Prediction of the various beef quality traits

Jean-François J.-F. Hocquette, Raphaëlle Botreau, I. Legrand, R. J. Polkinghorne, David Pethick, Michel M. Lherm, Brigitte B. Picard, Michel M. Doreau, Pierre-Yves Le Bail, Claudia Terlouw

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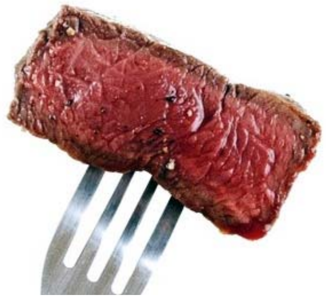
(adapted from Animal Production Science, 2014, 54, 1537–1548, Joint ISNH / ISRP International Conference 2014)



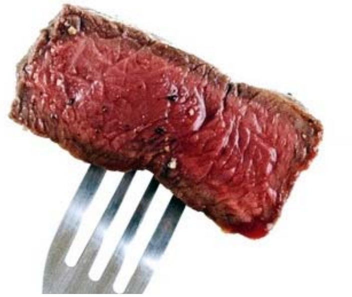
J-F. Hocquette, R. Botreau, I. Legrand*, R. Polkinghorne***,
D.W. Pethick****, M. Lherm, B. Picard, M. Doreau, PY Le Bail*, M.C. Terlouw

INRA, Unité Mixte de Recherches sur les Herbivores, Theix, and *LPGP, Rennes,
*Institut de l'Elevage, Service Qualité des Viandes, France,

***Polkinghornes, ****Murdoch University, Australia

INRA SCIENCE & IMPACT — INSTITUT DE L'ELEVAGE — Murdoch UNIVERSITY — POLKINGHORNES Beef at its Best

The definition of quality



***Intrinsic* quality refers to the characteristics of the product** itself and includes sensory traits (e.g. tenderness, flavor, juiciness, overall liking), safety, healthiness, convenience, etc.

***Extrinsic* quality refers to traits which are associated with the product**, namely (i) production system characteristics (from the animal to the processing stages including for example animal welfare and carbon footprint), and (ii) marketing variables (including price, brand name, distribution, origin, packaging, labelling, and traceability)

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Reviewed by Luning, Marcelis & Jongen, 2002; Grunert, Bredahl, & Brunso, 2004.

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1. Recent progress to predict beef quality

1.1. Grading systems

1.2. Recent progress in biochemistry and genomics

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3. Future research priorities

Different beef grading schemes

Country *Scheme*	Europe *EUROP*	S. Africa *S. Africa*	Canada *Canada*	Japan *JMGA*	S. Korea *Korea*	USA *USDA*	Australia *MSA*
Grading unit	**Carcass**						**Cut**
Pre slaughter factors							HGP implants & Bos Indicus
Slaughter-floor	**Carcass weight and sex**						
	Conformation Fat cover	Dentition Ribfat	Conformation				Electrical stimulation Hang
Chiller			**Marbling score** **Meat Colour**				
			Fat colour and fat thickness			**Ossification score**	
				Eye muscle area			**Fat thickness**
			Texture	Meat brightness Fat luster Fat texture Fat firmness Rib thickness	Texture Firmness Lean maturity	Meat texture Ribfat Kidney fat Perirenal fat	Hump height Ultimate pH
Post chiller							**Ageing time** **Cooking method**

The concepts of designation of origin and geographical indication

PDO: Protected Designation of Origin .
PGI: Protected Geographical indication

BIOLOGICAL FACTORS (raw material production: varieties, breeds,...)

Regional product (<u>with old fame of its geographic name</u>)

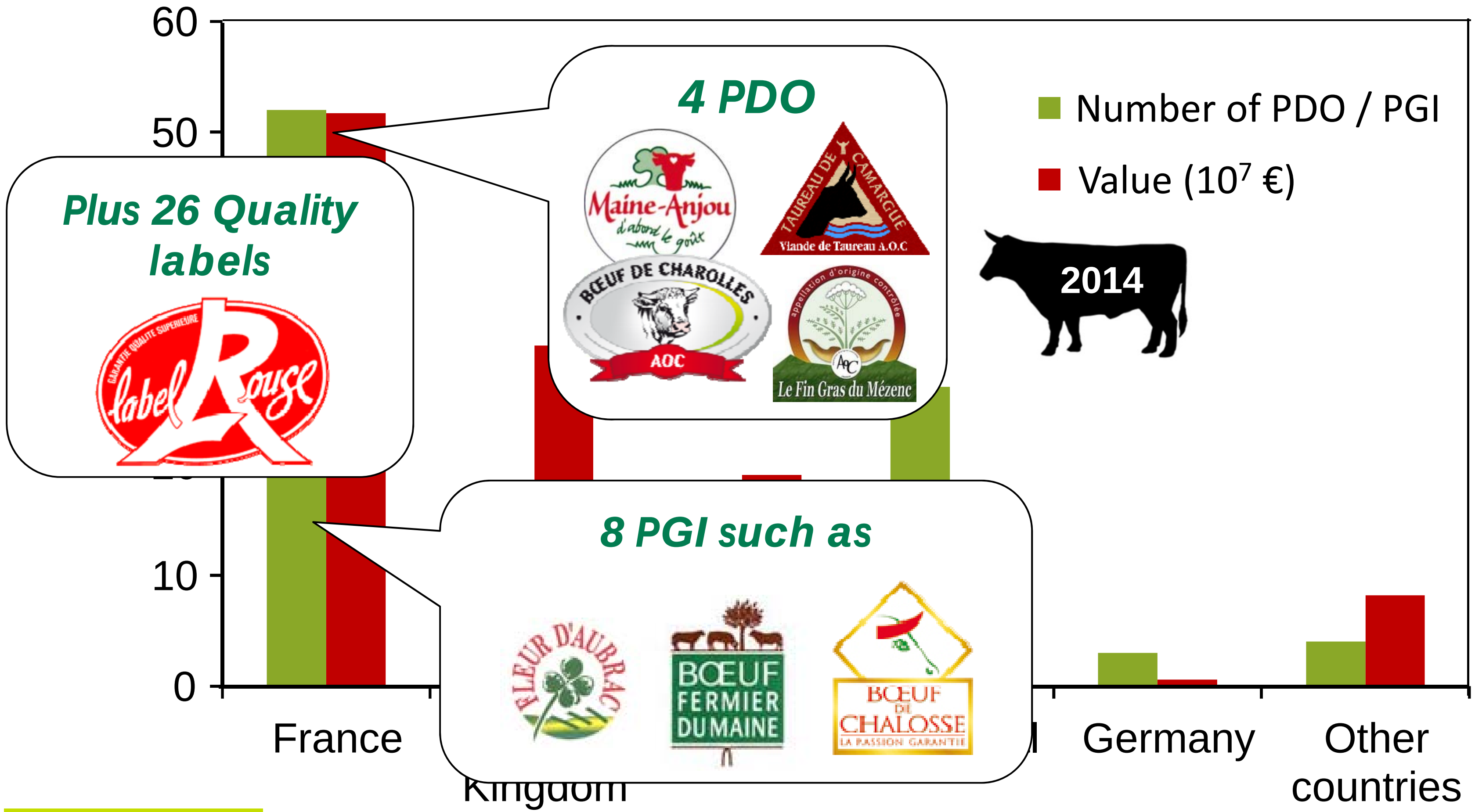
TERROIR (local area)

PHYSICAL FACTORS OF REGIONS (geology, pedology, relief, climate, ...)

HUMAN FACTORS (collective set of techniques and customs)

Numbers and values of PDO/PGI fresh meat products (all species) in European countries

In 2008, a total of 106 PDO and PGI in Europe for a value of **1 billion €**



Prediction of beef quality using the MSA system

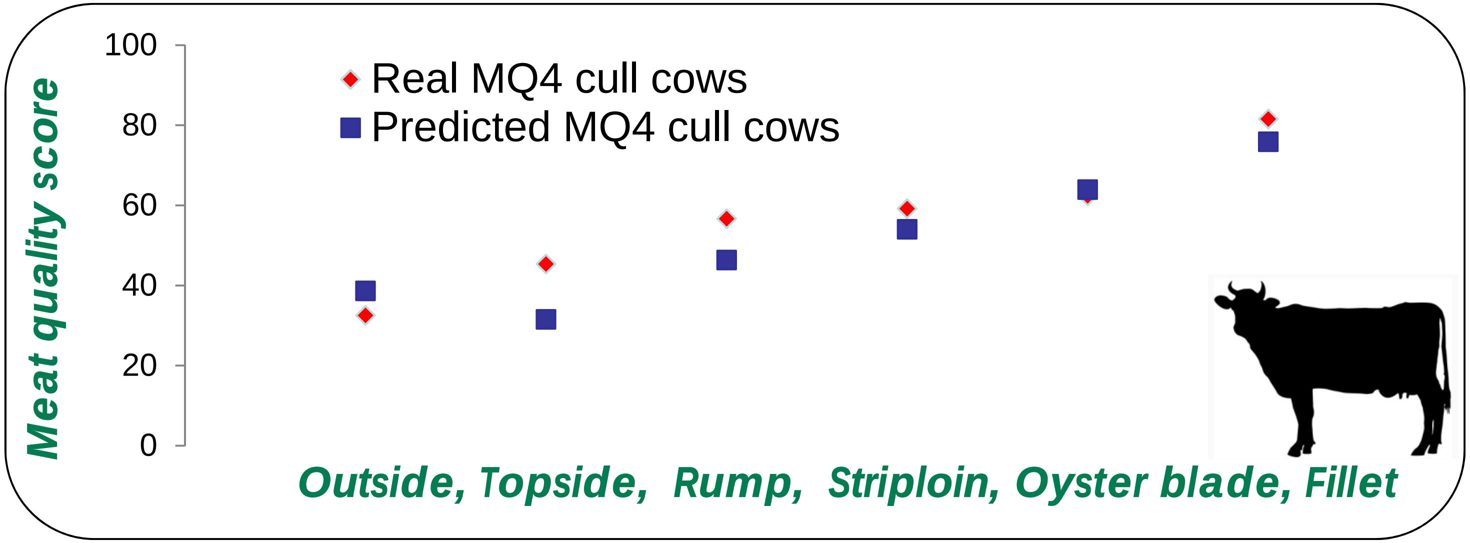
MSA2000model®

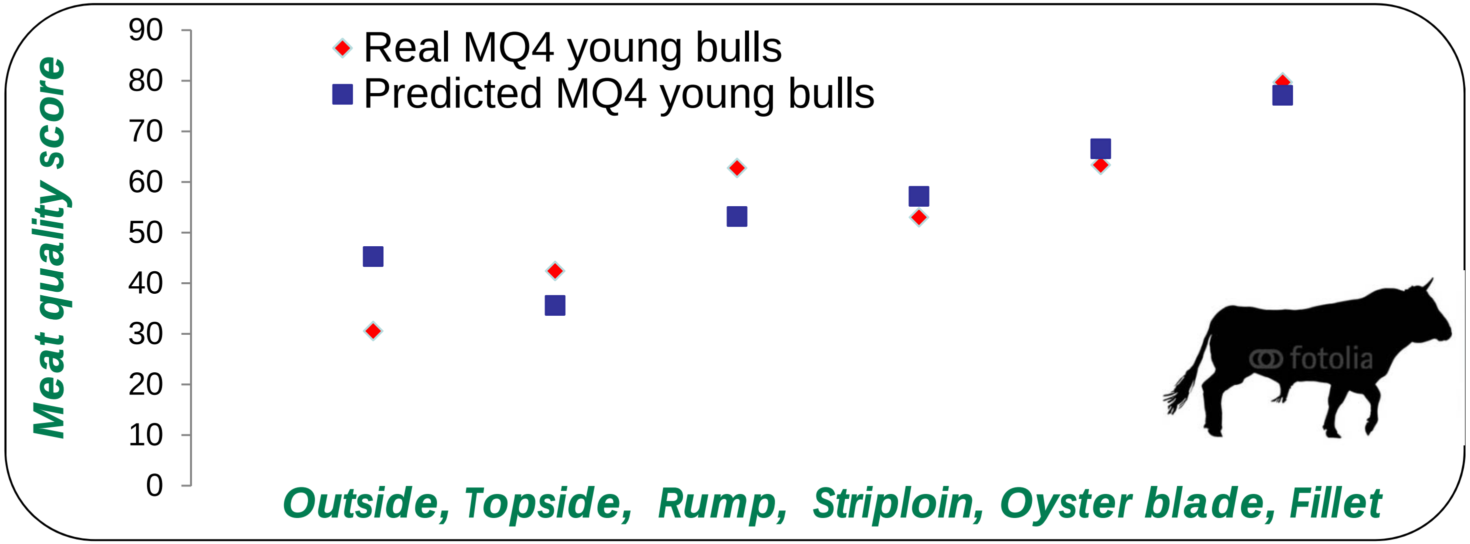
Hang (AT/TC/TS/TX)	AT
Sex (M, F)	m
Est.% Bos Indicus	0
Hump Height cms	0
Hot Std Carc Weight	250
USDA Ossification	140
Milk Fed Vealer Y/N	n
USDA Marbling	130
Days Aged (min 5)	5
Quarter Point Ribfat	12
Ultimate pH	5.50
AUSMEAT Meat Col.	2
Saleyard? (Y, N)	n
Wght/App.Maturity	0.86

Cut Description	Muscle Reference	Days Aged	Grilled Steak	Roast Beef	Stir Fry	Thin Slice	Cass-erole	Corned Beef
Tenderloin	TDR062		5	4	5			
Cube Roll	CUB045		3	3	3			
Striploin	STR045		3	3				
Oyster Blade	OYS036		4	3				
Bolar Blade	BLD096		3	3				
Chuck Tender	CTR085			3	3			
Rump	RMP131		3	3	3	3		
Point End Rump	RMP231		3	3	3	4		
Knuckle	KNU099		x	3	3	3	3	
Outside Flat	OUT005			x	x	3	3	3
Eye Round	EYE075		x	3	3	3	3	x
Topside	TOP073		x	x	x	3	3	
Chuck	CHK078			3	3	3	3	
Thin Flank	TFL051				3		3	
Rib Blade	RIB041				3			
Brisket	BRI056				x	3	3	x
Shin	FQshin						3	

Palatability grade

Prediction of quality in France using the MSA system





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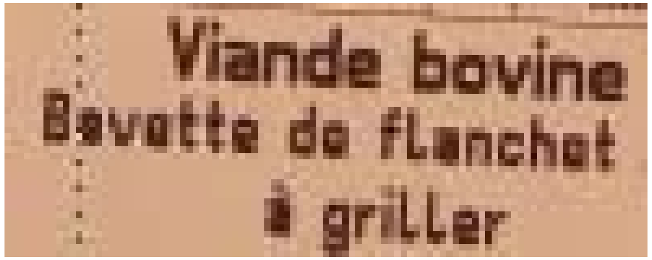
Legrand et al., 2013

prosafebeef

A new denomination of beef cuts in France

Before, on the label



Beef meat
Name of the cut
How to cook it

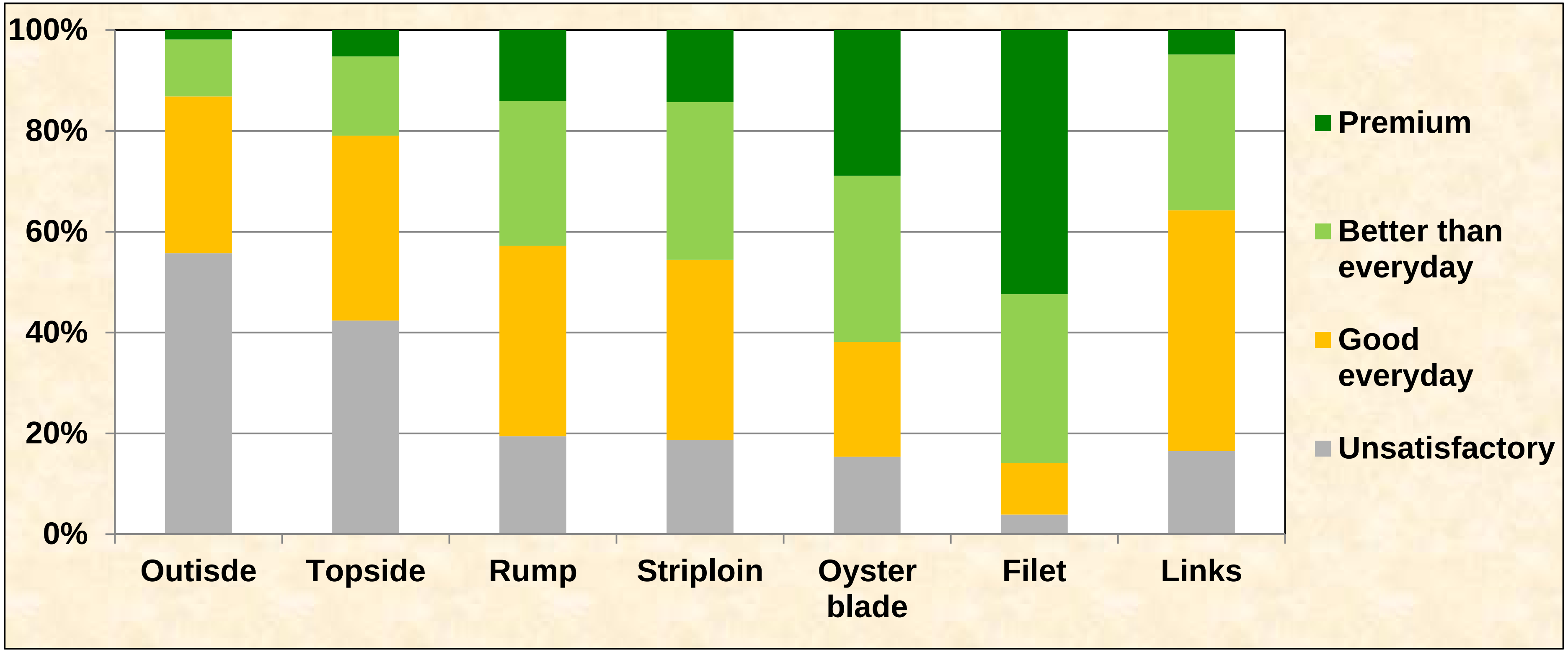
Last December

- **Cut (if already known) or group of cuts (for cuts not well known)**
- **Quality level indicated by stars**
- **How to cook it**

Instead of buying
« poire » (a cut part of topside not very well known),
the consumer will buy
« steak * to grill »**

Prediction of quality in France using the MSA system

- Considerable variability for each muscle
- But visible muscle hierachy (Link = Stiploin & rump)



Legrand et al., 2013

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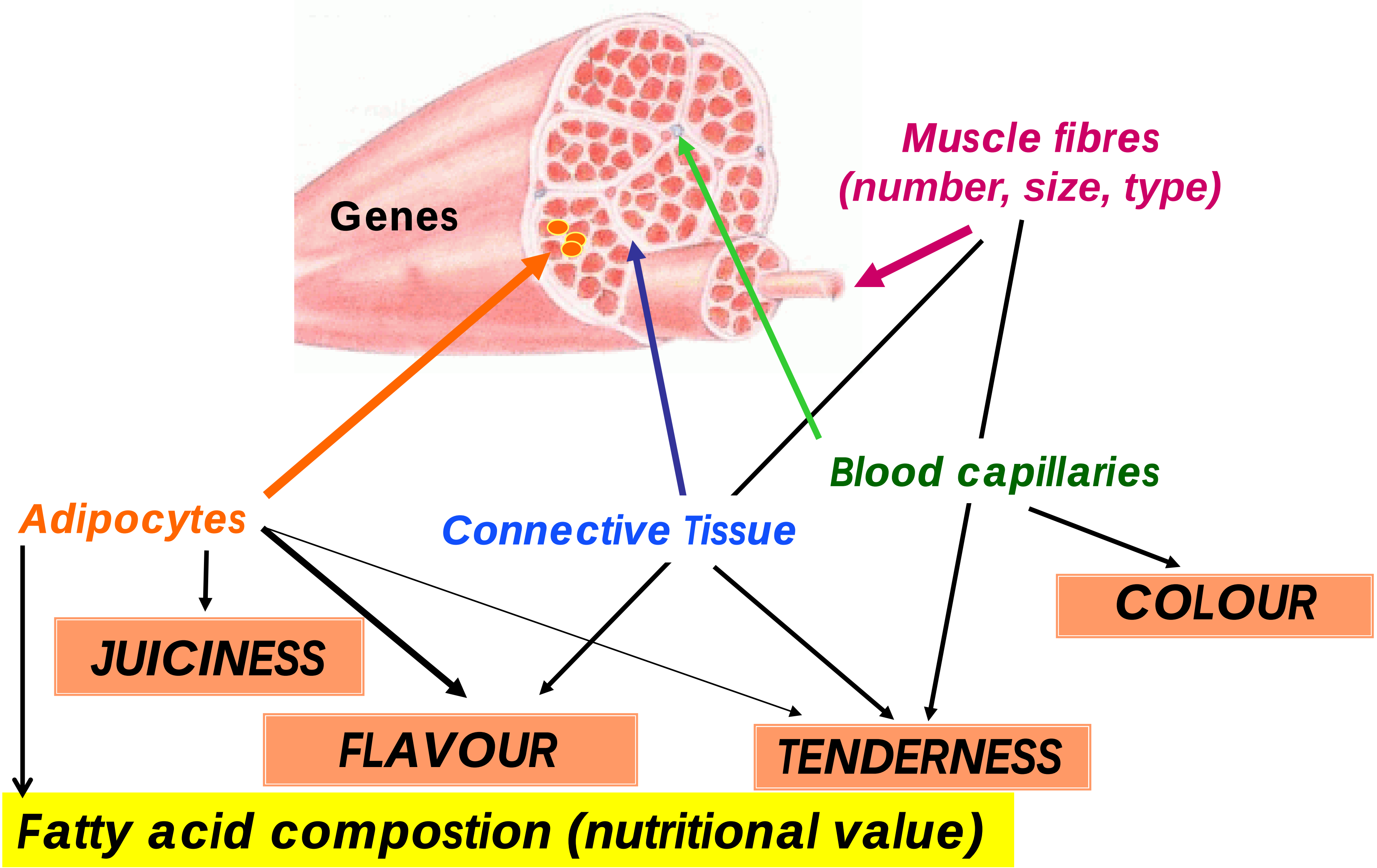
How muscle biochemistry affects beef quality



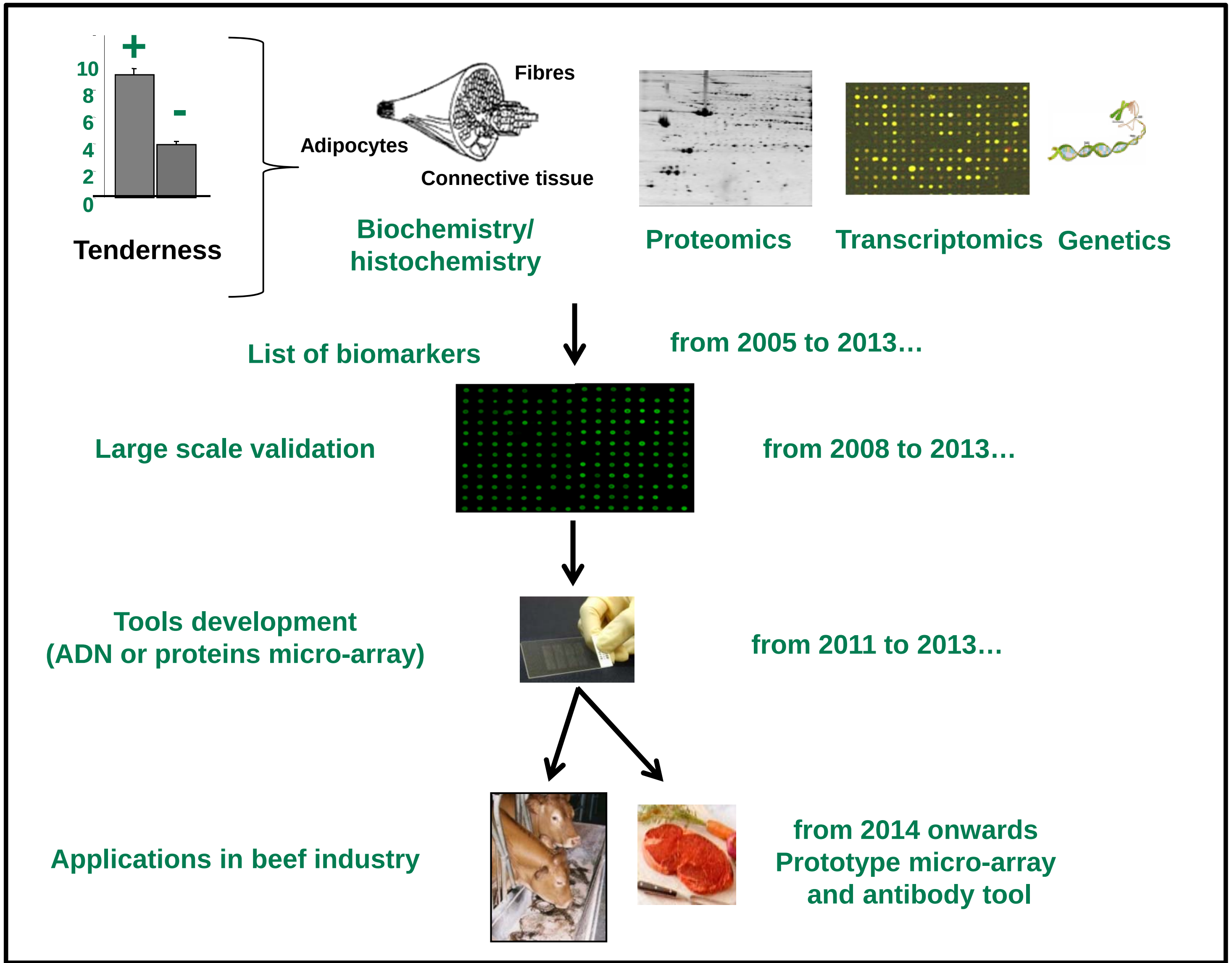
Relationships between genetic markers and Meat Quality attributes

Tenderness	Marbling
	RORC
	LEP
LOX	
CAST	
	DGAT1
	TG
	FABP4
	SCD
CAPN1	
	GHR

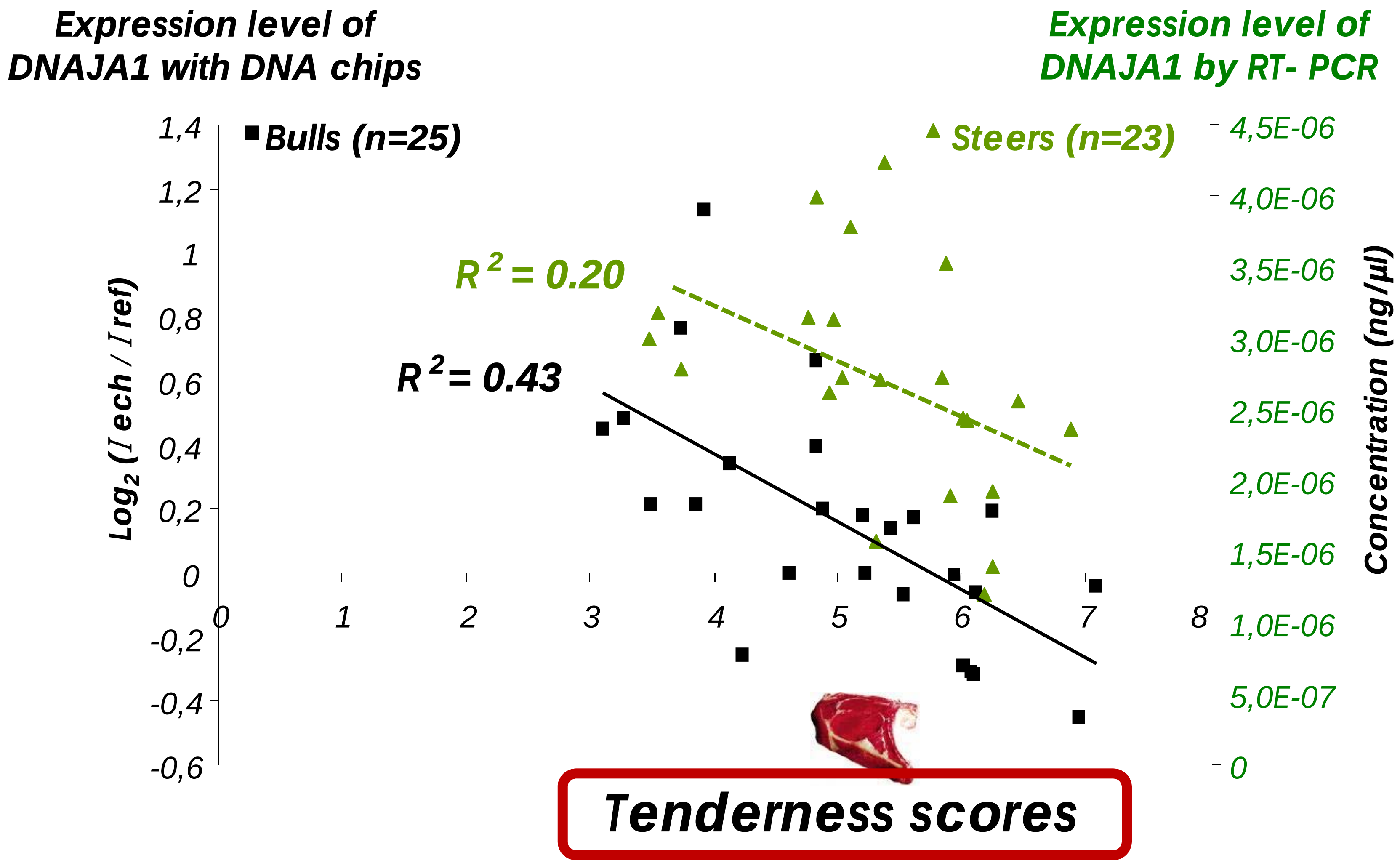
- RORC: *No effect*
- LEP: *Significant in Limousine only*
- RORC, LEP: *No effects. Pannier et al., 2009*
- LOX: *No effect*
- CAST: *Significant in Blonde d'Aquitaine only Allais et al., 2011*
- DGAT1: *No effects. Pannier et al., 2009*
- DGAT1, TG: *No effect. Renand et al., 2007.*
- TG, FABP4: *Small effect in Limousine only*
- SCD: *A small effect in LT but not ST muscle*
- CAPN1: *Significant in Charolais only Allais et al., 2011*
- CAPN1: *2 of 3 SNPs significant . Costello et al., 2009*
- GHR: *A small effect in SM but not LT muscle*

The effects of the markers studied are variable, breed specific and muscle-specific (French and Irish results)

The overall strategy in functional genomics

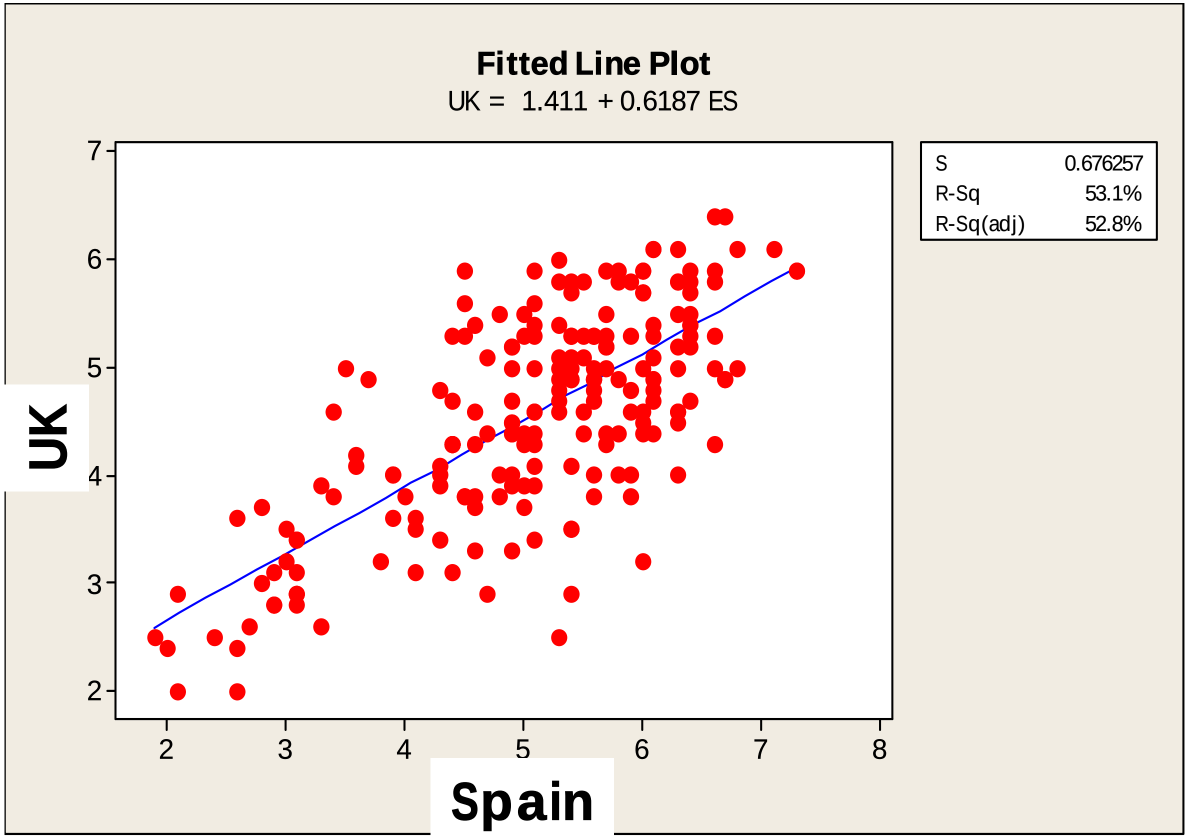


DNAJA1: A negative marker for tenderness (patented)



Sensory analysis in the GEMQUAL EU Programme (Genetics of Meat Quality)

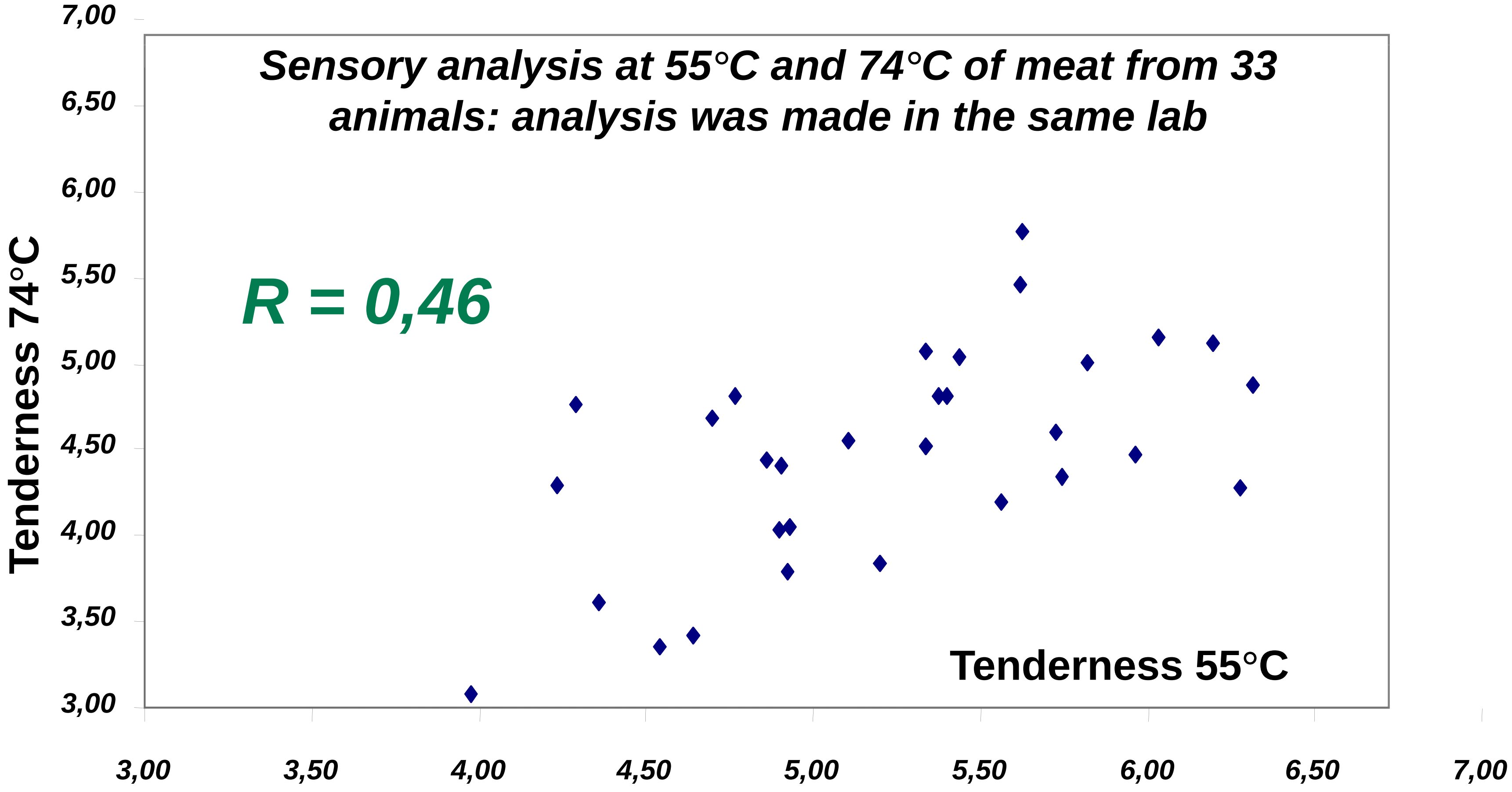
✓ *Comparison of the same samples between Spain and UK*



Measurement of tenderness is more or less repeatable across countries

Courtesy from Goeff Nute, University of Bristol

Tenderness scores at 55°C and 74°C



Measurement of tenderness is not very repeatable across temperatures

Micol et al., 2011. EAAP

Challenges

- Genotyping is performed in a standardized and automated way using robots.

  → It should be the same for phenotyping

- For traits with low measurement repeatability (r < 0.95), 2 or 3 independent measurements of the same trait should be obtained on the same samples.
- Individuals should be genotyped solely for strongly correlated traits for independent measurements *(Barendse 2011).*

  → In a few words: standardization, automation, high repeatibility.

- **'In the age of the genotype, phenotype is king'** *(Coffey 2011, ICAR Meeting).*

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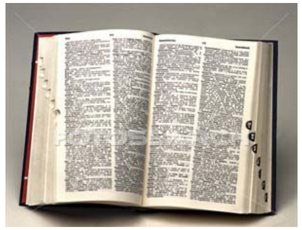
ATOL (Animal Trait Ontology of Livetock)
The objectives

1. ***To have** a reference ontology **for phenotyping of farm animals shared by international scientific and teaching community.***



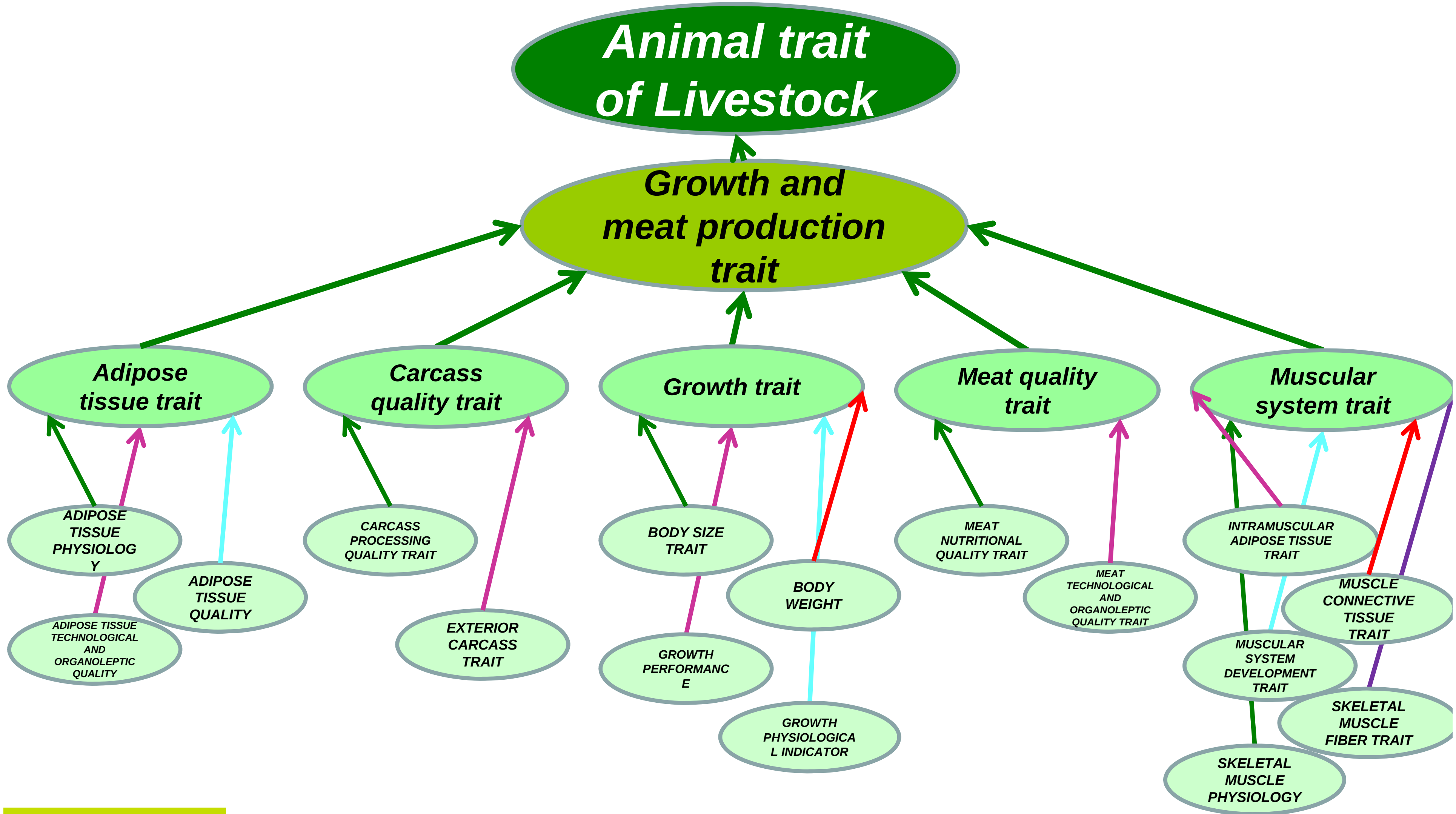
2. ***To have a** language usable by **software (data basis management, semantic analysis, modeling…)***

3. ***To have the traits as** generic **as possible***

4. ***To have the ontology as** efficient **as possible and close to technical measurements***

5. ***To have a structure applied to** production **targets***

Hierarchy for growth and meat production trait



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Slaughter: Stress and welfare – A lot of measurements

Physiological responses

GC, catecholamines, heart rate...
Muscle contractions

Metabolic changes

Blood; Muscle ante/post-mortem

Glycogen, enzymes, temperature, pH...

Behavioural responses

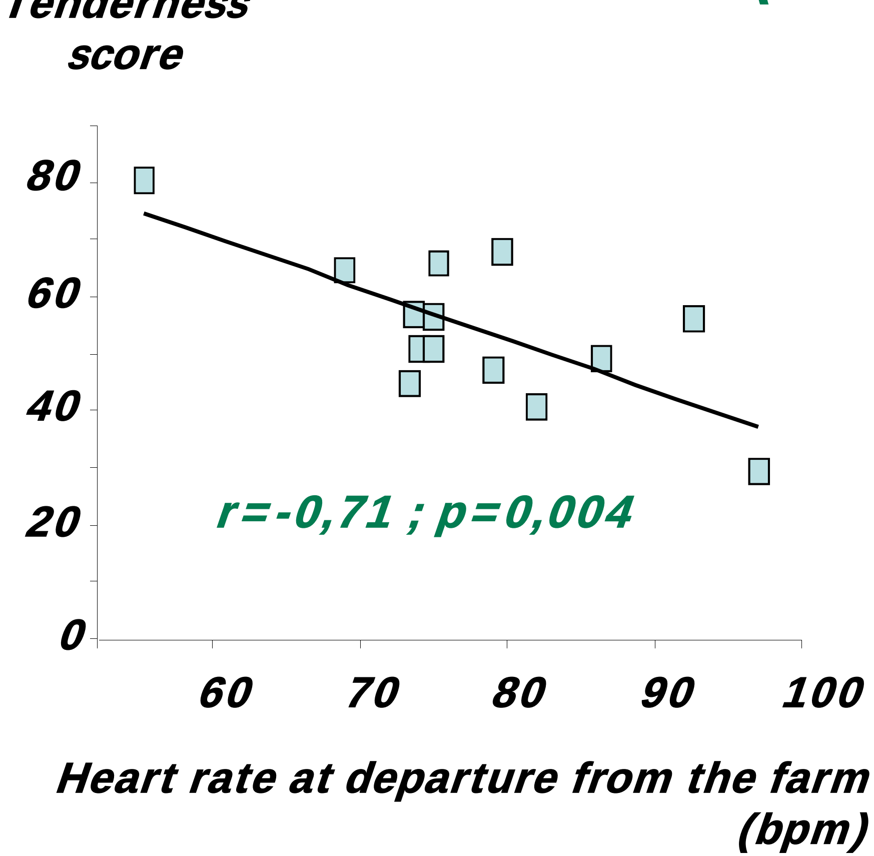
Vocalizations, escape, immobility...

Quality of meat

Stress and welfare

Stress at slaughter and beef quality

⇨ 14 cows (Normand breed)



Win-win relationship:

Cows

- with the lowest stress

low heart rate before slaughtering

- provide the most tender beef

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Environmental impacts of three contrasting diets

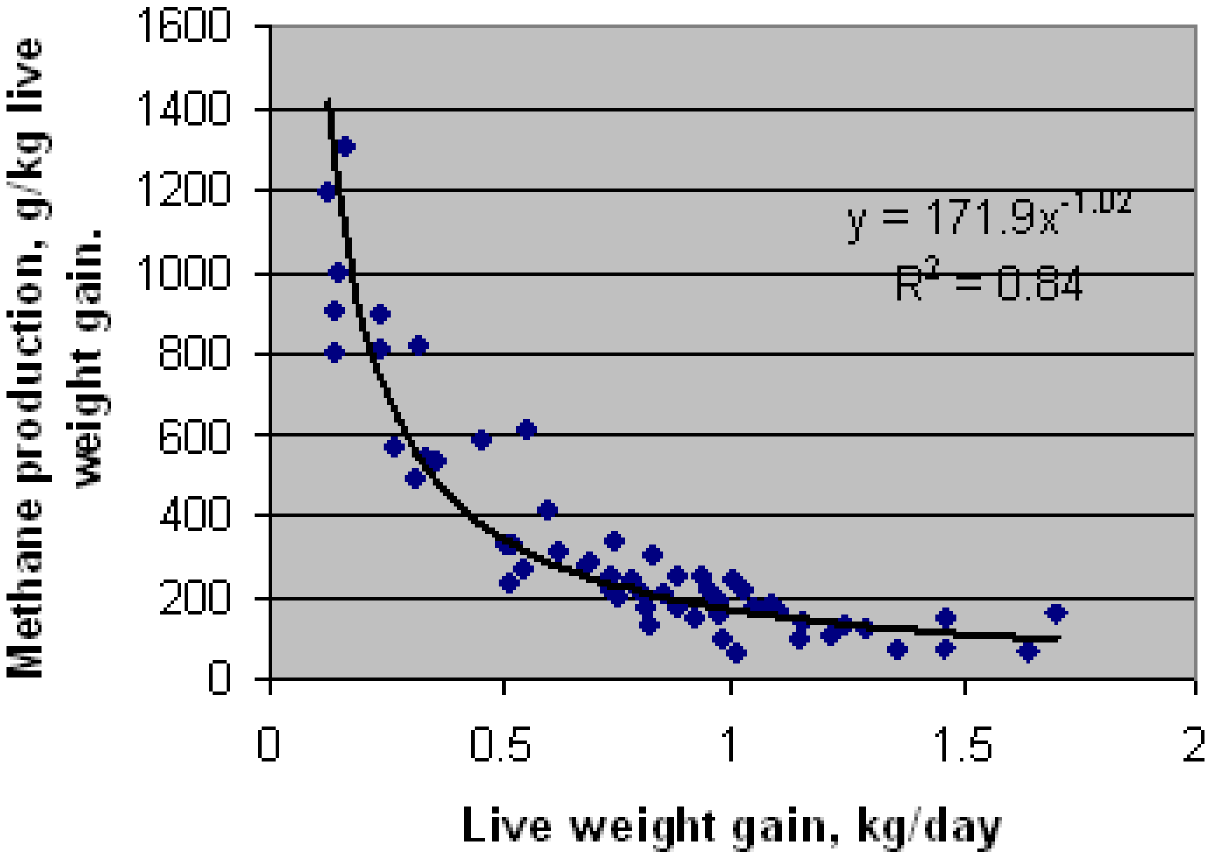
⇨ *Blond d'Aquitaine young bulls*

% concentrate → % forages →	35 % 65 % corn silage	50 % 50 % hay	86 % 14 % wheat straw
	Per kg of body weight gain		
greenhouse gas (GHG) emissions in kg eq-CO_2 ***Including enteric methane***	**4.74** ***2.23***	**4.56** ***2.23***	☺ **3.75** ***0.84***
Energy consumption eq-MJ	☺**13.0**	**18.7**	**19.8**
Eutrophication potential g eq-PO_4^{3-}	**18.6**	☺**15.8**	**20.8**

Each diet has different advantages and disadvantages

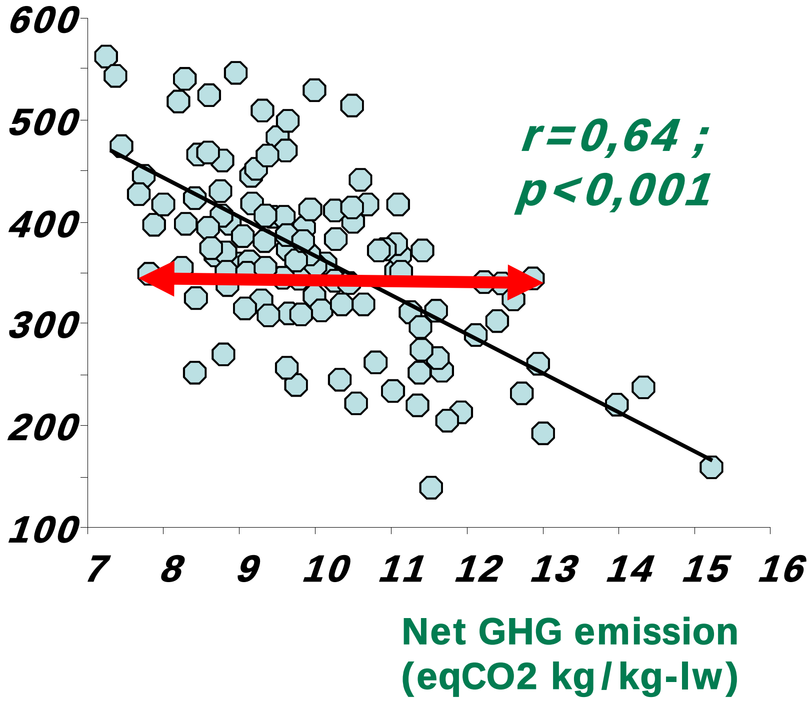
Doreau et al, 2011; Nguyen et al, 2012

The relationship between live weight gain and methane production per kg of gain



The most efficient animals produce the least methane

Win–win strategies between environmental value and economic efficiency



59 farms in the Charolais area from 2010 to 2011.

High variability :

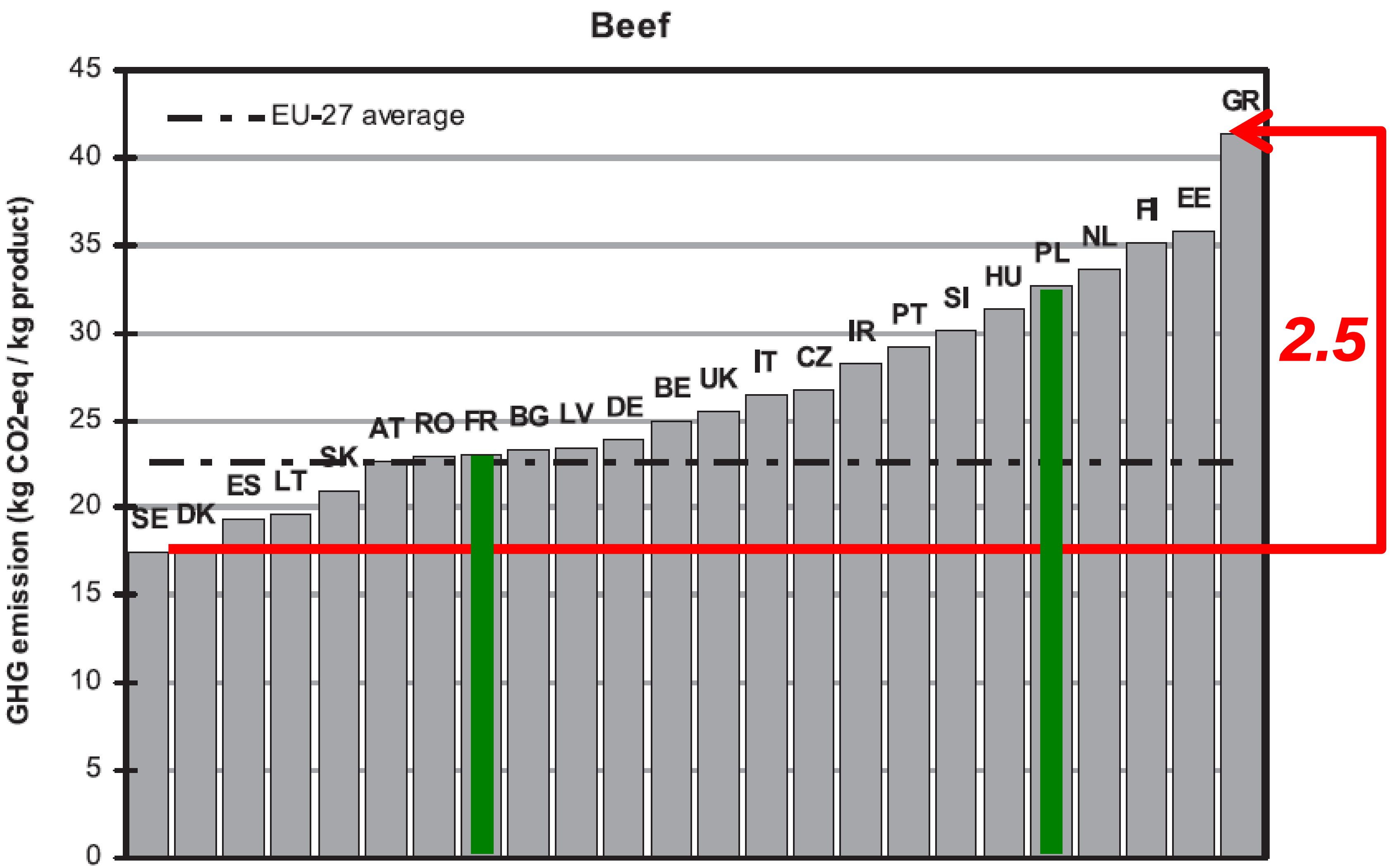
- from 7 to 15 for GHG emissions
- from 150 to 550 for gross margin

Win-win relationships:

Farms

- the most efficient on an economic basis
- are also the most efficient in terms of GHG emissions

GHG emissions/kg of beef for EU member states



Lesschen et al., Animal Feed Science and Technology
166– 167 (2011) 16– 28

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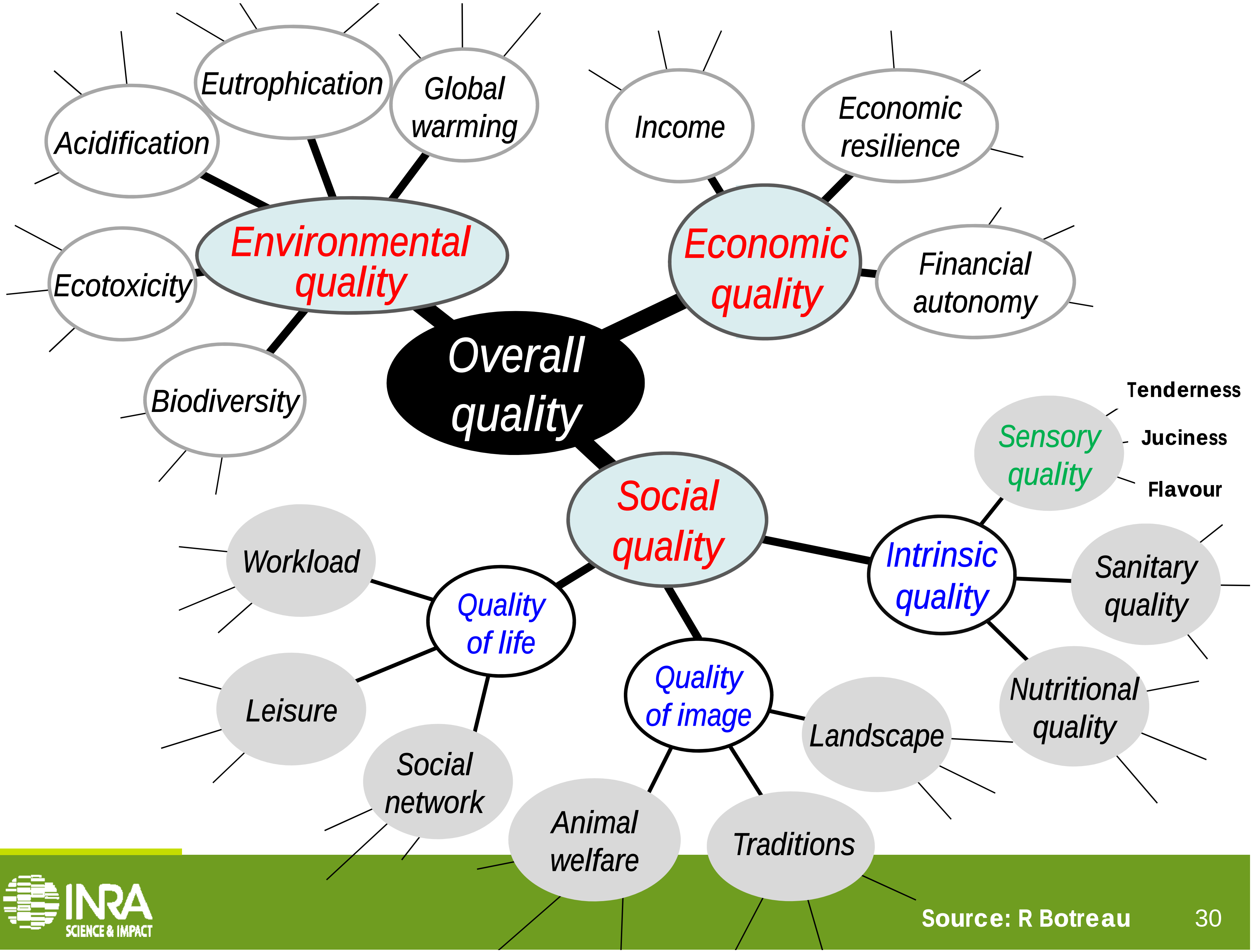
Overall quality
Environmental quality
Acidification
Eutrophication
Global warming
Ecotoxicity
Biodiversity
Economic quality
Income
Economic resilience
Financial autonomy
Social quality
Intrinsic quality
Sensory quality
Tenderness
Juciness
Flavour
Sanitary quality
Nutritional quality
Quality of life
Workload
Leisure
Social network
Quality of image
Animal welfare
Traditions
Landscape

Need to combine different criteria of quality. But how?

1. **Analysis by an expert:** done by traditional butchers. Not transparent, not exhaustive and also not consistent across experts.

2. **Minimum requirements (= thresholds)** easy to understand and implement but rough evaluation (good *vs* bad).

3. **A ranking system** from best (rank 1) to worst (rank n), and a summation of the ranks: this is only a 'relative' judgment, comparing alternatives among themselves, and not an 'absolute' assessment.

4. **Conversion of quality traits into value-scores** (e.g. quantitative information on a common scale) which are then compounded (e.g. the MSA system for sensory analysis based on a weighted sum, difficult to do).

Etc.

Potential of grazed based systems

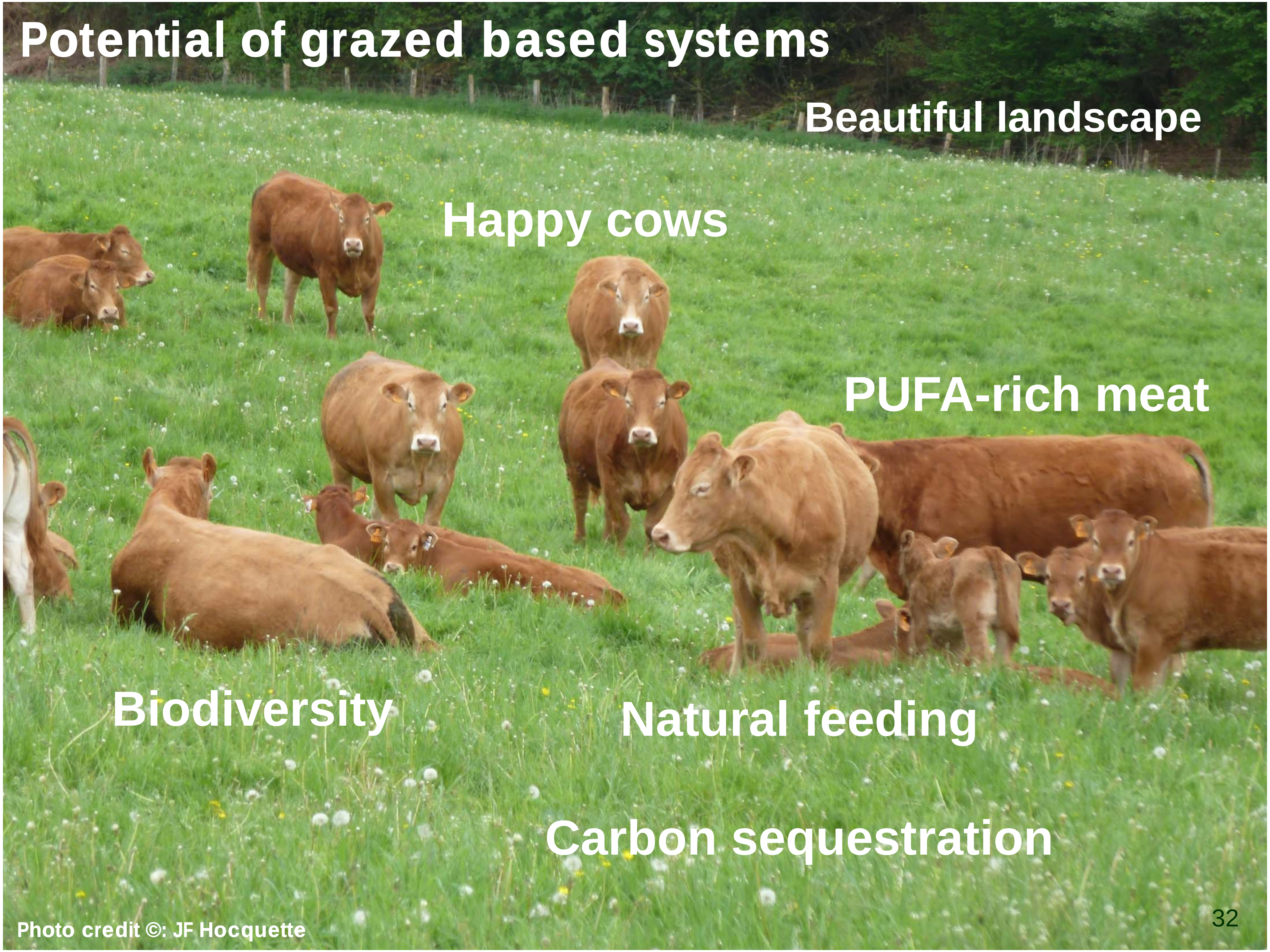

Photo credit ©: JF Hocquette

Conclusions about multicriteria approaches

- ✓ **Consumer satisfaction** when eating beef involves a complex response based on **objective** and **emotional** assessments of the product.

- ✓ **Scientific research** must provide **methods** to predict, in a reliable manner *intrinsic* quality traits of beef (as MSA does).

- ✓ **Scientific research** must also provide **methods** to predict, in a reliable manner *extrinsic* quality traits of beef.

- ✓ **Combining *intrinsic* and *extrinsic*** quality traits by relevant and new methods is a key driver for the future.