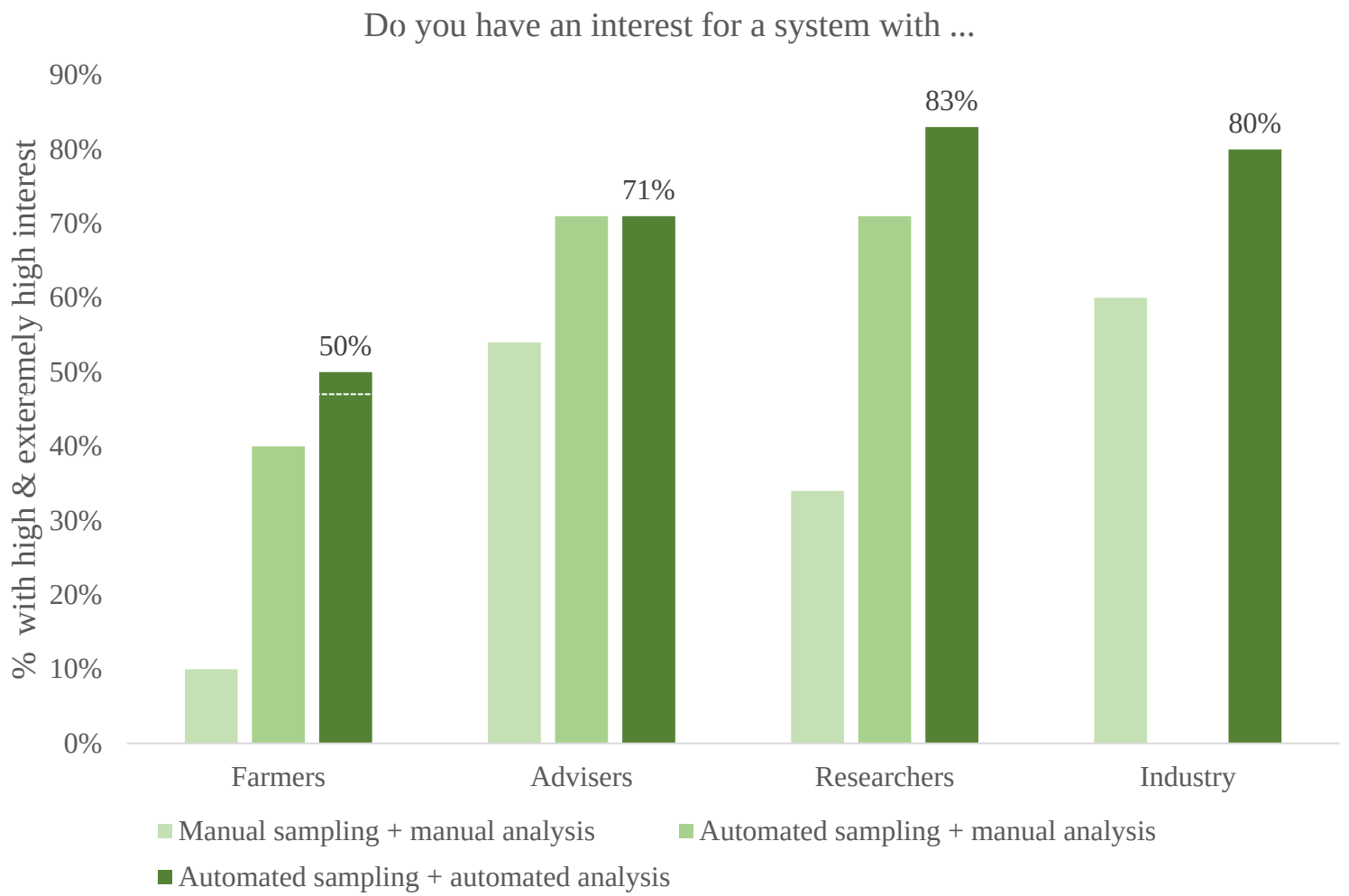
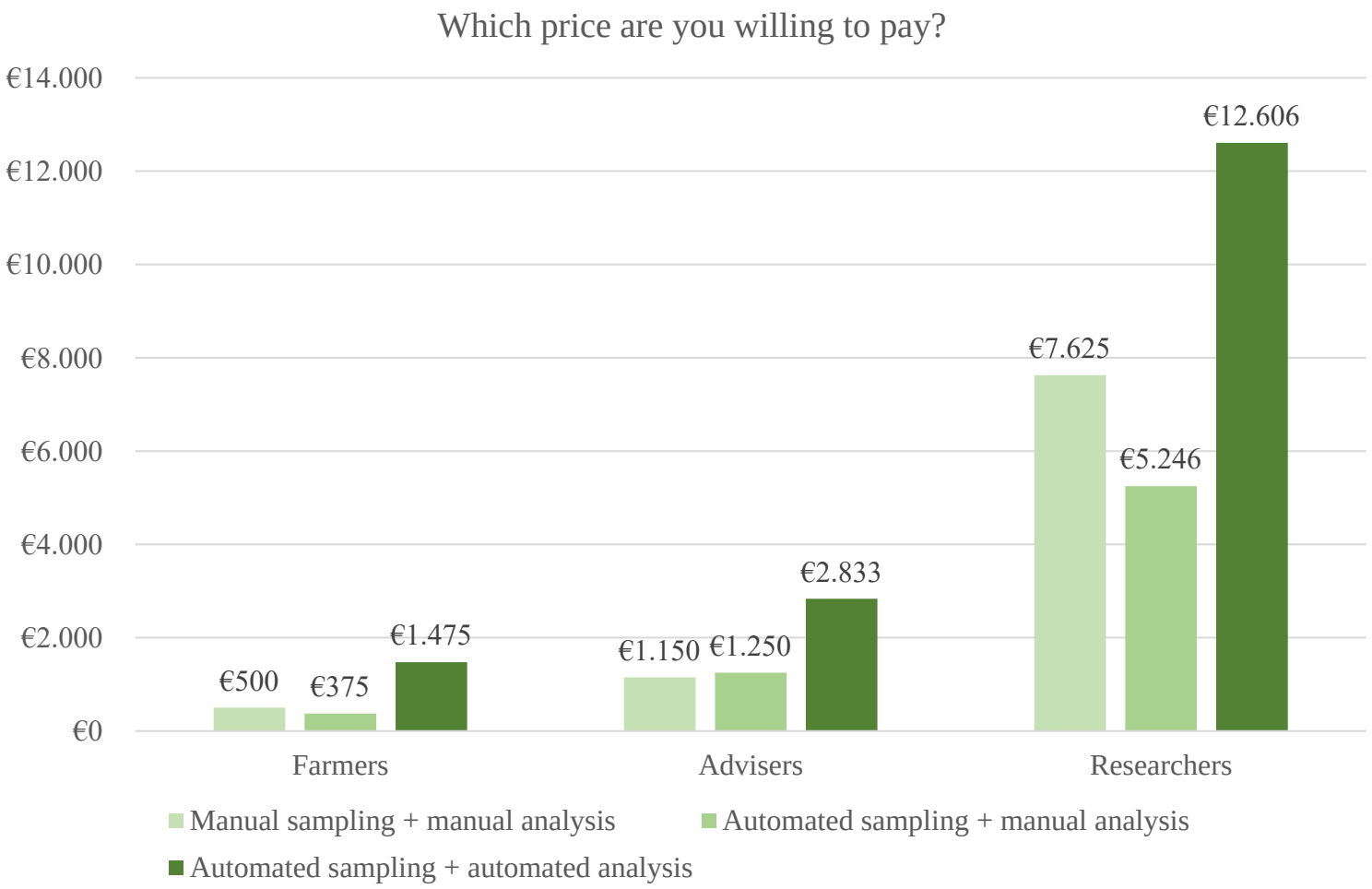
- What should be the frequency of analysis?





Interest for a portable MIR instrument?

- Interest regarding the type of system …



Interest for a portable MIR instrument?

- Which phenotypes?
- Rate of interested (%) among stakeholders (only +50% shown)

Phenotypes
Milk main components (fat, protein, lactose)
Mastitis detection
Acidosis detection
Feed efficiency
Negative energy balance detection
Ketosis detection
Cyclicity detection (fertility)
Pregnancy detection (fertility)
Milk nutritional quality (fatty acids, minerals…)
Lameness detection
Parasites detection
Milk ability to be processed into cheese, butter, yogurt
Information on cow status: environmental footprint

Interest for a portable MIR instrument?

- Which phenotypes?
- Rate of interested (%) among stakeholders (only +50% shown)

Phenotypes	**Farmers**
Milk main components (fat, protein, lactose)	90%
Mastitis detection	80%
Acidosis detection	60%
Feed efficiency	50%
Negative energy balance detection	
Ketosis detection	
Cyclicity detection (fertility)	
Pregnancy detection (fertility)	
Milk nutritional quality (fatty acids, minerals…)	
Lameness detection	
Parasites detection	
Milk ability to be processed into cheese, butter, yogurt	
Information on cow status: environmental footprint	

Interest for a portable MIR instrument?

- Which phenotypes?
- Rate of interested (%) among stakeholders (only +50% shown)

Phenotypes	Farmers	Advisers
Milk main components (fat, protein, lactose)	90%	58%
Mastitis detection	80%	83%
Acidosis detection	60%	50%
Feed efficiency	50%	63%
Negative energy balance detection		88%
Ketosis detection		71%
Cyclicity detection (fertility)		67%
Pregnancy detection (fertility)		63%
Milk nutritional quality (fatty acids, minerals…)		63%
Lameness detection		50%
Parasites detection		
Milk ability to be processed into cheese, butter, yogurt		
Information on cow status: environmental footprint		

Interest for a portable MIR instrument?

- Which phenotypes?
- Rate of interested (%) among stakeholders (only +50% shown)

Phenotypes	Farmers	Advisers	Researchers
Milk main components (fat, protein, lactose)	90%	58%	74%
Mastitis detection	80%	83%	71%
Acidosis detection	60%	50%	63%
Feed efficiency	50%	63%	63%
Negative energy balance detection		88%	63%
Ketosis detection		71%	66%
Cyclicity detection (fertility)		67%	66%
Pregnancy detection (fertility)		63%	66%
Milk nutritional quality (fatty acids, minerals…)		63%	57%
Lameness detection		50%	60%
Parasites detection			
Milk ability to be processed into cheese, butter, yogurt			
Information on cow status: environmental footprint			

Interest for a portable MIR instrument?

- Which phenotypes?
- Rate of interested (%) among stakeholders (only +50% shown)

Phenotypes	Farmers	Advisers	Researchers	Industry
Milk main components (fat, protein, lactose)	90%	58%	74%	100%
Mastitis detection	80%	83%	71%	
Acidosis detection	60%	50%	63%	
Feed efficiency	50%	63%	63%	
Negative energy balance detection		88%	63%	
Ketosis detection		71%	66%	
Cyclicity detection (fertility)		67%	66%	
Pregnancy detection (fertility)		63%	66%	
Milk nutritional quality (fatty acids, minerals…)		63%	57%	50%
Lameness detection		50%	60%	
Parasites detection				
Milk ability to be processed into cheese, butter, yogurt				67%
Information on cow status: environmental footprint				50%

Technical considerations?

- What are the important technical aspects? (on a scale from 0 to 10)

	Farmers	Advisers	Researchers	Industry
Easy to use information	8.9	8.6	8.6	8
Minimum maintenance requirements	8.7	8.3	7.4	7
Robustness to field conditions (farm/industry).	8.5	8.5	8.8	8.7
Accuracy of the measure (to reach ICAR thresholds).	8.2	8.3	8.6	8.8
Easy-to-use instrument.	8.2	8.8	8.2	7.8
Cost per analysis	7.8	8.3	7.7	6.8
Portability		7.9	6.7	7

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Technical considerations?

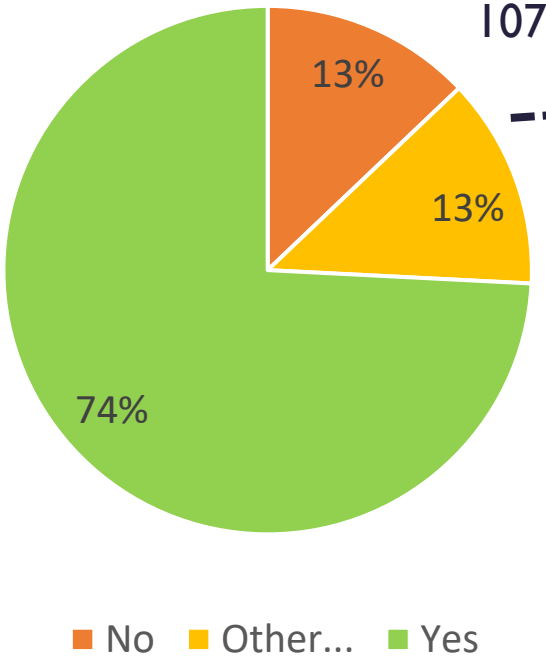
- Could you rank your priorities (1 to 11)

Priorities

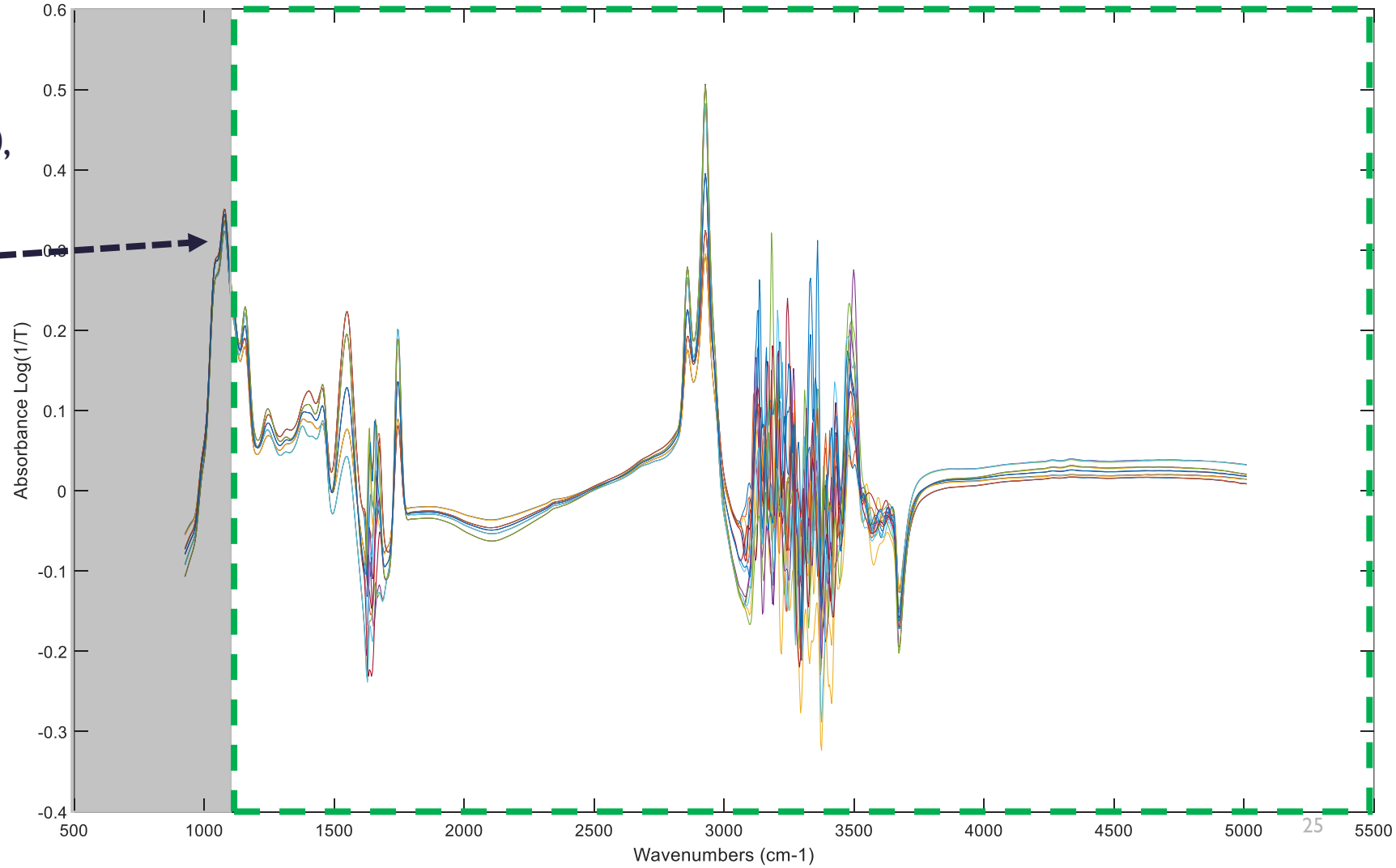
	Researchers
Good and easy washing procedure	7.37
Possibility to calibrate	7.34
Transferability of existing MIR models	7.25
Correction of drift in time	6.87
Homogenization of milk	6.87
Analysis at 40°C	6.53
Atmospheric compensation (CO2, humidity, temperature)	6.18
Possibility to export spectra	6
Possibility to import models	4.53
Possibility to visualize spectra	3.9
Possibility to name spectra	3.12

Technical considerations?

- Is the proposed range 1100-3000cm-1 usable?

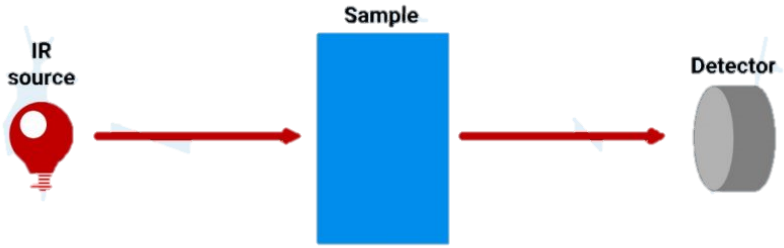


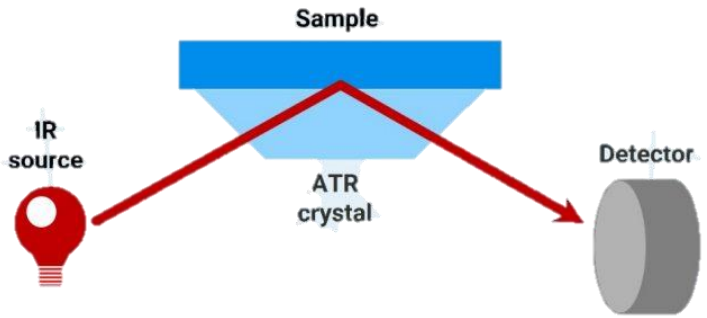
Missing lactose information (1040, 1076 cm-1; OH)

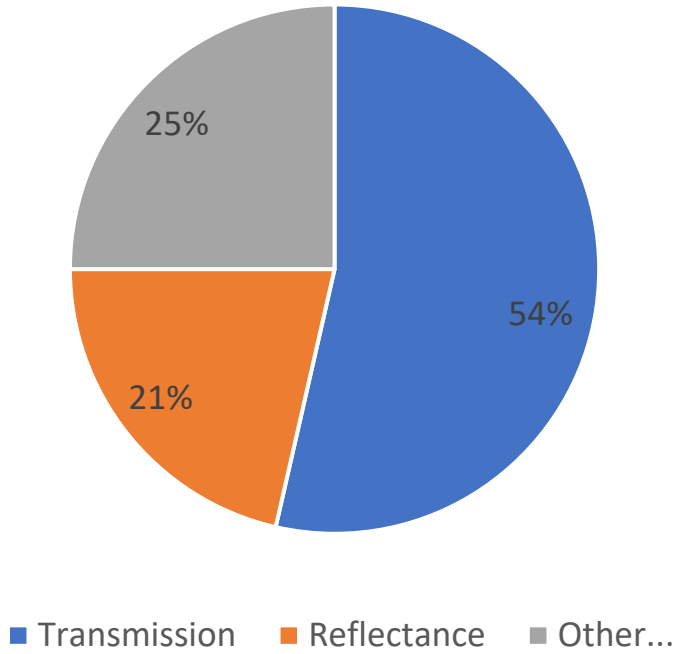


Technical considerations?

- Should the instrument be in transmission or reflectance (ATR)?







Transmission (54%)

- will give better results
- in line with benchtop instruments (transferability of models)

Reflectance (ATR) (21%)

- is easier/more robust
- sample do not need to passes in the cuvette (few microns) → no bypass?

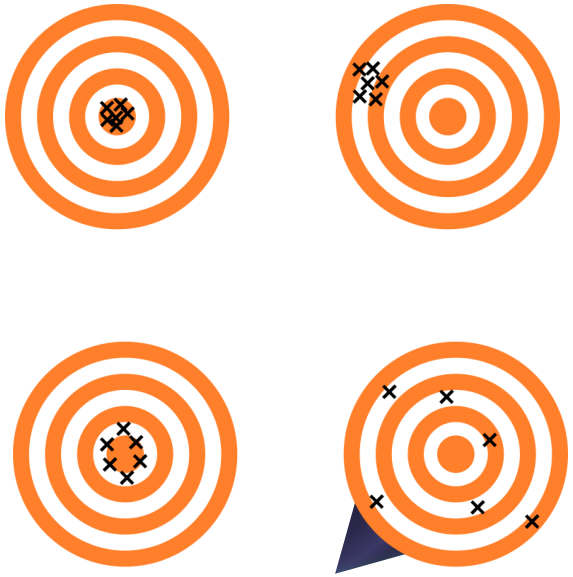
https://www.bruker.com

How to integrate these information?

- Which audience to target?
- How should the system be conceived?
  - Portable at-line
  - In-line automated instrument
- Transmission or reflectance?
- To consider
  - Information ease of use
  - Washing process
  - …

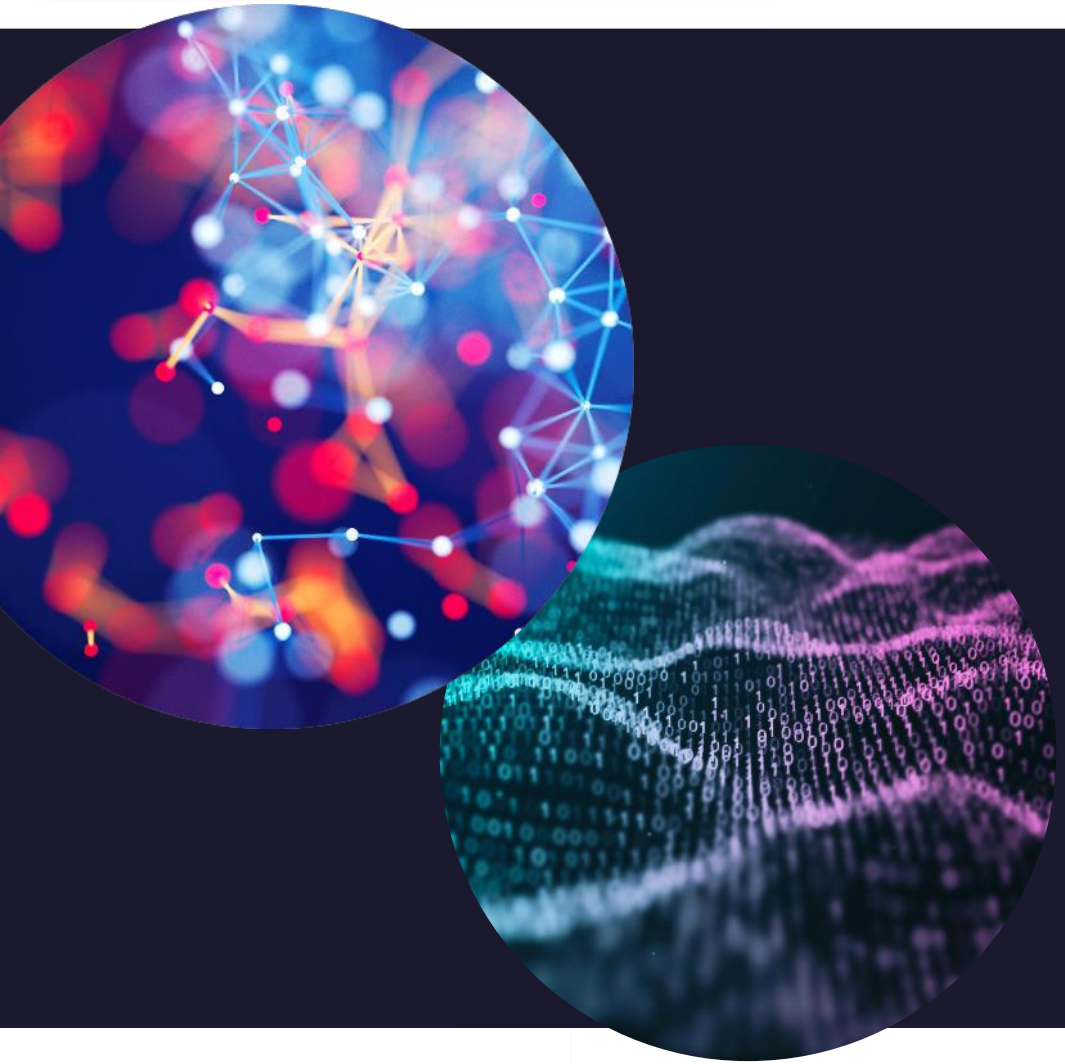
Next steps

- To conceive the instrument (prototypes)
- To test the instrument
  - In lab
  - In real barn conditions



- Accuracy/repeatability/reproductibility…
- Robustness to field conditions
- Ease of use
- Transferability of existing models

Funded by the European Union



Thank You

For more information, please contact:

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