EU PiG

EU PiG Innovation Group

Technical reports

Precision Production

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Challenge: Nutrient efficiency – feed

1. Introduction

In current intensive pig production systems feed provided to the animals represents the major contributor to production costs (up to 70%). Besides, energy content alone may represent 50% or more of the total cost. In addition, feed and its characteristics (i.e., composition and digestibility) are determinant to animal performance and to N and P excretion. To optimise performance and to reduce environmental impact of pig herds, it is imperative that feed offered and diet specifications match with animals' nutritional requirements. Ultimately, an efficient use of feed is a critically important topic to improve sustainability in pork production.

Feed efficiency represents the cumulative efficiency with which the pig utilizes dietary nutrients for maintenance, lean gain and lipid accretion. Feed efficiency is traditionally being defined as body weight gain per unit of feed consumed (feed conversion ratio) or, in the case of sow farms, feed consumed per year or per wean pig produced. However, feed disappearance is usually the actual measurement (which not necessarily accurately reflects feed intake by the pig). More recently, carcass gain as opposed to total body weight gain is increasingly being used as a more precise calculation of feed efficiency; and residual feed intake, which compares the observed with the expected feed intake of each pig based on growth and back fat, is commonly used in genetic selection programs. Despite the simplicity of its definition, feed efficiency is a complex parameter very difficult to address in commercial herds.

To increase feed efficiency and to maximize performance, all pigs in a herd are traditionally fed a single feed for a certain period of time in group phase-feeding programs. However, conventional group phase-feeding programs may lead to inadequate nutrient supply by disregarding pigs' nutritional requirements and dynamics. Pigs' nutritional requirements change during the growing period, with age and physiological status. In addition, the great variation among individual found in farms animals (even in animals grouped by age and/or gender) is a challenge to manage in modern intensive pig production systems. All these factors will influence feed efficiency. Furthermore, at a given weight, feed efficiency can be influenced by factors internal (e.g., maintenance processes, body composition, health status) and external to the animal (e.g., diet composition, feed additives, feed processing and presentation, environmental conditions, feed and water accessibility and barn design). Therefore, an efficient use of feed will significantly contribute to improve sustainability for pig producers.

The increased knowledge and technology advances currently available to pork producers together with the high formation level of the stock people results in a wide variety of strategies, management and solutions being implemented on farms to improve precision of feeding strategies and ultimately, overall feed efficiency. These practices are usually implemented locally and address feed efficiency based on each farm and production system characteristics and needs. Nonetheless, some of the best practices might provide effective solutions to improve feed efficiency to producers within the EU and globally.

2. Methodology

In order to identify the top five best practices to apply precision production on feed component with the aim to increase feed efficiency across all the EU PiG regions a series of criteria aiming at measuring the effectiveness of the collected practices to match the specific challenge were defined.

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 addressed the challenges pointed out by the R-Pigs Groups;
  - 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 MS or pig producing region/system;
  - Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
  - Level of innovation according to the Technology Readiness Level (TRL)
  - 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 Member State

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 is 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 practices followed a procedure in six steps:

1. All members of the TG had the opportunity to send their scoring sheets to the TG leader
2. The TG members provided brief comments to the first 10 practices they have chosen as best practices, as these comments facilitated the discussion about the first five
3. The TG leader standardized all individual scores by calculating Z-scores
4. The first 10 practices have been ranked according to the average Z-scores of all participants of the Thematic Group. All other lower ranked practices have been excluded.
5. The TG leader collected all the comments of the individual members of the TG for each of these 10 practices and sent them around to the TG.
6. In a dedicated meeting, the Thematic Group discussed the results and finally decided on the top five good practices for each challenge based on the comments provided by the group

3. Results and Discussion

3.1. Validation of top five practices

Best practice 'The Gestal farrowing house feeder and two week batch system' (United Kingdom)

The present practice consists on the capacity to programme six different feeding periods within a day in the farrowing house thanks to the installation of Gestal "Solo" feeders. The producer also determines also a feeding curve according to sow's parity. The feeder has a "toggle switch" in the trough that allows the sow to call for feed (additional up to 120% of her total daily allotment). All feed events (feeding events, amount of feed dropped at each feeding event, etc.) per sow are automatically logged at a computer. Sows that do not eat at the level of their assigned feeding curve are flagged both on the computer and on each feeder by using a LED light. In addition, the producer works in a two-week batch system which allows him to wean piglets at 32-33 days of age, with subsequent higher weaning weights.

Feeding of the lactating sows is one of the main concerns for producers. Achieving individual control of sows' intake during lactation and reaching the maximum intake potential of each animal is a challenging endeavour, especially in large herds. From a management point of view, one of the biggest difficulties in the farrowing house is to properly identify whether a sow is able to eat more or not. Maximizing feed intake of sows during lactation, preferably using a step-up strategy, reduces body weight loss during lactation and improves milk yield and litter body weight; it also has a positive effect on sows' reproductive performance in the subsequent cycles. However, there are evidences that offering feed to sows above their intake capacity might end up reducing their total feed intake. In addition, it has been observed that when sows are allowed to choose when to eat and how much to eat, they show increased appetite. The solutions provided by the Gestal feeding system used in this best practice are valid also for big herds, since it does not require for more labour (e.g., more time checking the feeders, looking for feed refusals, assessing body condition and litter size, etc.) and the final decision to increase feed allowance falls to the sow. This practice also allows to program up to six feeding periods and lactation based feeding curves within the farrowing house, hence adapting feeding to factors such as parity, body condition and/or litter size. Parity is a factor influencing daily and total feed intake during lactation, with first and second parity sows usually consuming less feed. Nonetheless, this practice requires the producer to be precise on setting the feeding curves and identifying the different sow characteristics and requirements within each batch. Installation cost of the feeding system could also be a handicap for its implementation.

Finally, growth check of piglets after weaning is another key aspect in modern pig production, which has economic, health and welfare implications. Increased body weight of piglets at weaning is one of the most influential factors minimizing the negative impacts of weaning. With a prolonged lactation length, the present practice not only improves weaning weight of piglets but their maturity, making them more resilient to the weaning stress. However, implementation of a longer lactation period through a two week batch systems might be limited by management and farrowing house capacity in farms.

Best practice 'Systematic routine weighing' (Denmark)

The present practice consists on the use of a weighing system that allows the farmer to record growing/fattening pigs' live weight on a weekly basis. The information is used to monitor pigs' growth (to compare it with the expected growth) and to choose the right feed mix to be offered to the animals. For finisher pigs weight can be monitored in shorter intervals and feed mix changed accordingly. The weighing system also allows for monitoring of average daily weight gain. The routine weighing system is also used in the farm to test new types of feed mixes since the producer is able to feed two different diets within the herd. Weighing the pigs routinely allows the producer to better select the largest pigs that are send to slaughter.

Despite the recent claims of using carcass weight as a more accurate measure of feed efficiency, body weight from live animals is arguably the most feasible parameter to record on farm to measure feed efficiency. Therefore, any system that periodically records live weight of pigs will provide valuable information to monitor growth performance and to apply management strategies to improve it. Nonetheless, to properly monitor feed efficiency, the system should also measure or estimate feed intake of the animals together with the live weight. Although there are a large variety of factors that impact feed efficiency (e.g., breed, environment, health, body composition, individual variation in maintenance requirements, etc.), body weight of the animals is arguably the most important factor driving pigs' nutritional requirements during the growing period. Besides, modern genotypes require diet specifications closely aligned with animals' nutritional requirements and the current practice not only provides continuous information of pigs' weight and growth but also allows to adapt the diet offered accordingly. On top, by comparing the observed growth to the expected growth, this practice allows to identify animals with different 'residual feed intake' (a measure of production feed efficiency) which can be useful when deciding to send pigs to slaughter for it provides indirect information on carcass fat content. Controlling for individual weight and growth also allows for monitoring variation in weight within pens which can allow for early management interventions at a pen or batch level when an increase in variation is detected. Feeding pigs a mixture of two feeds, blended according to their weight, is a practice that has the potential to optimise performance by reducing lysine intake and nitrogen excretion more than 20% thanks to a more precise feeding. Monitoring pigs weight and growth in a regular basis also offers the possibility for more accurate early warning of upcoming diseases or veterinary interventions (dosing of medicaments is linked to the animals' body weight in almost all of the cases), resulting in diseases having a lower impact on feed and growth efficiency. Finally, by being able to identify the heavier pigs in the pen/s and sending them earlier to slaughter this practice allows to increase space allocation for the remaining pigs across several pens reducing competence at the feed station or feeder.

Best practise 'Optimising feed based on systematic analyses of purchased feed ingredients' (Denmark)

The present best practice consists of the possibility to routinely adapt every feed ingredients in the production. Feed ingredients analysis are performed whenever a new ingredient or new batch of grain is introduced in the feed. In collaboration with the feed advisor each feed is optimized and adapted according to the actual analyses results before being used in the diets. According to the producer, adjustments of 2% in Soya inclusion have been done due to higher content of protein in the new incoming batch of grain. The herd has experienced improved feed conversion ratio and reduced occurrence of diarrhoea due to the implementation of the routine testing.

The great majority of practices/strategies to improve production and feed efficiency focus on a better knowledge and continuous monitoring of animals' requirements through their production cycle and adapting the feeding strategy to them. On the contrary, the present best practice focus on properly characterize the composition of the raw materials at their arrival to the farm to adjust the diets to the animals' requirements. Although purchased ingredients are usually characterized at origin, such information is usually obtained from a limited sample. However, there are a variety of factors that might introduce variations in feed composition: country or area of origin, growing conditions, time of the year of planting and harvest, hybrid or variety differences, storage and feed out conditions. Although it is recognized that it is difficult to control feed factors that influence performance and that there is uncertainty in feed composition, actual nutrient composition of ingredients or feed is usually overlooked in commercial settings. With the increase of information obtained from pigs in commercial farms, feeding strategies and diet characteristics are adjusted to closely match animals' requirements. In this more precise scenario it becomes more important to be sure of diets' characteristics to avoid having animals fed over or under their requirements. On one hand, this practice allows to reduce the incorporation level of an ingredient if its composition on a given component is higher than the expected thus, directly reducing the cost of the diet and reducing N or P content in the manure. To properly characterize the composition of the raw materials, together with accurately identify pigs' requirements, is key to minimize excretion, which can be an indirect cost to the farm and is a matter of environmental concern. On the other hand, this practice allows to increase the incorporation level of an ingredient if its composition on a given component is lower than expected, which might increase the cost of the diet but will prevent to increase the number of days to reach a certain weight by maintaining the growth efficiency of the animals.

Feed is a major production cost and this practice aims to maximise the return on investment through an actual knowledge of the composition of the feed ingredients. This practice is oriented to producers that elaborate their own feed with purchased ingredients and/or with their own produced grains. Nonetheless, given that manufacturing process of feed diets (e.g., pelleting, heat treatment, etc.) and storage conditions before being delivered to farms can also alter its characteristics, the present practice could also be of interest to producers that use a blend of different diets to feed their pigs. In all situations, this practice requires access to analytical equipment or laboratories and continuous collaboration with a nutritionist or feed advisor professional.

Best practise 'Feeding management precision systems: feeders, feed management, automation, measurement, analysis tools' (Belgium)

The present best practice consists in accurately monitor the technical performance and health of sows and piglets in each farrowing pen. Sows feed intake is weighted individually, resulting in a detailed analysis of the sow performance and health. The installation of a feeding kitchen scale mixer allows for the preparation of separate feed portions that can be send to piglets in an individual pen. The use of the feeding kitchen for piglets together with piglets weighing allows the producer to monitor the technical performance and health of suckling piglets pen by pen.

Although there are several factors influencing sow health and performance during lactation, feed intake is arguably the best indicator of sows' production efficiency. To support large litters it is important to maintain sows in good body condition during lactation. In modern sows, selected for high prolificacy, and for lean and efficient pigs, feed intake during lactation has become a limiting factor. Moreover, high feed or energy intake during lactation is positively related to milk production and lower weight loss during lactation. In turn, higher milk yield will enhance piglets weaning weight, and better body condition at weaning will improve subsequent reproductive performance. Therefore, feed intake during lactation is a key factor contributing to overall performance efficiency of the farm. By monitoring feed intake of the individual sows, the present best practice allows for an early detection of health problems that usually manifest causing reduced appetite in the sow with subsequent impairment of both milk production and growth of the litter. An efficient lactating sow is considered a sow that is able to maintain body condition during lactation (or to show a moderate loss of body condition) and to present a good litter growth rate at a minimum feed intake level. The information provided by monitoring of sows' feed intake and by measuring litter weight and growth provides farmers with the capacity to identify sows with different lactation efficiency. Nonetheless, it is highly recommended to complement the information provided with this practice with monitoring sows body condition. Once the farmer has identified sows with different lactation efficiencies, the feeding kitchen would allow to provide feed in different amounts to litters accordingly to each sow characteristics. Such practice should contribute to ensure a minimum growth of the litters and to reduce weaning weight variability within and among litters. Variation in body weight is inherent to pig farms and is a challenge in modern pork industry for it influences the overall production and feed efficiency of the growing and fattening period. Acting on weight variability sooner in the production cycle is arguably the most efficient solution from a strategic point of view. The present practice attempts to minimize the variation at weaning by monitoring piglets' growth pre-weaning and providing specific feed preparations for each pen. It can be implemented in sow herds of different sizes although it requires economical investment, especially to install the feeding kitchen.

Best practise 'Fine dosing of liquid feed for suckling piglets' (Belgium)

The present best practice consists of providing supplementary feeding for suckling piglets with an automatic feeding system installed in the farrowing pens (Weda Nutrix+). The feed offered can be milk, yoghurt, pre-starter and starter; and the amount delivered can be regulated and monitored through small portions. The producer supplements piglets with milk replacement/liquid feed (VIDA ForFarmers) to ensure a continuous growth and to maximize uniformity of the litters.

The weaning weight of pigs is arguably an important determinant factor of lifetime growth efficiency. Pigs with higher body weight at weaning usually present a more developed intestinal tract and start earlier their solid feed intake; they cope better with weaning stress and are less affected by post-weaning growth check. It has been reported that improvements in weaning weight of 1 kg have the potential to reduce the days to slaughter by 10. However, genetic selection of modern sows to produce larger litters has resulted in lower weaning weights due to reduced body weights at birth. Moreover, large litter sizes usually outnumber functional teats of sows hence, milk production becoming a limiting factor for piglet growth. It has been suggested that sucking piglet daily growth potential when offered free access to feed can double the observed growth of sow-reared piglets, and that the difference in voluntary feed intake start to be observed around 8 to 10 days of lactation. Although the present practice does not provide unlimited access to feed, it aims to increase lactation efficiency by providing extra feed to piglets thus, becoming less dependent on sows' milk production. Nonetheless, the present best practice provides feed to all litter, extra management might be needed to ensure that small piglets benefit from to it. In turn, supplementation of piglets might contribute to increase colostrum and milk intake from the sow. Offering sucking piglets extra liquid milk replacers provides the animals with a boost, that contributes to an increased growth and average weaning weight. However, such effect seems to be less evident in low birth weight piglets. At weaning, one of the most important stressors is the transition from liquid feed (milk) to a solid diet. The present practice offers the possibility to prepare piglets to weaning by gradually transitioning from milk replacement to solid feed during lactation. Recently, evidences on the physiological functions of compounds present in colostrum and milk (e.g., hormones, growth factors, nucleotides, etc.) has increased the interest in using these substances as feed supplements for piglets to enhance growth and maturation of the gastrointestinal tract, specially of low birth weight piglets. The present practice has the potential of introducing these substances as supplements during lactation. Although piglets' consumption of solid feed (e.g., creep feed) offered during lactation is reported to be low and very variable between animals, it has been observed that piglets eating solid feed during lactation are faster to start eating after weaning and might present better growth during the first two weeks post-weaning. In contraposition to offering creep feed, the present best practice allows to start supplementing piglets from very early stages of lactation in the form of milk replacement or yogurt before starting to offer solid feed which might contribute to enhance overall intake during lactation. In contraposition to artificially rearing piglets, the present practice might allow to rear supernumerary litters with the sow, reducing the cost of milk replacer. Since it does not require extra space to allocate surplus piglets, the present practice can be implemented in a wide variety of commercial sow herds prior consideration of the cost of installation.

3.2. Cost and benefit analysis of the EU PiG Ambassador

The costs and benefits of implementation of the systemic routine weighing have been analysed taken into account the changes in technical production performance parameters and necessary investments on the case study farm. Basing on the real farm data, literature review and calculations with the Interpig model the following changes has been assumed:

- daily rearing and finishing life weight gains were 5% higher (rearing 466 g/day and finishing 998 g/day). Feed conversion ratio was 0,1-0,15 (feed per kg) lower due to better utilisation of feed.

- farmer reported an extra labour input of 1 hour per week for weighting the pigs but reduced time spent when weighing pigs out for slaughter.

- an investment cost 31 500 DKK (ca. 4200 euro).

Based on these assumptions the variable production costs decreased by 3,03% and fixed costs decreased by 1,76% (additional fixed costs had smaller impact then the efficiency gains, which resulted in reduced average fixed costs per kg). In result the total costs were **2,72%** lower in case of implementation of the systemic routine weighing.

Challenge: Nutrient efficiency – water

1. Introduction

Availability of water is of vital importance for a good production. Water has several functions for a pig. Intake of water is needed to support the physiological processes. In this best practice we will focus on the water that is consumed by a pig. Water can also have an external function. Cooling, taking a mud bath and water for cleaning are topics that will not be discussed in this best practice. Be aware that when water is also used for cleaning of buildings and equipment it is often in combination with detergents or disinfectants.

With regards to water in precision production accurate allocation of water is important in modern pig herds. It is essential to use water in an efficient way due to several reasons. Although water is relatively inexpensive it is still a relevant indirect cost to the pig producer. Indirectly, water wastage increases the amount of slurry, which influences the size of the manure storage and the costs for manure disposal.

From an environmental perspective, clean water is a vulnerable resource, which we are highly dependent on. Agriculture accounts for 92 % of the freshwater footprint of humanity and about one third is related to animal products[1]. The water footprint for pigs is 5989 litre per kg of pig meat, 2.15 litre per kilocalorie, 57 litre per gram of protein and 23 litre per gram of fat[2].

Even though it is beneficial to reduce water consumption from a cost point of view it is also essential to use the adequate amount of water and in a high quality, since the growth and productivity of pigs is reduced if they do not have sufficient clean water available[3]. Because water intake is related to the health status and behaviour of pigs, it can be used to monitor and predict i.e. subclinical symptoms of diseases.

Due to water having several essential purposes in pig production a range of technologies are available to optimize and improve water efficiency. The suggested ”best practices” within this challenge include techniques to gain information about the production, which can support daily or strategic management related to the water consumption in the herd. Amongst the “best practices” are also methods to ensure clean and accessible water with a limited amount of waste.

Within this challenge the purpose has been to find “best practices” that has the potential to increase nutrient efficiency by applying precision production management. Precision production may refer to automated techniques whereby data and information from the pig production routinely is collected and processed, to support the farmer taking management decisions. The term also covers suggestions regarding standardized management routines and following specific protocols and blue prints.

2. Methodology

In order to identify the top five best practices by applying precision production on water management with the aim to increase feed efficiency across all the EU PiG regions a series of criteria aiming at measuring the effectiveness of the collected practices to match the specific challenge were defined.

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;
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- **Impact**
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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 is shown below (no half scores could be used).

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7. All members of the TG had the opportunity to send their scoring sheets to the TG leader
8. The TG members provided brief comments to the first 10 practices they have chosen as best practices, as these comments facilitated the discussion about the first five
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11. The TG leader collected all the comments of the individual members of the TG for each of these 10 practices and sent them around to the TG.
12. In a dedicated meeting, the Thematic Group discussed the results and finally decided on the top five good practices for each challenge based on the comments provided by the group

3. Results and Discussion

3.1. Validation of top five practices

Best practice 'Clean and accessible water'

Description:

This "best practice" consists of two key elements, which is to1) provide clean water without any contamination of bacteria, algae, viruses, faeces etc. and 2) ensuring adequate access to water. A water purification system from Danish Clean Water (DCW) ensures clean water and prevents formation of a biofilm in storage facilities, pipelines and drinking troughs. The component is a disinfectant, NEUTHOX®, which is biodegradable. It is stated, that the increased focus on clean water, accessible water and the use of a disinfectant, reduces the presence of pathogenic bacteria and thereby diminishes the use of antibiotics.

Documentation:

The system from DCW uses a technique known as "slightly acidic electrolyzed water" (SAEW). It is an electrolytic process, which produces hypochlorous acid from water and salt. Several studies have shown that SAEW has the ability to inactivate *Escherichia coli* [4–6], *Staphylococcus aureus* [4,5] and *salmonella* spp [4,6]. SAEW can be used as disinfectant on surfaces or equipment and has shown good results in reducing *Salmonella* and *E.coli* in both layer breeding houses [7] and in pig barns [8].

Besides, adding NEUTHOX® to the water, this best practice also includes adequate access to water. The second part of this best practice, aims to ensure adequate access to water.

Water is provided to newly weaned pigs in a trough, which are systematically cleaned a least once a day or more frequent deemed if necessary. Furthermore, two drinking cups are present in each pen, which is twice as much as recommended for this particular stocking density. There is a correlation between feed intake and water intake [9], but it is easier to affect drinking rather than feeding behaviour [9]. So, water is used as an indirect stimulus for feed intake. Literature is scarce on the effect of additional water troughs or drinking nipples, but one study showed that pigs weaned at 35 days of age grew faster, when they drank from trough instead of nipple drinkers and when sufficient trough length were available [10]. However, the effect of water deprivation has been investigated in some studies. Horn et al. (2014) [3] found that pigs exposed to 24 hours water deprivation at weaning showed a reduced average daily gain at day 1 and the body weight remained lower until day 27. Also, Torrey & Widowski (2006)[11] found that newly weaned piglets prefer a water source with easy access, such as a float bowl drinker.

Conclusion:
This particular "best practice" is well defined and includes both technical improvements and management strategies. The management strategies are focused on the group level and hardly show any precision background in the sense that automatic water intake monitoring or water control is performed. The SAEW concept is also available in several variations from different companies. The effect is well documented when used on surfaces and equipment but to a lesser extent when used in drinking water. The technique can be used for several purposes including cleaning of pipes, surfaces and equipment, but it also shows potential in reducing infection pressure and thereby the use of antibiotics. Due to the various applications, the technique can be beneficial in several regions. Most literature concerns weaners but the practice is suitable for finishers as well.
The second part of this best practice is related to management strategies, which makes it more difficult to define. Also, research within additional water is scare and the potential relies on whether pigs are depressed from water. Management strategies differ between regions and the effect will most likely vary.

Best practice 'Use of a novel on farm drinker system'
Description:
This "best practice" is a novel type of drinker systems for weaners. The system was changed from long troughs on the floor with nipple drinkers above to a combined nudge bar- trough designs. In this system the trough is placed immediately below the nudge bars, rather than on the floor. Also, the

troughs are shorter in length and can easily be tipped out on a daily basis to ensure clean water. Nudge bars replaced the traditional nipple drinkers. It is stated that this type of drinker system reduces water wastage and improve productivity by increasing growth rate and feed conversion ratio.

Documentation:
Newly weaned piglets' preferences for drinker types have been investigated. A study showed that they prefer a nipple drinker or a float bowl drinker rather than a push-lever bowl drinker. It was also observed that piglets endured more water wastage from the nipple drinker[11]. Another study also showed a higher water intake when weaned piglets were offered drinking nipples compared to water bowls. It was not reported whether the water wastage differed between groups, but pigs in the group with drinking nipples showed an improved daily gain[12]. One study showed that pigs weaned at 35 days of age grew faster when they drank from trough instead of nipple drinkers and when sufficient trough length were available[10].
Water troughs demands often and thorough cleaning to keep them clean. A study compared newly weaned piglets use of different water devices. A nipple drinker was compared with a float controlled bowl, a float-controlled bowl, which was not cleaned daily and a combination of a nipple and a cleaned bowl. At day 4 only the non-cleaned bowl showed a significant lower intake of water compared to the other 3 options[13].

The combined nudge bar's trough design elevates the trough from the floor. This might prevent pigs from contaminating water and thereby reduce the need to drain and clean the troughs. The literature shows varying results regarding preferences of water devices. The results are not consistent. Nipple drinkers are often mentioned to cause a large amount of water waste, which increases the manure volume. The use of troughs might diminish the amount of wasted water, but it demands a higher degree of inspection and cleaning.

The troughs used in this particular "best practice" might reduce the needs for cleaning compared to other troughs placed on the floor.

Conclusion:
For this suggested "best practice" literature is not consistent with regards to the potential benefits. Some studies show that nipple drinkers are preferred by piglets, while other studies show that piglets prefer drinking from bowls. By using the nudge bar combined with a trough, more options are available. It has also been reported by several studies that nipple drinkers might lead to increased water waste, which will increase the manure volume. The use of water troughs might prevent extended water waste. If it is decided to use troughs for drinking water the hygiene and cleaning is very important. The type of troughs suggested in this particular practice might reduce the contamination of water, since it is raised from the floor and it is easier to clean, since water can be tipped out of it. The effect of this practice is not very well documented and the outcome is closely related to management routines. Also, this best practice might be relevant for management strategies on group level, but there is no component of precision present.

Use of water meters

Description:

At Bramblemore pig farm in Ireland, water meters are used to monitor usage of water throughout the pig farm. It focuses the farm on its use of water, ensuring adequate delivery of water to the pigs while minimizing water waste and reducing manure volumes and the associated costs. They have installed a meter on their inlet line and monitor and record the usage on an ongoing basis.

Documentation:

The use of water meters can provide information about the water flow in different parts of the farm. This information can of course be used to detect if water is leaking or if the supply is insufficient in particular places. The information can also be used as a management tool, since a list of health- and productivity parameters are related to changes in water consumption. Studies have shown that subclinical signs for diseases such as diarrhoea or influenza can be predicted from water consumption[14,15]. Also, temperature and stress affects the use of water[16]. In finishers there is a strong relationship between water consumption, feed intake and average daily weight gain. Continuously registrations of water consumption are beneficial because of the aforementioned reasons. Furthermore, information regarding water use for a prolonged period can be used to evaluate the growth period, and investigate if any systematic fluctuations occur.

Water is also used for washing and disinfection between batches. Normally this water is added to the manure increasing volumes and associated costs as mentioned before. By using water meters it is possible to investigate the amount of water used for washing in each unit and optimize the processes.

Conclusion:

Regarding this practice, literature is really scarce, since the use of water meters by itself does not have any effect. The benefits rely on whether the use of water meters is followed by a management action plan as well as the frequency and the level of detail in collecting data (i.e. every day). Measuring the water flow provides information about the consumption in each part of the production, but this information can be used to varying degrees. Therefore, the effect is depending on the decisions that are made based on gained information. Water meters are available in a range of variants, it is easy to implement and can be used in all regions.

Best practice 'Risk analyses of drinking water'

Description:

This "best practice" consists of a risk analysis of drinking water systems. The whole system, from well to drinking points, is inspected. Through pictures and analyses the "points of improvement" are illustrated. It is claimed by the company that this risk analyses leads to better drinking water and thereby less use of antibiotics. These statements depend on the type of challenge and whether actions are initiated.

Documentation:
Studies have shown that water quality might affect water consumption and nutrient availability. An older study found that increasing the amount of total dissolved solids from sodium bicarbonate, sodium chloride and sodium sulphate resulted in decreased metabolizable energy[17]. Another study conducted with newly weaned pigs, found that water with elevated levels of minerals resulted in reduced gain and feed efficiency, when no antibiotics were applied. The use of antibiotics eliminated the effect of water quality[18]. A Danish study found a tendency towards higher bacterial counts in water from herds with weaning diarrhoea[19]. The risk of contaminated water depends on the source. Normally water in pig production is derived from groundwater typically from the farm's own borehole, or surface or pipeline water. The quality from these sources varies with the highest risk of contamination in the surface water. The risk of contamination will influence the effect of a risk analysis. Regular risk analyses of drinking water might be beneficial, to ensure that the water has a sufficient quality. It can also be used for troubleshooting if the farmer experiences impaired productivity.

Conclusion:
Risk analyses of drinking water are relevant to swine producers independently of region, but it is not clear why this particular analysis differs from others. Results from literature indicate that water quality might affect productivity and health in swine production, but it is unclear to what extent. It is stated that this practice should reduce the use of antibiotic. A risk analysis of the water will not change the quality of the water. It might indicate problems, but other initiatives are needed to improve the quality and possibly affect the use of antibiotics. The risk analysis is a tool that might be combined with advisory services, which then will help solve potential problems.

Best practice 'Aquamat'

Description:
This "best practice" has its origin in horticulture. It is developed to collect real-time data of soil and weather conditions. Some of these registrations might also be beneficial to pig producers.

This information is available on a web server, which you can reach from any internet-enabled device. It is possible to receive alerts and updates via text message, email or phone calls. A range of sensors are available for the system e.g. ambient temperature, humidity, wind speed and water flow. In the suggested best practice, a farmer uses the system for watering sows in the farrowing unit. It is possible to program the system to deliver water within defined periods.

Documentation:
According to EU regulations (council directive 2008/120/EC of 18 December 2008), pigs must always

have access to drinking water. Water is essential for a range of biological functioning and insufficient supply might have a negative impact on production. In lactating sows water deprivation can lead to reduced milk production and thereby reduces piglet growth[20]. On the other hand water wastage results in increased amounts of manure with associated cost of storage.

Conclusion:

This particular "best practice" is not very well defined or described yet. It claims to concern both technical improvements and management. The technology is not developed for use in pig production, but it is based on experiences from horticulture and it might be possible to adapt the system for other purposes. Since, the practice is not well defined and the technology is not regularly used in pig herds it is difficult to give a proper advice. No literature or test results are available from the company or others. Clean and sufficient drinking water is a concern in pig production independently of region, which makes this practice relevant to all regions if it is suitable in the particular system.

3.2. Cost and benefit analysis of the EU PiG Ambassador

The costs and benefits of implementation of the water purification system have been analysed taken into account the changes in technical production performance parameters and necessary investments on the case study farm. Basing on the real farm data, literature review, expertise of Danish Clear Water company and calculations with the Interpig model the following changes have been assumed:

- rearing and finishing mortality decrease by 1% (percent point).

- daily rearing and finishing life weight gain were 10% and 5% higher respectively. Feed conversion ratio was 3% better due to better utilisation of feed.

- the farmer reported 10 percent reduced illness with diarrhoea, which results in lower veterinary costs estimated for a decrease of 10%.

- additional maintenance costs of the system were estimated for 0,055 € per cubic meter of water;

Based on these assumptions the variable production costs decreased by **2,84%** and fixed costs decreased by **3,51%** (additional fixed costs had smaller impact then the efficiency gains, which resulted in reduced average fixed costs per kg). In result the total costs were **3,06%** lower in case of implementation of the clean water practice (€ 1,40/kg vs € 1,36/kg hot slaughter weight).

It has to be emphasized that results of implementation of DCW system will be more spectacular on the farms with a bit lower hygiene standards or water quality. According to DCW some farmers reported even 50% decreased usage of antibiotics. The farm under study had already a high standard of hygiene. The simulation in this case has to be treated an indication of possible improvements and benefits.

4. References

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