FOOD SCIENCES AND NUTRITION AT UCL

2009

The Research Administration of the *Université catholique de Louvain* (UCL) has collected the information gathered here, with the precious help of a reading committee composed of the Professors **Yvan Larondelle** (Chairman), Unité de Biochimie de la Nutrition, **Nathalie Delzenne**, Unité de pharmacocinétique, métabolisme, nutrition et toxicologie, and **Jacques Mahillon**, Unité de Microbiologie.

Edited by Anne BOVY (UCL ADRE) – September 2008
With the contribution of Jean COLIN, Olivier TIRIONS, Martine PLEVOETS and Fanny KLEIN.

Foreword

Food supply is indispensable for the development of human societies. Both food quantities and food quality are needed to fulfill man's requirements.

Food quality comprises a whole set of branches including microbial and chemical safety, organoleptic characteristics, technological behaviour, nutritional composition and health-promoting properties. All these different but complementary aspects are part of a multidisciplinary scientific discipline named "food science and nutrition".

The major objective of this brochure is to present the scientific skills and the research potential of UCL members in the field of food science and nutrition. Research groups from three different faculties of UCL have contributed to this booklet: the Faculty of Bioengineering, Agronomy and Environment, the Faculty of Sciences and the Faculty of Medicine.

The contributions cover two major areas:
- Nutrients and other components
- Biological targeting

The research teams acting in the first area deal with organic chemistry, microbiology, food technology and biotechnological processes. In the second area, the impact of nutrients, bioactive compounds and food contaminants on human health is studied following different approaches using cells in culture, animal models and human trials, as well as combining the expertise of geneticists, biochemists, immunologists and physicians.

All the research groups mentioned in the present booklet have close links with each other through research projects, shared equipments and/or training activities. Most of them also participate in European and international networks, covering thus all the aspects of food and nutrition sciences. Do not hesitate to contact them for more information and if you are interested in future collaborative projects.

Content

Yeasts of agro-industrial and environmental interest

SENIOR SCIENTIST :

- Heide-Marie DANIEL

Research Field and Subjects

Yeasts have been traditionally in the focus of food microbiology. Increasing interest for unicellular eukaryotes with properties relevant to industrial applications calls for the enrichment of strain and data depositories with new material.

The Mycothèque of the Université catholique de Louvain, working within the network of the Belgian Coordinated Collections of Microorganisms (BCCM/MUCL) and hosted by the Unit of Microbiology of the UCL harbours, apart from even larger numbers of filamentous fungi, about 3000 yeast strains representing more than 400 species. This collection is continuously enlarged by new isolates from environmental and industrial sources as well as by type strains of new species.

Specific activities include:
- Diversity assessments of natural and man-made environments
- Biogeographic and ecological studies
- Improvement of yeast classification based on phylogenetic analyses

Products and Services

- Identification and characterisation of yeasts (classical and molecular)
- Education in isolation, culture and preservation methods, identification and taxonomy

Main Equipment

- A comprehensive database of yeast fermentation and assimilation profiles generated by microplate absorbance readers

Representative References

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Partnership

- Member of BCCM (Belgian Coordinated Collection of Microorganisms)

KEY WORDS FOR R & D

Yeast
Brewery
Bakery
Biofuel
Biocontrol
Physiology
Diversity
Culture collection
Patent deposit
Identification
Classification
Molecular systematic

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Bioengineering of lactic acid bacteria

SENIOR SCIENTIST :

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Research Field and Subjects

Research activities are focused on a specific group of Gram-positive bacteria, generically referred to as "lactic acid bacteria" (LAB), which are of major industrial importance in food fermentation. Moreover, some LAB species are natural members of the intestinal microflora of mammals where they play a beneficial health role.

A multidisciplinary range of genomics/post-genomics, biochemical, and biophysical approaches are used to study the function of genes that are involved in **carbon metabolism, cell-wall biosynthesis, and metabolic adaptation to environmental parameters** of different LAB species (*Lactobacillus plantarum, Lactococcus lactis, Streptococcus thermophilus, and Bacillus coagulans*).

In order to improve our knowledge of LAB metabolism, we established the complete **genome sequence of *Streptococcus thermophilus***, a major dairy starter. DNA microarrays are currently exploited for **transcriptomic analyses** in order to study regulatory networks controlling bacteriocin production and natural DNA transformation.

Metabolic engineering and **heterologous gene expression** technologies are used to engineer LAB strains (GMO and non-GMO) to serve as starters in dairy fermentation, as cell factory for the production of lactate isomers, aromas, low calorie sugars, or as host systems for the production and the delivery of specific compounds of food and pharmaceutical interest. This includes the development of *L. plantarum* strains as live vaccine vectors for mucosal immunisation and as second generation probiotics (e.g. immunomodulation, ammonia removal).

Products and Services

- Heterologous gene expression in LAB
- Gene knockout in LAB
- Transcriptomic analyses using DNA microarrays (Agilent platform)
- Small-scale fermentation facilities
- Analysis of fermentation products (sugars, organic acids, lactate isomers, aa.).

Main Equipment

- DNA microarray scanner and bioinformatics servers
- Nanodrop spectrophotometer
- Capillary electrophoresis system (Bionalyser)
- Small scale fermentors (2 L and 10 L)
- High performance liquid chromatography machines (2) with UV, IR, ELSD detectors

Representative References

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Award

▸ Food Ingredients Research Award (Paris, 1999, UCL/NIZO food research) on « Efficient '*in-situ*' production of L-Alanine sweetener in dairy food products »

Partnership

▸ Contractual research with Belgian and European private companies

▸ Participant in national Biotech projects supported by the Walloon Region and private companies

▸ Life Sciences Institute (UCL/ISV) research group

▸ European collaborations with:
- NIZO Food Research, Ede, The Netherlands
- Wageningen centre for Food Sciences, WCFS, Wageningen, The Netherlands
- INRA, Jouy en Josas, France
- Institut Pasteur de Lille, IPL, Lille, France

KEY WORDS FOR R&D

Bacterial genetics
Lactic acid bacteria
Dairy products
Yoghurt
Cheese
Probiotics
Mucosal vaccines
Metabolic engineering
Genomics
Microarrays
Lactobacillus
Streptococcus

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http://www.biol.ucl.ac.be/gene/genome/index.html

Isolation, identification and quantification of biologically active molecules from crude extracts

SENIOR SCIENTISTS :

- Joëlle QUETIN-LECLERCQ
- Jean-Louis HABIB JIWAN
- Marie-France HERENT
- Céline RIVIERE

Research Field and Subjects

The Unit of Chemical and Physico-Chemical Analysis of Pharmaceutical and Pharmacology (CHAM unit) has an expertise in isolation, identification and quantification of biologically active molecules from plant material: preparation of crude extracts, fractionation and purification by different preparative methods (bio-guided or not), chemical identification of isolated compounds or known compounds in mixtures (including essential oils) and quantification. Our expertise allows us to validate some activities of plants, extracts or compounds and to identify active molecules from plants used in traditional medicine or having interesting health or nutritional values. We also develop methods for quality control and quantification of these molecules in plants or extracts. The laboratory is a agreed laboratory of the Belgian Federal Agency for Medicines and Health Products for analysis of natural and synthetic compounds.
The mass spectrometry laboratory of UCL has a strong collaboration with the CHAM unit for the structural and quantitative analysis of natural products by chromatography coupled to mass spectrometry.

Products and Services

- Isolation of bioactive molecules from plants or crude extracts – evaluation of their biological activities
- Molecule structure identification
- Quantification of natural compounds in plants or crude extracts
- Analysis according to European Pharmacopea
- Quality control
- Qualitative and quantitative analysis by mass spectrometry coupled to chromatography

Main Equipment

- Preparative and analytical chromatographies :
  - OPLC (over pressure laminar chromatography)
  - CPC (centrifugal partition chromatography
  - Column chromatography
  - HPLC-DAD, HPLC-MS
  - GC-FID, GC-MS
  - HPTLC-densitometry
- Lyophilisator
- Triple quad and ion trap mass spectrometer with GC and LC coupling

Representative References

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Partnership

▸ Institut malgache des Recherches Appliquées (IMRA), Madagascar
▸ University of Abomey-Calavi (UAC), Bénin
▸ University of Mauritius, Mauritius
▸ University of Fes, Marocco
▸ Université Paul Sabatier- Toulouse, France

KEY WORDS FOR R&D

Active natural products
Plants
Quantitative analysis
Flavonoids
Terpenes
Sterols
Essential oils
Alkaloids

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Genomic and proteomic studies on polymer producing plants

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- Pierre MORSOMME
- Bénédicte PURNELLE
- Hervé DEGAND

Research Field and Subjects

Biotechnologies provide many opportunities for food industry to improve the production and the quality of food or the development of new processes. In this respect, the genomic and proteomic technologies open a new area of research in food industry, providing a large amount of information that will be useful for new developments.

Our research group is involved in the systematic analysis of genomes and genome expression in several organisms. Deciphering whole genomes gives access to genes, functions and hence applications not reached by other approaches. We have developed facilities for DNA sequencing, protein analysis by 1D or 2D gel electrophoresis, HPLC and mass spectrometry.

Our current projects aim at identifying genes and proteins that are differentially expressed according to the cell type and the environmental factors. For instance, we have analyzed the proteome changes induced by cold stress on chicory roots. This plant is an important agronomic plant from which inulin, a plant polymer used in food industry, is produced.

Products and Services

- DNA sequencing
- Protein analysis by 1D and 2D gel electrophoresis
- Protein identification by mass spectrometry

Main Equipment

- DNA sequencer ABI 3100
- 2D-LC-MALDI-MS/MS Mass spectrometer: MALDI/TOF/TOF ABI4800 + 2D-nano and capillary LC (Ultimate3000, Dionex) + Microfraction collector and MALDI spotting system (Probot, Dionex)
- 2D-gel electrophoresis: IPGPhor + Ettan Dalt 6 (Amersham), Image scanner Labscan + Image Master 2D Platinum
- Basic equipment for molecular biology, biochemistry and cell biology

Representative References

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Patents

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- M. Boutry, Y. Stukkens, S. Grec, M. Jasinski (2003) Use of NpABC1 transporter and promoter thereof. PCT/EP03/08137

Award

- M. Boutry, member of the Belgian Academy of Sciences

Partnership

- This group belongs to the *Institut des Sciences de la Vie*, Louvain-la-Neuve, Belgium

KEY WORDS FOR R&D

Genome
Proteome
Plant
Yeast
Protein analysis
Sequencing
Mass spectrometry

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Brewing sciences, flavour stability and polyphenol chemistry

SENIOR SCIENTISTS :

- Sonia COLLIN
- Sabine BAILLY
- Marc MAUDOUX
- Laurent MELOTTE

Research Field and Subjects

The team is mainly active in the improvement of flavour stability through ageing (impact of raw materials, manufacturing, processes, …). This objective requires the knowledge of all chemical and biochemical pathways leading to food flavours (beer, wine, honey, chocolate,…). A large part of the activity is focused on the structures and properties (in vitro activity, health-potential, ...) of new antioxidants, mainly polyphenols (flavanoïds and resveratrol analogues) and melanoidins. With the aim of having efficient methods for extracting or analyzing aroma, part of our job is also devoted to the mechanisms responsible for aroma retention in food. In the brewing area, other research topics are also investigated: mycotoxins, yeast activity, or hop chemistry.

Products and Services

- Malt and beer analysis, consulting, new product design (« Centre de référence pour la qualité des malts et de la bière »)
- Extraction, identification and quanti- fication of food flavours and food packaging volatiles
- Polyphenol analysis

Main Equipment

- Several GC's including on column and split/splitless, SPME, static and dynamic headspace injectors; FID, NPD, ECD, SCD, PFPD detectors
- GC-MS
- GC-olfactometry
- Several HPLC's including UV, fluorescence, refractometry and electrochemical detection
- semi-preparative HPLC
- HPLC/diode array/MS-MS (ESI and APCI)
- Micro-brewery
- Fermentation material (including 30 L and 300 L fermentation vessels)
- Usual material for malt and beer analyses
- Various volatile extraction systems
- Sensory analysis

Representative References

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Awards

- Rutter C., Maes award, 1997
- Lermusieau G., Interbrew Baillet Latour award, 1998
- Counet C.,VABA award 2002
- Callemien D., VABA award 2002
- Callemien D., Interbrew Baillet Latour award, 2002
- Jerkovic V., Interbrew Baillet Latour award, 2003
- Gros J., Inbev Baillet Latour award, 2007

Partnership

Industrial partners: breweries, agro-food, industry, plastic producers

Academic partners :

- Laboratoire de physiologie cellulaire (Prof. B. André, IBMM), Belgium
- INAPG (Prof. E. Spinnler, Paris Grignon), France
- INRA (Dijon, Nantes, Rennes), France
- Faculté d'oenologie de Bordeaux (Prof. G. de Revel, Bordeaux 2), France

KEY WORDS FOR R&D

Aroma
Beer
Cocoa
Fermentation
Flavour stability
Hop
Mycotoxins
Polyphenols
Resveratrol
Saccharomyces cerevisiae
Sulphur flavours
Wine

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Food microbiology

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- François VAN HOVE
- Heide-Marie DANIEL

Research Field and Subjects

The major issues facing food microbiology can be summarized as follows. On one hand, we search on how to reduce or prevent microbial infections, how to quickly and accurately recognize potential contamination and what strategies to use to avoid microbial outbreaks. On the other hand, we work on how to improve the use of microorganisms in food production processes.
In order to efficiently face these issues, the laboratories of Mycology and of Food and Environmental Microbiology, have developed complementary expertises in the fields of traceability, food quality and biosafety, to match industrial quality requirements. Parts of the laboratory activities are certified ISO 9001:2000. Their activities include:

- Detection and characterization of pathogenic or industrial bacteria to assess their presence and fate throughout the production, processing and distribution steps of food products
- Genetic and genomic characterization of virulence factors from the *Bacillus cereus* group
- Molecular typing of food pathogens, with particular emphasis on *Bacillus cereus, Campylobacter* spp., *Escherichia coli* O157:H7 and *Listeria monocytogenes*
- Identification of mycotoxin-producing fungi in food matrices and study of biosynthesis pathways (e.g. fumonisin or patulin)
- Strain screening for the production of high added value compounds (e.g. enzymes)
- Physiological and molecular characterization of yeasts and analysis of metabolites (yeast fermentation and assimilation profiles)
- Preservation of filamentous fungi and yeasts of industrial interest (beer, wine or cheese production)
- Monitoring of production chains for contaminating fungi and yeasts, including their enumeration and isolation
- Preservation of valuable fungal and yeast strains (public, safe and patent deposits)
- Distribution of fungi and yeast strains (food production or the production of specific metabolites, enzymes)
- Practical courses in isolation, culture and preservation methods, identification and taxonomy
- Sampling of surfaces and air
- Identification of bacterial food contaminants and pathogens using advanced biochemical and molecular methods

Food Microbiology reference laboratory in Requasud, a network providing advises and technical support to SME industries in the Walloon Region.

Products and Services

- Detection, isolation, enumeration and screening of microorganisms in food and environmental matrices and production lines
- Targeted screening of bacterial and fungal strains
- Mycotoxin detection in food matrices
- Food quality consulting for SME: decontamination techniques, hygiene and authorized disinfectants
- Advices on legal issues: criteria, norms, regulation and HACCP

Main Equipment

- Capillary Electrophoresis (CE)
- Gas Chromatography (GC)
- HPLC apparatus with DAD and fluorescence detectors (Thermo Electron)
- Pulse-Field Gel Electrophoresis (PFGE)
- Scanning Electron Microscope (SEM)
- DNA Sequencer and (Real time) PCR machines
- Denaturing Gradient Gel Electrophoresis (DGGE)
- Air and surface samplers
- Microplate absorbance reader for yeast identification
- L2 and L2+ biosecurity laboratories

Representative References

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▸ Van Der Auwera, G., Timmery, S., Hoton, F., Mahillon, J., « Plasmid exchanges among members of the *Bacillus cereus* group in foodstuffs », *Int. J. Food Microbiol.*, vol. 113, pp. 164-172, **2007**.

Award

▸ Hoton, F., Andrup, L., Swiecicka, I., Mahillon, J., « The cereulide genetic determinants of emetic *Bacillus cereus* are plasmid-borne », BioMérieux Award: *Excellence in pathogen research* for the best Poster presented at the *Tenth Conference on Food Microbiology*, Liège, Belgium, June 23-24, **2005**.

Partnership

▸ Reference laboratory in Food Microbiology, in the Requasud network
▸ Belgian reference laboratory for bacteria of the *Bacillus cereus* group, including *Bacillus thuringiensis* and *Bacillus anthracis*
▸ Consulting for SME in the Walloon Region, including the identification and characterisation of pathogens
▸ Polygal: research project on molecules combinations able to enhance the conservation of foodstuffs (consortium of 5 private companies and 2 academic institutions)
▸ Consalim: research project on foodstuff modification mechanisms (consortium of 12 private companies and 5 scientific institutions)
▸ Member of BCCM (Belgian Coordinated Collection of Microorganisms), a consortium of four national culture collections of filamentous fungi, yeasts and arbuscular mycorrhizal fungi of agro-food and environmental interest

KEY WORDS FOR R&D

Bacteriology
Bacillus spp.
Culture collection
Food quality and biosafety
HACCP
Molecular epidemiology and systematics
Mycology
Mycotoxins
Opportunistic microorganisms
Pathogens
Patent, safe and public deposit
Quality consulting
Secondary metabolites
Transposable elements
Virulence factors

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Food quality control by spectrophotometric techniques

SENIOR SCIENTIST :

- Marc MEURENS

Research Field and Subjects

New instruments named spectrophotometric sensors (spectrosensors) are conceived and developed in the laboratory of spectrophotometry for the analysis and quality control of gaseous, liquid and solid food products. These instruments are digital spectrophotometers able to measure ultraviolet (UV), visible (Vis) and infrared (IR) absorption, fluorescence and Raman scattering in order to immediately determine the chemical composition of food products by chemometric conversion of their spectral data. The laboratory is expert in chemical analysis and quality control of numerous food products such as cereal grains, dairy products, meat, fish, eggs, fruits, chocolate, tea, coffee, beer and wine.

Products and Services

The laboratory of spectrophotometry offers the service of spectrum acquisition and performance evaluation of spectrophotometers in food quality control.

Main Equipment

- UV/Vis/IR lasers and LED light sources
- UV/Vis/IR, fluorescence and Raman digital spectrometers

Representative References

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Meurens, M., « Spectrophotometric Techniques, *Food authenticity and traceability* », Cambridge, M. Lees., Woodhead Publishing Limited, pp. 184-197, **2003**.

Rozenberg, R., Ruibal-Mendieta, N., Petitjean, G., Cani, P., Delacroix, D., Delzenne, N., Meurens, M., Quetin-Leclercq, J., Habib Jiwan, J-L., « Phytosterol analysis and characterization in spelt (*Triticum aestivum ssp. spelta L.*) and wheat *(T. aestivum L.)* lipids by LC/APCI-MS », *Journal of Cereal Science*, vol. 38, n°2, pp. 189-197, **2003**.

Benoudjit, N., François, D., Meurens, M., Verleysen, M., « Spectrophotometric variable selection by mutual information », *Chemometrics and Intelligent Laboratory Systems*, vol. 74, n°2, pp. 243-251, **2004**.

Benoudjit, N., Cools, E., Meurens, M., Verleysen, M., « Chemometric calibration of infrared spectrometers: Selection and validation of variables by non-linear models », *Chemometrics and Intelligent Laboratory Systems*, vol. 70, n°1, pp. 47-53, **2004**.

Ruibal-Mendieta, N., Rozenberg, R., Delacroix, D., Petitjean, G., Dekeyser, A., Baccelli, C., Marques, C., Delzenne, N., Meurens, M., Habib Jiwan, J-L., Quetin-Leclercq, J., « Spelt (*Triticum spelta L.*) and winter wheat (*Triticum aestivum L.*) wholemeals have similar sterol profiles, as determined by quantitative liquid chromatography and mass spectrometry analysis », *Journal of agricultural and food chemistry*, vol. 52, n°15, pp. 4802-4807, **2004**.

Ruibal-Mendieta, N., Dekeyser, A., Delacroix, D., Mignolet, E., Petitjean, G., Larondelle, Y., Meurens, M., « The ratio oleate/palmitate allows the distinction between spelt (*Triticum spelta L.*) and winter wheat (*T. aestivum L.*) wholemeal », *Journal of Cereal Science*, vol. 39, pp. 413-415, **2004**.

Meurens, M., Baeten, V., Yan, S., Mignolet, E., Larondelle, Y., « Determination of the conjugated linoleic acids in cow milk fat by Fourier Transform Raman spectroscopy », *Journal of Agricultural and Food Chemistry*, vol. 53, n°15, pp. 5831-5835, **2005**.

Rubayiza, Ab., Meurens, M., « Chemical Discrimination of Arabica and Robusta Coffees by Fourier Transform Raman Spectroscopy », *J. Agric. Food Chem.*, vol. 53, n°12, pp. 4654-4659, **2005**.

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Rossi, F., François, D., Wertz, V., Meurens, M., Verleysen, M., « Fast Selection of Spectral Variables with B-Spline Compression », *Chemometrics and Intelligent Laboratory Systems*, vol. 86, n°2, pp. 208-218, **2007**.

Bernuy, B., Meurens, M., Mignolet, E., Larondelle, Y., « Performance comparison of UV and FT-Raman spectroscopy in the determination of conjugated linoleic acids in cow milk fat », *J. Agric. Food Chem.*, vol. 56, pp. 1159-1163, **2008**.

Patent

▸ Meurens, M., *Sample preparation system for infrared spectroscopy*. (1990) PCT WO 90/15981

Award

▸ M. Boutry, member of the Belgian Academy of Sciences

Partnership

▸ Jean-Louis HABIB, Université catholique de Louvain, Département de Chimie (Louvain-la-Neuve), Belgium
▸ Pierre DARDENNE, Centre de Recherche Agronomique Wallon, Département Qualité, (Gembloux), Belgium
▸ Jean-Pierre HUVENNE, Université des Sciences et Techniques de Lille, Laboratoire de Spectro-chimie Infrarouge et Raman (Villeneuve d'Asq), France
▸ Lanfranco CONTE, Universita di Udine, Dipartimento Scienze degli Alimenti (Udine), Italie

KEY WORDS FOR R&D

Food Quality Control
UV/Vis/IR Light Absorption
Laser Induced Fluorescence
Raman Scattering
Spectroscopy
Chemometrics

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Spectrometric data analysis and machine learning

SENIOR SCIENTISTS :

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- Michel VERLEYSEN
- Vincent WERTZ

Research Field and Subjects

Spectrometry, in particular infrared spectrometry, has numerous applications in quality control. Among them, food quality assessment and control can advantageously benefit from spectroscopy because of its non-invasive character and low cost.

Spectrometric data, or spectra, are used, among others, to predict a physical or chemical property of the material under study, or to classify samples. Spectroscopy can be used to assess the quality of food, to discriminate between valid or non-valid samples after crop or production, to predict a quantity of interest without having to measure it directly, etc. Examples are the prediction of sugar concentration in orange juices, of cacao in chocolate, or of alcohol level in beverages.

Spectra analysis is typically carried out using standard, linear tools such as PLS (Partial Least Squares) and its derivatives. Nevertheless, modern machine learning techniques may greatly expand the applications of spectrometry by providing tools to analyze the spectra and improve the performances in a wide variety of applications. Two directions are mainly concerned: the use of nonlinear data analysis tools, most often increasing the performances in prediction and classification tasks with respect to linear ones, and the possibility to automatically select wavelengths or ranges of wavelengths that are needed for the model, in order to add interpretation.

The Machine Learning group develops tools and algorithms based on machine learning principles, and specifically adapted to spectrometric data. In particular, it is active in the following domains:

- regression based on and classification of high-dimensional spectra with nonlinear tools (artificial neural networks, or support vector machines);
- projection of spectra on interpretable bases;
- selection of wavelength ranges that influence the variable to predict, in order to guide interpretation.

Products and Services

- Besides its research activity on the above topics, the group provides expertise, support and development in collaboration with food industries, for the development of spectrometric data analysis methods and tools. Specific courses for in-house specialists are also organised on request.

Main Equipment

- Availability of necessary computing equipment
- Home-made data analysis software

Representative References

- Lendasse, A., François, D., Wertz, V., Verleysen, M., « Estimation non paramétrique de bruit pour la construction de modèles non linéaires en spectrométrie », *Chimiométrie 2005*, Villeneuve d'Ascq (France), 30 November - 1 December, pp. 143-146, **2005**.
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▸ Rousseau, R., Govaerts, B., Verleysen, M., Boulanger, B., « Comparison of some chemometric tools for metabonomics biomarker identification », *Chemometrics and Intelligent Laboratory Systems*, Elsevier, vol. 91, n° 1, pp. 54-66, **2008**.

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Partnership

▸ INRIA, France
▸ Helsinki University of Technology, Finland

KEY WORDS FOR R&D

Food quality control
Spectra
Spectroscopic data
Infrared spectroscopy
Data analysis
Nonlinear regression
Classification
Selection of wavelengths

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Process modeling, monitoring, control and real-time optimisation

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Research Field and Subjects

Well accepted trends in food process industries require plants to be flexible in order to adapt in real-time to market driven demand and to comply with safety and environmental requirements. This translates into the need of integrated tools for wide-plant operation support, that by having full access to plant conditions, are able to predict through reliable models, future scenarios and plant malfunction.

The main area of expertise is related to the mathematical modeling of the dynamics of chemical, biochemical and other industrial food processes, the analysis of the model properties, and the design and application of model-based monitoring and control algorithms.

The developed approaches are largely based on mass and energy balance models. One of the underlying ideas is to incorporate the knowledge about the process dynamics (e.g. basically, the metabolic network and the material balances) in monitoring and control algorithms; moreover the latter are able to deal with process uncertainties (in particular on the reaction kinetics) by introducing an adaptation scheme.

The monitoring and control strategies are applied to stirred tank reactors (dynamics described by ordinary differential equations) as well as to processes, the dynamics of which are described by partial differential equations, such as plug flow reactors, fixed or fluidised bed reactors as well as population balance based models (for processes with size-distributed particles or age-distributed cells). Monitoring is related in particular to the design of software sensors that are based on the available knowledge on the process dynamics and the limited number of process variables measured on-line in order to reconstruct on-line the values of the unmeasured key process variables. A special attention is also given to the design and implementation of real-time optimisation methods via adaptive extremum seeking control techniques that allow the process to reach a priori unknown optimal operating points, trajectories or profiles.

Several research projects have been carried out in cooperation with industrial partners. This includes an EC FP7 project "Computer-aided food processes for control engineering" (CAFÉ).

Products and Services

- Dynamical models
- Software sensors
- Control algorithms
- Real-time Optimisation algorithms

Representative References

- TITICA, M., DOCHAIN, D., GUAY, M., « Adaptive extremum seeking control of fedbatch bioreactors », *European Journal of Control*, vol. 9, n°6, pp. 618-631, **2003**.
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- SAUVAGE, F., GUAY, M., DOCHAIN, D., « Design of a Nonlinear Finite Time Converging Observer for a Class of Nonlinear Systems », *Journal of Control Science and Engineering*, paper 36954, 9 p., **2007**.

Partnership

- INRA, Laboratoire de Biométrie, Montpellier (Dr A. Rapaport), France
- Laboratoire de Biotechnologie de l'Environnement, Narbonne (Dr J. Harmand & J.Ph. Steyer), France
- Université de Technologie de Compiègne, Département de genie Chimique (Prof. A. Pauss, Dr. O. Schoefs), France
- LAGEP (Laboratoire d'Automatique et de Génie des Procédés), France

- Université de Lyon I (Prof. B. Maschke), France
- Ecole Polytechnique de Montréal, Département de Génie Chimique (Prof. M. Perrier), Canada
- Queen's University, Chemical Engineering Department (M. Guay, J. Ramsay), Canada

KEY WORDS FOR R&D

Modeling
Monitoring
Estimation
Software sensor
Control
Real-time optimisation
Population balance

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Signal transduction and regulation of gene expression

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Research Field and Subjects

We are studying signal transduction and gene regulation by cytokines and growth factors, in the context on inflammation, cancer and nutrition. In this respect, we have a long-standing interest for the SREBP transcription factors, which are key regulators of lipogenic enzymes. These factors are regulated by nutrients in the liver, in particular by carbohydrate and lipid uptake. SREBPs also play a role in membrane synthesis in proliferating cells.

Gene expression is monitored using cDNA- or oligonucleotide-based microarrays. We also develop computational data analysis tools.
SREBP activation is measured by Western blotting or in luciferase reporter assays.

Products and Services

- Transcription factors and microarray analysis

Main Equipment (MEXP unit)

- Microarray platform
- Luminometer for 96 well plates
- Odyssey IR scanner for Western blot
- Standard molecular and cellular biology equipment

Representative References

- DEMOULIN, J-B., ERICSSON, J., KALLIN, A., RORSMAN, C., RÖNNSTRAND, L., HELDIN, C-H., « Platelet-derived growth factor stimulates membrane lipid synthesis through activation of phosphatidylinositol 3-kinase and sterol regulatory element-binding proteins », *J. Biol. Chem.*, vol. 279, pp. 35392-35402, **2004**.
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Partnership

- Ludwig Institute for Cancer Research, Uppsala branch, Prof C.H. Heldin and J. Ericsson, Sweden
- Hematology unit, Cliniques Universitaires Saint-Luc, Brussels, Prof. C. Hermans and A. Ferrant, Belgium
- Rheumatology department, Cliniques Universitaires Saint-Luc, Brussels, Prof. B. Lauwerys and F. Houssiau, Belgium
- Inserm, Centre de Recherches des Cordeliers, Paris, Prof. F. Foufelle & P. Ferré, France

KEY WORDS FOR R&D

Transcription factors
Microarray
Bioinformatics
Signal transduction
Lipid metabolism
Cytokines
Nutrients

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Programming of adult degenerative diseases by nutrition in early life

SENIOR SCIENTISTS :

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- Brigitte REUSENS

Research Field and Subjects

Experimental research in animals supports the notion revealed by epidemiological studies of causal link between malnutrition in utero and in early life, leading to alterations in foetal growth and increased risk of chronic degenerative diseases. Mechanistic studies aimed at determining the key factors involved in these correlations are obviously impossible in humans. Therefore, rodent models of maternal malnutrition have been established as the major paradigm for finding mechanisms of early programming of adult disease.

The general objective of our research is to analyse how maternal malnutrition will affect the programming of the cells, and how this will lead to degenerative disease later in life. The specific aims of our research are to understand the basic mechanisms and to propose perspectives of prevention.

For that purpose, we have established models of maternal dietary protein deficiency or calorie restriction, and maternal obesity. The diets induce changes in foetal growth, metabolism and vasculature, with consequences at adult age. When administered at different periods of time during gestation and lactation, it may enable to identify precise windows in development when the function of one or more organs or pathways may become impaired.

During the last decade, we have focused on the development of the endocrine pancreas. Since three years, we have been analysing the programming of obesity, and we are starting now to determine how maternal malnutrition may lead to cardiovascular diseases.

Products and Services

- *In vivo* nutritional tests in animals (rodents): Analyses using different models of culture *in vitro* (endocrine cells, adipose cells, hepatocytes, neurons, etc.)

Main Equipment

- All types of microscopy, including electron and confocal microscopy ; image analysis, equipment for *in vitro* culture, HPLC, spectrometry, FACS, equipment for general biochemistry and molecular biology, animal facilities.

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Patents

▸ Hill D.J., Reusens B., Remacle C. PCT Serial N° CA00/00925, CA01/01137

Partnership

▸ FP5 European Union : NUTRIX Programme (Nutrition and Syndrome X) : http://www.nutrix.be/

▸ FP6 European Union : EARNEST programme (Metabolic programming)
http://earnest.web.med.uni-muenchen.de/index2.htm

KEY WORDS FOR R & D

Foetal programming
Protein restriction
Calorie restriction
Metabolic syndrome
Obesity
Diabetes
Cardio-vascular disease
Functional food
Taurine

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Cellular, nutritional and toxicological biochemistry

SENIOR SCIENTISTS :

- Cathy DEBIER
- Yvan LARONDELLE
- Yves-Jacques SCHNEIDER

Research Field and Subjects

The research team is part of the Life science institute (*Institut des Sciences de la Vie*) at UCL. The research activities focus on questions related to biochemistry, physio-pathology and pharmaco-toxicology of mammals, with special emphasis on the improvement of the nutritional quality and chemical safety of foods, in the objective of improving consumer's health. It also focuses on ecotoxicological questions. The studies are carried both *in vivo* and *in vitro*, using animals or cell culture systems.

The main topics currently investigated are:

- Understanding of the mechanisms whereby nutrients, food components, xenobiotics and other food contaminants interact with the human intestinal barrier
- Upgrading of under-exploited foods (Amazonian fruits, Andean roots and tubers, agricultural by-products, …), with a specific richness in bioactive compounds (polyphenols, carotenoids, glucosinolates) in the frame of functional food development
- Studying the toxicokinetics of persistent organic pollutants (POPs) in mammals and their relationship with the metabolism of liposoluble vitamins
- Evaluation and improvement of the quality of cow's milk fatty acid composition (omega-3 acids and conjugated linoleic acids - CLA)
- Determination of the dietary requirements of salmonid fish and impact of feeding strategies on the nutritional quality of their flesh

Products and Services

- Proximate analysis of feeds and foods
- Determination of fatty acid profiles (special focus on trans fatty acids and CLA isomers)
- Nutritional studies with fish, rats and cattle
- Determination of antioxidant capacity with different chemical and biological tools
- Determination of vitamin A and E contents in animal and plant tissues.

Main Equipment

- 6 HPLC chromatographs (UV-visible detectors, fluorimetry, refractometry, DAD)
- 4 gas chromatographs (GC- FID and capillary columns; one coupled to mass spectrometry)
- Basic equipment for biochemistry and molecular cell biology (FPLC, electrophoresis, spectrophotometers, PCR, transient transfections, enzymatic assays, radioactive assays, ELISA, fluorescence, ...)
- Basic equipment for food analysis (Soxhlet, Kjeldahl, Fibertec, lyophilisator, ovens, calorimeter, incubators, centrifuges)
- Standard equipments for animal cell culture (4 fully equipped rooms with incubators, laminar flows hoods, microscopes, centrifuges)
- Small scale bioreactors for animal cells (fully equipped for batch, fed batch and fixed bed perfusion)

Representative References

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Patents

‣ 10 patents and patent applications

Partnership

‣ Université de Liège ; Université Libre de Bruxelles ; Universiteit Gent ; Universiteit Antwerpen ; Facultés universitaires Notre Dame de la Paix, Namur ; Veterinary and Agrochemical Research Center, Tervuren ; Centre wallon de recherche agronomique, Gembloux, Belgium.

‣ Centre de Recherche Public Gabriel Lippmann, Luxembourg ; Institut national de recherche agronomique (INRA), Jouy-en Josas, France; University of St Andrews, Scotland ; University of Dublin, Ireland ; University of Helsinki, Finland, University of Uppsala, Sweden, Europe.

‣ Universidad Nacional Agraria La Molina, Facultad de Industrias Alimentarias, Lima, Peru; Universidade federal do Para, Belem, Brazil ; International Potato Center, Lima, Peru; Universidad Mayor de San Simon, Centro de Alimentos y Productos naturales, Cochabamba, Bolivia, Latin America.

‣ University of California at Santa Cruz, California ; Sonoma State University, California ; Fisheries and Oceans, Institute of Ocean Sciences, Sidney, Canada ; Institut National de recherche Scientifique, Québec, Canada, Northern America.

The group also takes part in several projects of the Walloon Marshall Plan (www.wagralim.be).

KEY WORDS FOR R&D

Biochemistry
Nutrition
Cell biology
Ecotoxicology
Functional food
Persistent organic pollutant
Fish feeding
Lactation
Fatty acid
Mycotoxin
Polyphenol
In vitro models

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Development of functional nutrients for the control of gut-related metabolic diseases

SENIOR SCIENTISTS :

- Nathalie DELZENNE
- Patrice CANI
- Audrey NEYRINCK

Research Field and Subjects

The development of functional food appears as an interesting way to modulate key metabolic functions in the body, in order to improve health and well-being. Our research group has focused its scientific activities to demonstrate how nutrients which escape the digestion and which are largely fermented in the colon by specific types of bacteria can be helpful in the control of obesity and associated diseases. Experimental models have been developed in vitro and in animals. They allowed us to study how the interaction of nutrients with the microflora creates a metabolic bridge allowing the colon to "dialogue" with the brain, the liver, and the adipose tissue, with relevant effects on the development of obesity and related metabolic diseases (diabetes, liver diseases, inflammation). Specific *in vitro* models (precision cut liver slices) have been adapted to study the contribution of tissue-fixed macrophages in the metabolic response to nutrients and drugs.
The studies are mostly performed *in vitro* or in animal models (genetic, pharmacologic or nutritional models of metabolic diseases) but intervention studies are also performed in humans in collaboration with clinicians.

Products and Services

- Testing for new ingredients (prebiotics, probiotics, dietary fibers…) prone to interact with gut microflora, in order to assess their interest in the control of inflammation or metabolic diseases
- Validation of a portfolio of biomarkers related to gut microflora, inflammation (LPS, pro- and anti-inflammatory cytokines), gut peptides controlling food intake and/or metabolism such as glucagon-like peptide 1, PYY, ghrelin, etc.

Main Equipment

- Molecular biology techniques, including q-RT PCR
- Bioplex technique (multiple immunoquantification of peptides or DNA)
- Immunohistochemistry
- Krumdiek slicer and adequate incubation of precision-cut organ slices
- Tissue and cell cultures (2 rooms)
- Spectrophotometry, gas and high performance liquid chromatography (5)

Representative References

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insulin resistance », *Diabetes*, vol. 56, n°7, pp. 1761-1772, **2007**.

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‣ Neyrinck, A.M., Mouson, A., Delzenne, N., « Dietary supplementation with laminarin, a fermentable marine beta 1-3 glucan, protects against hepatotoxicity induced by LPS in rat by modulating immune response in the hepatic tissue », *Int. J. Immunopharmacol*, vol. 7, n°12, pp. 1497-1506, **2007**.

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Patents

‣ "Prevention of mammary carcinogenesis and breast cancer treatment" Delzenne N, Roberfroid M, Coussement P. N° US 5,721,345 Réf : PRAFF 15/US (12/11/1997)

‣ "Composition for suppressing ghrelin and method for same" Delzenne N, Cani P, Franck A.N°EP 03022007.3 Filing date : (30/09/2003)

Awards

‣ Post-doctoral Award from Danone Institute, Belgium (Delzenne, 1993)

‣ « Research Award for the study of carbohydrates" from International Life Sciences Institute (USA) (Delzenne, 1997)

‣ Alpro Foundation Award (Paindavoine, 2004)

‣ Medal from the Royal Academy of Medicine, Belgium (Neyrinck, 2005)

‣ Young Award - from the Federation of the European Nutrition Societies, Paris, France (Cani, 2007)

Partnership

‣ Prof R. Burcelin, Dr C. Knauf INSERM, Toulouse, France

‣ Prof P. Ferré, Dr F. Foufelle, INSERM Paris, France

‣ Prof G. Gibson, DR K. Tuohy, Reading, United Kingdom

KEY WORDS FOR R&D

Prebiotics
Microflora
Obesity
Gut peptides
Satiety
Dietary fibers
Inflammation
Metabolic diseases
Diabetes

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Influence of bovine colostrum supplementation on the immune system of weaned piglets in a context of a full ban of in-feed antibiotics.

SENIOR SCIENTIST :

- Jean-Paul DEHOUX

Research Field and Subjects

Weaning is one of the most critical periods in animal production due to several stresses. This period was managed for decades by incorporating antibiotics in the diet. However, the European Union implemented a full ban on in-feed antibiotics since January 2006. In this context, many alternatives have to be found. Among them, the bovine colostrum, well known for its richness in essential nutrients and in bioactive peptides (growth and antimicrobial properties), is investigated for its use in newly-weaned piglet diet.

Products and Services

- Immunology and veterinarian expertise (animal health and husbandry, surgery)

Main Equipment

- Immunology ELISA and ELISPOT methods, panel of rat monoclonal antibodies, flow cytometry, mixed lymphocytes reaction and cytotoxicity tests, cell culture, molecular biology.
- Animal housing facilities

Representative References

- BOUDRY, C., BULDGEN, A., PORTETELLE, D., COLLARD, A., GIANELLO, P., THEWIS, A., DEHOUX, J-P., « Effects of oral supplementation of bovine colostrum on weaned piglets immunity », *Res. Vet. Sci.*, vol. 83, n°1, pp. 91-101, **2007**.
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Partnership

- Facultés agronomiques de Gembloux (unité de zootechnie), Belgium
- Centre d'économie rurale de Marloie (division immunologie animale), Belgium

KEY WORDS FOR R&D

Piglet
Colostrum
Immune system
Immunoglobulins
Cytokine

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Regulation of cardiac metabolism by nutrients and hormones under physiological and patho-physiological conditions

SENIOR SCIENTISTS :

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- Christophe BEAULOYE
- Jean-Louis VANOVERSCHELDE

Research Field and Subjects

Our research team is studying the intracellular signalling that controls cardiac metabolism. Our program mainly focuses on the interplay of the insulin, amino acids and AMP-activated protein kinase signalling pathways, which play a key role in the regulation of glucose and protein metabolism. Our previous works suggested that these signalling pathways are implicated in patho-physiological processes including ischemic injury, hypertrophy and diabetic cardiomyopathy. We are now studying whether the modulation of these signalling events by hormones, pharmacological compounds and nutrients could exert some potential therapeutic effects.

Products and Services

- Cardiac metabolic and functional measurements including human and animal cardiac imaging by (animal)-PET, (animal)-SPECT and echo-cardiography
- *In vitro* and *in vivo* protein kinase assay

Main Equipment

- Human and animal cardiac imaging (standard and high resolution echocardiography, SPECT and µSPECT, PET and µPET, MRI, CT)
- *Ex vivo* system of heart perfusion (for small and big animals)
- Standard biochemical and cellular biology equipment (1D and 2D electrophoresis, cell culture, immunohistochemistry)
- Liquid scientillation analyzers, multimodal imaging systems (chemiluminescence and fluorescence) and spectrophotometer

Representative References

- Beauloye, C., Marsin, A.S., Bertrand, L., Vanoverschelde, J.L., Rider, M.H., Hue, L., « The stimulation of heart glycolysis by increased workload does not require AMP-activated protein kinase but a wortmannin-sensitive mechanism », *FEBS lett.*, vol. 531, pp. 324-328, **2002**.
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Awards

- Prix Camille et Germaine Damman 1990 (JL Vanoverschelde)
- Prix de la Ligue Cardiologique Belge 1992 (JL Vanoverschelde)
- Prix Therabel 1995 (JL Vanoverschelde)
- Prix Van Vaerenbergh - de Visccher 1996 (JL Vanoverschelde)
- Prix Bekales 1996 (JL Vanoverschelde)

- Chaire Astra Foundation 1997-1999 (JL Vanoverschelde)
- Lecture Bischop 2001 (JL Vanoverschelde)
- Young Investigator Award of Belgian Society of Cardiology 2001 (C. Beauloye)
- Prix Léopold et Marthe Delsaux-Champy 2006 (L. Bertrand)
- Prix Camille et Germaine Damman 2007 (L. Bertrand)

Partnership

Partner in the program *Actions de recherche concertées* (ARC) on "Beyond myocardial damage: mechanisms of survival and regeneration of the cardiovascular tisue"

KEY WORDS FOR R&D

Heart metabolism
Signal transduction
Diabetes
Nutrient
Insulin resistance
Protein kinase
Cardiac imaging
Heart perfusion
Insulin
Hypertrophy
Cell therapy

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Contribution of adipokines to the pathogenesis of obesity and metabolic syndrome

SENIOR SCIENTIST :

- Sonia BRICHARD

Research Field and Subjects

The aim of our work is to get a better insight into the pathogenesis of obesity-related complications (the so-called metabolic syndrome which includes type 2 diabetes and cardiovascular disease).
To this end, our team searches for new regulatory peptides secreted by adipose tissue (adipokines), which are likely to play a key role in the pathogenesis of this syndrome. Our research group is involved in the systematic test of their regulation and their effects.
Our current projects also aim at characterizing the phenotype of transgenic mice that we have generated and that overexpressed some of these adipokines.

Products and Services

- Testing for the effects of different molecules (pharmacological or metabolic agents such as hormones) on human or murine adipose tissue function and metabolism *in vitro*.
- Studying the effects of the same agents *in vivo* in different mouse models of obesity or diabetes

Main Equipment

- Culture, RTQ-PCR, Immunoassays, etc.

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Awards

- Sanofi awards of the metabolic syndrome 2006
- Sanofi awards in diabetology 2005

Partnership

- University of Osaka, Japan
- University of Toulouse, France
- University of Geneva, Switzerland

KEY WORDS FOR R&D

Obesity
Regulatory peptides
Adipose tissue
Transgenic mice
Adipokines
Hormones

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Role of dietary factors in the prevention and treatment of obesity and diabetes

SENIOR SCIENTIST :

- Jean-Paul THISSEN

Research Field and Subjects

Our research consists in getting a better insight into the role and mechanisms of action of growth factors in skeletal muscle development.
To this end, we search for new regulatory peptides secreted by skeletal muscle (growth factors) and able to play a key role in the muscle development.

Our research also focuses on characterizing the role of specific foods in the prevention and treatment of obesity and diabetes

Products and Services

- Our team tests the effects of different molecules (pharmacological or metabolic agents) on skeletal muscle development (morphology and function)
- Studies of the glycemic index and satiety effect of different foods in humans

Main Equipment

- Animal facility
- Cell culture
- RTQ-PCR
- Western blot
- Immunoassays, etc.

Representative References

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Partnership

- L Grobet, Veterinary School, University of Liège, Belgium
- Y Le Bouc, INSERM 515, Paris, France
- D Attaix, INRA, Clermond-Ferrand, France

KEY WORDS FOR R&D

Skeletal muscle
Growth factors
Muscle atrophy
Cachexia
Anabolic agents
Obesity
Diabete

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Key Words Index