# Are We Getting the Best Out of Our Sows?
## The Use of Phytogenics in Sow Diets to Enhance Performance

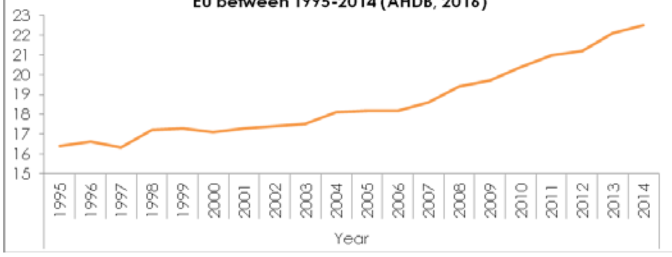
PEER REVIEWED

As we edge ever-closer to the challenging prospect of supplying food to an estimated 9 billion people by 2050, armed with fewer resources and in many cases without the use of antibiotic growth promoters (AGP), producers are undoubtedly faced with a difficult task.

In order to meet the future prospective consumer demand, pig producers must increase their output of pig meat (kg/sow/year). To do this, producers must start by improving sow performance. In theory, commercial producers should be reaping the incessant improvements that genetic companies are making to dam lines. The current commercial EU dam lines produce more piglets born alive and more finished pigs than ever before, with an increase of four finished pigs/sow/year in the last seven years alone (Figure 1). But at what cost to the sow are we producing these extra piglets? Continued selection for dam lines that produce leaner, faster-growing piglets has resulted in today's lean type sows exhibiting sub-optimal feed intakes, backfat and prolonged maternal growth. The rising number of intra-uterine growth restricted (IUGR) piglets produced by the modern sow present additional management and welfare issues, contribute to batch variability and can ultimately reduce production efficiency. The issue of IUGR piglets can result from the disproportional increase in litter size versus sow size and uterine capacity. However, the development of IUGR pigs is mainly due to a smaller size placenta, reduced placental blood flow and thus placental efficiency that these piglets experience compared to normal birth weight siblings. This, therefore, compromises their ability to acquire sufficient nutrients for normal growth; this issue can be exacerbated if protein and mineral levels are inadequate during late gestation (Ford *et al*., 2002; Kim *et al*., 2013). These smaller placentas are reported to exhibit fewer and less dense areolae, glucocorticoid receptors and specific amino acid transporters (Ashworth, 2013). This reduces the ability of the foetus to acquire essential amino acids such as leucine. These piglets are therefore not receiving sufficient quantities of essential amino acids and other nutrients required to reach their genetic potential with regard to birth weight. Moreover, if a sow is adequately nursing more piglets per litter for the entire duration of lactation, it will undoubtedly increase her negative energy balance when considering her metabolic status, with sows utilising more body reserves to sustain milk production until weaning. Therefore, if sow nutrition is inadequately managed or feed intake is not maximised during lactation, this can not only impede her current litter's performance, but also have adverse effects on oocyte quality and subsequent reproductive performance.

There is, therefore, a need to consider nutritional strategies that can be employed to help support the modern hyper-prolific sow. Typically, a sow's diet is formulated to meet her requirements based on an assumed feed intake. However, her actual feed intake is often less than predicted and consequently the diet may not reach her requirements, particularly during lactation. Therefore, it is imperative to supplement feed with low inclusion additives, which can either stimulate feed intake and/or help to improve nutrient utilisation from the formulated feed, without significantly impacting nutrient density.

Figure 1. The average number of pigs finished/sow/year in the EU between 1995-2014 (AHDB, 2016)




**Phytogenics:**
The use of non-antibiotic feed additives to enhance performance continues to gain strength and recognition as a result of the EU AGP ban in 2006, and the increasing global pressure to limit the use of antibiotics in pig production. Plant-derived or phytogenic feed additives have become an accepted group of such additives. It has recently been estimated that the phytogenic feed additive sector is worth around £375 million in sales per year, a figure which is anticipated to grow significantly in the coming years (Pig World, 2016). Oregano essential oil (OEO) is a well-accepted example of a phytogenic feed additive which can be used as a feed flavourant, antimicrobial, immunomodulatory or antioxidant agent, primarily containing the active components carvacrol and thymol.

The antimicrobial effects of the principal actives in OEO are thought to result from disruption to cell membranes and an exhaustion of the intracellular ATP pool (Friedman, 2014; Baser and Buchbauer, 2010). It is suggested that the actives are able to integrate with the lipid layers of the microbial cell membrane, altering the fluidity of the membrane and consequently increasing cell permeability to protons and leakage of potassium ions. Therefore, the osmotic pressure of the cell is disrupted, leading to loss of cell function and subsequently cell death. Oregano essential oil has demonstrated antimicrobial effects against a range of unfavourable microorganisms, seen in Table 1. Carvacrol possesses anti-fungal characteristics, including pathogenic and mycotoxin producing strains, such as *Aspergillus flavus*, *A. fumigatus*, *Fusarium oxysporum*, *F. verticillioides*, *Penicillium brevicompactum* and *P. expansum* (Friedman, 2014).

| Microorganism | Oregano essential oil (mg/L) |
|---|---|
| *Escherichia coli* | 250 |
| *Listeria monocytogenes* | 250 |
| *Salmonella enteritidis* | 128 |
| *Staphylococcus aureus* | 64 |
| *Staphylococcus aureus (MRSA)* | 250 |
| *Candida albicans* | 64 |

Table 1. MIC values of OEO against various microorganisms (Özkalp *et al*., 2010)

Both carvacrol and thymol exert antioxidant effects through the scavenging of free radicals. This antioxidant effect is suggested to be most potent in the liver (Friedman, 2014). However, OEO may also indirectly increase the antioxidant capacity of the sow by favourably shifting gastrointestinal microbial ecology and increasing the colonisation by beneficial bacteria, such as Lactobacillus spp. which can also scavenge free radicals (Wang *et al*., 2009).

Oregano essential oil can have immunomodulatory effects, helping to mitigate inflammation by reducing the expression of pro-inflammatory cytokines including IFN-γ and TNF-α, whilst increasing the expression of anti-inflammatory cytokines such as IL-10 (Zou *et al*., 2016; Friedman, 2014). In murine models, OEO has reportedly reduced pain associated with inflammation. It has been suggested that the analgesic properties of OEO may be due to the downregulation in TNF-α production and nitric oxide release (Friedman, 2014).

Oregano essential oil can be used in both ruminants and monogastrics to enhance gut health and performance. Anpario produces the market leading phytogenic feed additive by adding steam-distilled OEO to an appropriate carrier. The production technology that Anpario utilises ensures product consistency and thus reliable performance improvements in the animal.

**Using OEO to Enhance Sow Performance:**

Substantial physical and metabolic changes occur within the sow as gestation progresses and she transitions into lactation. These changes arise as a result of the increasing placental demands for nutrients and oxygen to support foetal growth, particularly during the last trimester of pregnancy when the majority of foetal growth occurs. In addition, the sow must also supply nutrients to the mammary glands to support mammary gland development and the production of nutrient-dense colostrum during the pre-partum period. These changes increase the production of reactive oxygen species (ROS), and consequently the degree of oxidative stress during the latter part of gestation and the postpartum period when compared to early gestation. Elevated levels of oxidative stress can have adverse effects on the animal, negatively affecting protein and DNA oxidation, lipid peroxidation, endothelial cell function and thus adsorption of nutrients, milk production, fertility and sow longevity (Kim *et al*., 2013; Tan *et al*., 2015). The oxidative stress status of the sow will not be fully recovered until she has weaned her litter (Berchieri-Ronchi *et al*., 2011). Research has suggested that the excess production of ROS, such as under conditions of oxidative stress, can result in sows developing insulin-resistance during the peri-parturient period, adversely affecting feed intake during lactation (Rains and Jain, 2011; Mosnier *et al*., 2010). This will have negative consequences on pre-weaned piglet performance and sow body condition at weaning, as the sow will have to mobilise a larger proportion of her body reserves to support lactation nutrient requirements.

Trying to get sufficient quantities of feed into the sows during lactation is a challenge that is only exacerbated during the summer months, particularly if the sows are outdoors or in poorly ventilated housing where they can become heat stressed. Pigs are not the most efficient animals when it comes to thermoregulation. Therefore, when ambient temperatures reach or exceed that of the sow's upper critical temperature, she will employ behavioural and physiological adaptions in an attempt to lower her body temperature. The sow will redirect blood flow away from the mammary glands to the capillaries near to the skin surface to dissipate heat. Consequently, a larger cardiac output would be required to produce the same volume of milk (Williams, 2009). The sow will also reduce her feed intake to try and mitigate some of the metabolic heat increment generated by digestion and metabolism. Consequently, fewer nutrients can be adsorbed to support milk production and more maternal lipid and protein reserves must be utilised, placing the sow in an increasingly negative energy balance. The detrimental effects that heat stress has on sow feed intake, and therefore milk yield, manifests itself in reduced growth rates of suckling piglets. Renaudeau and Noblet (2001) reported that piglets produced by heat-stressed sows were up to 2kg lighter at weaning when compared to those produced by sows housed in thermo-neutral conditions. Heat stress will also impede on the sows' performance in the next parity, with sows expressing poorer follicle development, delayed return to oestrus, lower conception rates, reduced embryo viability, farrowing rates and lower born-alive figures (Takahashi, 2011; Einarsson *et al*., 2008; Williams, 2009). Therefore, it is imperative, especially during times of heat stress, to encourage sow feed intake during lactation to try and alleviate some of the additional issues that heat stress imposes on sow performance. Oregano essential oil has been successfully used to help combat the effects of heat stress on sow fertility in Spain. A commercial trial was conducted on a 2500 sow unit in Northern Spain from June to October. Sows were divided into two groups: control and treatment. The treatment group received 250g and 500g per tonne of feed of an OEO product (Oreo-Stim, Anpario Plc) during gestation and lactation, respectively. Sows receiving the OEO treatment showed a 9.4% improvement in pregnancy rates, produced 0.3 more piglets born alive and weaned piglets that were 100g heavier than the control group.

In a recent trial (Tan *et al*., 2015), sows received either a diet supplemented with 300mg/kg of an OEO product or a control diet, which they were fed throughout the gestation (2.0kg/day between days 1-30, 2.5kg/day between days 31-90 and 3.0kg/day between day 91 of gestation and farrowing) and lactation period (ad libitum), until the piglets were weaned at 21 days of age. The study demonstrated that OEO reduced oxidative stress in the sow during the critical transition period between days 109 of gestation to the beginning of lactation. This was shown by significant reductions in serum oxidative stress markers such as ROS, thiobarbituric acid and 8-hydroxy-deoxyguanosine, and an increase in the antioxidant enzyme glutathione peroxidase. Insulin-sensitivity during the transition period was increased in sows receiving OEO compared to the control group, reducing the negative impact that insulin-resistance can exert on lactation feed intake.

Faecal samples taken on day 109 of gestation revealed that OEO favourably altered the sow's intestinal microbial ecology. Faecal lactobacilli counts were significantly improved, whilst faecal *Escherichia coli* counts were reduced, both of which aid in the reduction of ROS production. Carvacrol and thymol are known to exert bactericidal effects on unfavourable bacteria such as *E. coli*. This can reduce the degree of inappropriate immune stimulation in the sow and subsequently the degree of nutrient partitioning required to support immune system activation. Therefore, more nutrients can be conserved and utilised by the placenta to support foetal development. However, the beneficial effects of OEO on the sow gut microbiota may have even more far-reaching consequences. As we begin to understand more about the pig microbiome, there is an increasing body of evidence to suggest that the neonatal microbiome is established in the first 24 hours of life and will, in part, still be of similar composition in the pig at slaughter. We are also beginning to understand the relationship between the microbiota and metabolic phenotype. Therefore, if the microbiome and thus metabolic phenotype are determined to a certain extent within the first 24 hours of life, much of which is obtained from the sow via the urogenital tract, faeces and skin, then beneficially altering the microbial ecology of the sow has the potential for significant beneficial effects on gut health, metabolism and future performance of her litter.

While there was no effect on total born or the number of piglets born alive, OEO significantly increased piglet birth weight (Table 2). An increase in birth weight may be due to the beneficial effects that OEO exerts on tight junction integrity and intestinal morphology of the sow. Figure 2 depicts the effect OEO has on jejunum morphology, OEO increased villus height and the villi were less desquamated. With tight junction integrity and villus height increased, the gut of the sow will be more efficient at adsorbing nutrients and utilising them for foetal growth rather than supporting an immune response due to elevated levels of endotoxins in the plasma.

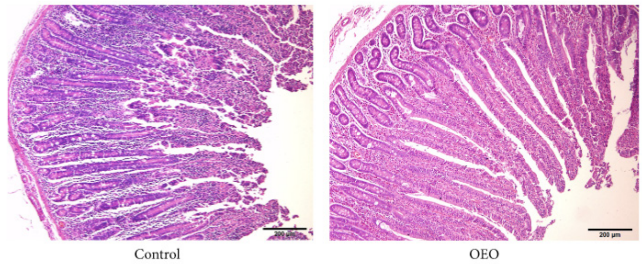
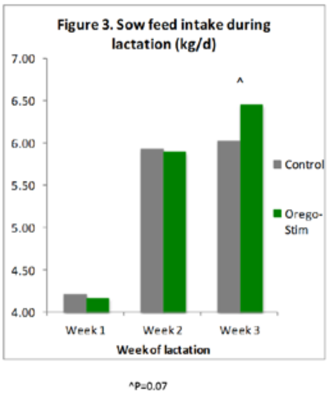
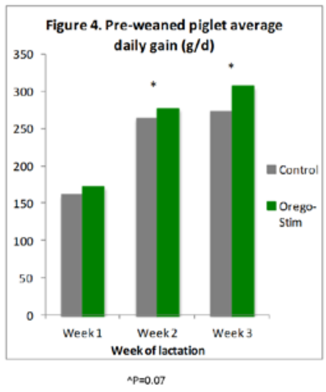



Figure 2. The effects of OEO on jejunum morphology in the pig (Zou *et al*., 2016)

During lactation, sows supplemented with OEO tended to consume more feed during the important final week of lactation (Figure 2), supporting improved piglet growth and weaning weights. This increase in sow voluntary feed intake may be as a result of heightened insulin sensitivity. However, a simpler explanation could be due to the appealing smell and flavour of the phenolic terpenes in OEO stimulating appetite through more palatable feed. The improved piglet growth rates and weaning weights would undoubtedly be a result of increased sow milk production (Figures 3 and 4, and Table 2, respectively).




| Table 2. Sow performance parameters | | | |
|---|---|---|---|
| Parameter | Control | Orego-Stim | P value |
| Total born | 11.59 | 11.28 | 0.65 |
| Born alive | 11.41 | 11.16 | 0.71 |
| Average birth weight (kg) | 1.44 | 1.56 | 0.04 |
| Number weaned | 9.45 | 9.6 | 0.70 |
| Average weaning weight at 21 days of age(kg) | 6.49 | 6.94 | 0.01 |

Table 2. Sow performance parameters

This recent study demonstrates the use of OEO as an effective feed flavourant, antimicrobial and antioxidant product for pigs. These product characteristics, when considered in combination, will help to improve sow health and aid her ability to nurse a large litter, while potentially improving her longevity. Encouraging lactation feed intake, particularly during times of heat stress, will help to reduce the mobilisation of maternal lipids and proteins for milk production, enabling the sows to wean their piglets in better condition. Consequently, follicle quality and weaning to oestrus interval should be improved and therefore, the reproductive performance of the breeding herd in the next parity. This beneficial carry-over effect of OEO on sow performance in the next parity has been demonstrated by Allan and Bilkei (2005) and Amrik and Bilkei (2004), with sows receiving a diet supplemented with OEO subsequently displaying increased farrowing rates and producing more piglets born alive.

Careful consideration is required when selecting a phytogenic feed or water additive in order to see the benefits obtainable. Method of oil extraction, harvesting time, soil quality and environmental conditions can all influence the levels of OEO and the individual active components in a product. To see the true and consistent potential of OEO, it is important to select a product that is manufactured to consistently high quality standards; Orego-Stim is an example of such a product that delivers consistent results.

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