



UNIVERSITÀ
DEGLI STUDI
DI TERAMO

DEPARTMENT OF BIOSCIENCE AND TECHNOLOGY FOR FOOD AND AGRICULTURE
Master Degree in FOOD SCIENCE AND TECHNOLOGY (A.Y. 2025/2026)

Zootecnia di Precisione

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Principles of Precision Livestock Farming (PLF)

Perché è Nata la Zootecnia di Precisione?

La crescita della popolazione mondiale

FORNTE ONU

QUOTIDIANO NAZIONALE



Perché è Nata la Zootecnia di Precisione?

OCSE-FAO PROSPETTIVE AGRICOLE 2025-2034

DOMANDA
ALIMENTARE **+13%**

PRODUZIONE
AGRICOLA
E ITTICA **+14%**

EMISSIONI GHG
INTENSITÀ
EMISSIVA **-6%**



Anno	Intensità Emissiva
2000	Alta
2034	Bassa (-6%)

APPORTO CALORICO
DA PRODOTTI
ANIMALI E ITTICI

PAESI A REDDITO MEDIO **364 kcal**

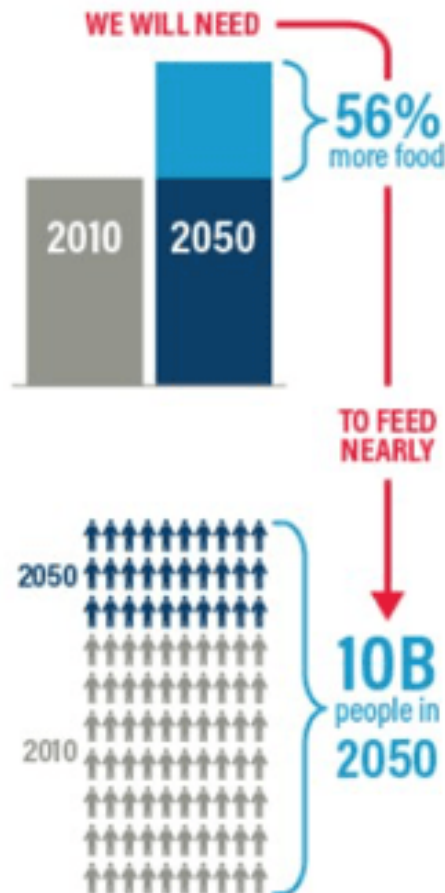
PAESI A BASSO REDDITO **143 kcal**

L'aumento della popolazione a livello globale determina un aumento della domanda di prodotti di origine animale...

Perché è Nata la Zootecnia di Precisione?

CREATING A SUSTAINABLE FOOD FUTURE BY 2050

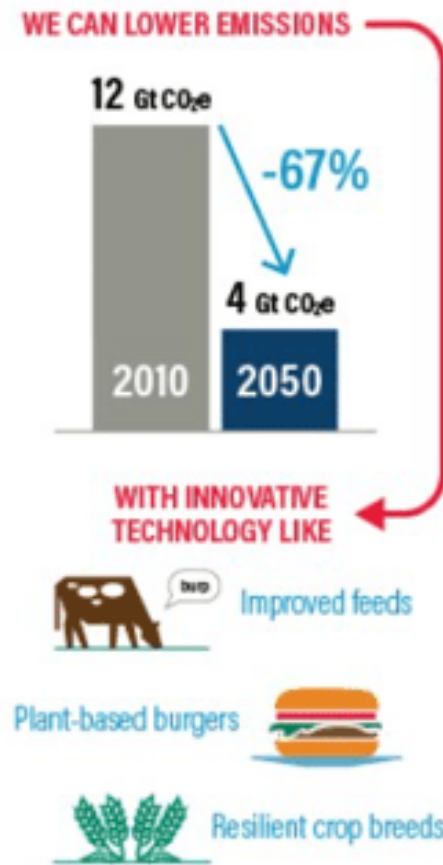
How do we feed
10 billion people...



...without using
more land...



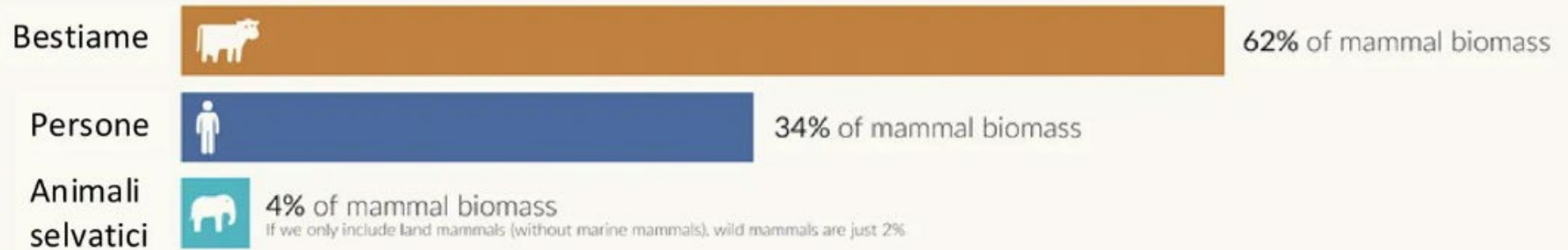
...while lowering
emissions?



Ad oggi la distribuzione della biomassa animale è la seguente...

Mammiferi

All mammals – including land and marine – have a combined biomass of around **162 million tonnes of carbon**.
Wild mammals are just 4% of global mammal biomass

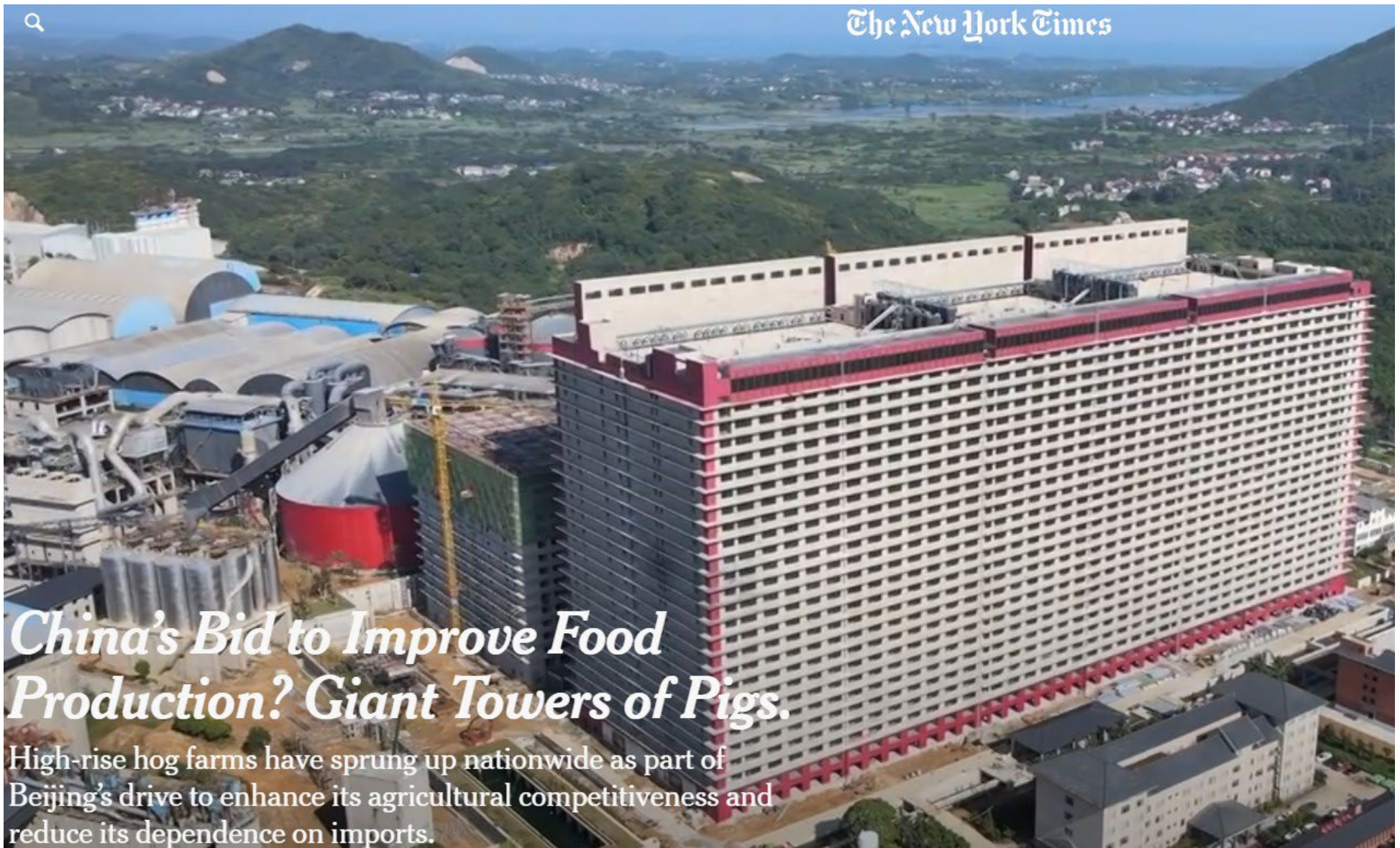


Volatili

All birds have a combined biomass of around **7 million tonnes of carbon**.
Poultry – mostly chickens – biomass weigh more than twice that of wild birds.



How will 10 billion people be fed in 2050?



The New York Times

China's Bid to Improve Food Production? Giant Towers of Pigs.

High-rise hog farms have sprung up nationwide as part of Beijing's drive to enhance its agricultural competitiveness and reduce its dependence on imports.

How will 10 billion people be fed in 2050?



Perché è Nata la Zootecnia di Precisione?

La zootecnia di precisione nasce dall'esigenza di rendere ancor più efficienti i processi produttivi, con la possibilità di rispondere in modo adeguato alla crescente domanda di prodotti di origine animale a livello globale.

...Quindi la selezione genetica è arrivata al capolinea?

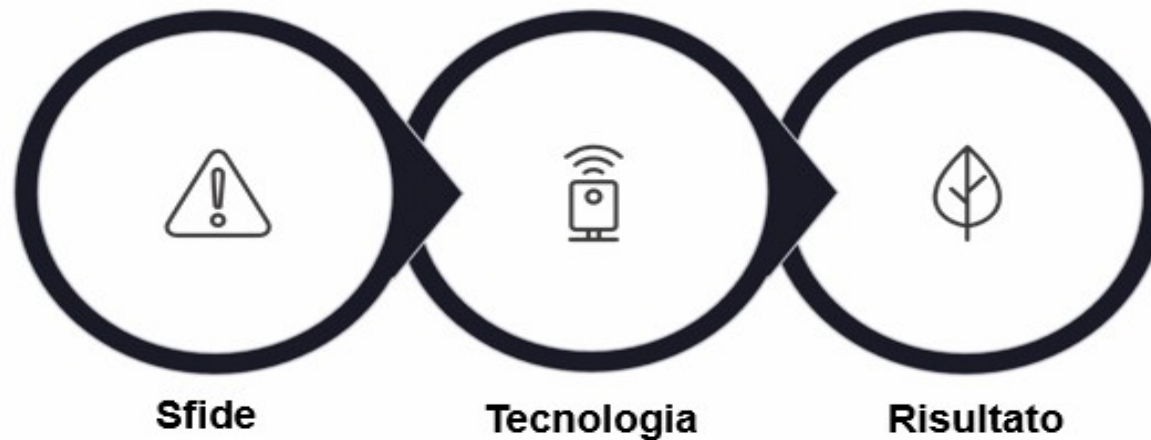
Perché è Nata la Zootecnia di Precisione?

...andare oltre appare complicato

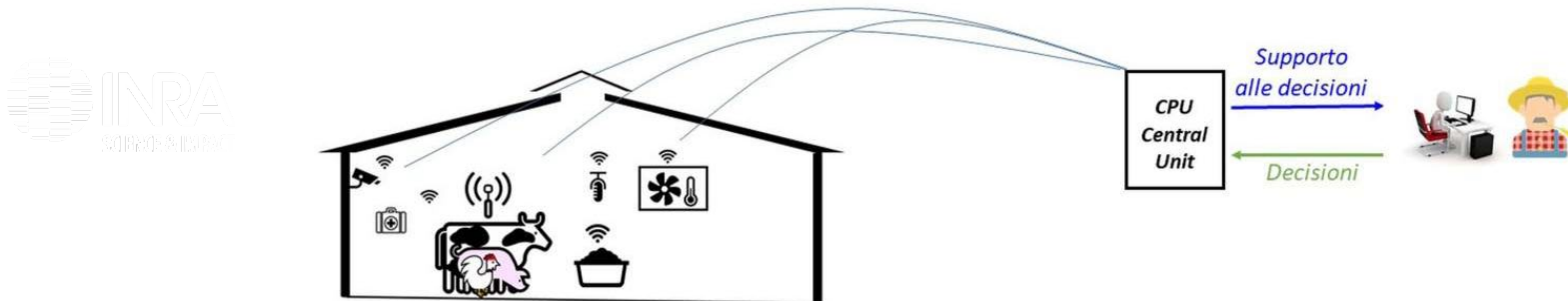


Perché è Nata la Zootecnia di Precisione?

Il settore zootecnico moderno affronta sfide sempre più complesse: allevamenti di grandi dimensioni, costi in crescita, pressione ambientale e aspettative di benessere animale. La zootecnia di precisione risponde a queste esigenze con un approccio integrato basato su dati, automazione e monitoraggio continuo.



Ogni decisione produttiva diventa più precisa, tempestiva e misurabile.



Principi di Zootecnia di Precisione

La zootecnia di precisione è un approccio moderno all'allevamento che utilizza tecnologie digitali per monitorare, analizzare e ottimizzare la gestione degli animali. Si basa sull'uso intelligente dei dati per migliorare **produttività, benessere animale e sostenibilità**, rendendo l'allevamento più efficiente e moderno.



Principi di Zootecnia di Precisione

1. Monitoraggio continuo degli animali, al fine di individuare precocemente problemi sanitari o comportamentali. Il benessere animale rappresenta ormai un elemento centrale anche nella valutazione della qualità complessiva del prodotto.



Principi di Zootecnia di Precisione

2. Raccolta e analisi dei dati tramite software e algoritmi (anche di intelligenza artificiale). La gestione passa da “reattiva” a “predittiva”.
3. Alimentazione di precisione; strumenti di analisi rapida e sistemi automatizzati, permettono di adattare la dieta a ciascun animale o gruppo, migliorando l’efficienza produttiva e la sostenibilità.



Principi di Zootecnia di Precisione

4. Automazione di tutti i processi aziendali (anche non strettamente associati all'animale), con conseguente riduzione del lavoro manuale e maggiore precisione.



Principi di Zootecnia di Precisione

5. Sostenibilità ambientale; la riduzione delle emissioni e l'ottimizzazione delle risorse favoriscono un allevamento più sostenibile.



Principi di Zootecnia di Precisione

- Integrazione e connettività; tutti i sistemi sono collegati e gestibili da remoto, consentendo la tracciabilità completa della filiera.

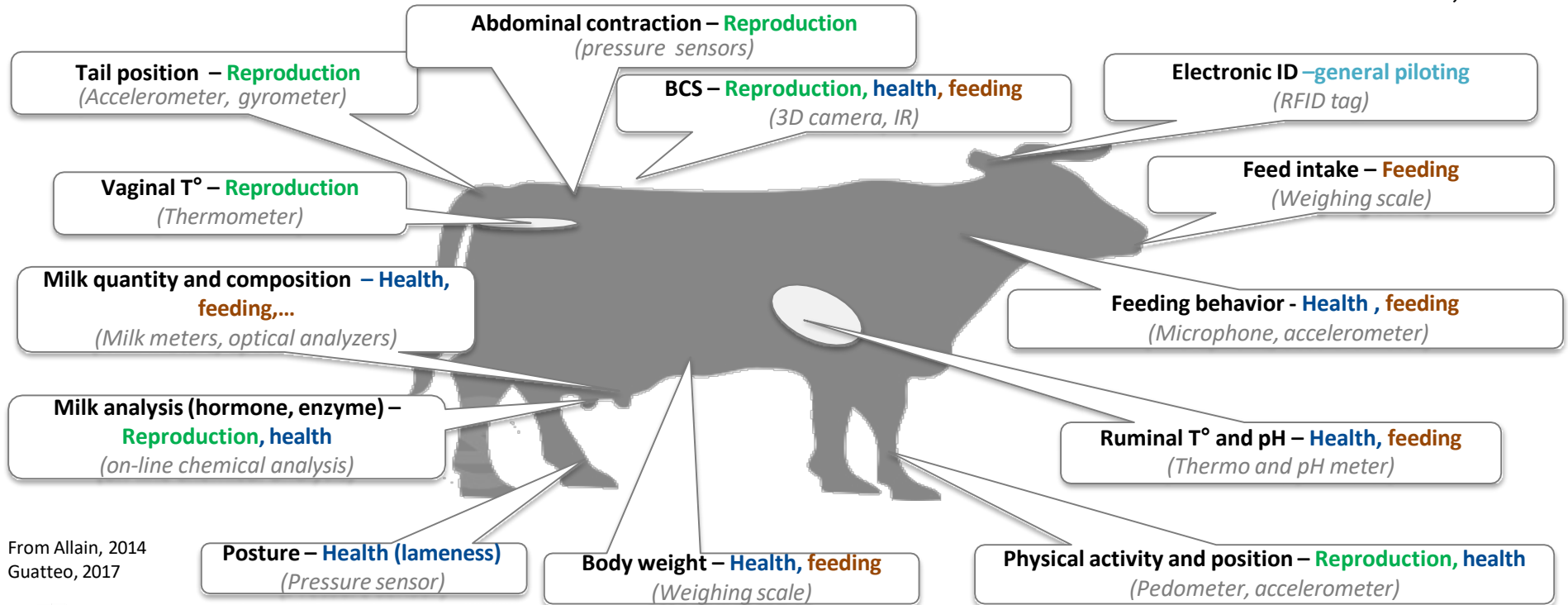


Sensors and automatons in cattle

Large panel of possibilities

Alone or in combination

Guatteo et Richard, 2017



From Allain, 2014
Guatteo, 2017



Nutrition - a major lever to improve the sustainability of animal production

❖ Economy

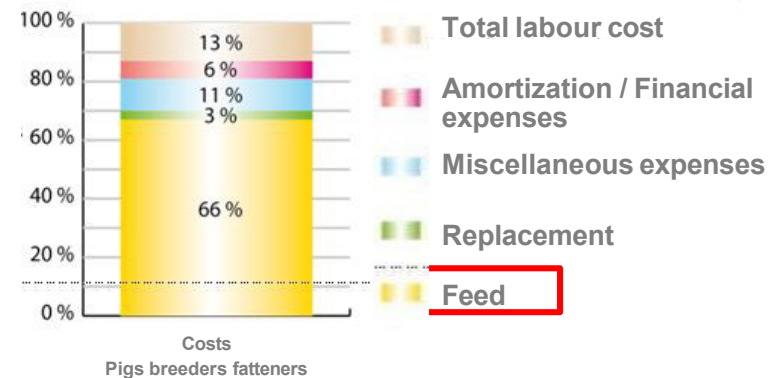
- feed = about 2/3 of production cost

❖ Environmental impact

- Reduction of resource use (feed)
- Reduction of nutrient excretion (N, P...)

❖ Quality of products

- Lean to fat ratio, Fat quality
- Homogeneity of products



➔ The improvement of feed efficiency is a major issue for sustainability of all production systems (conventional & alternative)

Evaluation of efficiency of utilization of feed

❖ Expressed as a ratio

- **Feed conversion ratio = Feed / Growth**
=> economic representation of a « cost of production »
- ***Feed efficiency ratio = Growth / Feed***
=> *representation of the efficiency of a biological process*

❖ Different units of expression

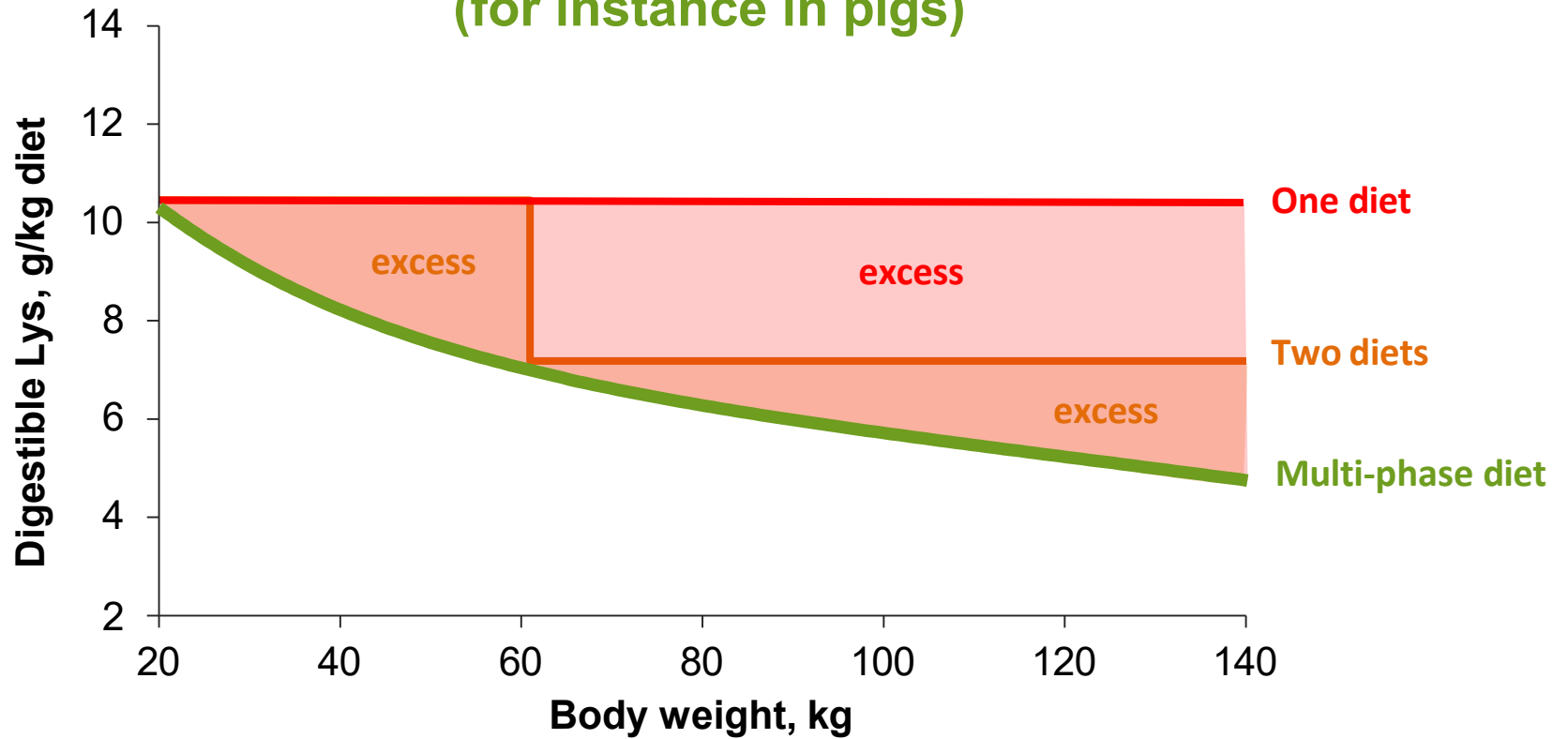
- **kg feed / kg gain** => *most common !*
- **MJ Energy / kg gain** => *biological efficiency !*
- **€ of feed / kg gain** => *economic efficiency !*

Strategies to improve feed and nutrient efficiency

- ❖ **Insure adequate, energy, amino acid and mineral supplies (for growth, health...)**
 - sufficient to maximize growth (↘ FCR)
 - not in excess to avoid the increase in excretion and in FCR
 - the optimal supply depends on animal genotype and sex, and age
- ↪ **Difficult to implement in practice**
 - variation of requirements over time
 - variability between animals

⇒ **New opportunities offered by precision livestock farming**

Accounting for changes in nutrient requirements during growth (for instance in pigs)



Principles of precision feeding

❖ Improve the characterization of individual animals (or small groups)

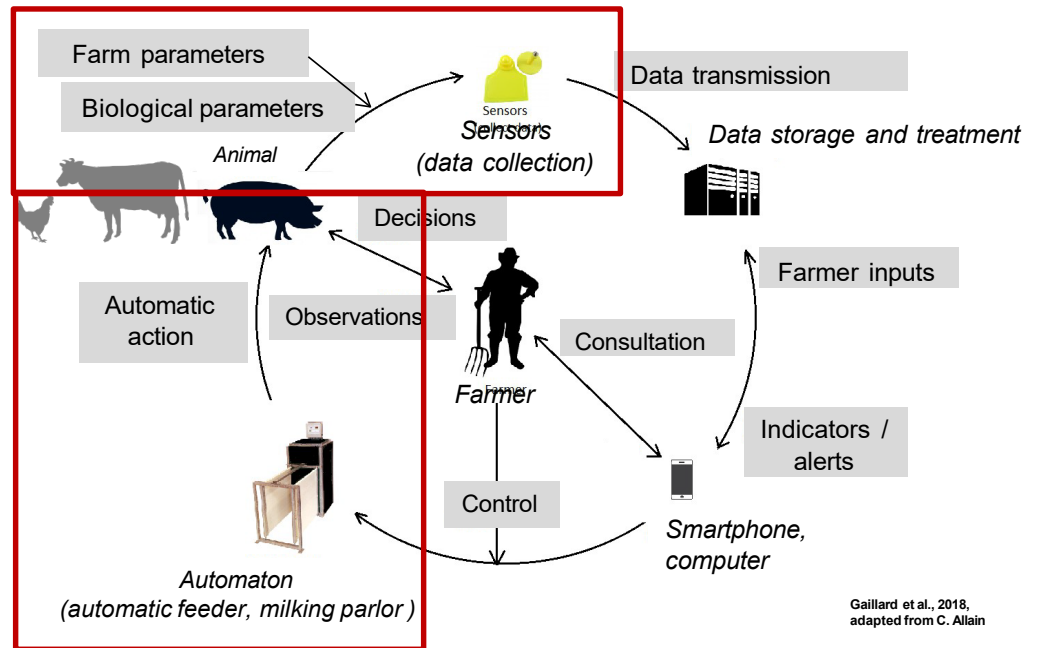
- Feed intake, Growth potential
- Body condition
- Physical activity, health...

❖ To better adapt supplies ...

- Quantity / Quality
- According to time
- to groups or individuals

❖ ... and improve efficiency

- reduction of cost
- reduction of excretion
- control of quality



Apply up-to-date nutritional concepts and use simulation/prediction models

❖ Protein-Amino acids

- Digestibility

❖ Energy

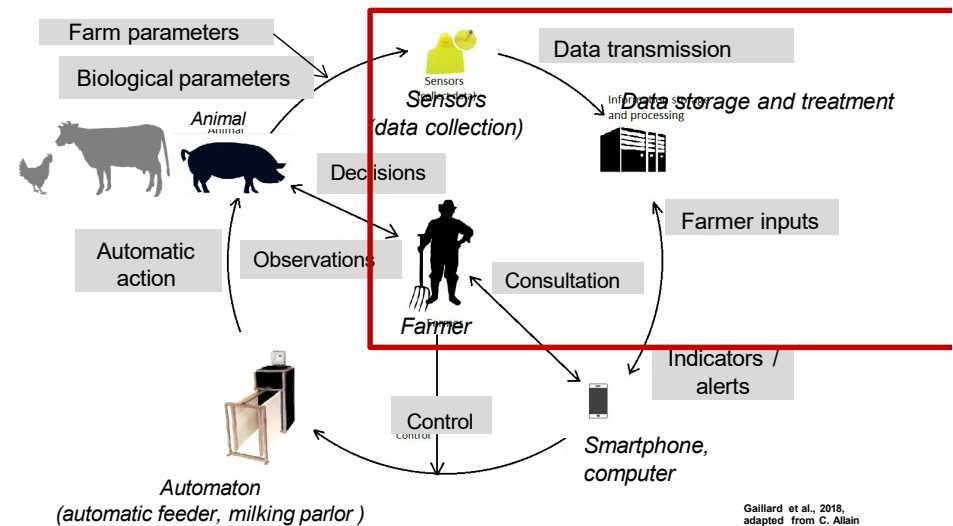
- Energy system

❖ Phosphorus

- Digestible phosphorus

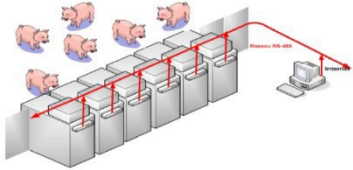
❖ Using nutritional simulation models to handle the information and take the decisions

- Determination of optimal nutrient supplies

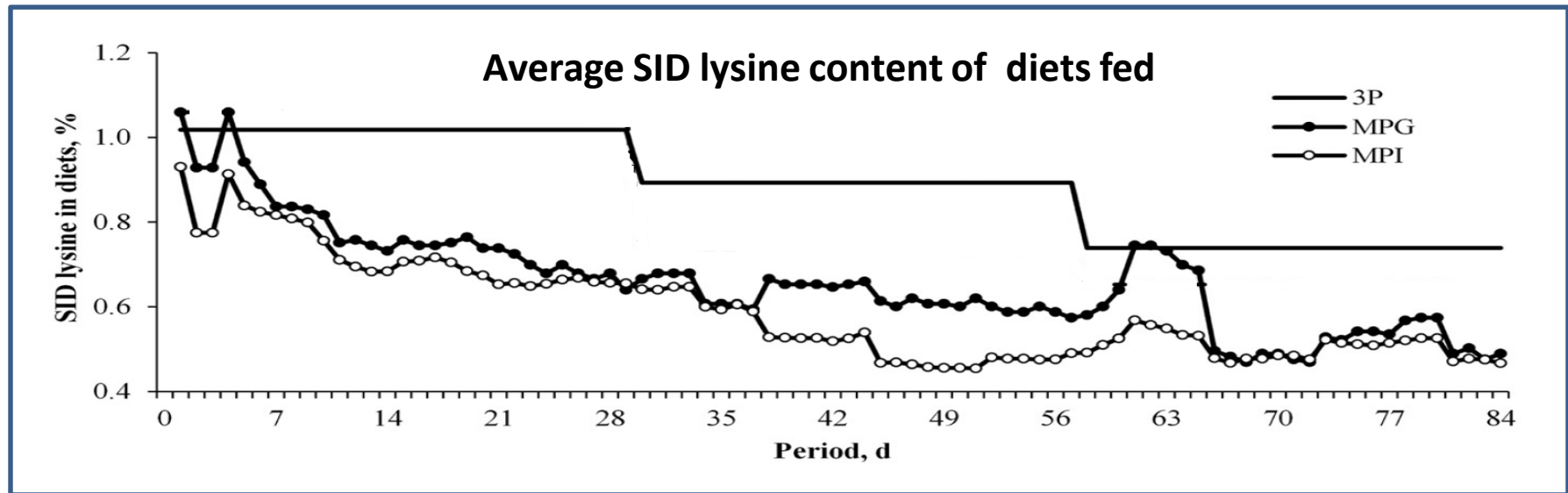


Some results in fattening pigs

Andretta *et al.* (2014)



Comparison of : **3-Phase group feeding** **(3P)**
 multiphase group feeding **(MPG)**
 multiphase individual feeding **(MPI)**

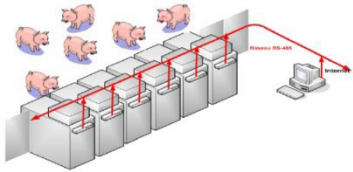


SID (Standardized Ileal Digestible - Lisina Digeribile Ileale Standardizzata) è il parametro fondamentale per definire il fabbisogno proteico nei suini.

Rappresenta la quota di lisina effettivamente assorbita a livello ileale, eliminando la variabilità legata alla digeribilità delle materie prime.

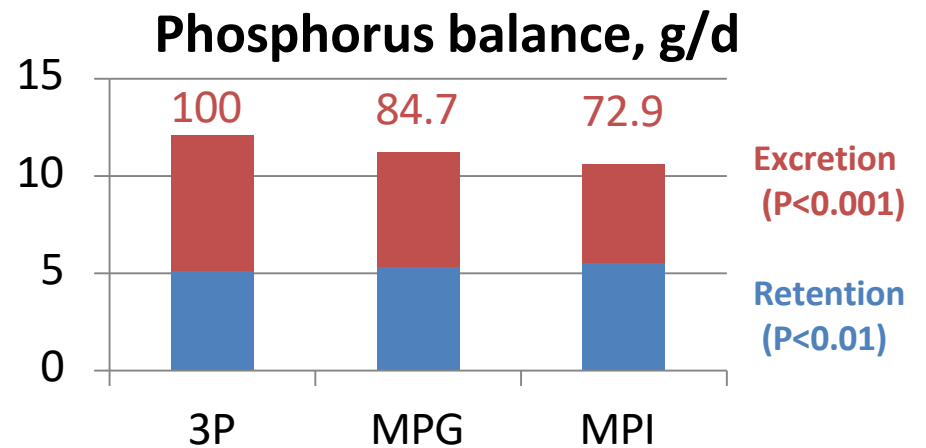
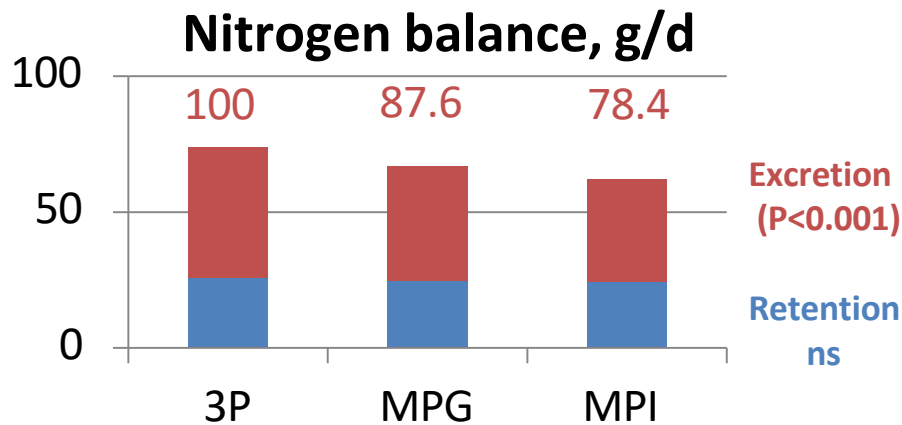
Some results in fattening pigs

Andretta *et al.* (2014)



Comparison of : **3-Phase group feeding (3P)**
 multiphase group feeding (MPG)
 multiphase individual feeding (MPI)

No effect on ADG and FCR



EU funded
Research
project

2015
2020

€10 M
Budget

Feed-a-Gene



Adapting the **feed**, the **animal**
and the **feeding techniques**
to improve the efficiency and
sustainability of monogastric
livestock production systems

www.feed-a-gene.eu

23

Partners
EU + China

15

Industry

8

Academic



The Feed-a-Gene Project has received funding from the European Union's H2020 Programme under grant agreement no 633531.

Objectives of the Feed-a-Gene project



➤ Feed:

- Develop new local feed resources that are not/less in competition with food
- Improve the nutritional value of feed resources



➤ Gene:

- Use of novel traits indicative for feed efficiency and robustness that can be used as selection criteria → **genetic selection can still be useful!**
- “Do better with feeds that may be worse”



➤ Traits, models, and feeding techniques:

- Appreciate variation among animals
- Develop precision feeding techniques
- Evaluate the overall sustainability

New animal traits for innovative feeding and breeding strategies



behavior and welfare



image analysis
serotonin, cortisol

individual feed intake



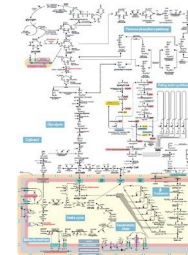
feed intake patterns
feeding behavior

digestive efficiency



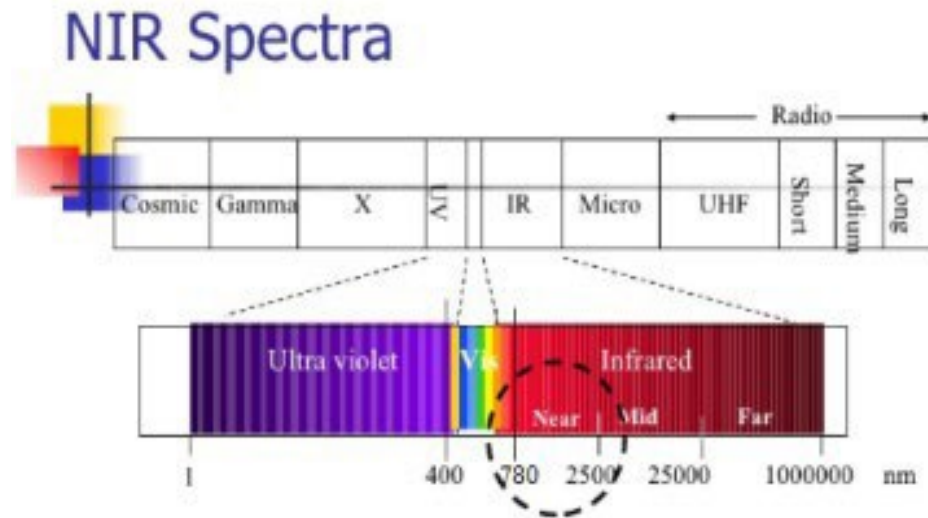
digestibility markers
gut health
microbiota

metabolic efficiency



metabolomics

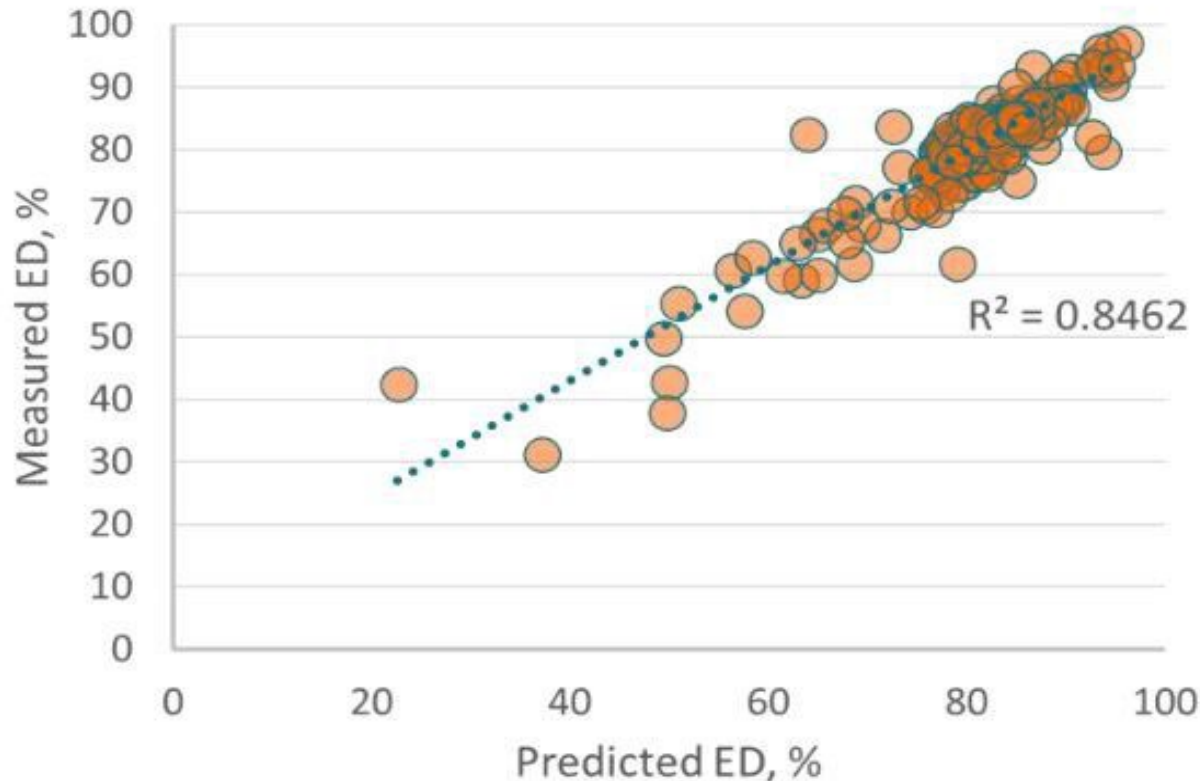
Development of models to predict the nutritional value of feedstuffs and feed mixtures by NIRS in real-time



➤ Objectives

- To determine if it is possible to use NIRS to predict the nutritive value of animal feed
 - Chemical components
 - Digestible energy and macronutrients, and metabolizable energy in pigs
- For characterisation of chemical and nutritional properties of feed in real time

Energy digestibility of cereal grains in pigs: measured vs predicted by NIRS



(Noel et al., 2018,
Aarhus University)



- In general, NIR calibration models had good predictive ability and robustness, though they were not suitable to predict the mineral composition of cereals

Consequences on feed management



- **With PLF and precision feeding techniques, possible to mix two or more diets → change in formulation practices:**
 - ❖ **two “extreme” balanced diets (high/low nutrient content)**
 - ❖ **more than two diets (intermediate diets to reduce costs)**
 - ➔ A-B mix then B-C mix then C-D mix with nutrient content $A > B > C > D$
- **Better knowledge on animal status and feed/composition impact through real-time in situ data**

Precision livestock farming...

- **Requires to transform data into information, which needs to be integrated**
- **Increases resource efficiency and reduces environmental impact**
- **Accounts for the needs of individuals**
- **New possibilities offered to feed and feed additives producers**
 - ❖ formulation
 - ❖ use of new feedstuff
 - ❖ use of additives for more reactive and targeted actions
 - ❖ larger scale (several farms) management of feed provisional...

A future to write...

- **PLF is still in its infancy, with a great potential to change the design of animal production systems**
- **Large progress to come**
 - ❖ Technical and decision systems
- **Still to do before innovation acceptance**
 - ❖ Return on investment to calculate
 - ❖ Usefulness and ergonomic for farmers...

To learn more...



Animal selection and feed efficiency

https://www.youtube.com/watch?v=Cr8Cjoo5_RU&list=PLxk-vnpldeUWyYxTgtahequmg9-4ROEBt&index=4

Feed efficiency parameters and gut microbiota

<https://www.youtube.com/watch?v=IPvQkr3BYCw&list=PLxk-vnpldeUWyYxTgtahequmg9-4ROEBt&index=7>



To learn more...

Alimentazione automatizzata dei bovini da carne

<https://www.youtube.com/watch?v=L8f4UmRIObs>

Is it right to give all this space to genetic selection in livestock farming, when until recently we were shocked by the use of OGM in agriculture?

