Demonstration of a precision feeding system for growing pigs at a commercial farm operation to demonstrate practical feasibility

. Universitat de Lleida, . Exafan, . Institut Du Porc, . Inrae, . Association Française de Zootechnie

FEED-A-GENE

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

Deliverable D4.8

Demonstration of a precision feeding system for growing pigs at a commercial farm operation to demonstrate practical feasibility

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1. Summary

Demonstration objectives of precision feeding

On-farm demonstration activities have been organised to validate the prototypes of automatic feeders, to refine their characteristics under field conditions, and to promote the adoption of this technology by farmers. For this purpose, two kinds of precision feeder systems have been developed or adapted during the last phase of the project for demonstration and validation purposes: a) a system for growing pigs fed *ad libitum* and b) a system for growing pigs under restricted feeding.

For growing pigs fed *ad libitum*, a pre-industrial precision feeder system was developed based on the integration of components and technologies developed in the previous tasks of the project. The system was capable to manage the amount and composition of feed to be distributed according to the nutrients requirements of individual pigs and capable to operate under commercial farm conditions. To build this precision feeding system, the three main components need to be integrated in a robust way: precision feeders (PF) manufactured by Exafan, a DSS to determine the individual nutrient requirements in real-time developed by INRAE, and a controlling module to integrate these components, devices and sensors, developed by the University of Lleida. A suitable pig farm was identified where the demonstration activities could be performed, and the demonstration activities (i.e., Open days, multimedia virtual tours, and writing materials) were conducted by Gran Suino Italiano Interprofessional Organization.

For growing pigs under restricted feeding, the prototype of a precision feeder available at IFIP was adapted to be integrated with a DSS and a controlling module. For demonstration purposes, two complete fattening cycles were carried out to perform a comparative analysis of daily multi-phase precision feeding with a commercial three-phase fattening system. Video material was produced for the demonstration activity.

Some demonstration activities were organized as part of the final Feed-a-Gene conference to favour uptake of Feed-a-Gene results by different stakeholders. The pre-industrial precision feeder system for growing pigs was shown in operation and accessible to visitors during the meeting

Teams involved:

The document has been developed by UdL in collaboration with Gran Suino Italiano, EXAFAN, IFIP, INRAE, and AFZ.

Species and production systems considered:

Precision feeding systems for growing-finishing pigs.

2. On-farm demonstration for growing pigs fed *ad libitum*

2.1. Development of technologies for precision feeding of pigs for demonstration purposes

2.1.1. Technical requirements for precision feeders for demonstration purposes

The Deliverable D4.4 *"*Prototypes of precision feeding systems adapted to different species and production types*"* described the technical requirements for required use in WP4 experiments. For growing pigs fed *ad libitum*, two major points were identified concerning the design of the structure and the electronic hardware. The structural design of the feeder should include two hoppers and two mobile doors. It should be built with resistant material and equipped with a demand sensor (operated by the pig) to provide the feed. The design of the electronic hardware required the implementation of features such as real-time communication, I/O management, data storage, notifications, and system configuration. All these requirements were implemented in the demonstration feeders.

2.1.2. Identification and verification if the precision feeding technology for growing pigs could be operated at a commercial farm and used for demonstration purposes

To verify that the precision feeding technology for growing pigs could be installed and run at a commercial farm and used demonstration purposes, each of the three components (i.e., feeder device, Controlling Module, Decision Support System (DSS)) was tested and checked.

- Feeder device

Design of the mechanical structure	Ready?
Two hoppers	✓
Stainless steel structure	✓
Two mobile doors	✓
Lateral panels (preferable material: plastic)*	✓
Stainless steel bowl	✓
Space for the scale	✓

**Instead of plastic, the lateral panels were made of stainless steel.*

Features of the electronic hardware	Ready?
Able to provide the right mixture of feed	✓
Hardware based on a microcontroller	✓
Reliable power supply	✓
High degree of protection (IP63)	✓
Able to read inputs (e.g., RFID) and activate actuators	✓
Fulfil EC regulations	✓
Execute algorithms in real-time	✓
Computing capability	✓
Communication network based on the TCP/IP protocol	✓
Capacity to add sensors and actuators for future requirements	✓
High resolution converter A/D	✓
Able to work all alone (i.e., without communication with controlling module)	✓
Availability to work only for one machine or for several machines in parallel.	✓

- Controlling Module

Controlling Module	Ready?
Monitoring of the precision feeding system:	✓
- Feeder components	✓
- RFID subsystem	✓
- Scale component	✓
- Feed micromixer subsystem	✓
Events:	✓
- Incidents	✓
- Failures/errors	✓
- Checking & support items	✓
Data processing and reports	✓
Communication supervision	✓

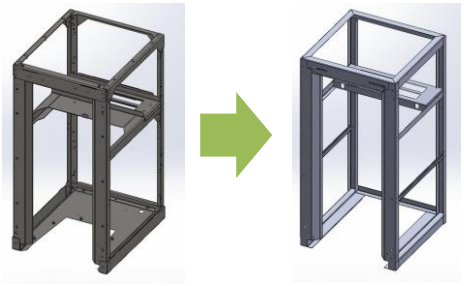
- Decision Support System

Decision Support System	Ready?
Implementation of submodules:	✓
- Prediction of body weight	✓
- Prediction of feed intake	✓
- Calculation of the lysine requirement	✓
Log files	✓
Daily file formulation	✓

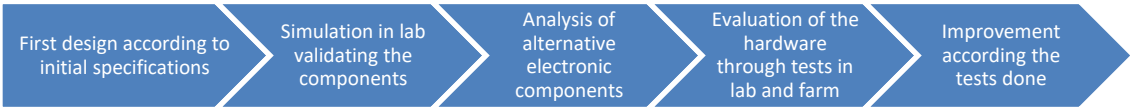
2.1.3. Manufacturing a preindustrial precision feeding system for demonstration purposes

The final version of the feeder prototype had enhanced some points:

- The mechanical structure was modified by reducing the thickness of a part of the geometry, simplifying some structural parts, and replacing screws (used in the first prototype) by rivets and welding.



- The design of the electronic hardware that manages all the processes in real-time. The communication board provides a user interface and a wireless connection.



- The feed outlet was made of a PVC tube instead of metal, and was modified to offer protection at the feed outlet.
- The doors, by simplifying the design.

2.2. Equipment installation, operation, and training

The installation of the Precision Feeding System at a farm of Gran Suino (Italy) required the following equipment:

- Four Intelligent Precision Feeders (IPF)
- One computer with the feeder control software and the DSS installed.
- Communication via wi-fi with internet access.
- Seventy RFID ear tags and a manual reading device (optional).
- Two feedstuffs with different composition (i.e., low and high lysine concentration).
- Manual scale to weigh the pigs in the control pens and to check the weight measured by the IPF.

The equipment was installed at the farm during the last week of February 2019 and a first trial was planned to start in March 2019.

The IPF models used in the trials are “All-in-One” feeders. The assembly of this type of feeder includes all the sensors, actuators, and other external devices (e.g. the scale to

weigh the pigs) in one structure. Consequently, the installation can be done quicker and easier.

To ensure the communications between the feeders and the computer, an access point was installed because of the long distance between the two components, that are placed in different buildings.

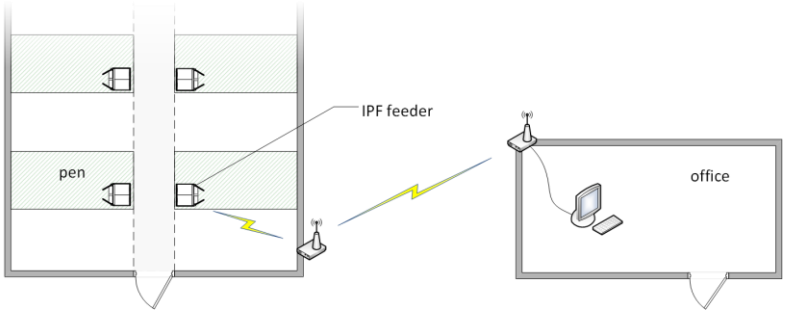


Figure 1. Scheme of the communication components.

Exafan provided ear tags to identify all animals of the trials. A protocol was provided to the staff of the farm indicating the use these tags, registration of the animals, and the management of the information when the animals are weighed manually.

Two additional manuals were provided by UdL. The manual "Installation & Configuration – *IPF server software*" aimed to help the farm staff to set up the parameters of the application controlling the feeder. The manual describes:

- the configuration of the feeders
- the calibration of the hoppers and the weighing scale
- procedures in case of incidences

The manual "Quick user overview – *IPF server software*" describes the management of the controlling software. It describes the main interface of the program and the different tools to control the system. Photos of the installation are given in Annex 6.1.

2.2.1. Monitoring of the real-time precision feeding system

The IPF equipment monitors the main productive parameters in real-time (feed intake and body weight of individual pigs). These traits are used by the DSS and are stored in a database to create reports.

The Controlling Module shows the current status of the IPF feeders. It allows identifying the state of each feeder, the amount of feed provided. With the integrated tools, it is possible to control system parameters such as the dose and the antenna RFID.

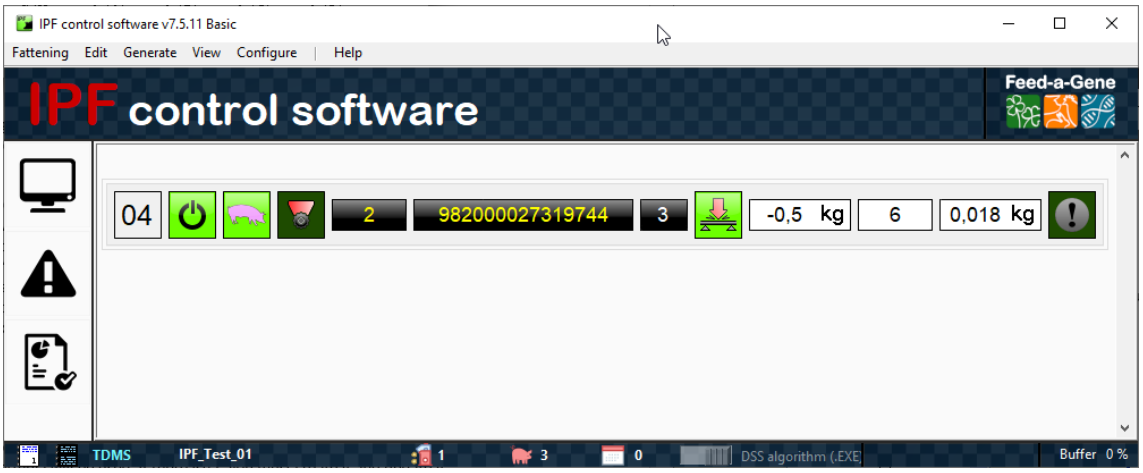


Figure 2. User Interface of the Control Module.

2.2.2. Support assistance

At the beginning of each trial, Exafan provided technical staff to set-up the feeders. Exafan and UdL provided technical assistance to the farm staff, which was provided by email and by remote intervention of the software.

2.3. Trial design, results, monitoring and support assistance

Two fattening cycles (trials) were carried out to perform a comparative analysis of the daily individual precision feeding with a commercial one-phase fattening system.

2.3.1. Trial 1

Trial1 was carried out between March 8 and June 4, 2019.

Table 1. Diet composition of the feeds used in Trial 1.

Group	Feed	%SID Lys	%Crude Protein
Individual precision feeding (IPF)	Diet A	0.981	16.76
	Diet B	0.389	9.49
One-phase feeding (Control)	One-phase	0.817	14.5

Sixty growing-finishing pigs were fed *ad libitum* in the precision feeding group. The two diets of this group are blended by the precision feeder. Both strategies were formulated to provide a diet with the same net energy content (9.78 MJ/kg), but they provided different ratios of standardized ileal digestible (SID) lysine to net energy (SID Lys/NE; Table 1). Consequently, when the proportion of diets A and B changes, a change in the amino content of the diet is induced to account for the lysine requirement, determined daily in real-time for each animal. Based on historical data, the body weight (BW) and

body weight gain (BWG) are forecasted for each pig by the DSS and used to assess the daily amino acid requirement.

Thirty growing-finishing pigs were fed *ad libitum* in the control group with a one-phase feeding program. Traditional feeders were used that distributed the feed provided as mash.

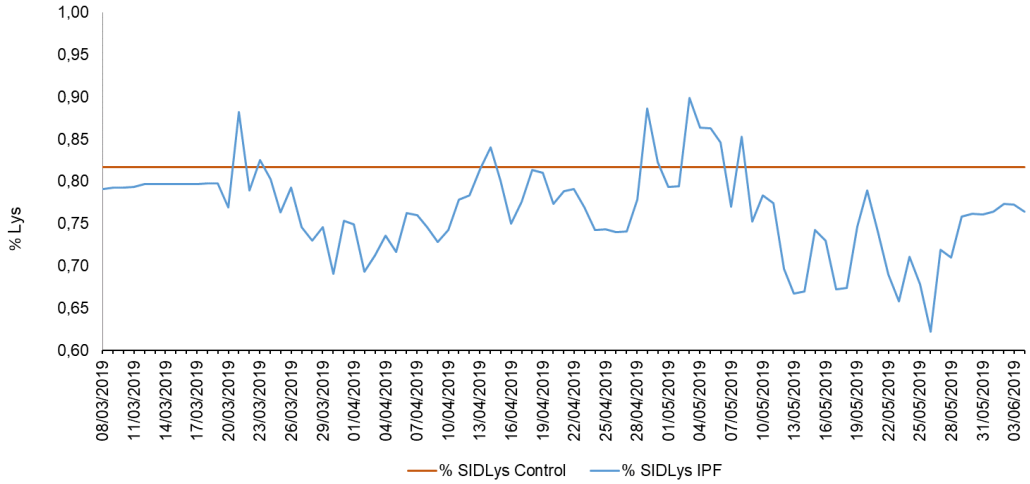


Figure 3. Standardized ileal digestible Lys content (% SID Lys) of the diet provided each day (Trial 1).

For the individual precision feeding group, the daily feed intake was measured individually by each feeding station (i.e., FAB001, FAB002, FAB003, and FAB004). The feed intake by pigs of the Control group was determined by counting the number of sacks of feed used.

Figure 4. Daily feed consumption as determined by the four feeders (Trial 1).

The IPF station can measure daily the weight of the animal, from which the average daily gain was determined. Also, the staff of the farm weighed the animals with a manual scale on days 1, 7, 43, 70, and 89.

Table 2. Body weight measurement and calculated average daily gain (ADG) of pigs fed using an individual precision feeding (IPF) system or a conventional one-phase feeding system (Control) in Trial 1.

	d1 (08/03/2019)	d7 (14/03/2019)	d43 (19/04/2019)	d70 (16/05/2019)	d89 (04/06/2019)	ADG (kg/d)
IPF	40.3	42.9	76.7	105.5	119.2	0.89
Control	34.5	—	67.4	90.4	106.6	0.83

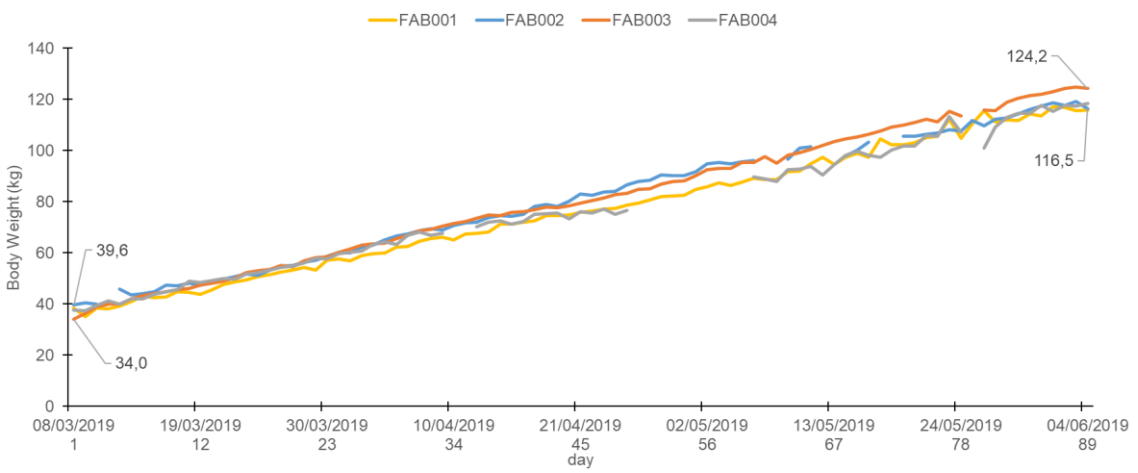


Figure 5. Average body weights of pigs as determined by the four feeder systems (Trial 1).

The occupation rate of the feeder by the pigs for each hour of the day is a trait that can be measured for the behaviour of the group of for the behaviour of individual pigs. A value of 100% means that the feeder is used all the time.

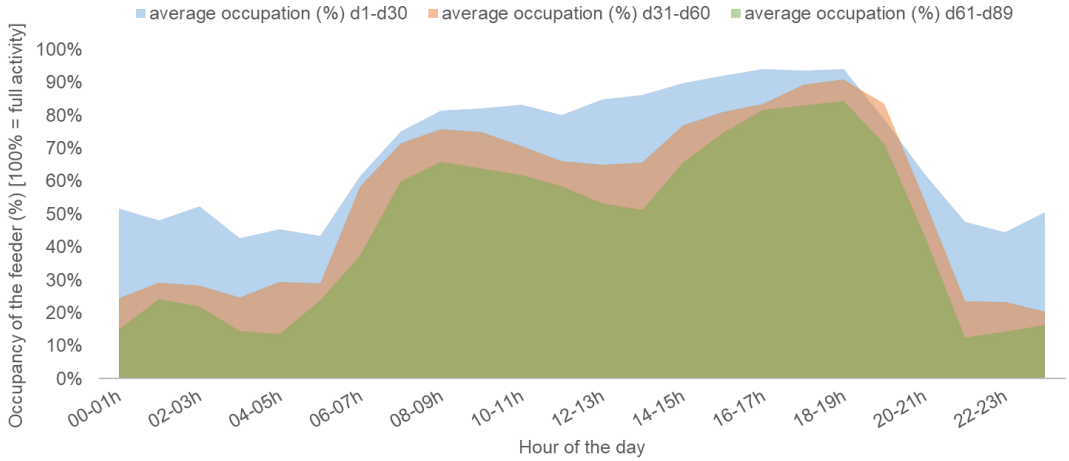


Figure 6. Average feeder occupation rate during different growing-fattening periods (Trial 1).

2.3.2. Trial 2

Trial 2 was carried out from October 4 to December 19 2019 using the same design, feeding strategies, and diets as in Trial 1.

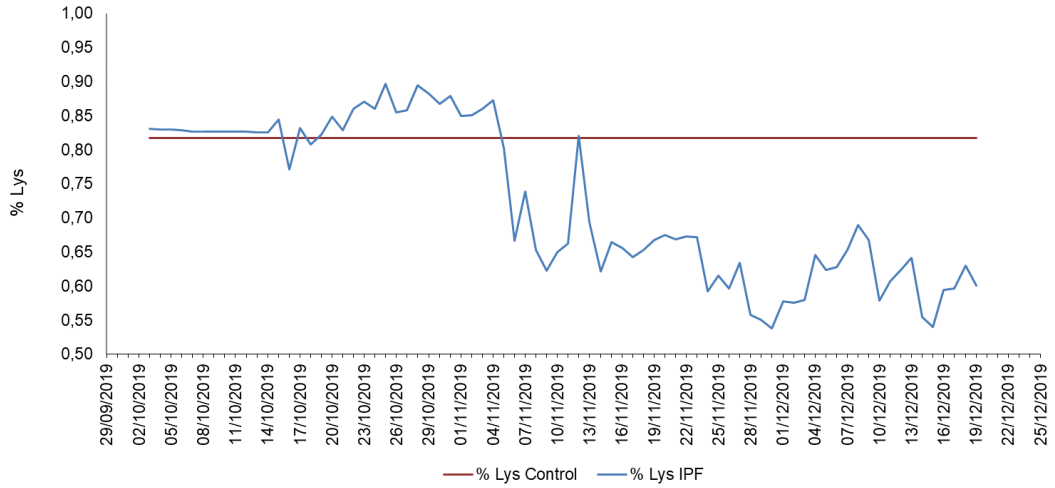


Figure 7. Standardized ileal digestible Lys content (% SID Lys) of the diet provided each day (Trial 2).

The staff of the farm weighed the animals with a manual scale on days 1, 42, and 77 for both groups.

Table 3. Body weight measurement and calculated average daily gain (ADG) of pigs fed using an individual precision feeding (IPF) system or a conventional one-phase feeding system (Control) in Trial 2.

	d1 (04/10/2019)	d42 (14/11/2019)	d77 (19/12/2019)	ADG (kg/day)
IPF	30.7	70.0	103.3	0.94
Control	35.7	70.4	102.1	0.86

Due to a problem with the ear tags, the individual feed consumption and body weight measurements acquired by the IPF station started three weeks after the start of the trial.

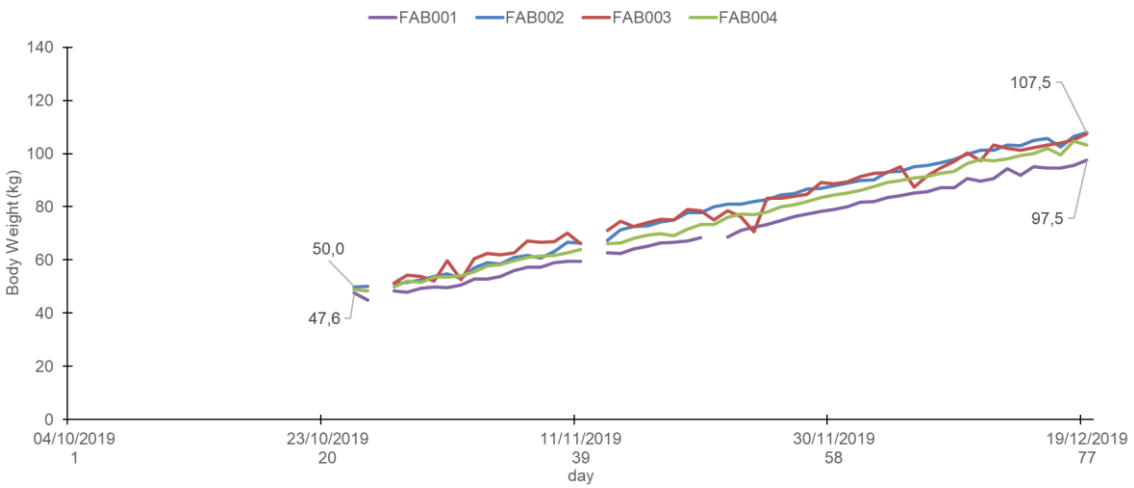


Figure 8. Average body weights of pigs as determined by the four feeder systems (Trial 2).

Figure 9. Daily feed consumption as determined by the four feeders (Trial 2).

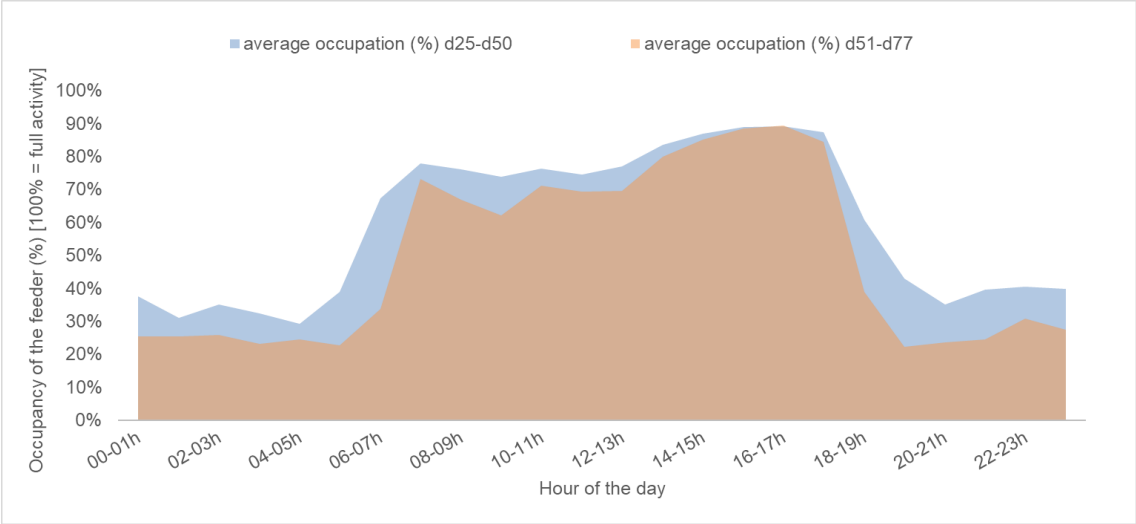


Figure 10. Average feeder occupation rate during different growing-fattening periods (Trial 2).

2.4. Demonstration activities organized by Gran Suino Italiano, an interprofessional organization

2.4.1. About Gran Suino Italiano

The Gran Suino Italiano (GSI) interbranch organization was created in 2012 by the initiative of members of the swine supply chain (i.e., breeders, packers, and meat processors) in the Emilia Romagna Region, located in the North of Italy. The aims of the organization are:

- To improve knowledge and the transparency of production and the market
- To improve the forecasting of the production potential
- To better coordinate the way pigs and their products are placed on the market
- To draw standard forms of contracts
- To develop initiatives to strengthen economic competitiveness and innovation

- To seek ways of better to manage inputs, ensuring product quality and soil and water conservation, promoting food safety, in particular through traceability of products, and improving animal health and welfare
- To encourage healthy and responsible consumption of the swine products

In the Feed-a-gene Project, one of the members of the association agreed to take part in the demonstration activity and to share his experience and the results of the trials with other farmers operating in the swine sector.

The farm chosen for the demonstration activity is a swine farm located in Parma (in the heart of Emilia Romagna Region) with around 850 breeding pigs.

2.4.2. Open days

Date	Venue	Participants	Activities
May 14, 2019 (Annex 6.2.1)	Farm "Campo Bò" located in Montechiarugolo (Parma)	members of Gran Suino Italiano; farmer members of Confagricoltura agricultural trade union.	Tour of the facilities in which the precision feeding system was installed. The farmer was in charge of the demonstration. Participants had the opportunity to assist in the daily functioning of the prototype and to analyse data from the DSS together. During the meeting, they discussed about the strengths and weaknesses of the system.
June 7, 2019 (Annex 6.2.2)	Modena (Gran Suino Italiano organization meeting)	Breeders involved in international research projects; officials from the Emilia Romagna Region.	Virtual tour[1] of the farm, presentation of the Feed-a-gene project and a discussion about the partial results of the demonstration.
February 3, 2020 (Annex 6.2.3)	Modena (Confagricoltura meeting on the swine sector)	Breeders involved in international research projects; researchers from the University of Bologna.	Virtual tour of the farm, presentation of the Feed-a-gene project and a discussion about the portability of the prototype in the Emilia Romagna area.

[1] Due to sanitary precautions, the farmer in charge of the demonstration requested to limit the number of visitors in the farm. Other Open Days have been organized showing the demonstration through a previously recorded video.

2.4.3. Video recording of the demonstration activity

The video, with English subtitles, shows the functioning of the prototype in a real situation and the specific context of the Emilia Romagna Region (https://www.feed-a-gene.eu/media/precision-feeding-system-demonstration-a-commercial-pig-farm). The video starts giving inside of the context in which the demonstration activity was conducted: an intensive swine farm located in the heart of the Italian food valley. It continues with an overview of the farm based on three pillars: profitability, productivity, and sustainability. The video shows an interview with the farmer involved in the demonstration, who explains the reasons why he decided to take part in the project. The main motivation was the opportunity to obtain information on every individual animal in a real-time. The farmer underlines the advantages of the new feeding system such as the diminution of aggressivity of pigs when feed is available *ad libitum* and the possibility to adapt the diet of animals to reduce the protein intake and, consequently, to improve the ecological footprint. In the second part of the video, the technician in charge of the daily activity in the farm highlights the strengths and weaknesses of the system. Among the strong points, she underlines the possibility to have accurate periodic reports and access to real-time data that permit to the farmer to make decisions about single pigs. Among the weaknesses, she points out that the machine does not work with liquid feed, which is the typical way fattening pigs are fed in the Emilia Romagna Region.

Video 1. Demonstration of the precision feeding system in a commercial farm in Italy.

2.4.4. Information in the press

Two articles about the demonstration activity in Italy will be published at the end of the project in a national specialist magazine for swine breeders (Rivista di Suinicoltura; https://suinicoltura.edagricole.it/). The first article concerns the demonstration of the

system in the context of the Feed-a-Gene project and second article will be an interview with the farmer involved in the demonstration.

2.4.5. Results and conclusions

Dissemination activities linked to the demonstration of the Prototype in a commercial pig farm in Italy has a threefold effect:

- **Boosting the interest of decision-makers on farmers involved in the Research and Innovation Project**. During the meeting, the main question was how to arise the number of producers involved in this kind of project. A suggestion was to recognize the effort of these producers in the evaluation grid of Regional calls.
- **Strengthening the research network of Gran Suino Italiano in the project:** the Gran Suino Italiano Interbranch Organization has been involved in other research projects concerning the swine sector both at a regional and international level. The goals and results of the Feed-a-Gene project have been spread by Gran Suino Italiano among the members of its network increasing the interest on the subject.
- **Improving the willingness of agricultural producers to join Research and Innovation Projects:** the interaction between the farmer involved in the demonstration and other farmers was useful to convince them about the advantages to be part of an innovation project and, in general, to help researchers to adapt their findings to real situations through demonstrations in the field, such as in a commercial farm.

Feed-a-Gene, as a multi-actor Horizon 2020 Research and Innovation Programme project, required a strong interaction between different actors (research, industry, and farmers). This requirement has been appreciated by the members of Gran Suino Italiano organization, because they affirmed that too often in the past, academic activities were not applicable in real situations. The Italian demonstration study shows that is very important that entrepreneurs with a solid academic background exchange with researchers. The potential reduction in income for the producers who take part in the project has to be considered as a cost to the project to facilitate the involvement of producers in these projects.

3. On-farm demonstration of a precision feeding system for growing pigs under restricted feeding conditions

The precision feeding prototype was set up in the demonstration farm of IFIP. It was used first to refine the DSS and for demonstration activities thereafter. Demonstration activities consisted mainly of demonstration trials that started in September 2018. These trials were supposed to be completed by January 2020 but an additional batch of pigs started its fattening period on that months and will be available for visits up to month April 2020 (i.e., two months after completing the project). Visits have been organized for demonstration purposes since the beginning of 2018.

3.1. Description of the precision feeding system used at IFIP

In France, most pigs are restrictively fed because of the incentive carcass payment grid to have lean pigs. A precision feeding prototype was designed and tested that allows restricting the feed allowance. The precision feeding system has been described in Deliverable D4.5. Most of the characteristics of the feeder are like the system developed for *ad libitum* feeding. The main difference is related to the organization of the pen so that the access to the feeding area by individual pigs is controlled. The system is designed to keep pigs that have consumed their daily feed allowance away from the feeding area, to avoid stealing behaviour from pigs that have already consumed their daily feed allowance. The room is divided into three specific areas on a concrete slatted floor: a feeding area, a sorting area, and a living area (Figure 11). Control of access to the feeding area is done by a sorting-weighing (SW) device. The SW device and precision feeders are all connected to a computer equipped with the controlling module and the DSS.

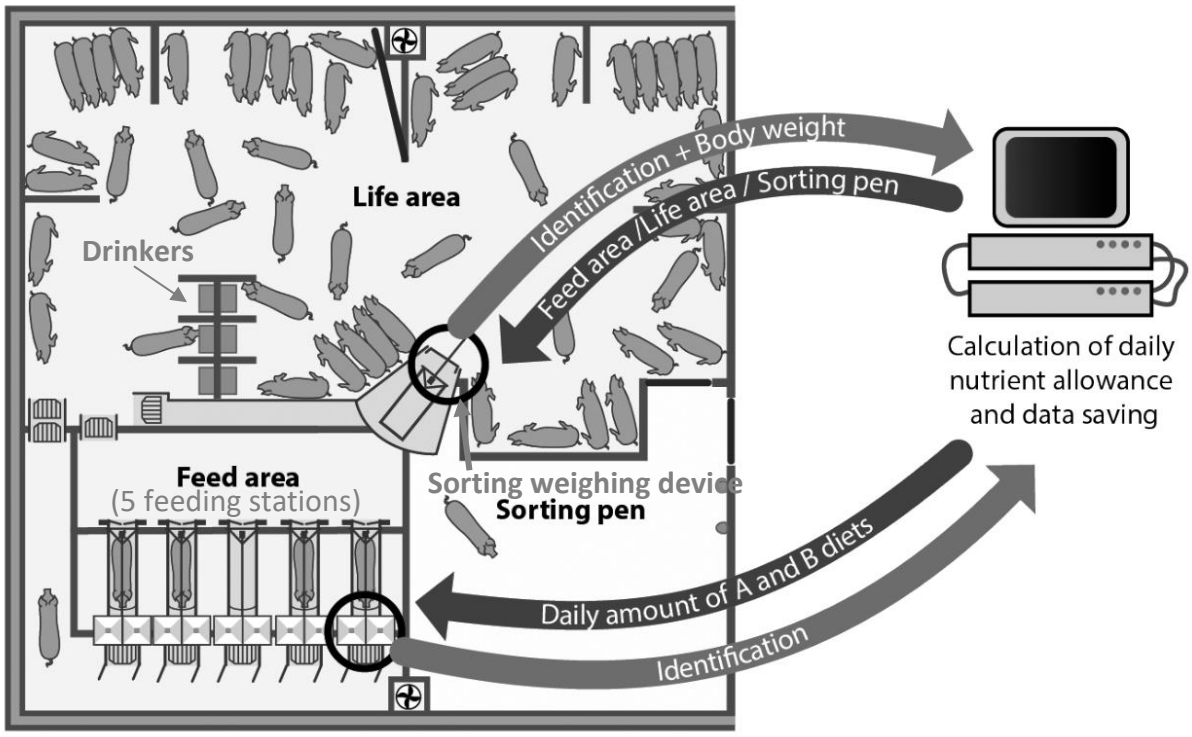


Figure 11. Design of the room, location of devices and, connection to the computer (with the controlling module and the DSS).

Specifications of the precision feeders were co-designed by IFIP and the equipment manufacturer ASSERVA (Lamballe, France). This company is not a partner of the Feed-a-Gene program, but it is interested in the way its devices can be used in a whole system. Devices are connected to a computer equipped with the DSS and the controlling module developed with other partners involved in the project (i.e., INRAE, UdL, IFIP).

3.2. Demonstration trials

3.2.1. General information

Three batches of growing-fattening pigs have been used for the demonstration trials. In each batch, pigs were allocated to different feeding strategies. The reference consists of a 2-phase feeding strategy (2P), which was compared to a multiphase feeding strategy implemented either at the individual level (MPi) or at the group level (MPg).

Two diets were used and blended by the precision feeder. Both were formulated on the same net energy basis (i.e., 9.75 MJ/kg), but they had different ratios of standardized ileal digestible lysine to net energy (SID Lys/NE). The SID Lys/NE is 1.0 in diet A and 0.6 in diet B. Consequently, when the relative proportion of diets A and B changes it induces a change in the amino content of the diet fed to the pigs. For group MPi, the proportion of diets A and B was adapted daily to the amino acid requirements of each pig. Based on previously recorded data, their body weight (BW) and body weight gain (BWG) were forecasted by the DSS and used to assess their amino acid requirement. For group 2P, the diets were mixed in a constant proportion supplying 0.9 g SID Lys /MJ NE during the growing phase and 0.8 g SID Lys/MJ NE once the average group weight was 65 kg BW.

The feed restriction plan corresponded to a supply of feed that initially represented 4% of BW. Afterwards, it was increased by 27 g/d up to 2.40 kg/d for gilts and up to 2.70 kg/d for barrows.

When daily BW data were collected for each pig, the successive values can fluctuate, and the recorded BW change (BWdiff) from one day to another does not necessarily correspond to the actual growth rate of the pig. In the DSS, the difference in recorded BW was considered only when it ranged between a minimum and maximum value. The minimum value (BWGmin) was obtained by linear regression of BW over the last 20 days. The maximum value (BWGmax) was based on BWGmin multiplied by a constant value (C). Investigations on the value of C were performed during the successive demonstration trials.

3.2.2. Batch 1

Batch 1 (N° 507 as referred to in the farm) was performed between September 18, 2018 and January 22, 2019. Two strategies were compared: 1P vs. MPi, with C = 1.05.

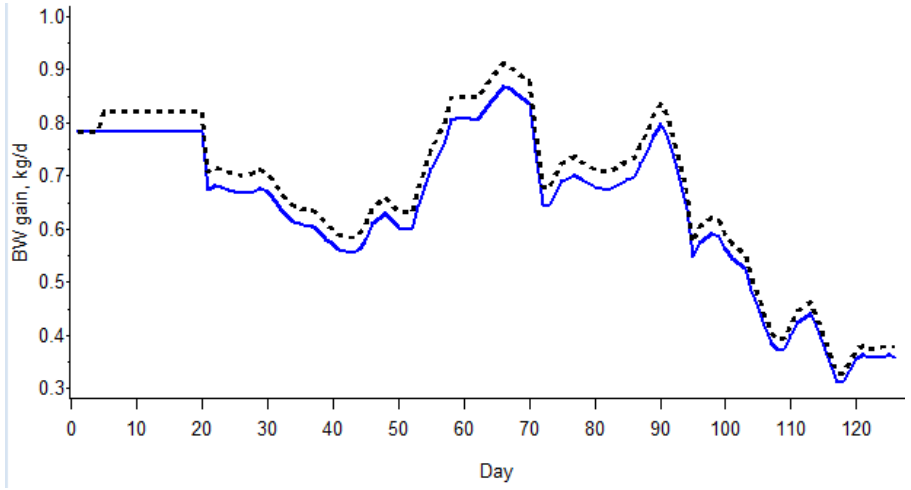


Figure 12. Average body weight gain based retained each day for individual multiphase feed of pigs on the individual minimum (continuous line) and maximum body weight values (dotted line, = 1.05 x maximum; (batch 1).

The forecasting procedure for BW failed after d20 for 10 pigs and after d38 for 9 pigs. This problem was due to the weighing device that considered the measurement as an outlier when it differed by more than 5% compared to the average BW recorded on the previous day. Subsequently, these pigs did not have enough available historical data to implement the forecasting method of BW after d20. This problem was solved when the threshold value used to check the quality of the measurements was increased to 10%. As the assessment of the amino acid requirement was performed on wrong forecasted values of BW for these 19 pigs, they were not considered in the analysis of the results.

Based on the data collected by the DSS, it is possible to detect problems with the feeders (e.g., feeder N° 2 in Figure 13 between d36 and d41) or with a pig (Figure 14).

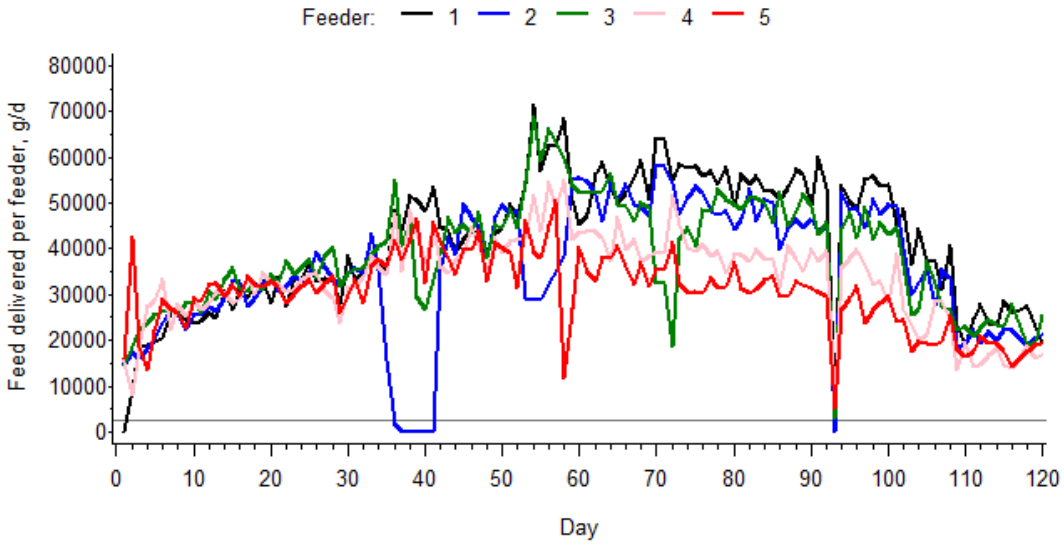


Figure 13. Cumulated daily quantity of feed delivered by each of the five feeders (batch 1).

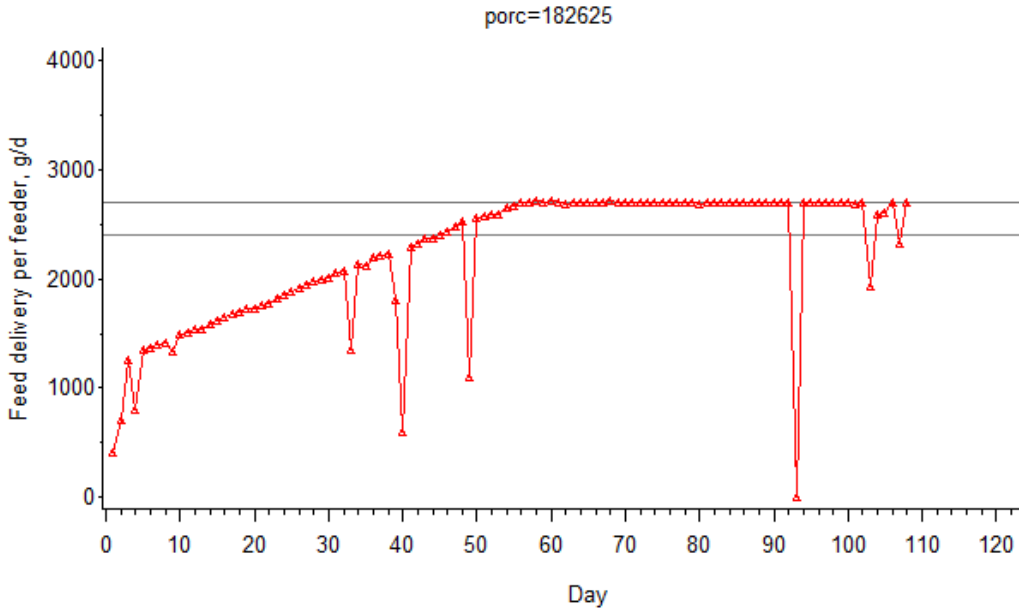


Figure 14. Cumulated amount of feeds delivered to pig 182625 (batch 1).

The quality of the blend delivered to each pig each day (black line in Figure 15) can be compared to the expected blend, expressed in the ratio between SID Lys and NE calculated from the relative amounts of diets A and B consumed. Figure 15 presents the results obtained for a pig from group 2P (left panel) and a pig from group MPi (right panel).

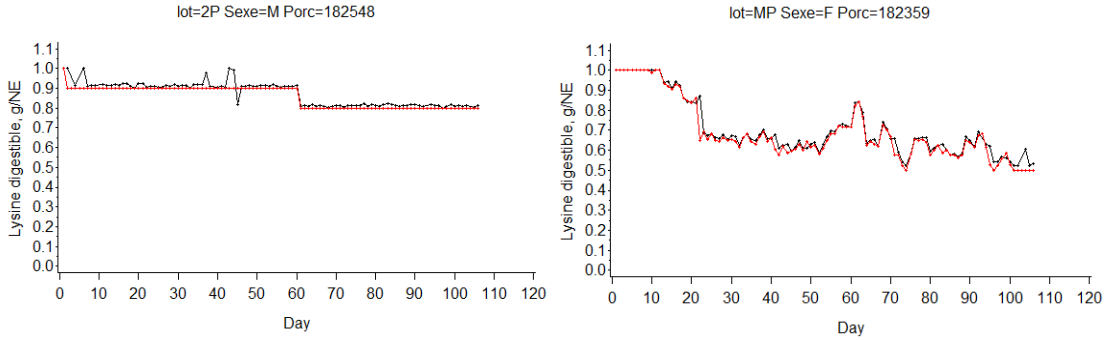


Figure 15. Quality of the blend (expressed in grams of standardized ileal digestible lysine per MJ of net energy, SID Lys/NE) evaluated from the amounts of diets A and B consumed and their respective SID Lys/NE ratio. Example of a pig from group 2P (left panel) and a pig of group MPi (right panel). The expected value is given in red and the observed value in black (batch 1).

Overall, the quality of the implemented blend met the expected values calculated by the DSS, as illustrated in Figure 16.

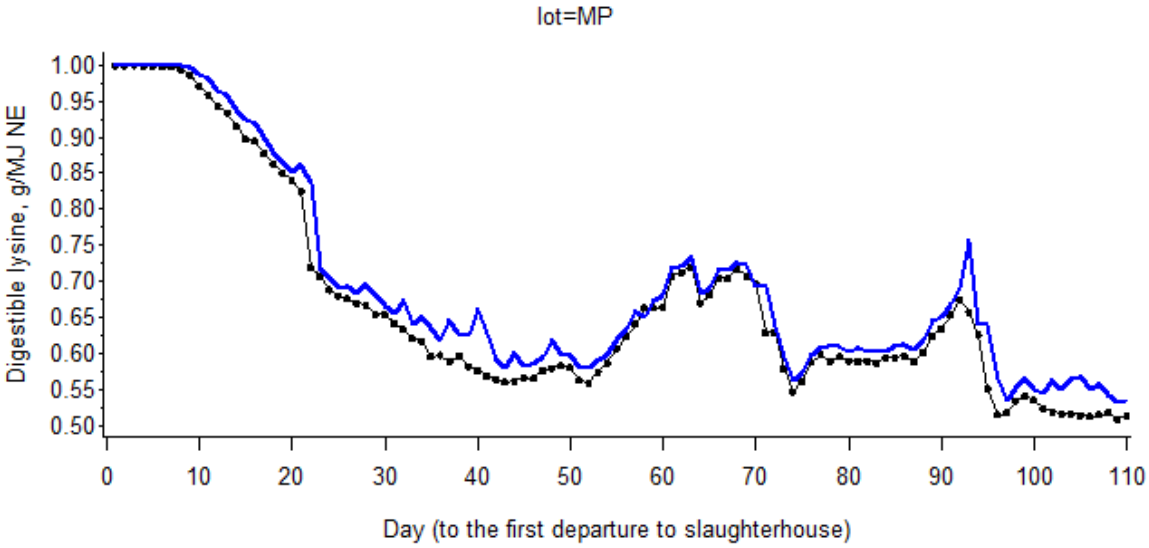


Figure 16. Average standardized ileal digestible Lys to NE ratio of the blend delivered to the pigs of group MPi (continuous line) compared to the expected value (dotted line).

3.2.1. Batch 2

Batch 2 (N° 517 as referred to in the farm) was carried out between February 12, 2019 and June 4, 2019. Three strategies were compared: 2P vs. MPg vs. MPi, with C=1.10.

3.2.2. Batch 3

Batch 3 (N° 526 as referred to in the farm) was carried out between June 20, 2019 and October 20, 2019. Strategies implemented were similar to those used in batch 2, with C=1.10. Average growth performance was reduced due to the severe heat stress that occurred late June, July, and late August.

Data collected on pigs from batches 2 and 3 are available, but calculations have been finalized yet.

3.3. Open days and visits

One hundred eighty-five visitors from various origins visited the rooms equipped with the precision feeding system for pigs during the demonstration trials. The list is mentioned below.

Date	Number	Origin
18/01/2018	2	Visitors from the equipment manufacturer Asserva
15/02/2018	3	Visitors from the equipment manufacturer Asserva
28/02/2018	9	Students in agriculture
06/04/2018	6	Economists (IFIP team)
24/05/2018	15	French legal controllers of pig farms
27/06/2018	4	Visitors from the equipment manufacturer Asserva
04/09/2018	4	Geneticists from an organisation of pig production
09/11/2018	4	Visitors from the equipment manufacturer Asserva
28/11/2018	4	Agricultural chamber of Brittany (France)
14/01/2019	4	Smartfarm
08/02/2019	6	Smartfarm
25/02/2019	2	French legal controllers in pig farms
28/02/2019	1	Journalist of Porc Magazine
07/03/2019	30	French technical institutes (ACTA)
28/03/2019	5	Visitor of the Kersia company'
24/04/2019	4	Visitors from the equipment manufacturer Asserva
02/05/2019	4	Adventiel informaticians
16/05/2019	9	Students
16/05/2019	20	French legal controllers
10/08/2019	2	Students (trainee period at IFIP)
09/09/2019	10	University of Ghent (Belgium)
16/10/2019	11	Italian visitors
05/11/2019	9	Veterinary school Alfort/Nantes
27/11/2019	10	Pig farmers
27/01/2020	7	France Futur Elevage (Carnot institute)
Total	185	

Photo 1. A group of visitors at the IFIP facility for precision feeding used with restricted feeding conditions.

4. Feed-a-Gene final conference: demonstration activities for stakeholders

The demonstration activities took place during the final conference of the Feed-a-Gene project on January 22 and 23, 2020 at the Hotel de Rennes Métropole, in Rennes (France). One hundred forty-six people attended the meeting, half of which were external stakeholders.

4.1. Demonstration activity about precision feeding for growing pigs fed *ad libitum*

The demonstration activity was organized in the hall just outside the main conference room. The area dedicated to WP4 activities included the following elements:

- A precision feeding system for growing pigs from Exafan was installed in the hall. It included the feeder, software, and the controlling hardware in operation. A real-size plastic pig made the area highly visible and attractive for visitors.
- A 43" video screen showing 3 videos related to precision feeding:
  - A video presenting the prototype of the precision feeding system for growing pigs (INRAE, IFIP, 4 min 26 s)
  - A video presenting the prototype of the precision feeding system for growing pigs, and the installations at the IFIP experimental station (IFIP, 8 min 34 s)
  - A video presenting the precision feeding system for growing pigs installed in the Campo Bo farm in Italy (Gran Suino Italiano, 7 min 43 s)
- 5 posters:
  - Gaillard *et al.*: Dynamic modelling of nutrient use and sows' individual requirements
  - Guyot *et al.*: Towards precision feeding in laying hens: Update of a mathematical model to predict daily calcium and phosphorus flows
  - López *et al.*: Operational precision feeding systems: main components and integration
  - Quiniou: Precision feeding of restricted-fed pigs
  - Jansman *et al.*: Precision feeding in growing-finishing pigs

The area was always open to the public during the conference (including to visitors who did not participate in the meeting). The main demonstration took place on January 22 between 14h00 and 16h30 during a dedicated "Discoffeery" session. Staff from Exafan, UdL, INRAE, IFIP, IRTA, and Gran Suino were present at the booth to discuss the functioning of the system with participants.

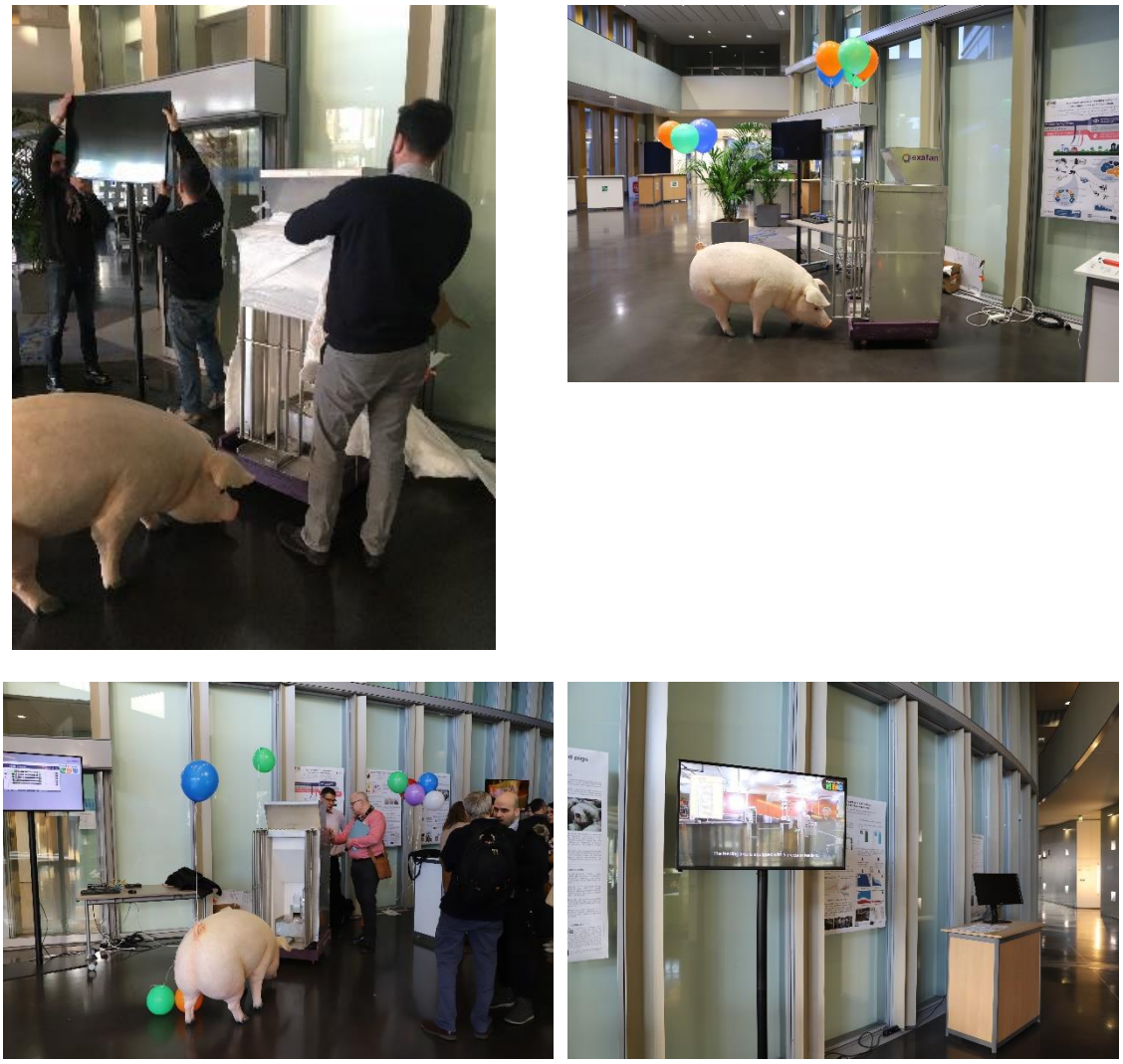


Photo 2. Demonstration activity at the final Feed-a-Gene conference in Rennes. Installation of the feeder (top left), demonstration area with the precision feeding system and a plastic pig top right), discussion with stakeholders and Jesús Haro of Exafan (bottom left), video screen and posters.

4.2. Workshop sessions

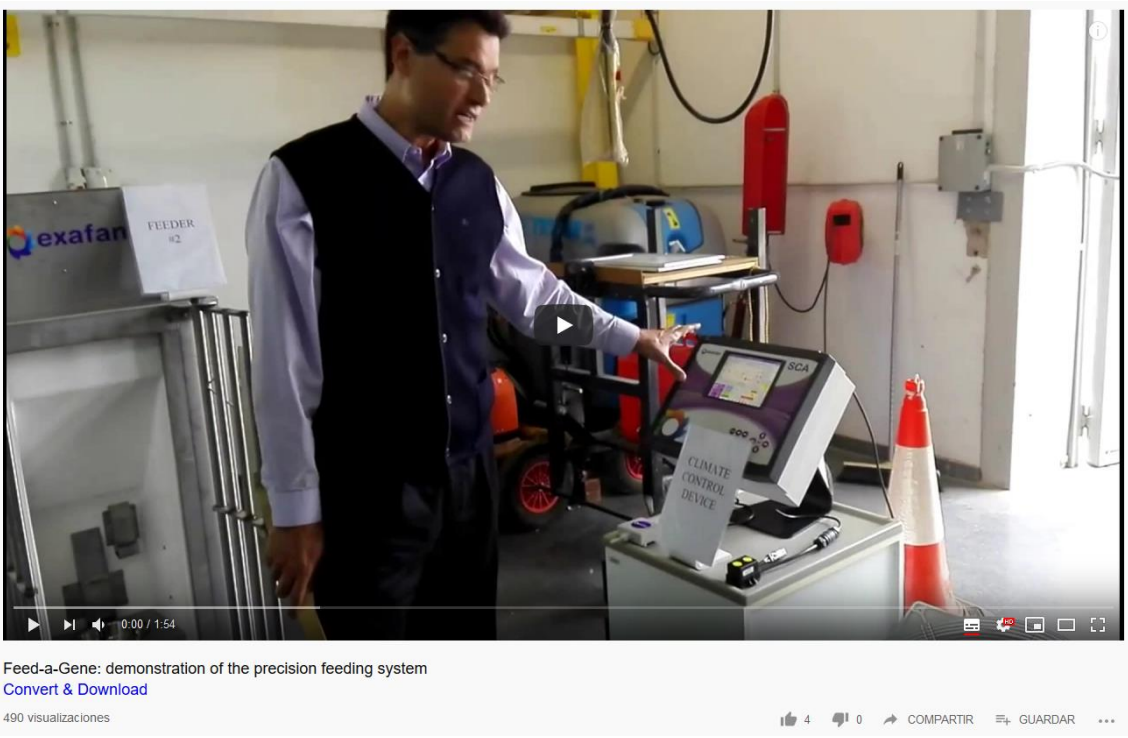
The results on precision feeding were discussed during four dedicated workshop sessions entitled “Novel feeding technologies: precision feeding” that took place on January 23 from 9h00 to 10h30. The sessions were moderated by staff from WP4 partners and members of the Stakeholder Advisory Board. All participants of the conference participated to one of the four sessions. The sessions aimed to develop a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) with the stakeholders. Aspects of the strengths and weaknesses were identified beforehand by staff of WP4, and amended by the participants during the workshop. Opportunities and threats were identified by the participants. The outcome of the SWOT analysis was presented in the plenary session (annex 6.3).

Photo 3. Workshop on precision feeding technologies at the final Feed-a-Gene conference in Rennes. Workshop session developing the SWOT analysis of precision feeding technologies led by Jean-Yves Dourmad of INRAE (left) and presentation of the SWOT analyse during the plenary session by Bertrand Méda of INRAE (right).

5. Other demonstration activities

5.1. Demonstration of the feeder system during the 2nd annual Feed-a-Gene meeting held in Lleida, Spain

A video was developed during the second annual project meeting on how the precision feeder system works (https://www.youtube.com/watch?v=JKx3RCJBg04&vl=fr).



Video 2. Demonstration of the precision feeding system by Jesús Haro (Exafan).

5.2. Concept and theoretical basis of precision feeding

Two videos have been created by IFIP, INRAE, and Exafan (in collaboration with Asserva, a partner of IFIP but not involved in the Feed-a-Gene project) explaining the concept and the functioning of precision feeding systems. The video describing the concept is available from https://www.youtube.com/watch?v=Z8OzNeBZoNs and https://www.youtube.com/watch?v=mSeUsrpZ810 has a duration of 4 min and 26 s and has been viewed almost 1500 times since September 19, 2018. The video about the functioning of a prototype of a precision feeder is available from https://www.youtube.com/watch?v=K8cbY1zPT2k. and has been viewed over 100 times.Both videos have been subtitled in English for use at the final Feed-a-Gene conference (Section **Erreur ! Source du renvoi introuvable.**).

Video 3. Concept of precision livestock feeding systems.

Using pictures and graphs, the video presents the concept of precision feeding of growing pigs, both in *ad libitum* and restricted feeding conditions. It includes the work that has been performed to manage in real-time the data collected from the devices, the forecasting method, and the prediction of the nutritional requirement. It also shows how the quality of the blend is adapted to each pig each day.

5.3. Interview with Ludovic Brossard, INRAE

Ludovic Brossard was interviewed during the professional SPACE fair (September 15-18, 2018, Rennes, France) on the potential of precision feeding systems for growing pigs. The video is available from https://www.youtube.com/watch?v=61PKmZ4FMrM

and https://www.youtube.com/watch?v=cy44N-1pZ6U) and has been viewed more than 50 times since March 2019.

Video 4. Ludovic Brossard (INRAE) explains to the visitors of the SPACE fair in Rennes the potential of precision feeding systems for growing pigs.

5.4. Videos prepared for the final Feed-a-Gene conference

5.4.1. Video of the theory on precision feeding

A video (https://www.youtube.com/watch?v=wPPrH-TFAws in French with English subtitles) was prepared by prepared by INRAE and IFIP to present the concept and the theoretical basis of precision feeding implementation. It was released and shown at the final conference at Rennes.

5.4.2. Video of the on-farm demonstration activities

The video https://www.youtube.com/watch?v=TvbZA_fb49Q (in French with English subtitles) was by IFIP and has a duration of 8 minutes 34. Nathalie Quiniou (IFIP) explains how precision feeding is implemented in the IFIP demonstration farm.

5.5. Visits at INRAE

Visits were organized at INRAE (Unité Expérimentale Porcs de Rennes, UEPR) to show the experimental devices used for the development and tests of precision feeding for

growing pigs fed *ad libitum*. During these visits, the principles of precision feeding were explained and the functioning of the systems was demonstrated.

Date	Number	Origin
10/01/2018	13	Students in agriculture
29/01/2018	17	Students in agriculture
09/03/2018	40	Students in agriculture
21/08/2019	2	University of Melbourne (Australia)
16/01/2020	30	IFIP and INRAE colleagues
Total	102	

5.6. Presentations at conferences

Ludovic Brossard (INRAE) explained the work performed on precision feeding during an invited presentation at the FeedAdditives Global Event dedicated to professionals in feed ingredients from around the world (September 26-28, 2018, Amsterdam, the Netherlands). Results from experimental tests performed at INRAE for precision feeding of growing pigs fed *ad libitum* were presented by Ludovic Brossard at the 70th Annual Meeting of EAAP (oral presentation, August 26-30, 2019, Ghent, Belgium). Ludovic Brossard and Nathalie Quiniou (IFIP) both presented posters at the 52èmes Journées de la Recherche Porcine (February 4-5, 2020, Paris, France). The principles, the material, and results for precision feeding of growing pigs fed *ad libitum* were also orally presented by Ludovic Brossard during “Défis scientifiques” days of INRAE Phase Research Division (November 6-8, 2019, Rennes, France).

6. Annexes

6.1. Photos of the installation of the individual precision feeding system in Italy for the demonstration trials.

Four stainless individual precision feeders were installed in Italy.

Motherboard based on a microprocessor that controls all the sensors and actuators of the feeder.

The office of the farm was located far away from the pens in which the pigs are housed. It required to install an access point was installed to ensure a connection between the office and the pen.

Rear view of the feed where the Wi-Fi antenna allows the feeder to communicate with the computer.

Front view of the individual precision feeder

Lateral view of the individual precision feeder.

The animals got used to feed from the individual precision feeder since the first day.

The individual precision feeder can provide two different diets to each animal.

6.2. Open days organised by the Gran Suino Italiano Interbranch Organization

6.2.1. First Open Day.

Attendance sheet

Confagricoltura Emilia Romagna

Feed-a-Gene

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

	Ser Suinicola 14/05/2019	
Nome e Cognome	**Provincia**	**Firma**
ANDREA ANTONIACCI	FC-RN	
CARLOANDREA SARTORI	PARMA	
GIOVANNA PARMIGIANI	PC	
GIORGIO MAZZACANI	R.E	
GIANNI TOSI	BOLOGNA	
GUGLIELMO GOLINELLI	MODENA	
CAVAZZUTI ANDREA	MODENA	

Photos of the first Open Day

6.2.2. Second Open Day

Attendance sheet

Feed-a-Gene

WP4 Open Day at Modena/ 7th June 2019

FEED A GENE - WP4

OPEN DAY FEEDING PRECISION SYSTEM

LIST OF PARTECIPANTS

7th JUNE 2019

Partecipant	Organization/University/Company	Signature	Email
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Photos of the second Open Day

6.2.3. Third Open Day

<u>Attendance sheet</u>

Feed-a-Gene

WP4 Open Day at Modena/ 3rd February 2020

FEED A GENE - WP4

OPEN DAY FEEDING PRECISION SYSTEM

LIST OF PARTECIPANTS

3rd February 2020

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[illegible]	Elena		Mediatore	[illegible]			WERISAN - NOVELLO[illegible]
				[illegible]			
LUPPI	FRANCESCO		ALLEVATORE	[illegible]	x	x	[illegible].it
[illegible]	CARLO		INDUSTRIA	[illegible]	x		[illegible]
FRANCHI	LUIGI	PROGEO	VETERINARIO	[illegible]	x	x	[illegible]
SCHEDONI	ANDREA	MSD AH	AGENTE D. COM	[illegible]			
GRISENDI	PAOLA	Az. Agr. Bucchelli	Contitolare impresa	[illegible]	x	x	impbucchell@yahoo.it
LUPPI	Gaetano	Soc. AGR. S.ANNA SRL	SUINI INGRASSO	[illegible]	x	x	societa@agricolasanna-191.it

Photos of the third Open Day

6.3. Strengths, Weaknesses, Opportunities and Threats for precision livestock feeding systems identified with stakeholders during the final Feed-a-Gene conference (Rennes, January 22-23, 2020).

Item	Strengths	Weaknesses
Equipment for precision feeding	- Growing pigs: Specific devices developed and validated in experimental and commercial farms (e.g., “all-in-one” device) - Broilers: Combining existing devices for implementing precision feeding PF in broiler farms - (e.g., weighing scales and mixing hopper) - Sows: Commercial devices or prototypes used in experimental farms for implementing precision feeding of in pregnant and lactating sows - Real-time monitoring of performance traits at the individual or group level - Open and high-level communication language developed to integrate - multiple hardware devices (sensors) and software	- Pigs and sows: precision feeding systems are not available for liquid feed systems (e.g., for the demonstration farm in Italy) - Broilers: precision feeder using existing devices not tested in commercial farms - Sows: precision feeders not tested yet in commercial farms - with the DSS developed in Feed-a-Gene - Real-time = lots of data! - Precision feeding systems = complex systems comprising multiple and heterogeneous hardware and software components
Decision Support System (DSS) and real-time models	- “Light” DSS models = low computational power requirement - Few input data required - to implement precision feeding in practice (e.g., body weight and feed intake for ad libitum fed pigs) - DSS based on up-to-date nutritional models at the individual or group level - Genetic potential of animals can be considered in DSS (e.g., growth, protein deposition, feed intake, breeding value)	- Daily computations and decisions - (possible interest of shorter time steps to be evaluated) - Perturbations not yet considered - in real-time prediction models - Other data available on farms - not yet integrated in the DSS (e.g., temperature, physical activity)

Interest and social acceptance	- Higher nutrient efficiency:
	  - Lower N and P excretion
	  - Lower environmental impacts
	- Increase nutrient efficiency: lower feed cost
	- Broilers: Interest of precision feeding systems demonstrated in experimental farms
	- Pigs: Interest of precision feeding systems demonstrated in commercial farms for growing pigs and in experimental farms for sows
		- Actual environmental impacts
		- not measured (i.e., “only” calculated)
		- Return on investment not calculated
		- Sows and broilers: Interest of precision feeding not demonstrated in commercial farms
		- Economic and environmental interest evaluated from simulations
		- Perceptions on precision feeding
		- by citizens and consumers
		- not evaluated

Item	Opportunities	Threats
Supply chains	- Consequences of PLF on supply chain activities (e.g., new approach of feed formulation?) - Compromising the different objectives of stakeholders at the chain level?	- Consequences of PLF on supply chain activities (e.g., new approach of feed formulation?) - Compromising the different objectives of the stakeholders at chain level?
Technology	- Integrate new/available information to generate more value (temperature, health…) - Adaptability to all technologies, devices, and production systems	- More data/equipment implies more complex/complicated systems - Robustness & lifetime of equipment
Data	- Data organization, management, and sharing	- Data ownership
Economy	- Higher resource efficiency	- Return on investment?
Environment	- Higher resource efficiency	- Environmental impacts of data and technology (e.g., servers, chips)
Social acceptance	- Farmer: “sexy” jobs (= “geek farmers”) - Time saving? - PLF could be adapted to a diversity of systems (conventional or alternative)	- Difficult fit to “society/consumer” expectations (i.e., expectations evolution) - Natural farms vs. artificial ones? - Simple vs. smart and complex farming systems
Welfare	- More efficient perturbation detection - Opportunities for “improved welfare” housing systems - Improved “feeding welfare” (e.g., sow body condition)	- Possible negative behavior (e.g., increased competition to access the feeder)
Communication	- Economic and environmental benefits as “positive points” for communication - Integrate PLF in a global communication strategy (livestock farming is “good”)	- Technology-centered communication