Traditional and new methods to assess beef quality

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France and *UK

Summary

- The concept of quality and reference methods at the consumer end
- *Post-mortem* prediction of beef quality at the abattoir or by beef retailers
- Prediction of beef quality at the producer level

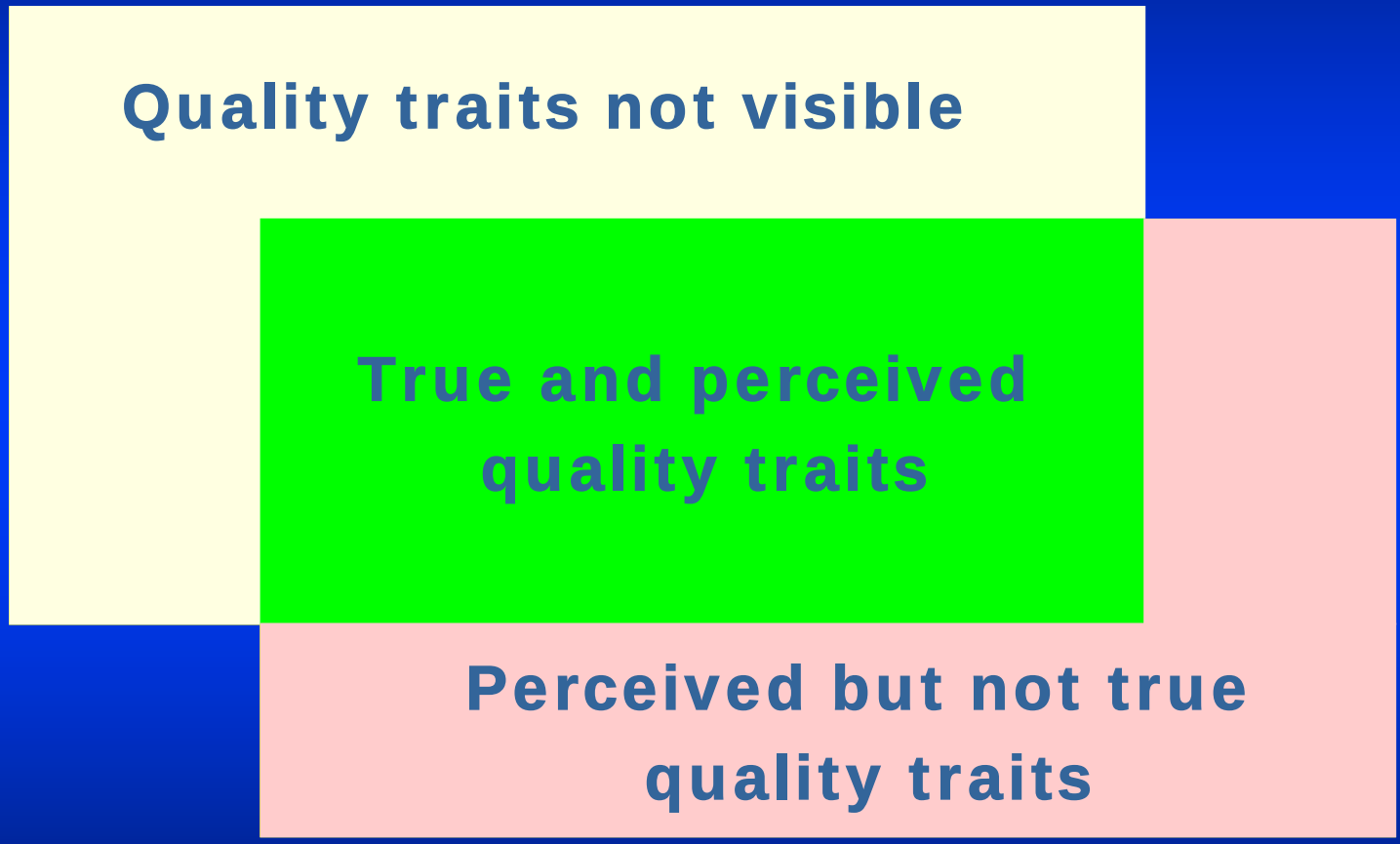
Quality can be defined as

"the properties of a product that contribute to and satisfy the needs of end-users".

Perception by consumers (end-users) of product characteristics

Quality is thus a social concept, i.e. a convergence between end-user expectations and product characteristics

The new concept of quality



Science is here to reduce this gap

The first problem: What does enhancing quality of animal products mean?

For consumers, products should be

- **safe**
- **healthy**
- **traceable**
- **consistent**
- **diverse**
- **convenient**

- **product differentiation**
- **added value**
- **sustainability**

are important for the producers and society

The second problem: the diversity of end-users

Producers

Abattoirs and retailers

Consumers

At the consumer end, the diversity of food preference

In Japan, raw fish and marbled beef

In Europe, cooked fish and lean beef

Sensory Assessment (1/6)

- The optic impression
- The odour or aroma impression (while smelling and while tasting)
- The taste impression
- The consistency or texture impression

Beef: Comparisons of beef quality from 15 breeds by Sensory Panels in UK and Spain

Approach used:-

Trained assessors in both countries

UK & Spain , 8 point intensity category scales

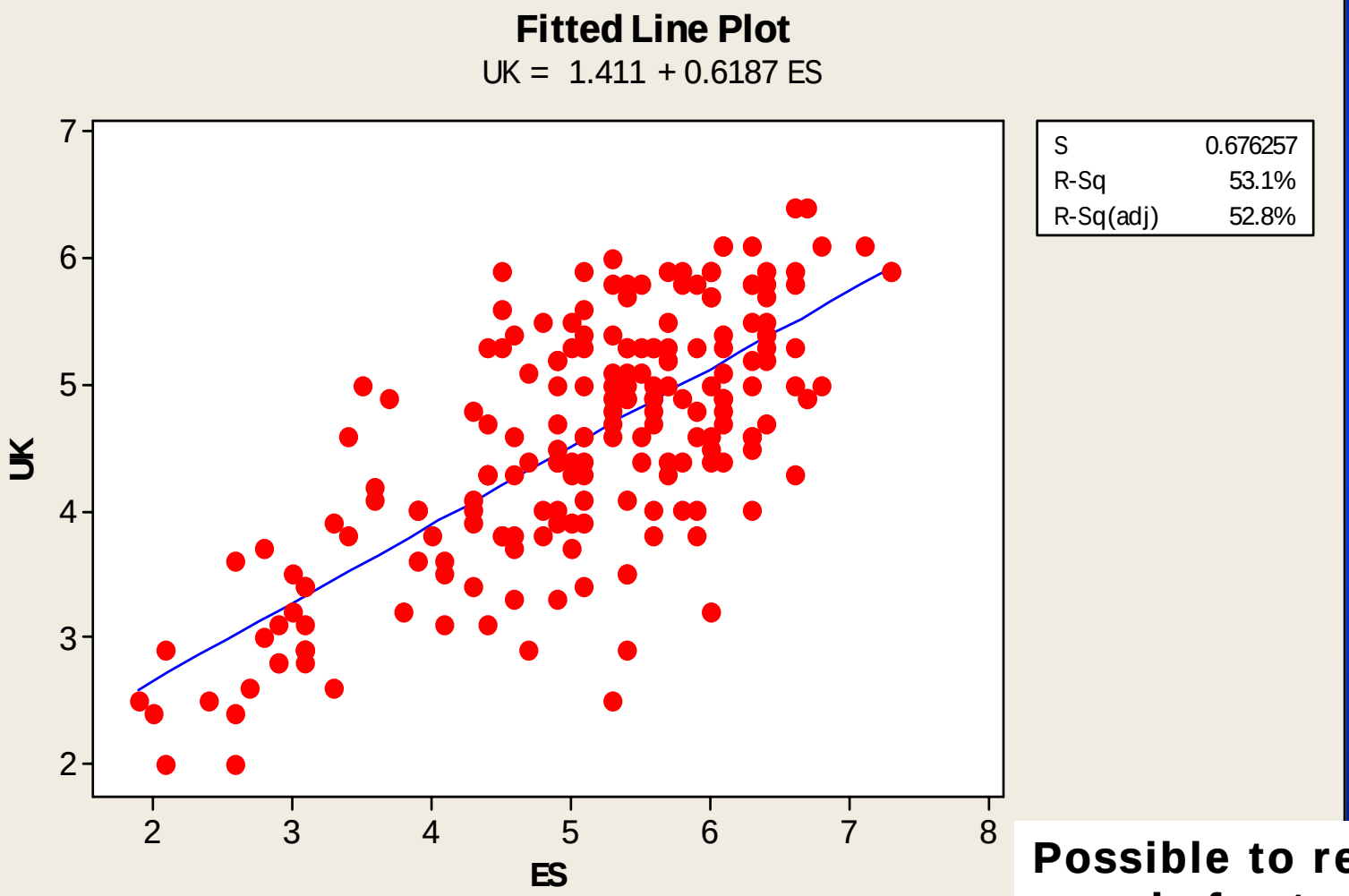
Common profile across countries

Texture, Juiciness, Beef Flavour Intensity, Abnormal flavour intensity & *Overall Liking*.

(Nute et al., 2006)

Calibration results for texture

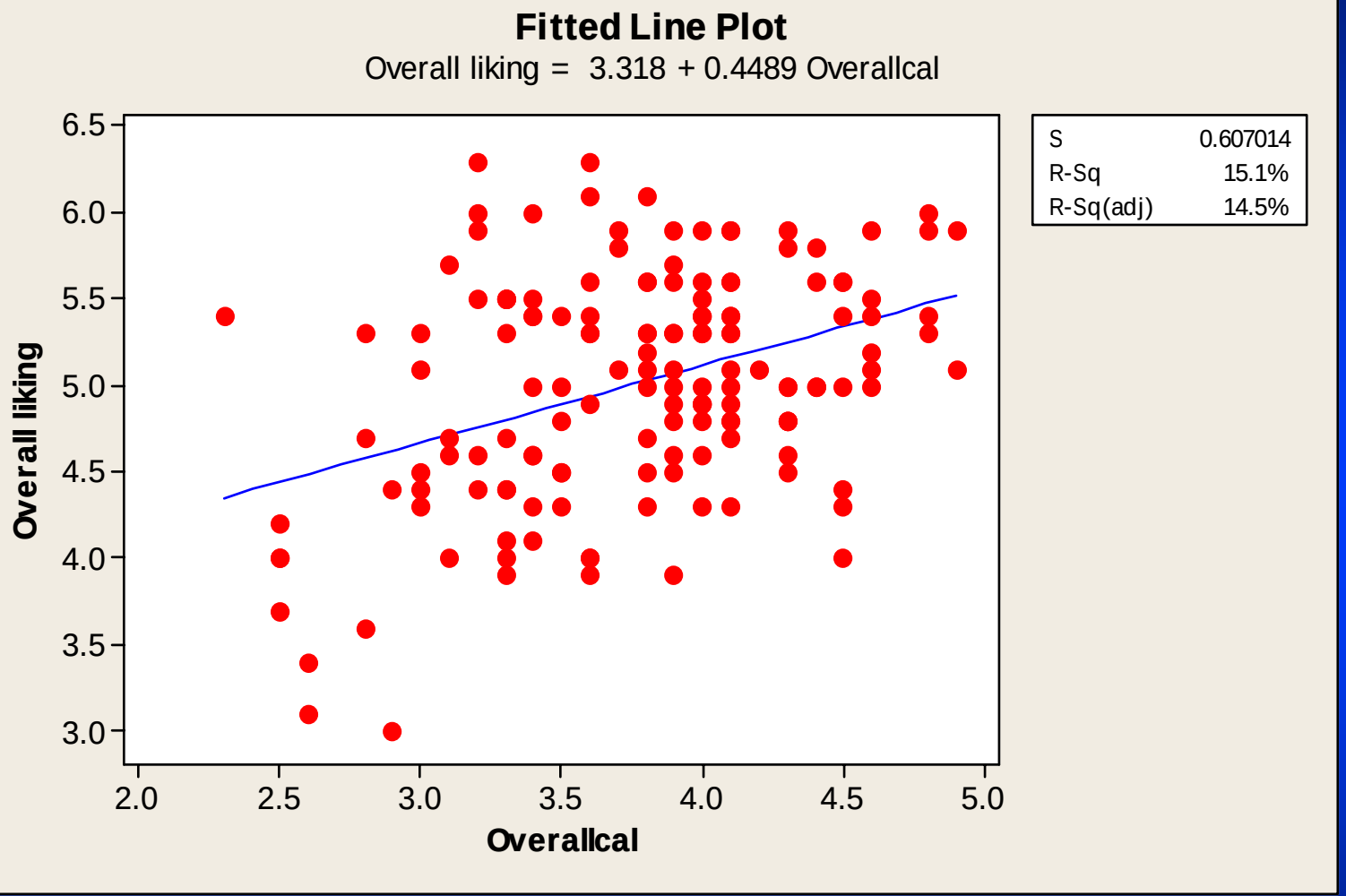
UK = 1.4 + 0.6 ES (n=206 paired values)



(Nute et al., 2006)

Possible to relate the two panels for texture and Flavour

Overall liking



(Nute et al., 2006)

Appear to be differences between the 2 panels.

These are hedonic (preference judgements)

Differences probably related to the meat they are used to eating.

Lamb Odour Intensity, Tenderness, Juiciness, Lamb Flavour Intensity.

- Similar sensory results were produced in both UK and Spain
- Lamb flavour higher in grass fed lambs
- Linolenic C18:3 n-3 higher in grass fed lambs
- Abnormal flavour reduced in grass fed lambs
- Linoleic C18:2 n-6 lower in grass and higher in concentrate fed lambs.

Consumer Assessment (untrained people)

- Does it taste good, do I like it.

Summary

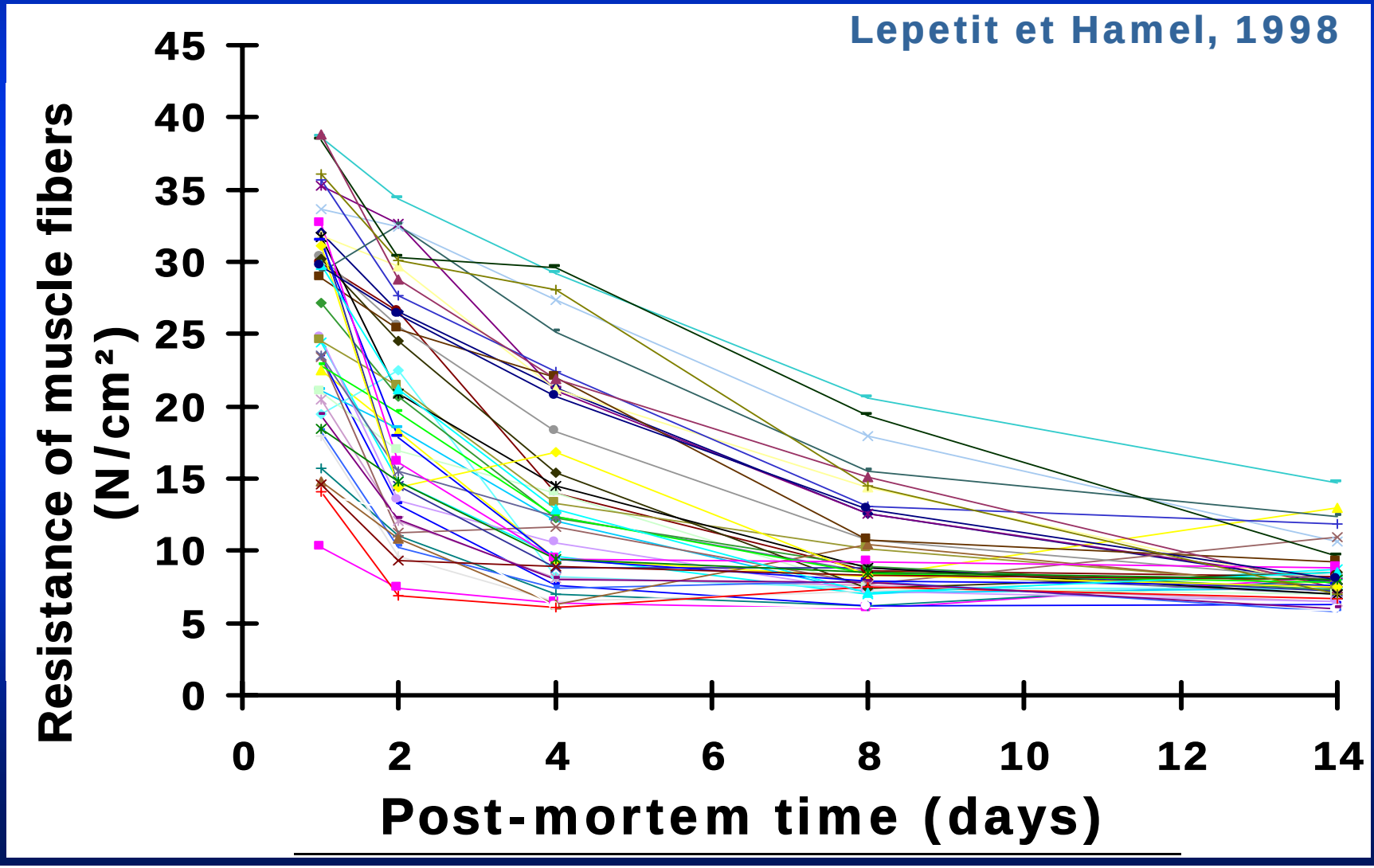
- The concept of quality and reference methods at the consumer end
- *Post-mortem* prediction of beef quality at the abattoir or by beef retailers
- Prediction of beef quality at the producer level

Requirements for physico-chemical methods

- Accuracy
- Not so expensive
- Rapid
- Capability to be fully potential fully automated
- Non-invasive
- Should bring a benefit by being related to the desired quality trait

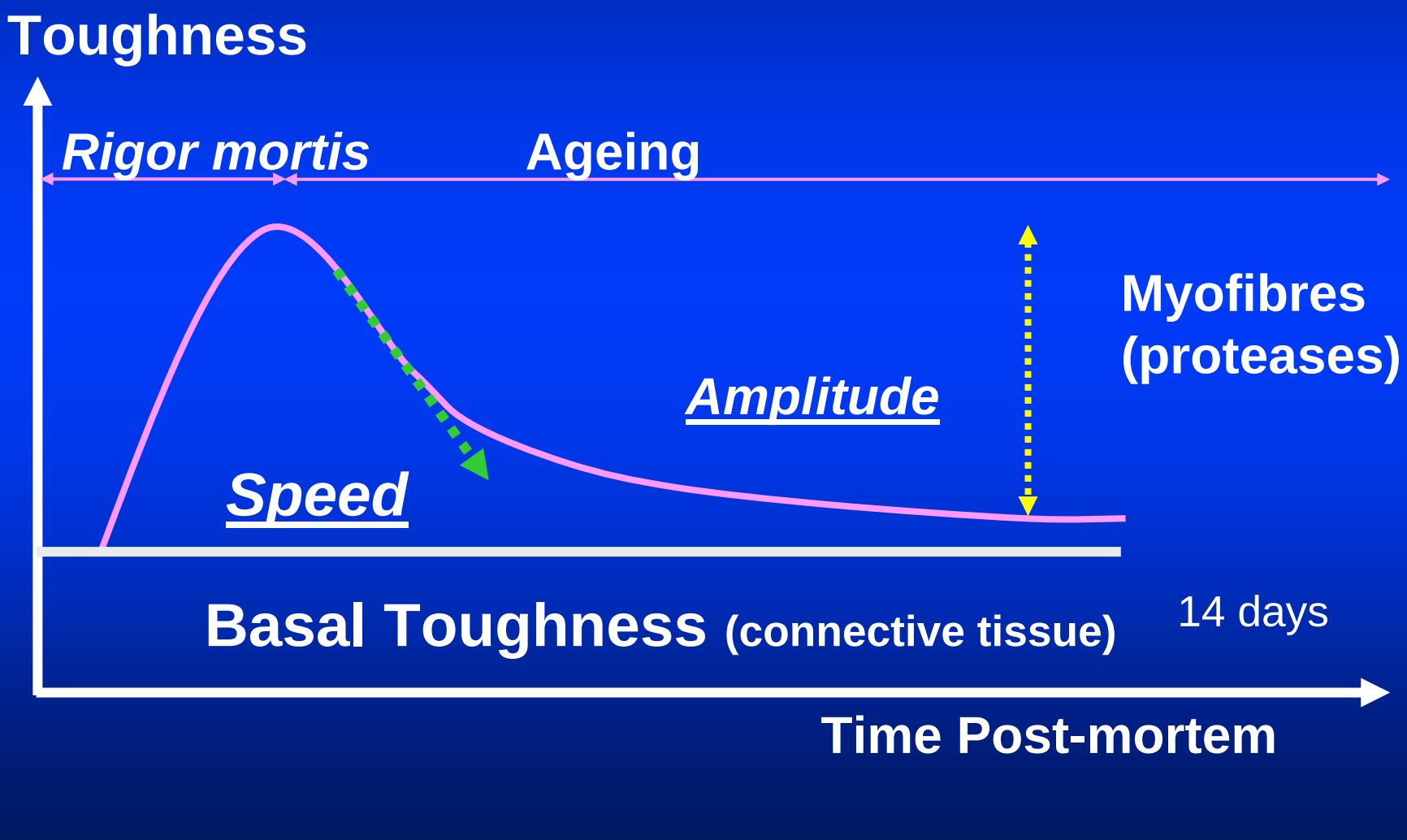
Prediction of ageing time to improve tenderness

Individual variability in meat tenderness

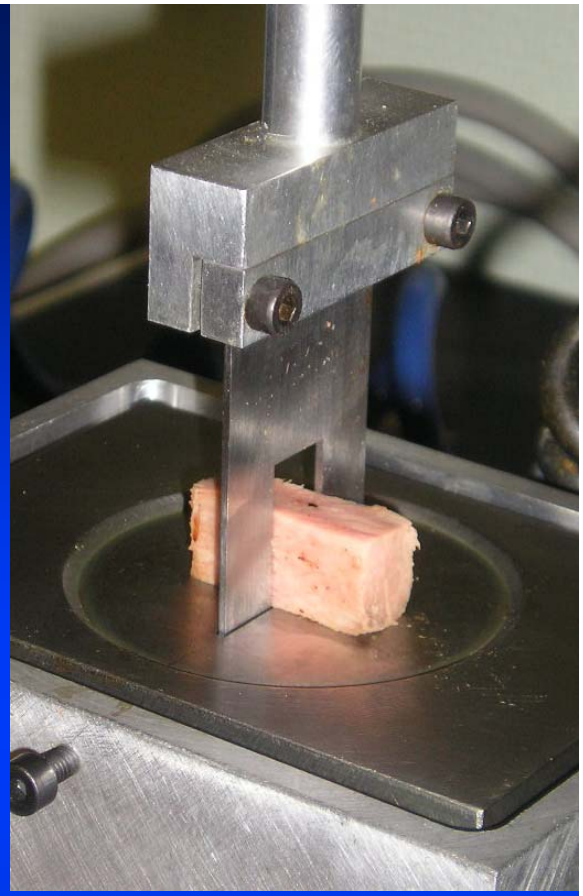


Ageing and tenderness

Important for beef



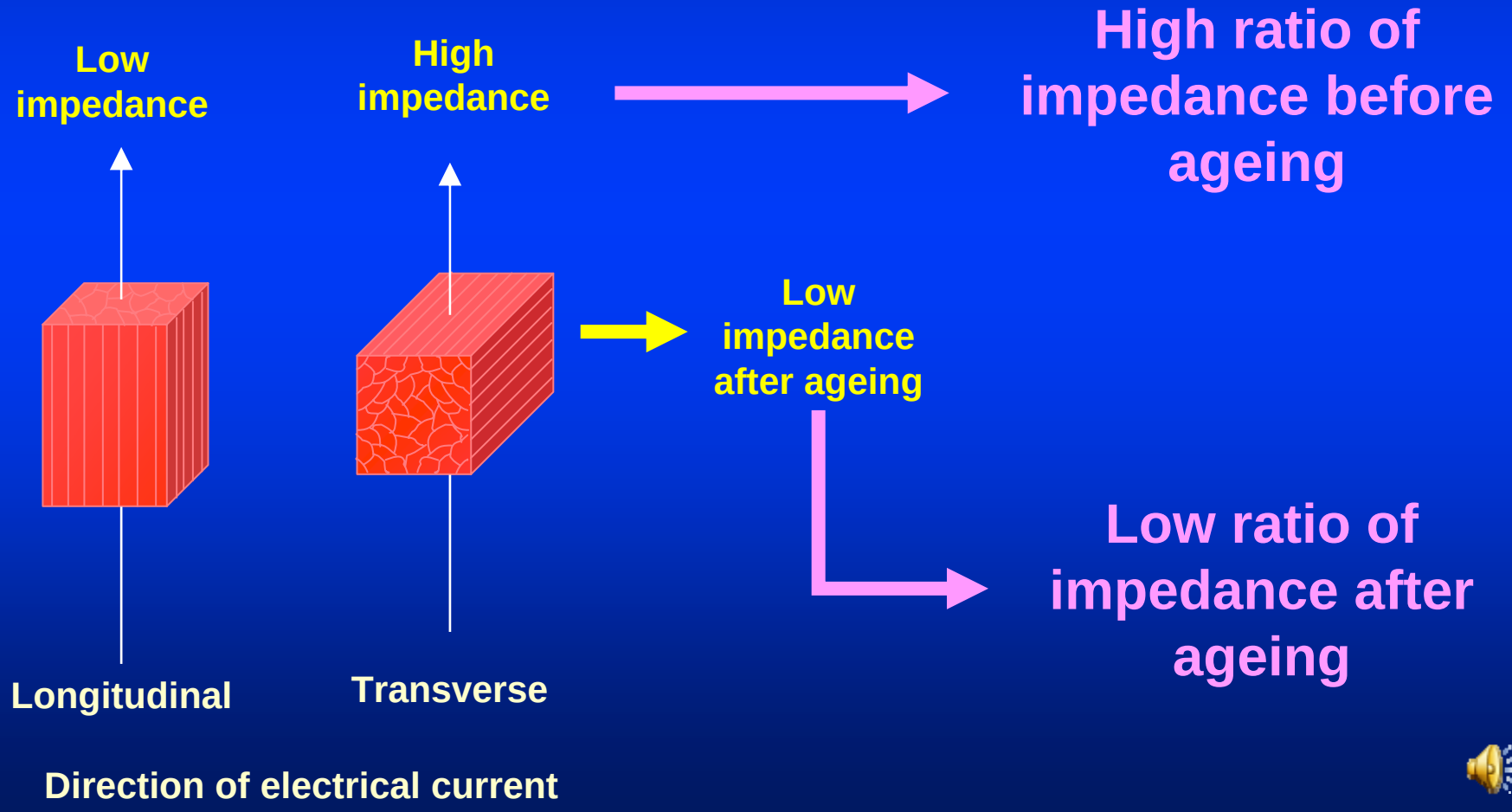
Mechanical methods



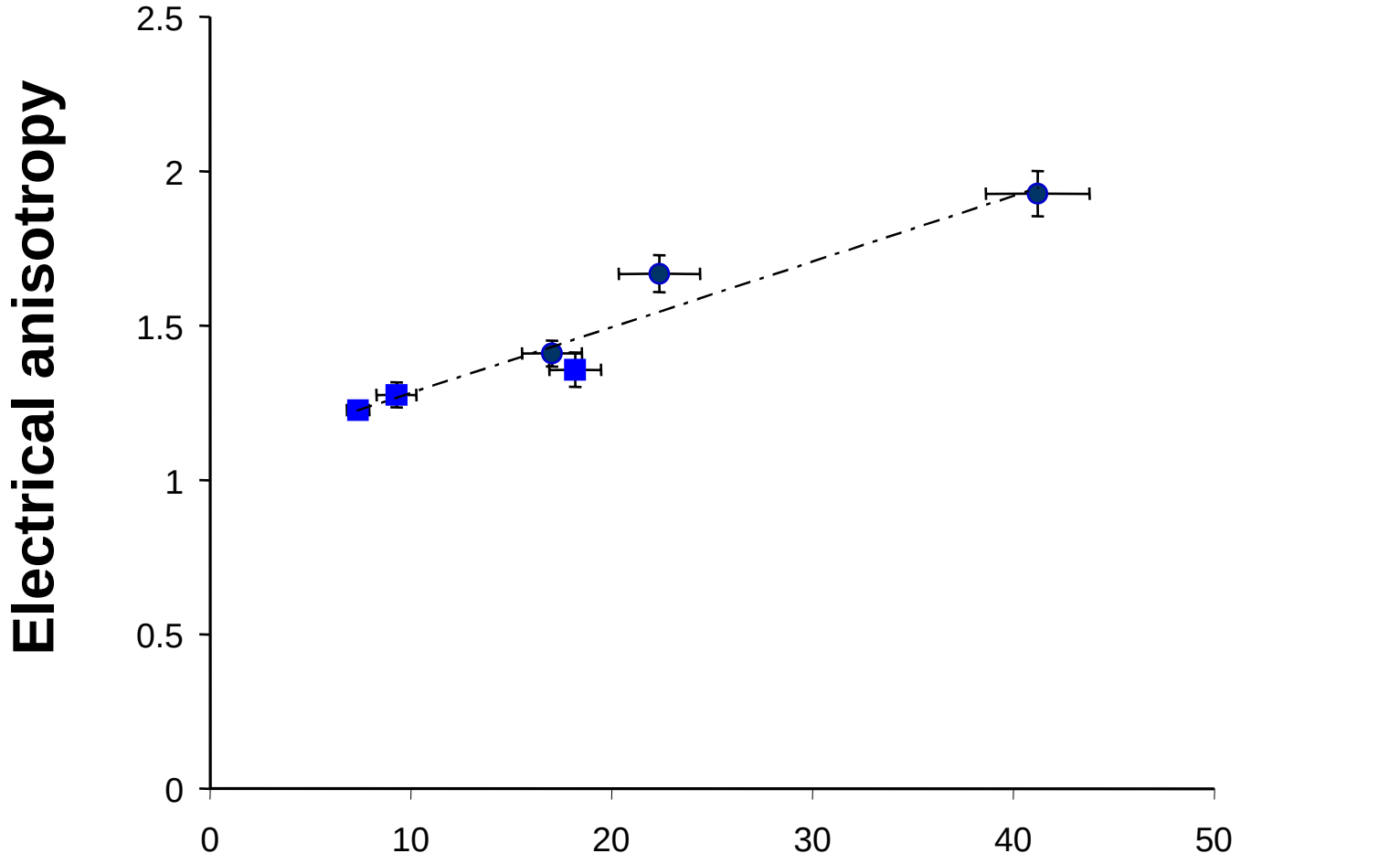
- Based on shear, tensile, compressive or torsional strain
- Correlation between them
- Myofibrillar resistance on day 2 is predictive on that on day 8
- Poor correlation between raw and cooked beef
- More or less correlated with tenderness (R^2=0.5 max).
- The Warner Bratzler shear force is considered as a reference

Electrical methods (1/3)

Impedance = resistance and capacitance components



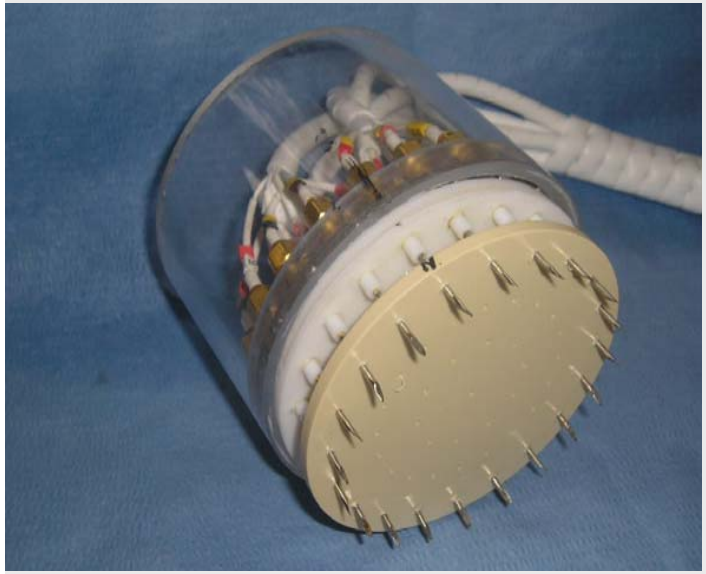
Electrical methods (2/3)



(Lepetit et al., 2002)

Electrical methods (3/3)

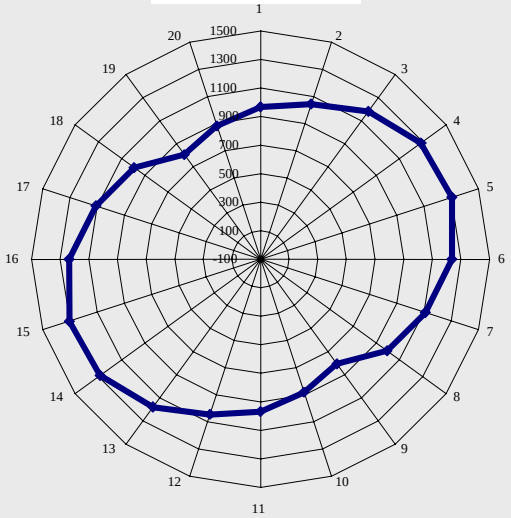
A circular captor



diameter: 8 cm.

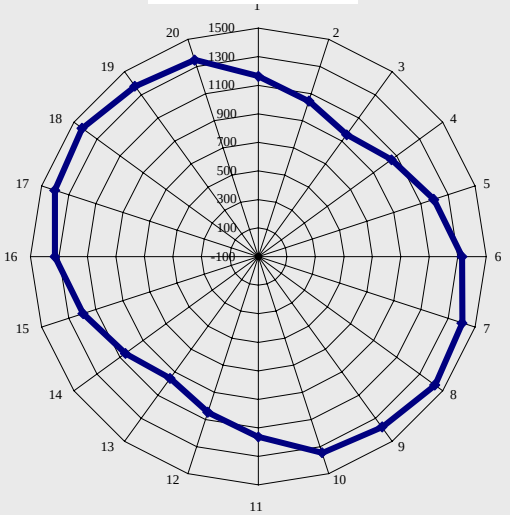
Rectus Abdominis

Day 2



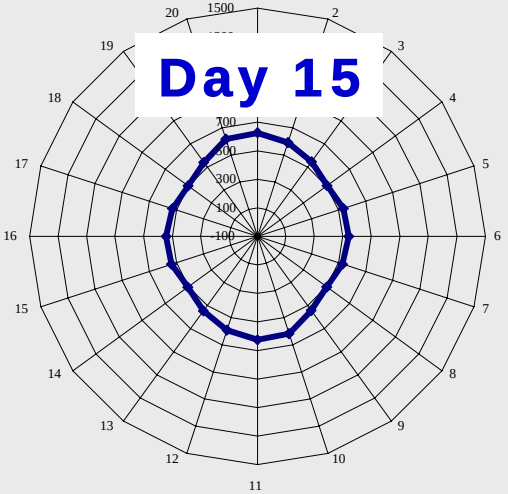
J 02 a=1307 b=854 anisotropie=1.53

Day 7



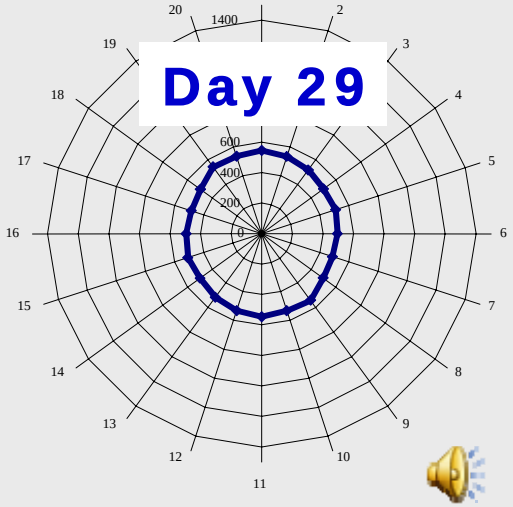
J 07 a=1454 b=1005 anisotropie=1.45

Day 15



J15 a=599 b=507 anisotropie = 1.18

Day 29

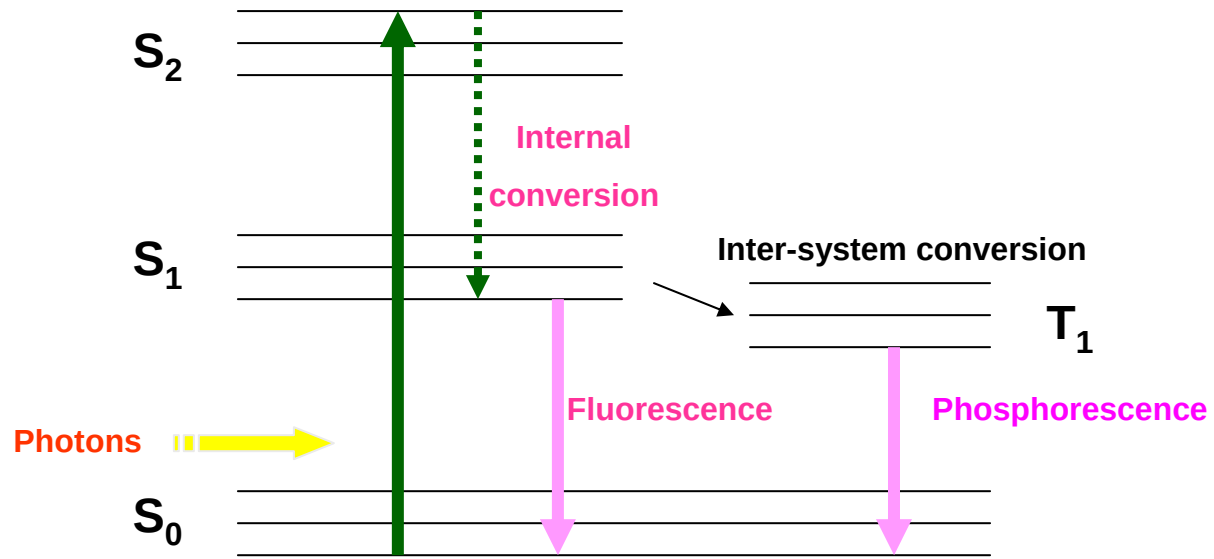


J29 a=542 b=489 anisotropie=1.11

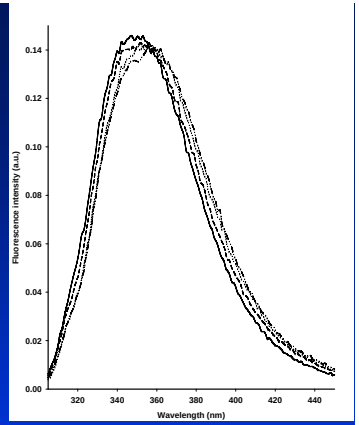
Fluorescence methods (1/4)

Fluorescence: emission of photons following excitation by light of molecules exhibiting conjugated double-bonds

Representation of electronic transitions



Fluorescence methods



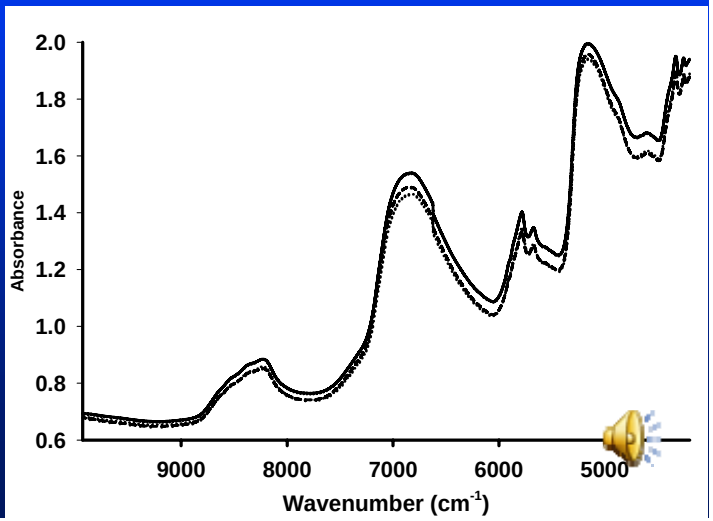
Intrinsic fluorophores

	Excitation	Emission range	Peak
Tryptophan (proteins)	280 nm;	300-400 nm	330 nm
Vitamin A (in fat)	322 nm	350-500 nm	387 nm, 440 nm
Pyridinoline (collagen)	380 nm	400-550 nm	440 nm, 460 nm
Riboflavin (vit B2)	380 nm	400-650 nm	530 nm (reduced) 475 nm (oxidized)

NIR methods

Bands of absorbance
in the near-infrared region (800-2500 nm)

	Bands
Water	1409 nm, 1460 nm, 1910 nm
Protein	1187 nm, 1690 nm, 2235 nm
Fat	1212 nm, 1722 nm, 2306 nm



Advantages and limits

Spectroscopic techniques are rapid and non destructive (require little or any sample preparation)

Spectra allow to predict qualitative (texture, tenderness, ..) and quantitative (quantify a component) parameters

NIR technique : useful for measuring constituents > 0.1% :

- water, protein, fat, collagen

Fluorescence technique : 100-10000 times more sensitive than other spectrophotometric techniques, allowing to quantify components present in micro-molar to nano-molar ranges

Advantages and limits

The development of predictive methods based on spectroscopic techniques requires :

-large databases with spectra and data from the reference method

- chemometric methods for data pre-processing, calibration modeling and transfer of calibration models

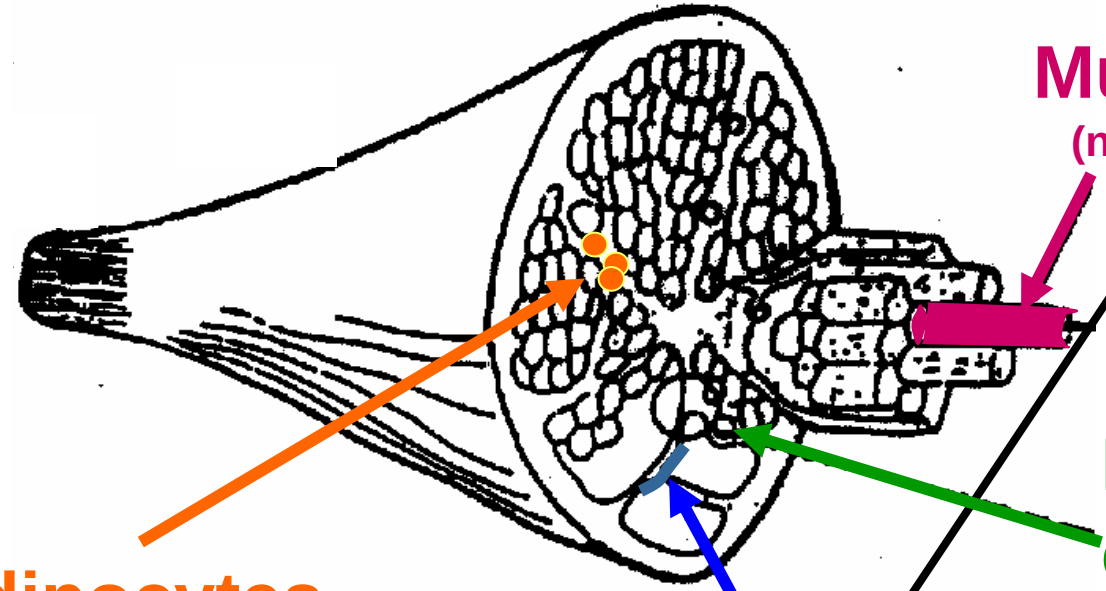
- chemometric methods allow development of reliable and stable calibration models for the prediction of the considered parameter

Sensory analysis / Fluorescence spectroscopy (R)	**0.95**
Texturometer / Fluorescence spectroscopy (R)	**0.92**

Summary

- The concept of quality and reference methods at the consumer end
- *Post-mortem* prediction of beef quality at the abattoir or by beef retailers
- Prediction of beef quality at the producer level (sensory traits, healthiness, traceability)

From the muscle tissue to meat quality



Muscle fibers
(number, size, type)

Blood capillaries

Adipocytes

Connective tissue

JUICINESS

COLOUR

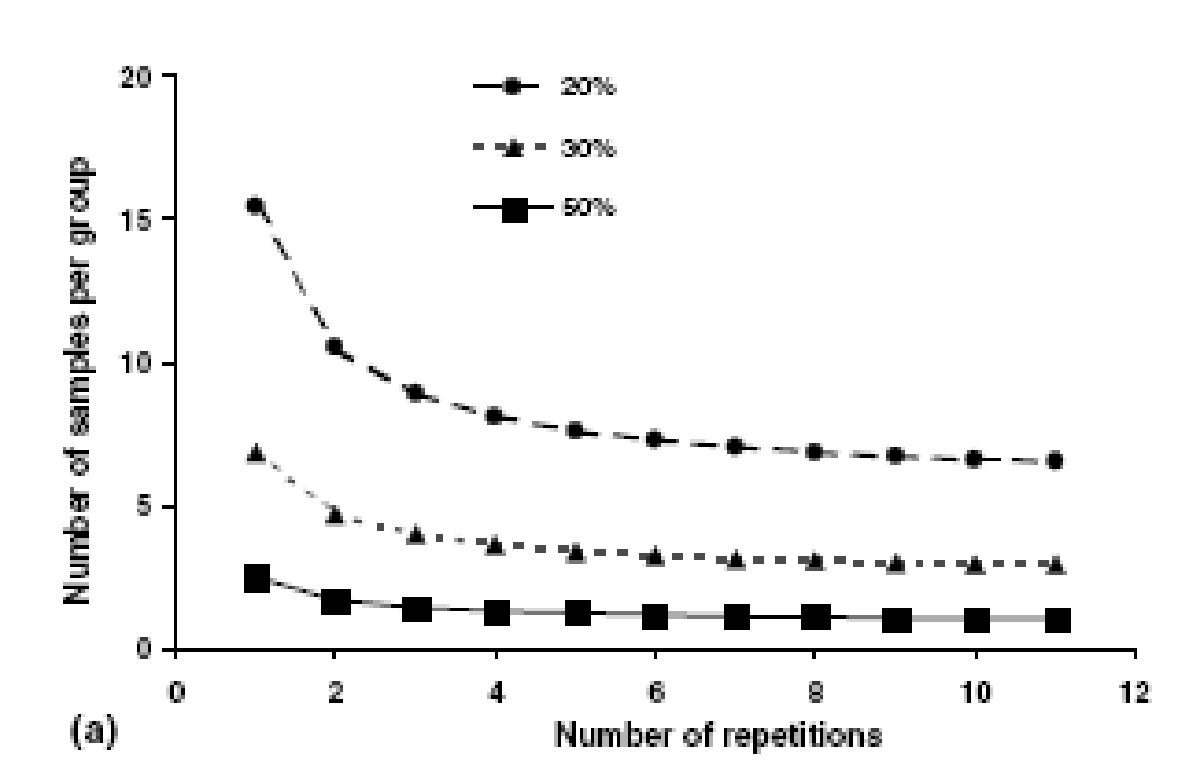
FLAVOUR

TENDERNESS

HEALTHINESS

Up to 1/3 of tenderness variability can be explained

Total Collagen amount



Total collagen amount is low in *longissimus*.

Taking into account technical and biological variability, you need to calculate the number of animals and of technical replications to detect any significant difference.

(Listrat & Hocquette, 2004)

Some results

With 1200 young bulls,
variance explained by the animal effect

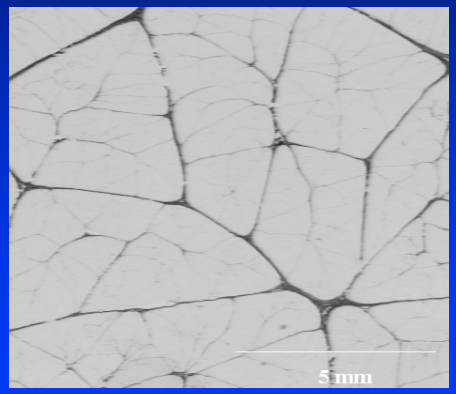
Intramuscular fat content (n=2):	93%
Collagen content (n=3):	61%
Muscle fibre area (n=2):	81%
Colour (n=5):	85%
Shear force (n=10):	28%
Tenderness (12 sensory assessors):	8-20%
Flavour (12 sensory assessors):	2-4%

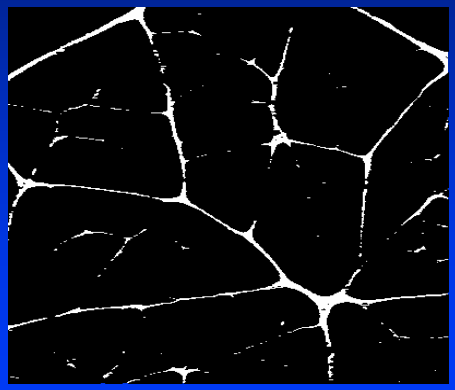
Image analysis

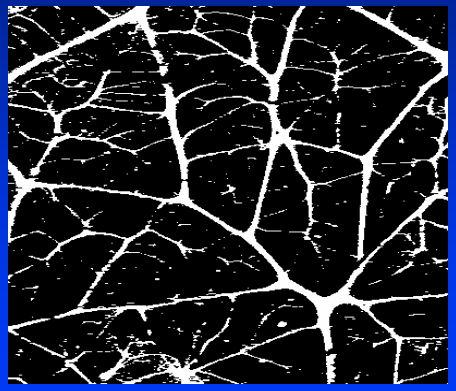
Thick Frame

Complete frame

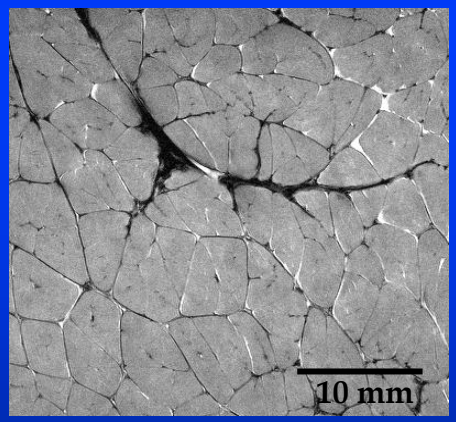
Histology

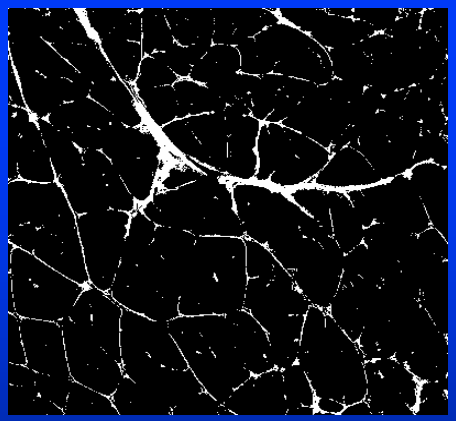


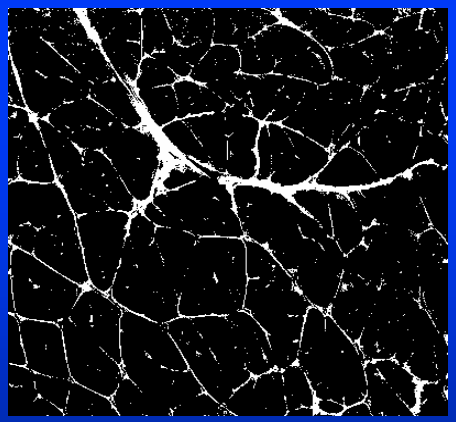




Magnetic Resonance Imaging





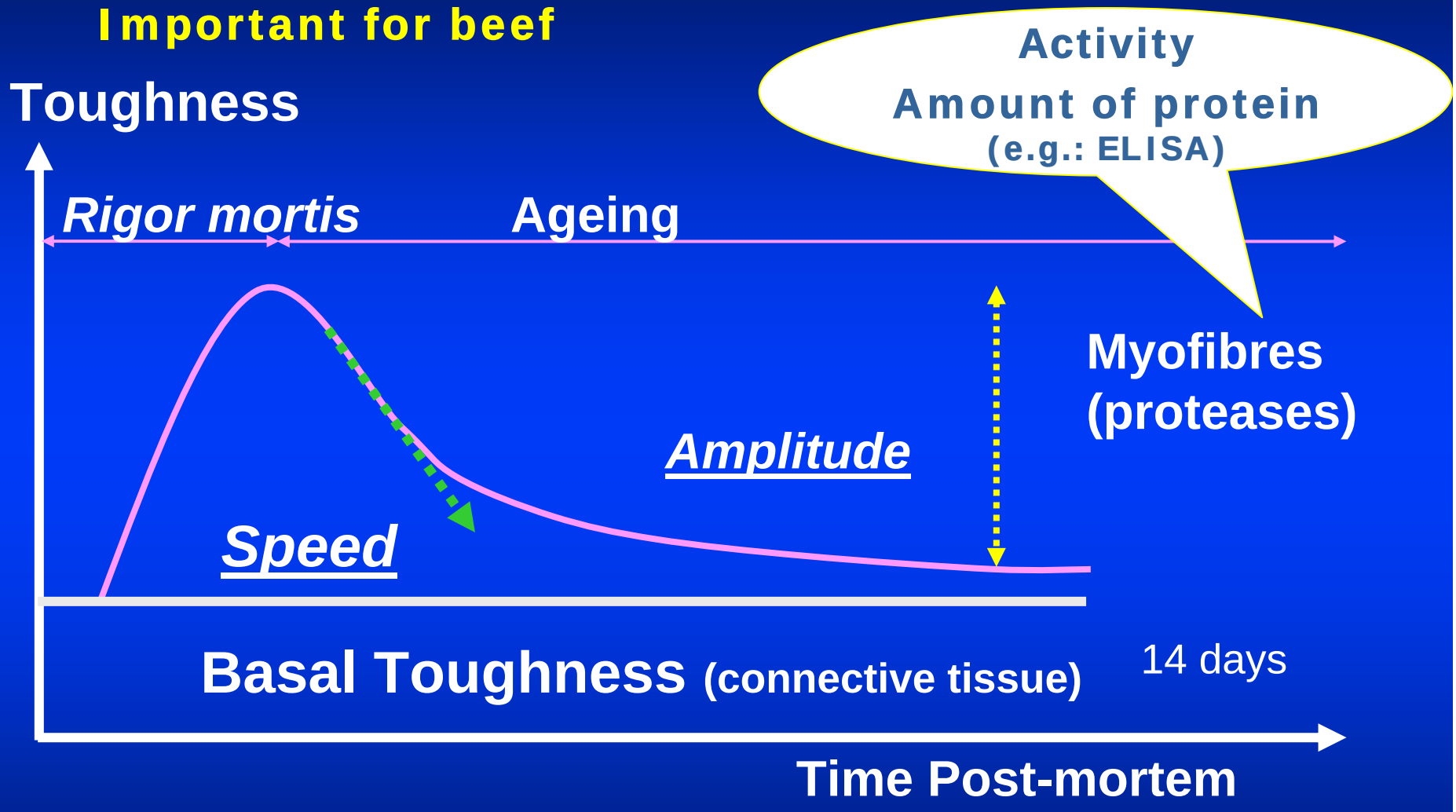


To draw the connective tissue frame

(Sifre-Mounier et al., 2006)

Ageing and tenderness

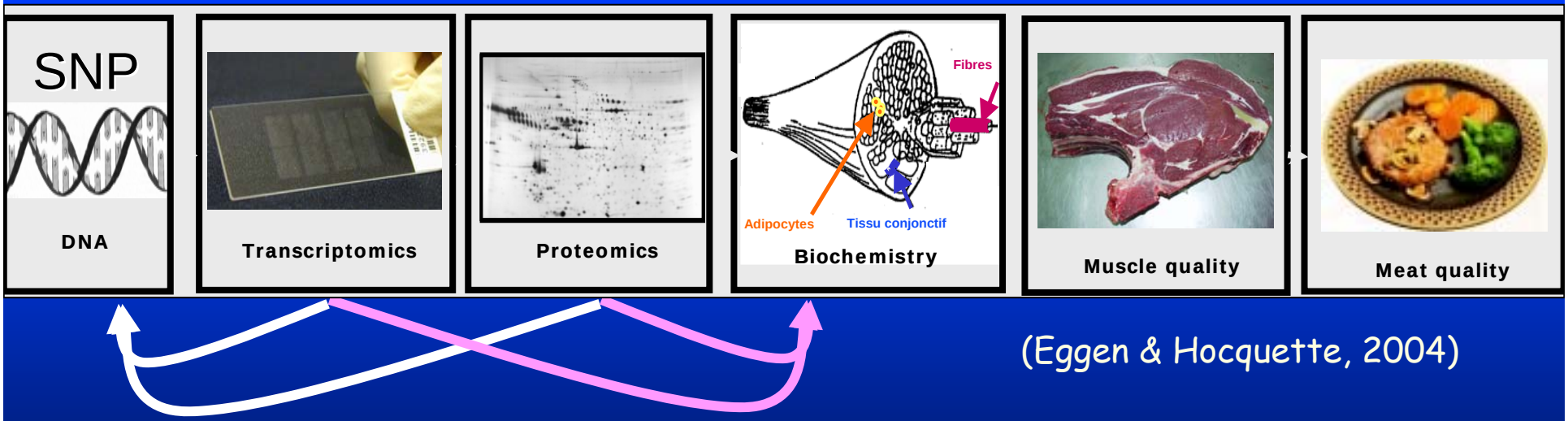
Important for beef



Characteristics of fibre types
are important for ageing (not completely understood)

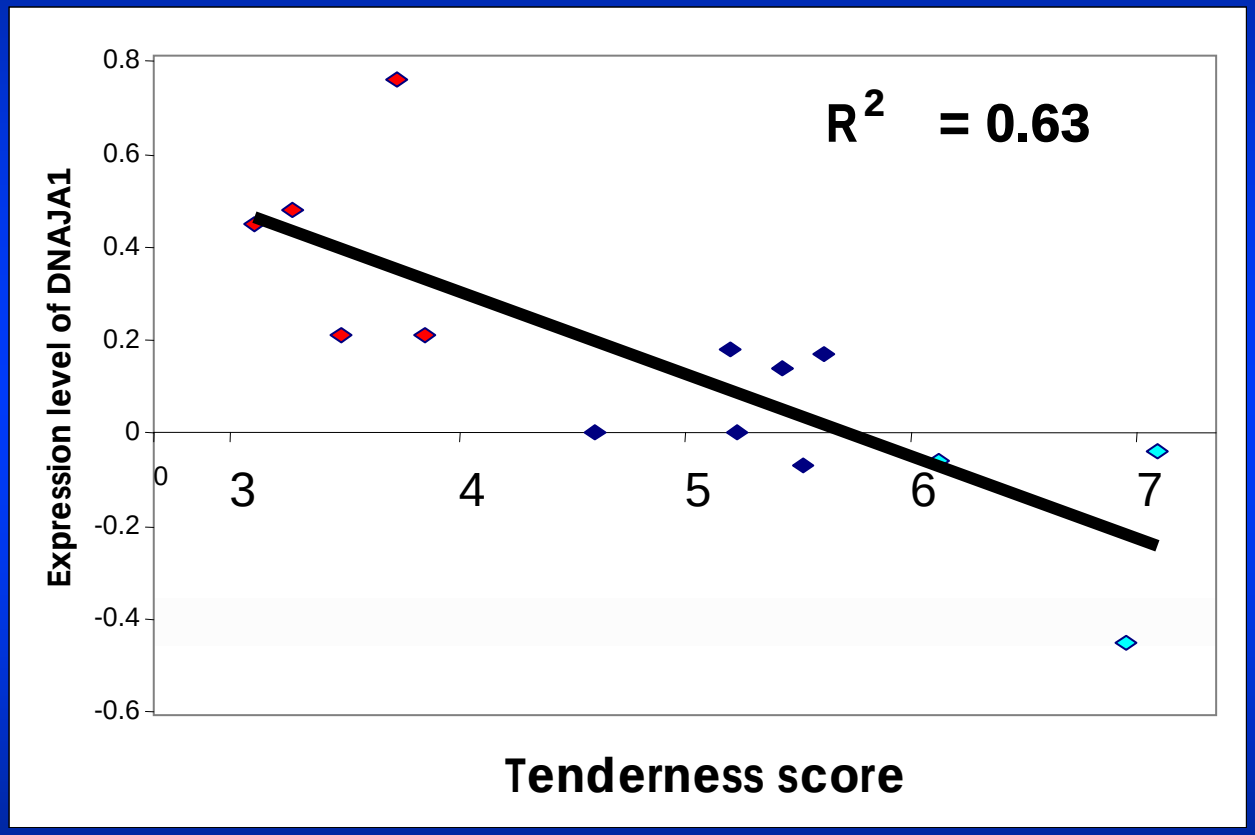
The potential benefits of genomics

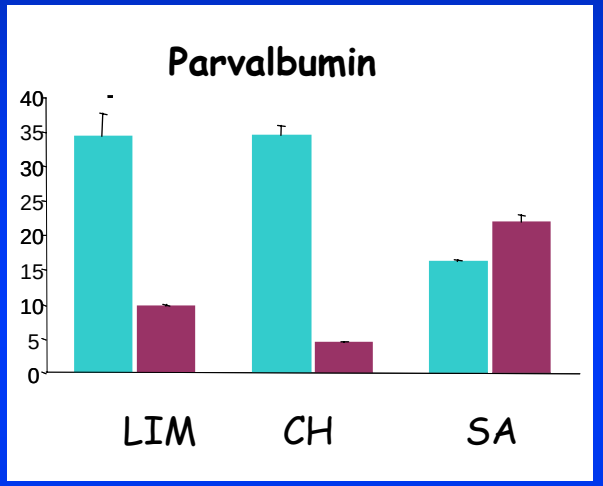
The detection of new genes which are differentially expressed between “good” and “not good” beef

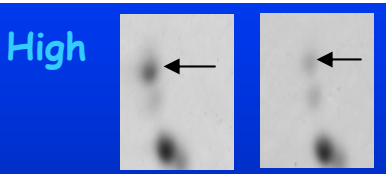


(Eggen & Hocquette, 2004)

Transcriptomics and Proteomics:
Identification of markers of tenderness







High tenderness

Low tenderness

(Bernard et al., 2006)

(Bouley et al., 2004)

Genetic markers (1/2)

Australia

GeneSTAR®

GeneSTAR Marbling is a DNA-based diagnostic that tests for a major gene associated with marbling in beef cattle. It is believed there are a small number of genes that have a major effect on marbling.

CAPN1 (proteolysis), CAST (inhibitor), LOX (collagen synthesis): toughness

These tests have been validated in a limited number of breeds and breeding systems.

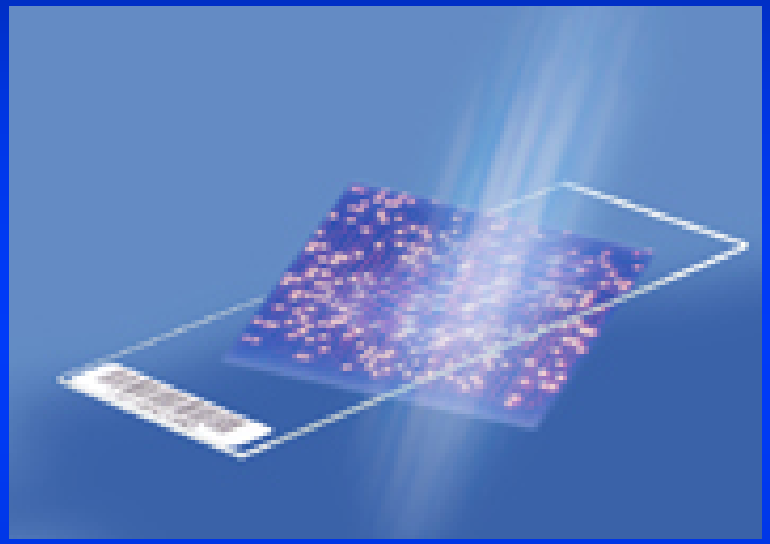
Review by Kühn et al., 2005. EAAP Publ. 112

SNP-DNA Profiling: Past and future (2/2) technology

Manual procedure (high cost)

Automatic procedures and data analysis (low cost)

Safety: food contamination by bacteria, The chip from GeneScan



The NUTRI®Chip is a ready-to-use chip for the analysis of foodstuffs. It provides fast and sensitive detection of bacterial contaminations.

Animal product components and Nutritional properties (1/2)

♦ **PROTEIN (fish, meat): 16 – 22% with a well balanced IAA content**

☞ Highly digestible protein with high biological value

♦ **MICRONUTRIENTS** contribute to meet human needs

- In beef, Vitamins B (B1, B2, B6, B12, niacin), minerals and trace- elements (zinc, heminic iron…..)

♦ **LIPID : emphasis on fat content and on the positive role of n-3 PUFA and CLA**

☞ reduce cardio vascular diseases (sudden cardiac death), inflammatory diseases, diabetes, cancer

☞ enhance brain development

♦ **REQUIREMENTS**

- Accuracy, sensitivity, reproducibility, …

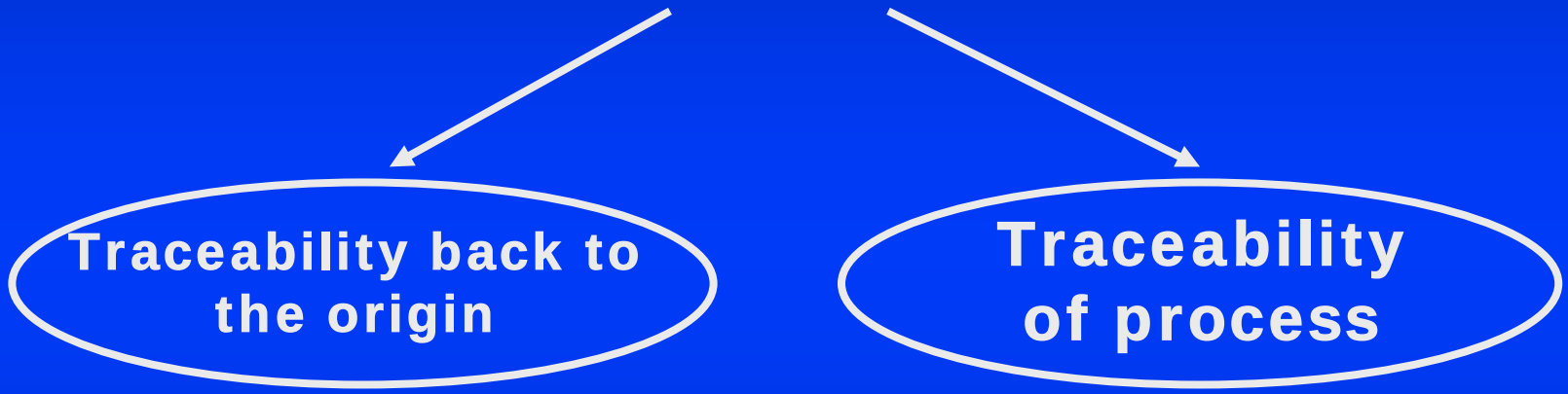
Metabolic high-throughput approaches

The *Metabolic Profiler™* is a concept to investigate *metabolism in humans, animals, plants and cells* based on *expandable hardware* and *Integrated software* from sample preparation to metabolite identification, quantification and statistical evaluation of metabolite patterns (e.g.: amino acid profile, fatty acid profile, mycotoxins, …)

Dedicated, integrated system, with a combined NMR and MS approach for metabolic profiling

Traceability (1/2)

Ability to trace the history, application or location of an entity by means of recorded identifications.



Geographical origin

Animal identity

Breed

Genetic

Production systems including feeding diets

Processing

Conservation processes

Adulteration of products

Traceability (2 / 2)

Development of analytical tools to quantify specific compounds in the product, or the animal tissues and fluids

Plant biomarkers	Carotenoids, terpenes, flavonoids
Metabolite markers	Fatty acid composition
	Volatile compounds
Physical markers	H, O Isotopes : geographical origins (latitude, altitude)
	C, N Isotopes : alimentation
New approaches	Near infrared spectroscopy
	Genomics

Great variability of the response.
The next challenge

Necessity to combine different methods or different markers

The Future of research on quality …

- … should improve the available methods
- … should address statistical issues
- … should take advantage of the huge scientific and technical progress (genomics, integrative biology, etc)
- … should meet new consumer expectations (healthiness, safety, etc) and societal challenges (sustainability, etc)

"the properties of a product that contribute to and satisfy the needs of end-users".

Natural Livestock practices

Taureau de Camargue

Culture & Tradition

Taste and Flavour

Quality is thus a social concept, i.e. a convergence between end-users expectations and product characteristics

A great success: modeling beef tenderness (to be completed in other countries)

Inputs

Cooking

Grade

Cuts

MSA2000model®

Hang (AT/TC/TS/TX)	AT
Sex (M, F)	m
Est.% Bos Indicus	0
Hump Height cms	0
Hot Std Carc Weight	200
USDA Ossification	100
Milk Fed Vealer Y/N	N
USDA Marbling	130
Days Aged (min 5)	5
Quarter Point Ribfat	5
Ultimate pH	5.40

AUSMEAT Meat C

Saleyard? (

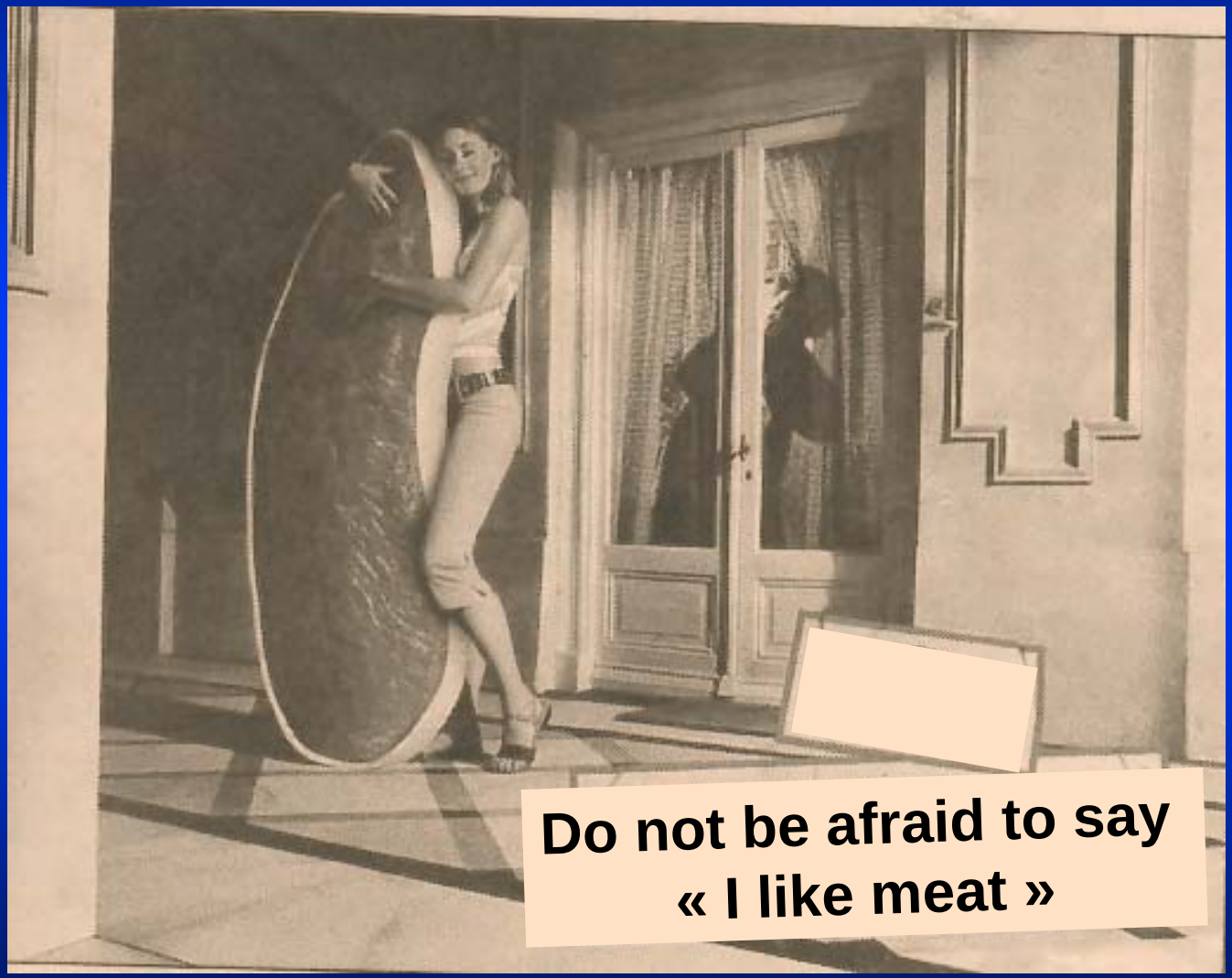
Wght/App.Mat

Cut Description	Muscle Reference	Days Aged	Grilled Steak	Roas Beef	Fry	Slice		
Tenderloin	TDR062		5	4	5			
Cube Roll	CUB045		3	3	3	4		
Striploin	STR045		3	3	3	3		
Oyster Blade	OYS036		4	3	4	4		
Bolar Blade	BLD096		3	3	3	3	3	
Chuck Tender	CTR085			3	3	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	3	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	

The next challenge:

the introduction of genomic markers

The best method
to improve beef consumption is Communication



Thank you for your attention

For any question, send an E-mail to

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