Six factsheets presenting the results of the six R&D WPs of the project to be used during the final stakeholder meeting

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FEED-A-GENE

Adapting feed, animals and feeding techniques for more efficient and sustainable monogastric livestock production systems

Deliverable D7.7

Six factsheets presenting the results of the six R&D WPs of the project to be used during the final stakeholder meeting

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Table of contents

1 Summary

This deliverable includes six factsheets presenting the results of the six R&D work packages of the Feed-a-Gene project. For each WP, the content of corresponding factsheet was established by the WP leader with contributions of the researchers involved in the WP. The factsheets were reviewed by the project coordinator and their design and final layout created by AFZ, who also organized the printing and the distribution of the factsheets. The factsheets will be distributed in hardcopy to the participants of the final stakeholder meeting that will take place on 22-23 January in Rennes, France. They will also be provided online on the project's website.

2 Factsheets

2.1 Introduction

The Feed-a-Gene project is coming to its term and, at the time of writing this deliverable, most of the work has been carried out. It is then possible to propose a recapitulative and prospective presentation of the work done during the 5 years of the project.

One factsheet was made for each WP. Each factsheet consists in an A4 recto-verso leaflet. The front page presents the general challenge that the WP was addressing, and the solutions found to solve this challenge. The back page presents in more detail, and with illustrations, the main novel technologies and concepts developed in the WP, followed by a take-home message.

2.2 Methodology

The layout and structure of the factsheets were defined by AFZ. Each WP leader was invited to send the corresponding texts and images. AFZ then edited the factsheets and sent them for review to the project coordinator, to the WP leaders and to other concerned researchers, who sent back their remarks. The operation was repeated until the factsheets were found satisfying by all the participants.

2.3 Results

2.3.1 Delivery format

The factsheets are provided in 2 formats.

- As a PDF file available on the project's website under Results > Factsheets.
- As a printed A4 leaflet distributed during the final stakeholder meeting on 22-23 January 2020.

2.3.2 Content

The leaflets are presented in the following pages:

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Factsheet n°1

January 2020

European protein autonomy: more and better

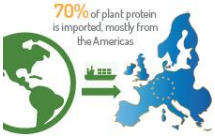
More European protein

Better protein quality

Better use of existing protein sources

The challenge

70% of plant protein is imported, mostly from the Americas



Europe has for long been deficient in protein for its livestock production. Although rapeseed meal (RSM) is increasingly produced in Europe, its use for monogastric animals is hampered by its lower content and digestibility of protein and amino acids compared to soybean meal (SBM).

European-grown soybeans and protein from green biomass are promising alternatives to imported SBM. However, little is known how processing technologies can be used to improve the nutritional value of these locally-produced protein sources.

Non-conventional feed ingredients vary more in nutrient content and value than conventional ones. Advances in near-infrared spectroscopy (NIRS) make it a promising tool for predicting nutrient content and value in real-time.

Our solutions

The Feed-a-Gene project has worked with:

- Technologies for the processing of European soybeans, green biomass and rapeseed meal
- Biotechnologies to improve feed quality
- Nutritional evaluation for pigs and poultry
- NIRS for the real-time determination of nutritional value

These technologies and methodologies allow to increase protein production in Europe, make a better use of existing European protein sources, and evaluate the nutritional value in real-time.

The developed technologies allow to improve the quality and quantity of European-grown protein for livestock production.

Novel technologies & concepts

Several technologies and methodologies have been developed in the Feed-a-Gene project for the production and evaluation of novel protein sources.

Soybean meal

- Processes that involve extrusion or cooking with or without dehulling have been used to produce expeller SBM with a reduced content of antinutritional compounds and high protein and amino acids digestibilities.
- The products can be produced in medium-sized crushing plants from local and GMO-free soybeans.

Expeller soybean meal

Green protein

- A process involving separation of green biomass from grass into a liquid stream high in protein and a fibre-rich solid stream has been developed and the resulting products have been evaluated nutritionally.
- The produced protein concentrates are lower in quality compared to SBM but their quality has been improved during the course of the project.

Green protein from grass biomass

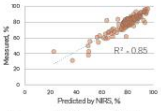
Rapeseed meal

- Tail-end dry fractionation of RSM can be used to separate RSM in a fine, high protein-low fibre fraction, and a coarse high-fibre fraction. The fine fraction has a superior nutritional quality relative to reference RSM.
- Biotechnological means can be used to reduce antinutritional compounds and increase feed efficiency.

Fine and coarse fractions of rapeseed meal

Real-time evaluation of nutritive value

- A NIRS-based system has been used to develop equations enabling the real-time prediction of nutrient content, of the digestibility of macronutrients, and of the metabolizable energy of feedstuffs and diets for pigs.



Energy digestibility in pigs predicted by NIRS vs digestibility measured *in vivo*

Recommendations & benefits

- The technologies developed by Feed-a-Gene will ensure a higher supply of European protein, as they make possible the production of optimally processed protein concentrates obtained from European-grown soybeans and rapeseeds. Biotechnologies can be used to further improve the nutritional value of these protein sources.
- The developed NIRS methodologies enable the real-time evaluation of key nutritional parameters of economical importance.

Feed-a-Gene

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The Feed-a-Gene Project has received funding from the European Union's H2020 Programme under grant agreement no 633531.

Feed-a-Gene

www.feed-a-gene.eu

Factsheet n°2

January 2020

New animal traits for innovative livestock management strategies

New traits for performance and feed efficiency

These traits will be available for precision feeding and breeding programmes

The challenge

Monogastric production animals are usually kept and fed as a group. However, animals, although of the same genotype, differ in feed intake, growth performance and feed efficiency. For this reason, individual animals or characterized groups of animals have different nutrient requirements and should be fed diets differing in nutrient composition.

The background of these differences is not clear but can be related to *e.g.* genetic differences and differences in birth weight, health status, and the animal's response to social interactions, and environmental and management conditions.

Our solutions

Feed a Gene explored new traits related to performance and feed efficiency for potential use in future precision feeding concepts and breeding programmes in pigs, broilers and rabbits:

- Feed intake of individual animals housed in a group (broilers and rabbits)
- Faecal nutrient digestibility in individual pigs using NIRS
- Birth weight and genomic information of piglets and consequences on N-efficiency later in life
- Metabolites in blood related to feed and nutrient efficiency
- Behaviour and feed efficiency in pigs

New traits related to feed efficiency were identified, which can be used in future precision feeding concepts for production animals kept in groups and in future breeding strategies.

Novel technologies & concepts

New traits related to performance and feed efficiency were investigated in different animal species and experimental settings.

Individual feed intake in broilers and rabbits

- In rabbits and broilers between animal variation in feed intake could be measured and related to feed efficiency.
- This trait can be used in future breeding and feeding strategies for further optimized feed efficiency.

Birth weight and genomic information of pigs and N-efficiency

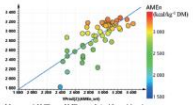
- Birth weight of piglets influenced absolute growth performance but did not affect N-efficiency (N-retention as % of N-intake) later in life.
- Genomic information on protein deposition capacity of individual pigs can be used to predict actual performance, to refine nutrient requirements of pigs and optimize dietary nutrient composition.

Faecal nutrient digestibility in individual pigs

- Using NIRS, faecal nutrient digestibility can be measured in individual pigs.
- This trait can be used in future breeding and feeding strategies and *e.g.* for selection of animals capable of digesting diets containing a relatively high proportion of by-products.

Blood metabolites and nutrient efficiency

- The metabolic fingerprint in blood is complex, but contains valuable information in relation to nutrient digestion and metabolism. Specific combinations of metabolites show relationships with digestive and metabolic efficiency in broilers and pigs.
- The value of these biomarkers for practical applications should be further investigated.



Measured AMEn vs AMEn predicted from blood serum in chickens (Beaudeau et al., 2018).

Behaviour and feed efficiency

- Agonistic behaviour as determined in groups of pigs (Duroc) using Social Network Analysis had little effect on feeding behaviour and feed efficiency.
- Tracking and evaluation of behavior of individual pigs housed in groups.
- Energy requirements for locomotion of pigs were quantified and allow for adjusting maintenance requirements for energy of pigs in different production systems.

Evaluation of behaviour of individually tracked group housed pigs (Cowton et al., 2019, in press).

Recommendations & benefits

- New traits were identified at animal level in pigs, broilers and rabbits showing relationships with performance and feed efficiency. These traits can be used for grouping animals which are more homogeneous and can be fed more precisely and for implementation in future breeding strategies.
- The validation and practical implementation of these traits in a practical setting requires further attention.

Feed-a-Gene

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Feed-a-Gene

Factsheet n°3

January 2020

www.feed-a-gene.eu

Models and tools for predicting feed and nutrient utilization in pigs and poultry

Nutritional models for pigs and poultry

A free software tool for research, development and education in genetics and nutrition

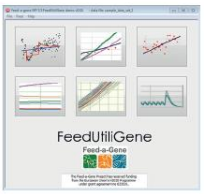
The challenge

How are nutrients digested? How are digested nutrients used in metabolism to produce meat and eggs? How does the genotype influence nutrient partitioning? Is it possible to detect perturbations that impair feed intake and growth? Is it possible to estimate the individual variation in a population if we have only a limited number of animals?

These questions can be explored by modelling, since this provides insight in the response of the animal to different scenarios. Different nutritional models have been developed and published, and some have served as a basis to develop software tools. However, few models are readily accessible for users.

Our solutions

Feed-a-Gene has further developed existing models of nutrient digestion and metabolism for pigs and poultry. A robustness module has been developed that detects perturbations and characterizes the response of the animal in terms of resistance and resilience. A stochastic module simulates variation of individuals animals in a group and estimates the heterogeneity of the population.



These models have been implemented in the FeedUtiliGene software tool. Users can play with the models and visually understand their functioning.

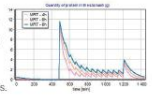
FeedUtiliGene is a demonstration tool with a modular structure and interactive interface for a better understanding of the response of the animal to different conditions, including feed use mechanisms.

Novel technologies & concepts

The FeedUtiliGene software contains 6 modules: a digestion module, a parameter estimation module, a nutrient partitioning module simulating energy, amino acid, and phosphorus utilization, a fatty acid module for pigs, a robustness module, and a stochastic module.

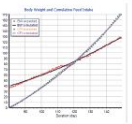
Digestive module

The digestive module is based on a generic model for pigs and poultry simulating the digestion all along the digestive tract. It predicts the digestible nutrient content of feed components or mixed feeds.



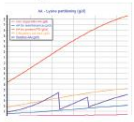
Parameter estimation module

The parameter estimation module adjusts the model parameters and model outputs to existing body weight and feed intake data.



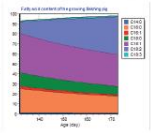
Nutrient partitioning module

This module simulates growth performance, body composition, and nitrogen and phosphorus excretion of pigs and broilers in relation to the diet and ambient temperature. It helps to define nutrient requirements and to reduce the environmental footprint of monogastric farm animals.



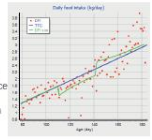
Fatty acid module

The fatty acid module estimates the fatty acid composition of the carcass of fattening pigs as affected by the level and source of fat.



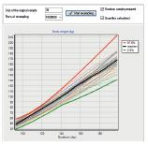
Robustness module

This module quantifies the robustness of the adaptive response of the animal in term of resistance and resilience, when facing known or unknown perturbations.



Stochastic module

This module addresses variation among individuals, which may originate from differences in nutrient partitioning. The module generates a population of animals with consideration of plausible individual variance.



Recommendations & benefits

FeedUtiliGene is a free software tool that can be used in education and extension services. It provides easy access to models developed in the project and published in peer-reviewed publications. The tool is useful for nutritionists and geneticists, and it provides insight on feed-use mechanisms and animal variation.

Feed-a-Gene

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Feed-a-Gene

Factsheet n°4

January 2020

www.feed-a-gene.eu

Precision feeding systems for pigs and poultry

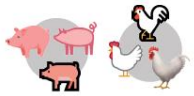
Better nutrient efficiency

Lower feed cost

Reduced environmental impact

The challenge

In conventional production systems, monogastric animals are mostly fed as a group, even though there is a large variation in nutritional requirements among individuals. The requirements also change very rapidly over time and according to physiological stage.



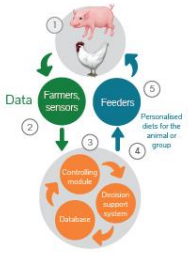
Each animal is unique!

As a result, providing the same diet for long periods of time and without taking individual variation into account is associated with poor adequacy between nutritional requirements and supplies. This impairs the efficiency of nutrient utilization.

Our solutions

The Feed-a-Gene project developed novel precision feeding systems:

- for growing pigs, fed *ad libitum* or in restricted feeding
- for gestating and lactating sows
- for broilers and laying hens



These systems adjust the nutrient supply in real-time to the nutritional requirements of the animal or group of animals, taking into account daily performance and physiological stage.

Precision feeding improves feed and nutrient efficiency, and reduces feed cost and environmental impact.

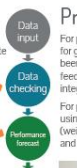
Novel technologies & concepts

Several novel technologies have been developed in the Feed-a-Gene project. These technologies are combined in systems for precision feeding that can be adapted to different situations in pig and poultry farms.

Decision support system

The decision support systems (DSS) developed for growing pigs, sows, broilers and laying hens integrate biological models that predict performance and nutrient requirements for the next day. The DSS ensures data flow and data integrity.

The application of the DSS was tested and validated in experimental pig and poultry farms.



Precision feeders

For pigs, several pre-industrial prototypes of precision feeders for growing animals (*ad libitum* or restricted feeding) have been developed and validated in farm conditions. Commercial feeders for sows (gestating, lactating) have been adapted to integrate the DSS and enable appropriate mixing of feed.

For poultry, current commercial devices can be combined using the controlling module, to measure performance (weighing scales) and adapt diet composition (weighing and mixing hopper) using the DSS.

Controlling module

The controlling module includes the hardware and software for managing all devices including feeders, scales and sensors. It stores data from devices, communicates with the DSS, and manages events.

Communication language

A high-level agent communication language developed for precision feeding systems is used to share data and information among heterogenous system components.

Recommendations & benefits

- Precision feeding systems ensure an optimal nutrient supply by blending two pre-mix feeds with different nutritional characteristics. This allows reducing feed cost, nutrient excretion, and the associated environmental impacts.
- Precision feeding systems ensure the real-time monitoring of performance traits (*e.g.*, feed and nutrient intake, and weight gain) in individual animals or in groups of animals, and enable the detection of early perturbations.

Feed-a-Gene

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Feed-a-Gene
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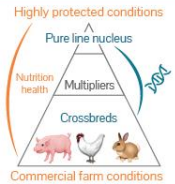
Factsheet n°5
January 2020

More efficient and better adapted animals
Faster population improvement

New selection strategies for better feed use

The challenge



Monogastric animals are usually selected as purebred lines using records from nucleus farms, whereas commercial farms raise crossbreds. Nucleus farms provide better sanitary and nutritional conditions than production farms so that animals can express their best performance. Also, purebreds have different gene combinations compared to crossbreds. As a result, predictions in commercial farms always deviate from the standards obtained in nucleus farms.

Directly improving feed efficiency of crossbreds through genetic selection of purebreds is a promising goal, but feed efficiency is challenging to measure in production farms due to the specific and often costly resources necessary to record it. This makes it difficult to select for crossbreds that consume less feed and have a lower environmental impact.

Our solutions

The Feed-a-Gene project tested approaches that could be used to improve the accuracy of selecting feed efficiency for production farms:

- Individual measurements of feed intake in groups of poultry and rabbits through automated devices or video cameras.
- Individual measurements of body samples (*e.g.* feces, blood, saliva, hair).
- New statistical models based on existing data to capture timeline dynamics, dynamics of groups, and trait heterogenity.

After testing more than ten types of measurement, five were found to be promising to further improve feed efficiency by genetic selection in different production environments.

Novel technologies & concepts

The transmission of the tested indicators from one generation to the next one was quantified with state-of-the-art genetic models, resulting in the identification of the most promising criteria to improve feed efficiency.

Individual feeding devices

In rabbits and poultry, new technologies allow the recording of individual feed intake in small groups (for rabbits) or large groups (for poultry), with the following results:

- Individual records of feed intake were found to be heritable.
- Feed intake could be used for selection for feed efficiency.

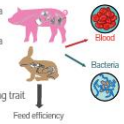

Individual feeding device for group-housed broilers

Intestinal microbiota

The quantification of the composition of intestinal microbiota in pigs and rabbits resulted in two important findings:

- Some components of microbiota are heritable.
- Some components of microbiota differ with feed efficiency.

The next step is to reconcile these findings to turn the results of the analysis of microbiota into a breeding trait for feed efficiency.



Group records

Group records can be used in pigs for two different purposes:

- To estimate the influence of penmates individual performance, to better select for the ability to grow in groups.
- To consolidate individual records when costs or management limit individual recording.

Nutrient & energy digestibility

Using NIRS technology to quantify digestibility, it was shown that the digestibility of energy, organic matter and nitrogen of the feed could be predicted and that these digestibilities have a potential to be used for selection purposes.

Blood traits

- In broilers, a specific wavelength of the NIRS spectra of blood serum was found to predict digestive efficiency with high accuracy.
- In pigs, it was possible to identify combinations of gene expressions that predicted differences in feed efficiency between individuals.

Recommendations & benefits

- In each of the three livestock species targeted by Feed-a-Gene, at least one promising solution (individual feeders in rabbits and poultry, group records in pigs) was proposed, either to increase genetic gain or to reduce phenotyping costs.
- Digestibility, microbiota and biomarkers are promising for genetic selection and still require further investigation and validation before they can be implemented in farms.

Feed-a-Gene
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The Feed-a-Gene Project has received funding from the European Union's H2020 Programme under grant agreement no 633531.

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Factsheet n°6
January 2020

Novel feeds and feeding techniques with positive environmental, economic and social impacts

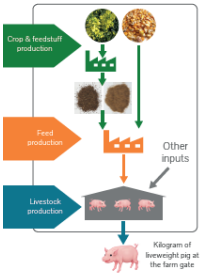
More sustainable pigs and poultry production systems

The challenge

The Feed-a-Gene project has developed a range of new approaches to feeding pigs and poultry with the aim of improving efficiency and reducing environmental impacts. This has been done by developing novel feed resources and technologies, while at the same time identifying animals better adapted to changing global conditions, and introducing techniques that ensure feeds are used as efficiently as possible.

These approaches have economic, environmental and social implications that must be assessed before they can be adopted.

Our solutions



Well-established techniques were used to assess the sustainability of the new feeding approaches that have been developed in the project.

- Life-cycle assessment and cost-benefit analysis are used to, respectively, evaluate the environmental and economic impacts of novel feeds, precision feeding systems and selective breeding for pigs and poultry.
- Interviews with farmers and questionnaire surveys of citizens provide insights in the acceptability of feeding approaches and practical issues around their implementation.

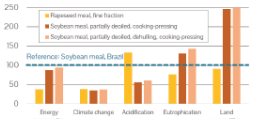
- A simple composite indicator, weighted using the results of a survey of industry experts, provides a means of evaluating the sustainability of our proposed solutions.

Positive effects on sustainability

Feed-a-Gene provides encouraging results for livestock producers seeking to reduce the environmental footprint and at the same time improve their profitability. Many consumers and farmers are supportive of the innovations proposed by the project.

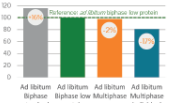
Environmental impacts

- Novel feeds have the greatest environmental benefits when they replace Brazilian soybean meal, resulting in a reduction in climate change impacts but leading to land-use transfer and more land being used to produce livestock feeds.



Impact of novel feeds on the environment relative to Brazilian soybean meal

- Precision feeding can have significant environmental benefits particularly in reducing nitrogen excretion in pigs.



Nitrogen excretion with multiphase precision feeding strategies relative to biphase strategies

Economic impacts

- For pigs, novel feeds can have a positive impact on farm income provided that increases in feeding costs are small. An individual precision feeding strategy can improve economic performance.
- For broilers, small income gains are associated with the use of European soybean meals, while green protein has a negative impact.

Social impacts

- Surveys in the UK and Spain revealed that consumers are willing to pay a premium for eggs produced with a lower carbon footprint.
- Consumers find precision feeding technologies and novel feeds acceptable, tough they may be reluctant to certain aspects (*e.g.*, interactions between the farmer and the animal). Farmers are open to the use of these technologies in the right circumstances.

Sustainability appraisal

- These new approaches yield a combination of economic, environmental and social benefits.
- Individual *ad libitum* precision feeding strategies for pigs and the use poultry feeds incorporating European soybean meal are found to offer important sustainability gains compared with the current situation.

Recommendations & benefits

The feeding solutions proposed in Feed-a-Gene offer a number of important opportunities for livestock producers to become more sustainable.

- Replacing Brazilian soybean meal in the diet with locally-produced protein, such as rapeseed meal or European soybean, can reduce energy costs and impacts on climate change, though this will result in a transfer of land-use and in more arable land used to produce animal feed.
- Precision feeding is another route to more sustainable livestock production. The adoption of feeding systems that allow pigs to eat when they choose reduces key environmental impacts and increases profitability compared to conventional alternative feeding systems.

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2.3.3 Dissemination

At the beginning of 2020, the factsheets will be uploaded on the website and information will be sent about their availability to the stakeholders by different channels:

- by email for those who have registered on the stakeholder platform
- on social networks, including Twitter, LinkedIn and Facebook

On 22 January, copies of each factsheet (200 copies per factsheet) will be brought to the venue of the Final stakeholder meeting and a copy of each factsheet will be included in the folder given to each participant.

3 Conclusions

The factsheets are a dissemination tool meant to inform stakeholders of the results of the Feed-a-Gene project, with a practical focus on the expected benefits of each novel technology and concept developed during the project.

4 Partners involved in the work

All partners contributed this deliverable.

5 Annexes

- 6 factsheets