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Implementing a phytomolecule supplemented diet during lactation to reduce the incidence of meningitis in sucker piglets

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Executive Summary

A micro-encapsulated phytomolecule dietary supplement added to sow lactation feed, to improve appetite and feed intake, was investigated. Additional benefits to piglet health have been hypothesized. Meningitis is a condition observed in sucking piglets and can be caused by *Streptococcus* infections. These bacteria are easily transmitted from the sow to the piglet. Intake of phytomolecules by the sow could reduce the infectious load by disrupting the transmission of the bacteria to piglets and hence reduce the incidence of meningitis within the herd. The inclusion of the phytomolecule treatment in a preliminary experiment aimed to determine if any detrimental impacts were observed on piglet growth or mortality during lactation. As no damaging effects were observed, an experiment was conducted to test if the incidence of meningitis could be reduced with the addition of the dietary phytomolecules in the pre-farrow and lactation period.

Upon entry to the farrowing house, sows were allocated to one of two dietary treatments, either a *Control* barley-wheat based lactation sow diet, or the same diet with the addition of 200 g/t of the phytomolecule supplement (Activo®, EW Nutrition GmbH, D-49429 Visbek, Germany). Sows were fed a single scoop of allocated diet through to the day of farrowing, with *ad libitum* access to feed on day after farrowing. Management and processing of the litters was as per standard commercial practice, with fostering occurring within treatment. The detection, recording and medication of piglets with meningitis occurred daily.

The inclusion of the phytomolecule supplement in the diet of the lactating sow had no impact ($P > 0.05$) on the number of litters requiring treatment for meningitis or the number of cases per litter. However, differences in reproductive performance were observed between treatments, with those sows receiving the phytomolecule supplemented diet tending to wean more pigs per litter ($P < 0.10$) and significantly reducing the number of pre-foster deaths ($P < 0.05$).

The inclusion of this phytomolecule supplement in the diets of sows immediately prior to farrowing and throughout lactation would appear to be an effective strategy to reduce the incidence of mortality within the first 24 hours post-farrowing, potentially increasing the number of pigs weaned, but has no observable impact on the incidence of meningitis.

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1. Background to Research

The performance of litters in the farrowing house contributes significantly to the productivity of sow herds. Weaning a high number of heavy, healthy pigs ensures sales budgets are met later in the production phase. For some herds, health status is a limiting factor for farrowing house and nursery performance as young piglets are susceptible to disease infection.

Streptococcal infections are common and cause arthritis, septicaemia and meningitis in young pigs (Swildens *et al.* 2007). The pig is infected via a contaminated environment through the navel immediately after birth, breaks in the skin (injury), or wounds from husbandry procedures like tail docking, ear notching and teeth clipping (Riising *et al.* 1976). The most common occurrence is observed in newly weaned pigs in the nursery phase, but it can also present throughout life. *Streptococcus suis* is a gram-positive bacterium with different serotypes varying in prevalence across herds and geographical locations, and is commonly isolated from the nose and tonsils of clinically healthy pigs (Swildens *et al.* 2007). It is transmitted from carriers through ingestion, inhalation or nose to nose contact, and can even be mechanically transferred via flies and rodents (Jeppesen, 1984; Enright *et al.* 1987). *Escherichia coli* (*E. coli*) is a common bacterium of the gut, and infection occurs in a similar manner to *S. suis*. The current control of *S. suis* and *E. coli* is through improved hygiene and ventilation, and reduced stressors such as overcrowding. Vaccines can be used but are sometimes ineffective given the number of serotypes that exist (Amass *et al.* 1996; Clifton-Hadley *et al.* 1984). As infection of carriers occurs at birth, any intervention that could reduce incidence should be tested around farrowing and lactation. Perhaps lowering maternal shedding of the bacteria into the farrowing crate environment in which piglets are born is a potential way to reduce streptococcal infection.

Phytogenics are secondary plant metabolites derived from herbs, spices or plants. Phytomolecules have been found to have important biological functions such as antiviral, antimicrobial, antioxidant and anti-inflammatory effects (Baydar et al. 2004; Sökmen et al. 2004; Dundar et al. 2008; Liu et al, 2012; 2013a, b; 2014a, b). The use of phytogenics to help improve the pig's ability to prevent pathogenic bacteria from colonising the intestinal system, may play an important role as the industry moves away from routine use of in feed antibiotics. Previous work conducted by Lie et al. (2013a;b) found that supplementation of weaner diets with phytomolecules, helped to alleviate the negative impacts of infection with *E. coli* and porcine reproductive and respiratory syndrome virus. As measured by a reduction in the viral and bacterial load, serum concentrations of inflammatory mediators and gut barrier function and integrity. There is evidence that these effects are not just limited to weaner piglets with relatively naïve immunity, as Hutter et al. (2019) demonstrated that supplementation of phytomolecules in sow diets significantly reduced the shedding of *S. suis* and *E. coli,* when measured in sow faecal samples. In addition, previous work into the effects of phytomolecules in the grower-finisher period, most of which has found similar results of increased average daily gain and feed conversion ratio (Cullen *et al.* 2005; Janz *et al.* 2007; Grela *et al.* 1998; Dunshea *et al.* 2003). As such, phytogenics present the possibility of replacing routine in feed antibiotics, by improving gut health and providing evidence of reducing impacts of viral and bacterial infections.

As such this experiment aimed to investigate the effect of feeding a pre-farrow and lactation diet that included the addition of a phytomolecule blend. We hypothesised that the included phytomolecules would reduce the shedding of harmful bacteria into the farrowing crate, thus resulting in improved piglet health and performance.

2. Objectives of the Research Project

The objectives of the following project were to:

1. Determine the effectiveness of a phytomolecule on prevalence, incidence and severity of meningitis (caused by *S. suis* infection) during the sucker period
2. Assess whether the phytomolecule was a successful deterrent for other infections such as *E. coli*.
3. Quantify any other production advantages/disadvantages when the phytomolecule is included in the lactation sow diet such as mortality and ill thrift.

3. Introductory Technical Information

Activo® (EW Nutrition GmbH, D-49429 Visbek, Germany) is a micro-encapsulated phytomolecule dietary supplement added to pig feeds to improve gut health, appetite and feed intake. The product has also been hypothesised to reduce the risk of pathogen transmission via the actions of essential oils contained within it (Lebel *et al.* 2019).

4. Research Methodology

4.1 Site

This study was conducted at a SunPork breeder unit in South Australia that experiences a Mediterranean climate (cool wet winters and warm dry summers). The farrowing shed held approximately 240 sows per rotation and the experiment was conducted over two rotations approximately five weeks apart. The majority of the sows were F1 crossbreds (PIC Camborough 42), however the herd is self-replacing and as such pure-bred animals were included in the experiment (PIC 1020). Experimental sows farrowed from July to September 2021.

4.2 Animals and housing

Sows were moved into the naturally ventilated farrowing sheds approximately five days prior to expected farrowing date. Housing consisted of a standard farrowing crate 1.8 x 2.4 m in size with a creep area heated via lamp for piglets, an *ad libitum* feeder, two water nipples for the sow and one for the piglets. Sows that farrowed during working hours (0700-1600) were observed for farrowing progression, and manually assisted if piglet birth interval exceeded 45 min. The sows were 'booked in' between 0700 and 1000 daily, litter size (TB, BA, BD) recorded at birth, and any piglet deaths recorded daily. At 24 h of age, piglets were cross fostered within treatment based on the sows rearing capacity (functional teat number). All litters were left intact after this initial fostering event, unless a piglet was observed to be losing condition, at which point it was removed and recorded as 'ill thrift'. On day 3, piglets were tail-docked, administered an iron injection and an oral coccidiostat. Litters were inspected once daily for health and medicated as per the SunPork Veterinarian approved medication list. Common health issues resulting in medical treatment on this site were scouring, meningitis, and physical injury. Piglets were weaned at approximately 21 days of age.

4.3 Diets, feeding and treatments

Experimental diets were prepared at a SunPork Farms feed mill. Formulation of the two experimental diets are presented in Table 1.

Table 1. Lactation diet specifications

	Control	Activo
BARLEY	33.570	33.570
WHEAT	28.500	28.500
MILLRUN	5.000	5.000
PEAS-FIELD	7.000	7.000
CANOLA MEAL	2.500	2.500
SOYBEAN MEAL	4.000	4.000
BLOOD MEAL	0.500	0.500
MEAT MEAL	7.000	7.000
SALMATE OIL	0.400	0.400
VEGE OIL BLEND	3.300	3.300
LIMESTONE FINE	0.350	0.350
MONOCALCIUM PHOSPHATE CHAN	0.400	0.400
BETAINE (ACTIBEET) LIQ 40%	0.480	0.480
ACTIVO		0.020

On entry to the farrowing house, sows were allocated to one of the two treatments as outlined below. Treatments were balanced for parity and previous number of pigs weaned. After treatment allocation, sows were fed 2.5 kg of mash feed (once daily at 0700) and after farrowing sows were given access to feed *ad libitum* (to approximately 8 kg delivered twice daily at 0700 and 1400).

Experiment 1
CON: standard lactation sow mash (n = 221)
PM: lactation sow mash with phytomolecule blend (Activo®, EW Nutrition GmbH, D-49429 Visbek, Germany) @ inclusion rate of 200 g/tonne (n = 224)

4.4 Measurements

Farrowing

- Induction, observed at farrowing
- Received farrowing assistance, number of assists, number of piglets pulled, whether oxytocin was administered

Performance

- Total pigs born, born alive and born dead
- Mortality and removals (ill thrift)
- Number of pigs weaned

Meningitis

- Percentage of litters medicated, and medicated for scours or meningitis
- Meningitis cases within a litter
- Age at detection of meningitis
- Number of medications for meningitis

4.5 Statistics

All data were analysed in SPSS v25 (IBM SPSS Statistics for Windows, Armonk, NY, USA) and significance established at $P < 0.05$. Normally distributed data were analysed using a general linear mixed model, but generalized linear mixed models were applied to binary data (induced, assisted, oxytocin, medicated) using binary logistic regression, and to count data (all piglet mortalities) using Poisson regression. The model applied included room as a random term and parity (P1, P2-5 and P6+), days on treatment before farrowing (<5 days, 5-7 days, and 8+ days) and treatment as fixed effects and all two-way interactions between these terms. No two-way interactions were significant and so these results are omitted from the report.

5. Results

The average parity of sows was 3.4 ± 0.1 and was not different between the CON and PM litters (*P* > 0.05). PM sows were in the farrowing house for 5.9 ± 0.2 days prior to farrowing whilst CON sows entered 5.3 ± 0.2 days before (*P* < 0.05; Table 2). The proportion of sows that were induced to farrow, those that were observed during working hours, or those that required manual assistance during farrowing did not differ between treatments (*P* > 0.05).

Table 2. Mean ± SEM farrowing measures for sows fed a control diet during lactation (CON) and sows fed the control diets supplemented with 200g/tonne phytomolecule during the lactation period (PM).

	CON		**PM**		*P* value
	Mean	**SEM**	**Mean**	**SEM**	
Length pre-farrow (days)	5.3	0.4	5.9	0.2	**0.015**
Induced (%)*	29	(12.3-54.5)	37	(16.4-63.8)	0.424
Observed (%)*	42.2	(31.1-54.2)	44.6	(34.3-55.3)	0.769
Assisted to farrow (%)*	7	0-66.2)	24	(7.6-54.9)	0.942
Manual assists per observed sow	0.01	0	0.28	0.24	0.853
Piglets pulled per observed sow	0.01	0.21	0.34	0.27	0.901

**Confidence intervals rather than SEM presented for binary data*

There was no effect of treatment in total pigs born, born alive or born dead (*P* > 0.05; Table 3). There was a tendency (*P* = 0.065) for more pigs to be weaned from the PM sows. PM also significantly reduced pre foster piglet mortality by 0.3 pigs per litter (*P* < 0.05).

Table 3. Mean ± SEM litter characteristics for lactation sows fed a control diet during lactation (CON) and sows fed the control diets supplemented with 200g/tonne phytomolecule during the lactation period (PM).

	CON		**PM**		*P* value
	Mean	**SEM**	**Mean**	**SEM**	
Number					
Total born	13.7	0.4	13.5	0.4	0.721
Born alive	12.6	0.4	12.2	0.4	0.329
Born dead	1	0.1	1.3	0.1	0.123
Post foster	12	0.1	12.1	0.1	0.484
Weaned	9.8	0.2	10.3	0.2	0.065
Mortality and removal					
Pre foster	0.9	0.1	0.6	0.1	**0.018**
Post foster	1.2	0.1	1.2	0.1	0.972
Ill thrift	0.9	0.1	0.8	0.1	0.462

There were no differences in the incidence of medication, or medication for scour or meningitis between litters of treated sows (*P* > 0.05; Table 4).

Table 4. Mean ± SEM litter medication measures for sows fed a control diet during lactation (CON) and sows fed the control diets supplemented with 200g/tonne phytomolecule during the lactation period (PM).

	CON		**PM**		*P* value
	Mean	**SEM**	**Mean**	**SEM**	
Litters medicated (%)	31.9	(17.7-50.4)	41	(30.4-52.5)	0.374
Litters medicated - scours (%)	22.1	(0-68.7)	20.6	(8.8-41.1)	0.872
Litters medicated - meningitis (%)	12.3	(5.2-26.3)	16.7	(5.2-29.6)	0.454
Meningitis cases per litter	0.2	0.1	0.4	0.1	0.175
Age at first treatment (days)	13.4	2	15.4	1.5	0.310
Number of medications per diagnosed pig	3.9	0.7	3.9	0.5	0.983

**Confidence intervals rather than SEM presented for binary data*

6. Discussion

This experiment investigated the effect of feeding a pre-farrow and lactation diet that included the addition of phytomolecules. We hypothesised that the included phytomolecules would reduce the shedding of harmful bacteria, thus resulting in improved piglet health and performance. Our hypothesis was not supported as the treatment group did not display a reduced incidence of meningitis, but did reduce pre-foster mortalities, and tended to result in a higher number of piglets weaned. Thus whilst not effective at improving sucker piglet health, the phytomolecule can be included in lactating sow diets to improve reproductive performance.

Initial infection of piglets with *S. suis* and *E. coli* occurs within the farrowing crate immediately following birth, due to the prevalence of the bacteria in the faecal matter of the sow (Staats *et al.* 1997). We hypothesised that the addition of phytomolecules to the prefarrow and lactation diet of the sows would decrease this shedding, thereby reducing the incidence of meningitis and scours in sucker piglets. Previous work conducted by Hutter *et al.* (2019), found that the addition of phytomolecules to lactation diets reduced the faecal bacterial load of *S. suis* by up to 97.2% and *E. coli* by up to 98.3%. As such, the lack of effect the addition of phytomolecules had on scours and meningitis cases in piglets is surprising. However, as a number of sows were only in the farrowing crates for four days or less, this simply may not have been an adequate amount of time for the phytomolecules to shift the bacterial populations in the gut prior to farrowing. In order to overcome this time pressure, the addition of phytomolecules to gestation and lactation diets should be considered. Another potential explanatory factor to consider is the state of the farrowing crate prior to sow entry, it is possible that the environment may have already been contaminated from the previous sow and litter. Further research is necessary to optimise the timing of supplementation with phytomolecules prior to farrowing.

The use of phytomolecules has been shown to reduce the shedding of harmful bacteria by the sow (Hutter *et al.* 2019), as such we hypothesised that the use of phytogenics would reduce the counts of meningitis and scour in sucker pigs. Despite the rejection of our hypothesis the phytomolecule blend may have improved farrowing crate hygiene, which is supported by the improved survival of piglets in the first 24 hours of life. This hypothesis is supported by work conducted by Nowland *et al.* (2021), where piglets from pens that had all faecal matter removed daily, showed increased growth rates and decreased pre-weaning mortality, thought to be due to decreasing the pathogenic matter during arguably the time of highest risk of disease for the piglet (Lay *et al.* 2015). As the faecal matter is not cleared away daily on this farm the addition of phytomolecules may provide these piglets the ability to better cope with the microbial load, enabling them to increase the intake of colostrum with in the first 24 hours of life.

Pre-foster mortality was improved by the addition of the phytomolecule blend to the pre-farrow and lactation diet, which was a novel finding outside of our hypothesis. This may be attributed to the increased comfort of the sow, due to the protective GIT properties of the phytomolecules. It known that the majority of piglet mortality occurs within the first 24hrs of life and is most commonly caused by the sow over-laying piglets during posture changes. Farrowing is a time of high physiological stress and as such free radicals are often produced, leading to oxidative stress and eventual immunosuppression (Boudal 2014). Phytomolecules have been shown to have potent antioxidant properties, with the potential to protect animals from oxidative damage caused by free radicals. The prescence of phenolic OH groups, found in many plant extracts, acts as a hydrogen donor to the peroxy radicals produced during the first stage of lipid oxidation, therefore retarding the hydroxyl peroxide formation (Farag *et al.* 1989; Djeridane *et al.* 2006). Frankič et al. (2010) demonstrated that when pigs were placed under dietary-induced oxidative stress, the supplementation of phytomolecules reduced the DNA damage in lymphoctyes, indicating the potential beneficial effects on the immune system. In addition, phytomolecules have been shown to have anti-inflammatory properties in *in vitro* cell culture models, as they inhibit the production of proinflammatory cytokines and chemokines from endotoxin stimulated immune cells and epithelial cells (Lang *et al.* 2004; Lee *et al.* 2005; Tung *et al*. 2008; Liu *et al*. 2012). Therefore, the addition of phytomolecules in the pre-farrow and lactation diet of sows, has the potential to reduce the physiological stresses associated with the farrowing process.

This experiment investigated the effect of feeding a pre-farrow and lactation diet that included a phytomolecule blend. We hypothesised that the included phytomolecules would reduce the shedding of harmful bacteria into the farrowing crate, thus resulting in improved piglet health and performance. The treatment was not successful in reducing the incidences of sucker piglet meningitis, but did reduce pre-foster mortality, and tended to result in a higher number of piglets weaned.

7. Implications & Recommendations

While the addition of phytomolecules to a pre-farrow and lactation diet did not reduce the incidence of meningitis in piglets, we are unable to determine if the bacterial load of *S. suis* or *E. coli* was reduced, and as such further research should be conducted into this effect. The significantly decreased pre-foster mortality, and tendency for a higher number of pigs weaned in the sows fed the treatment diet, is a promising result that requires further investigation. The inclusion of the phytomolecule blend in gestation diets as well as lactation diets would appear warranted , as the beneficial effect it appears to be having on the GIT of farrowing and lactating sows would be of benefit to sows coping with oxidative stresses occurring in gestation.

8. Intellectual Property

There has been no protectable intellectual property developed or discovered as part of this current pilot study.

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10. Publications Arising

Not Applicable