

Final report

Developing an innovative enrichment product to improve pig welfare

An effort to include the feed industry in development and production of innovative enrichment product for the intensive pig industry



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Executive summary

Enrichment products are used to improve pig welfare by stimulating pigs to execute their natural behaviours in intensive pig husbandry systems. Our project aims at developing an innovative enrichment product that improves pig welfare and include the feed industry in this process. A seven step action plan was made to guide our team during the creative process and to create a design. In the first step, one main research question and several sub-questions were defined, which are answered at the end of this project. After this step, a literature study was performed to find out which requirements need to be taken into account when designing an innovative enrichment product. Then, it was explored how to score existing enrichment products, by using the scoring system RICHPIG. Lastly, knowledge was gained on what kind of enrichment materials and products are currently available, including their strengths and weaknesses.

Based on gained knowledge from literature, brainstorm sessions were held to come up with ideas for a new enrichment product. After these sessions, a new product was designed by combining ideas from the individual designs into one final design, named PIGOOD®.

Farmers and the animal feed industry are important stakeholders in the development process, therefore, a meeting with a farmer and staff members from multiple animal feed companies was conducted. Experts in pig welfare were also invited to this meeting to provide additional information. During this meeting, shortages of our product, innovative ideas and practical limitations of our product were discussed. All information and suggestions given are checked and validated by literature.

Finally, combining this feedback with validated literature led to the development of an improved design of our innovative enrichment product. Recommendations were made to follow-up with this project as the improved PIGOOD® design is not finalised yet. Feedback must be obtained on this design and further improvements need to be made before a definitive design can be launched onto the market.

Table of content

Executive summary	3
Table of content.....	4
Introduction	5
Step 1. Define the problem.....	7
Step 2. Literature study.....	8
Requirements for pig enrichment.....	8
Scoring of enrichment products	10
Existing enrichment products	12
Sensory enrichment.....	12
Physical enrichment.....	14
Nutritional enrichment	17
Knowledge gaps	18
Step 3. Brainstorm and analyse ideas.....	20
Step 4. Design innovative product	21
Specifications	21
Step 5. Feedback.....	23
Substantiation of feedback	25
Step 6. Adjusting and improving the design	28
Specifications	28
Options for on-farm implementation	29
Recommendations	32
Conclusion.....	34
Acknowledgements.....	35
References	36
Appendices.....	41
Appendix 1: Designs brainstorm session	41
Appendix 2: Signed consent forms	43
Appendix 3: Minutes from the feedback session with stakeholders.....	49

Introduction

Pigs are intelligent animals, but are usually housed in a barren environment (Marino & Colvin, 2015). As a consequence, they can get bored and express that by directing harmful behaviours to themselves and others (Van Rooijen, 1991). Animals kept in a barren environment often have trouble expressing natural behaviours, leading also to harmful behaviours, such as tail biting, which compromises welfare and leads to stress, expressed in behavioural and physiological changes (D'Eath *et al.*, 2014). OIE - World Organization of Animal Health (2004) has defined animal welfare as: "An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress." Hewson (2003) mentioned that improving welfare can increase production and improve feed conversion ratios in animals. Different studies have shown that a lack of enrichment products can increase the incidence of harmful behaviours and thus decrease welfare. For instance, Schouten (1986), found that suckling piglets, lacking environmental stimulation and space, show harmful behaviours like chewing the sow and their littermates. Moreover, in finishing pigs a barren environment led to tail biting (Wiepkema *et al.*, 1983), which was substantiated by Sambraus (1985), who found that tail biting occurs in situations where rooting, nibbling and chewing on materials is prevented. A clear natural behaviour of pigs is foraging for food by rooting in the ground, therefore, enrichment materials such as straw, hay or peat are suitable for expressing natural behaviours (Studnitz *et al.*, 2007). Unfortunately, these options are very laborious for farmers and are therefore not very frequently used in barren environments.

Pigs in Peril (Varkens in Nood, VIN), a Dutch animal welfare organisation, is committed to improve the quality of life for pigs. They stress that it is important that pigs have access to adequate enrichment materials. Therefore, VIN contacted the Wageningen University & Research Science Shop (WUR Science Shop) with this problem and they turned it into an assignment for an Academic Consultancy Training (ACT) team at the Wageningen University & Research (WUR). The WUR Science Shop supports non-profit organisations by carrying out research projects with an eventual societal impact in the fields of food and living environment. As ACT team, our goal is to design an innovative enrichment product for pigs, by combining the requirements for pig welfare, preferences of farmers and by including the ideas of the feed industry. The innovative final product can be used by farmers to improve the welfare of pigs.

At the moment, there is a lack of enrichment products that both meet the requirements for pig welfare and the preferences of farmers. Combining results from studies about providing enrichment products for pigs has resulted into a list of requirements for enrichment products, namely; safe, cleanable, edible, chewable, rootable, destroyable, novel, challenging and all pigs must be able to use it and reach it at the same time (ACT-report group 2060, 2018). Unfortunately, these requirements do not take preferences of farmers into account, such as labour intensity and costs. Enrichment products that do meet requirements for pig welfare, but not the preferences of farmers are therefore still not implemented on most farms. Moreover, the link between welfare enhancing enrichment materials and feed companies is missing. Pigs like to eat, and eating is high on their activity list, therefore challenging them with feed will motivate them to show natural behaviour and so improve their welfare

(Studnitz *et al.*, 2007). The feed industry has a direct link with farmers and farmers trust their feed suppliers. Therefore, a possibility for the feed industry to start producing enrichment materials and sell them to farmers is one of the considerations that needs to be taken into account. Hereto, it is important to include the opinion and experience of the feed industry. Eventually, the enrichment product we are going to design should be implementable in every pig husbandry system, but for this project we will focus on finishing pigs, because they are fed ad libitum. This means we do not have to take the nutritional value of the enrichment product into account.

To be able to solve this problem we developed a seven step action plan (Figure 1), as mentioned in our proposal (ACT-proposal group 2166, 2018). Following the seven steps of the action plan, we started with defining the problem and conducted a literature study to determine what current knowledge there is on enrichment for pigs. Using knowledge gained from literature, we proceeded to the next step and had a brainstorm session. This session led to Step 4, designing an innovative enrichment product. Next, we organised a meeting, further called feedback session, with stakeholders that provided feedback about the product. Finally, we incorporated the feedback from the feedback session and adjusted and improved our design. To be able to launch the product onto the market, more feedback will be needed, so Step 5 and Step 6 need to be repeated until the product is completely optimized, but this will be outside the scope of our project due to time constraints. Therefore, also the last step will be not executed during this project.



Figure 1. Seven step action plan to develop the final product.



Step 1. Define the problem

In this step, the problem was defined by formulating research questions. The main research question of this project was: “What kind of innovative enrichment product for pigs can be developed by combining input from the feed industry and farmers, and taking into account the requirements for pig enrichment materials?” To solve this main question, sub-questions were set up:

I. How to define the known requirements to ensure proper pig welfare according to the (Dutch) law?

This can give us information about the requirements that enrichment materials should meet.

II. What kind of enrichment products are currently on the market and what are their strengths and weaknesses?

Investigate the current market, gain knowledge about the existing problems. Inspiration can be deduced from existing products.

III. What kind of enrichment materials are farmers willing to implement on their pig farms?

Farmers may prefer to use a certain kind of material, depending on how much labour they have to put into providing the material, physical properties of the material or costs.

IV. What are the possibilities of the feed industry to be involved in the development and production of the enrichment product?

This can give us information about the possible ways of how the feed industry can be involved in our design. Also, both the nutritional value and the enrichment materials’ requirements of the used feedstuff need to be taken into account.

For this project we figured out what kind of enrichment products are already available and what the pros and cons of these products are. Taking these pros and cons into account, together with requirements for pig welfare, farmers’ preferences and Dutch law, we designed an innovative enrichment product. We presented the designed product to experts in pig welfare and enrichment, experts in nutrition, and a pig farmer, so that opinions of multiple stakeholders can be taken into account, and so a product can be developed that is widely implementable.

In the next chapter a literature study was conducted based on the research questions mentioned above.



Step 2. Literature study

In this step, a literature study was conducted, in which an explanation is given about requirements for pig enrichment, including requirements that make a certain product suitable enrichment for pigs and requirements of the Dutch law. In this literature study it was also discussed what kind of enrichment products are already on the market, including their pros and cons.

Requirements for pig enrichment

Research shows that enrichment products can improve welfare and overall health of captive animals, by modifying the environment (Ralph *et al.*, 2018), but Dutch law is limited and unclear in what kind of enrichment products are suitable for pigs. It states that “pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities, such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such, which does not compromise the health of the animals” (European Commission, 2001). To clarify this statement, the following requirements for enrichment materials, next to safety, are explained by the European Union (European Commission, 2016) as follows:

- “Edible - so that pigs can eat or smell them, preferably with some nutritional benefits;
- Chewable - so that pigs can bite them;
- Investigable - so that pigs can investigate them;
- Manipulable - so that pigs can change their location, appearance or structure.”

These requirements need to be taken into account in such a way that they are of sustainable interest, meaning that the enrichment product should encourage pigs to exhibit exploratory behaviour and can be regularly replenished or replaced. In addition to this, enrichment should be accessible for all pigs and should be cleanable. Requirements mentioned by Dutch law were developed by looking at natural behaviours of pigs and the current situation on intensive pig farms. Pigs are domesticated descendants from the wild boar, therefore it is assumed that the natural behaviour of domesticated pigs is fairly similar to that of the wild boar. Research has shown, for instance, that domesticated pigs, that live in an environment similar to their natural environment, use 52% of the daylight period for foraging, which includes rooting and grazing. From this can be seen that even after domestication, pigs show behaviours similar to their wild ancestors (Studnitz *et al.*, 2007).

Unfortunately, not all requirements are explained clearly by the European Commission (2001), but a clear understanding is needed in order to know which requirements our newly developed product must meet. As mentioned before, for implementation of enrichment products it is important that also farmers’ preferences, such as low costs, are taken into account. In the following part, important requirements found during the literature study were explained in more detail.

Legal

Enrichment product follows laws and regulations.

According to the law of the European Union, pigs “must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities” (European Commission, 2001). According to recommendations made by the Maatlat Duurzame Veehouderij (MDV), enrichment

products should meet at least three of the following characteristics: rootable, chewable, edible, destructible, and novel. It is recommended that enrichment should be placed in the pen where most activity takes place already, and not at the resting place (Stichting MilieuKeur, 2017; Verrijkingmaterialen varkens Maatlat Duurzame Veehouderij, 2018). A certain enrichment product can increase in value when it stimulates interaction with pigs in neighbouring pens, the material is reachable from both pens and, when manipulated, it causes visual or tactile stimuli in a neighbouring pen (Verrijkingmaterialen varkens Maatlat Duurzame Veehouderij, 2018).

Safety

Enrichment product must guarantee animal safety.

One of the most important requirements for the enrichment product is that it is safe to use for pigs. It is important that pigs are not injured or infected by the material in any way. So, the product's components must not contain any toxic ingredients and its use cannot result in any physical trauma. For instance, when using wood as enrichment material, it should not splinter as this might lead to harmful wounds to the mouth. Very pointy, large splinters might even cause internal damage, which can lead to death (Verrijkingmaterialen varkens Maatlat Duurzame Veehouderij, 2018).

Rootable

Enrichment product is promoting foraging behaviour when provided on the ground.

Rootable enrichment products can be defined as solid material that is on the floor, so that pigs can root in it with their snouts. It is important for pig welfare that pigs are able to show natural foraging behaviour, like rooting (Studnitz *et al.*, 2007).

Edible and chewable

Enrichment product is edible and pigs can chew or nibble on the material.

From the natural behaviour of pigs it can be seen that they forage a large part of the day. This foraging behaviour includes grazing, chewing and nibbling (Studnitz *et al.*, 2007). Stimulating pigs to exhibit this behaviour can be done by enrichment material that is edible and chewable.

Investigable, manipulable and destructible

Enrichment product can be investigated, manipulated and destructed by pigs.

Pigs like to investigate, pull on and destroy things, therefore, pigs should be able to investigate, move, deform or (partially) destroy the material.

Novel and challenging

Enrichment product is continuously interesting for pigs.

A new enrichment product can be very interesting for pigs when they first come in contact with it, but after a while they might lose interest, if it is not challenging enough. Therefore, enrichment products should be novel and keep the interest of pigs. For instance, by having multiple enrichment products or by continuously changing and replenishing the material.

Cleanable

The product can be cleaned inside the pen or be easily removed from the pen to be cleaned.

It is important, for both farmers as well as for pigs, that the pen, and everything in it, is cleaned properly. When either the pen or the enrichment product is not clean it can increase the risk of pigs getting diseased (Stichting MilieuKeur, 2017). Therefore, an important requirement for the enrichment product is that it is cleaned easily, either inside or outside the pen.

Low-cost manufacturing

Enrichment product meets the needs of farmers in an economic and efficient manner.

For farmers to be willing to implement enrichment products on their farm, the products have to be produced at low-cost. Farmers have to make a living from their farms, so they decide how much money to spend on enrichment materials. For instance, the use of by-products (wood, metal leftover) from other industries can decrease the costs of enrichment products.

Large scale manufacturing

Enrichment product is suitable (for the feed industry) to produce in large scale.

An important requirement for the production process is that enrichment products should be produced in large quantities. This will not only be beneficial for the price, but it will also create a continuous supply of products, so that it is always available to farmers. Another important feature of the manufacturing process is that it is not laborious. Laborious production would raise the price of the product, which contradicts the requirement of low-cost.

Low labour intensity

Enrichment product meets the needs of farmers in a time efficient manner.

The labour input, such as the time it takes and the frequency with which the material should be replenished should be as low as possible, so that farmers are able to easily implement the enrichment product. Furthermore, the material should not be so small that it will fall through the slatted floor, because this can block the liquid manure system, which in turn leads to more labour input for farmers.

After conducting this part of the literature study, it became clear which requirements should be taken into account when creating an innovative enrichment product. To be able to compare all these enrichment products, a scoring system is needed. Next, an existing scoring system for enrichment products, namely RICHPIG, was explored. This provides information on which materials improve pig welfare the most, when creating an innovative enrichment product.

Scoring of enrichment products

To support the Dutch Ministry of Agriculture with further implementation of the Commission Directive 2001/93/EC, which lays down minimum standards for the protection of pigs, the model RICHPIG has been developed. Scientific information on enrichment products was collected in a database and used to derive enrichment product scores on a scale of 0 (worst) to 10 (best). This model scored a reference pen, which did not include any enrichment products, with a score of 1.46. This

reference pen did, however, meet the minimal legal standards for animal welfare. Material that is often used as enrichment on pig farms is a metal chain, which was scored by RICHPIG with a 2.24 out of 10 (Bracke, 2008). RICHPIG assessed fourteen different enrichment materials, which can be found in Table 1.

Table 1. Example description and enrichment scores of several enrichment materials in RICHPIG (Bracke, 2008).

Enrichment material	Score	Description
Reference pen (no enrichment)	1.46	Pen without enrichment material, otherwise (just) meeting minimum legal requirements for animal welfare. Typical/standard pen for weaners (as of 25 kg), growers and fatteners (up to 100 kg), respectively. Pen surface for fatteners 0.7–1 m ² pig. Pigs typically fed <i>ad libitum</i> pellets, partly slatted concrete floor, stable group of approximately 10 pigs per pen.
Metal chain	2.24	A metal chain, hung vertically, at shoulder height, some 20 cm off the back of the pen.
Plastic ball	2.32	Heavy plastic ball (35 cm diameter) free on the pen floor.
Rubber hose cross	3.04	Two rubber hoses, fixed in the form of a cross, suspended on a chain, slightly above shoulder height.
Rope	3.29	Straight sash cord (cotton 1 cm diameter, 40 cm long) suspended from the pen gate at shoulder height (daily) adjusted according to consumption.
Pinewood beam	4.25	Pinewood beam (13 cm diameter, 1.5 m long) suspended by chains to the wall, at 'knee' (carpus) height.
Earth	4.71	Earth in a small trough (dimensions: 15 × 20 cm).
Foodball	5.20	The Edinburgh Foodball [®] , containing food pellets that drop out when the ball is rooted upon (refilled once daily).
Mushroom compost	6.53	Spent mushroom compost on a horizontal metal rack (1 m ² above the pigs' heads), grid size 30 mm ² , compost refreshed daily, approximately 1/3 kg pig ⁻¹ day ⁻¹ .
Strawrack device	6.54	Coarse chopped straw from a rack with a trough, a chain (to facilitate sliding of the straw) and a soft-wood beam (8 cm diameter, 50 cm long) hung horizontally above the trough on two chains (straw use: 10–20 g pig ⁻¹ day ⁻¹ ; straw length: 11 cm).
Straw twice daily	7.08	A handful of long straw provided twice daily (approximately 20 g pig ⁻¹ day ⁻¹).
Fodderbeets	7.09	Roughage, chopped fodderbeets (low DM) in a trough, provided <i>ad libitum</i> once daily.
Long straw and branches	8.34	Long straw provided once daily in a pen with two fir branches (which are renewed every month or when destroyed).
Straw and beet roots	8.54	When whole straw mixed with chopped beet roots provided <i>ad libitum</i> on the pen floor once daily.

When designing our innovative enrichment product we used this model to judge whether the materials we wanted to use have a high score on welfare. However, this model only uses animal based parameters, and does not take farmers' preferences into consideration (Bracke, 2008).

In the paragraph above, we investigated which requirements should be taken into account and how the animal based parameters can be scored. In the following paragraph, an overview of currently used enrichment products that were found in literature is given, including their pros and cons. All products mentioned can be implemented in a conventional pig husbandry system, and promote natural behaviours and therefore enhance welfare.

Existing enrichment products

A lot of research has been done on enrichment products in pig husbandry systems. Different materials and products can be provided in order to improve pigs' living conditions, hereby enhancing their welfare. However, not all of these products meet all requirements for pig enrichment products mentioned in the previous paragraph. Pigs should be able to express natural behaviours, such as rooting and chewing. If pigs in barren environments are not able to express these kinds of behaviours, they can become bored and frustrated, which can lead to unwanted, harmful behaviours towards pen mates (Agriculture and Horticulture Development Board Pork, 2017). It has been shown that a lack of good quality food and absence of proper enrichment materials can increase the incidence of harmful behaviours, like tail biting (Telkänranta *et al.*, 2014b). During this project we focussed on enrichment products that promote natural behaviours and therefore enhance welfare. This can be either by reducing harmful behaviours or stimulating positive behaviours, such as playing or rooting.

Currently, many different kinds of enrichment materials are available to implement in pig husbandry systems. Many of these materials have already been subject of studies that tried to determine what pigs prefer. For example, van de Weerd *et al.* (2003) conducted a study related to the interaction between pigs and various objects with different characteristics. They found that pigs prefer characteristics such as odorous, deformable, destructible, edible and chewable. In the report of the previous ACT-team, it is shown that there are different classes of enrichment. The existing enrichment products are therefore divided into three classes, namely sensory, physical and nutritional enrichment (ACT-report group 2060, 2018).

Sensory enrichment

Music

Noise in pig husbandry systems can be an indicator of pig welfare, as loud or sudden noises, such as operation of equipment, pig vocalisations and people in the stable, can be aversive for pigs (Weeks, 2008). On a noisy farm, music can mask these noises and make pigs less stressed. It is well-known that music can have an impact on people's welfare, by making them more relaxed, refreshed or even by relieving pain (Silva *et al.*, 2017). According to the same study, for pigs, music can also be used as enrichment product. They found that sows with musical enrichment had a clear reduction of stereotyped behaviour and agonistic interactions compared to sows without musical enrichment. Furthermore, various styles, rhythms and speeds of music can have different effects on animals' behaviours (Alworth & Buerkle, 2013). The results of the study of de Jonge *et al.* (2008) also confirmed that playing music to post-weaning piglets facilitates welfare. In this research one group of piglets was led to a playroom with music, where enrichment, such as straw, was provided. The control group did not have a playroom, but the same music was played whilst this group stayed in the pen. Piglets that associated music with the playroom showed more play behaviour and less aggressive behaviours than piglets exposed to music without playroom. Playing music did encourage the control group, without playroom, to play, however, significantly less compared to the group with playroom. In other words, music has the potential of improving pig welfare. According to a survey of the Royal Society for the Prevention of Cruelty to Animals (RSPCA), this idea of playing music is also something that is done on

farms already. It was shown that 69% of farmers in the survey believe playing the radio makes pigs more relaxed and calm (Vet times, 2012).

Unfortunately, music does not meet many requirements for enrichment. Though playing music is safe and not illegal, it does not meet other legal requirements, like edible, chewable, investigable and manipulable. Playing music does meet the preferences of farmers, because it does not cost much time or money. As music can have a beneficial effect on welfare it can be used as enrichment, but should be combined with other enrichment products that do meet legal requirements.

Odours

Pigs have a highly developed sense of smell, with which they can well distinguish between dangerous, safe and preferred food (Kyriazakis *et al.*, 1990; Cairns *et al.*, 2002). Nowicki *et al.* (2015) conducted a research in which the influence and preference of odours of pigs was investigated. In this research, they found that the group of pigs treated with aromatic objects (moist soil) showed interest in the object for a longer time compared to the group of pigs treated with odourless objects. Furthermore, this study showed that pigs spent more time near natural aromas of moist soil, grass and dried mushrooms, than synthetic vanilla, orange and strawberry aromas. According to a review, pigs' exploratory behaviour is best stimulated by the provision of environmental enrichment that is odorous, chewable and destroyable (Nowicki *et al.*, 2015).

Therefore, natural odours, such as grass or moist soil, have the potential of improving welfare of pigs and can be used as enrichment. However, using only odour would not meet all requirements of enrichment. Like with music, it is not illegal to use it, but it does not meet all legal requirements and, therefore, needs to be used in combination with another type of enrichment.

Flavours

Palatability of feed, including taste and texture, is an important factor in determining the preference of pigs and is usually quantified by relative responses of feed intake compared to other diets. A trial of adding flavours to normal feed has shown that adding flavours, like apple delight, can significantly increase piglets' feed intake and weight gain (Creswell, 2002). Furthermore, according to Frederick & Van Heugten (2003), the strategic use of flavour can be beneficial in four conditions, namely: 1) the first week post-weaning when a pig is in a dietary transition from the sow's milk to solid feed; 2) during times when changes in diet formulations are made; 3) during times of heat stress; and 4) to mask the taste of relatively low palatable ingredients.

In other words, the use of flavours in pig feed can increase feed intake and eliminate negative effects caused by feed transition and stress. As with aforementioned sensory enrichment, only using flavour does not meet requirements of enrichment and it should thus be used in combination with something else.

Physical enrichment

Jute

Jute sacks can be used as enrichment material for pigs. Jute has the benefits that it can be destroyed by pigs, it is a relatively cheap material, and it is mainly composed of cellulose, hemicellulose and lignin and therefore safe for pigs to eat and to chew on (Río Andrade *et al.*, 2009). Ursinus *et al.* (2014) showed that the presence of jute sacks led to a reduced amount of tail and ear damage, both between littermates and towards the sow, within one pen. When jute sacks were hung on the wall, at a height pigs can reach, tail damaging post-weaning was reduced fivefold. Harmful behaviour towards pen mates was decreased up to 50% in pens provided with jute sacks. So, piglets seem to hurt the sow and their littermates less when they are distracted by jute. However, habituation to jute in pens occurs quite quickly, and therefore interest in it declines fast (Van de Weerd *et al.*, 2003).

In conclusion, jute meets all legal requirements as it is safe, edible, chewable, investigable and manipulable. It also meets animal based requirements, such as destroyable and it is rootable material, when parts of it are on the floor. Jute is cheap material and can be produced on large scale. Nonetheless, jute cannot be cleaned and potential small, loose parts can get stuck in the liquid manure system, as jute does not putrefy.

Rope

Rope of natural material can be supplied in a pen, so that pigs can nibble and chew on it. It is important that synthetic rope or rope with non-natural parts are not used, since this is unsafe for pigs to eat (Agriculture and Horticulture Development Board Pork, 2017). Pigs show sustained interest in ropes, which are destructible, especially in knotted rope, or in hanging ropes that have another edible component attached to them, such as wood (Trickett *et al.*, 2009). Moreover, 'flavoured rope' devices for pigs are currently sold commercially in Finland (Van de Weerd *et al.*, 2003). According to these studies, the interaction with ropes decreased significantly with time, but changing the rope prompted interest again. Furthermore, in another study it was concluded that providing rope and paper in early life before weaning has promising potential for reducing the severity of later tail biting (Telkänranta *et al.*, 2014c).

Even though rope is interesting for pigs and it meets the legal requirements safe, investigable, manipulable, chewable and eatable, it does not meet the requirement cleanable. However, rope might be destructed quickly and does not have to be cleaned. Small parts of the rope that is destructed might get into the liquid manure system where it can get stuck and cause problems, which can be a disadvantage of rope.

Wood / Wooden logs

Pigs can nibble and chew on wooden logs placed inside a pen. However, the wood has to meet some requirements based on safety. The wood may not be contaminated and should not splinter (Verrijkingmaterialen varkens Maatlat Duurzame Veehouderij, 2018). It is possible to hang a wooden log on a chain (Agriculture and Horticulture Development Board Pork, 2017). Wooden poles were found to be an effective enrichment material for reducing tail damage, when using freshly felled tree trunks 5 to 10 cm in diameter suspended on chains horizontally below snout level (Telkänranta *et al.*, 2014a). However, there is a difference between the use of trees that are freshly cut and the timber that can be purchased commercially. This is due to the drying process of the timber, which decreases

the odour and makes the consistency more firm, which in turn decreases the attractiveness of this to pigs (Telkänranta *et al.*, 2014b; Van de Weerd *et al.*, 2003). It is therefore advised to use natural wood as enrichment material.

So, when taking into account safety issues, wood meets all legal requirements for enrichment. It will also putrefy when ending up in the liquid manure system and will therefore probably not pose a problem. Wood does need to be replenished more often and is more expensive than, for instance, chains, which is a disadvantage to most farmers.

Loose toys

Loose toys like plastic balls or rubber materials can be put in a pen, in order for pigs to play with. Multiple toys are needed, so that they are available for all pigs in a pen. Also, they are prone to get dirty, because they are rolling on the floor. When there are loose toys available, pigs will be less inactive and display much more positive social behaviour and play. Toys can also provide an outlet for frustration (Van de Weerd *et al.*, 2009).

Even though loose toys can get dirty easily, they can be cleaned and they promote active behaviour, meet all legal requirements, can be purchased at low costs and can be left in the pen for a while. In spite of this, pigs will get bored easily if the same toy is always in the pen, so to enhance welfare, multiple toys or a combination of products should be used.

Hanging toys

Besides loose toys, toys can also be hung inside a pen, so they are less prone to get dirty. In a research conducted by Apple & Craig (1992), four different toys were provided for pigs. These toys were: 1) a 30.5 cm rope with knots on both ends and in the middle; 2) a 30.5 cm piece of rubber hose; 3) a 30.5 cm piece of brass-plated metal chain; 4) a rubber, hourglass-shaped, dog toy. Each pen of pigs was provided with two copies of the same toy, hanging from the ceiling by a bungee cord, for ten consecutive hours. After all pigs had the opportunity to play with all toys, the researchers concluded that pigs spent a significantly greater amount of time playing with the rubber dog toy compared to the other toys. According to a study Bracke (2017) conducted, metal objects, like short metal chains without anything attached, were least preferred as a type of enrichment material by pigs. Subsequently, the Dutch government banned the use of short metal chains, which end at the pigs' nose height, without the use of other enrichment products. Unfortunately, this did not help, as pigs cannot put the chain in their mouth to chew on it when something is attached to it, and a short chain attached to a hard plastic ball or pipe, therefore, still gets low scores in the RICHPIG model. However, short chains with wood score higher than short chains alone (Bracke *et al.*, 2007). Another study showed that pigs seem to prefer to 'root' on a chain when it is lying on the floor, so that they can manipulate such a chain while lying on the floor themselves (Wind, 2012). Longer chains have also been shown to substantially reduce ear biting under the compromised condition of limited access to a water nipple (De Grau *et al.*, 2005).

This kind of enrichment is easy for a farmer to implement as the labour costs are low and so are the production costs for chains, for instance. However, pigs' interest in these products decreases quickly, and therefore, using only these products does not increase welfare of pigs on a longer term.

Bedding material

Overall, bedding material provides a suitable environment for pigs as they can root in it and thus show natural behaviour. Pigs prefer their pen to be enriched with bedding, even though a clear preference for certain beddings can be seen (Beattie *et al.*, 1998). Pigs' natural behaviour consists of rooting, which can be performed when bedding material is present in their pen. Expressing natural behaviour leads to a lower amount of stress and less abnormal behaviour. Beattie *et al.* (1998) performed a preference test of seven different substrates for pigs. These were concrete, mushroom compost, peat, sand, sawdust, straw and wood bark. Pairs of substrates were formed and groups of six pigs were placed in choice pens where they were able to choose from two different substrates, which were all about 5 cm thick. Based on the results from this test, it was concluded that pigs prefer peat, mushroom compost and sawdust most. Wood bark and straw were only preferred when the other option was concrete (Beattie *et al.*, 1998). This can be explained by the fact that pigs have a poor ability to optimally digest fibrous leafy or woody materials optimally (Fuller, 2014).

Overall, bedding material meets the requirements rootable, manipulable, chewable, investigable, novel and safe. However, bedding material can easily get stuck in the liquid manure system, or get mixed with the manure. This is not desirable for farmers, as they cannot use the liquid manure system anymore or sell the manure, as it is not pure anymore. Nevertheless, this does depend on the type of bedding.

Mushroom compost

Mushroom compost can be used as bedding material that promotes exploratory behaviour of pigs, because it can be used to root in. A comparative study determined what effect mushroom compost had on rooting behaviour in pigs (Beattie *et al.*, 2001). In this study, three groups of pigs were given a different treatment: 1) Control barren pen (0.7 m² per pig) with slatted flooring; 2) Empty horizontal rack suspended above the pigs' heads; 3) Horizontal rack suspended above the pigs' heads with mushroom compost on it. Results showed that pigs nosed the filled rack and the floor beneath the rack almost twice as many times as the barren rack. Significantly fewer pigs in treatment group 3 expressed harmful behaviour towards pen mates compared to pigs in treatment groups 1 and 2 (Beattie *et al.*, 2001).

Peat

Peat is a type of material that arises from decaying organic matter. It can be used as bedding in pig stables. Research on the use of peat as bedding compared to no bedding, during the first nine weeks of age, showed that the presence of peat significantly increased exploratory behaviour in piglets (Vanheukelom *et al.*, 2011). The results also showed less fighting, less harmful behaviour towards other pen mates and more activity. However, all pigs were relocated after weaning at 9 weeks of age to pens without peat, where no significant difference in fighting and manipulation of pen mates between the two different treatments (peat or no peat) could be observed. These results suggest that peat can be effective as an enrichment material to enhance exploratory behaviour and decrease harmful behaviour towards pen mates, but a long-term effect of peat during the suckling phase was not observed (Vanheukelom *et al.*, 2011).

Nutritional enrichment

Bigger sized pellets

Feed, or daily ration, has a direct and long term influence on pigs' behaviour and welfare (Brooks, 2005). One option to use feed as enrichment material is to change the size of the pellet. Edge (2005) found that pigs fed bigger sized pellets spent more time on feeding, compared to pigs that were fed smaller, traditional pellets. Taking this into account, feed company Coppens Diervoeding has developed enrichment materials in the form of feed for piglets, called BigXplore, which can also be used for adult pigs. This pellet is much larger than traditional feed for piglets. Coppens Diervoeding states that the larger size distracts the piglets, which decreases stress and the nutritional value is adapted to their requirements, which makes the piglets feel satiated, which in turn has a soothing effect. Piglets throw the large pellets out of the trough and play with it, which stimulates positive behaviour (Coppens Diervoeding, 2018).

The BigXplore thus meets many requirements of enrichment materials for pigs, namely that it is safe, edible, chewable, investigable and manipulable. Because of the size of the pellet it will not block the liquid manure system and due to the fact that the pellets already contain all nutritional requirements for pigs, it is not labour intensive. However, bigger sized pellets do not meet the requirement of rootability and novelty, but this last problem can be overcome by providing the pellets in different ways.

Silage

Silage is fermented, high-moisture stored fodder, and it can be used as feed for pigs. It can also be used as bedding material when provided on the floor, additional to conventional feed. This high level fibrous material was found to increase lying behaviour and reduce exploratory behaviour in gestating sows, because fibres increased satiety and reduced feed motivation (Zonderland *et al.*, 2004). A longer chewing period and less other active behaviours of pigs likely reduce disturbance to resting animals, which will improve the welfare of the whole group (O'Connell, 2007). Even though silage can increase lying behaviour, it did not reduce levels of aggression when sows were housed in large dynamic groups (Van der Mheen *et al.*, 2004).

Silage, therefore, meets all legal requirements as it is safe, edible, chewable, investigable and manipulable. It also meets the requirements of novelty and rootability (when provided on the floor). However, silage cannot be cleaned, so it should not be provided on the part of the floor where pigs defecate. Silage also has the disadvantage that it can contain mycotoxins, which is bad for the health of pigs. When used as feed, silage is not labour intensive, but when used as bedding material there will be more labour for the farmer as it needs to be replenished and the pen needs to be cleaned properly.

Straw

As mentioned in many research articles, straw, provided in different forms, like as bedding material or provided in a rack, seems to be a very effective way of enriching pig stables, and hereby improving pigs' welfare (Arey, 1993; Fraser *et al.*, 1991; Scott *et al.*, 2006a; Tuytens, 2005). Straw enables pigs to express rooting and foraging behaviour, which leads to a positive effect on behaviour as pigs are occupied with rooting instead of showing harmful behaviour, such as tail biting, towards pen mates (Fraser *et al.*, 1991; Scott *et al.*, 2006a). In Western Europe, current pig housing systems contain fully

or partly slatted flooring with a liquid manure system. Large amounts of straw might block this system, which makes straw a difficult enrichment product to implement on a farm.

Overall, straw meets all requirements for pig enrichment, except for cleanable. Straw cannot be cleaned, but when provided in, for example, a rack, it will not get dirty. Straw stays novel due to seeds inside, which pigs can find. However, for straw to meet the requirement of rootability, it should be on the floor. Supplying only small amounts of straw, like in a foraging-tower, lowers the risk of blocking the liquid manure system. Also, straw is a natural material, which will putrefy when left in the liquid manure system. Nonetheless, straw is more laborious for a farmer than, for instance, a chain.

So, the non-edible materials mentioned above are toys that attract pigs' interest and allow them to be more active, by investigating and manipulating the materials (European Commission, 2001). While these objects do seem to distract pigs, using bedding material seems to provide more occupation. Using a suspended plastic chewable enrichment material was, for instance, used more when it was presented in slatted housing compared to straw-based housing (Scott *et al.*, 2006b). The same has been observed for sisal rope provided to pens of finishing pigs (Seddon *et al.*, 2012). According to another study, providing two different enrichment products simultaneously, in slatted housing, leads to an increase in the total amount of time engaged with both enrichment products (Trickett *et al.*, 2009). In general, it is said that enrichment materials that are replenished regularly seem to show less reduction in use (Van de Weerd *et al.*, 2003; Scott *et al.*, 2006b; Trickett *et al.*, 2009).

In this paragraph we found out which enrichment products are already on the market and what the advantages and disadvantages of certain products are. Next, we defined the knowledge gaps.

Knowledge gaps

After conducting this literature study we have gained knowledge about the available materials to create a new enrichment product and which requirements the product must meet. However, there are still some knowledge gaps that need to be filled, in order for us to start creating the product. To make sure that the new enrichment product will actually be used and thus will have a positive effect on the welfare of pigs, it is important to know if a farmer has interest to implement it. Besides, it is not sure what requirements farmers take into account, next to low-cost and low labour intensity, when deciding on enrichment products, and if they prefer certain types of enrichment. This is very important for implementation on farm, but there is no scoring model for enrichment products which includes farmers' preferences. Moreover, in our design process we want to take into account all requirements for enrichment products, which is challenging in the timeframe of this project. To further improve our design, experimental on-farm trials should be performed, however, due to time constraints we are not able to do this. Furthermore, we want to explore a possible cooperation with the feed industry. Among other things, the feed industry can provide information about the implementation of feed in enrichment products. For instance, how different types of feed and materials will go together, such as whether feed will extend the period a pig is interested in the enrichment product.

To expand our knowledge on these topics, we organised a feedback session with farmers, feed industry specialists and enrichment experts. In this way, we gained insight into the options how feed can be implemented in enrichment materials, about the preferences of farmers and about what is possible when combining all requirements when designing a new enrichment product.

In this part, we gained insight into current knowledge and the knowledge gaps, when it comes to designing a product, were defined. In the following part the development of the innovative enrichment product is elaborated on. We started with a brainstorm session, which is described in the next chapter.

To expand our knowledge on these topics, we organised a meeting with farmers, feed industry specialists and enrichment experts. In this way, we gained insight into how feed can be implemented in enrichment materials, about the preferences of farmers and about what is possible when combining requirements for a new enrichment product.

In the following part the development of the innovative enrichment product is elaborated on. We started with a brainstorm session, which is described in the next chapter.



Step 3. Brainstorm and analyse ideas

In this step, we started brainstorming about an innovative enrichment product. A total of three brainstorm sessions took place. In the first session, we tried the random word association brainstorm technique (pers. comm. Stefan Nortier). This was a productive and creative session, but because the results were too general, it did not create a good starting point for a new enrichment product. In the second session, we individually thought about possible designs that would have potential. We took thirty minutes to individually draw ideas and presented them to each other. These individual designs can be found in Appendix 1. Afterwards, all individual designs were evaluated, using the literature study to determine which materials fit the requirements for enrichment best. The best ideas were combined to create a first rough sketch of the new product. When creating this sketch the requirements for pig welfare, Dutch law and preferences of farmers, mentioned in the previous chapter, were taken into account. Moreover, the pros and cons of the existing enrichment products were taken into consideration when brainstorming.

While deciding on what materials to use, we mostly thought about ‘what would pigs like?’. With this in mind, we wanted to combine jute, ropes and the idea of interaction between pens (Appendix 1). Pigs will be more attracted to an interactive enrichment product, because they are triggered by movement. Jute and ropes are chewable, investigable, manipulable and destructible materials, which are requirements for enrichment products for pigs. Rootability was also important to be taken into account. Small amounts of straw on the ground can be used to root in and eat. Moreover, these materials are already used in existing enrichment products, therefore, it can be said that these materials are safe and legal to use.

After designing the product, an original name needed to be created in order to have a name to refer to. During the third brainstorm session, various names have been suggested. Finally, we chose the name PIGOOD[®] (Figure 2). This name refers to pigs and to good, since the product needs to be beneficial for pigs, in order to enhance welfare.

These creative sessions provided us with some initial ideas for what materials we could use in the innovative enrichment product. In the next step we designed an innovative enrichment product, based on ideas from the brainstorm session.

Figure 2. Brand name of the innovative enrichment products.



Step 4. Design innovative product

Based on step 3, we combined the ideas from the brainstorm session and discussed the details of the chosen materials. Here, an innovative enrichment product was designed and the specifications are given. This designed innovative enrichment product is called PIGOOD[®] Jute Ball and consists of a jute ball filled with straw and large pellets. The outside of the ball has natural ropes attached to it. The ball is hanging from natural rope, which is attached to a bungee cord, connected to the ceiling. Parts of the product will be destroyed or eaten by pigs. Remaining parts can be removed by the farmer and materials that fell on the ground can be cleaned at the same time as the pen. An illustration of this product is shown in Figure 3.

Specifications

Ball

The ball is made out of jute. Jute is a long, soft fibre obtained from plants that can be spun into long, strong fibres. These fibres are natural materials and can therefore be safely destroyed and eaten by pigs. Because pigs are able to destroy the ball, it ensures that the content of the ball is reachable.

- *Diameter:* 1 m
- *Thickness:* To make the ball stronger, so that pigs do not destroy it that easily, multiple layers of jute can be used. Also the fineness of the woven jute can be altered, so the thickness and firmness is as strong as possible.

Exterior

Attached to this ball are multiple pieces of rope. Common natural fibres for rope are flax, hemp, kenaf, ramie, isora, nettle, sisal and coir (Kicińska-Jakubowska *et al.*, 2012). The ropes are attached on the outside of the ball so that pigs can chew and destruct them from the outside. The ropes are covered with an attractive flavour, so that pigs will chew on the ropes. Using multiple of the same ropes also makes the product better to be used by multiple pigs at the same time.

- *Number of ropes:* 18 ropes per ball; 8 ropes in the middle, 5 on top, 5 on the bottom. Because of this number of ropes, multiple pigs can manipulate the ball at the same time.
- *Length:* Top ropes: 109 cm; Middle ropes: 70 cm; Bottom ropes: 34 cm. The ball is at the height of a pig's nose, and they should not touch the ground. When making one or multiple knots in the ropes, the length of the ropes should be longer. Lengths mentioned here are based on the size of a fully grown pig, but can be adjusted to smaller pigs, as long as materials do not touch the ground.

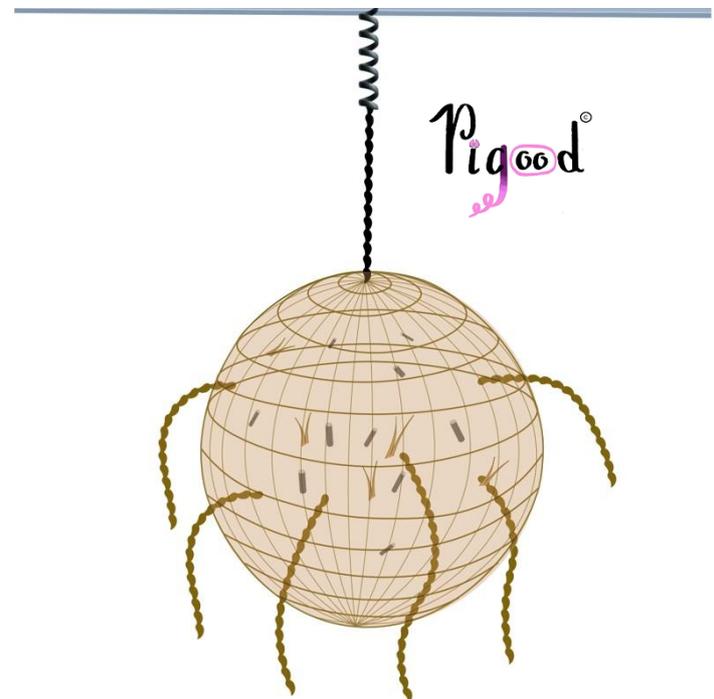


Figure 3. First developed PIGOOD[®] product. PIGOOD[®] Jute ball is a ball made of jute, hanging on natural rope and bungee cord. Outside of the ball includes natural rope. Inside includes bedding material and larger feed pellets.

Content

The jute ball will be filled with a mixture of straw and pellets. These pellets will be larger than regular pellets. Larger sized pellets keep pigs occupied for a longer time than regular sized pellets and because they are larger they will not fall through the slatted floor into the liquid manure system. The size of larger pellets is therefore dependent on the used flooring system. Since there is a mixture of straw and pellets inside the ball, pigs will smell this and will probably start to destroy the jute ball itself. When the ball is destroyed, the straw and pellets will fall down on the floor and pigs can root in the straw to find the pellets.

- *Amount of straw:* 75% of the total volume.
- *Amount of pellets:* 25% of the total volume.
- *Pellets size:* The gap width of the slatted flooring for post weaned pigs is between 14 mm and 20 mm (RVO, 2018), so the diameter and the length of the pellet should be more than 20 mm.

Hanging system

The jute ball is attached to natural rope. The upper part of this natural rope is connected to a bungee cord that is attached to the ceiling, and can be adjusted to be on snout-height, depending on the size of pigs. In this way, pigs that reach the top of the ball can nibble on the rope, without being able to reach the bungee cord. In addition, the bungee cord can be quite short, because it is only used so that the ball moves more when pigs touch it.

- *Material:* Small piece of bungee cord and longer piece of natural rope.
- *Height:* The length of the hanging system is depending on the farm system in which it is implemented. However, the middle of the ball should be at snout-height and the bottom of the material should not touch the ground.

Interaction model

As interaction between pens increases the value of enrichment products (Verrijkingmaterialen varkens Maatlat Duurzame Veehouderij, 2018), we wanted to incorporate this in the product. In PIGOOD® Interplay, a pulley system is used to hang two jute balls from the ceiling, connecting two pens (Figure 4). When pigs in one pen pull on the ball or ropes, the ball in the other pen will move, prompting action. Specifications for this model are similar to the specifications of the jute ball, except for the bungee cord, as movement is already incorporated in this model. A system has to be designed to make sure that pigs cannot pull the ball of the other pen up too high, so that pigs in the other pen cannot reach the ball anymore.

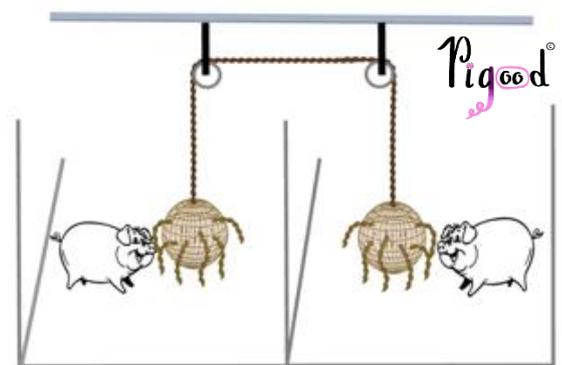


Figure 4. PIGOOD® Interplay: an interactive model between two pens.



Step 5. Feedback

In this step, we collected feedback from pig experts to improve our designed PIGOOD[®] product. On Friday 5 October 2018, a feedback session with stakeholders was organised. The aim of this feedback session was to get feedback on the innovative enrichment product we designed. We wanted to get feedback from feed companies to get information about the possibilities of designing, producing and selling such a product. From farmers we wanted to get feedback on the feasibility to implement this product on their farm. Pig welfare experts were invited to provide new insights regarding nutrition and enrichment.

An introduction on the project and our team was given and all stakeholders introduced themselves. After this, all group members explained their individual design (Appendix 1) and eventually, the final PIGOOD[®] Jute Ball was presented. Based on this design, a discussion was opened where feedback was given and all our remaining questions on the design were answered by stakeholders. We asked permission to make video recordings of the meeting. Signed consent forms documenting the stakeholders' permission and minutes of the whole meeting can be found in Appendix 2 and Appendix 3, respectively. A summary of the most important feedback, information and suggestions on the enrichment product is given here.

Present were Johan Zonderland from feed company de Heus Voeders B.V., Maarten Hollemans from feed company Coppens Diervoeding, Sharon van Schaijk from feed company AgruniekRijnvallei, pig farmer Wim Schut from Maatschap gebroeders Schut, and pig welfare experts Marion Kluivers from Wageningen Livestock Research and Inonge Reimert from Wageningen University & Research.

In general, the design of the PIGOOD[®] Jute Ball was well received, but it needed some changes. Both jute and rope are natural materials, which is very much preferred, but, unfortunately, easily destructed by pigs. Also, jute and rope are not well digestible, do not putrefy easily and can get stuck into the liquid manure system. Moreover, rope can also be harmful according to some of the stakeholders. They said if it is too long, there is a possibility that pigs hang themselves, or their ear tags might get stuck. In order to keep the enrichment clean, it should not touch the floor. Also considering safety and destructibility, it was suggested by a stakeholder that it is better to replace all ropes with chains, which pigs will also like, due to the ringing sound the chains make. All stakeholders agreed that rope was one of the best materials to use, but it is not entirely practical and has some safety issues.

The idea of interaction between pens was received very positive, and the ceiling connection was a good idea. This is feasible for most (new) stables. Also, installing stops, so that pigs in both connected pens can always reach it, is easily done. Though, we do need to take into account that the stops must also be very sturdy, as pigs will pull on them whilst playing. The enrichment only has to move a few centimetres up and down in order to trigger pigs and since it is hanging loose, it already has quite some movement. However, pigs in one pen synchronize behaviour, which means that a pen with active pigs might disturb a pen with resting pigs, when using an interactive type of enrichment,

according to Maarten Hollemans. So, to not interfere with behaviour of pigs in the other pen, it might be more practical to install enrichment per pen.

Location of the enrichment product is also important. It has to hang above solid flooring, so that the content will not fall into the liquid manure system right away, but this may cause pigs to find another resting place. Also, it needs to be reachable from the corridor of the stable, so that it can easily be replaced in a way that the farmer does not have to enter the pen. Farmers check on their pigs every day, and at the same time they can replace the enrichment from the corridors.

When filling an enrichment product with a mix of bedding material and feed, the optimal ratio would be 90-95% bedding material and 5-10% feed. It was suggested by multiple stakeholders that it is probably enough to only put in bedding material, as this triggers pigs to play with it already. As filling, straw or lucerne, or a combination of bedding materials like long straw with chopped straw can be used. These materials are preferred by pigs, together with wood shavings, because they can easily root in it. When provided in small amounts, these materials will not block the liquid manure system, as they putrefy.

The production of flavoured ropes by feed companies is possible. However, pigs are already attracted to natural rope, so the added value of flavour might be negligible. Adding flavours could work for materials that are almost indestructible, such as chains, to keep it interesting for pigs.

At the moment, there is a weak link between feed companies and manufacturers of enrichment products. Feed companies stick to producing feed, which can be incorporated in the product, but producing the eventual product should be done by manufacturers of enrichment products.

Needs of pigs are very important, but needs of farmers should also be taken into consideration for the implementation of an enrichment product. Costs, labour and practicality are factors that need to be taken into account. If farmers have a lot more work to do and higher costs because of the enrichment product, they will not be eager to implement it. Nowadays, the market in The Netherlands does not pay back costs spent on enrichment, which is a reason why it is difficult to get enrichment products implemented on farms. A product that is better for welfare will often be more costly. A good balance needs to be found between the farmers' and pigs' needs. Pigs want to destroy the enrichment product and farmers do not want to replace the enrichment product that often. When designing enrichment for pigs, it is important to keep it simple. It needs to combine pig welfare with low costs, practicality and not too much extra labour for the farmer. For example, a basket is easy to fill and almost unbreakable, but still liked by pigs.

Substantiation of feedback

When reflecting on the feedback session, the pig welfare experts, the feed companies and the pig farmer had a lot to say about the PIGOOD[®] Jute Ball. All information, feedback and suggestions given on the design were evaluated by the team by the use of literature.

Rope

According to the invited stakeholders, rope is destructed very easily by pigs and is therefore not a long-lasting solution for enrichment material. Bracke (2007) conducted research to validate his enrichment scoring model, RICHPIG. Among other things, sisal rope and chains were used to look at the response of pigs to this and the importance of destructibility, hygiene and sound as factors of enrichment was determined. Recordings of the pigs' response towards sisal rope only continued for one hour as pigs had destructed the sisal rope within this time period. For this study, 11 pigs per pen were used and these pigs were all between 100 and 135 kg (Bracke, 2007). Furthermore, a study on the role of novelty in enrichment used two lengths of suspended rope, which were each 0.51 m long. The ropes were knotted to a suspended bracket that was a maximum of 0.6 m high. The ropes had to be replaced once every two weeks, due to progressive destruction (Trickett *et al.*, 2009). This shows that pigs can also take a longer time than only a few hours to destroy rope. However, the pigs that were used in this study were very young (just weaned, 4 weeks of age) compared to the pigs used in the previously mentioned study (pigs were between 100 and 135 kg).

During the feedback meeting it was mentioned by multiple stakeholders that rope or structures made out of rope might be unsafe to pigs as they can get stuck in this, which can eventually lead to death, or ear tags can get ripped off when they get stuck behind rope. In a research conducted by Stärk *et al.*, (1998) it is made clear that ear tags have multiple problems as they might get lost or get ripped off due to fighting incidents, however, no research mentioned the dangers of rope. Based on the knowledge and years of experience of the stakeholders, it is assumed that accidents with ropes have happened in the past.

Based on this information, it can be said that the feedback given by the stakeholders should be implemented in an improved/adjusted design. Even though not all pigs destroy rope within a short time period, we do need to take into account that older pigs should also be able to use the enrichment product and therefore, it should not be destroyed within hours.

Jute

As said before, jute has benefits that it can be destroyed by pigs, it is a relatively cheap material, and it is mainly composed of cellulose, hemicellulose and lignin (Río Andrade *et al.*, 2009), and therefore safe for pigs to eat and chew on. In the study of Van de Weerd *et al.* (2003), pigs showed a lower interest in jute compared to straw as bedding material, this may be because straw is easier to eat than jute. So, it is not efficient to put a jute ball in a straw-bedded pen. Compared to metal chains, pigs interacted much more with jute sacks, because a jute sack is destructible (Feddes and Fraser, 1994; Ursinus *et al.*, 2014).

During the feedback meeting, the farmer mentioned that one of the disadvantages of jute is that it is easily polluted by manure, because jute fibres absorb water really good. Costa & d'Almeida (1999) agreed with this point, because jute has this physical property. Taking hygiene into consideration, the

jute ball cannot be put close to the floor. Another important problem of implementation is the durability of the jute ball. How often should a jute ball be replaced and how long will it take for pigs to break the jute ball? Durability is an important practical question for farmers, because it will have a direct influence on profit and labour. However, the frequency of replacing the jute can be influenced by the environment. According to Camerlink *et al.*, (2015), for 14 finishing pigs, 4.3 jute sacks were consumed per week in a barren environment, while only 2.8 jute sacks were consumed per week in an enriched environment.

In conclusion, jute is destroyed easily by finishing pigs, which might increase cost and labor intensity, especially in a barren environment. Therefore, stakeholders suggested to use other materials, such as a metal basket, which is indestructible for pigs, to replace the jute ball.

Chains

During the feedback session it was suggested by stakeholders to replace ropes by metal chains, because it is more durable material that cannot be destroyed easily by pigs, but is still likable. According to Van de Weerd (2003), chains are a simple type of enrichment that is readily available and does not have to be replaced very often, which makes it very practical and popular to be used by farmers. However, pigs like to repeat motivated behaviour, like rooting behaviour, which a chain does not support, because pigs habituate to it quickly and it is therefore unlikely to have a long-term effect on welfare. A destructible object, which a chain is not, will continue to be novel when interacted with, and therefore keep the pigs' attention for a longer period (Day, 2002). Bracke (2006) concluded that metal objects as enrichment would have very few significant benefits on welfare. This was based on a comparison of several papers, with all of them showing disadvantages. However, a study of Schaefer *et al.* (1990) showed that when hanging tyres on chains, harmful social behaviour and aggressive behaviour were reduced, especially head to head knocks. Guy (2002) found that when pigs were provided with a 'pig mobile' (a cylinder fixed onto the floor with a rotating cross and rubber toys suspended from chains), the pigs were less inactive. They played more and also showed more positive social interactions with each other.

It is clear that a chain alone as enrichment material for pigs is not enough. It does not have welfare benefits and pigs will ignore it quickly. However, as previously mentioned studies state, when combining a chain with other enrichment, there are many combined benefits in terms of welfare, behaviour and practicality. Thus, as suggested during the feedback session, hanging enrichment materials from a chain could be better. Even though a chain is a metal object, and should be indestructible for pigs, the duration of replacement is still uncertain as no literature could be found on this topic.

Synchronizing behaviour

The idea of interaction between pigs or between pens was overall received as positive by the invited stakeholders. Nevertheless, there were also some impracticalities with this idea. For instance, the stakeholders all agreed that pigs synchronise their behaviour, meaning that when a few pigs in a pen start playing, the rest of the pigs in the pen will also start playing. When two or multiple pens are connected through enrichment material, the synchronised behaviour of one pen might be disturbed

by that of the other pen. Research on synchronisation of pigs in different age groups showed that pigs indeed show synchronisation behaviour with regards to activity, inactivity and object directed behaviour. Some differences were seen between age groups, like a lower degree of synchronisation for object directed behaviour and a higher degree of synchrony for both activity and inactivity in sucklers (3 weeks), compared to weaners (5 weeks) and growers (13 weeks) (Docking *et al.*, 2008). This behaviour must be taken into account when designing enrichment material that makes interaction between multiple pens possible.

Taking into account the feedback we received during the feedback session and keeping in mind what we found in literature, we adjusted the design in Step 6.



Step 6. Adjusting and improving the design

Every part of Step 5 was taken into consideration, and the first designed PIGOOD[®] product as altered. Here, alterations of the innovative enrichment product and new specifications are given. Altering the design meant that the materials used for the ball and the hanging system were replaced. This was done because during the feedback session it became clear what the destructive capacity of pigs is. The materials, that were used in the first design, appeared not strong enough. Therefore, other materials should be used which are destroyed less easy. Also, the practicality for the farmer needs to be taken more into account. The way that the farmer can implement the product on-farm and can refill the bedding material was considered when altering the design. In the new design the jute ball is replaced by a metal basket. Also, the natural rope, with which the ball was essentially attached to the ceiling, is replaced by metal chains. Moreover, besides only using natural rope hanging from the basket, metal chains were added. An illustration of this altered design PIGOOD[®] Basket is shown in Figure 5.

Specifications

Metal basket

The metal basket is hanging loose in the pen, connected to the ceiling. The idea came from the fact that some farmers already own a potato basket. In this way, farmers have to invest less money to implement this new enrichment product, because they already have certain materials. Moreover, the metal basket is not easily destroyed by pigs and can be refilled much easier than the ball. It can also be easily cleaned when the pen is cleaned.

- *Size:* Standard size of metal baskets is 45 cm x 40 cm. Smaller baskets can be used for smaller pigs.
- *Material:* Stainless steel.

Exterior

In addition to the first design, which uses only natural ropes, metal chains were used in this altered design. It was suggested that natural rope is preferred by pigs, but when pigs have eaten/broken the natural rope, metal chains can be still interesting to them. The ropes can be knotted to the basket and be replaced by the farmer when necessary. The metal chains need to be attached to the basket by the manufacturer and are therefore not replaceable. The metal chains can be cleaned when the rest of the basket is cleaned.

- *Amount of metal chains:* 5 metal chains in total: 1 metal chain in the centre of the bottom; 2 metal chains around the bottom periphery; 2 metal chains around the middle of basket periphery.
- *Length metal chains*:* Metal chain in the bottom centre: 20 cm; metal chain around the bottom periphery: 20 cm; metal chain in the middle of basket periphery: 40 cm.
- *Thickness of metal chains:* 7 mm diameter of metal is recommended, with link size 36 x 23 mm (Bracke, 2017).



Figure 5. Altered design of the PIGOOD[®] product. PIGOOD[®] Basket is a metal basket hanging on metal chains. Outside of the basket includes natural rope and metal chains. Inside includes bedding material and if preferred larger feed pellets.

- *Amount of natural ropes*: 8 natural ropes in total: 4 ropes on top of basket periphery; 2 ropes in the middle of basket periphery; 2 ropes in bottom periphery.
- *Length natural ropes**: Top periphery: 50 cm; middle periphery: 40 cm; bottom periphery: 20 cm.
- *Thickness of natural ropes*: Natural ropes should be around 5 cm thick (Stichting Beter Leven Keurmerk, 2018). The thickness of the rope can be adjusted to the destructive capacity of pigs.

*Lengths mentioned here are based on the size of a fully grown pig, but can be adjusted to smaller pigs, as long as materials do not touch the ground.

Content

The basket can be filled with edible bedding material. The farmer can choose which kind of bedding material is used. If preferred by the farmer, pellets can be added together with bedding material. Depending on the structure of the added bedding material, pigs can get the bedding material out of the basket either easy or more difficult.

- *Amount of bedding material*: 90-95% of total volume.
- *Amount of pellets*: 5-10% of total volume.
- *Pellet size*: The gap width of the slatted flooring for post weaned pigs is between 14 mm and 20 mm (RVO, 2018), so the diameter and the length of the pellet should be more than 20 mm.

Hanging system

The handles of the metal basket are connected to metal chains, which connects it to the ceiling. The combination of natural rope and bungee cord as hanging system is replaced by metal chains, because natural rope is easily damaged by pigs when they can reach it. In addition, bungee cord can be stretched out and needs to be replaced more often than metal chains.

- *Material*: Metal chains.
- *Height*: The length of the hanging system is dependent on the farm system in which it is implemented. However, the middle of the basket should be at snout-height and the bottom of the material should not touch the ground.

Options for on-farm implementation

Even though the first designed product PIGOOD[®] Jute Ball was altered according to feedback from stakeholders, this design can still be used. Because all farms have different characteristics, and farmers have different preferences, different amounts and sorts of enrichment products should be provided, taking into consideration the size of pens, the number and behaviour of pigs, and the wishes of the farmer. Therefore, we would like to give farmers the opportunity to choose an enrichment product which is best suited for their farms.

The enrichment products should be reachable by the farmer from the stable corridor, to easily replace or refill the product. The best place to hang the basket is in the front of the pen, above solid flooring, but it should also be far enough from the walls, so that pigs can reach the product from all sides. Farmers can decide themselves how far they want the basket to be in the pen. Refilling or replacing the product can be done by using, for instance, a hook to pull the product towards the corridor.

PIGOOD® Jute ball

This enrichment product is probably more expensive because of the materials used and the expected short durability of the product. Therefore, not all pig farmers are willing or able to implement this product in their stables. However, considering the used materials and taking into account literature and the RICHPIG model, it was assumed this product would score higher on welfare compared to the commonly used metal chain.

PIGOOD® Basket

This enrichment product probably lowers the barrier for farmers to implement it on their farm. This is because the materials used can be purchased more easily and have a longer durability. Moreover, which bedding material will be put into the basket is a farmer's own choice. Also, the number of ropes attached to the basket and whether they have knots or not is a farmer's own choice. By changing the exterior and content materials, the basket can be suitable for pigs of different ages and it stays novel. Farmers also have the option to put feed, such as big pellets, into the basket. They can also choose to put in combinations of different bedding materials, to make it even more interesting for pigs.

PIGOOD® Interplay

A third option for farmers is to implement an interactive model of enrichment. In this model, a pulley system is used to hang either the PIGOOD® Jute Ball or PIGOOD® Basket from the ceiling, connecting two pens. There needs to be a stop on the pulley system, so that pigs in both pens can always reach the product. Even though interaction appeared to be beneficial for the welfare of pigs it may not be possible to implement this on every farm.

Nutritional value of enrichment product

A large part of the materials from our design can be eaten by pigs, the nutritional requirements of pigs and the nutritional values of these materials are described in Table 2 and Table 3, respectively.

Table 1. Nutrients requirement of finishing pigs from 100-135 kg (National research council of the national academies, 2012).

Finishing pig (100 – 135kg)	
NE (kcal/kg)	2475
ME (kcal/kg)	3300
Crude Protein (%)	13.4
Linoleic acid (%)	0.1
Calcium (%)	0.46
ATTD Phosphorus (%)	0.18
Apparent ileal digested Lys (%)	0.71
Apparent ileal digested Met + Cys (%)	0.43

Table 2. Nutritional value of different materials (Caslin & Finnan, 2010; Blok & Spek, 2016; SELF Nutrition Data, 2018).

		ME, kcal/kg	CP,% DM	CFat,% DM	Ca,% DM	P,% DM	Lys,% DM	Met + Cys,% DM
Different materials	Jute	1420.0	4.7	0.3	0.2	0.08	0.219	0.105
	Maize silage	2579.5	8.6	2.5	0.15	0.2	0.2	0.24
	Grass silage	2488.8	17.3	4	0.5	0.42	0.58	0.33
	Barley straw	3511.0 ^a	4.3	2.6	0.34	0.09	-	-
	Wheat straw	3439.4 ^a	4.1	1.2	0.43	0.09	-	-
	Lucerne hay	1289.8 ^b	17.5	2	1.29	0.28	0.84	0.49

a. gross energy,

b. digestible energy

From these tables, it can be concluded that straw has the highest gross energy which might be an additional energy source in cold weather. Lucerne hay can be used in summer to reduce heat stress of pigs. Lucerne hay contains less energy compared to other materials, so pigs will produce less heat when digesting it. Silage fulfils most nutritional requirements for pigs, so it can be directly used as feed, but it is more beneficial when combined with other feed. However, when keeping in mind the risk of mycotoxins, we recommend using straw as bedding material inside the product.



Recommendations

Arriving at the end of this project, we have already altered the design according to received feedback (Step 6). However, due to time constraints, no further feedback session on the new design can be arranged and therefore, we cannot go back to Step 5. To follow-up with this design, there might be possibilities for future ACT-teams to acquire more feedback on this design and we recommend to start trials with it on (research) farms to see how pigs react to the product and to gain information about the durability of the product. Based on the implementation on (research) farms and the reaction of pigs towards the product, a definitive product can be designed and eventually, marketing campaigns might be set up to promote selling this newly developed enrichment product, which completes the process of developing a new product. We recommend to score the enrichment product after trials, based on RICHPIG or another scoring system, so that it can be compared to other enrichment products.

During and after the feedback session there were some things that we ran into, such as the production of natural flavours and odours. We found out that flavours and odours can be produced by feed companies, but that adding flavour or odour to a rope might not have added value, because pigs already like rope. It is a possibility to add flavour or odour to indestructible materials, such as the chains or the metal basket, so that it stays interesting to pigs. We recommend to find out if natural flavours and odours, like moist soil, can be produced by the feed industry and to do an on-farm trial to see whether adding this increases the novelty of the product. Another thing we ran into was the durability of the used materials. Durability of the product is important for the farmer in terms of costs and labour intensity. If a material should be replenished every day, such as straw, than this will cost more money and labour than hanging a chain that lasts for years. It has come to our attention that ropes and jute do not putrefy easy and therefore can get stuck in the liquid manure system. However, this system is farm specific so possibilities of implementation of these materials will differ between farms, therefore we recommend to also test this during a (research) farm trial.

We also found that so far, farmers' preferences are (mostly) not taken into consideration when designing enrichment products and, because of this, the implementation of most enrichment products is still lacking. Therefore, we would recommend to design a new scoring system for enrichment materials that takes into account farmers' preferences, such as labour intensity, but also things like durability, as these are very important variables for implementation of new products.

At the start of this project we wanted to create a link between the feed industry and the production of enrichment products. During the feedback session it became clear that multiple employees of feed companies have knowledge on enrichment products. However, as feed companies are specialized in producing feed and not in producing enrichment, they do not put this knowledge into practice. In addition, the feed industry thinks producing enrichment products is not something that is beneficial for them to pursue. Therefore, we recommend to let feed companies produce only feed and possibly feed as enrichment, but to leave the production of enrichment products, such as chains and balls, to manufacturing companies. It did not become clear what the costs of production would be for our

product, because there was no interest from the feed industry to produce this product. Therefore, we suggest to contact enrichment manufacturers to gain knowledge about this.

We have found out that creating a link, to develop enrichment products, between farmers and the feed industry is not likely to happen. However, collaboration between the feed industry and enrichment manufacturers has not been investigated yet. Creating this link may contribute to improving enrichment products.

To farmers who are going to use our product, we recommend to change and replenish the enrichment product regularly, because this keeps the product novel and thus interesting to pigs.

Conclusion

During this ACT-project, a design of an innovative enrichment product was made that was provided with feedback by a team of pig welfare experts, employees from different feed companies and a pig farmer. Based on this feedback session, we adjusted the design. From the 7-step action plan (Figure 6) can be seen that this currently places us at Step 6.

A new enrichment product was created based on literature and suggestions from stakeholders. First, we conducted a literature study to find out what requirements enrichment for pigs should meet. Examples of these requirements are, for instance, the legal requirements for enrichment products, such as safe, edible and chewable, but also pig based requirements, such as destructible, rootable and novel. This literature study also contained information on what current enrichment products are available and what their strengths and weaknesses are, hereby answering our first two sub-questions. The existing enrichment products all have pros and cons, for example, straw is the most suitable bedding material but it is often too labour intensive for farmers. Moreover, a chain is cheap and can be used for a long time, but it improves pig welfare less than, for instance, straw. With this information in mind, a first design of an innovative enrichment product was made, called PIGOOD[®] Jute Ball, which was a jute ball, hanging from the ceiling, with ropes coming out of it. An interaction model was added to this to promote interaction between different pens, called PIGOOD[®] Interplay.

It became apparent that requirements for farmers, such as low-cost, cleanable and low labour intensity, are also vital for enrichment products, so that farmers are willing to use the product. During the feedback session we received feedback about preferences of farmers, answering our third sub-question.

Our last sub-question referred to including the feed industry in the development of enrichment products. During the feedback session it became clear that this was not an option. All invited stakeholders from feed companies agreed that these companies are already specialized in producing feed and that it would not be beneficial for them to also start producing enrichment. Nonetheless, feed can be provided as enrichment in different shapes and ways, such as the larger sized pellets. The invited stakeholders from feed companies had a lot of knowledge on pigs, and how to properly take care of them, and their feedback was therefore very useful. However, they all showed little interest in implementing feed in an enrichment product.

After the feedback session, literature was found to substantiate the received feedback. Taking all of this into account, the design was adapted by using a metal basket instead of a jute ball, because jute might be easily destructed by pigs, which will decrease benefits for farmers. Ropes and chains attached to the basket and bedding material inside the basket can promote chewing and rooting behaviour.

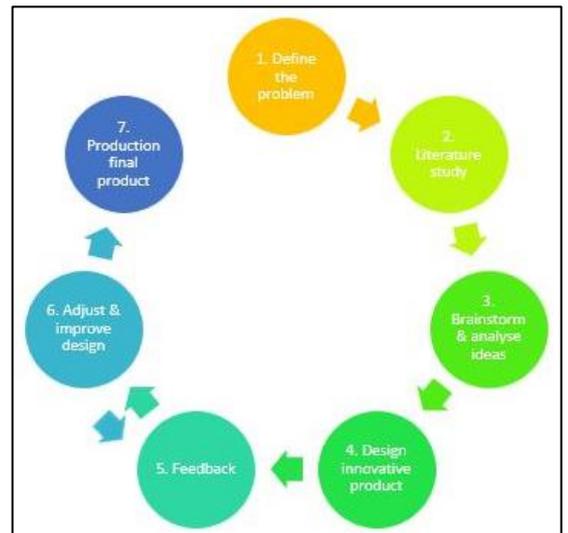


Figure 6. Seven step action plan to develop final product.

PIGOOD[®] Basket can be easily implemented in almost all pig farms, and renewing bedding materials and ropes will not cost too much labour. While the metal basket can be used for bigger pigs, which are more destructive, the jute balls score better on welfare and may be used for smaller pigs. Moreover, the interactive enrichment model we came up with is an extra way to improve pigs' welfare.

In conclusion, both our designs meet aforementioned requirements for pig welfare, legislation and farmers' preferences, but the jute ball consists of more materials that enhance welfare. However, farmers can determine how to use the metal basket themselves, which is beneficial for meeting their preferences and thus for implementation of the product.

Due to time constraints it was not possible to go through all steps of the action plan, so the design still needs to be optimised by receiving more feedback and adjusting the design according to this. The main research question was answered by thinking about, creating and designing an innovative enrichment product for pigs, named PIGOOD[®].

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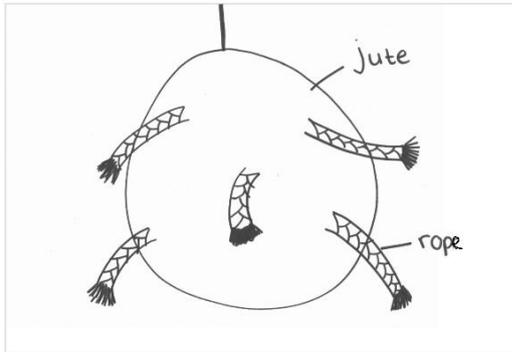
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Appendices

Appendix 1: Designs brainstorm session

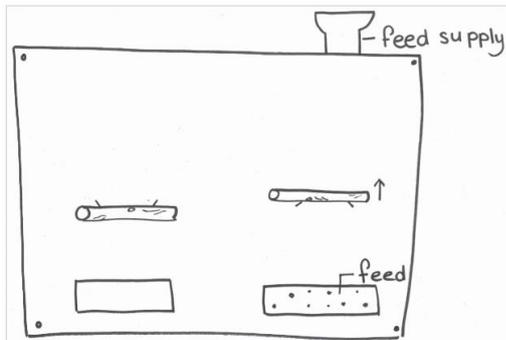
Designs individually created during the brainstorm session of Tuesday 2 October 2018, including a short explanation.

Design 1:



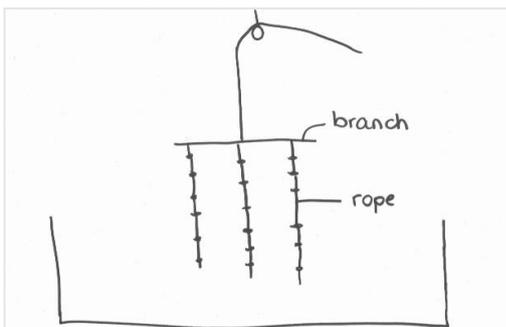
This design consist of a ball made out of jute, which is hanging from the ceiling. Straw combined with treats, like raisins, is inside the ball, which will fall out when the pigs have destroyed the jute. On the outside of the ball, natural rope is attached that has a special odour like vanilla or chocolate.

Design 2:



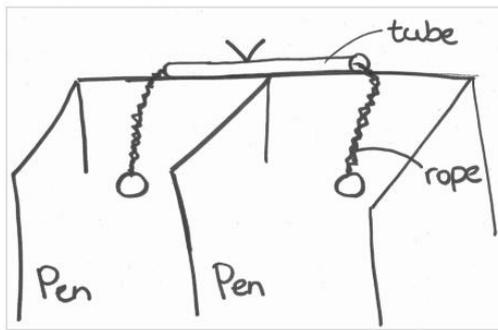
This design is fixed on the wall of a pen. With this design pigs can lift the branch-like lever in order to get a food reward. The weight of this lever can be adjusted, depending on the size and age of the pigs, so that they have to put more effort in it to get the reward. Moreover, the weight can be so heavy, that pigs need to cooperate together to get the feed reward.

Design 3:



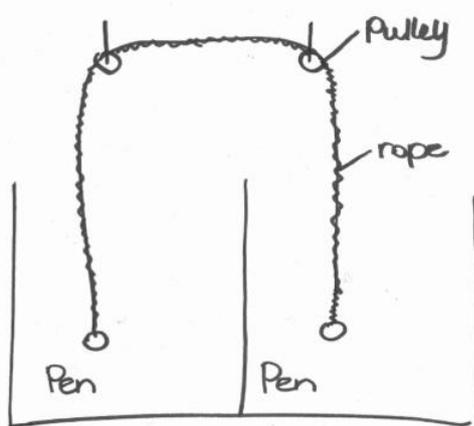
This is a design focused on ropes. These ropes are made by fibrous material, and there are many knots on one rope. To the rope some attractive flavours are added and in every knot, concentrate feed is involved. What is more, the rope can be moveable by the pulley system. The ropes are hanging from a branch to support them, and when the ropes are destroyed, the pigs can start on the branch.

Design 4a:



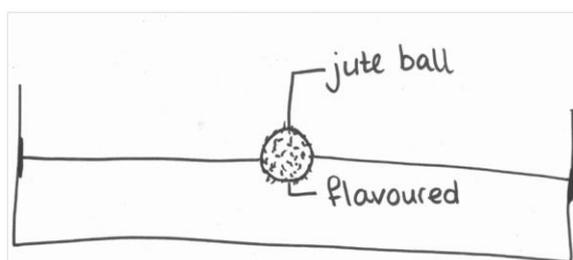
This design considered interaction and competition among two pens. It consists of a tube with a feed input hole. A rope was pulled through the tube with a ball attached to both endings. When pigs pulled down one rope, feed in the tube would fall on the ground and pigs will get rewards for this behaviour. Also they can get triggered by the movement of the enrichment, caused by the other pen playing with the rope.

Design 4b:



To improve the design 4a, a pulley system is used to replace the tube, as this might not be feasible in every stable. Pulleys are harder to destroy by pigs than the tubes on the pen side, but the extra feed element is left out with this design. Also, the interaction between pens is still possible. The pigs get triggered by the movement of the rope and can compete for it.

Design 5:



In this design, a jute ball is attached to the two sides of the pen with bungee cord, which makes the ball easy to move. On the outside of the ball, straw is sticking out. Also flavours and odours can be added to the ball to make it more interesting, like lavender, rose and vanilla.

Appendix 2: Signed consent forms

Agreements upon the use of information and feedback given in 'Step 5: Feedback' are sent by email to the secretary, these agreements are available upon request. Marc Bracke, expert in Animal Welfare from Wageningen Livestock Research, was not able to sign the consent form, since contact is done via email and telephone.

Wim Schut, pig farmer from Maatschap gebroeders Schut in Bennekom:

Participation consent form

Research project title:

Developing an innovative enrichment product to improve pig welfare: *An effort to include the feed industry in development and production of innovative enrichment products for the intensive pig industry.*

This form is to document that I, Wim Schut volunteer to participate in the above-mentioned research project. I agree to participate to the feedback session on Friday 5 October 2018 and how the information and feedback of this session will be used. I understand and approve the following:

- The feedback session will be recorded and information/feedback from the participant will be used in the report; its actual recording will be destroyed at the end of the research project (26-10-2018).
- The participant will be identified by name in the final report of this research project.
- Information/feedback from the participant during the feedback session will be used in the final report after being reviewed and agreed upon by the participant.
- The information/feedback will only be used for this research project and the overall project of our commissioner The Science Shop WUR, and will not be given to any third parties.
- The participation to the feedback session is on a voluntary basis and the participant is aware he or she can leave the meeting at any time.



Signature participant

05-10-2018

Date



Signature secretary

5-10-18

Date

Participation consent form

Research project title:

Developing an innovative enrichment product to improve pig welfare: *An effort to include the feed industry in development and production of innovative enrichment products for the intensive pig industry.*

This form is to document that I, Maarten Hollemans volunteer to participate in the above-mentioned research project. I agree to participate to the feedback session on Friday 5 October 2018 and how the information and feedback of this session will be used. I understand and approve the following:

- The feedback session will be recorded and information/feedback from the participant will be used in the report; its actual recording will be destroyed at the end of the research project (26-10-2018).
- The participant will be identified by name in the final report of this research project.
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- The participation to the feedback session is on a voluntary basis and the participant is aware he or she can leave the meeting at any time.



Signature participant

5-10-18

Date



Signature secretary

5-10-18

Date

Participation consent form

Research project title:

Developing an innovative enrichment product to improve pig welfare: *An effort to include the feed industry in development and production of innovative enrichment products for the intensive pig industry.*

This form is to document that I, Johan Zonderland..... volunteer to participate in the above-mentioned research project. I agree to participate to the feedback session on Friday 5 October 2018 and how the information and feedback of this session will be used. I understand and approve the following:

- The feedback session will be recorded and information/feedback from the participant will be used in the report; its actual recording will be destroyed at the end of the research project (26-10-2018).
- The participant will be identified by name in the final report of this research project.
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- The information/feedback will only be used for this research project and the overall project of our commissioner The Science Shop WUR, and will not be given to any third parties.
- The participation to the feedback session is on a voluntary basis and the participant is aware he or she can leave the meeting at any time.



Signature participant

5-10-2018

Date



Signature secretary

5-10-18

Date

Participation consent form

Research project title:

Developing an innovative enrichment product to improve pig welfare: *An effort to include the feed industry in development and production of innovative enrichment products for the intensive pig industry.*

This form is to document that I, ...Sharon...van...Schaijk..... volunteer to participate in the above-mentioned research project. I agree to participate to the feedback session on Friday 5 October 2018 and how the information and feedback of this session will be used. I understand and approve the following:

- o The feedback session will be recorded and information/feedback from the participant will be used in the report; its actual recording will be destroyed at the end of the research project (26-10-2018).
- o The participant will be identified by name in the final report of this research project.
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- o The information/feedback will only be used for this research project and the overall project of our commissioner The Science Shop WUR, and will not be given to any third parties.
- o The participation to the feedback session is on a voluntary basis and the participant is aware he or she can leave the meeting at any time.

Sharon van Schaijk
Signature participant

5-10-18
Date

M. Werdschoten
Signature secretary

5-10-18
Date

Marion Kluijvers, expert Animal Welfare at Wageningen Livestock Research:

Participation consent form

Research project title:

Developing an innovative enrichment product to improve pig welfare: *An effort to include the feed industry in development and production of innovative enrichment products for the intensive pig industry.*

This form is to document that I, Marion Kluijvers volunteer to participate in the above-mentioned research project. I agree to participate to the feedback session on Friday 5 October 2018 and how the information and feedback of this session will be used. I understand and approve the following:

- The feedback session will be recorded and information/feedback from the participant will be used in the report; its actual recording will be destroyed at the end of the research project (26-10-2018).
- The participant will be identified by name in the final report of this research project.
- Information/feedback from the participant during the feedback session will be used in the final report after being reviewed and agreed upon by the participant.
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- The participation to the feedback session is on a voluntary basis and the participant is aware he or she can leave the meeting at any time.


Signature participant

5/10/18
Date


Signature secretary

5-10-18
Date

Participation consent form

Research project title:

Developing an innovative enrichment product to improve pig welfare: *An effort to include the feed industry in development and production of innovative enrichment products for the intensive pig industry.*

This form is to document that I, Inonge Reimert volunteer to participate in the above-mentioned research project. I agree to participate to the feedback session on Friday 5 October 2018 and how the information and feedback of this session will be used. I understand and approve the following:

- o The feedback session will be recorded and information/feedback from the participant will be used in the report; its actual recording will be destroyed at the end of the research project (26-10-2018).
- o The participant will be identified by name in the final report of this research project.
- o Information/feedback from the participant during the feedback session will be used in the final report after being reviewed and agreed upon by the participant.
- o The information/feedback will only be used for this research project and the overall project of our commissioner The Science Shop WUR, and will not be given to any third parties.
- o The participation to the feedback session is on a voluntary basis and the participant is aware he or she can leave the meeting at any time.

Inonge Reimert
Signature participant

5-10-2018
Date

M. A. M. de Vries
Signature secretary

5-10-2018
Date

Appendix 3: Minutes from the feedback session with stakeholders

10.00h: Opening

Mandy: Thank you for joining us today.

We will talk about the enrichment we designed.

10.30h: Agreements

Mandy: We have a camera and we will record this session, and we would like to quote you in our final report. If you agree with this we have a form for you to sign. This is because our project is confidential. Also if there are misunderstandings in English, somebody of the team will be translating.

Signing contract.

Introduction team members.

10.15h: Introducing stakeholders

Johan Zonderland, feed company de Heus Voeders B.V. Responsible for the R&D globally in pigs. Not only in the NL, but also in 50 other countries. He has done lots of research on environmental enrichment. Has done a PhD on tail biting.

Maarten Hollemans, feed company Coppens. Coordinator of R&D projects. Coppens Diervoeding makes feed for both pigs and poultry.

Marion Kluivers, expert. Veterinarian, specialised in pigs and animal welfare. Works together with Johan.

Wim Schut, pig farmer.

Sharon van Schaijk, feed company AgruniekRijnvallei. Pig nutritionist.

Inonge Reimert, pig welfare expert. (Will arrive later)

10.40h: Introducing our individual designs

Mandy: jute ball with ropes attached to it.

Marion Kluivers: Do you know long it will take for pigs to break the jute?

Mandy: It depends on the size of the ball and pigs, we asked Marc Bracke.

Johan Zonderland: What are the requirements exactly in legislation?

Mandy: Safe and cleanable, eatable, chewable, rootable, destroyable, innovative, challenging.

Johan Zonderland: Which one doesn't this design meet?

Mandy: Rootable and cleanable.

Marion Kluivers: Cleanable and hygienic are not the same.

Wim Schut: So how long would this product last, one day? And it is for finishers.

Sharon van Schaijk: Why finishers?

Mandy: They are fed ad libitum, so we do not have to take nutritional value of product into account.

Maarten Hollemans: Doing this with finishers is most important, you can test products with them and see if it works then on weaners.

Johan Zonderland: What is the main target group?

Mandy: Pigs and farmers.

Johan Zonderland: So are there also requirements from farmers?

Wim Schut: The filling of the ball can get into the slurry system.

Sharon van Schaijk: So where to put this design?

Mandy: Above the solid floor.

Maarten Hollemans: If you put in above the slatted floor, the pigs will defecate on another place. If you hang it above the solid floor, you have to keep in mind that this will not be a place that they will rest anymore. Usually this doesn't matter so much, but some farmers say this is a problem.

Wim Schut: This is a problem. It will get crowded and dirty. If you hang enrichment on the wrong location you can influence defecation behaviour.

Maarten Hollemans: A toy can be put on a place where you want the floor to be clean, this helps. Also take into account the reaching into the air, pigs like to have their snout on the ground.

Xana: Lever system with feed rewards and based on collaboration.

Maarten Hollemans: Why is this different from normal feeders?

Xana: Now there has to be cooperation and they have to do something before they can get food.

Marion Kluivers: The advantage of this design can be in the branch of wood, the pigs want to bite it, but it can also raise competition between pigs.

Shawn: Rope with knots hanging from a branch, hanging from the ceiling.

Marion Kluivers: The branch, is it meant to be eaten also?

Shawn: Yes, but they cannot eat it immediately it also just supports the ropes.

Marion Kluivers: If they can reach it, it can be destroyed easily. It can be replaced by some other material maybe.

Maarten Hollemans: Be careful with rope, they can hang themselves if the rope is too long and reaches the ground. Also watch out with the ear tags, these can get stuck behind the rope, and then there's going to be drama.

Charlotte: Interaction system between pens with rope, via a tube or the ceiling

Johan Zonderland: Via ceiling is good idea, connected to pens is not liked by the pigs. But when it is loose from the walls it is found interesting by the pigs.

Marion Kluivers: Stimulation between pens is very nice. The rope needs to have a stop so that both pens always can reach it, not that one pen pulls all the rope to their side. A ball underneath is a disadvantage. Rope can get loose, and get dirty, so maybe exchange it for a chain. Also a piece of wood may be a good alternative underneath. The idea is very nice. I'm very pro natural material, but rootability is more important.

Maarten Hollemans: The chain needs to stay on the ground. Nevertheless there's the effort of pulling from the other pen, but stops on the chain for this are easy to make.

Wim Schut: Rope is the best, but only for a couple of hours, for it is destroyed easily.

Zhanhua: Odorous balls, attached to rope between walls.

Marion Kluivers: I like how you think about what the pigs want, but practical things are very important. Jute and rope are easily destroyable, and flavour and movement is nice. You need to separate the requirement for pigs and farmers to make smart combinations of materials and systems. But still I like how you think about what the pig needs.

10.55h: Introducing our final design

10.10h: Questions/remarks/feedback from stakeholders

Wim Schut: It is awesome, the material used is the best for welfare, but it is destroyed very fast. It needs replacement to soon.

Mandy: How often would be okay?

Wim Schut: Not too often, because this will mean more costs. Also, it would be nice if I do not have to enter the pen.

Marleen: We were thinking about something that you can reach from the hallway.

Wim Schut: Rope is an amazing product but it is destroyed too quickly. Also it will get stuck into the slurry system.

Maarten Hollemans: Straw will also get into everything.

Wim Schut: Straw is okay but rope won't rot, and it will get stuck. Chains are also nicer because it rings and pigs like that.

Marion Kluivers: Officially a chain alone doesn't meet legal requirements, it is not enough.

Sharon van Schaijk: Feed falling out from the product on the ground, is that allowed?

Marion Kluivers: Yes it is, but it needs to stay hygienic .

Maarten Hollemans: It should not get dirty. I think even a chain touching the ground is already forbidden.

Marion Kluivers: Remark on design. Rope is destructible, not in favour of jute, this is gone in few hours.

Xana: What about other material like hard plastic? Where we attach rope to then.

Marion Kluivers: Like a Football, or a potato basket with bigger openings, then you can use straw. It needs to be able to be pulled out and be edible.

Maarten Hollemans: You need to keep it very simple. It looks nice and might work until a certain point but the farmer needs to buy it. With many pigs you need to compete in terms of price with other products. Because if you just hang a cheap chain then it's also 'okay'. Lots of clients do not buy good enrichment because they can also buy something cheaper.

Marion Kluivers: There is tension between farmer and pig needs. Pigs want to destroy but then the farmer needs to replace the product often. And if replacement is not often needed, than the pigs cannot destroy it, so both are never happy. Pigs are happy when supplied with straw two times a day. They like an element of surprise.

Johan Zonderland: Focus on welfare now, but costs, labour and practicality need to be taken into account. 95% of things people come up with are nice for pigs, but have trouble with costs, labour and practicality. You need to find something that combines it all, and simple.

Wim Schut: The idea of Xana is the most practical now. You can install it, refill it and you're done.

Maarten Hollemans: Does rope really disappear in a few hours? We have different types of rope. We put it in a pen and it remains for weeks, and the pigs keep playing with it.

Wim Schut: The thicker the rope, the longer it remains. Even when it has knots they take more time but still manage to destroy it quite quickly.

Marion Kluivers: This eagerness might be an indicator of a need?

Wim Schut: Well if you were standing there they would also get you. It's the novelty that is fun and interesting. And destroying is their hobby.

Presentation Johan Zonderland

Purpose enrichment, needs to comply with welfare but also with legislations. What is the key? Still unknown after 20 years of research. Triggering is rootability, rewards, interaction and change of material.

Sight is the 4th sense of a pig, rooting (nose) is one of the most important. They are focussed on enrichment on the floor, not up in the air. Wild pigs spend hours and hours on finding food and this is what you still see in the pigs now. Pellets you eat in 5 minutes are not satisfying enough.

In chains you can root! Other examples of enrichment: rooting disks, Edinburgh football, Rooting apparatus, stroswing. Interaction between pens is nice. It doesn't matter what you put into the pen, as long as you change it often enough. Something new will already provide the interaction. Practical aspects are very important. If the enrichment reduces daily feed intake, it will limit growth and that is not what a farmer wants. If the welfare score is higher, the costs and labour time will be higher and quality of work environment for the farmer will be lower. Scoring is about welfare, labour and practicality. In the end getting rid of manure is also work. Welfare is a very important part, but the other three parts are very important to if you want it to work.

Wim Schut: Basically, what is better, is more expensive.

Johan Zonderland: Innovations need to fix these problems with filling all criteria.

Wim Schut: All extra measures do not results in extra profit now. Only when there are actual problems we'll do something with it. It costs more labour and time, but no extra money.

Marion Kluivers: This is an important point, the current market doesn't pay it back. So either it needs to pay back or there have to be a lot of advantages.

There was a research that compared pigs grown up in an enriched environment vs a non-enriched environment. They were also infected with a disease. The pigs grown up in an enriched environment (toys, more space, more pigs together) were sick for a shorter time, and were also sick less intense. So it seems that pigs from an enriched environment are less sensitive towards sickness.

Wim Schut: I don't want to enter the pens if I don't have to. Keeping more pigs together is nice, but it is the farmers that can infect the pigs with a disease, and not pig-to-pig. I also can not completely change my stable.

Marion Kluivers: There are more advantages to enrichment next to preventing tail biting.

Wim Schut: There are just too many practical problems and the costs don't get covered. Right now, the consumers say a lot but they don't pay for it.

Johan Zonderland: This is important, the commodities in The Netherlands are just not set to implement all kinds of enrichment because it just doesn't pay.

Marion Kluivers: Does your design meet the legal requirements, what are they?

Mandy: Yes, but they are very vaguely defined.

Marleen: It needs to be good, enough, and safe.

Marion Kluivers: They are not that vague, but an open norm. It states the end products. What makes it difficult, is that you cannot say it meets the requirement until you see it in practice.

Johan Zonderland: I disagree, because it is an open norm, it does provides room for innovation.

Marion Kluivers: True, it's not a problem, it's all about the animal in the end.

Mandy: What if we make a rubber ball instead of jute, with holes, filled with straw and larger pellets?

Wim Schut: The idea is not bad but it has to be 'pigproof'. And a ball, how to refill this. If you have a basket, you can just throw them around and they don't break, and it is more difficult for the pigs to get the content out.

Marion Kluivers: There is a system that consists of a black bucket with a chain with straw inside, if they touch it, something will fall out. This will also stimulate interaction, and the reward is important then.

Xana: Jute is also hung, and it is very cheap, so that's why we wanted to use jute.

Wim Schut: Jute will be in pieces very fast and might mix with the manure, which is not wanted.

Marion Kluivers: Also the ear tags will get stuck in it. It is very important to give pigs interaction, it creates peace within the pens. Then their needs can be fulfilled.

Maarten Hollemans: Pigs have evolved in a way that they like rooting to get their feed.

11.30h: Break

11.45h: Summary

11.50h: Questions from us

Replacing and replenishing: how often is acceptable, according to you?

Wim Schut: I'm willing to do something for it every day. I'm there to check on my pigs anyway. As long as I don't have to enter the pen.

Is it feasible to connect something to the ceiling?

Wim Schut: This can be realised in my stable.

Sharon van Schaijk: It is probably doable in most stables. Farmers are very handy.

Wim Schut: The lighting is also hanging from the ceiling. It should be possible at almost all new stables.

Maarten Hollemans: Do not focus on this too much, focus on the ball, it should be possible.

How much movement of the material is needed to trigger pigs?

Should or can there be a mechanism to balance height

Marion Kluivers: Mechanism is technical, this will need to withstand pulling.

Johan Zonderland: You can easily mount metal plates. The enrichment doesn't need to have a lot of up and down movement. A few centimetres is enough, to trigger the pigs, and since it is hanging loose there are already quite some movements.

What kind of bedding material can we work with, without blocking the slurry system?

Wim Schut: Straw or lucerne.

Maarten Hollemans: Wood shavings or sawdust.

Wim Schut: Wood doesn't rot very well, also it is not digestible, so it will get into the manure.

Marion Kluivers: CCM has a nice smell and flavour but not chewable.

Maarten Hollemans: Mushroom compost can be dangerous for humans so rather not.

Sharon van Schaijk: Rather something eatable so they can also root in it.

Marion Kluivers: Lucerne has some advantages.

Maarten Hollemans: Also think about mycotoxins, for example they can be in cheap straw.

Marion Kluivers: Also silage has this.

Maarten Hollemans: A combination of materials like straw and chopped straw will make it better.

Wim Schut: Elephants grass can also be a great alternative.

Xana: And what about flax?

Maarten Hollemans: With flax you need to be careful of mycotoxins again, flaxseeds need to be harvested but then can be toxic. Rape straw is also okay.

What kind of bedding material is preferred by pigs, according to you?

Marion Kluivers: Straw and wood shavings. Hay they will eat.

Maarten Hollemans: Most important is that they can root in this, maybe even sand can be an option.

Marion Kluivers: It can be bedding with food, so they can root in this.

Maarten Hollemans: In this way they can have an easy reward.

Xana: Is sand a problem in the slurry system?

Wim Schut: Yes, this is a big problem. However, the sows do not destroy the bedding.

Johan Zonderland: What works best is to fill bedding with feed so they will root in this.

Marion Kluivers: What about a full bale of straw with feed? There are also different functioning areas in the pen, they will not root in some of these.

Is it possible for the feed industry to produce flavoured ropes? Or in cooperation with the enrichment industry?

Johan Zonderland: Yes, this shouldn't be a problem.

Wim Schut: I don't see the added value of this, pigs already like the rope very much.

Johan Zonderland: It might be a nice idea to add flavour or odours to materials that are almost indestructible, to keep it interesting.

Mandy: So a flavoured chain maybe?

Johan Zonderland: Yes, so this can keep them occupied.

Xana: What would be the optimal ratio of bedding material and feed?

Marion Kluivers: 90-95% rooting material, and 5-10% feed.

Wim Schut: I would put in only straw or lucerne.

Maarten Hollemans: I would also only put in rooting material.

Marleen: We are asking about this because it is also a question from our commissioner. She feels the link between enrichment and the feed industry is missing.

Maarten Hollemans: We as Coppens produce feed, but not other things. We do know the companies that do that. We sell the big pellets, but we are not going to sell balls or anything.

Johan Zonderland: On the production side, there is probably not much we can do. The amount of feed produced for the enrichment would be so much, and then another company should produce the enrichment. The link can be in there, that is no problem, it can be stronger.

Marleen: How do you see this link?

Johan Zonderland: I don't have the answer, otherwise we wouldn't be sitting here.

Marion Kluivers: You can calculate the nutritional value and you don't want your pigs to take in a lot of fibres. I don't really see the link of the feed industry with developing enrichment.

Johan Zonderland: If an animal has a certain requirement, which is missing and thus not provided by the basic feeding, we can install licking stones with salt or minerals, or something.

What is the ideal height when hanging the enrichment?

Marion Kluivers: The height depends on the age, it is also in legislation.

Maarten Hollemans: It should be as low as possible.

12.15h: Discussion - let stakeholders discuss the design with each other

Marion Kluivers: How about boar smell, when reaching puberty this can also be stimulating.

Xana: How about different shapes, like a football?

Sharon van Schaijk: It is important that the feed can fall out easily, flat shapes might not be the optimal shape for this.

Marion Kluivers: It also needs to be refilled easily.

Maarten Hollemans: It needs to be practical, and a ball is difficult to store, for example when the pens need to be cleaned, balls fill wheelbarrows quickly and also they can't be stacked. So maybe cubic shapes are better.

Marion Kluivers: A potato basket can also be a good option, they can be attached to a variety of materials and the basket is easy to fill and indestructible.

Sharon van Schaijk: Also it can easily be made by farmers themselves as they might have those baskets already, so then the costs can be lower as well.

Maarten Hollemans: Plastic colanders are also interesting, they can be cleaned easily. They will be hanging so they also won't get dirty, no manure is touching it. So they can easily stay hanging. But a chain instead of a bungee cord and rope is a good idea, because that can all be destroyed.

Sharon van Schaijk: In the design, multiple things can be destroyed, and there will be tension about the rope, it is not needed.

Marion Kluivers: The advantage of that is that multiple pigs can play with it.

Maarten Hollemans: If the pigs pull out all the bedding material the ropes are still there, a little ball is more than enough, they can also play with the straw.

Inonge Reimert: The interaction is nice, but from a study it appeared that combining enrichment with different pens doesn't seem to be preferable for pigs. Other toys presented there were more preferred.

Maarten Hollemans: Yes, this is questionable. Also, pigs will synchronize in behaviour. What if one group is resting and the other group starts to play, then the resting group might be disturbed as the toy in the pen starts to move.

Inonge Reimert: It is more practical to put this in per pen.

Maarten Hollemans: Also the pulley system can be destroyed. If you have ammonia in the stable, it can affect the movement in the system. I also wonder if the interaction system really works and is needed. Keep it simple and this way it can also be cheaper.

12.55h: Closing - thank everybody for participating

Time for presents!