EU PiG

EU PiG Innovation Group

Technical Report

Health Management

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Challenge: Early Warning of Diseases and Production Errors

Introduction

Optimal health and management routines in pigs are crucial to guarantee good productivity and animal welfare. Due to intensification of pig production, which goes along with increase in herd size and productivity, the pig industry needs to keep up with the latest practices in order to remain competitive. Therefore, the aim of this project is to identify best practices regarding the specific challenges and share experience-based knowledge among participating EU Member States.
The challenge “early warning of disease and production errors” has been investigated more and more over the last half century and holds great potential in the future due to the development of precision livestock farm tools [1].The overall aim with early warning of disease and production errors is the ability to avoid or reduce an eminent problem on farm. Early detection of disease enables the farmer to respond timely and to put in place measures to contain the problem.

The present technical report has the aim of providing both an overview of current challenges in early warning of disease and production errors and examples of solutions from five best practices selected in Europe. By shedding light on this issue, potential lack of knowledge was revealed which led to a better understanding of what is needed in the future regarding early warning and detection of disease and errors related to pig production.

1. The Background of the Challenge

In last decades, European pig herds increased in size, and therefore the number of animals per employee on the farms [2] , thus making early detection of disease and production errors an everyday challenge.

To overcome this challenge, automation and technology can represent a valid support in pig farming. In fact, the application of automated techniques to record health parameters of individual animals gives the possibility of improving animal performance and welfare [3]. Nowadays, big data obtained by sensors can be elaborated through algorithms and communicated to the farmer, who has the possibility to intervene promptly when errors are detected [4].

Changes from the baseline of measurements like feed and water consumption, activity and coughing have been associated with disease [5-8]. Thus, early detection of variations in

oestrus cycles or behavioural changes such as pen fouling can make a great difference in farm management [6, 9] .

Measuring body temperature is fundamental for early detection of hyperthermia and fever. Nevertheless, the use of a rectal thermometer is time-consuming and can generate biased results due to stress caused by animal handling. Studies have shown that the use of infrared thermographic cameras can be a valuable tool to measure body temperature, although training of the personnel might be required [10-12].

Early detection of respiratory symptoms is crucial in pig farming. Coughing index, obtained either via clinical examinations and/or by using automatized methods, is an effective indicator of respiratory disease. Even though clinical examinations and physical observations are commonly used in practice [5], these methods are time-consuming, subjective and require standardization. Automation of manual observations is possible by using cough monitoring systems, which are gaining more and more ground in pig practice. Sensors detecting air humidity and temperature combined with a microphone recording coughing-like sounds obtain large amount of data, which is then translated into a respiratory distress index.

Besides focusing on early detection of disease and production errors, ensuring that errors do not occur can mean the difference between success and failure. Therefore, prevention through implementation of biosecurity and correct management is fundamental. Traditionally, veterinarians have provided counselling regarding biosecurity, and several recommendations have been conveyed over the years, e.g. the SPF system in Denmark (http://spfsus.dk/en) and the McRebel method to reduce exposure to secondary bacterial infections during acute outbreak of PRRS [13]. Nevertheless, achievement of good biosecurity level is often impaired by difficulties in maintaining farmer and/or workers' compliance [14], thus emphasizing the need for structural and easy tools enabling the farmer to make better decisions regarding health and productivity management.

2. Addressing the Challenge

Aim of the project is to point out different strategies for early detection of changes in health and production parameters in pig farming. It should be shown how various practices use different strategies to improve health on farms and their innovative reaction to various problems related to pig production. Furthermore, potential gaps in knowledge should be detected which may eventually lead to better understanding what is needed in the future to improve productivity and health management in the swine industry.

3. EU PiG Best Practice

In order to identify the top five best practices across all the EU PiG regions, a series of criteria has been used, which are able to measure the effectiveness of the collected practices to match the specific challenge.

The following set of criteria have been scored for each practice.

- **Excellence/Technical Quality**
  - Clarity of the practice being proposed;
  - Soundness of the concept;
  - Knowledge exchange potential from the proposed practice;
  - Scientific and/or technical evidence supporting the proposed practice.

- **Impact**
  - The extent to which the practice addresses the challenges pointed out by the Regional Pig Innovation Groups (RPIGs);
  - Clear/obvious benefits/relevance to the industry;
  - Impact on cost of production on farm and/or provide added value to the farming business or economy;
  - The extent to which the proposed practice would result in enhanced technical expertise within the industry e.g. commercial exploitation, generation of new skills and/or attracting new entrants into the industry;

- **Exploitation/Probability of Success**
  - The relevance of the practice to each Member State (MS) or pig producing region/system;
  - Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
  - The extent to which there are clear opportunities for the industry to implement the practice/innovation;
  - Degree of development/adaptation of the practice to production systems of more than one MS

- **Innovation**
  - Evaluation of innovation (novelty) with the good practice
  - Level of innovation according to the Technology Readiness Level (TRL)

Scores had to be in the range of 0-5 (to the nearest full number). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guidelines for scoring are shown below (no half scores could be used).

0	The practice cannot be assessed due to missing or incomplete information.
1 – Poor	The practice is inadequately described, or there are serious inherent weaknesses.
2 – Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3 – Good	The practice addresses the criterion well, but a number of shortcomings are present.
4 – Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5 – Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The selection of the top five best practices followed the procedure described below:

1. Members of the thematic group (TG) were asked to score all submitted best practices according to the defined guidelines and sent their scoring sheets to the TG leader
2. In addition to the scores, TG members provided brief comments indicating weak points or particular strengths of submitted best practices
3. A conference call was used to discuss the scoring results and select the top 5 best practices. During this call, the top 10 best practices were discussed based on the ranking submitted by thematic group members. The discussion of the top ranked best practices was started from the lowest rank, i.e. best practice with the highest average score, to rank number 10. A selection of the top 5 best practices was made during the call.
4. A summary of all discussions was sent out after the call to review the decision of the selected five best practices by TG members.

4. Results and Discussion

4.1. Validation of the Top Five Best Practices

The following top 5 best practices within the challenge of “Early warning of diseases and production errors” have been selected by the thematic group:

Title of best practice	**Country**
Degree2act app	Spain

Soundtalks (from Bram Matthys)	Belgium
Day 28 benchmarking/early warning	Denmark
From Pig Data to Big Data	Denmark
Avoiding risky movements (PRRSONS project)	Spain

Degree2act App

Fever is one of the first symptoms of acute disease. Thus, early detection of hyperthermia in pigs ensures prompt diagnostics and application of measures to prevent and contain disease spread. The most common tool used to measure body temperature in animals is a rectal thermometer. This method ivolves animal containment, which often produces stress and consequently also an increase in body temperature. Moreover, the use of the same thermometer among different animals without proper disinfection raises the risk of spreading infections [15].

This best practice describes the use of an infrared thermographic camera Flir One for the assessment of body temperature in pigs. The camera is connected to a compatible smartphone and data is elaborated through a software that recognizes temperature patterns according to algorithms [16].

Degree2act is a tool developed by BeinFive, a marketing and software company from Barcelona, Spain, and has been validated with more than 4,500 cases from collaborative farms from Spain, Germany, Brazil and USA. Degree2act works as a traffic light: green light means detected temperature is within physiological range, orange light notifies a slight increase in temperature, and red light appears with a warning message, which informs that an elevated body temperature, compatible to fever, has been observed [17]. It´s an affordable technique: costs can vary between 250 € and 500 € for the camera and start at 300 €, if a compatible smartphone needs to be purchased. The app offers 1 month free trial, after which it costs either 2.99 € or 4.99 € per month or 49.99 €/99.99 € per year.

Thematic group members selected this practice and found that it successfully met all requirements (technical quality, impact, probability of success and innovation).

Specifically, the following benefits were highlighted:

1. A non-contact temperature measurement method reduces risk of disease spread through fomites and avoids stress derived from animal handling, thus improving animal welfare.
2. It´s time-saving and cost-effective.
3. It´s easy to use, even if it might require a short introduction to the app.

4. Early detection of hyperthermia allows the farmer to promptly manage disease outbreaks and, by acting timely, the efficiency of therapeutic measures increases too. The latter is especially important in terms of global fight against antimicrobial resistance.
5. It reduces vaccination failure rate, by identifying sick animals before vaccination.
6. The application is available worldwide and can easily be implemented in other countries.

Cons:

1. Degree2act does not measure exact temperature of an animal. It works within temperature ranges common for each production cycle and detects alterations.
2. Possible pitfalls in farrowing sections, during lactation period and in weaner herds with heated floor, which transfers heat to the pigs.

The tool aids the farmer with easier evaluation of health status of individual animals with many advantages. It is, however, important to understand the advantages and limitations of the tool as this tool does not give indication for production errors as such. Using the tool in diagnostics and timely interventions is crucial in handling an outbreak of enteric or pulmonary disease. However, it must be considered that the tool does not prevent disease from occurring or an outbreak from spreading, since often the pathogen can be shed from an animal before the occurrence of fever. Furthermore, future development should focus on using the tool in conjunction with other tools enabling the farmer to perform better diagnostics of herd health problem using the Degree2act.

Unfortunately, the best practice does not describe how the farm is actively using the system. Degree2act enables a quick check for fever, but, since frequency of checks for fever is not stated, the practice of how to use the technology it is difficult to transfer directly to other farms.

Soundtalks (from Bram Matthys)

Respiratory diseases have a high prevalence in intensive pig farming [18] and cough is one of their most evident symptoms [19]. Respiratory distress determines a reduction in pig metabolism, a consequent drop in feed uptake, reduced growth rate, and it can lead to higher mortality rates. Fast identification of respiratory disease would allow the farmer to adopt early intervention measures, like isolation, diagnosis and treatment and, in some cases, prevent the spread of disease. This would result in better performance, less veterinary costs and reduction in antimicrobial use. Assessment of respiratory conditions can be done through physical observations and manual recordings of findings. Nevertheless, this procedure can be time-consuming, it can be done only for a limited period during the day and can be subjected to bias when standardization is deficient. Moreover, due to the

increasing amount of pigs per barn, farmers and veterinarians have more difficulties in frequently monitoring each individual pig.

This best practice describes the use of a cough monitor for early detection of respiratory distress in pigs. This tool has been developed by SoundTalks NV (https://soundtalks.com/) and consists of two sensors to measure air humidity and temperature in the stable and one microphone that detects cough-like sounds. SoundTalks NV is a spin-off company from the KU Leuven & UNIMI which is specialized in monitoring animal welfare & health, using sound. This hardware system monitors the pigs 24/7, elaborates sound, temperature and humidity data through a specialized algorithm, and allows early identification of respiratory symptoms by using an indication system (using LED-lights) that shows the respiratory health status of the monitored pigs. SoundTalks is easy-to-use, robust and resistant to the harsh environmental characteristics of a pig barn. The user, which can be a farmer, veterinarian or integrator, also has access to a web portal and mobile app, which provide even more data and real-time tracking from anywhere in the world.

Thematic group members selected this practice and found that it sufficiently met all requirements (technical quality, impact, probability of success and innovation). Most of the thematic group members showed enthusiasm for the described cough monitoring system, which is getting more and more ground in pig practice.

Specifically, the following testimonials regarding benefits were discussed among the group of experts evaluating the good practices:

1. The automation of cough monitoring might lead to a reduction of economic losses, i.e. following an outbreak of a respiratory disease.
2. It´s time-saving
3. It allows a continuous monitoring of animal respiratory distress and immediate notification.

Some potential drawbacks in the use of this system, the way it was described in the submitted practice, have been discussed:

1. It´s relatively expensive (around 3000 € per monitor plus the cost of a license to be paid annually that is required to access the data) and not all farms can afford to purchase a monitor for each barn. One monitor has a range of 18-20 meters [20], which means that more monitors should be installed in each section of a barn.
2. The practice describes the sole use of cough monitor system, without combining it with physical observations. This system cannot replace clinical examinations as it focuses on the detection of only one animal-related parameter (cough). Therefore, this practice should be intended as an integration of visual observations and not as a substitute of them.
3. It cannot differentiate between productive and dry cough.

Suggestion for implementation:

Combining this approach with physical observations would allow a more complete evaluation of animal status. Moreover, it would give the farmer the possibility to adjust the protocol to his/her specific farm and take into account its history of diseases.

In conclusion, Soundtalks possesses great potential for farmers. The system offers a tool for monitoring coughs during the period of time when no one is present in the barn. Research with Soundtalks is already focusing on improving guidelines [20-23] and the aim should be to aid the farmer in making better decisions when cough index has increased and no clear diagnosis is obtained. The pitfall could be overtreatment of animals, if the coughing index gives too many false alarms. Furthermore, it is crucial to understand that a coughing index is an aid in the diagnosis and the farmer must always conduct a physical examination of the animals to have a complete picture.

A further potential is to use the objective data on coughing across batches to allow a better understanding of timepoint for infection of each batch. Evaluating these objective data can help to avoid recall bias when trying to understand at which time point clinical infection occurred in each batch. This could allow for optimizing the vaccination strategy and time of treatment for future batches.

Day 28 Benchmarking/Early Warning

Feed conversion ratio (FCR) is a measure of pig performance. More specifically, it is a measure of cost efficiency for converting feed into pig meat and is expressed as feed intake/weight gain. Poor FCR signals an increase in feed costs i.e. economic losses [24]. As such, the FCR does not give information about weight gain per se but specifically about the amount of feed, which is required to achieve the weight gain. Often, an increased FCR is also accompanied with a reduced weight gain. Therefore, early detection of FCR variations can be beneficial for correction in current batch and prevention of errors in future batches.

This best practice describes the continuous monitoring of feed intake and weight gain using a day 28 KPI (Key Performance Indicator) for FCR from entering the barn until day 28. By doing so, this strategy aims at ensuring early detection of production errors and variations in nutrition status of the animals. FCR data obtained from current batches are benchmarked against FCR data from previous batches as well as from other farms. This allows the farmer to have a constant reference point for assessing his/her farm production. To perform this measurement, the farmer needs two systems: a feed scale to measure feed consumption on room level or pen level, and a system to estimate pig weight gain.

The farmer used PROGROW (camera weighing) in focus pens as weighing system, and their feeding system was able to supply the necessary feeding data

(https://www.skov.com/en/pig/Pages/Progr.aspx). Thanks to “day 28 FCR” measurements, the farmer could prove to the pig supplier that pigs did not meet normal standard. Once the pig supplier was informed about a drop in the quality of the pigs, actions were taken to reduce the error. Traditionally, at best, farmers can detect reduction in FCR only after completion of the batch. With this system errors can be found already at day 28 and can be corrected for future batches, as well as for the remaining growth period of the current batch.

Thematic group members selected this practice and found that it sufficiently met most of requirements (technical quality, impact, probability of success and innovation).

Specifically, the following benefits were pinpointed:

1. It can be implemented in all kind of farms. The use of this procedure is independent of the feeding system used in the farm.
2. The day 28 KPI for FCR ratio enables the pig producer to detect irregularities timely enough to intervene if necessary.
3. Costs depends on which kind of feeding and weighing system the farmer decides to use. But if these systems are already in place, there are no additional costs.

Cons:

1. Lack of innovation. Some companies are already using this practice. On the other hand, the field is still restricted and it is not a common practice yet. Furthermore, these experiences further confirm numerous benefits derived from the use of this practice.

Application of a day 28 KPI does not supply the farmer with continuous monitoring but rather an interim surveillance. The monitoring system is not an alarm system for immediate action, but rather aimed towards strategic decisions for future batches of pigs as the KPI for day 28 FCR is the only point of measurement in the monitoring program. It is however a strong tool in the evaluation of productivity rather than evaluating only on outcome of each batch.

From Pig Data to Big Data

A business dashboard is an information management tool that is used to track key performance indicators, metrics and a few key data points relevant to a business, department or specific process [25]. Due to increasing amount of data that can be obtained from a pig farm, a tool that allows easy visualization of production and health parameters can make the difference.

This practice describes the collection of data, such as feed and water intake, daily weight gain, and their transfer into a series of graphs and trends using Agrovision Dashboard (https://www.agrovision.com/pighusbandry/).

Through this system, complete monitoring of feed intake, water intake, performed procedures and traditional farm recordings can be visualized in real time by farmers and employees. Routine weighing of pigs in a few pens serve as sentinel monitoring for daily weight gain for the pigs. Graphs showing trends serve as alarm system (early warning) decision support tool for all sites. When employees start the day, they check the system for alarms and check the curves for obvious issues not detected by the alarm. Employees find the system motivating as production can be followed when the pigs are alive rather than having a retrospective view on productivity when pigs have been delivered to slaughter. By detecting errors early, employees can often still handle the problem and improve/correct the issues at hand. Additionally, this system allows better monitoring of pig health. For example, after 2 days of reduced feed intake, the farmer has an indication that extra attention should be paid to minimize the risk of disease in the herd/room.

Price of monitoring equipment depends on the level of surveillance needed and the layout of the farm. Monitoring equipment can be installed for approx. 10,000 – 15,000 € on farm level.

Thematic group members agreed on unquestionable importance of this tool to implement quick and ready communication among employees

Pros

1. When used appropriately, this system allows to avoid errors, reduce consequences of errors and detect reduced productivity or health issues timely
2. Daily visual presentation of data and dynamic monitoring of relevant parameters like water- and feed intake as well as weight of few pigs is of high relevance and value for the majority of ambitious farmers
3. This practice addresses also challenges for “Benchmarking/Dashboard”.

Cons:

1. Lack of innovation. This system is not unique; several dashboarding systems are already available on the market.
2. Rather expensive. Costs for total system installation including sensors was 10,000 – 15,000 €. On the top of this price, the fee for using Agrovision as a general management software should be taken into account.

Daily monitoring of water consumption and productivity allows for prompt actions. It has been shown that health parameters and welfare parameters can be monitored using water and feed consumption [26]. A broader implementation might be obtained by integrating alarm systems into these monitoring systems.

Avoiding Risky Movements (PRRSONS project)

Porcine reproductive and respiratory syndrome virus (PRRSV) is one of the most economically significant pathogens in swine industries of many countries. It is reported that PRRSV accounts for around 664 million dollars in annual economic losses in USA [27]. The biggest challenge in controlling PRRSV infection today is represented by introduction of new PRRSV strains or re-infection due to indirect transmission. Several studies described fomites and farm personnel as an important route of PRRSV transmission among animals within the same farm [28]. Therefore, the adoption of appropriate biosecurity measures is the key to curb the spread of PRRSV among different barns. Specifically, biosecurity measures can be distinguished between those that aim at preventing pathogens from entering into a herd (external biosecurity) and those that limit the dissemination of the pathogen between different animal groups within the herd (internal biosecurity) [29, 30]. The application of the latter to minimize indirect PRRSV transmission is herein discussed.

This practice describes the monitoring of people movements within the farm in order to prevent internal dissemination of PRRSV through people. This system is based on the control of farm personnel movements along with the classification of farm areas at different levels of risk, depending on the health status of the animals (determined by laboratory results and symptomatology). In this way the movements are categorized into correct and incorrect depending on the origin and / or destination of the movement [30]. People movements are recorded via a GPS connected to the phone and these data is ultimately sent to a central database where it is possible to observe wrong movements in real time. The system, developed by PigChamp through the PRRSons project, allows to detect all “risky” movements of farm workers and gives a quantitative measure of how many people are breaking the rules and who is responsible for that.

Four farms with history of continuous re-circulations of PRRSV were included in this study. At a first stage, the farm is analyzed, and the equipment is installed to record “normal” movement patterns. Afterwards, if wrong movements have been detected, farm personnel are briefed during regular meetings on corrective measures that need to be applied. Thanks to this practice, the risky movements of people have been reduced by 70-80%. Therefore, it is expected to have an impact on control and reduction of PRRS virus circulation, which will increase productivity, and compensate the initial investment costs for setting up the system (7,000 €).

Thematic group members agreed on the importance of implementing internal biosecurity to control PRRSV circulation and thus found this practice worthy to be included in the top 5 list.

Pros:

1. Easy to be implemented as it can be installed in any farm with Wi-Fi.
2. It helps maintaining workers’ compliance.
3. Since the technology is a tool for implementing general internal biosecurity, the system could be used to control the spreading of pathogens other than PRRSV.

Cons:

1. Using GPS to track people´s movements could create issues with data privacy.
2. The costs are rather high, and it is yet to be evaluated, if there is an effect on PRRSV of optimizing bio-security routines in the farms. It may not only be the employees who contaminate the herd.

In conclusion, automatic tracking of farm workers´ behavior, transportation from and to the farm and real-time monitoring of disease status in adjacent farms might be beneficial for the implementation of farm biosecurity. With GSP tracking and direct online access from all-around, these real-time automatic recordings and biosecurity risk-modelling might represent the future of pig industry [2, 13]. Moreover, the tool might be implemented as training and compliance surveillance system to cover more challenges than PRRSV. However, for an optimal biosecurity, it needs to be considered that not only people but also utensils and equipment are risk factors in the internal biosecurity.

4.2. Cost and Benefit Analysis of the EU PiG Ambassador

Costs and benefits of Degree2act app

For the early detection of hyperthermia in pigs, IR thermographic camera Flir One can be used, connected to a compatible smartphone. A dedicated software has been developed to recognize temperature patterns according to an algorithm. The farmer, Pep Peraire, bought a Flir One infrared thermographic camera, connected to a compatible smart phone, and downloaded the Degree2act app which monitors temperature patterns. He stated that using Degree2act daily may reduce antibiotic treatment costs up to 50% through individual pig care.

According to a study carried out in Belgium concerning Individual Pig Care, the cost of antibiotics may fall from 1.33 € to 0.71 € per animal. Information obtained from the Spanish farmer indicates a 25-30% decrease of the cost of antibiotics and reduction of 20-25% in mortality rates. The average daily gain (ADG) may increase by 10-15%. Vaccination failure rates have not been estimated yet, but they will probably be reduced: it is important not to vaccinate animals with hyperthermia, as their immune status is compromised. Flir One camera costs between 250 € and 500 €. A compatible smartphone starts at 300€. The app offers 1-month free trial, after which it costs between 49.99 €/99.99 € per year as subscription. Introducing this practice establishes higher standards of animal health and welfare, which gives value to the final product. Setting a higher standard throughout the entire market becomes welfare for all, consumers and producers included, not just animals.

The farm data have provided information about the percentage change of technical parameters (ADG, FCR, mortality rates) and the investment costs of Degree2act. Assuming a 20% decrease in mortality rates, a 10% increase of the average daily growth and a decline

of 25% of the costs of antibiotics, the production costs per kg pig meat using Degree2act decrease by 1.7%. Feed, other variable costs and labor costs are reduced because of the increase of technical efficiency and because of the decline of veterinary and medicines costs. The finance costs are reduced due to the combined effect of reduction of the feed and other variable costs on which lower interest costs are charged. The costs related to the purchase of the equipment and the subscription rate for the app do not have a significant impact on the results.

In the table below, the costs and benefits of Degree2act have been summarized.

	Without Degree2act	With Degree2act	% change
Feed (€/kg cold weight)	0.914	0.908	-0.7
Other variable costs (€/kg cold weight)	0.233	0.228	-2.1
Labour (€/kg cold weight)	0.097	0.095	-2.8
Finance cost (€/kg cold weight)	0.126	0.118	-6.9
Results			
Total costs (€/kg cold weight)	1.372	1.349	-1.7

NOTE:

- The category "other variable costs" includes veterinary costs, energy, maintenance and bedding material.
- The category "finance costs" contains costs related to depreciation of buildings and equipment and interests on invested capital and on anticipated expenditures.

4.3. Expert Analysis

The cost benefit analysis shows that early detection of hyperthermia by means of Degree2act could reduce total cost in pig farming.

In general, experts found difficulties in interpreting the cost benefit analysis, due to lack of information. It was not clear to some experts how the use of this tool could result in a reduction in feed costs and how this could be linked to a decline in veterinary and medicine costs, as the cost-benefit analysis reported. The range of potential benefits and costs is difficult to estimate, as the data provided could just allow some speculations.

Additionally, experts highlighted the need of practical information, such as measures applied towards febrile animals, frequency of measurements and which groups should be monitored.

This kind of information would be beneficial to other farmers who want to achieve similar results.

Nevertheless, the use of a portable device that enables the farmer to detect the temperature of individual animals, without containing them, can facilitate the early detection of diseases, and gives the farmer the possibility to respond timely to the problem. Certainly, the type of advantages brought by the tool will depend on the measures applied by the farmer, once febrile animals have been detected in a production unit.

Due to the lack of information in the cost-benefit analysis, the company has been contacted by the Work Package Leader and asked to provide more inputs.

The company declared that:

"Neither Degree2act app nor Flir One camera are diagnostic tools. Veterinarian advice is always required to determine the appropriate handling and treatment in each case. If hyperthermia is detected by Degree2act, the company recommends confirming the measurement with a rectal thermometer. Usually when fever was detected, the animals and the herd were monitored for the next 24 hours to check if more animals got hyperthermia, got better or other signs appeared. After 24 hours, if more cases of hyperthermia were detected and animals with fever didn´t get better, a veterinarian was called to the farm in order to examine the animals and, if needed, prescribe treatment and handling. We suggest checking once a day at approximately the same time, and to do it daily."

Pep Peraire, the farmer, was asked to talk about the use of Degree2act on his farm. He affirmed that due to the dimensions of the farm (only 600 animals per year) and the conditions in which the animals are housed (bedding deep litter, good ventilation and natural sun, low density of animals, etc.), health-related incidents are few. He said he used the Degree2act app following manufacturer's instructions (as reported above). Importantly, he advises other farmers to follow his practice as administering individual care upon detection of early signs of disease improves production parameters, reduces mortality rate and helps reducing antimicrobial consumption.

In conclusion, the Degree2act app should not be considered a diagnostic tool, but rather a screening tool that enables the detection of animals with fever in an easy and practical way. This tool is not intended to replace completely the use of the rectal thermometer, but rather to allow a more efficient use of it. Measuring the temperature by using a rectal thermometer is not a suitable method for a daily mass application. The combination of both methods, combining the screening of animals through the infrared camera followed by individual measurement with rectal thermometer, allows for a better monitoring of animal health.

Lastly, experts also stated that the benefit could vary greatly between farms, since several factors might have an influence on both costs and benefits.

4.4. Conclusions and Advice to Industry

The great advantage of using a portable camera to detect pig body temperature relies on it being quick and less stressful, enabling the user to perform the task after receiving just a short introduction to the app. Moreover, the fact that the cost of initial investment is easily covered by the benefits derived from its use makes this practice cost-effective and consequently highly relevant to the pig producers.

However, economic benefit depends of the type of farm, where the practice is applied. For example, farms aiming at reducing the use of antibiotics might be more interested than others in the early detection of hyperthermia, which allows for early isolation of the sick animals and deliver of individual treatment.

5. The Future

Prevention, containment and treatment of disease are the main pillars of health management. The early detection of swine diseases provides an important tool to contain further spreading of pathogens and thus prevent losses in pig production. Through the early identification of animals with fever, producers can apply appropriate measures to reduce losses, like isolation and separate treatment of sick animals. This approach allows a more targeted treatment, which results in lower medicinal costs and in a more tailored use of drugs, like antimicrobials. The development of advanced technologies to optimize the early detection of disease warnings should therefore be highly encouraged.
In general, it can be concluded that applying precision livestock technologies can be highly beneficial to the farmer, when proper measures to control the identified problem are set-up in time.

Specifically, the easy measurement of temperature, allowing for early detection of febrile animals, enables the farmer to seek for earlier diagnostics and apply corrective measures in time. By isolating sick animals promptly, the farmer might contain the spreading of the pathogen, thus reducing the morbidity and consequently minimising the number of animals that require treatment. Importantly, the reduction in antibiotic consumption is beneficial to the farmer as it reduces veterinary costs, and it is an issue of high relevance to the Global Health.

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Challenge: Influence of Gut Health on Disease and Production

Introduction

Optimal health in pigs is crucial for achievement of good production results and animal welfare. Due to intensification of pig production, which results in increased herd size and productivity, the pig industry needs to catch up on latest and most effective practices in order to remain competitive. Therefore, the purpose of this project is not only to identify the best practices regarding one specific challenge but also, most important, to share knowledge among participating EU Member States.
The challenge “influence of gut health on disease and production” is one of two challenges chosen within the “Health management” theme (WP2) this year.

The present technical report has the aim of providing both an overview of current challenges in gut health and respective solutions from five best practices selected in Europe. By shedding light on this issue, potential lack of knowledge should be revealed which can lead to better understanding of how intestinal diseases can be prevented and treated. Implementing gut health becomes both a priority and a challenge, especially after European Union´s decision to ban the use of Zinc Oxide (ZnO) and heavily reduce the use of antimicrobials in livestock production.

1. The Background to the Challenge

Following Bischoff´s definition, the term “gut health” covers multiple positive aspects of the gastrointestinal (GI) tract, such as the effective digestion and absorption of food, the absence of GI illness, normal and stable intestinal microbiota, effective immune status and a state of well-being [1]. Optimizing gut health and handling of intestinal diseases is a very important challenge in the pig production today [2]. To gain high productivity of the growing pigs and the sows, animals must consume a high level of energy provided by finely ground feed. Nutrition and strategies to implement gut health are more and more under the spotlight, especially since extensive research recently proved the fundamental role of gut microbiota in influencing general animal health [3].

Most intestinal diseases are successfully treated with antimicrobials, but as the demand for diminishing antibiotic usage in livestock grows, other solutions to prevent and contain the problem must be sought. Intestinal diseases presumably account for most of the antimicrobials used worldwide [4, 5] and causes great economic losses and reduction in

productivity [6, 7]. Furthermore, the EU must abandon the use of medical zinc (ZnO) in pig production by June 2022 [8] and this, together with an increasing demand for reduced use of antimicrobials, will indeed create a great challenge for European pig producers. Additionally, the fact that not all intestinal disorders are of infectious origin [9, 10] further reinforces the importance of finding alternative ways to antibiotics to handle intestinal diseases.

Diarrhea is especially a problem in the nursery period [2, 11, 12]. In fact, weaning is an important source of stress for piglets and can severely affect their gut microbiome [13]. Researchers and companies worldwide have extensively looked into possible feeding strategies and feed additives.

Concerning gut health of sows, emphasis is typically given on providing appropriate nutrition to enable sows to reach an optimal health status during lactation and thus to wean strong piglets. Here, studies have shown that different additives in sow feed such as lactic acid bacteria, polysaccharides and essential oils can potentially improve the health of piglets [14-19], but the scientific community does not fully agree on the significance of their positive effects.

Different strategies for feeding of weaners and finishers also includes feed additives such as fatty acids and organic acids, which can improve gut health and thereby decrease the need for antibiotics and ZnO [20-22].

Probiotics are live microorganisms that can confer a health benefit on the host. Amongst various mechanisms, probiotics are believed to exert their effects by production of antimicrobial substances, competition with pathogens for adhesion sites and nutrients, enhancement of mucosal barrier integrity and immune modulation. Through these activities probiotics can support three core benefits for the host: supporting a healthy gut microbiota, a healthy digestive tract and a healthy immune system [23]. Inulin has been reported to improve the homeostasis in the gastrointestinal tract (GIT) of pigs by modulating the intestinal microbiota and fermentation [24]. Also, supplementation of post-weaning diets with exogenous enzymes has been suggested to control post-weaning syndrome, by compensating for the under-developed endogenous enzyme secretory capacity and increasing nutrient digestibility in newly weaned pigs. However, the effect of in-feed enzymes in improving gut maturation, growth and/or health in weaned piglets is not always consistent [25].

Even if it can be expensive and time-consuming, giving a little extra attention to the quality of the weaner feed can be fruitful. For example, skim milk supplementation before and after weaning can improve pig growth performance [26] and better digestible feed such as fermented feed can influence the ecology of intestinal microbiome [27-30].

Attention must also be given to intestinal diseases of non-infectious origin, such as stomach ulcers. This condition occurs in all ages, but sows and finishers seem to be predisposed. Here, larger grounding of feed and supplement with straw can be beneficial preventive measures [31-33].

2. Addressing the Challenge

Gastrointestinal problems can cause large economic losses in the pig industry. Several studies have been carried out to address the influence of gut health on disease and production. The Cost Action PiGutNet has been established in 2014 to set up a European Network on the factors affecting the gastro-intestinal microbial balance and the impact on the health status of pigs. According to scientific literature, the mammalian gastrointestinal tract, during the prenatal, neonatal and post-weaning periods, undergoes various morphological and physiological changes alongside with an expansion of the immune system and microbial ecosystem; the composition of the intestinal microbial communities seems to be affected by the early postnatal environment, which might also contribute to gut maturation, metabolic and immune development [34]. Recently, the concept of combining probiotics and prebiotics, i.e. synbiotics, for the beneficial effect on gut health of pigs has attracted major interest, and examples of probiotic and prebiotic benefits for pigs are pathogen inhibition and immunomodulation [23].

The purpose of this project is to show different strategies to implement gut health, which have been already used successfully on farms across Europe. By describing up-to-date strategies to improve gut health, this report provides the farmer with experience-based solutions to address this challenge, in a context where ZnO is banned and antibiotic use is restricted.

3. EU PiG Best Practice

In order to identify the top five best practices across all the EU PiG regions a series of criteria has been used, which are able to measure the effectiveness of the collected practices to match the specific challenge.

The following set of criteria have been scored for each practice.

- **Excellence/Technical Quality**
    - Clarity of the practice being proposed;
    - Soundness of the concept;
    - Knowledge exchange potential from the proposed practice;
    - Scientific and/or technical evidence supporting the proposed practice.

- **Impact**
    - The extent to which the practice addresses the challenges pointed out by the Regional Pig Innovation Groups (RPIGs);
    - Clear/obvious benefits/relevance to the industry;

- Impact on cost of production on farm and/or provide added value to the farming business or economy;
- The extent to which the proposed practice would result in enhanced technical expertise within the industry e.g. commercial exploitation, generation of new skills and/or attracting new entrants in to the industry;

- **Exploitation/Probability of Success**
  - The relevance of the practice to each Member State (MS) or pig producing region/system;
  - Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
  - The extent to which there are clear opportunities for the industry to implement the practice/innovation;
  - Degree of development/adaptation of the practice to production systems of more than one MS.

- **Innovation**
  - Evaluation of innovation (novelty) with the good practice
  - Level of innovation according to the Technology Readiness Level (TRL).

Scores had to be in the range of 0-5 (to the nearest full number). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guidelines for scoring are shown below (no half scores could be used).

0	The practice cannot be assessed due to missing or incomplete information.
1 – Poor	The practice is inadequately described, or there are serious inherent weaknesses.
2 – Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3 – Good	The practice addresses the criterion well, but a number of shortcomings are present.
4 – Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5 – Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The selection of the top five best practices followed the procedure described below:

1. Members of the thematic group (TG) were asked to score all submitted best practices according to the defined guidelines and sent their scoring sheets to the TG leader
2. In addition to the scores, TG members provided brief comments indicating weak points or particular strengths of submitted best practices
3. A conference call was used to discuss the scoring results and select the top 5 best practices. During this call, the top 10 best practices were discussed based on the ranking submitted by thematic group members. The discussion of the top ranked best practices was started from the lowest rank, i.e. best practice with the highest average score, to rank number 10. A selection of the top 5 best practices was made during the call.
4. A summary of all discussions was sent out after the call to review the decision of the selected five best practices by TG members.

4. Results and Discussion

4.1. Validation of the Top Five Best Practices

The following top 5 best practices within the challenge of “Early warning of diseases and production errors” have been selected by the thematic group:

Title of best practice	Country
Fermenting liquid feed, an alternative to Zink Oxide	The Netherlands
Seaweed to Improve Gut Health	Ireland
Use of Medium Chain Fatty Acids to Improve Gut Health	Ireland
Milk Bowls After Weaning	Ireland
Hot Gruel to Improve Gut Health	Ireland

Fermenting Liquid Feed, an Alternative to Zinc Oxide

The Company van Asten Group (Sterksel, Netherlands) started feed fermentation in 2008. Learning from experiences and looking at cheesemakers, they started a 3-year trial with the aim of establishing a failure-free system. The main innovation is cleaning with 70-degree hot water and also add raw material in hot water to kill all present bacteria. Afterwards, cold water and the liquid active bacteria are added to reduce temperature and secure a fast

growth. The temperature and cleanliness is important to have good lactic acid values and low acetic acid [35]. The lactic acid metabolizes anti-nutritional factors (ANF) and difficult digestible starch: This acid acts as a probiotic and, by lowering the pH first in the feed and secondly in the pig stomach, reduces the risk of an overgrowth of pathogens, such as *Salmonella* spp. and coliforms [36]. Fermented liquid feed stabilizes gut microbiome and improves pig performances. For maximum effect, it is fed together with wheat barley mixture and plant-based proteins.

Van Asten aims at marketing antibiotic-free pigs, they expect to achieve this quickly. At the beginning, they could reduce the use of antibiotics of 50% and now they are aiming at phasing them out. Additionally, they work on producing Non-GMO and Regional feeding for pigs. Van Asten claims the fermentation of peas and beans is a key element for the success of this process and the access to the market. Indeed, laboratory tests show a strong reduction in ANF in peas and beans, which reduces the risk of gastric distortion in piglets.

To get the maximum result in weaned piglets, the sows should also be fed fermented feed as well as the piglets. This should positively influence intestine quality and bacterial life in the intestines. The 3-year test to develop a failure-free system was initiated together with ForFarmers and Weda Holland.

The system is successfully implemented at 3 of the locations in the Netherlands and Germany of the van Asten group and several other farms in Europe. In addition, another location of van Asten in Germany is at the start-up phase and a new location in the Netherlands is planned. The use of liquid feeding systems is widespread in the EU. This system can be easily added and handled by a person who is able to run a liquid feeding system. Enough capacity is needed to prepare the fermented product and the fermented feed can be stored in tanks for at least 24 hours.

Many publications highlighted the potential of fermented liquid feed as an alternative to the use of antibiotics [37, 38], and its role in improving overall animal health [39].

This best practice has been selected by thematic group members as it was, innovative, well described and included a proper cost benefit analysis. Also, thematic group members agreed that fermented liquid feed could be a good idea as an alternative to the use of antibiotics and Zink Oxide, although there was some doubt about the quality and standardization of the fermentation process on farm.

Seaweed to Improve Gut Health

This practice describes the use of seaweed-based product in pig feed to improve gut health. Sealac is an Irish company, established in 2016 and based in the county of Mayo, Ireland (http://www.sealac.eu/). Sealac is a dried product derived from *Ascophyllum nodosum*, a large, common brown algae in the family *Fucaceae*. The species has long strap like fronds

with large egg-shaped air bladders at regular intervals and grows in rocky sheltered areas near by the west coast of Ireland. More specific, this algae is harvested from the sea near Mayo.

This product owns several characteristics properties. This seaweed is high in valuable polysaccharides, including Alginic Acid, fucoidan, Laminarin and Mannitol, and it contains over 60 minerals and elements. It is collected, dried and milled and then sold for €1300 per ton. It is included in all sow feed at 1%, so is costing €16 to €17 per sow per year based on 1.3 t of feed/sow/year. The lactating sows are eating much better in the farrowing house, as a result of the use of the product, leading to a greater milk output during lactation. It appears to stimulate appetite and improve the overall health of the sows. Sealac's unique process maintains the cell wall of seaweed, which is composed of several polysaccharides, which appear to stimulate the growth of healthy good bacteria in the gut. It is also used in weaned pig diets and the farm has noticed a reduced incident of scour in pigs and increased weight gain.

Thematic group members selected this practice and found that it sufficiently met most of requirements (impact, probability of success and innovation). The majority of the thematic group members showed enthusiasm for this seaweed-derived product, which is getting more and more ground in pig practice.

Specifically, the following benefits were pinpointed:

1. The use of seaweed appears to provide several benefits for commercial farming by reducing the need for antibiotics and selective growth promoters as well as promoting animal health, and even having a positive environmental impact, due to improved gut health and reduced animal waste [40, 41].
2. Seaweed is an innovative prebiotic

Cons:

1. Lack of scientific evidence that justifies the observed benefits.
2. Lack of information concerning cost-benefit analysis impairs a clear evaluation of economic benefits
3. It´s a local product in Ireland, but seaweed is not available in all member states.

Use of Medium Chain Fatty Acids to Improve Gut Health

The practice describes the use of NuScience's Vita GP (https://www.nuscience.be/en/solutions-database/vita-gp/) in pig feed to ensure better performance by improving gut health. Vita GP offers broad protection over the complete gastro intestinal tract of fattening pigs by combining antibacterial medium chain fatty acids (MCFA) with a specific agglutinating prebiotic fiber (INSOLFI). Due to their lower molecular weight and smaller size, MCFA are more soluble in water and biological liquids than long-

chain fatty acids (LCFA). MCFA are usually absorbed by portal circulation and transported to the liver for rapid oxidation [42]. This makes them easy to digest and become a source of readily available energy. An additional characteristic of these acids relies in their undissociated, fat-soluble form, which allows them to penetrate the semi-permeable membranes of bacteria and enter the cytoplasm [42], thus conferring them an antibacterial activity. In order for them to be more effective against bacteria in the gut, a low pH level in the digesta is needed and usually this low pH environment is provided in the stomach. MCFA are weak organic acids: this means that at high pH they are predominantly present as salts, which decrease their ability to penetrate the bacterial wall [43]. Thanks to their specific chemical properties, MCFA have an important role in balancing the gut microbiome, thus being referred as “microbiome regulators” [44]. The resulting healthy gut microflora and morphology result in improved feed conversion ratio, lower antibiotic uses and increased pig growth and health status. Vita GP is used in weaner and finisher pig diets. It costs €0.80-1.0 per pig. Improved gut health resulting in increased growth rates, improved feed conversation ratio and lower healthcare costs.

Thematic group members selected this practice and found that it sufficiently met most of requirements (impact, probability of success and innovation).

Specifically, the following benefits were pinpointed:

1. Several members of thematic group members found the combination of medium fatty acids with agglutinating prebiotic fiber innovative.
2. This practice seemed to be quite convenient (1 euro per pig)
3. It can be applicable to most producers

Cons:

1. Lack of information in the cost-benefit analysis impairs optimal evaluation. Improvement in pig health, performances and cost benefits is not supported by evidence and data.

Milk Bowls After Weaning

This practice describes the use of Milk bowls to deliver milk replacer in addition to dry creep feed immediately after weaning. The main purpose of this strategy is to improve pig performance immediately after weaning. Post-weaning feed intake is usually rather low in early weaned pigs. This is probably due to the fact that weaning at 3 or 4 weeks is more stressful than the natural weaning at 8 weeks [45]. This results in some degree of appetite depression in weaned pigs under most commercial situation. In fact, weaning is a very important moment for piglets: they need to learn how to feed themselves and discover water to satisfy their thirst. Early weaned pigs require about 300 g./day of dry feed during the first week post-weaning to maintain their pre-weaning growth rate. Actual feed intakes, however, rarely exceed 200 g./day [46] .

The system is used to get pigs to drink liquids, thus preventing dehydration, quickly after weaning. It is comprised of a small dedicated mix tank and a separate feed line directly to each weaner house. Each pen within the houses has a milk bowl. The milk replacer is mixed with warm water and then fed to the latest weaned pigs for 5 days. It is fed 2-3 times per day in addition to dry creep feeders in the house. The whole system is thoroughly washed every 24 hours. It´s important to keep the mix tank clean and in optimal hygienic conditions in order to avoid contamination and bacterial overgrowth.

The owner of the farm, where this practice has been applied, reports good results. Weaner mortality decreased and the transfer weight of pigs into 2nd stage increased. The number of pigs failing to eat/'falling back' and having to be removed to the recovery pen has also reduced significantly. Milk replacer costs (circa €2,000 per tonne).

Thematic group members selected this practice as they found it an innovative approach to improve weaning procedure. Nevertheless, many shortcomings were observed

Benefits:

1. Promising impact: Milk replacer next to dry creep feed may be very effective to maintain gut health at weaning and helps pigs to gradually leave sow tits and get used to feeders.
2. Concept is innovative and could be transferred

Cons:

1. Milk replacer for 5 days could be quite expensive
2. Lack of information in cost-benefit analysis. It´s not mentioned how much milk replacer should be used, only the cost per ton is mentioned.

Hot Gruel to Improve Gut Health

This practice describes the use of a JFC Milk Kart (http://jfcagri.com/cattle/milk-karts/) with motorized mixer to deliver a hot gruel mix to pigs at weaning. To maximize feed intake during post-weaning period is important to use highly palatable diet. Pigs at weaning will preferably eat warm gruel rather than solid food. Furthermore, gruel feeding seems to have a positive effect in reducing villus atrophy and dehydration that usually occurs during weaning [47].

The following process is used:

1. Fill a mobile mix tank with warm water; 2. Add in creep feed, starting with 12kgs of creep and increase in small amounts each day; 3. Allow water and creep to mix for 6 minutes until it has a consistency of 'pouring concrete'; 4. Initially place a very small amount onto feeding trays in the pen, over the following days progress to placing it on the trays and into the probe feeder. By the end (day 5) place all the mixture in to the probe feeder; 5. Feed small amounts 5 times per day. If the gruel gets cold pigs won't eat it, so it's important to only give enough

that will be eaten immediately. 6. Do not leave mix in the feeder, wash after each feed; 7. Increase the amount fed each day & have supplementary dry creep feed in the pen at all times; 8. Switch to link feed via the probe feeder after 5 days.

As a consequence of the application of this system, weaned pigs perform better, adjust quickly to their new environment and feed, have an improved gut health, resulting in better growth rates (150 pigs weighed last week, 4 weeks weaned, gained an average of 510g/day).

Apart from the purchase of JFC Milk Kart there are no additional costs, but a significant time commitment.

Benefits:

1. Well tested in practice
2. Accessible in term of costs

Cons:

1. Feed preparation is time consuming
2. Hygiene is crucial.
3. Lack of information in the description.

4.2. Cost and Benefit Analysis of the EU PiG Ambassador

Costs and Benefits of Fermenting Liquid Feed, an Alternative to Zinc Oxide

In order to improve the gut health of sows, piglets and fattening pigs the van Asten group in the Netherlands started a 3-year trial to make a failure-free system. The main innovation consists of cleaning with 70-degree hot water and the adding of raw material in hot water to kill all present bacteria. After that cold water and the liquid active bacteria are added to reduce temperature and secure a fast growth. The temperature and cleanliness are important to have good lactic acid values and low acetic acid. The feed stays homogeneous which prevents diarrhoea and there is no segregation while feeding. The lactic acid metabolizes ANF (anti-nutritional factors) and difficult digestible starch; it works as a probiotic and it lowers the pH to reduce the risk of bacteria. Fermented liquid feed stabilizes the intestines and improves the growth of the pigs. To obtain the maximum effect it is fed together with wheat barley mixture and plant-based proteins. At the start the farm experienced a reduction of 50% of antibiotics use and now they are working up to antibiotic free. To get the maximum result with the weaned piglets, the sows are also fed fermented feed as well as the piglets at the sow. This is in order to positively influence intestine quality and bacterial life in the intestines.

According to the data delivered by the van Asten group administering fermented liquid feed is able to reduce sow mortality by 33%, the pre-weaning mortality by 15%, the rearing mortality by 24% and the finishing pig mortality by 17%. The quantity of feed per sow, per weaner and per finisher pig can be reduced by 8%, 3% and 1% respectively. Also the prices of the feed are lower than the standard feed with a decline by of up to 5% according to the different categories of pigs. Of course the energy costs for heating and administering the feed will increase. The extra expenditure for energy has been estimated in +3% for sows and +5% for finishing pigs.

As has been indicated in the introduction, veterinary and medicine costs will decline substantially. These changes are between 30 and 50%. Finally, the manure disposal costs are lower because of the fact that a slightly lower quantity of feed is administered to the pigs.

	Without fermented liquid feed	With fermented liquid feed	% change
Variable costs, (Euro /kg cold weight)	**1.197**	**1.151**	**-3.8**
Feed, (Euro/kg cold weight)	0.855	0.818	-4.3
Breeding cost, (Euro/kg cold weight)	0.034	0.032	-5.9
Vet and med, (Euro/kg cold weight)	0.042	0.041	-2.4
Energy, (Euro/kg cold weight)	0.049	0.051	4.1
Maintenance, (Euro/kg cold weight)	0.037	0.037	0.0
Miscellaneous, (Euro/kg cold weight)	0.180	0.173	-3.9
Fixed costs, (Euro/kg cold weight)	**0.354**	**0.349**	**-1.4**
Labour, (Euro/kg cold weight)	0.139	0.136	-2.2
Depreciation, (Euro/kg cold weight)	0.159	0.157	-1.3
Average interest costs, (Euro/kg cold weight)	0.041	0.040	-2.4
Interest on working capital (Euro/kg cold weight)	0.016	0.015	-6.3
Results			
Total costs (Euro/kg cold weight)	**1.551**	**1.500**	**-3.3**

From the calculations with the Interpig model it turns out that this innovation, able to improve gut health, can contribute to a 3.3 % reduction of the overall production costs of pig meat. The higher energy costs for warming up the feed and the adding of liquid active bacteria are more than compensated by the decline of all other cost categories. This is primarily due to lower mortality rates, lower quantities and prices of feed and significantly lower use of medicines, which denotes the improved health status of the pigs.

4.3. Expert Analysis

In general, the experts agreed on the cost-benefit analysis. However, some experts raised their concern on the completeness of the provided data. They found the analysis too simplified and lacking in information. For instance, data on mortality rates were provided

only as reduction in percentage, while data before and after the intervention would have been more useful to better evaluate this practice.

Recent literature suggests that fermented liquid feed can be a good tool to implement the gut health, which results in a lower need for antibiotic treatment as well as an improved productivity. Potential benefits depend also on how great the is demand for antibiotic reduction in the different member states. Greater the demand for reduced antibiotic consumption, the greater the willingness of farmers to invest in feeding systems that secure a lower need for antibiotic treatments.

Other ways to achieve a similar benefit, such as careful feed hygiene, addition of organic acids to regular dry food and increased access to eating and drinking spaces have been mentioned by the thematic group members. Nevertheless, the experts would need more information on these practices to thoroughly evaluate their benefit in comparison to the use of fermented liquid feed.

4.4. Conclusions and Advice to Industry

The use of fermented liquid feed might be a suitable alternative to the use of zinc oxide. However, the beneficial effects of this practice can be susceptible to variations depending on the initial situation of the individual farm.

5. The Future

Several approaches might be able to implement gut health. The choice of a dedicated feed type for each specific production phase, the selection of feeding compounds, the improvement of management, the implementation of internal biosecurity and the monitoring of pig general health status are all strategies that can reduce the incidence of post-weaning diarrhea and other gastro-intestinal- related diseases.

The adoption of a feeding system like fermenting liquid feed can bring good results, especially when a well-standardized process of fermentation is put in place. Critical points that need to be monitored in the process of fermentation are the temperature and cleanliness of the system. This is important to reach good lactic acid values and low acetic acid. If the feed is not properly fermented, a high concentration of yeast can generate “off-flavors” and taints due to the production of compounds such as acetic acid. The presence of these undesirable odors makes the feed less palatable, thus resulting in lower feed intake.

Therefore, both pigs and farmers will benefit from this kind of system, only when an optimal steady concentration of lactic acid and acetic acid in the feed is guaranteed in a hygienic and cost-efficient way.

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