Student Research Project

'Save the Piglet'

A partnership between: Nutreco & Sunjin

Impact of different feeds on performance of weaned piglets

CONFIDENTIAL

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Abstract

To assess the influence of four different feeds on weaned piglet performance, a total of 824 piglets were allotted to four different dietary treatment groups (NS, NP, OS, and OP). Feed effects on average daily feed intake (ADFI), average daily gain (ADG), feed efficiency (FE), health (incidence of diarrhea and respiratory problems), body condition score (BCS) and mortality were determined. It was hypothesized that overall the piglets on New Feeds would perform better than piglets fed Old Feeds. The experimental groups consisted of a total 88 litters that were supplied with creep feed according to their dietary treatment group. After weaning (day 21), piglets were allotted to 44 pens with a maximum mixing of two litters per pen and taking the dietary treatment group pre-weaning into account. Climate was controlled by a computer-linked fan system that required manual setting.

Compared to OS feed, the NS feed has been adjusted to form a new concept with less antibiotics, less crude protein (CP) with a better digestibility, more fermentable carbohydrates (FC), additional organic acids (OA) and improved taste. This resulted in significantly healthier piglets when fed NS feed (lower incidence of both respiratory signs and diarrhea) and NP feed thereafter (lower diarrhea scores than piglets on Old feeds).

Compared to the OP feeds, the concept of the NP feed consisted of the same NS factors but with additional increased energy value and higher levels of lysine and other amino acids. This resulted in a significantly better FE for NP dietary treatment groups ($P<0.011$ and $P<0.001$).

Although only significant for the trial period d14-20 ($P<0.001$), over the entire trial period, the ADFI of New feeds was higher compared to the Old feeds. The ADG was higher for the Old feed trial groups than for the New feed trial groups. Overall, OP feeds had the highest mean BCS and within the New feed trial groups, mean BCS for piglets on NS feed was highest. Taking the entire trial period into account, mortality rates were highest in the NS trial group and lowest in NP and OS trial groups. Results may have been influenced by the air temperature in nursery house that was an average 5°C higher than optimal temperatures related to age of the piglets.

Feeding the total concepts of New Safety (NS) and New Performance (NP) diets to piglets age 14-68 days resulted in an overall better piglet performance and health than feeding Old Safety (OS) and Old Performance (OP) feeds.

Keywords: piglet • weaning • diet • performance • organic acids • fermentable carbohydrates • fermentable protein • mortality • health • climate

List of abbreviations: **NS**: New Safety, **NP**: New Performance, **OS**: Old Safety, **OP**: Old Performance, **ADFI**: average daily feed intake, **ADG**: average daily gain, **FE**: feed efficiency, **BCS**: body condition score, **FC**: fermentable carbohydrates, **CP**: crude protein, **FP**: fermentable protein, **OA**: organic acids, **VFA**: volatile fatty acids, **WBC**: white blood cells, **GIT**: gastro intestinal tract, **ZnO**: zinc-oxide, **PWDS**: Post Weaning Diarrhea Syndrome, **ETEC**: Enterotoxigenic *Escherichia coli*, **MCFA**: medium-chain fatty acids, **APP**: *Actinobacillus pleuropneumoniae*, ***PCV-2**: Porcine circo virus* type 2, **PMWS**: Porcine Multisystemic Wasting Syndrome.

1. Introduction

The two year 'Save the Pig' project was a cooperation between the Dutch Animal feed company Nutreco and their South-Korean partner Sunjin. Sunjin is a South-Korean pig integration with different business parts which, when combined, aim to produce high quality pork. To achieve this Sunjin has specialized in animal feed production, farming and processing of the meat products.

Fig. 1 Piglets suckling on the Boram Farm

Sunjin and Nutreco started the Save the Pig project with the goal to improve survival and piglet performance in the Sunjin pig integration. To do this Nutreco advisors visited the pig farms and determined critical control points (CCP's) that are important for piglet survival. After determining those, via management changes and Nutreco products and concepts, these CCP's are tackled. The most important CCP's were piglet vitality and survival, management and nutrition in farrowing house and nursery.

Nutreco has already advised Sunjin on microclimate and management, therefore this trial will focus on nutrition.

Fig. 2 the Boram Farm complex

The first trial results of the 'Save the Pig' project were very positive. In 2007, 25% of the weaned piglets died in the nursery period. Summer 2008, this number was drastically reduced to a mortality rate of 8% in the nursery house. Another Nutreco trial showed that it is possible, under Sunjin Farm circumstances, to further decrease the mortality in nursery house to 4%. This is another great improvement, although compared to Dutch standards of an average 2.6%[1] mortality in Dutch nursery houses, mortality is still quite high.

Day	Antibiotic	Dose	administered
21-30	Amoxicillin[1]	20 mg/kg	water
31-32	Amoxicillin[2]	20mg/kg	water
33-46	None[3]	-	-
47-70	CTC[4]	30mg/kg	water

Table 1 Normal antibiotics use on the Boram Farm after weaning. 1.dose is increased daily, dependent on performance of piglet. 2. depending on the health status of the piglets, the treatment is continued or stopped. 3. No antibiotics are administered due to vaccination against CSF and E.Rhusiopathiae. 4. CTC is only given when the mortality is >5% in the post weaning period prior to day 47. CTC = chlortetracycline

This trial was executed Boram Farm, central Korea, see Fig.'s 1 and 2. At weaning on day 21, the piglets at the Boram farm usually have an average bodyweight of 6,2kg. During the period in Nursery house the piglets gain another 19 to 24 kilogram to have a total bodyweight between 25 to 30kg per piglet on day 70, delivery. This means that during the lactation period, day 0-21, the piglets grow an average 225g/piglet/day and in nursery house, day 22-70, the average growth increases to ±500g/piglet/day.
Momentarily the laws in South-Korea for the use of antibiotics are not as strict as they are in Europe. Due to this the South Korean pigs are commonly treated with antibiotics, not only as a curative therapy, but mainly as a preventive measure and growth stimulator. Table 1 shows which antibiotics are normally used at the Boram farm after weaning:

In 2012 however, these laws will be revised and the preventive use of antibiotics will be prohibited. Therefore the search for alternatives is currently intensifying. New options include feed additives, not based on antibiotics, which have a similar or even improved effect on the production level and health of the piglets.

[1] *Kengetallen Spiegel Varken juni 2007-juni 2008*

Tokach et al. (2003) listed the three major concepts when formulating diets for newly weaned pigs as:
1. Adjusting pigs to the simplest and relatively lowest cost diets as quickly as possible after weaning,
2. Maximizing feed intake to ensure that the pig consumes sufficient energy and nutrients at a time when excess mobilization of body reserves (primarily lipid) can occur, and
3. Formulating the initial diets with highly digestible ingredients that complement the pattern of digestive enzymes, and digestive enzyme development, in the gastrointestinal tract.

Nutreco and Sunjin combined all this information in the 'Save the Pig' project by developing new feeds that can support and adapt to the nutritional needs of growing piglets, while reducing the amounts of antibiotics needed.

2. Aim of the trial

The aim of this research project was primarily to increase vitality of the piglets and thereby improve growth rates and decrease mortality rates for piglets 14 to 68 days while using less antibiotics. To achieve this, the trial mainly focused on nutrition and feed changes.

The NS and NP feeds should have a positive effect on piglet health. Te new formulation will preserve a healthy intestinal condition needed for optimal feed digestion and therefore the new feeds will prevent diet induced diarrhea and prevent reduction in feed intake after feed transitions.

3. Hypothesis

From the last week pre-weaning (day 14-20) up to delivery (day 70), the New feed piglets, on NS and NP feeds, will perform better then the Old feed control piglets, on OS and OP.

- Average daily feed intake (ADFI):
  - Over the entire trial period (d14-68), ADFI will be as follows: NS>OS and NP>OP.
  - Piglets on NS and NP feeds will have a higher ADFI after feed transitions than piglets on OS and OP diets.
- Average daily weight gain (ADG):
  - Over the entire trial period (d14-68), ADG will be as follows: NS>OS and NP>OP.
  - Piglets on NP have a higher ADG performance than piglets on NS feeds.
- Feed Efficiency (FE):
  - Over the entire trial period (d14-68), FE will be better for piglets on Performance feeds than on Safety feeds.
  - Piglets on NP will have the best FE
- Health:
  - Over the entire trial period (d14-68), the incidence of diarrhea and respiratory problems will be as follows: NS<OS and NP<OP.
  - Piglets on NS will have a lower incidence of diarrhea and respiratory problems than piglets on NP feeds.
- BCS:
  - The BCS will indicate the performance of piglets on ADG and ADFI.
  - BCS will be as follows: NS>OS and NP>OP.
- Mortality:
  - In farrowing house (d14-20) the mortality rate will be less than 2% for all dietary treatments
  - In nursery house (d21-68) the mortality rate will be will be as follows: NS<OS and NP<OP.
  - Piglets on NS will have a lower mortality rate than piglets on NP feeds.

4. Complementary literature on dietary treatments

It is well known that weaning is a very stressful event for piglets and challenges their still fragile immune system. The changes, particularly in environment and diet, increase the piglets' susceptibility to harmful microorganisms and enteric diseases, which are associated with decreases in feed intake and growth performance (van Beers-Schreurs et al. 1998). This susceptibility to disease is largely a result of the delicate balance between commensal and pathogenic bacteria in the gut of newly weaned pigs (Williams et al. 2001). The young pig's enteric microbiota are unstable and vulnerable to proliferation of pathogens.

Crude protein (CP) is the most important risk factor for (dietary induced) diarrhea. High dietary protein levels may stimulate protein fermentation and encourage proliferation of pathogenic bacteria in the gastrointestinal tract (Ball et al. 1987). Proteolysis is the first step in the utilization of protein by bacteria. Subsequent amino acid deamination, decarboxylation or urea hydrolysis by microbial urease (Visek 1984; Anderson et al. 1999) limits their availability to the host and yields several putrefactive compounds including ammonia, amines, branched fatty acids, indoles, phenols and sulfur-containing compounds (Swanson et al. 2002). These compounds are considered to be detrimental for the host animal (Nollet et al., 1999) and can influence function and diversity of the gut microbiota (Gaskins 2003). Prohaszka and Baron showed that high amounts of CP in the diet of newly weaned piglets may predispose them to post weaning coli-bacillosis, and Bikker et al. (2006) showed that additional fermentable protein (FP) tended to increase Clostridia spp. counts.

To reduce the toxic effects of protein fermentation it seems helpful to decrease the amount of protein available for fermentation. Therefore, the amount of CP in pig diets could be lowered from 23 to 17% (Nyachoti et al., 2006) and this is supported by an experiment of Bikker et al. (2006) which showed that diets low in CP resulted in a lower concentration of ammonia in the small intestine, indicating reduced protein fermentation.

Another option, thoroughly studied by many researchers is the inclusion of fermentable carbohydrates (FC) in the diet, such as fructo-oligosaccharides (Houdijk, 1998), lactitol (Piva et al., 1996), resistant starch and wheat bran (Govers et al., 1999), lactose and inulin (Pierce et al., 2006) and a combination of sugar beet pulp, native wheat starch, lactulose and inulin (Awati, 2005).

An increased supply of FC may decrease the concentration of putrefactive compounds that are generated during proteolytic fermentation. (Williams et al. 2001; Swanson et al. 2002). With extra FC available, the N produced during the fermentation of an excess of indigestible protein is more likely to be incorporated into bacterial protein rather than being fermented to be used as a source of energy (Houdijk, 1998 and Morgan and Whittemore 1988). Inclusion of FC in the diet thus influences the composition and activity of the gastrointestinal micro-biota (Williams et al. 2001) and according to Konstantinov et al. (2003) increased bacterial diversity and promoted a more rapid stabilization of the bacterial community.
In this way the FC in dietary fibre may provide some protection against post weaning coli-bacillosis (Aumaitre et al., 1995) and may prevent proliferation of harmful Clostridium spp. (produces amines) in the hindgut of young pigs (Allison and Macfarlane 1989; Gilliland 1990). The fermentable fiber in the diet stimulates microbial fermentation and organic acid production in the fore- and hindgut of pigs (Williams et al., 2001; Jensen, 2001; O'Doherty et al., 2006) which enhances gut health and animal productivity (Jeaurond et al. 2008).

Bikker et. al (2006) and Jeaurond et. al (2008) showed that a diet of high FC and low CP, in the small intestine, increased the number of lactobacilli, tended to decrease the number of coliforms, tended to increase the lactic acid content, and reduced the concentration of ammonia. In the colon, the concentration of total volatile fatty acids (VFA), acetic acid, and butyric acid was increased, and tended to decrease the ammonia concentration.

The higher concentrations of total VFA, acetic acid, and butyric acid in the large intestine indicate that fermentation was stimulated by the high dietary FC level. As the ammonia concentration in the colon tended to be lower with the high-FC diets, it implies that mainly carbohydrates, and not proteins, were fermented. (Konstantinov et al.,2004, Awati, 2005).

The increase in lactobacilli, with subsequent decrease in the coliforms in the small intestine, can be attributed to the phenomenon of *colonization resistance* (Van der Waaij, 1989). The increased lactobacilli may out-compete the coliforms for space for adhesion and nutrient availability in the gastrointestinal tract (Bikker et al., 2006)

Besides the positive effects of the inclusion of FC in the diet on protein fermentation, an increased supply of FC resulted in a decrease in blood plasma counts of white blood cells (WBC) and segmented neutrophils. Zhang et al. (2002) noted that normally 1 wk after weaning, WBC counts increased significantly and this was associated with post-weaning stress in piglets. Because WBC and segmented neutrophils are a defense mechanism against pathogens, lower WBC counts and segmented neutrophils reflect lower exposure to pathogens or a reduced immune response in pigs fed FC.

Another positive effect of high FC diets is the increase of VFA formation (Jeaurond et al. 2008) as they are, with butyric acid in particular, the main sources of energy for colonocytes. Volatile fatty acids may also decrease digesta pH and have potent antimicrobial effects on many pathogenic species (Williams et al. 2001). The increased contents of VFA in colonic digesta, as a result of more FC in the diet, may contribute to improvements in growth performance of pigs (Jeaurond et al. 2008).

As explained above, it should be possible to prevent colibacillosis and create colonization resistance against other pathogenic bacteria by decreasing the amount of FP reaching the large intestine, either by decreasing the amount of CP in the diet, increasing the digestibility of the CP or increasing the content of FC in the diet.

Besides this there are some other possibilities to improve (GIT) health of a young piglet without the use of antibiotics. Among these, short chain organic acids (or salts thereof, e.g. Ca-formate) and yeast products are commonly used (Meijer et. al). Yeast products not only have nutritional value but can also have immune stimulatory effects and toxin-binding properties. Toxin-binding properties and binding of bacterial fimbriae are related to mannans in the yeast cell wall. Immune stimulation is due to β-1,3/1,6 glucans of the yeast cell wall, mainly modulating the non-specific immune system (Robertsen et al., 1990). Meijer et al found that organic acids and β-glucans appear to increase growth performance in piglets and they regarded them as promising alternatives for antibiotic growth promoters in weaner pigs.

Organic acids (OA) are known to inhibit gram-negative bacteria due to their pH-reducing effect and direct bacteriostatic action of non-dissociated acid molecules (Partanen and Mroz,1999). Recently also medium-chain fatty acids (MCFA) have caught the interest because of strong bactericidal properties, also toward gram-positive bacteria (Dierick et al., 2002). Based on these findings, van Hees et. al conducted an experiment to test if MCFA, in combination with OA, would improve antibacterial strength in a synergistic way, and lead to improved growth performance of weaned piglets with compromised gut health. They found the average daily feed intake (ADFI) tended to be improved for MCFA and MCFA+OA. Besides that, feed efficiency (FE) was improved when only OA were included in the dietary treatment. It has to be said that this trial was conducted under sub-optimal husbandry conditions.

Anyhow, these findings were supported by an experiment of Tsiloyiannis et al. (2001) He proved that organic acids (especially lactic acid) can be very useful tool in controlling post-weaning diarrhea syndrome (PWDS) of piglets, which is caused mainly by Enterotoxigenic *Escherichia coli* (ETEC) strains. He tested six organic acids for their efficiacy by offering six groups feed supplemented with either 1.0% propionic acid, 1.6% lactic acid, 1.2% formic acid, 1.2% citric acid, 1.5% malic acid or 1.5% fumaric acid. Groups were compared with regard to the appearance of clinical signs, mortality, weight gain and feed conversion. All groups supplemented with organic acids had reduced incidence and severity of diarrhoea, and performed significantly better than the negative control group (P<0-05).

Another feed supplement to reduce the need for antibiotics is the use of zinc-oxide. Højberg et al. (2005) showed that dietary doses of 2,500 ppm ZnO-Zn reduced bacterial activity (ATP accumulation) in digesta from the gastrointestinal tracts of newly weaned piglets compared to that in animals receiving 100 ppm ZnO-Zn. They found that the influence of ZnO on the gastrointestinal microbiota resembles the working mechanism suggested for some growth-promoting antibiotics, namely, the suppression of gram-positive commensals rather than potentially pathogenic gram-negative organisms. Reduced fermentation of digestible nutrients in the proximal part of the gastrointestinal tract may render more energy available for the host animal and contribute to the growth-promoting effect of high dietary ZnO doses.

The ability of feed related measures, such as the addition of 2500ppm ZnO, to prevent or reduce Post Weaning Diarrhea Syndrome (PWDS) was also examined by Melin et. al. (2002) They found that the ZnO, amongst others, decreased the incidence of diarrhea and thus may alleviate symptoms of PWDS. It has to be said that the use of ZnO is aggravating for the environment and some countries, including the Netherlands, uphold a ban on ZnO dosed above 100ppm to prevent zinc pollution of soil. The use of ZnO is permitted in South Korea.

Based on all this information, Nutreco and Sunjin formulated two new feeds, hereafter called *New Safety* (NS) and *New Performance* (NP) to improve piglet performance. The two new diets were based on two other feeds, *Old Safety* (OS) and *Old Performance* (OP), which were already used on the Boram farm where the experiment was conducted.

5. Materials and Method

5.1 Genetics

The trial piglets were commercial crossbreeds between a Duroc boar and F1 sow (landrace x large white). The animals were bred for the production of pork meat.

5.2 Housing and the piglets

5.2.1 Farrowing house

The farrowing house comprised 6 barns, each with 16 individually housed sows in pens of 2.5 × 2m. Each pen was equipped with a sow stand with slatted floor and a nest for the piglets with a heating lamp and concrete floor as shown in Fig. 3..

Fig.3. Individually housed sow in farrowing house.

The experiment was conducted with piglets all born in the same farrowing house in week 34, 2008. Out of 96 sows, 910 piglets were born. At day 14 the litters were allotted to 1 of 4 dietary treatments to form trial groups with an average 210 piglets each. The litters were selected and assigned to one of the four trial groups based on the following criteria and conditions:

- housing conditions, see diagram 1, annex 7.
- every *trial group* had more or less the same *size* with an equal number of litters
- the average *litter-size* in trial groups and between trial groups was similar, thereby also the standard deviation of the average litter size between the 4 trial groups was comparable
- the average *litter-weight* in trial groups and between trial groups was similar, thereby also the *standard deviation* of the average litter-weight between the 4 trial groups was comparable.
- the average *age* of the piglets in trial groups and between trial groups was similar, thereby also the *standard deviation* of the average age between the 4 trial groups was comparable

To distinguish the piglets assigned to the four different trial groups, all were ear-tagged (Fig. 4). The color of the ear-tag corresponded with the trial group, and thus the feed the piglet would receive.

5.2.2 Nursery house

After weaning on day 21 (range between 19-26 days), the piglets were housed in an environmentally controlled battery unit of 47 × 17 × 4.8-5.0m with 48 pens which had a maximum capacity of 30 piglets each. The pens measured 3.5 × 3.5m with half slatted, half solid floors. Of the total 48 pens, 4 pens were used as a 'hospital wing' for sick and weak piglets as shown in diagram 2, annex 7. This meant that every trial group had 1 pen, at first empty, to separate animals if necessary.

Fig. 4 Placing ear tags

The average 22 litters per dietary treatment group were assigned to 11-13 nursery house pens in a systematic way that minimized the influence of external factors such as climate. Thereby:

- per pen a maximum of *two litters* of the same dietary treatment group were mixed. Gilts and barrows were not separated.
- each pen housed about *19 piglets*

Table 2 summarizes some of the characteristics of the piglets and the trial.

Characteristic	Farrowing house	Nursery house
Breed	Duroc boar x F1 sow (landrace x large white)	Duroc boar x F1 sow (landrace x large white)
Weaning – day 55	Weaning: age 21 days (range between 19 and 26 days) Weaning weight: 6.39 kg, std 0.76kg (range: 5.1-8,5 kg)	Weight d. 55: 16.75 kg, std 1.94 (range: 12.4-20.3 kg)
Trial period	From age 14 days to 20 days	Post-weaning: from age 21-68 days
Allocation of piglets to trial group	Piglets were blocked by litter size, body weight and age.	Piglets were blocked by litter size, body weight and age.
Allocation of litters per pen	1 litter per pen, still with the sow	Max. 2 litters per pen, blocked within trial groups by litter size, body weight and age.
Number of piglets	Total = 832	Total = 825

Table 2. Trial characteristics

5.3 Feed

The characteristics of the four experimental diets (NS, NP, OS and OP) are listed in table 3. The feed transitions, between the three different phases in the new diets are fine-tuned. Due to better synchronized feed composition, with only slight differences in nutritional content and taste, the feed transitions shall not influence piglet performance as much as the Old feeds do.

		NS	NP	OS	OP
	Group (# piglets)	Trial (206)	Trial (228)	Control (191)	Control (199)
Phase	I	small pellet	powder	powder	crumbs
	II	small pellet	small pellet	crumbs	small pellet
	III	large pellet	large pellet	crumbs	large pellet
	starter	large pellet	large pellet	large pellet	large pellet

Table 3. Texture and some characteristics of the four experimental diets.

'New Safety'

The 3 phase NS feed was developed with a primary focus on piglet health to ensure strong and fit piglets, reduce mortality, diarrhea and PWDS. To achieve this the feed was produced to promote gut health and gastrointestinal function. Compared to the OS the following improvements have been made:

- **Raw materials with a better digestibility** – the digestibility of ingredients, such as crude protein, have been improved to decrease the amount of indigestible materials reaching the large intestine. By improving the digestibility more nutrients can be absorbed from the GIT to be utilized by the animal instead of being excreted in the faeces or fermented by harmful microbia. A better digestibility increases the efficiency of the feed.
- **Ingredients of better and more constant quality –** the source of raw materials was checked more thoroughly then before and subjected to verification of the claimed quality. The feed was checked for pollution, chemicals, sand, mycotoxins, weed seeds, etc.
- **Less crude protein** - to prevent unnecessary protein fermentation and thus prevent proliferation of pathogenic bacteria, the content of crude protein has been reduced. The digestibility of the remaining crude protein was enhanced and digestible amino acids, especially lysine, were sufficiently supplied.
- **More fermentable carbohydrates** – As explained above, the addition of fermentable protein may counteract the negative effects of protein fermentation in the hind gut. The FC also increases the amount of VFA available in the colon and may cause a beneficial shift in the composition of microbial population in the gut due to stimulation of colonization resistance.
- **More organic acids** (OA) – the feed contains extra MCFA, citric acid and formic acid as they may inhibit gram-negative bacteria due to their pH-reducing effect, have a direct bacteriostatic action of non-dissociated acid molecules and the MCFA have strong bactericidal properties. As the OA influence the taste of the feed, the OA's are excluded from Phase I to prevent negative effects on the taste. They are however included from Phase II onward.

- **Adjustments to minerals and spore-elements** The content of especially Ca, P and the spore-elements are better adjusted to the needs of growing piglets. Normally these elements are overdosed, but the *New Safety* feed contains exactly what a young piglet needs, so the piglet is not unnecessarily burdened.
- **Improved taste** – this stimulates and increases the feed intake and can therefore be very helpful to increase the ADFI and ADG. To achieve this, extra sodium, sucrose, and liquid blood (plasma) was added. In Phase-I no organic acids were yet added and the antibiotics were removed as both have a negative taste effect.
- **Less antibiotics -** The antibiotics were removed from Phase-I of the *New Safety* feed as piglets which feed on Phase I are still protected by maternal immunity and the antibiotics caused a bad taste of the feed. Instead, to all phases of NS feeds, a high dose of 2500ppm ZnO, short chain organic acids and yeast products were included for their antimicrobial effect. β-glucans were added for their stimulating effect on the antibody formation by the immune system and the adjustments to CP and FC as explained above prevent negative shifts in microbial gut flora.

'New Performance'

The 3 phase NP feed was developed with a primary focus on piglet growth. To achieve this, the feed was formulated to promote fast weight gain and a good meat production in a short time. Many of the new insights used for the formulation of the NS feed were also used for the NP feed and therefore the two new feeds are similar in many ways. The NP feed compared to the OP feed has been improved on the following aspects:

- **Raw materials with a better digestibility**
- **Ingredients of better and more constant quality**
- **Less crude protein**
- **More organic acids** (OA)
- **Adjustments to minerals and spore-elements**
- **Improved taste**
- **Less antibiotics**
- **More lysine and other digestible amino acids** A young piglet needs protein for growth, especially those amino acids that are used for the development of muscle tissue. When the amount of CP is lowered in the diet, attention has to be paid to the digestibility of the remaining protein in the diet. This should be improved and of the supplied amino acids, especially lysine is important. An experiment of Apple et. al showed that increasing the lysine:energy ratio (Lys:ME) has increased ADG and G:F linearly (P < 0.01) as Lys:ME increased from 1.7 to 3.1 g/Mcal. Besides that with increasing Lys:ME, lumbar muscle depth (P < 0.01) and area (P < 0.01) increased linearly, and actual ham lean yield (P < 0.01) increased.
- **Increased energetic value** – the NP feed contains more protein with a better digestibility then before. The addition of extra fermentable carbohydrates and lipids further increased the energetic value of the feed.

To make sure that the differences in performance are all attributed to differences in feed compositions and that the results are comparable, all other factors are similar for all four dietary treatment groups and the experimental conditions are optimized and synchronized. This means that in this trial no antibiotics were used, unless it was absolutely necessary for the survival of individual piglets.

5.3.1 Feeding and water supply

In the farrowing house the feed was supplied in special small round-feeders for young piglets that could hold 500g of feed and were secured to the slatted floor to prevent shifting. In the nursery house the round feeders were bigger and could hold 2kg of dry feed (see Fig. 5). They were only used the first week after weaning to supply liquid feed. Thereafter dry feeders with a length of 180cm and 9 feeding spaces were used. Feeders were cleaned whenever fouled or dirty.

Fig. 6. Water supply of the nursery house

Water supply

Water supply was ad libitum through drink nipples in both Farrowing house and Nursery house (see Fig. 6). Each piglet had access to two water points, which were shared between two pens. The water points were cleaned when fouled or dirty.

5.3.2 Feed scheme

Phase I (day 14-17)

When the piglets are 14 days of age and still with the sow, the piglets will start their dietary treatment according to the trial group they were assigned to. See table 4 for a scheme of the feed transitions.

	Liquid* (% dry)	Dry
Day 21	100% (33%)	-
Day 22	100% (33%)	-
Day 23	100% (33%)	-
Day 24	100% (50%)	-
Day 25	75% (67%)	25%
Day26-35	-	100%

*Table 5. Feeding scheme phase II feeds. *Liquid feeds consists of an amount of dry feed mixed with water of 38ºC*

Phase II (day 18-35)

At the age of 18 days, the piglets moved on to phase II of each diet, which was also supplied the first two weeks after weaning. To make the weaning process easier for the piglets, they were supplied with (warm) liquid feed the first 5 days after weaning. In this way, the piglets would take in more feed then they would have taken in case they were supplied with only dry feed. See Table 5. From day 26 on the piglets were fed only dry feed.

Phase III (day 36-53)

Each diet changed to Phase III when piglets were 6 weeks of age

Starter feed (day 54-68)

All piglets from all trial groups changed to the same starter feed at the age of 54 days.

Feed	**age**
milk	**1**
milk	**2 (14)**
I **II**	**3 (18)**
II	**4**
II (liquid)	**5**
II **III**	**6 (36)**
III	**7**
III **Starter**	**8 (54)**
Starter	**9**
Starter	**10**

Table 4, feed scheme. Age in weeks (day of feed transition)

Although it was planned to create fluent feed transitions between phases for the piglets on New Feeds, this has not happened due to miscommunication. Therefore both for the Old feed trial groups and the New feed trial groups the feed transitions were acute without a period wherein the feeds would be mixed to give the piglets the opportunity to slowly get used to the new feeds.

5.4 Data Collection

See table 7 for a summary.

5.4.1 Feed intake

During the trial feeding was carried out manually twice every day or more when necessary. This ensured very accurate data collection, ad libitum feed supply and fresh feed. See Fig. 7.

Feed was distributed with use of feed-scoops with a capacity of either 1kg or 2kg of feed. This way the feed intake per litter (farrowing house) or per pen (Nursery house) was accurately recorded with every feeding.

Fig. 7. Feeding manually and with use of a scale to ensure accurate data collection

If feed was left in the round feeder or trough from the day before, it was removed and weighed to be excluded from the ADFI data.

Day	Method	Unit	important event
14	Scale (max. 125kg)	Litter	start of experiment
20	Scale (max. 125kg)	Litter	weaning
34	Scale (max. 250kg)	Pen	FT PII → PIII
55	Truck + weighbridge	Pen	FT PIII → starter feed
69	Truck + weighbridge	Pen	delivery

Table 6. Weighing methods and moments. FT = feed transition, P = phase

5.4.2 Weight

The piglets were weighed using different scales, according to piglet size. Weighing moments were scheduled to coincide with important events as listed in table 6.

5.4.3 Health status

Daily the health status of the animals is determined. Therefore all animals are checked twice a day for signs of illness. At first impression mainly attention is paid to:

- Behavior
- Posture and gait
- BCS
- Prominent clinical irregularities

When a piglet is notably not OK the next step was to determine the main problem through clinical diagnostics as listed below:

- skin, hair coat, hoofs
- respiration

When necessary, attention was also paid to pulse and temperature, and eventually examination of the organ systems could follow.

Diarrhea score

Three times a day, before cleaning and at feeding, faeces consistency was scored according to the following scoring system:

- 9 → no score possible, no faeces produced
- 1→ normal faeces
- 2 → flattened, shapeless
- 3 → diarrhea
- 4 → watery diarrhea
- 5 → diarrhea mingled with fresh blood
- 6 → melena

The highest abnormal faeces core was used

Respiratory score

Twice a day, inspection of individual piglets. The registration of the scores was per litter or pen. This means that one piglet showing respiratory signs (coughing, sneezing, nasal discharge), caused the entire litter or pen to be annotated as positive for respiratory problems. The following scoring system was used:
0 – no respiratory signs
1 – respiratory signs

5.4.4 Body Condition Score (BCS)

Twice a week, Monday and Tuesday, the BCS was scored per litter (farrowing house) or per pen (nursery house). This score was based on the average body conditions of all littermates or pen mates per litter or per pen respectively. The following scoring system was used:

- 1 → cachexia
- 1,5 → poor
- 2 → normal
- 2,5 → good
- 3 → excellent

5.4.5 Mortality

The mortality was recorded daily. For each individual case the date of death, dietary treatment group, pen number, ear number and reason of death were registered. The mortality has been scored during the entire trial period (day 14-68). On day 61, 66 and 68 all very weak piglets were culled and this resulted in mortality peaks. As piglets were only culled when it was certain that they would not survive another week, the findings of post mortem examination were considered the cause of death.

5.4.6 Climate

Special sensors (data loggers), strategically placed in the barns, registered temperature (ºC) during the entire trial. The collected data was plotted in graphs using HOBOware pro (2003-2006 onset computer corporation, version 2.3.0). The barn ventilation, and thereby temperature and relative humidity, were controlled by a computer linked fan-system which was set manually on a daily basis. For more details see annex 6.

Dependent on the outside air temperature, the ventilation and/or outlet was adjusted. In the beginning, when the piglets were 21 days of age, the room temperature was set on 28°C, which was gradually decreased to 24°C by week 9.

Characteristic	Farrowing House	Nursery house
Body weight	Initial weight at the age of the piglets in days 14 and 20	Initial weight at the age of the piglets in days 34, 55 and 69
Feed intake	Twice a day	Twice a day
BCS	Twice a week, per litter	Twice a week, per pen
Faeces consistency	Abnormal faeces score per litter, three times a day (highest score per day is used): score: 9 - no score possible, no faeces produced 1 - normal faeces 2 - flattened, shapeless 3 - diarrhea 4 - watery diarrhea 5 - diarrhea mingled with fresh blood 6 - melena	Abnormal faeces score per pen, three times a day (highest score per day is used): score: 9 - no score possible, no faeces produced 1 - normal faeces 2 - flattened, shapeless 3 - diarrhea 4 - watery diarrhea 5 - diarrhea mingled with fresh blood 6 - melena
Respiratory problems	Twice a day, inspection of individual piglets. Registration per litter: 0 – no respiratory signs (coughing, sneezing, nasal excharge) 1 – Respiratory signs	Twice a day, inspection of individual piglets. Registration per pen: 0 – no respiratory signs (coughing, sneezing, nasal excharge) 1 – Respiratory signs
Health/other	Registration of deviations and of both group and individual (medical) treatments. Vaccination day 18 against PCV-2	Registration of deviations and of both group and individual (medical) treatments. Vaccination day 40 against E.Rhusiopathiae and CSF.
Registration mortality/culling	Daily. date, ear number, reason	Daily. date, ear number, reason
climate	Reading thermometer twice a day (morning, afternoon). calculate the average temperature	Data loggers registrating the temperature every 10 minutes.

Table 7 Observations and data collection

5.5 Medical treatments

All piglets were vaccinated against PCV-2 in Farrowing house on day 18 after birth. In Nursery house the piglets were vaccinated against *Classical Swine Fever* (CSF) and *Erysipelothrix Rhusiopathiae* at the age of 40 days. The latter vaccination caused a ban on the use of antibiotics from day 33 to 46, to make sure the immunization against *E. rhusiopathiae* was not counteracted.

In this trial no antibiotics were used as a preventive measure or growth stimulator, unless it was absolutely necessary for the survival of individual piglets. At first sick or very weak animals were separated from their pen mates and placed in the special hospital-pens, as shown in diagram 2. The date, cause of health problem, pen number, ear number and antibiotic administered to the piglet were registered.

The piglets were excluded from the trial from the day they were placed in the hospital pens. This way, the performance of the very sick and weak piglets does not greatly influence the results of the experiment.

It has to be said that the health status of the piglets gradually decreased after weaning. Group-therapy was no option as this could affect the outcome of the experiment. By starting a group therapy it would afterwards be impossible to ascribe the results to the differences in dietary treatment as the antibiotics would overrule the health promoting feed-additives in the New feeds.

As from day 14 to 54 only individual therapy was applied in case a piglet's life was threatened, the health status of the piglets was suboptimal. This may have negatively influenced the results.
If necessary the individual piglets were treated with either Amoxicillin (respiratory problems and locomotory problems due to arthritis, dose: 0.5ml/10kg BW, once a day, 3 times, every 1.5 day), Excenel-ceftiofur (meningitis, extreme respiratory distress, dose (50mg ceftiofur/ml): 1ml/15kg, once a day, 3 times every 24h).

The first two weeks after weaning also penicillin G has been administered to some weak piglets and piglets in the hospital wing with locomotory problems due to arthritis, and Tulathromycin to some piglets with arthritis.

After day 54, when all piglets were fed starter feed, it was decided to start a group therapy and other measures to improve the health of the piglets. The measures taken are listed below:

- day 54-56 group therapy amoxicillin through drinking water (20mg/kg bodyweight in barn)
- day 59, again group therapy with a higher dose of amoxicillin through drinking water as no improvements were observed after the first therapy
- all pens were provided with sawdust enriched with bactericidal powder
- reduction of standard ventilation with 10% on day 56 and another 10% on day 63
- culling of very weak and sick piglets
- all other weak piglets were relocated to hospital pens
- piglets in the 4 hospital pens were redistributed over the pens to create two pens with the weakest piglets and two pens with already or almost recovered and thus stronger piglets. Piglets of the four different trial groups were thereby mixed.
- The piglets in the hospital pens and weak piglets not redistributed to a hospital pen were all individually treated with either amoxicillin (respiratory problems, weakness) or excenel (neurological signs, extreme dyspnea) injections. Total number of individually treated piglets: 172 = 21%
- Pens from all trial groups with more than 50% weak piglets were not fed started feed but phase II of the OS feed.

6. Analysis

6.1 Calculations and statistical Analysis

A general linear model procedure (SAS version 9.01, SAS Institute, Cary, NC) was used to estimate means of the four dietary treatments. The effect of diet composition per pen (20 animals; n=10, 4 groups) on zootechnical performance was evaluated. Initial body weight did not differ between treatments. Analysis was also performed with body weight at day 20 as a co-variable. However, general conclusions remained the same.
The final statistical model was:

$$Y_{ij} = \mu + D_i + e_{ij}$$

where Y_{ij} is independent variable; μ = overall mean; D = fixed effect of diet (j = 1, 2, 3, 4); e_{ijkl} = overall error term.

The data regarding faeces consistency are not normal distributed and therefore analyzed with a χ^2 - homogeneity test of the Catmod Procedure. This procedure calculates probabilities for categorical nominal variables. The incidence of non-consistent faeces was analyzed per period. The analysis compares the distribution of the number of days and pens with a certain faecal score (1, 2 or 3) per treatment during the interval after a log transformation.

A probability of $P<0.05$ was accepted as significant and differences between treatments with $P<0.10$ were identified as trends.

Microsoft Excel was used to organize the data.

7. Results

The results are presented in both graphs and tables. The graphs are shown in Annex 1-6. In some cases the period from day 55 to 69 is not taken into account. It was decided that these data are not sufficiently reliable and not useful as from day 54 all piglets received the same starter feed and many management changes were introduced. These changes were considered necessary to secure the piglet's health as the group was showing clinical signs of both respiratory and GIT disease. When the data are indeed published, this was only to illustrate a trend or tendency of which the reliability is too low to be taken into account.

7.1 Average daily feed intake (ADFI), average daily gain (ADG), growth and Feed efficiency (FE)

The results of ADFI are presented in table 8.

Table 8. *Average daily feed intake (ADFI, g/day/piglet), body weight (BW), average daily gain (ADG, g/day/piglet) and feed efficiency (FE = ADFI/ADG) per treatment (LSmeans).*

Treatment	Day [1]	DIETS				Overall means	CV [2]	P-level
		NS	OS	NP	OP			Diet
ADFI (g/day/piglet)	14-20	36a	29b	35a	31b	33	14.6	**0.001**
	20-34	187b	213a	180b	200ab	195	12.5	**0.009**
	34-55	602	591	555	579	581	14.7	0.627
	20-55	436	440	405	427	427	13.3	0.503
	55-69	926	898	954	895	919	14.4	0.722
	21-68	587.3	581.7	57.7	571.8	578.5		
	14-68	517.2	511.4	504.3	502.9	509.0		
BW (kg)	14	4.55	4.32	4.55	4.43	4.47	12.5	0.777
	20	6.55	6.33	6.24	6.44	6.39	11.9	0.811
	34	8.61	8.42	8.45	8.83	8.57	10.8	0.739
	55	16.51	16.61	16.74	17.20	16.76	11.6	0.871
	69	24.29	25.00	24.46	24.52	24.54	8.6	0.959
	21-55	10.58	10.46	10.52	10.82	10.60		
ADG (g/day/piglet)	14-20	333	334	283	335	321	21.3	0.210
	20-34	147	149	157	171	156	27.0	0.587
	34-55	376	390	395	398	390	16.5	0.871
	20-55	284	294	300	307	296	14.4	0.671
	55-69	495	518	435	463	475	18.1	0.397
FE	14-20	0.11	0.09	0.10	0.09	0.10	24.2	0.149
	20-34	1.29	1.47	1.37	1.21	1.33	32.3	0.603
	34-55	1.60b[3]	1.54ab	1.41a	1.46a	1.50	10.0	**0.011**
	20-55	1.53b	1.50ab	1.36a	1.40a	1.45	7.9	**<0.001**
	55-69	1.91	1.99	2.40	2.01	2.07	17.5	*0.077*

[1]Abbreviations used: day 14 is regarded as day of start of trial, day 21 weaning, day 28 is seven days post weaning; [2] CV = coefficient of variation; [3] a,b = significant diet effect at p <0.05. ***Bold*** *script indicates a P-value below 0,05.*

7.1.1 ADFI

The first week, when the piglets are still in the farrowing house, the piglets on NS (36g/day) and NP (35g/day) dietary treatments have a significantly (P<0.001) better feed intake than piglets on OS (29g/day) and OP (31g/day) diets. Over the entire period post weaning (d21-68) the piglets on New feeds had a higher ADFI than piglets on Old feeds (587.3 vs. 581.7 and 572.7 vs. 571.8 for NS vs. OS and NP vs. OP).

The first two weeks after weaning, from day 21 to 34, the results are reversed as piglets fed with Old feeds have a significantly higher feed intake (P=0.009) than the piglets on New feeds. The OS group clearly performed better than the other groups on ADFI (213g vs. 187, 180 and 200; for OS vs. NS, NP and OP). In the period piglets are staying in the Nursery house (d21-68), the overall mean ADFI was 579g per piglet, while the normal standard is an ADFI of 900g per piglet. The ADFI progress normally goes from an ADFI of about 600g/day in week 5 (d28-36) and increases to an ADFI of about 1100g/day in week 9 (last week in Nursery house). Over the entire trial or over the period in Nursery house the piglets on New feeds have a higher ADFI than piglets on Old feeds, although this is not significant.

Graph 2 (annex 1) shows that after day 36 the feed intake drops from an overall ADFI of 650g/day to 200g/day on day 38 for all treatment groups. It took the piglets, regardless of the dietary treatment group, 4 weeks to reach an ADFI above 650g/day. It was only the last week in nursery house that the feed intake was restored to normal (1100g/day, age 9 weeks).

After day 34, the results of ADFI between dietary treatments do not show any significant differences. Overall, just after the feed transition from liquid feed to solid feed (d26) and phase II to phase III (d36), the ADFI for all groups decrease. After the last feed transition, phase III to starter feed (d54), the ADFI increased. Each of the four moments on which the ventilation was adjusted, seemed to cause a decrease in ADFI one or two days later. The ventilation changes are shown as blue labeled arrows in graph 2, annex 1.

7.1.2 ADG and growth

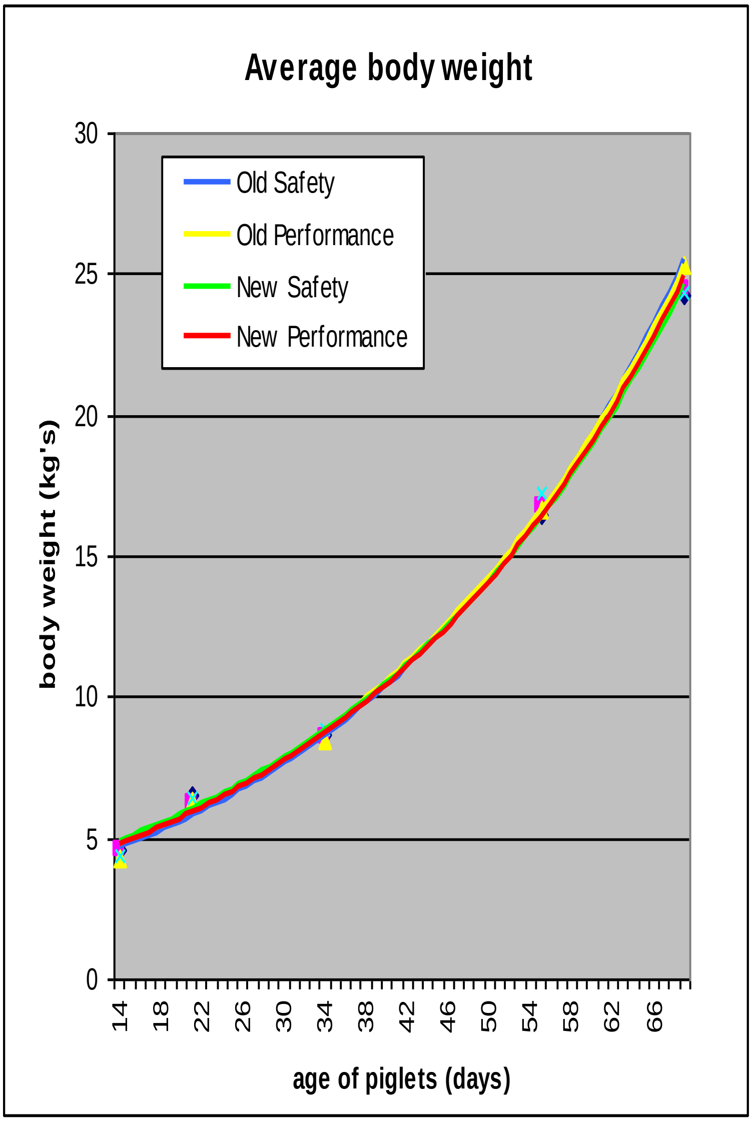
All piglets had a very good ADG in the last week pre-weaning and reached an overall average weight of 6.4kg on day 20. The BW results for all trial groups in the experiment are similar as is clearly shown in graph 1. The average BW over the period day 21-55 for all trial groups was 10.60 kg (10.58kg, 10.46kg, 10.52kg, 10.82kg for NS, OS, NP, OP).

At the end of the trial, day 68, the trial piglets had an average BW of 24.5kg. When this is compared to Dutch bodyweight standards, the performance is similar to the performance of Dutch piglets (24.9kg at the age of 74days). (agrovision kengetallenspiegel).

Over the entire trial period the ADG has been slightly higher for piglets on Old feeds, than on New feeds as listed in table 8. However, the differences are not significant. The overall ADG after weaning in the period d21-55 is 296g per piglet.

7.1.3 FE

Although the ADFI was considerably lower in the period from day 34 to 62, the growth performance does not reflect this over the same period of time. When the observations of ADFI and ADG are combined in feed efficiency (FE=ADFI/ADG), we found that the Performance feeds were significantly more efficient than the Safety feeds for piglets 34-55 days (P=0,011) or 20-55days (P<0.001) of age. The NP feed had the best FE (1.36 vs. 1.53, 1.50 and 1.40 for NP vs. NS, OS and OP). The FE of piglets on NP feeds was also significantly better than the FE of piglets of the NS trial group.



Graph 1. *Average bodyweight of piglets during the entire trial period.*

7.3 Diarrhea

All graphs concerning diarrhea are shown in Annex 2.

Both table 9 and graphs 8 and 9 clearly show that the piglets on New feed dietary treatments had a lower diarrhea incidence than the piglets on Old feed diets. The results from day 14 to 20 in Farrowing house are not shown as there was no diarrhea observed in this period.

Table 9. *Incidence of diarrhea (%) per dietary treatment (means per period during 21 to 55 days post weaning; the best value is **bold**, the worst value is underlined). Incidence of diarrhea is calculated as the % of pens with a diarrhea score of 2 and 3 or only 3*

	NS		OS		NP		OP		Overall			
Days	**mean**	**std**	**mean**	**std**	**mean**	**std**	**mean**	**std**	**mean**	**std**	**χ²**	**P-value**
d21-34	35.26	15.39	27.86	15.59	31.17	18.15	**27.14**	19.58	30.49	16.92	2.47	0.480
d21-34	22.88	11.87	**17.86**	13.15	24.03	16.37	20.71	17.64				
d34-55	**21.21c**	13.53	50.00a	15.27	32.47b	20.18	55.71a	17.68	39.23	21.39	74.51	**<0.001**
d34-55	**14.72c**	10.74	43.33a	17.16	24.24b	21.02	50.00a	21.33				
d21-55	**26.82b**	12.72	41.14a	10.01	31.95b	16.55	44.29a	10.63	35.73	14.26	36.99	**<0.001**
d21-55	**17.98b**	9.06	33.14a	12.86	24.16b	16.48	38.29a	14.27				

a, b, c = different subscripts within a row indicate a significant difference (p<0.05)

When both shapeless faeces (defined as score 2) and diarrhea (defined as score 3) are taken into account (table 9), the first two weeks after weaning do not show significant differences between dietary treatments. However, the observations from day 34 to 55 show with strong significance (P<0.001) that piglets on NS diets (21%) have least diarrhea. Also the incidence of diarrhea for the NP diet (32%) is significantly lower compared to the observations for OS (50%) and OP (56%) diets.

When the first two weeks post weaning are included in the observations for up to day 54 post weaning, this confirms the observations from day 34 to 55. Piglets on NS and NP diets still have the least chance to suffer from diarrhea compared to the Old feeds (27% vs. 41% and 32%vs. 44% for NS vs. OS and NP vs. OP) with an extremely high reliability (P<0.001).

When only real diarrhea scores (score 3) are considered in the statistical analysis, the results are even more clear as shown in table 10. For the period day 34 to 55, piglets on NS and NP diets still have the least chance to suffer from diarrhea compared to the Old feeds (15% vs. 43% and 24%vs. 50% for NS vs. OS and NP vs. OP. The overall χ^2 value (74.51) for both score 2+3 and 3, when all four dietary treatment groups are taken into account, was very high and thus indicates that the possibility that this result was due to chance is thus small.

Graph 3 clearly shows that from day 40 onward the incidence of diarrhea is 20-30% higher for the OS group than for the NS group. Graph 4 shows the same differences in diarrhea incidence in favor of NP treatments plotted against the OP treatments diarrhea incidence. When the observations of the New feeds (graph 5) and Old feeds (graph 6) are plotted against each other, it is clear that piglets on NS and OS feeds have less diarrhea than piglets on NP and OP feeds.

Overall four trial groups, the percentage of pens suffering from diarrhea quickly increases just after weaning. After day 26 the piglets seem to recover as the line's decline. The percentage of pens with diarrhea scores is reduced to 5-10% a week later. However, the inclining lines after day 36 show that the diarrhea problems flare up again.

7.4 Respiratory problems

All graphs concerning respiratory problems are shown in Annex 3

The respiratory scores resulted in a certain percentage of pens per treatment group with a positive score (1) for respiratory problems. For the four different dietary treatment groups these scores are all plotted against each other in graph 7. The capricious course of the lines makes it difficult to interpret the results, but they do show the overall increase of respiratory problems during the trial period in Nursery house. Besides, the important events have been pointed out and labeled. It seems as if changes in the diet (as shown by the red labels) temporarily decrease the occurrence of respiratory problems, while adjustments in ventilation (blue labels) tend to increase the percentage of pens with respiratory problems. The vaccination on day 40 does not directly seem to influence the percentage of respiratory signs observed

The results pre-weaning have not been included in the graphs as the piglets showed no signs of any respiratory problem. Within a week post weaning the overall respiratory problems have increased to 40% of all pens. Another week later, around day 35 the problems affected an average of 60% of the pens. In the next 4 weeks of the trial (day 36-66) the problems spread in such a way that by day 63, 95% of the pens showed signs of respiratory disease.

Graph 8 presents the results within the Safety trial groups and clearly shows that piglets in the NS trial group, compared to the OS group, had the lowest percentage of pens with respiratory problems. Graph 9 shows the results within the Performance trial groups are not significantly different. When NS groups are compared with NP groups (graph 10), the piglets on NS dietary treatment still show least pens with respiratory problems. The courses of the lines in graph 11 show that the results within the Old feed trial groups are not significantly different. Both piglets on OS and OP dietary treatments have more or less the same percentage of pens coping with respiratory problems.

7.5 BCS

All graphs concerning BCS are shown in Annex 4.

*		Day													
		25	**28**	**32**	**35**	**39**	**42**	**46**	**49**	**53**	**56**	**60**	**63**	**67**	**average**
NS	**BCS**	2.3	2.1	2.0	2.1	2.2	2.2	2.3	2.2	2.1	2.1	2.1	2.1	2.0	2.2
	stdev	*0.5*	*0.3*	*0.4*	*0.4*	*0.4*	*0.4*	*0.5*	*0.5*	*0.4*	*0.4*	*0.4*	*0.4*	*0.5*	*0.4*
NP	**BCS**	2.0	1.9	2.0	2.0	2.0	2.2	2.2	2.1	1.9	1.8	1.8	1.8	1.8	1.9
	stdev	*0.2*	*0.4*	*0.5*	*0.4*	*0.4*	*0.5*	*0.6*	*0.5*	*0.6*	*0.4*	*0.4*	*0.4*	*0.3*	*0.4*
OS	**BCS**	2.1	2.1	2.1	2.0	2.1	2.2	2.2	2.3	2.1	2.0	2.0	2.0	2.0	2.1
	stdev	*0.2*	*0.4*	*0.4*	*0.4*	*0.3*	*0.3*	*0.4*	*0.5*	*0.6*	*0.5*	*0.5*	*0.5*	*0.5*	*0.4*
OP	**BCS**	2.1	2.2	2.2	2.1	2.2	2.3	2.3	2.4	2.2	2.0	2.0	2.0	2.1	2.2
	stdev	*0.6*	*0.3*	*0.3*	*0.3*	*0.4*	*0.4*	*0.5*	*0.5*	*0.4*	*0.5*	*0.5*	*0.5*	*0.3*	*0.4*

Table 10. *BCS over period day 25-67*

The BCS before day 25 are not presented as they were similar for all four trial groups. The BCS has been plotted against age of the piglets for all trial groups in graph 12. The lines are close together which indicates that the average BCS between different trial groups were not significantly different. Table 10 confirms this as the maximum difference between trial groups is 0.3 points (1.9 vs. 2.2 and 2.2 for NP vs. NS and OP).

A correlation, with an R squared value of 0.69, was found between ADFI and BCS as shown in graph 13. This means that the higher the ADFI, the higher the BCS. A similar correlation ($R^2 = 0.62$) was found for ADG and BCS as shown in graph 14 indicating that a higher BCS score for a higher ADG. This indicates that BCS is a good measure to give an impression of piglet performance on ADFI and ADG.

7.6 Mortality

Before mass culling on day 61, only 24 piglets had died. After the three culling moments (d61, 66 and 68) this had more than doubled to a total of 51 piglets as also shown in graph 15, annex 5. Either way, the NS group had the highest (29,4%) and the OS the lowest mortality (16,7%), as presented in table 11 and 12. Over the entire trial period the mortality in the NP group (5.8%) was lower than the mortality in the OP group (6.1%).

	Treatment				
	NS	**OS**	**NP**	**OP**	**TOTAL**
Respiratory problems	-	1	4	-	5
Meningitis	2	1	-	3	6
Locomotory problems		-	-	1	1
Liver rupture	3	1	-	-	4
Polyserositis (wasting)	7	6	7	5	25
Unknown	3	1	1	2	7
Other		1		2	3
Total mortality (n)	**15**	**11**	**12**	**13**	51
percentage	**29.4**	**21,6**	**25.5**	**23.5**	100
relative %	**7.4**	**5,8**	**5.8**	**6.1**	**6.2**

Table 11. *The mortality during the* ***entire trial period (day 14-68).*** *The relative% = (mortality (n)/average amount of piglets within 1 trial group from d14-68)*100.*

The total mortality during the trial (51 for d14-68) in relation to the total amount of piglets that were included in the trial after weaning (825) was 6.2%. Over the same period the mortality rates per trial group were 7.4%; 5.8%; 5.8% and 6.1% (for NS, NP, OS and OP). Before culling, thus up to day 60, the mortality rates per trial group were 4.5%; 2.7%; 2.1% and 2.5% (for NS, NP, OS and OP).
Only 4 piglets died in nursery house (data not shown), which resulted in a mortality rate of 0.5%.

	Treatment				
	NS	**OS**	**NP**	**OP**	**TOTAL**
Respiratory problems	-	-	3	-	3
Meningitis	2	-	-	3	5
Locomotory problems	-	-	-	-	0
Liver rupture	3	1	-	-	4
Polyserositis (wasting)	1	1	1	-	3
Unknown	3	1	2	1	7
Other		1		1	2
Total mortality (n)	**9**	**4**	**6**	**5**	24
percentage	**37.5**	**16,7**	**25**	**20.8**	100
relative %	**4.5**	**2,1**	**2.7**	**2.5**	**2.9**

Table 12. *The mortality during the* ***trial period (day 14-60),*** *thus excluding mass culling. The relative% = (mortality (n)/average amount of piglets within 1 trial group from d14-60)*100.*

The outstanding observations are listed below:

- 75% of the deaths (3/4) caused by a liver rupture occurred in the NS trial group before day 61;
- 50% of the total mortality (day 14-68) was caused by polyserositis and consequently wasting. Most of these piglets (22 out of 25 in total) were culled and therefore died after day 60. Each trial group had relatively the same share in death by polyserositis (7,7,6,5 for NS, NP, OS, OP)
- 80% of deaths (4/5) caused by respiratory problems occurred in the NP trial group
- Before day 61, 21% of the mortality was due to meningitis

See figure 8 for some pictures of examples of findings during postmortem examination of trial piglets.

Figure 8 from top left clockwise: nephritis, sincere pericarditis, accumulation of fluid around the heart, splenitis

7.7 Climate

The course of room temperature in the nursery house from day 21 to 68 is plotted against time in graph 16, annex 6. As the labels show, an increase in ventilation only lowers the room-temperature if the setting temperature remains unchanged. When the ventilation is decreased, but the setting temperature is set lower, the room temperature will still decrease according to the setting temperature. When the ventilation is decreased, but the setting temperature is set higher, the room temperature will also increase.
Although the setting temperature was never set above 28ºC, the data logger recorded an average temperature over the period of time of 28.7ºC. Table 13 shows the recorded and desired room temperature for piglets a certain amount of weeks after weaning. The recorded temperature is on average 5ºC higher than the desired room temperature.

	Weeks after weaning (day 21)						
	week 1	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**
	d21-d27	**d28-34**	**d35-d41**	**d42-48**	**d49-d55**	**d56-62**	**d63-d68**
RT (ºC)	30.0	29.8	28.3	28.9	27.2	27.8	26.5
Desirable	26	25	24	23	22	22	22
difference	4	4.8	4.3	5.9	5.2	5.8	4.5

Table 13, the difference in recorded room temperature (day 21-68) and desirable room temperature. RT = Room temperature

The relative humidity (RH) results are only partly shown as the RH data logger broke down. It is presumed that the RH was between 70 and 90% in nursery house from day 21 to 68.

8. Discussion

ADFI, ADG and BW

NS and NP dietary treatment groups had a significantly better ADFI performance in the farrowing house (d14-20) than piglets in OS and OP trial groups in the same period. This better ADFI performance of New feed groups is most likely caused by the better taste of both NS and NP feeds as the negative tasting antibiotics and organic acids (OA) have been removed, while the taste was enhanced by the addition of sucrose, liquid blood and natrium.

However, the first two weeks after weaning the ADFI of the New feeds was unexpectedly lower (P<0,009) than the ADFI of the Old feeds. This reversal in results might be caused by the changes inflicted on the Old Feeds to formulate the New Feeds. In both NS and NP feeds, OA's (citric acid, formic acid and MCFA's) were introduced while these ingredients were not present in OS and OP feeds. OA's have beneficial effects on the microbial flora in the gut (Dierick et al., 2002), but also a negative taste that might suppress the feed intake. This negative taste has a bigger influence on the feed intake after weaning as the piglets are fully dependent on dry feed instead of mother milk. This influence might be bigger as our piglets were weaned early (age 21 days). As a consequence weaning imposes profound social and environmental stresses as well as acute changes in both the pattern of intake and the type of diet. This transition from nursery to eating solid feed usually results in a critical period of underfeeding during which piglets need to eat and adapt to digest the solid feed (Le Dividich and Seve, 2000). As over the entire period in nursery house (d21-68) the ADFI is highest for the New feed trial groups (although not significant), this is conform the findings of van Hees et al. They found the average daily feed intake (ADFI) tended to improve for the addition of MCFA and MCFA+OA to feeds.

In this trial, the relatively low ADFI by piglets of all dietary treatment groups contradicts with our hypothesis as the feed intake does not significantly differ between trial groups and is overall too low (an overall mean ADFI for the trial groups of 579g/piglet (period 21-68) vs. an ADFI of 900g/piglet as normal standard). Besides, the ADFI of all trial groups suddenly drops sharply from day 36 onward. As all diets face the same downfall in ADFI it is unlikely that this was caused by the feeds. It is more plausible that a condition (diet form, crowding, health status), that affected all piglets similarly, caused the overall too low ADFI and sudden decrease in ADFI after day 36.

Diet form

It is unclear if the diet form of the feed (phases), as listed in table 3, might also have had influence on the ADFI problems during the transition from phase II to phase III. All dietary treatment groups received their phase II feed in the form of small pellets and this changed to large pellets for phase III. The OS feed was the exception as both phase II and phase III feeds were same sized crumbs. This might have been an advantage for the piglets feeding on OS feed as they only had to get used to a new taste and nutritional composition and not to a new texture or form. It would have been preferable to have the same texture for all feeds to exclude external factors to be able to make genuine comparisons between trial groups.

Crowding

Besides this diet form effect, a lower feed-competition between pen mates might explain the meager ADFI in all dietary treatment groups. The pens have a maximum capacity of 30 animals. In this trial there was a lot more space per piglet as each pen housed on average of 19 piglets. When the pen occupation is maximal, there are more animals feeding during the day compared to a pen occupation of only 65%. Due to hierarchy, the piglets higher in rank will also feed themselves when piglet's lower in rank try to eat. The more piglets per pen, the more moments piglets are feeding and thus automatically stimulating others to feed as well.

Health status

Immediately after weaning the diarrhea scores and respiratory problems increase. This suggests that the piglets are not as healthy as expected and thus challenged, not only by the weaning process, but also by pathogens. Sick piglets will take in less feed than healthy piglets. Thereby it is known that, on the Boram farm, vaccination on day 40 usually causes a decrease in feed intake for 3-4 days. In the trial this vaccination might have stopped the recovery of ADFI that started on day 39 as shown in graph 2, annex 1. This recovery ends with a sudden dip in ADFI after day 43 and it takes all piglets about a week to recover the ADFI to normal again. This delayed drop might have still been correlated to the vaccination on day 40. The animals' immune systems, which in that period were already provoked by respiratory and intestinal problems, were possibly unable to cope with another challenge in the form of the vaccination. Health status will be discussed more thoroughly further on in the discussion.

The phenomenon of an overall low feed intake the first two weeks post weaning can be explained by a study by Pluske et al (1995). They found that, even though creep feed was available before weaning, piglets aged 3–4 wks have consumed very little of solid feed, and therefore are unfamiliar with the weaning diet. It follows that feed intake of piglets, abruptly deprived of liquid milk provided by their dam and offered a solid feed after weaning, is often very low. Le Dividich and Seve, 2000 found that, regardless of the age at weaning, the level of metabolizable energy (ME) intake attained at the end of the 1st post weaning week ranges between 700 and 800 kJ ME/kg0.75, which accounts for 60–70% of the pre-weaning milk ME intake. In fact, the pre-weaning ME intake is only attained at about 2 wk after weaning.

The found lower ADFI of piglets on New feeds the first two weeks after weaning, were also reflected in the ADG results in this period. Burrin and Stoll (2003) highlighted the temporal changes in gastrointestinal development and growth after weaning, showing that early-weaned pigs (14 days in their experiment) have an 'acute phase' lasting about 7 days and a subsequent 'adaptive phase' in which the gastrointestinal tract recovers from the immediate post-weaning insults. Although the duration and magnitude of these phases varies according to factors such as weaning age, environment, genotype and health status, they are generally coincidental with patterns of energy intake and weight gain after weaning (Le Dividich and Seve, 2000). In practice, studies conducted at farm level indicated that 20% of pens gained less than 200 g/d during the first 2 wk post weaning (Madec F. et al, 1998). In our trial the overall means for this period was an ADG of 156g/day and for the period d21-55 only 296g/piglet.

As the results for ADG and BW show no significant differences between the four dietary treatment groups, they will be discussed only briefly.

In contrary to the insignificant differences between trial groups on ADG and BW, the FE showed that the Performance feeds were significantly more efficient than the Safety feeds for piglets 34-55 days ($P=0.011$) or 20-55days ($P<0.001$) of age and piglets on NP feeds had the best FE. This was conform our hypothesis and it is likely that this can be ascribed to the increased content of lysine, other digestible amino acids and increased energetic value of the NP feed. For growth a young piglet needs protein, especially those amino acids which are used for the development of muscle tissue. As the digestibility of the crude protein has been improved and as the amount of available essential amino acids are better adjusted to the needs of the growing piglets, the NP piglets apparently needed less feed to gain a kg of body weight than piglets on the other three dietary treatments (NS, OS, and OP). The increased ADG that Apple et. al found for piglets on diets with an increased lysine:energy ratio (Lys:ME) was not found in this trial as the ADG of piglets on NP feed was not better than the ADG of piglets on NS or OP feeds.

The assumption that an increased content of VFA in colonic digesta, as a result of more FC in the diet, may contribute to improvements of growth performance of pigs was not proved. Since both NP and NS feeds were enriched with FC, one would expect a similar positive effect on growth performance in both New feeds. However, the piglets on NP feeds had the best FE and the piglets from the NS dietary treatment group had the least effective FE.

Health

The general health status of the piglets may relate to the low observed ADFI and ADG for all dietary treatments groups. It is well known that the first signs of illness are a decreased feed intake. It is possible that the respiratory problems, which were slowly intensifying after weaning as shown in graph 7 (annex 3), were an indication that respiratory disease was about to increase in severity. The stress that the feed transition on day 36 generally causes, may have had a negative effect on the already struggling immune system. This may have resulted in an inadequate immune response of the piglets and therefore they were unable to properly cope with micro-organisms threatening their health. It was unknown which micro-organism(s) were exactly causing problems, but postmortem dissection and clinical signs strongly suggested the complicity of *Actinobacillus Pleuropneumoniae (APP), Streptococcus suis, Mycoplasma hyopneumoniae* and *Haemophilus parasuis.*

(Preventive) treatment with antibiotics was not favorable as this could have affected the outcome of the experiment by overruling the health supporting effect of the New Feeds, especially NS. This policy created a situation in which many piglets with a suboptimal health status and non-life threatening ailments were not supported in their recovery by antibiotics. This choice resulted in the continuation of the trial with relatively weak piglets which had a supposedly lower urge to take in feed and had to spend a lot of energy on the recovery process. As this policy was the same for all dietary treatment groups, the results are still considered to be reliable.

When the piglets were still in the farrowing house (d14-20), no respiratory signs or diarrhea have been observed and therefore the piglets were considered to have an equal health condition before weaning on day 21. After weaning the overall health status of the piglets was not good but the incidences of diarrhea and respiratory problems within the different trial groups still corresponded with the hypotheses. Within the Safety dietary treatments, NS piglets had the lowest incidence of health problems. Within the Performance groups, the piglets fed NP, showed least diarrhea although the incidence of respiratory problems was similar.

The trial results prove that the adjustments to OS and OP feeds to create NS and NP feeds, had a significant ($P<0.001$ for d21-55) positive effect on diarrhea reduction, and to a lesser extent respiratory signs reduction. The observations are a result of the sum of effects of each individual ingredient change or there might even have been a synergistic effect between two or more ingredients. The better digestibility of raw materials, better and more constant quality of raw materials, less crude protein, more FC's and more OA's are potentially all contributing to the lower incidence of health problems in NS and NP piglets compared to OS and OP piglets. It was beyond the scope of the trial to determine the individual effectiveness of the various new ingredients in the New feeds on animal health.

As already explained in the introduction, less CP and an increased supply of FC; decreases the concentration of putrefactive compounds like ammonia; positively influences the function and diversity of the gut micro biota and prevent the overgrowth of pathogenic bacteria through colonization resistance. Besides, the increased FC content stimulates microbial fermentation (primarily carbohydrates instead of proteins), VFA and OA production in the fore- and hindgut of pigs. Together with additional OA's (acetic acid, formic acid and MCFA's) this inhibits both Gram negative (OA's) bacteria due to their pH-reducing effect and Gram positive bacteria (MCFA's) because of strong bactericidal properties. Tsiloyiannis et al. also proved this as all his trial groups supplemented with organic acids had reduced incidence and severity of diarrhea, and performed significantly better than the negative control group ($P<0.05$)

The substitutes for antibiotics (2500ppm ZnO, short chain organic acids and yeast products) and the antibody formation stimulating β-glucans, which have been added to the New feeds, are likely to have influenced the better health of piglets in NS and NP dietary treatment groups as well.

BCS

As expected there was a correlation between ADFI and BCS (R^2=0,69) and between ADG and BCS (R^2=0.62) and these results confirms our hypothesis that the BCS is a useful indicator for ADFI and ADG performance of piglets.

We also stated that the BCS of piglets from the NS dietary treatment group would have a higher BCS that piglets from the OS group and BCS NP > OP. The first is confirmed by our results (average BCS 2.2 vs. 2.1 for NS vs. OS) but the latter part of the hypothesis was not (BCS 1.9 vs. 2.2 for NP vs. OP). This might be caused by the lower ADFI of piglets on NP diets in the period day 21-55 (405g vs. 436g, 440g and 427g for NP vs. NS, OS and OP), although the ADG did not significantly differ during this period. Besides, the ADFI over the entire trial period was not lowest for the NP group.

Mortality

As we hypothesized, the mortality (0.5%) in farrowing house (d14-20) was less than 2% for all dietary treatments. This low mortality rate was probably caused by the very good health of the piglets (concluded as from day 14-20 no respiratory signs or diarrhea have been observed).

Although the piglets on NS Feeds had significantly less diarrhea and the lowest incidence of respiratory problems, this trial group had the highest mortality rate compared to the other trial groups. Over the entire trial period, the mortality rate of the NP trial group (5.8%) was lower than that of the

Figure 9. Black piglets due to rolling in their own manure

OP trial group (6.1%). However, before mass culling this was reversed (NP:2.7%, OP:2.5%).

After weaning the health declined as more respiratory signs and diarrhea were observed At first (day 21-60) this did not drastically influence the mortality rate as the average mortality rate was 2.9%. 21% of the deaths in this period were caused by meningitis. When also the high prevalence of respiratory problems and polyserositis (50% for day 14-68) are taken into account, this may indicate that most probably *Streptococcus suis* and/or *Haemophilus parasuis* (Glässer's disease) have been important pathogens in the nursery house. Both pathogens can cause meningitis in young piglets, especially just after weaning when the maternal immunity decreases. Glässer's disease is known to cause polyserositis and this can explain the 50% polyserositis deaths in this trial. Besides, both *Streptococcus suis* and *Haemophilus parasuis* can cause (broncho)pneumonia and thus respiratory signs as coughing and nasal discharge. During the trial there has also been a high incidence of piglets with locomotory problems due to arthritis (3.4%, results were not shown) which is often a clinical sign for involvement of *Streptococcus suis*. As the piglets were ear tagged in farrowing house the accompanying wound may have provided an easy porte d'entrée. Besides, the warm climate in nursery house stimulated piglets to roll in their own manure to cool down. This increased the contact of the piglets with faeces and therefore might have increased the transmission and infection of pen mates. See Figure 9.

Other pathogens that might have played a role are *Actinobacillus pleuropneumoniae* (APP), *Mycoplasma Hyopneumoniae* (Enzootic Pneumonia) and *Porcine circo virus* (PCV-2 causing PMWS: Porcine Multisystemic Wasting Syndrome), although the piglets were vaccinated in the farrowing house against the latter.

There have been some problems concerning the treatment of sick piglets. There was no preventive use of antibiotics and no group-therapies before day 54 to make sure that the antibiotics would not overrule the feed effects on health of the piglets. When necessary, sick piglets were treated individually with mainly amoxicillin and Excenel as this were the cheapest options. Unfortunately the first two weeks after weaning, due to miscommunication, some piglets have been treated with more than one antibiotic. As only a few piglets were involved it was presumed that this had a negligible effect on the results.

It might have been possible to lower the mortality and amount of sick piglets when antibiotics would have been used with more care. Normally blood test of sick piglets will only be executed when the mortality in the nursery house is over 10%. This means that in case of disease caused by pathogens that rarely kill, but do reduce growth performance and meat quality, the antibiotic treatment is rarely specific and therefore does not have a maximal curing effect.

On the Boram farm especially the broad spectrum antibiotic Amoxicillin is used as a treatment either orally (drinking water) or parenterally by injection. When an amoxicillin treatment is ineffective the dose is increased and the treatment is repeated. This increases the probability of pathogen resistance for amoxicillin and in many cases is by far not the best first option therapy.

As some piglets were suspected to suffer from either APP or enzootic pneumonia, neither of the administered antibiotics in case of respiratory problems (amoxicillin, Excenel) were first or second choice. The ceftiofur in Excenel can help against APP, but the use should be drastically restraint as ceftiofur is also used for human medication and resistance should absolutely be prevented. In case of enzootic pneumonia, neither amoxicillin nor Excenel will be very useful and a better choice would have been tiamulin, lincomycin, tilmicosin or tylosin orally or lincomycin or tylosin parenterally.

Climate

The average room- temperature that has been detected by the data-logger in Nursery house from day 21 to 68, was 28.7°C. As the setting temperature was never higher than 28°C, this may indicate that;

- the data-logger or the computerized fan-system was not working properly
- the computerized fan-system was not set properly or
- an outside air temperature above the setting temperature, caused the temperature inside the barn to rise above the setting temperature

Regular manual temperature measurements exclude a malfunctioning data-logger which means that during the entire nursery house period the room temperature has been suboptimal. As setting of the ventilation and temperature was done by farm workers, miscommunication or human mistakes may have played a role. The influence of outside air-temperature on room temperature in Nursery house is unknown, but it may be assumed it has an effect especially during hot days as there only is a heating system for cold days and no cooling system.

The recorded temperature was between 4 and 6°C higher than the desired room temperature in the barn. Partly this was done intentionally to increase the room temperature for sick and weak piglets to provide them with a more comfortable climate in the barn. The first two weeks after weaning the piglets were not troubled by the warmth in the Nursery house barn, but in the third week post weaning it became apparent that the piglets were bothered by the heat. The heat in the barn forced piglets to adapt to the circumstances by reducing heat production and increasing heat loss. Concurrently with the rise in room temperature from day 39 (see graph 16, annex 6) onwards, most piglets showed signs of heat stress: roll in their own manure to increase heat loss, lay on the slatted floor instead of the clean concrete floor, decreasing their physical activity and an overall increase of respiratory rate. An experiment by Huynh et. al (2005) showed that for pigs (average BW 61,7kg) heat production and voluntary feed intake (VFI) were decreased above inflection point temperature (IPt = 'upper critical temperature' above which certain animal variables started to change) of 22.9 and 25.5°C, respectively ($P < 0.001$). For each degree Celsius above IPt, the VFI was decreased by 81, 99, and 106 g/(pig·d) for a RH of 50, 65, and 80% respectively. The first indicator of heat stress was respiratory rate, which increased when IPt was in the range from 21.3 to 23.4°C

Although the piglets in this trial were not yet as heavy as the piglets in the trial of Huynh et. al (2005), it is still obvious that temperatures above the range 23-26°C (depending on the age of piglets) can decrease the urge to take in feed and thus ADFI and increase respiratory rate. This may clarify why the overall ADFI in nursery house is (579g/piglet d21-69) in this trial was lower than the Boram farm standard ADFI (900g/piglet). It may also explain part of the high amount of piglets scored to have respiratory problems, as an increased respiratory rate due to heat stress can also be interpreted as gasping for breath due to respiratory problems

9. Conclusion

In conclusion, feeding NS and NP feeds resulted in better overall performance of piglets from the age of 14 days to 68 days compared to the overall performance of piglets on OS and OP diets. Although not significant, the ADFI of NS feed was higher than the ADFI of OS and the intake of NP feed was higher than the ADFI of OP feed. Feed transitions have the same negative effect on ADFI for all trial groups and this indicates that piglets on New Feeds are equally affected by feed transitions as Old feed groups.

During the entire trial the ADG was higher for the Old feed trial groups than for the New feed trial groups. Within the New feed trial groups, piglets on a NP diet showed the highest ADG when the piglets were 21-55 days of age. Piglets on the NP feed turned out to have the best FE over the entire trial period compared to all other feeds.

The piglets remained significantly healthiest on New feed diets. Piglets feeding on NS had both the lowest incidence of diarrhea and least respiratory problems. Piglets of the NP trial group had significantly less diarrhea but a similar amount of respiratory problems compared to the Old feeds. Early weaning at age 21 resulted in very vulnerable piglets, reflected by the fast increase in health problems (respiratory and gastro-intestinal).

BCS turned out to be correlated to ADG and ADFI parameters. The mean BCS for piglets in the NS trial group was higher than for piglets in the OS group, but within the Performance trial groups, OP had the highest overall average BCS. The mortality in the farrowing house was less than 2% for all trial groups as hypothesized. In the nursery house the NS trial group suffered the highest mortality rate, compared to all other trial groups. Before mass culling on day 60 of the trial, the mortality in the NP trial group was higher than in the OS group, but over the entire trial period the mortality in the NP trial group was lowest.

The abnormally high incidence of health problems (respiratory, diarrhea, polyserositis) has been a major factor that decreased ADFI, reduced ADG, BW and BCS and increased mortality. The problems encountered in climate control, such as an average air temperature of 28,7 ºC and adjustments in ventilation, have also negatively influenced piglet performance. Decreasing the amount of ventilation and increasing the setting temperature >27ºC, with the intention to support sick piglets with a more comfortable climate, seemed to have decreased piglet performance (lower ADFI, less physical activity, increased body contact with faeces) as heat stress developed.

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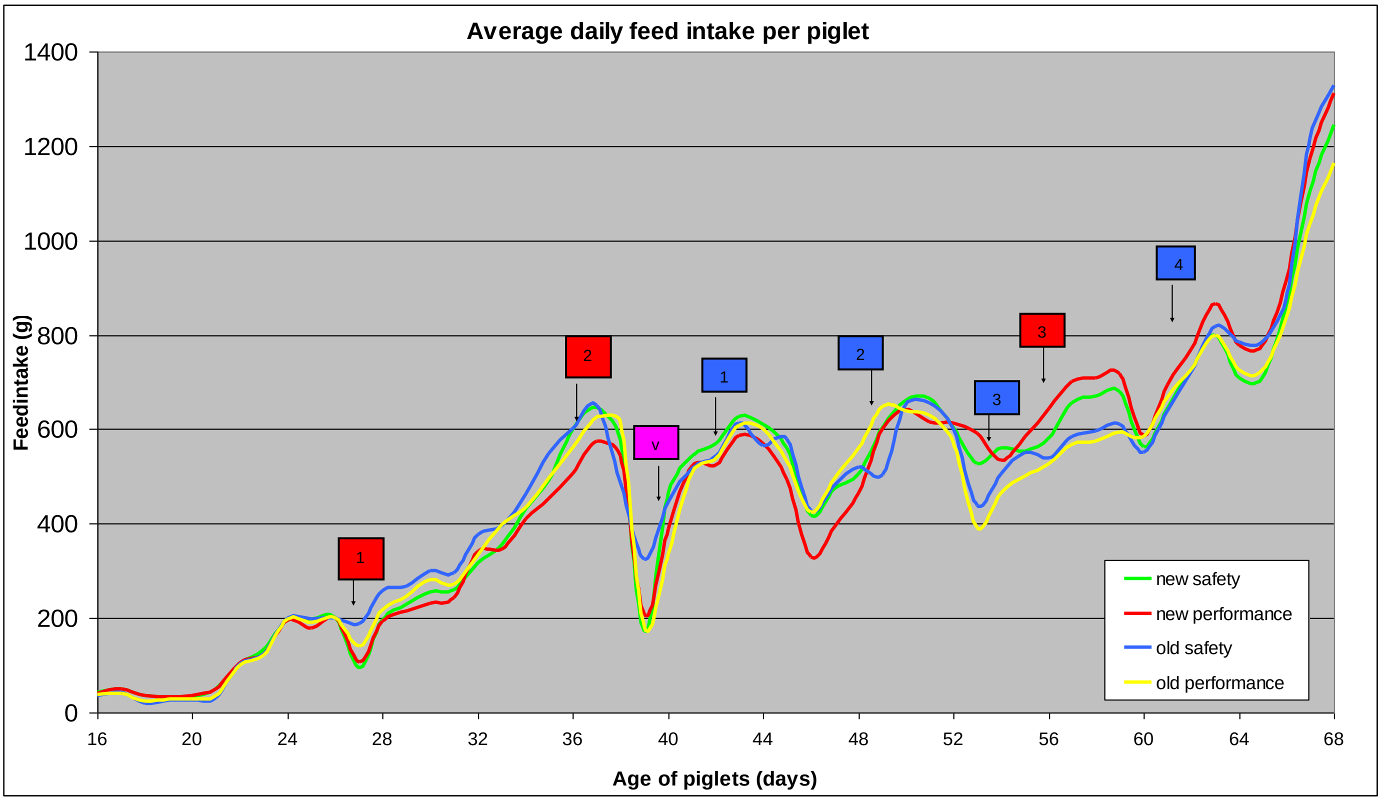
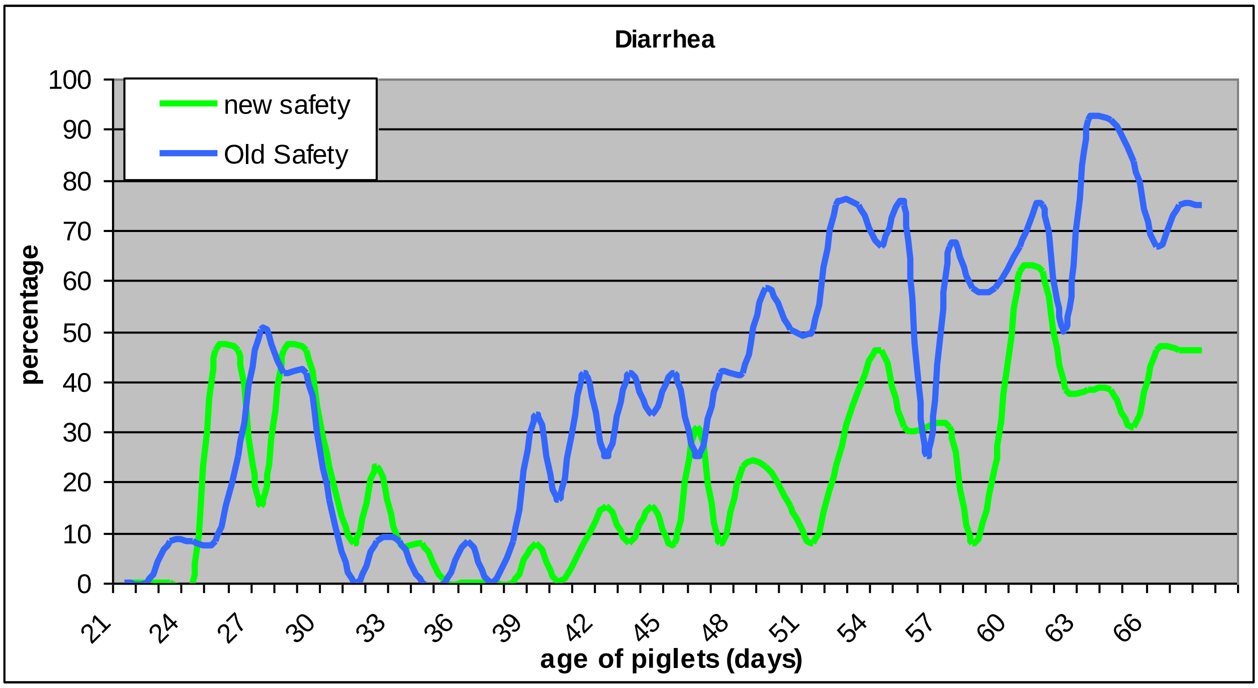
Annex 1 ADFI

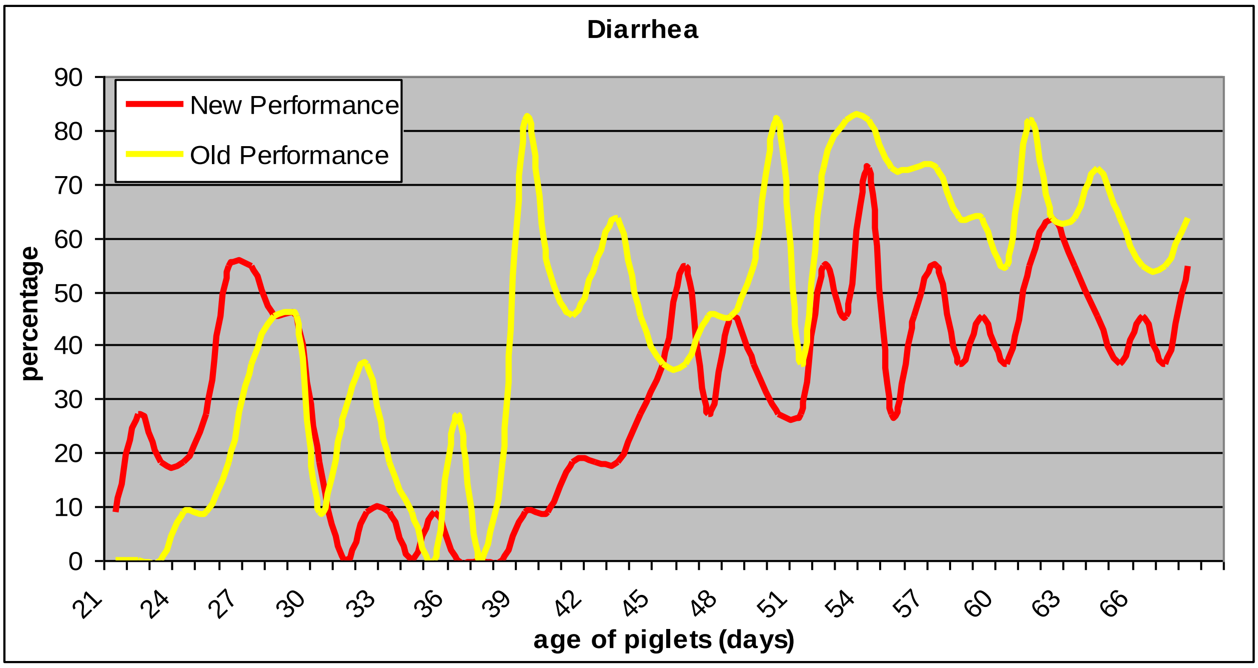


***Graph 2**, Average daily feed intake. Important events: 1. 26. 100% solid feed, 2. 36. phase II-> phase III, 3. 54. phase III-> starter feed, 1. 42. ventilation +20%, 2. 49. ventilation standard, 3. 56. ventilation -10%, 4. 63. ventilation -10%, temp. >27ºC, v. 40. vaccination*

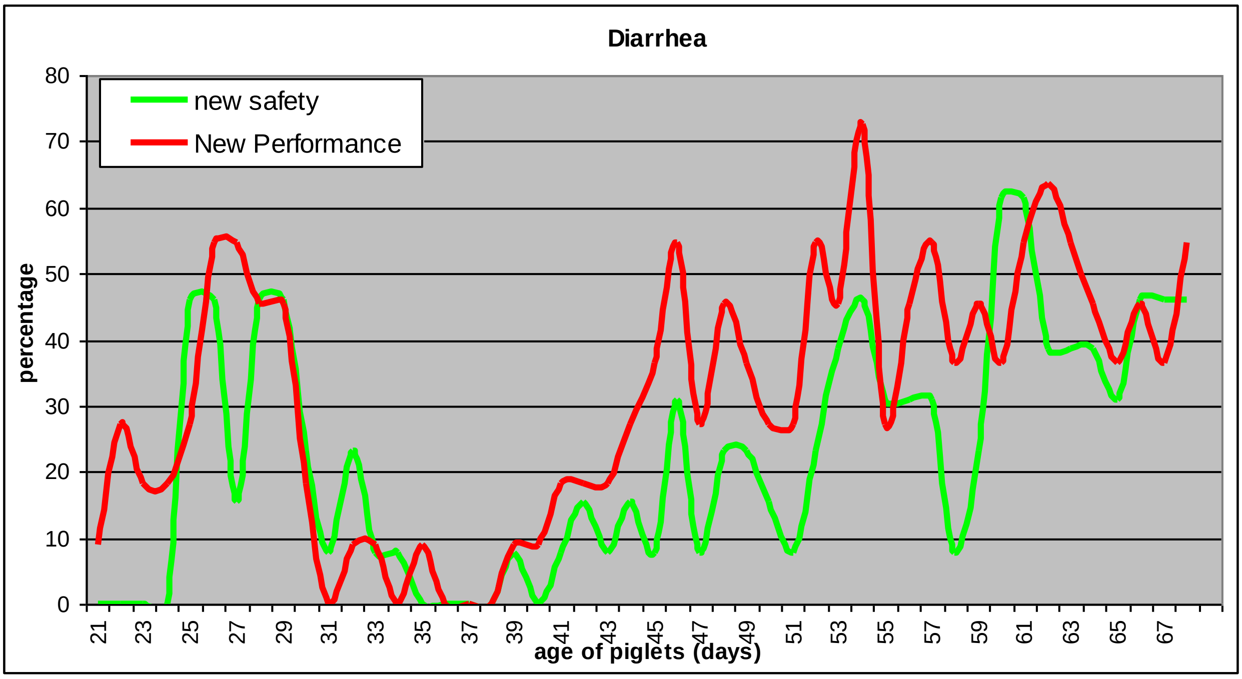
Annex 2 Diarrhea



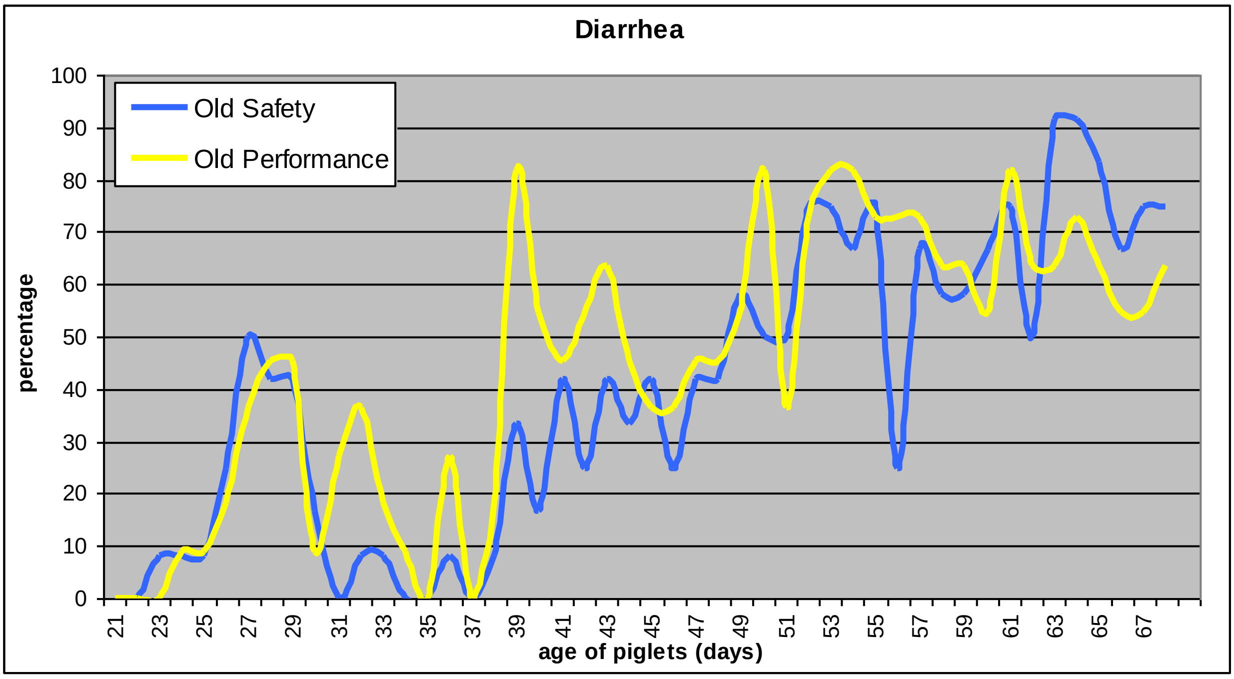
***Graph 3**. Relative context between the percentage of pens scored with diarrhea (score 3) and age of the piglets. Within **Safety trial groups**.*



***Graph 4**. Relative context between the percentage of pens scored with diarrhea (score 3) and age of the piglets. Within **Performance trial groups**.*

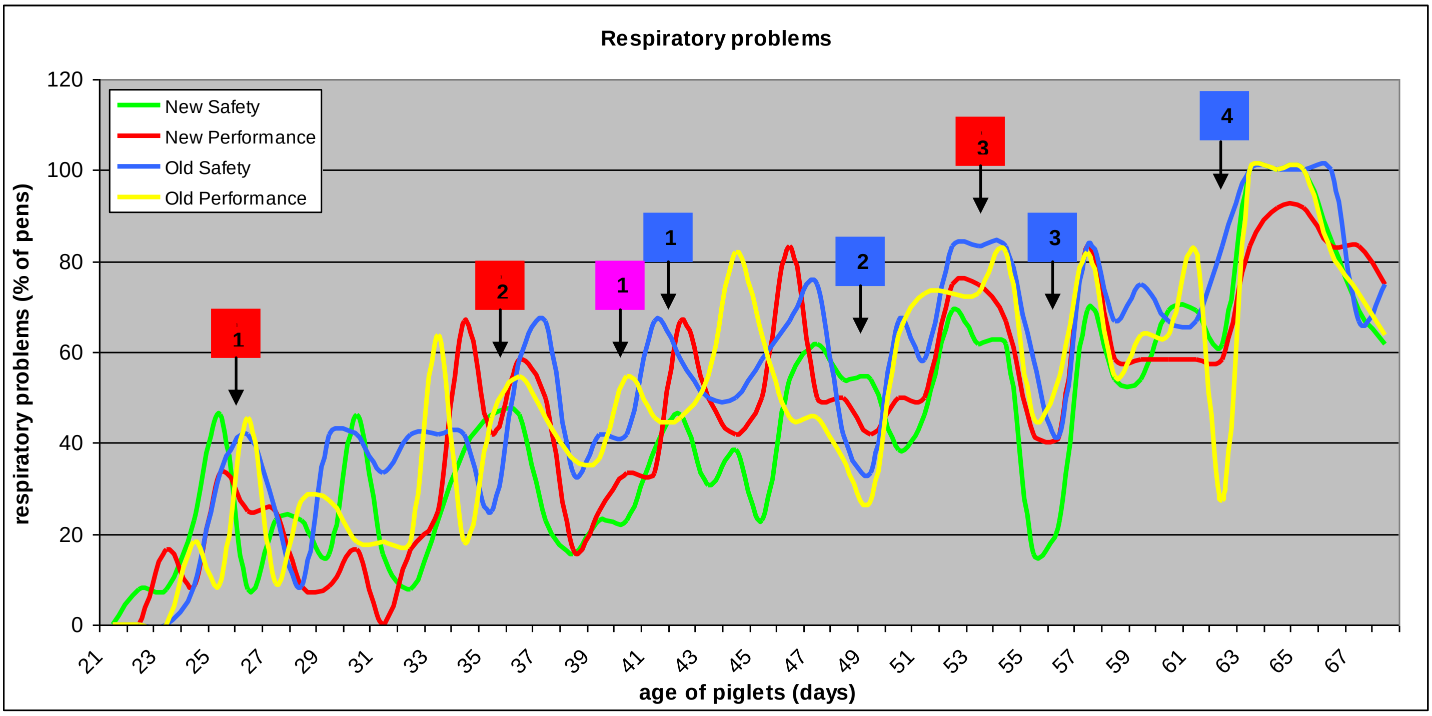


Graph 5. *Relative context between the percentage of pens scored with diarrhea (score 3) and age of the piglets. Within the* ***New feed*** *trial groups.*

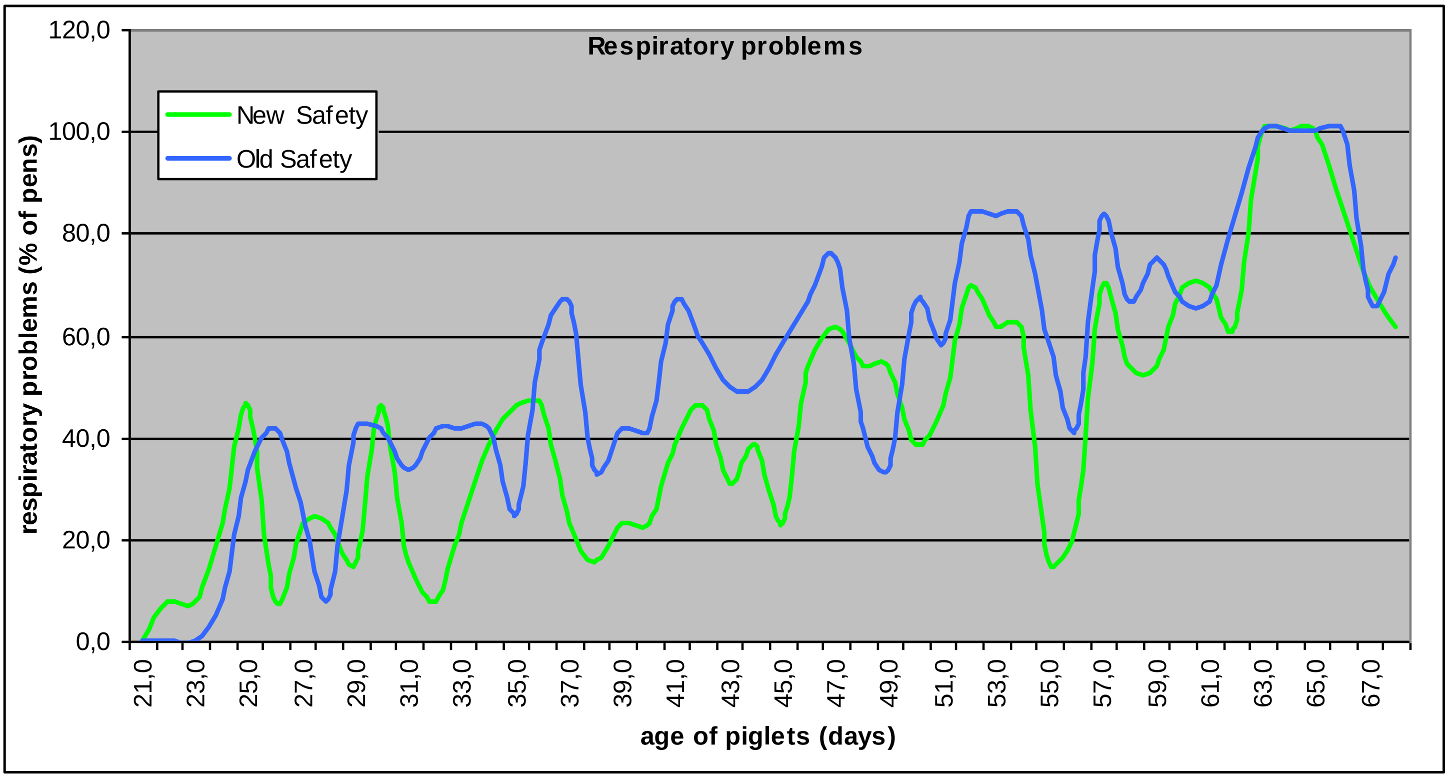


Graph 6. *Relative context between the percentage of pens scored with diarrhea (score 3) and age of the piglets. Within the* ***Old feed*** *trial groups.*

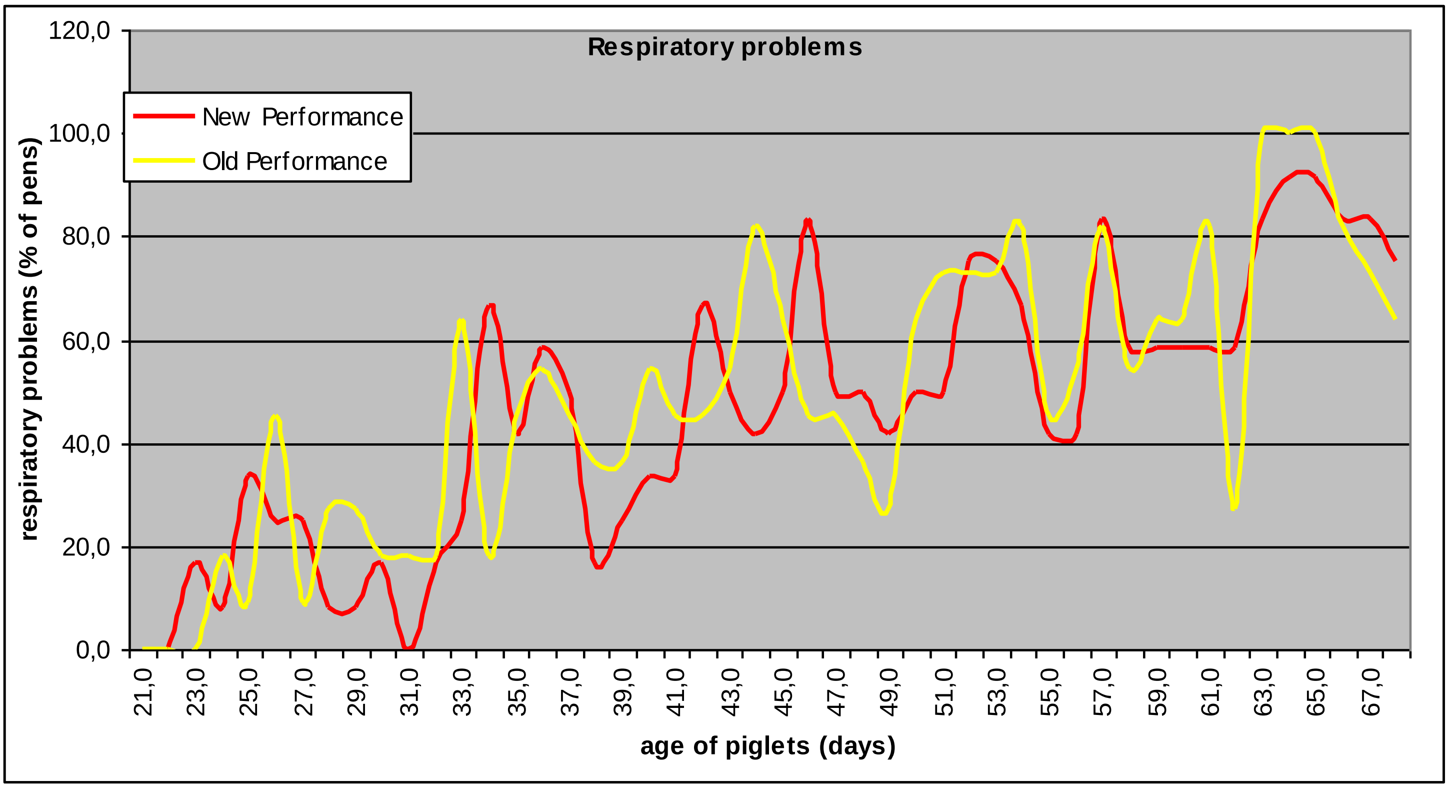
Annex 3 Respiratory problems



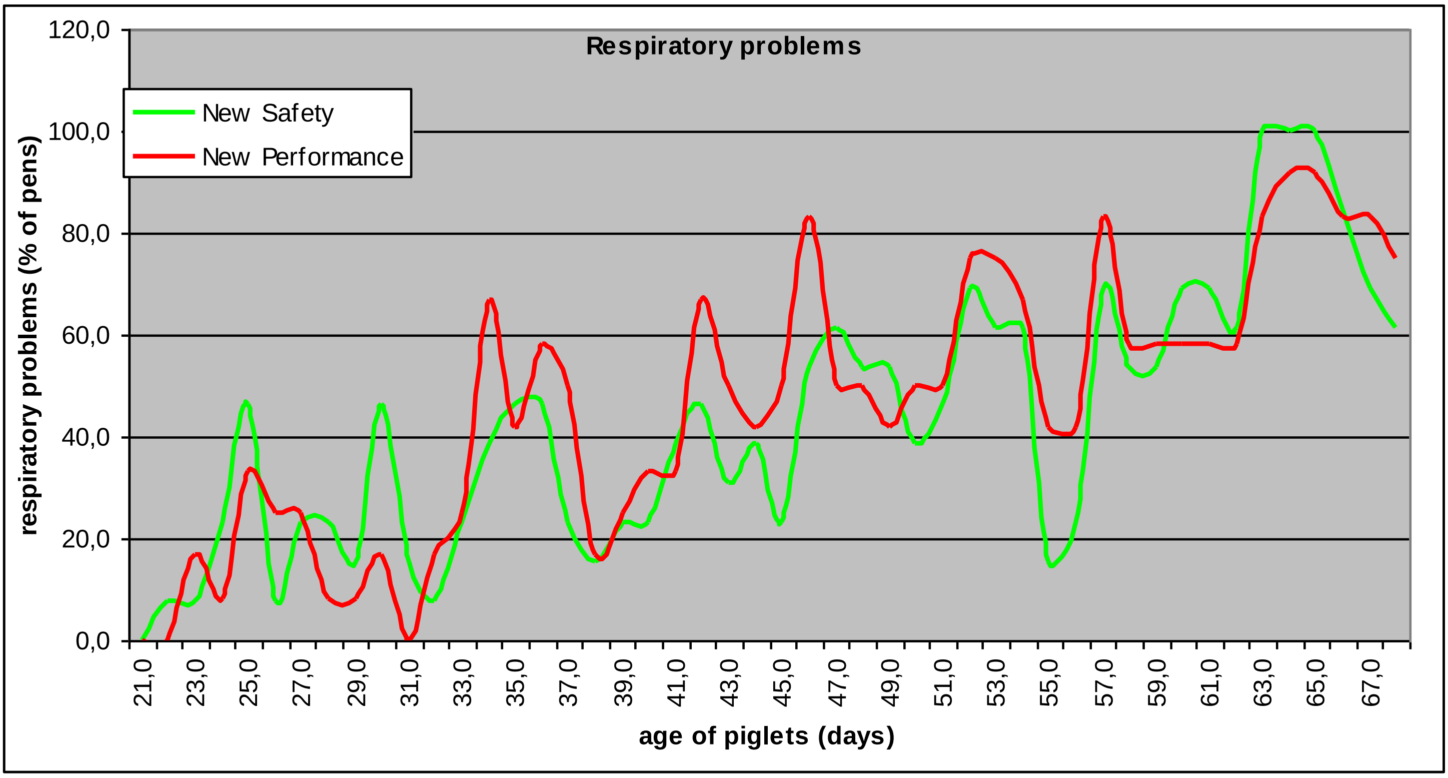
Graph 7. *Respiratory problems for all four dietary treatments. Important events: 1. 26. 100% solid feed, 2. 36. phase II-> phase III, 3. 54. phase III-> starter feed, 1. 42. ventilation +20%, 2. 49. ventilation standard, 3. 56. ventilation -10%, 4. 63. ventilation -10%, temp. >27ºC, 1. 40. vaccination*



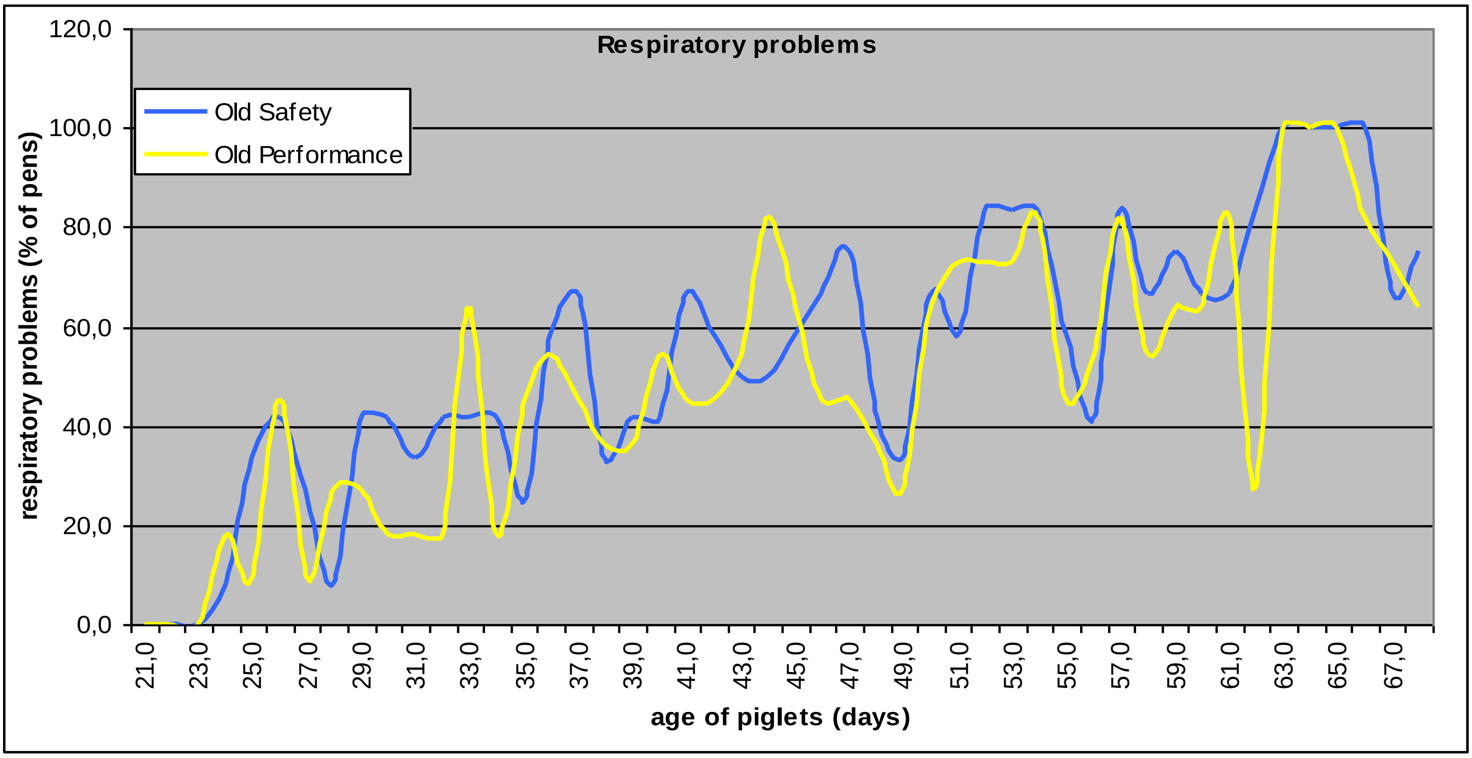
Graph 8. *Percentage of pens with respiratory problems within the* ***Safety trial groups***.



Graph 9*. Percentage of pens with respiratory problems within the* ***Performance trial groups****.*

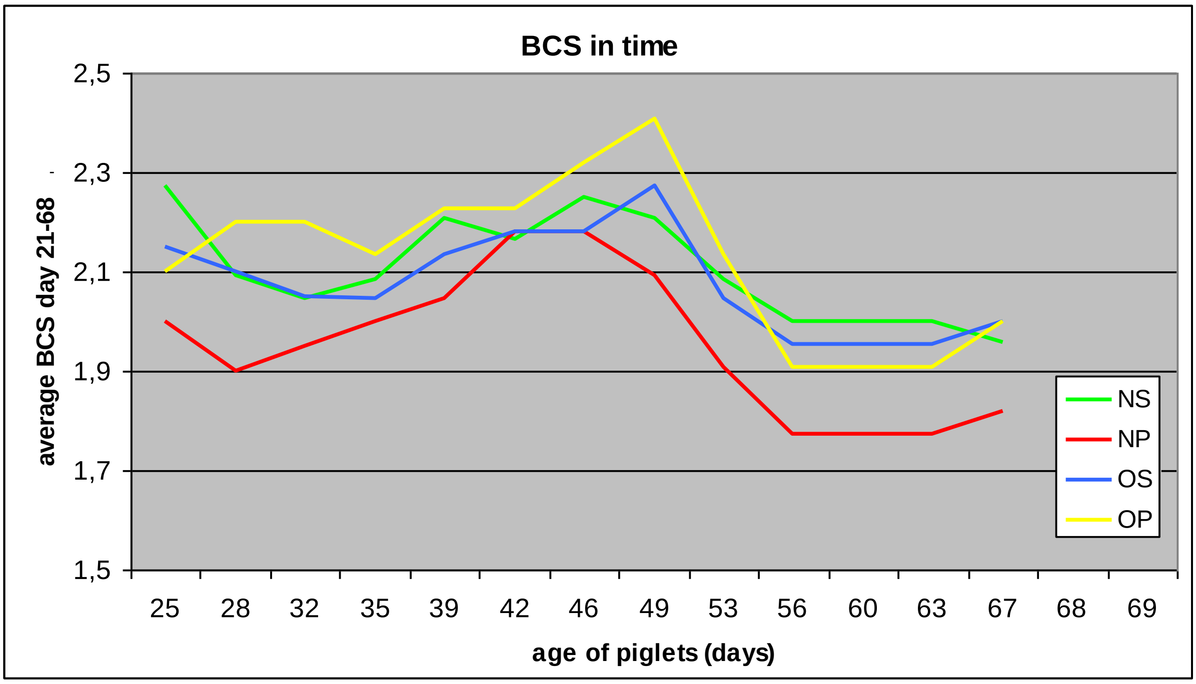


Graph 10*. Percentage of pens with respiratory problems within the* ***New feed trial groups****.*

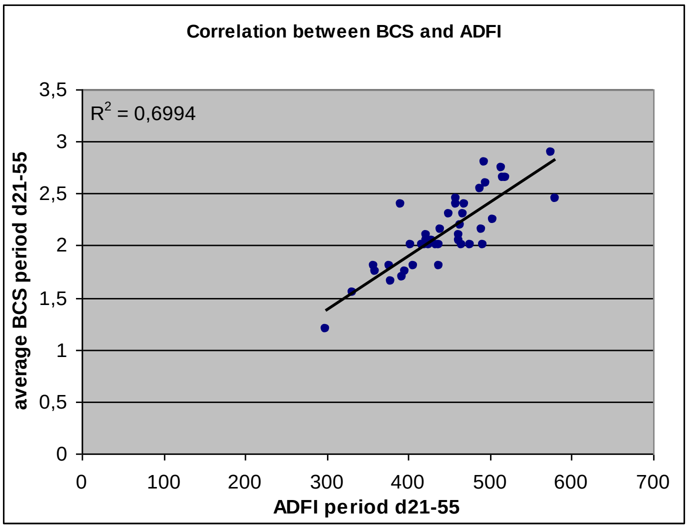


Graph 11. *Percentage of pens with respiratory problems within the* ***Old feed trial groups****.*

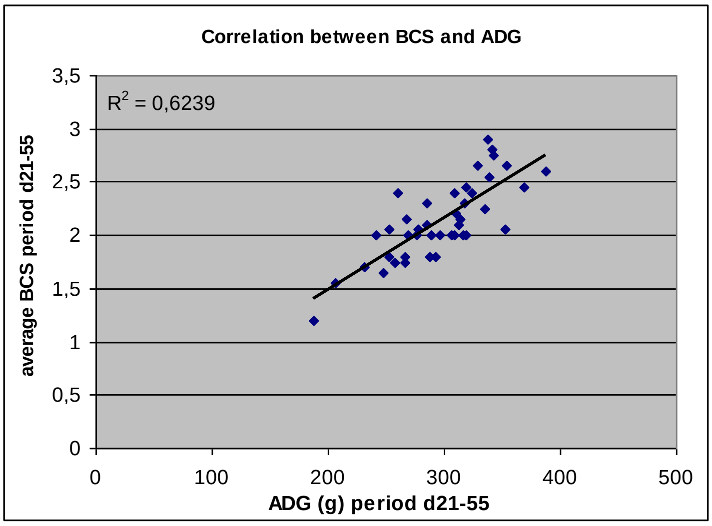
Annex 4, BCS



Graph 12. *Course of BCS scores for all trial groups in the trial period day25-69*

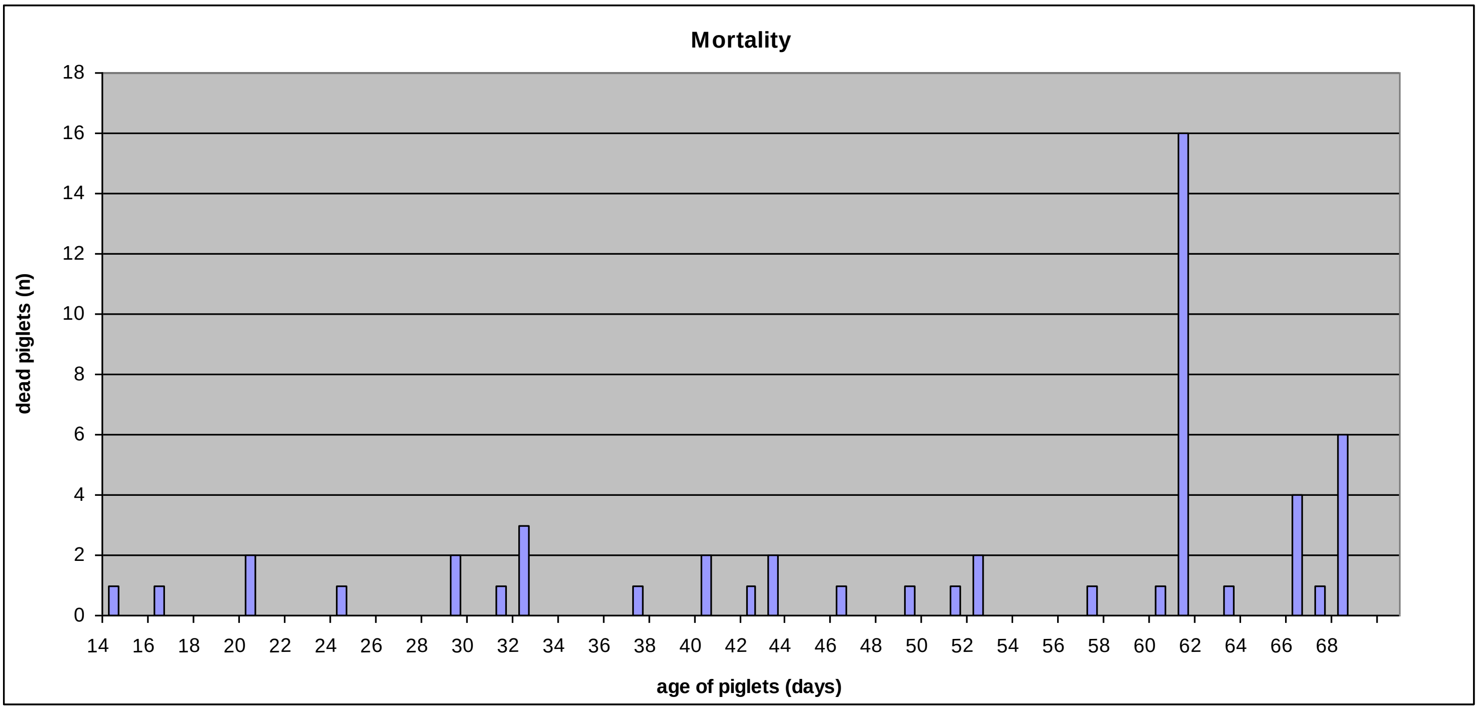


Graph 13. *The correlation between BCS and ADFI over the first 5 weeks post weaning (d21-55)*



Graph 14. *The correlation between BCS and ADG over the first 5 weeks post weaning (d21-55)*

Annex 5 Mortality

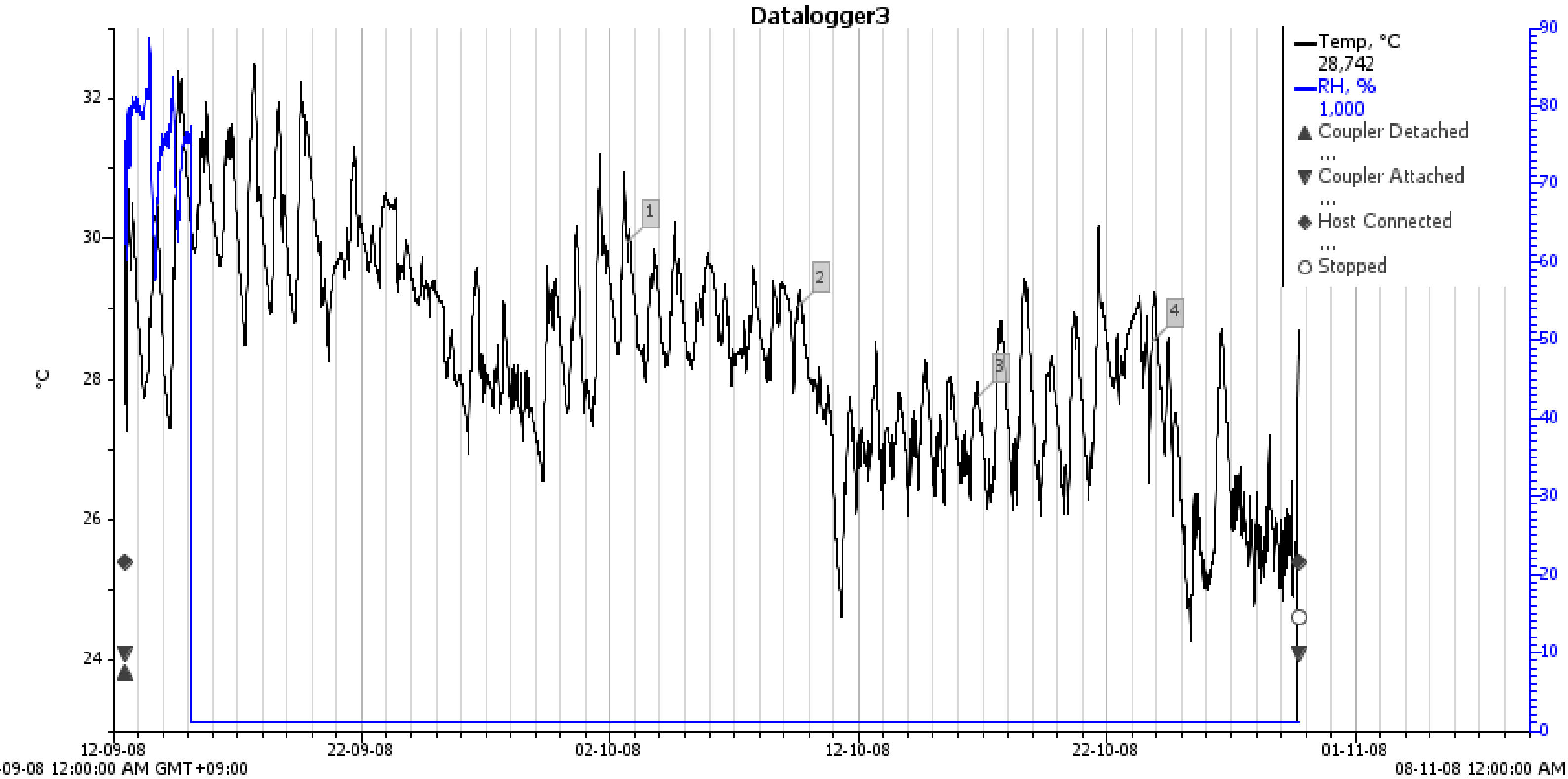


Graph 15. *The daily mortality (n) over the entire trial period (d14-68). Culling days: 61, 66 and 68*

Annex 6 Climate

Besides the East-entrance 3 large inlet fans, with a diameter of 63cm and max. wind speed of 12m/s, were located centrally as shown in Diagram 2. The ventilation capacity of each fan ranged from a minimum of 1800m^3 to a maximum of 13,500m^3. The fans blew the air into elongated, perforated plastic tubes for carrying the air along the length of the barn which distributed the air to each side of the barn and admitted fresh air to manifold without causing draft.

The adjustable, 8cm wide, outlets were located at the peak of the roof, along the entire length of the barn, for discharging stale air from the barn.



Graph 16. Course of room temperature in Nursery house from day 21 to 68 (age of piglets). Ventilation labels from left to right: 1: +20%, 2:-20% +st =26ºC, 3:-10%, 4: -10%, st =27,5 ºC. St= setting temperature. 12-09-08 = day 22 of the trial, 22-09 = day 32, 02-10 = day 42 etc.

Annex 7, Floor plans housing

1	1	3	5	7	9	11	13	15
								E
	2	4	6	8	10	12	14	16
2	17	19	21	23	25	27	29	31
								E
	18	20	22	24	26	28	30	32
3	33	35	37	39	41	43	45	47
								E
	34	36	38	40	42	44	46	48
4	49	51	53	55	57	59	61	63
								E
	50	52	54	56	58	60	62	64
5	65	67	69	71	73	75	77	79
								E
	66	68	70	72	74	76	78	80
6	81	83	85	87	89	91	93	95
								E
	82	84	86	88	90	92	94	96

Diagram 1** Floor plan of **FARROWING HOUSE** pens assigned to the four different trial groups. E=entrance, **1** = number of barn in farrowing house, 1=number of pen. 12 = not included in trial. Trial Groups: New Safety, Old Safety, New Performance, Old **Performance

		East-E		
	X	X	X	
1	2		3	4
5	6		7	8
9	10		11	12
13	14		15	16
17	18		19	20
21	22		23	24
25	26		27	28
29	30		31	32
33	34		35	36
37	38		39	40
41	42		43	44
45	46		47	48
		West- E		

***Diagram 2.** Floor plan of **NURSERY HOUSE** pens assigned to the four different trial groups. E=entrance, X= fan, 1=number of pen. 45 = not included in trial. Trial Groups: New Safety, Old Safety, New Performance, Old Performance*