

**SPECIFIC
FOR YOUR
SUCCESS**



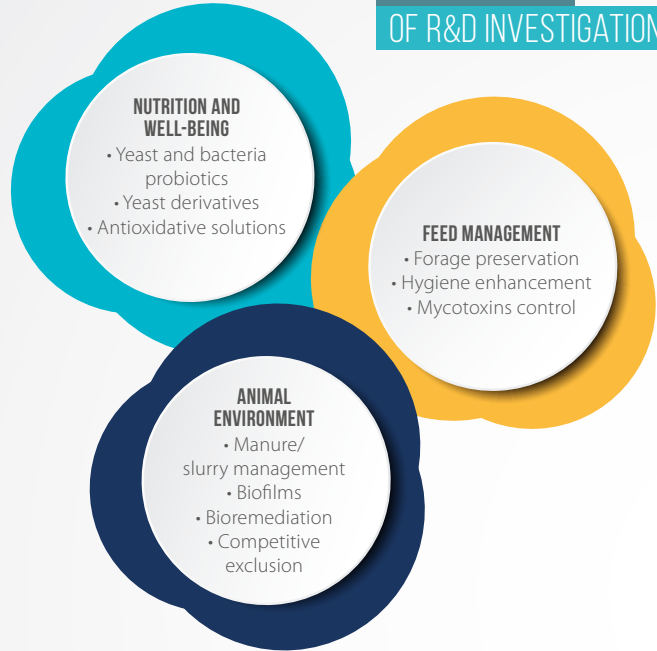
RESEARCH & DEVELOPMENT AT LALLEMAND ANIMAL NUTRITION

DRIVEN BY INNOVATION, SUPPORTED BY R&D

Lallemand Animal Nutrition is committed to innovation by providing specific, research-based microbial solutions to optimize animal performance and well-being.

- > No Lallemand product is brought to market without a substantial base of research and proof of performance.
- > We have experts across multiple disciplines who are skilled in molecular microbiology, omics and other techniques.
- > Lallemand has a specific R&D process to ensure we produce quality products with practical applications.
- > Our products and services are supported by more than 100 years in microbial production and more than 25 years of expertise in the animal probiotic and forage inoculant fields.

TOP 3 AREAS OF R&D INVESTIGATION





THE LALLEMAND R&D PROCESS

SPANS FROM DISCOVERY
TO CUSTOMER USE



1 DISCOVERY AND PROOF OF CONCEPT



2 SCALE-UP AND REGISTRATION



3 PRODUCT DEPLOYMENT

WORKING TOGETHER



Lallemand Animal Nutrition works with key opinion leaders. Our research and development team develops partnerships with renowned universities and research centers around the world. Privileged collaborative partnerships have been established with leading research organizations, creating Centers of Excellence to foster innovation in all areas of microbial solutions.

Excellence to foster innovation in all areas of microbial solutions.

Lallemand Animal Nutrition continuously supports:

- > Collaborative research with external partners
- > Local production trials (study design, analysis, funding, etc.)
- > Key scientific events
- > Internships and student programs for new scientists

An important part of our research and development is conducted in partnership with our industry partners. Lallemand Animal Nutrition offers its customers continuous technical support to ensure the optimal application and efficacy of its solutions.

LALLEMAND RESEARCH AND DEVELOPMENT IS SPECIFIC FOR YOUR SUCCESS.





DISCOVERY AND PROOF OF CONCEPT

STRAIN SCREENING AND SELECTION

- Functional assays (*in vitro* and *ex vivo*)
- Lallemand Aquapharm screening platform
- >12,500 strains
- Ecosystem-specific microbial collections



STRAIN CHARACTERIZATION AND SAFETY

- Strain identity: whole genome sequencing
- Antibiotic resistant genes, presence of mobile genetic elements
- Microbial fractions characterization
- Functional properties



Complete genome atlas of a bacteria strain

DEVELOPMENT OF MODELS AND METHODS

- Functional microarrays
- Quantitative real time PCR
- Dynamic *in vitro* models
- Diverse type of biomarkers



In vitro model of piglet gut (INRA-UCA)

IN VITRO/IN VIVO PROOF OF CONCEPT

- Proof of concept animal and silage trials
- Mini silo trials for forage inoculants

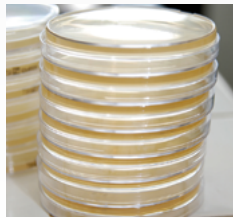


Internal poultry proof of concept study facilities in France and UK

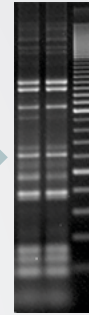
EXAMPLES

SELECTION OF A RUMINANT SPECIFIC YEAST STRAIN

After screening of thousands of strains, one single strain was selected for its ability to improve rumen function and microbiota balance



Yeast cells bank screening



Delta-PCR strain identification

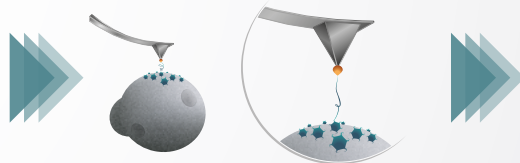
Selection of a unique strain to maximize energy from forage

YEAST CELL WALL CHARACTERIZATION USING ATOMIC FORCE MICROSCOPY

Use of single molecular microscopic techniques to characterize yeast cell wall binding properties and select the best strains for an innovative yeast cell wall combination



Yeast microscopy observation (atomic-force microscopy)



Yeast characterization and selection



Development of a new yeast based solution to reinforce animals' natural defences

FIBROCHIP: FROM GENE TO FUNCTION

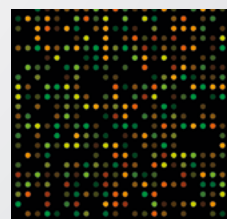
Development of a functional DNA microarray as a targeted metatranscriptomic tool to study fiber degradation activity in rumen microbiota



Rumen content sample



RNA = Reflects Microbe Activity



DNA microarray
430 genes from
57 microbial species

Better understanding of microbial mechanisms of fiber degradation and their influencing factors



SCALE-UP AND REGISTRATION

PRODUCTION SCALE-UP, PROCESS OPTIMIZATION

- Internal process optimization and scale-up team
- Internal pilot plants
- State-of-the-art analytical tools: cytometry, cryomicroscopy, differential scanning calorimetry (DSC)



Pilot fermenter

PRODUCT STABILITY AND APPLICABILITY

- Product formulation optimization
- Internal pilot feed processing unit
- Strain and matrix specific analytical methods
- Next generation microbial cell counters



Pilot feed pelleting equipment

IN VIVO EFFICACY ASSESSMENT

- Strong collaboration network with research partners to perform efficacy trials in all livestock species (ruminant, swine, poultry, aquaculture, etc.), companion animals, and equine
- Dedicated large experimental bunker units for forage inoculants



Shrimp cages for performance trials in commercial conditions

PRODUCT REGISTRATION

- Dedicated team of territory specific specialists for the preparation of regulatory dossiers

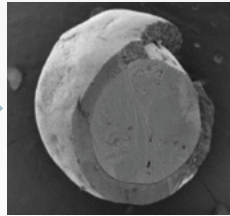


EXAMPLES

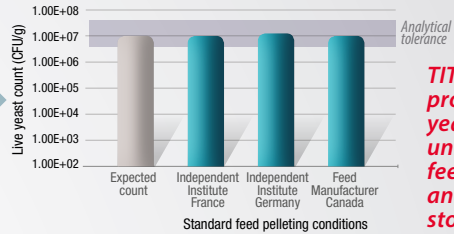
DEVELOPMENT OF PATENTED LIVE YEAST PROTECTION TECHNOLOGY



Pilot microencapsulation unit



Electron microscopy section of a TITAN beadlet containing millions of live yeast cells



TITAN coated probiotic live yeasts are stable under industrial feed processes and long term storage

EVALUATION OF FORAGE INOCULANTS



Evaluation of kinetics of fermentation and aerobic stability in micro-silos (Lallemand Forage Center of Excellence)



Farm-scale assessment of dry matter losses and silage analysis (Lallemand Forage Center of Excellence)



Dairy barn with individual feed intake monitoring at external research facility in Blanca dairy hub (Spain)

Monitoring of animal response to the silage based diet

DOCUMENTATION OF NEW APPLICATION FOR A PROBIOTIC YEAST FOR FOOD SAFETY BENEFITS IN BROILERS



Extensive mode of action documentation of *Saccharomyces cerevisiae* boulardii CNCM I-1079



Commercial trials under various conditions in several countries (meta-analysis)



First feed additive authorization in the European Union for the reduction of Salmonella spp. contamination on carcasses of broilers



PRODUCT DEPLOYMENT

MODE OF ACTION INVESTIGATION

- Focus on the role of our solutions on microbial ecosystems and associated impact on animal response, such as performance, welfare, immunity, oxidative stress, metabolism etc.
- Controlled *in vitro*, *ex vivo* and *in vivo* studies to understand modes of action for strains in order to optimize and extend applications
- Application of novel biomarkers and sensors to assess effects of products beyond animal performance (e.g. animal welfare)

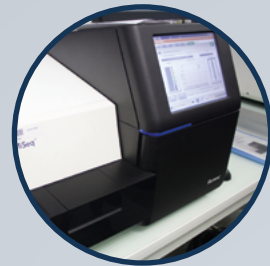
APPLIED TRIALS

- Controlled large scale trials
- Multi-analysis of field trials
- Pilot farms network in ruminants, swine, poultry and aquaculture

DEVELOPMENT OF AUDIT TOOLS AND ON-FARM SERVICES

LALLEMAND

FORWARD



Last generation sequencing equipment (INRA)



Ruminant microbiota establishment trial (INRA)



Post-weaning piglets in commercial farm



Rumen Efficiency Investigation program for on-farm audits

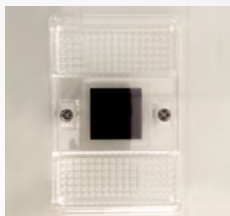
EXAMPLES

DEVELOPING A GENOMIC TECHNIQUE TO ASSESS FISH MUCOSAL IMMUNE RESPONSE

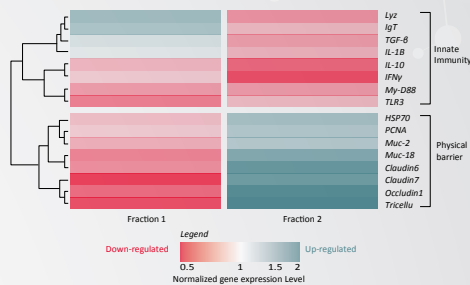
Advancing understanding of strains' modes of action and further developing product benefits



Controlled trial, mucus sampling



Use of high throughput real-time qPCR platform to analyze the expression of 62 immune related genes



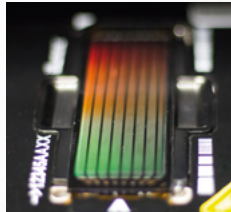
Deciphering feed ingredient effect on fish mucosal immune cascades

DECIPHERING PIGLET MICROBIOTA CHANGES USING METAGENOMICS

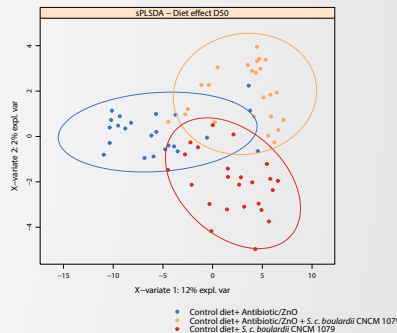
Metagenomic studies of piglet fecal microbiota conducted pre- and post-weaning to evaluate the effects of weaning and influence of dietary probiotics



Controlled trial



Sequencing of fecal microbial DNA



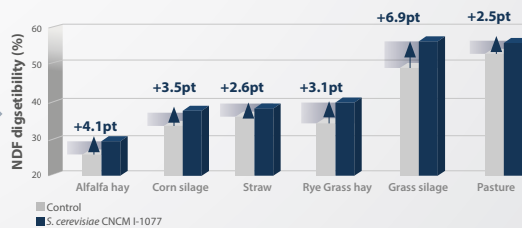
Effect of the diet on gut microbiota diversity around weaning

FINE-TUNING PRODUCT APPLICATIONS

Development of a predictive sub-model for formulators taking into account the effects of live yeast on feed degradation



In sacco NDF digestibility of 200+ forage types with/without live yeast



References: Guedes et al, 2008; Guedes et al, 2010; Lallemand unpublished data from China and Brasil, 2014

Data mining and analysis



Sub-model predicting the nutritional effect of the live yeast

WORLDWIDE RESOURCES AND COLLABORATIVE NETWORK

A research team organized around six major platforms:

- 1 Lallemand microbial culture collection and strain screening expertise (over 2,500 yeast strains and 10,000+ bacteria strains)
- 2 Microbial characterization laboratory
- 3 Process and formulation laboratory
- 4 Mechanistic research group
- 5 Applied research and development team
- 6 Corporate transversal team including an autonomous disruptive research unit

Based in:

- In-house facilities and
- Long-term partnerships with leading research organizations worldwide





OBAN (SCOTLAND)

GRENAA (DENMARK)

TALLINN (ESTONIA)

UK

MALVERN (UK)

FRANCE

SPAIN

TOULOUSE (FRANCE)

INTERNAL RESEARCH FACILITIES

CENTERS OF EXCELLENCE

Established within leading research organizations around the world, as part of privileged collaborative partnerships









A global network of partnerships with independent universities, research centers, experimental facilities and commercial farms in:

- Algeria
- Australia
- Belgium
- Brazil
- Canada
- China
- Denmark
- Egypt
- Finland
- France
- Germany
- Greece
- Hungary
- Italy
- Japan
- Netherlands
- Norway
- Poland
- Portugal
- Scotland
- South Africa
- South Korea
- Spain
- Sweden
- Switzerland
- Thailand
- UK
- USA
- Vietnam

INCLUDING LONG-TERM PARTNERSHIPS WITH OVER 60 INSTITUTIONS

Lallemand Animal Nutrition is committed to optimizing animal performance and well-being with specific natural microbial product and service solutions. Using sound science, proven results and knowledge, Lallemand Animal Nutrition develops, produces and markets high value yeast and bacteria products - including probiotics, forage inoculants and yeast derivatives. These innovative solutions positively benefit animal nutrition and well-being, forage management and animal environment. Lallemand offers a higher level of expertise, leadership and industry commitment with long-term and profitable solutions to move our partners **Forward**. Lallemand Animal Nutrition is *Specific for your Success*.

KEY FIGURES

35+	SPECIFIC MICROBIAL STRAINS DEVELOPED FOR COMMERCIAL APPLICATIONS	
24	ANIMAL SPECIES STUDIED	
1 IN 15	FOR EVERY 15 LALLEMAND EMPLOYEES, AT LEAST ONE IS IN R&D	
15+	PEER-REVIEWED PUBLICATIONS PER YEAR	
±20	SCIENTIFIC MEETINGS PARTICIPATED IN EACH YEAR	
50+	ANIMAL AND FORAGE TRIALS PERFORMED PER YEAR	

Lallemand Animal Nutrition is part of the Lallemand group, a privately owned Canadian company founded at the end of the 19th Century. Lallemand develops, produces and markets specific yeast, bacteria and derivatives of micro-organisms for applications in:



BAKING



OENOLOGY



BREWING / DISTILLED SPIRITS



HEALTH SOLUTIONS



PHARMA



ANIMAL NUTRITION



FOOD INGREDIENTS



SPECIALITY CULTURES



BIOFUELS



PLANT CARE