Assessing and predicting carcass and meat quality traits

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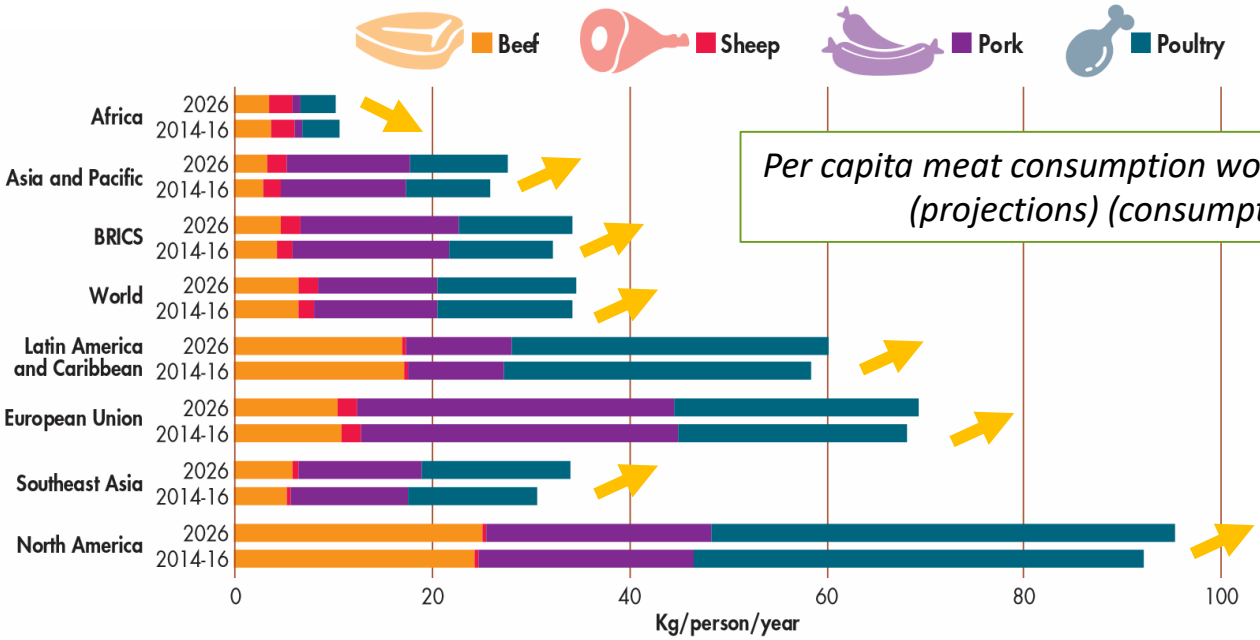
70th Annual Meeting of the European Federation of Animal Science, City of Ghent (Belgium), 26 - 30 Aug 2019

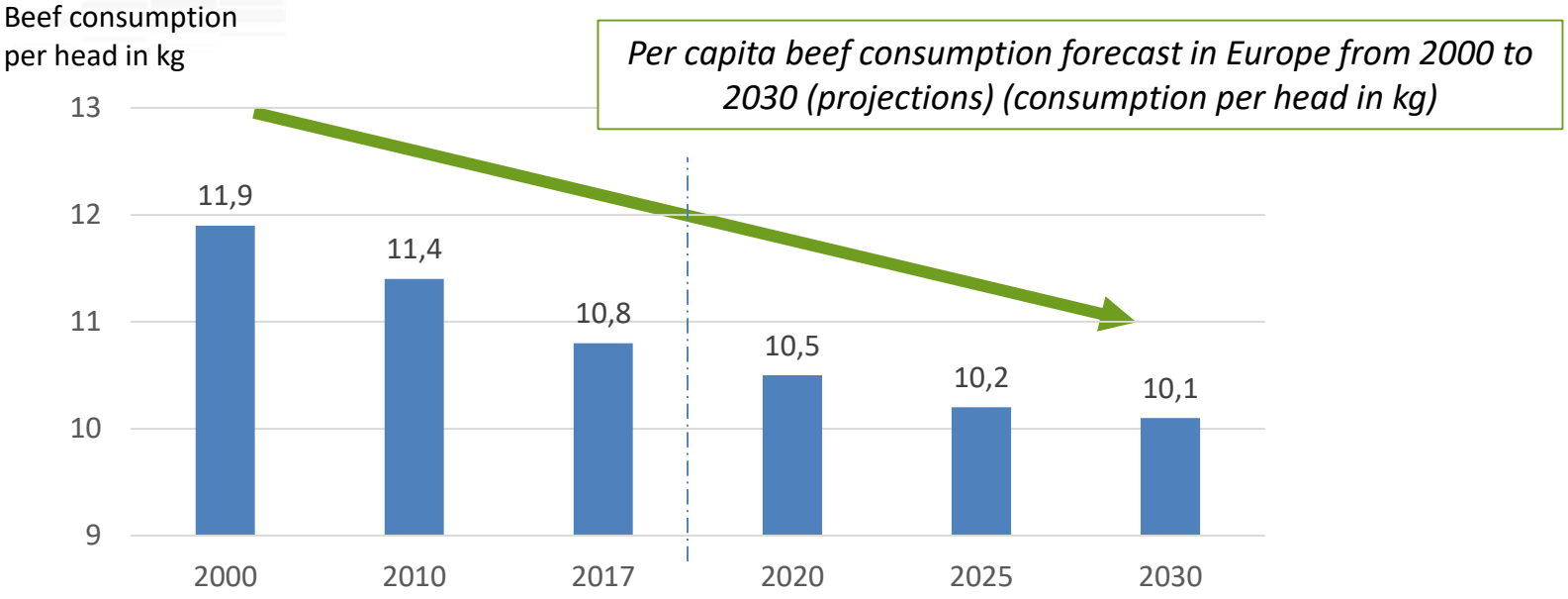
Introduction



Per capita meat consumption worldwide in 2014-16 and 2026 (projections) (consumption per head in kg)

OECD-FAO, 2017

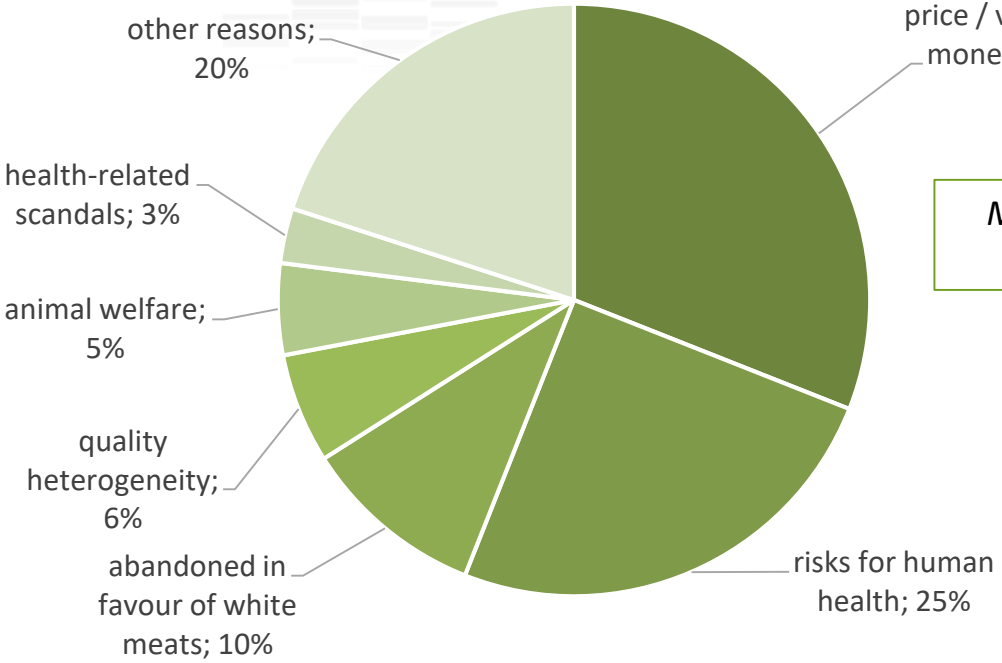
Introduction



Per capita beef consumption forecast in Europe from 2000 to 2030 (projections) (consumption per head in kg)

European Commission, 2017

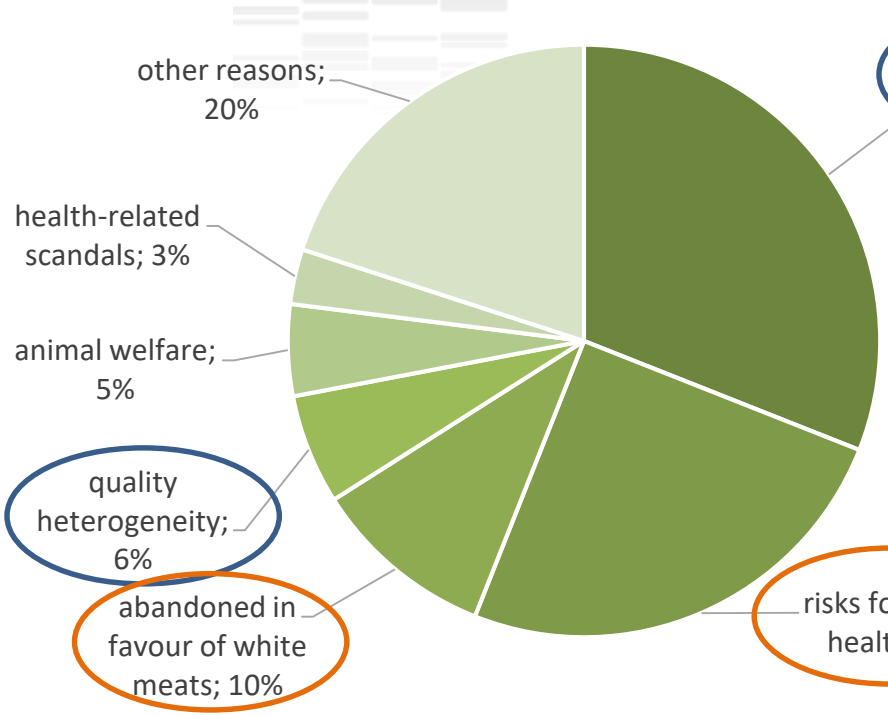
Introduction



Main causes of the decline in meat consumption in France

Ellies-Oury et al., 2018

Introduction



Sensory quality

Nutritional quality

Main causes of the decline in meat consumption in France

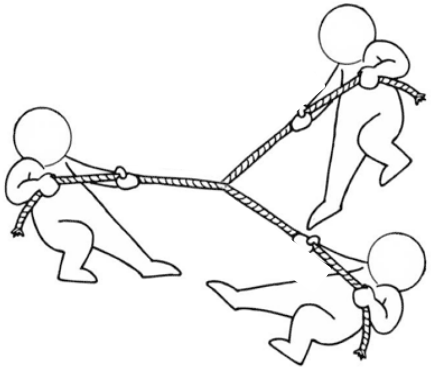
Ellies-Oury et al., 2018

Introduction

Beef chain => satisfying retailers and consumers at the same time

Trade-off

Efficiency



Nutritional value

Carcass quality

Sensory quality

Valorization

Introduction

Breeders => increasing animals feed efficency

Efficiency

⇗ Average daily gain, ⇗ protein content
⇘ Lipid content

Nutritional value

- Carcass quality
- Valorization
- Sensory quality

There are also compromises to reach to satisfy the whole beef chain

Negative impact
Positive impact

Introduction

How to predict and manage carcass and meat quality traits all over the meat chain ?

Plan

Expectations concerning carcass and meat quality: current systems and perspectives

Quality modulation and prediction

- Predictive models
- Interrelations between the various qualities
- Trade-off management

Steering quality and quality management

- Upstream management
- Downstream management

Expectations concerning carcass and meat quality:

current systems and perspectives

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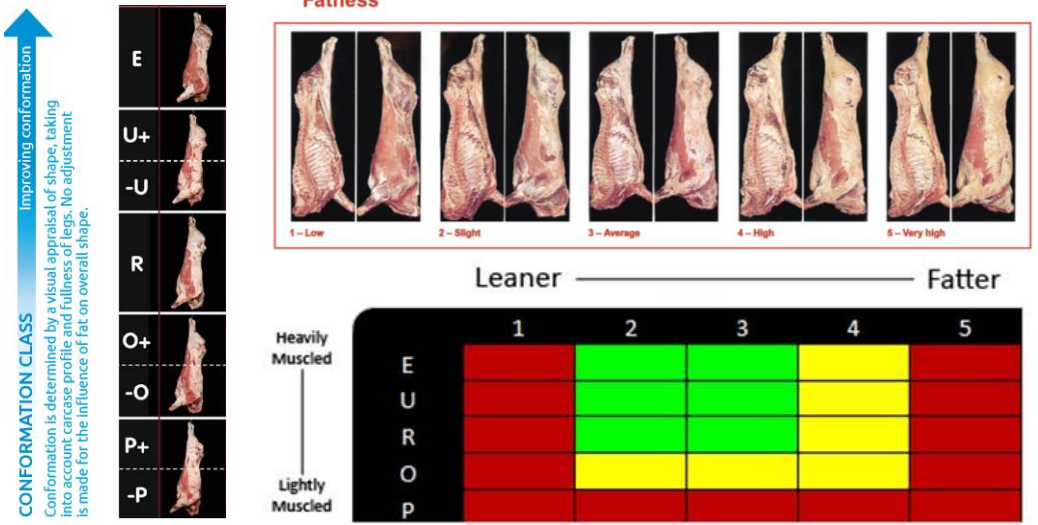
Definition of carcass quality

Are the carcasses oriented on the different markets according to their level of quality ?

Parameters used to evaluate carcass quality according to the EUROP grid

Country	**Europe**
Scheme	***EUROP***
Grading unit	**Carcass**
Pre slaughter factors	-
Slaughter-floor	**Carcass weight and sex**
	Conformation
	Fat cover
Chiller	-
Post chiller	-



Definition of carcass quality

Are the carcasses oriented on the different markets according to their level of quality ?

Numerous beef carcass classification systems have been implemented throughout the world

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	Conformation Fat cover	Dentition Ribfat	Conformation	**Carcass weight and sex**			Electrical stimulation Hang
Chiller			Texture	**Marbling score** **Meat Colour** **Fat colour and fat thickness** Meat brightness Fat luster Fat texture Fat firmness Rib thickness	**Eye muscle area** Texture Firmness Lean maturity	**Ossification score** Meat texture Ribfat Kidney fat Perirenal fat	**Fat thickness** Hump height Ultimate pH
Post chiller							**Ageing time** **Cooking method**

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A set of indicators proposed in addition to the EUROP system

Step 1

Inventory of indicators used in scientific literature (142 articles from 2010 to 2015)
➔ 89 different candidate indicators

Step 2

Organization according to a hierarchical structure to consider the interests of the differents stakeholders – expert appraisal

Step 3

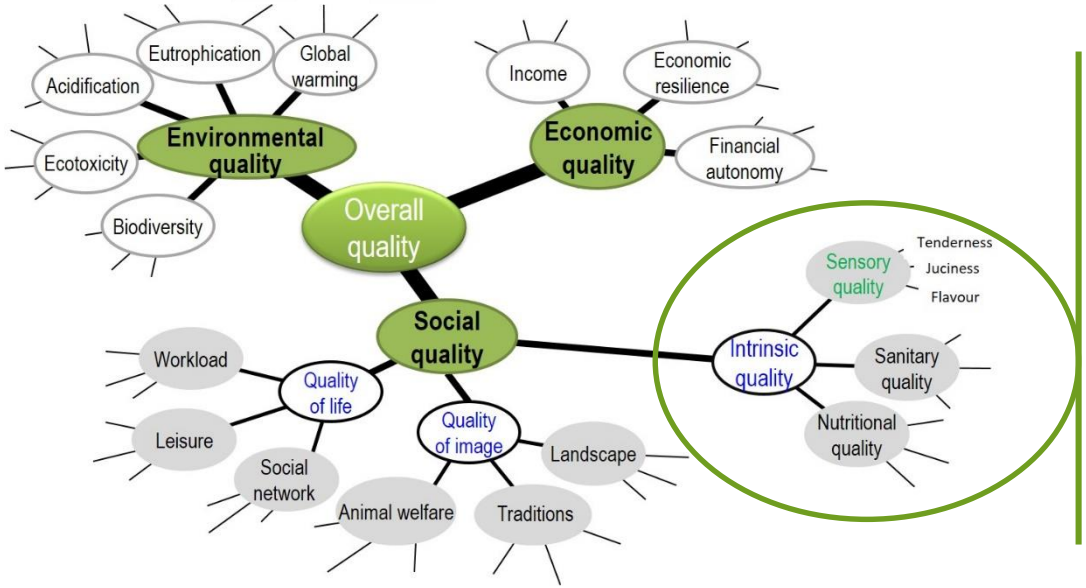
Selection of a indicators set according to :

- The hierarchical structure
- The citation count in the literature
- The complementarity with the EUROP system and between them

Additional indicators	Principles to which the indicators relate
	Animal characteristics
	Carcass characteristics
Hindquarter weight	Carcass characteristics and Economic value
Meat colour	Tissue characteristics and Economic value
Retail-cut yield	Technological value and Economic value
	Economic value
	Economic value
Rib-eye area	Economic value
Marbling score	Economic value

Monteils et al., 2017

Definition of meat quality according to the consumer



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

Hocquette et al., 2014. Animal Production Science.

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.

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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).

Quality modulation and prediction

1. Predictive models

How to predict meat quality ?
Examples of the interest of the integrative approach

Predictive models of carcass quality class

From rearing practices of the fattening period:	Sensitivity: 57,9% Accuracy: 61,2%

From rearing practices of the whole life:	Sensitivity: 64,0% Accuracy: 64,3%

Soulat et al., 2018

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Typology of rearing practices

Suckling period
Growth period
Fattening period

} Typology of rearing practices can identify sensitive period and main influential rearing practices to carcass properties

The rearing management can be defined by the combination of classes at different periods

Soulat et al., 2018

How to predict meat quality ?
Using innovant statistical methods

The package ModVarSel:

A new computational methodology that simultaneously selects the best regression model and the most interesting covariates

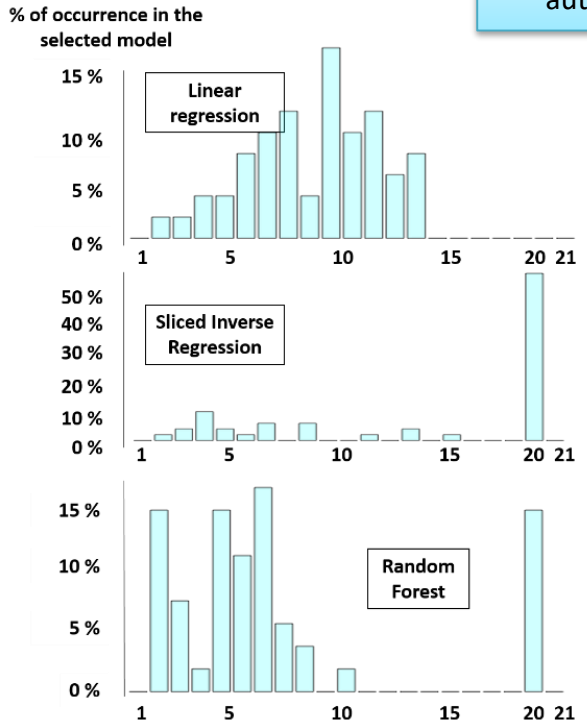
Application :

Prediction of 1 parameter (for example: tenderness)
by a pool of 21 variables (breeding factors for example)

To install the current version of the R package modvarsel from github, use : https://github.com/chavent/modvarsel.

How to predict meat quality ?
Using innovant statistical methods

Information of the number of usefull variables automatically selected



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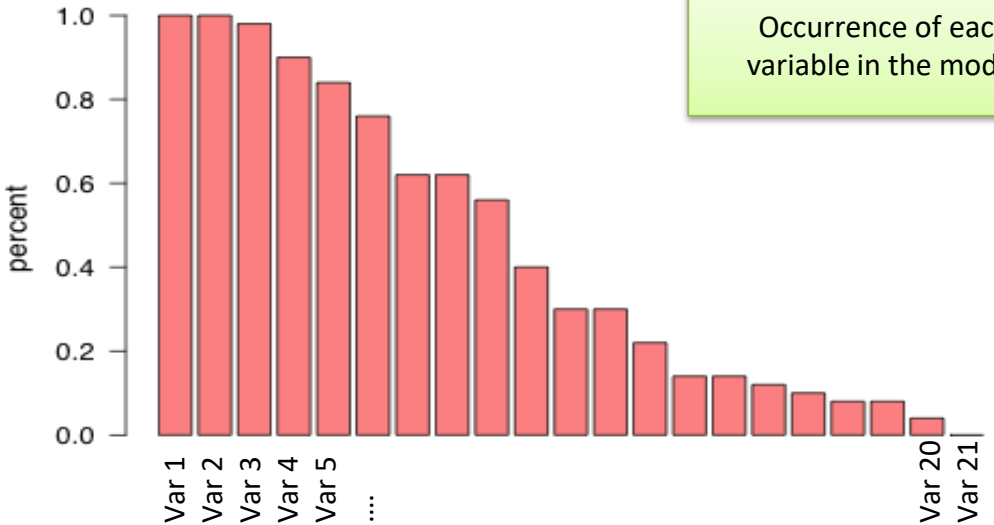
Ellies-Oury et al., 2019 (Scientific Report)

How to predict meat quality ?
Using innovant statistical methods

How to select variables ?

The occurrence of each variable is calculated, leading to a ranking of variables according to their importance



Occurrence of each variable in the model

How to predict meat quality ?
Using innovant statistical methods

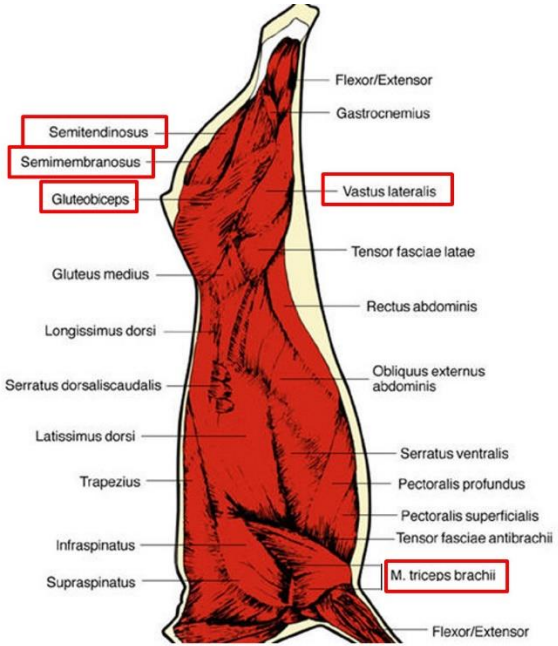
The Data-Driven Sparse Partial Least Square:

Approach allowing a variable selection in the covariable and in the output parts

Possibility to predict several variables in the same time and by the same pool of factors

Application :

Prediction of the tenderness of 5 muscles simultaneously



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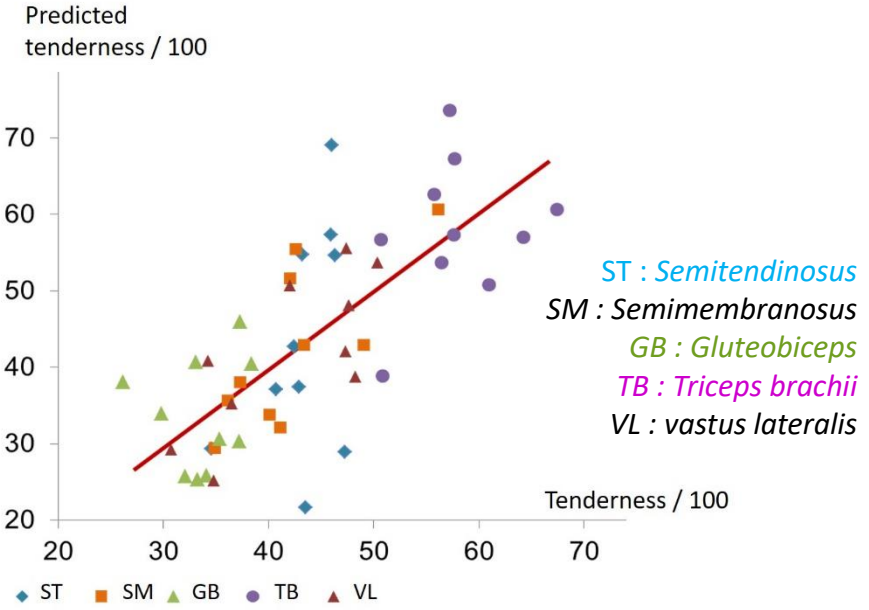

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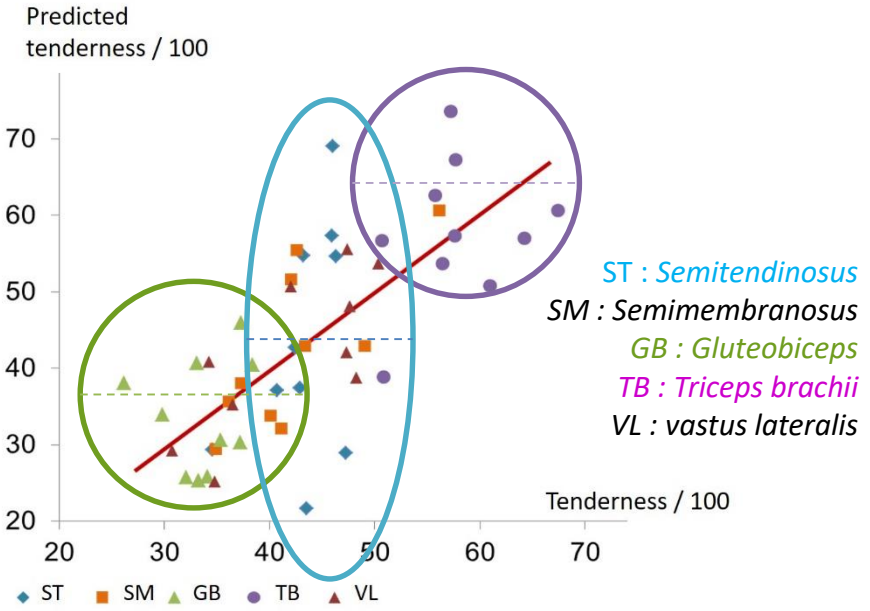

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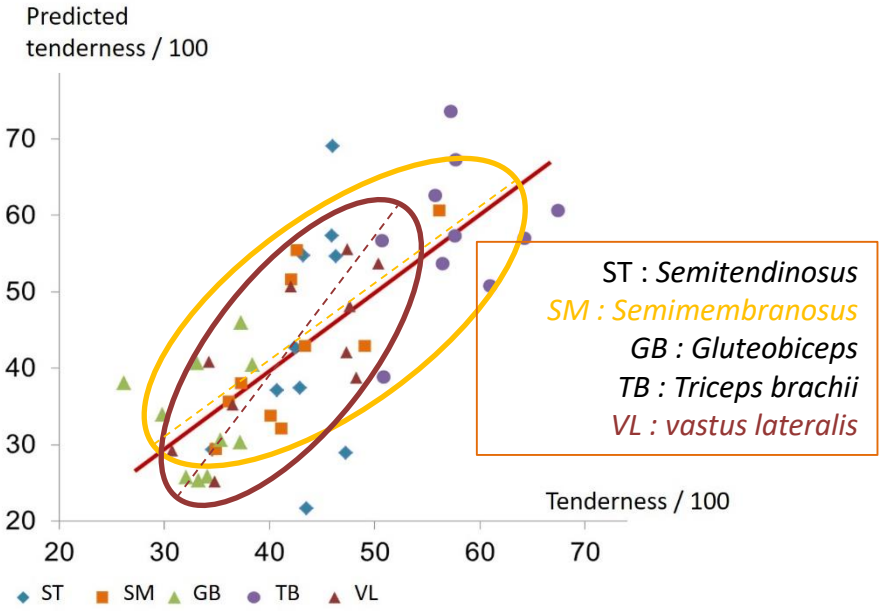

Quality modulation and prediction

2. Interrelations between the various qualities

Establishing the links between animal performances and meat quality

ClustOfVar

An innovate statistical method applied to the evaluation of trade-off between different data sets

Example :

Evaluation of the trade-off between animal efficiency, nutritional value and sensory quality of meat

Multi-table data analysis

- ✓ Establishing the links between various variables
- ✓ Identification of action levers to modulate quality
- ✓ Proposition of trade-off between the different expectations of the bovine meat chain

Ellies-Oury et al., 2016

Establishing the links between animal performances and meat quality

71 young bulls characterised by *p* variables coming from 3 data-sets (*p* = 97)

Set 1 : p_1 variables of performances (p_1 = 36)

Set 2 : p_2 variables of sensory quality (p_2 = 29)

Set 3 : p_3 variables of nutritional quality (p_3 = 32)

Ellies-Oury et al., 2016

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Clustering on the p_i variables of each data-set => ***Reduction of variables number***

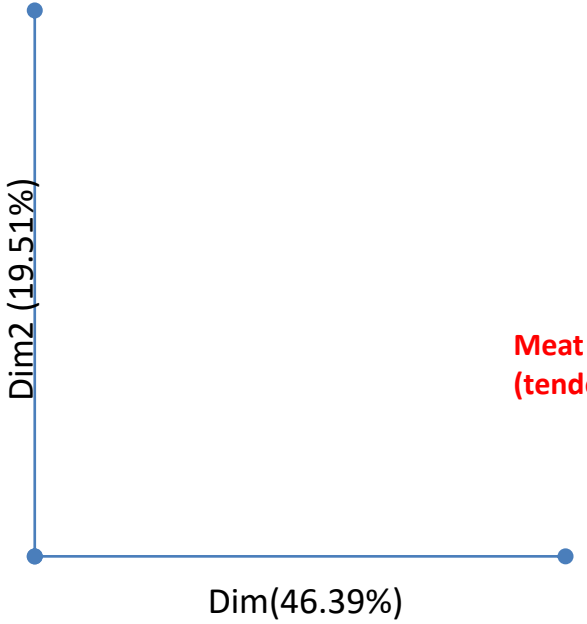
Construction of 5 synthetic indexes for each data-set: *linear combinations of a subset of variables constituting an homogeneous pool*

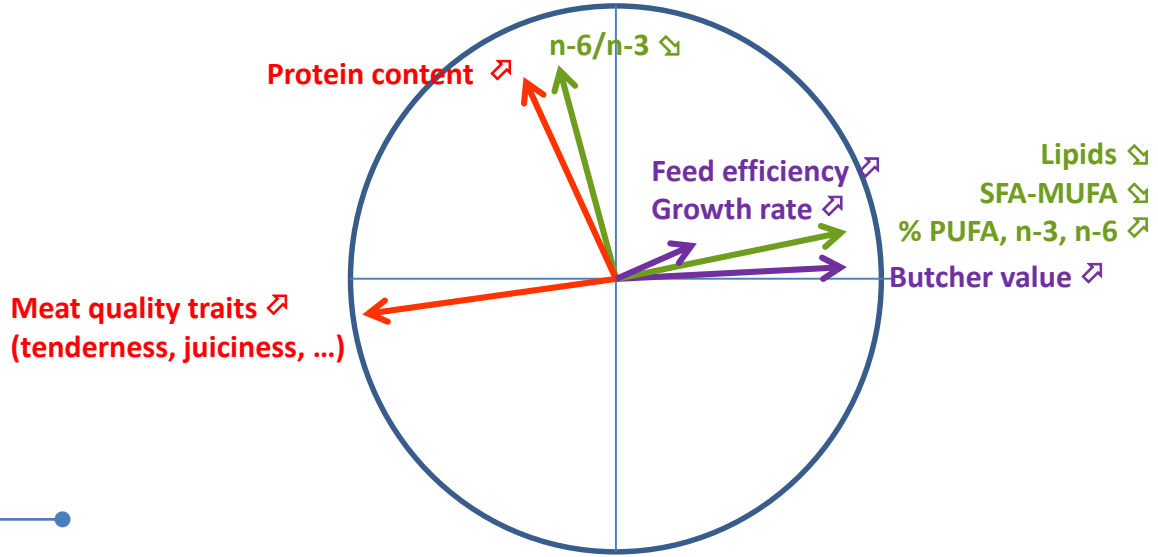
Clustering on the 3x5 synthetic indexes => ***highlighting of the interrelations***

Identification of relationships between the 3 data-sets

Ellies-Oury et al., 2016

Establishing the links between animal performances and meat quality





Ellies-Oury et al., 2016

Quality modulation and prediction

3. Trade-off management

How to predict meat quality ?
Trade-off between meat quality objectives

Mathematical problem of Multi-Objective Optimization (MOO)

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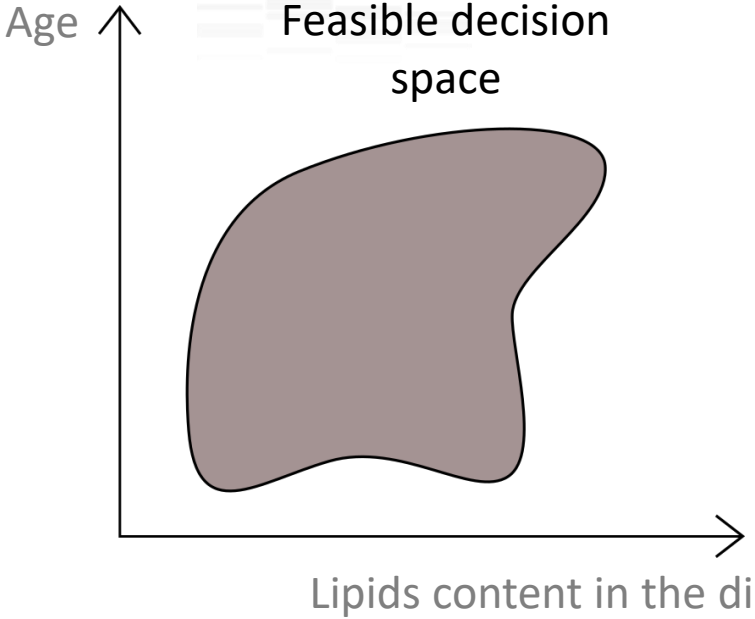
Trade-off between meat quality objectives



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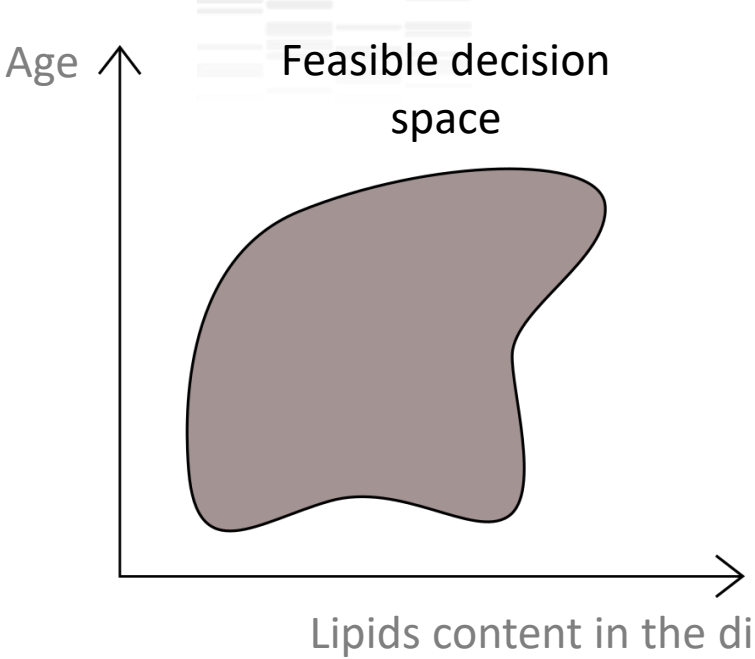

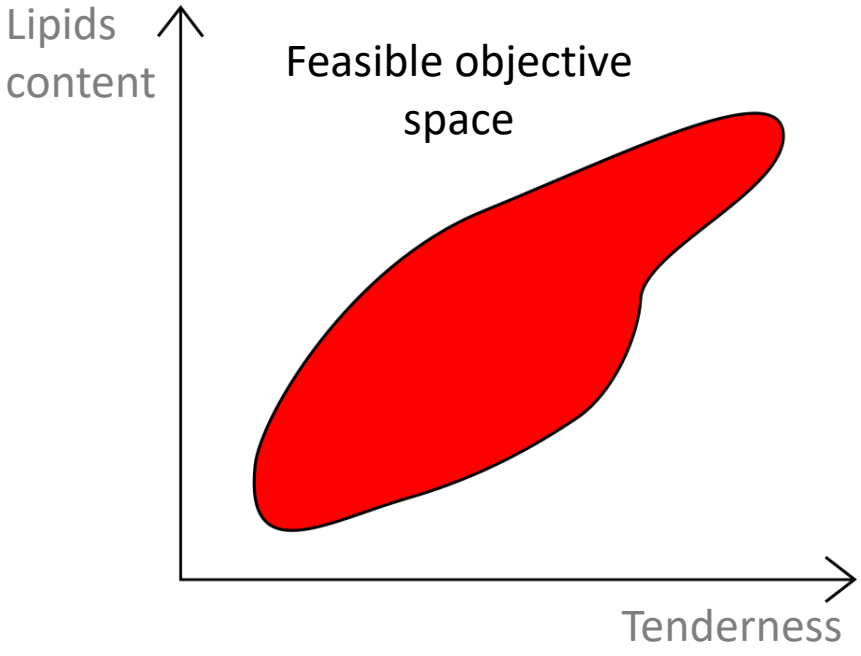

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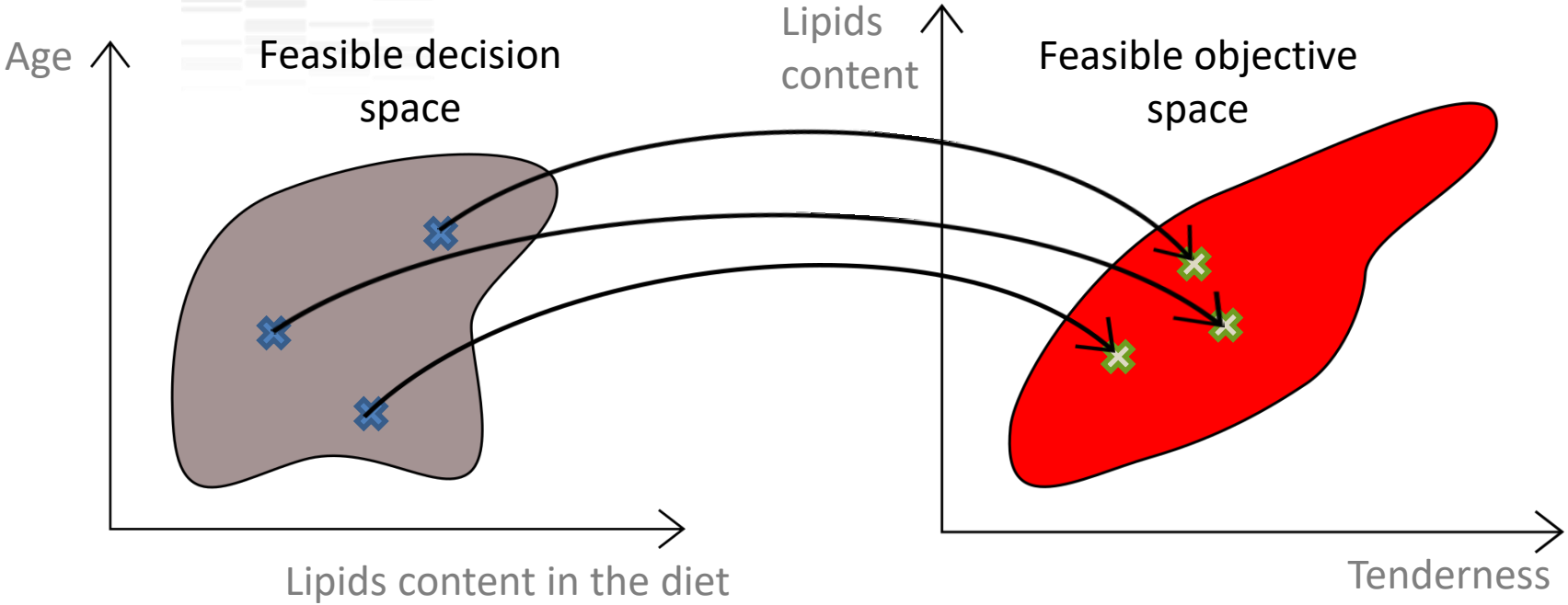

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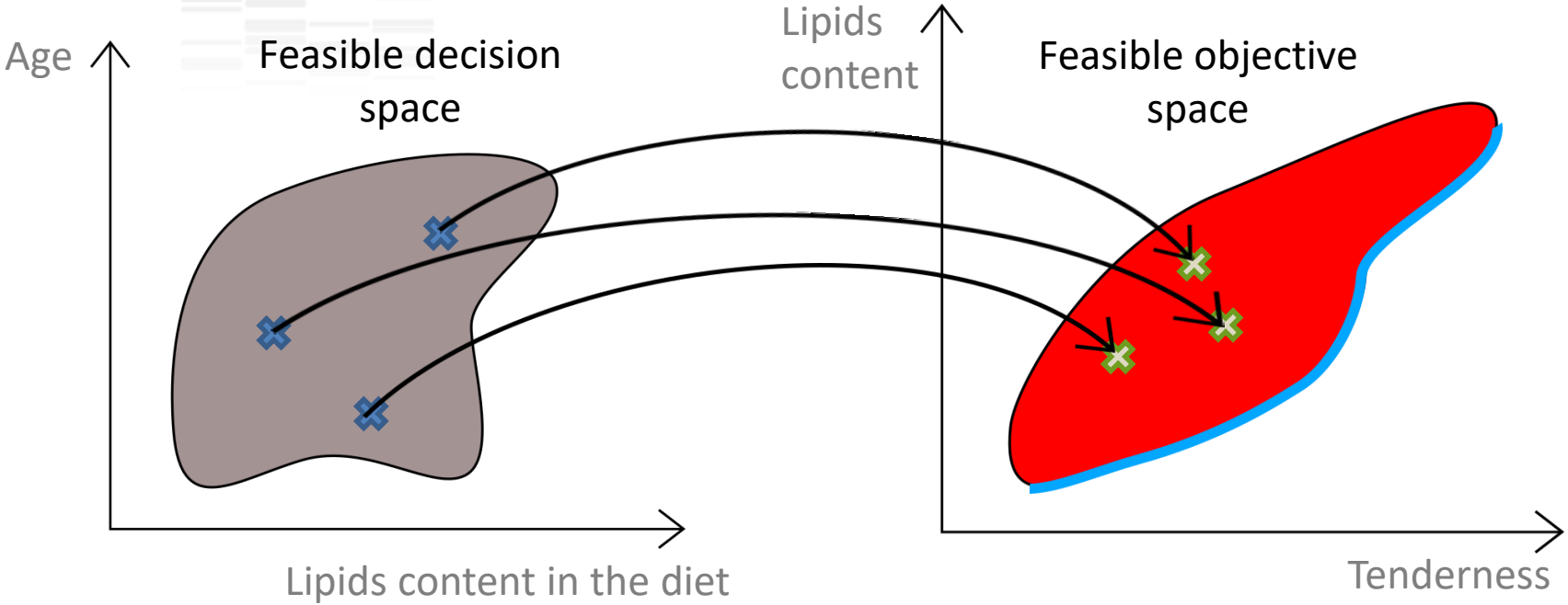

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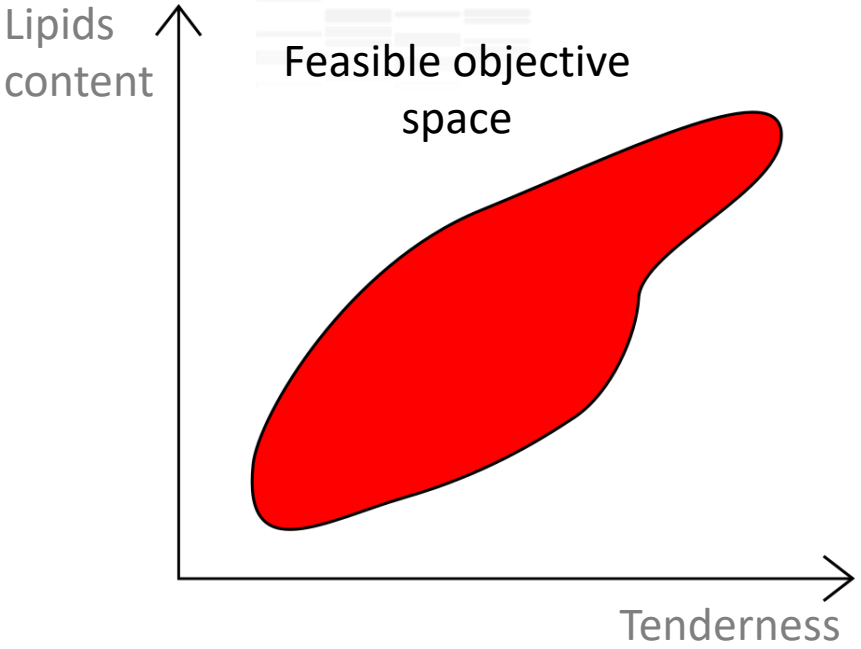
How to predict meat quality ?
Two Multi-Objective Optimization approches

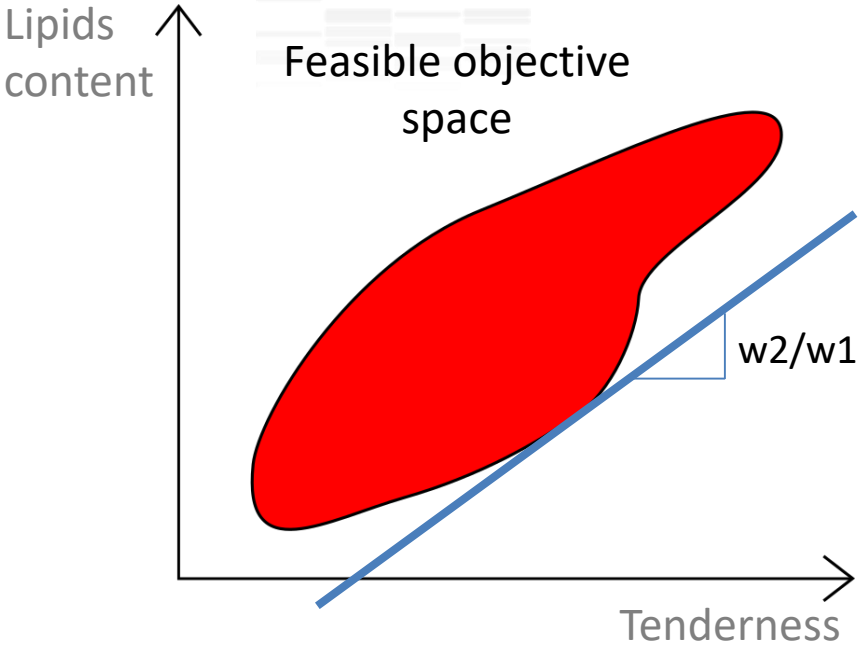


Score = w1*Tenderness + w2* Lipids content

A priori aggregation

Conanec et al. (2019)

How to predict meat quality ?
Two Multi-Objective Optimization approches



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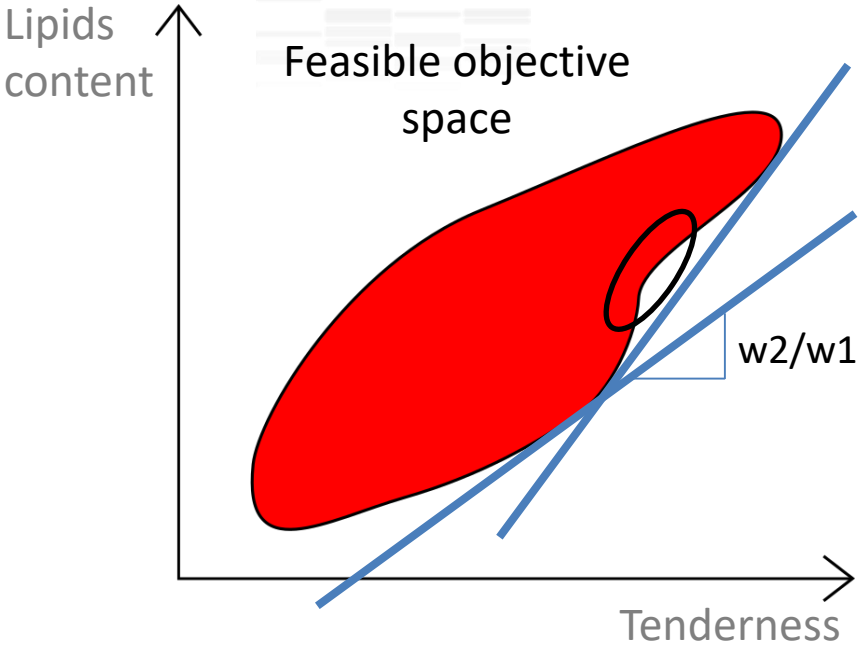

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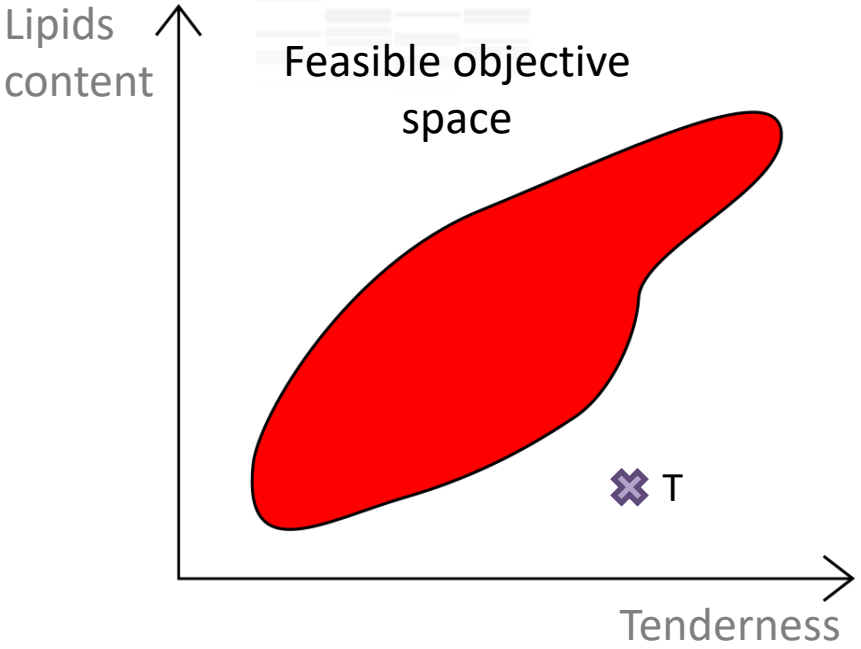

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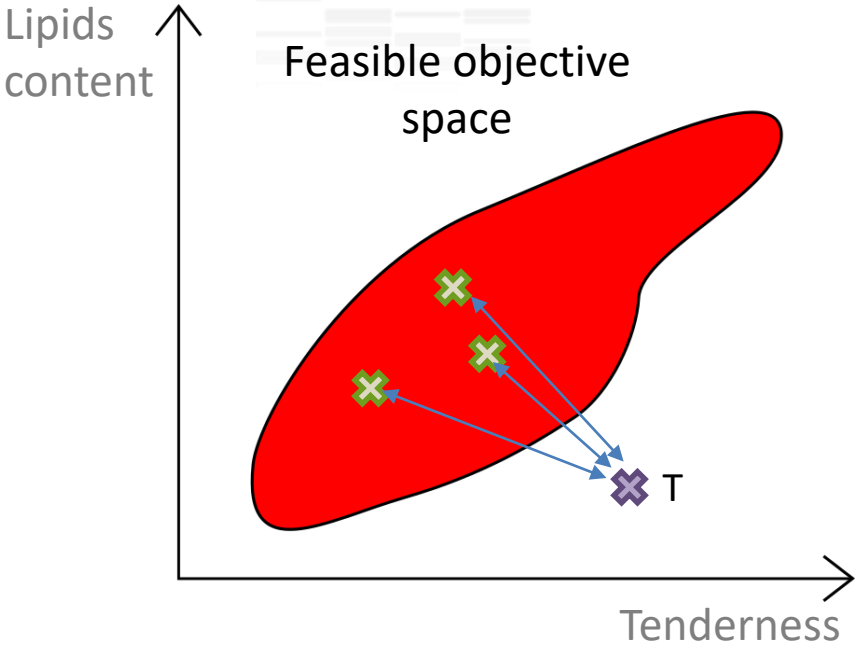

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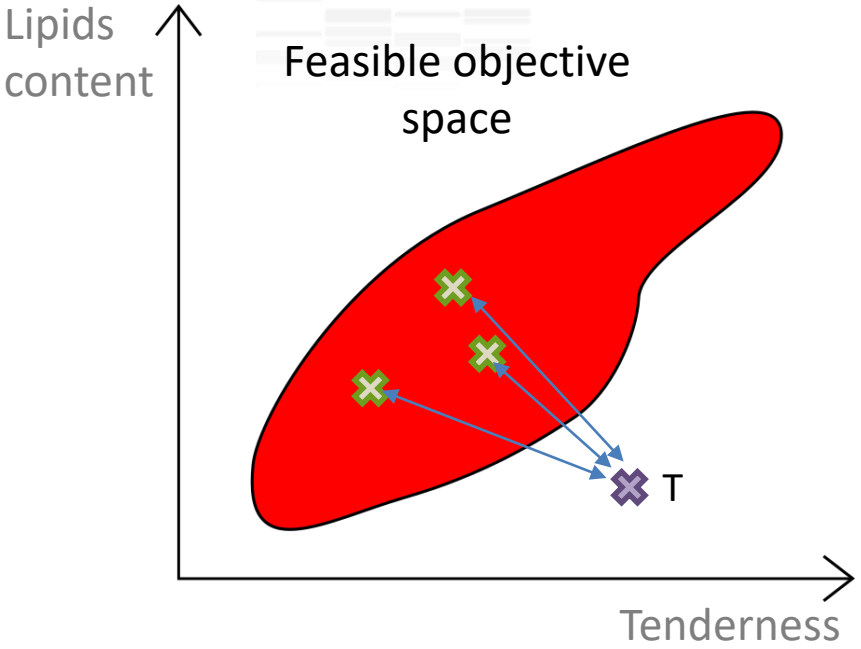

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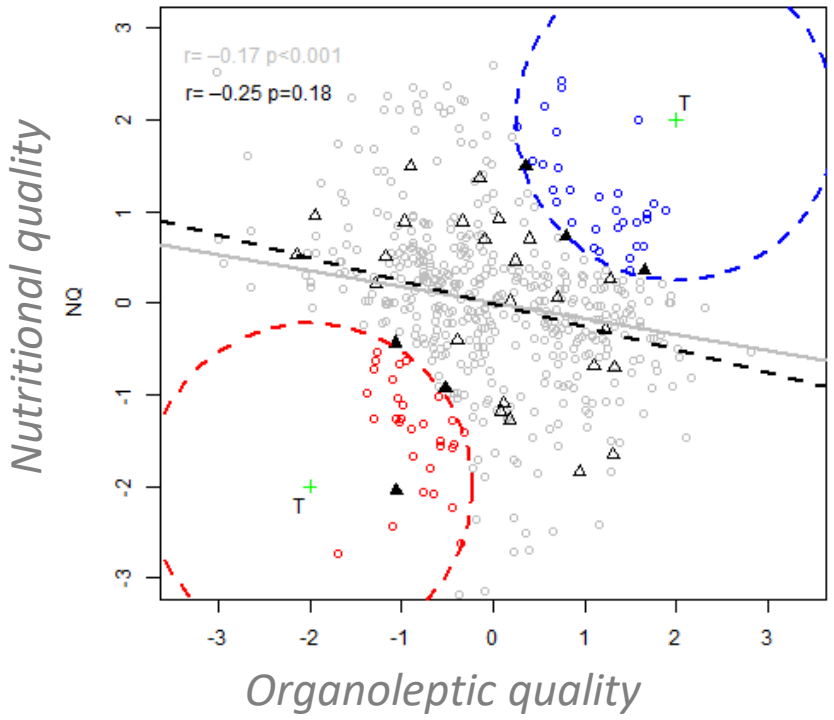

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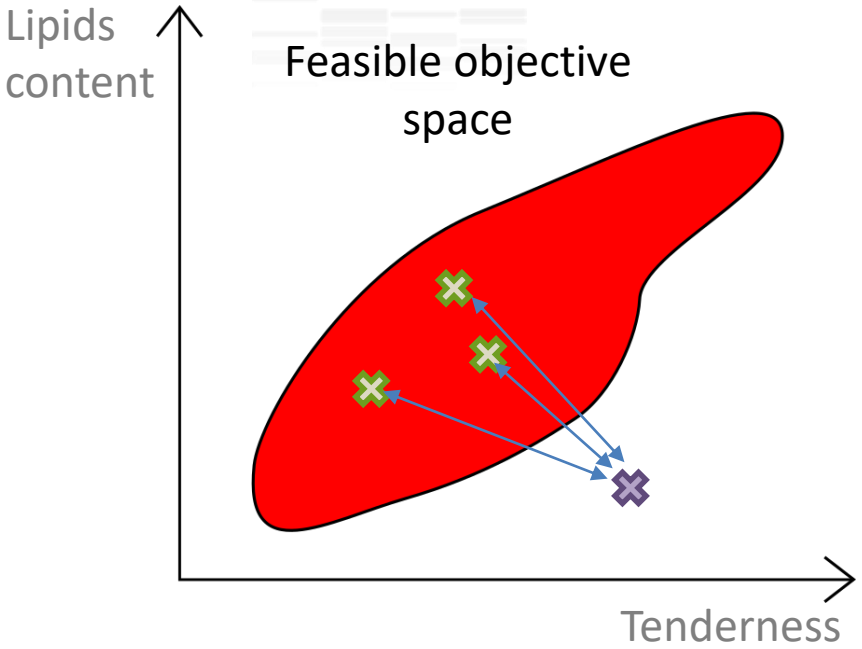

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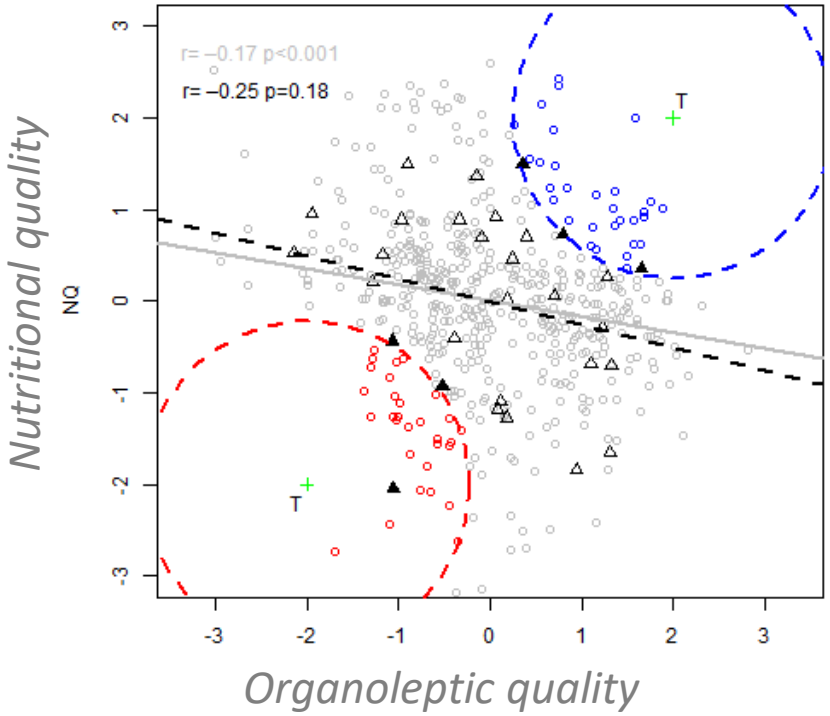

Mardani et al. 2015

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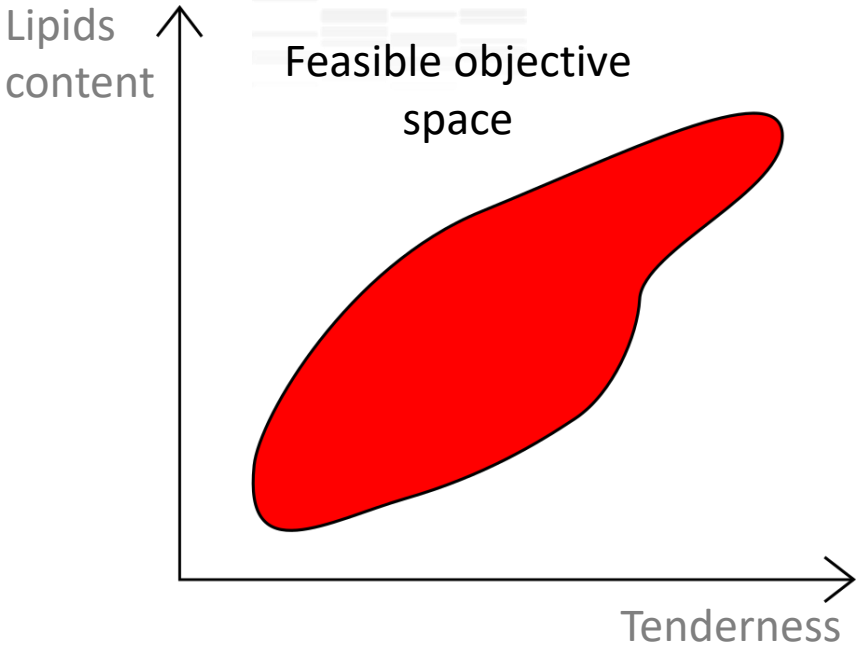
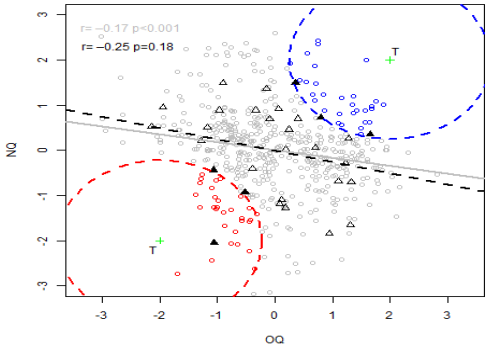


A posteriori aggregation



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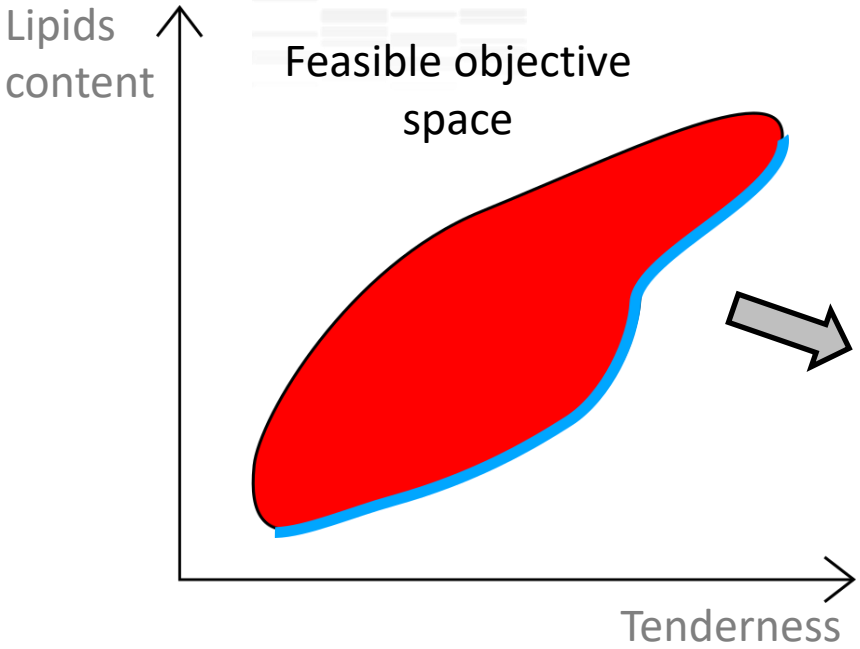
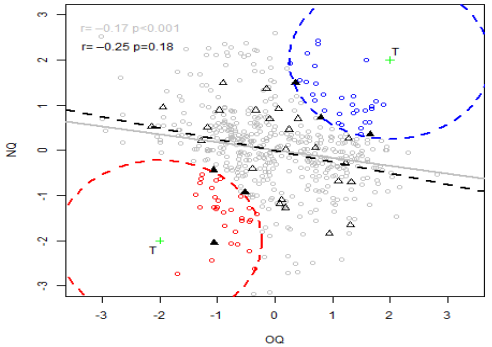


Set of trade-off solutions

A posteriori aggregation



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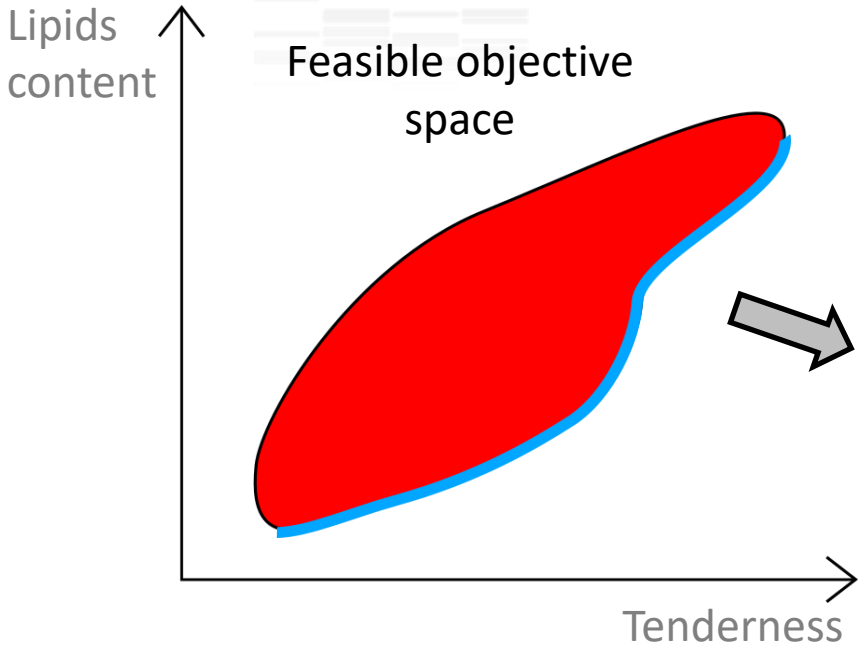
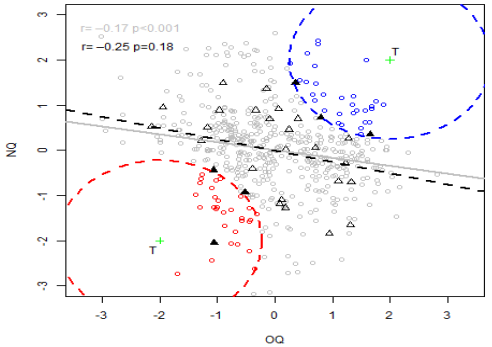


A posteriori aggregation

Set of trade-off solutions



A priori aggregation

Multicriteria decision making (MCDM)

Mardani et al. 2015

Steering meat quality traits
1. Upstream management

From prediction to steering tools

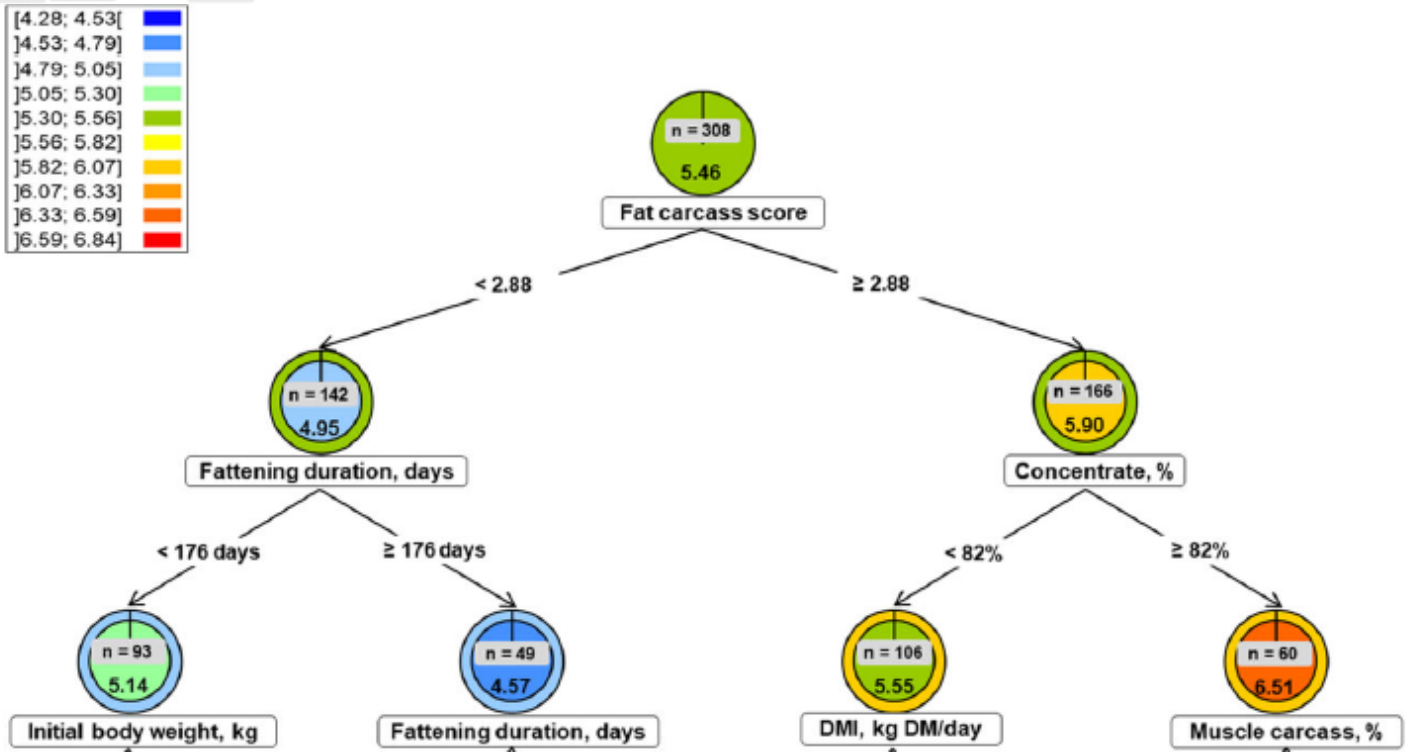
- Aim :

Providing breeders with decision-making keys to adapt farm management in order to optimize carcass and meat quality

- Method :

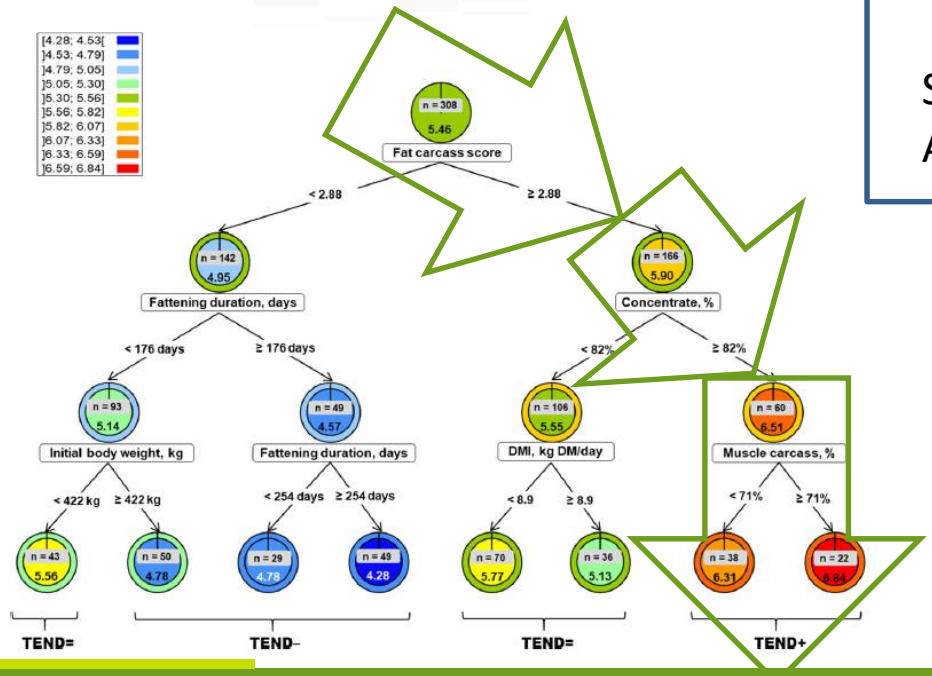
Integrating a large number of data in a statistical model that could predict carcass and meat quality, but also determine farming methods that could allow to reach a given level of quality

Decision tree principles



Decision tree for steering meat tenderness

Improvement of prediction efficiency of tenderness classes by considering simultaneously rearing practices and carcass properties



Rearing practices

Sensitivity: 71,0%

Accuracy: 70,8%

Carcass properties

Sensitivity: 68,1%

Accuracy: 67,2%

Rearing practices + carcass properties

Sensitivity: 83,4%

Accuracy: 84,4%

Identification of rearing managements in **favour** or **defavour** of meat tenderness

(Gagaoua et al., 2019)

Decision tree for steering meat tenderness

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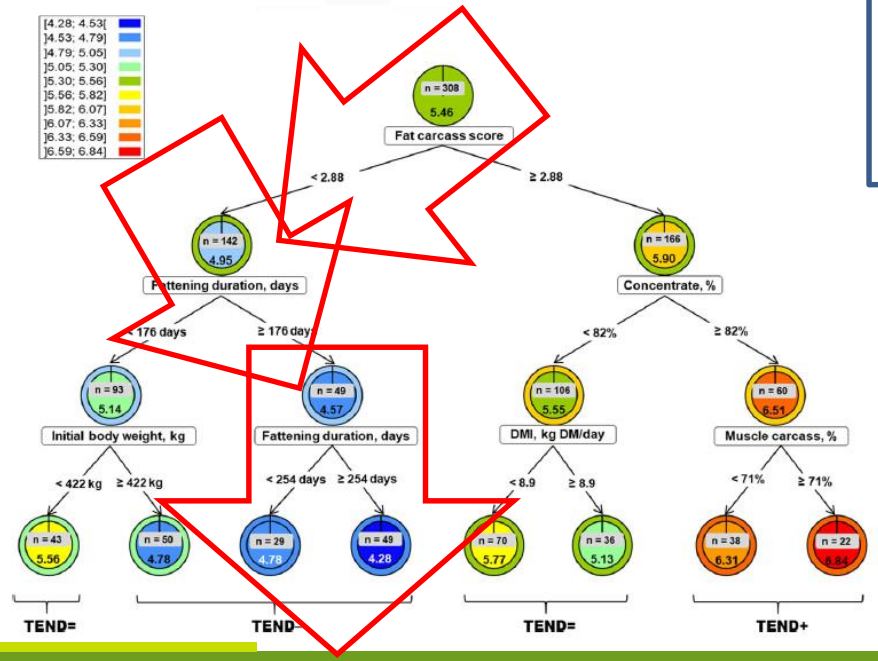

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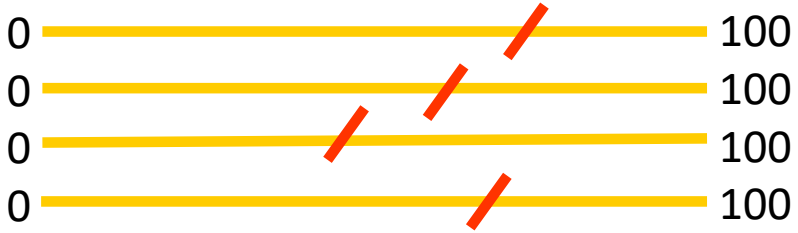
(Gagaoua et al., 2019)

Steering meat quality traits
2. Downstream management

The Meat Standards Australia System

- Scores for
  - Tenderness 0 100
  - Juiciness 0 100
  - Flavour 0 100
  - Overall Liking 0 100



The Meat Standards Australia System

- Scores for
  - Tenderness 0 — 100
  - Juiciness 0 — 100
  - Flavour 0 — 100
  - Overall Liking 0 — 100

- Scores then weighted and combined into a single MQ4 value

Tenderness x 0.3
+
Juiciness x 0.1
+
Flavour x 0.3
+
Overall Liking x 0.3

Global quality score

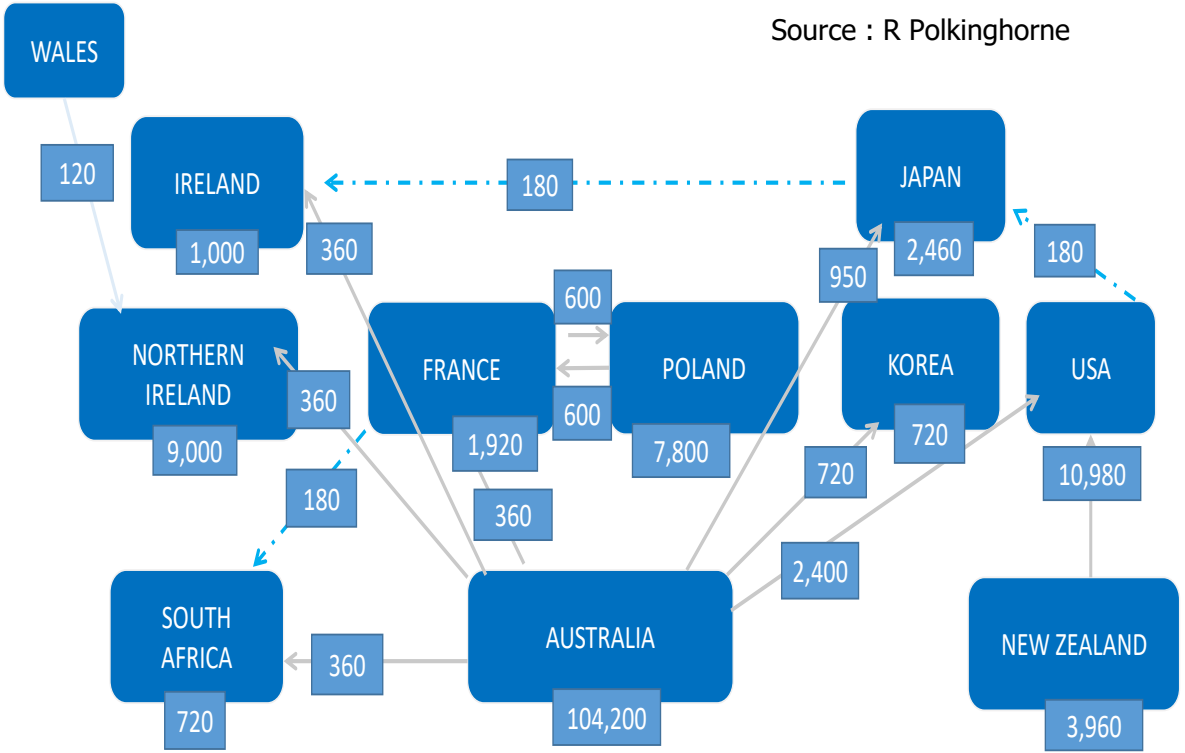
MQ4

The Meat Standards Australia System

Consumers also class meat as:

The Meat Standards Australia System

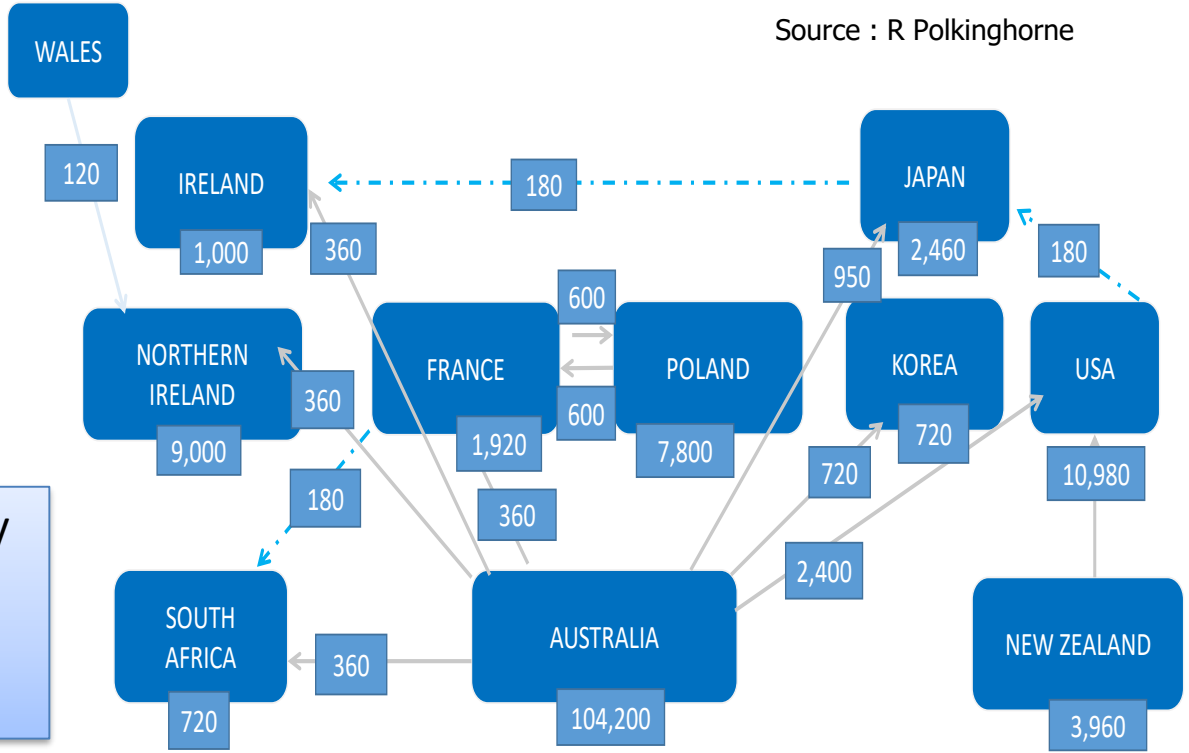
International research on MSA in beef
Tests made in each country



The Meat Standards Australia System

Source : R Polkinghorne

International research on MSA in beef
Tests made in each country



- Relevant methodology
- Various Relative weighting and Optimal limits

The Meat Standards Australia System

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 Col.	2
Saleyard? (Y, N)	n
Wght/App.Maturity	1.32

The Meat Standards Australia System

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Meat Colour

Marbling

Temperature and pH

Ossification

Fat colour

Cut Description	Grilled Steak	Roast Beef	Stir Fry	Thin Slice	Cass-erole	Corned Beef
Tenderloin	5	4	5			
Cube Roll	3	3	3	4		
Striploin	3	3	3	3		
Oyster Blade	4	3	4	4		
Bolar Blade	3	3	3	3	3	
Chuck Tender		3	3	3	3	
Rump	3	3	3	3		
Point End Rump	3	3	3	4		
Knuckle	x	3	3	3	3	
Outside Flat		x	x	3	3	3
Eye Round	x	3	3	3	3	x
Topside	x	3	x	3	3	
Chuck		3	3	3	3	
Thin Flank			3		3	
Rib Blade			3			
Brisket			x	3	3	x
Shin					3	

The Meat Standards Australia System

Quality factors of variation

- Age and sex
- Weight
- Fat thickness
- pH
- **Marbling**
- Hanging method
- Ageing

Prediction

Sensory quality level (3-4-5 stars)

This method makes it possible to pay the actors (including the breeders) according to the predicted sensory quality of the meat

Cut Description	Grilled Steak	Roast Beef	Stir Fry	Thin Slice	Cass-erole	Corned Beef
Tenderloin	5	4	5			
Cube Roll	3	3	3	4		
Striploin	3	3	3	3		

... 40 muscles

INSTITUT DE L'ELEVAGE idele

Most important factors also developed in France

Prediction of the quality of all carcass muscles by the International Meat 3G foundation

INTERNATIONAL MEAT RESEARCH 3G FOUNDATION

OBROUGE VIANDE LIMOUSINE D'EXCEPTION

https://imr3gfoundation.org

The Meat Standards Australia System

- The International Meat Research 3G Foundation on beef eating quality has been established.

International research on beef and lamb eating quality

- The Specialized Section of the United Nations Economic Commission for Europe (UNECE) on Standardization of Meat will support it (2/7/2018).

Conclusion

Take home Messages

- Consumer satisfaction when eating beef is a complex response based on objective and emotional assessments,
- Safety and healthiness are very important in addition to taste and convenience,
- But some other parameters are really important for breeders
- Many models were recently developed in order to predict each quality trait
- Now, the next step will be to develop methodological approach to predict different traits simultaneously or in combination

to be continued ...

WORLD ASSOCIATION for ANIMAL PRODUCTION

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LYON

27-31 August 2023

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