Control of the nutritional quality of the bovine meat

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Research Centre of Clermont-Ferrand /Theix

France

General portrait of INRA

The National Institute for Agronomic Research

- Set up in 1946
- A public, scientific and technological establishment
- Under the joint authority of the Ministries of Agriculture and Research
- Second largest French public research organisation
  with a staff of nearly 9000 and a budget of 680 millions euros
- Largest European organisation for agricultural research

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Key stages

- **1946/1960** INRA was one of the principal actors in the modernisation of farming.
- **1960/1980** Through its research and innovation, INRA contributed to development of the French agrifood sector.
- **1980/2000** The Institute integrated new and fundamental technologies in the life sciences (biotechnologies, molecular biology, genetic engineering,etc.) in response to changing environmental and consumer demands).

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Resources and organisation

- A President and board of Directors
- 21 regional research centres
- 14 scientific research departments
- 8868 permanents composed of 1842 scientists, 2263 research assistants and 4643 technicians and administrative staff
- 468 units
  - > 257 research units (140 associated with other organisations)
  - > 80 experimental units
  - > 131 support units

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Partnership

- Contribution to **higher education**

  > **More than 1150 staff members provided more than 15,000 hours of lectures, 8000 hours of seminar work and 2400 hours of continuing training**

  > **1600 doctoral students being trained every year, and some 250 doctoral theses presented**

  > **Considerable efforts made to welcome post-doctorate researchers**

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Partnership

> Construction of the European Research Area

- **European PRTD** (Programme for Research and Technological Development): 60% of INRA projects concern food quality and safety. Coordination of three major programmes: Eadgene (animal health), Co-extra (coexistence of GMO/non-GMO industries), Evoltree (forest genetics).
- **Bilateral agreements** with European Union partners (Netherlands, United Kingdom, Sweden, Greece, Portugal, Spain, etc.).
- **Scientific cooperation**
  - **> with Central and Eastern European countries** (some 60 projects)
  - **> with Mediterranean countries,** in collaboration with the CIHEAM (International Centre for Advanced Mediterranean Agronomic Studies)
- Member of **Euragri** and of the **European Science Foundation**

The major research fields of INRA

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- INRA is strengthening its resources in **three major fields** :
  1. *The development of sustainable agriculture*
  2. *Nutrition and its effects on human health*
  3. *The environment and regional development*
- integrating them in the construction of the European Research Area
- actively participating in the internationalisation of science
- responding to new demands from society (food safety and quality, ethics, science-society debate, etc.)

Portrait

Three major fields

Diet Agriculture Environment

... in **six research areas**:

> Environment and rural areas

> Human nutrition and food safety

> Quality of agricultural products

> Knowledge of the living world

> Agricultural practices and systems

> Social sciences

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Quality of agricultural products

> The focus of INRA skills, diversifying products and their uses in response to expectations

> Qualification and segmentation of **food or non-food product sectors**

> **Interdisciplinarity**

> Joint Technology Units, technology platforms

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The INRA Research Centre of Clermont-Ferrand/Theix

- **3 main sites**
- **770 persons** composed of 320 scientists, 450 technicians and administrative staff
- **300 students/year and 60 PhD**

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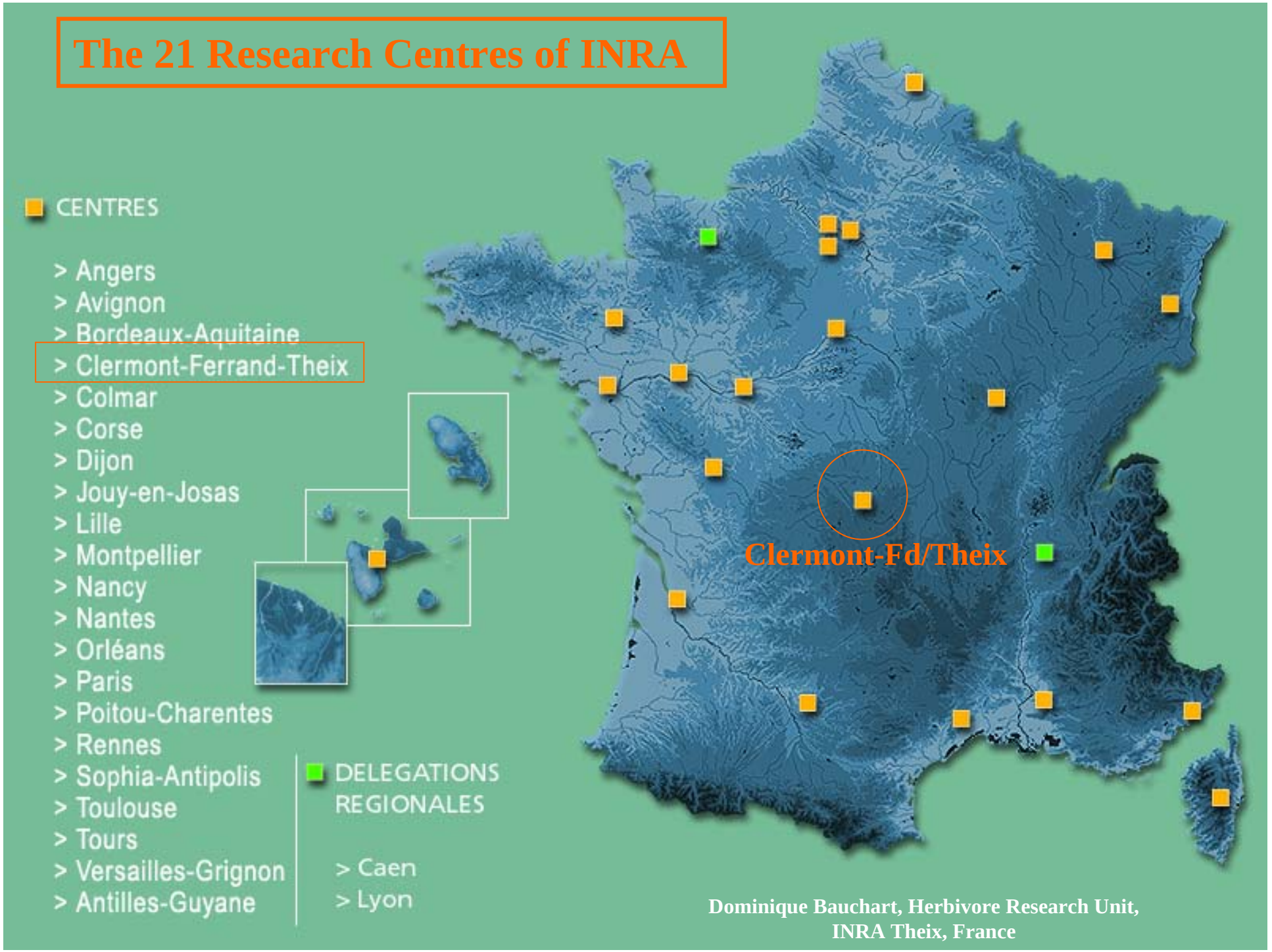
The 21 Research Centres of INRA



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The main research topics of the INRA Research Centre of Clermont-Ferrand/Theix

- **Sustainable breeding and environment in mountain grasslands**

- **Quality elaboration of animal products : from grass to meat and cheese**

- **Preventive human nutrition and ageing**

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The Herbivore Research Unit

(Director: Jean-François Hocquette)

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The Structure of the Herbivore Research Unit

172 permanents, 7 Research Teams

« Production Systems » Team (n=9)

« Relationships Animal-Plants and Animal Feed » Team (n=20)

« Adaptation and Social Behaviors » Team (n=10)

« Microbial Digestion and Absorption » Team (n=25)

« Nutrients and Metabolisms » Team (n=14)

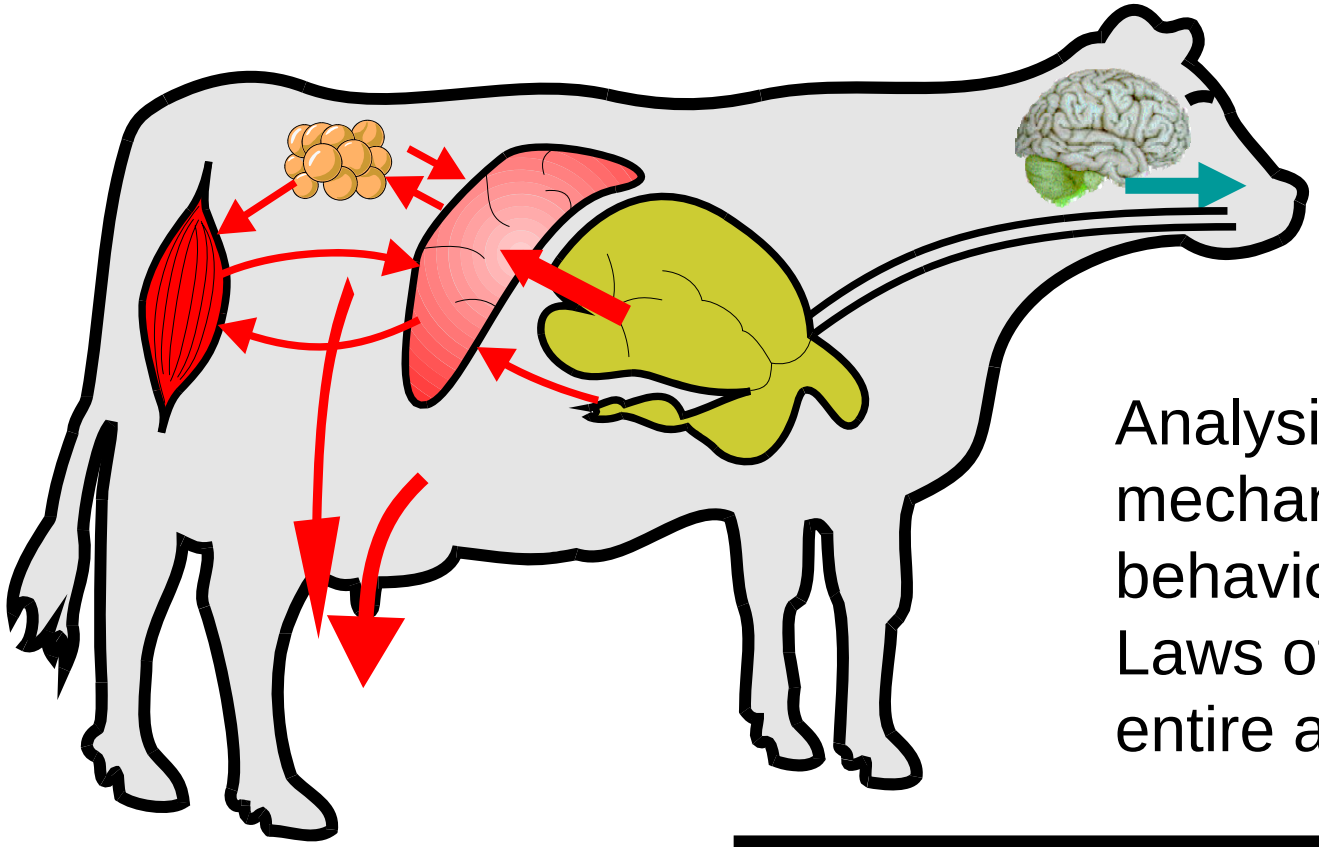
« Muscle Growth and Metabolism » Team (n=13)

« Adipose Tissues and Milk Lipids » Team (n=14)

associated to technical (animal experiments and slaughter) and administrative resources (n= 63)

The Mission of HRU

Evaluation of production systems, innovating breeding systems



Analysis of biological mechanisms and behaviors.
Laws of response of the entire animal

Experiment

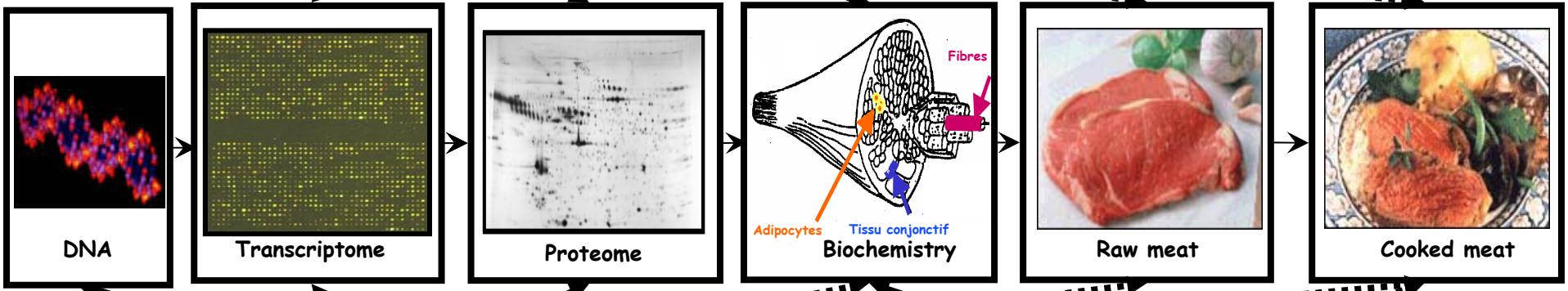
⬅➡

Modelisation

Welfare	Environment	**Quality**
Efficiency of production systems Durability of breeding systems		

Nutritional and sensorial meat qualities

Breeding and feeding systems



Genetic and physiological factors : allelic variations, age, sex, animal stress

Slaughtering conditions; ageing, packaging and long-term storage conditions of meats

Impacts on the health and nutritionnal values (composition of lipids and fatty acids, lipolysis and lipoperoxydation) and on tenderness/colour of ruminant meats and meat products

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The « Nutrients and Metabolisms » Team

(Coordinators : Drs Isabelle Ortigues–Marty and Dominique Bauchart)

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The « Nutrients and Metabolisms » Team

General topic of research:

To develop mechanistic studies on in vivo **regulation of nutrient** (fatty acids, amino acids, energy compounds) **metabolism** and **prevision of nutrient fluxes** by modelisation in ruminants; consequences on the **nutritional and health value of raw meat** and variations of these characteristics with meat **technological** and **cooking treaments.**

Main deliverables:

- Effects of variations of liver energy and amino acid metabolism with feeding conditions on **nitrogen excretion** in the high producing dairy cow in relationship with environment protection (« Rednex » Program, 7th PCRD, 2008-2012),
- Effects of factors linked to animals (genotype, age, emotional stress) and their feeding conditions (plant lipid and antioxidant supplements) on **fatty acids** and **lipoperoxidation** in finishing cow beef submitted to **technological** (ageing/packaging) treatments (« Lipivimus » Program, French National Agency for Research, 2007-2009) .
- Effects of dietary unsaturated fatty acids and antioxidants on the **nutritional** and **health value** of **beef fatty acids** and **lipoperoxidation** in young **bulls (**varying with fat or lean genotypes) at slaughter or after cooking (« ProsafeBeef » Program, 7th PCRD, 2007-2011).

Experimental models for nutrient metabolism

(The « Nutrients and Metabolisms » Team)

➢ In vivo models

- **on muticatheterized animals** (portal vein, hepatic vein and artery,..) equiped with ultrasonic blood flow probes for determination of balance of nutrient fluxes (amino acids, lipids, lipoproteins), throughout organs (liver, splanchnic tissues) **on intact animals** given nutrient tracers containing stable isotopes

➢ Ex vivo model

on **incubated tissue slices** maintained fonctionnel in a medium containing **radiolabeled nutrients** to determine the intensity of the different nutrient pathways (ex: β oxidation, bioconversion, esterification and secretion of fatty acids)

➢In vitro model

on **cell extracts** for determinations of **gene expression** and **biological activity** of proteins involved in the regulation of nutrients in tissues and organs

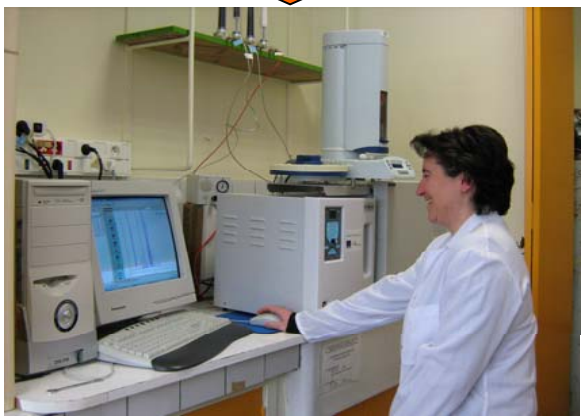
Analytical equipments

Double–beam spectrophotometer UV/visible (DBS)

Gas-liquid chromatograph coupled with a mass spectrometer (GLC-MS)

High-Performance Liquid Chromatograph coupled with a fluorimeter (HPLC-Fluo)

Gas-liquid chromatograph-FID coupled with a radioactivity counter (GC–RAM)



Gas-liquid chromatograph-FID equiped with a H_2 generator (GC-FID)

Ultracentrifuges equipped with swinging-bucket and fixed angle rotors

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Characterization of the nutritional value of meat

❑ Lipids and fatty acids

- Isolation/quantification of **total lipids** by homogeneization of meat powder (prepared by mixing in N_2 liquid) **with organic solvants** and **gravimetry**. Preparation of fatty acids (FA) as methyl esters by trans-esterification for GC analysis and as FA dimethyl-silyl derivates for their structural analysis by GC-MS.
- Quantitative determination of the **lipid profile** **by HPLC-light scattering detection.**
- Qualitative and quantitative **determination of FA profile** by **high resolutive CPG-FID** on high-polar capillary column; analysis of **cis and trans isomers of 18:1** by **preparative HPLC** and **GC-MS.**
- Separation annd quantification of **radiolabeled fatty acids** by **GLC-RAM**
- Preparation of **neutral and polar lipids** by **low pressure liquid chromatography** on silicic cartridges
- Quantification of **triglycerides, free/esterified cholesterol** and **phospholipids** **by enzymatic methods.**

❑ Proteins and amino acids

- Determination of **total proteins** by the methods of **Kjeldhal** and/or **Dumas** or **by liquid chromatography**
- Separation and quantification of **amino acids (AA)** of meat proteins **by GLC-FID** ; quantification of the ratio C12/C13 of total AA with an AA marked with a stable isotope (C13 Val) by **GC-MS**.

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Characterization of the nutritional value of meat

❑ Vitamins E and B12

- Isolation/quantification of **vit E** from total lipids by **HPLC fluorimetry**
- Separation and quantification of **vitamin B12** **by radioimmunoassay**

❑ Lipid and protein peroxidations

- Lipoperoxidation status by determination of **malonedialdehyde** (MDA) by **HPLC fluorimetry** and of specific **markers of peroxidation** of polyunsaturated FA of the n-3 (**hydroxyhexenal, HHE**) and n-6 (**hydroxynonenal, HNE**) families by **GC-mass spectrometry**.
- Protein peroxidation status by determination of **carbonyls** **with an enzymatic method**

❑ Antioxidant status

- Determination of the **total antioxydant status** (SAO) by **the randox method** adapted for beef
- Determination of **vitamins E** and **A** by **HPLC-fluorimetry**
- Determination of the **activity of hydrosoluble** (ACW) **and liposoluble** (ACL) **antioxidant compounds** by **photochemiluminescence (PCL)**

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