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Diverse effects of linseed oil and fish oil in diets for sows on reproductive performance and pre-weaning growth of piglets

S. Tanghe [a], J. Missotten [a], K. Raes [a,1], J. Vangeyte [b], S. De Smet [a,*]

[a] Laboratory for Animal Nutrition and Animal Product Quality, Department of Animal Production, Ghent University, Proefhoevestraat 10, 9090 Melle, Belgium

[b] Institute for Agricultural and Fisheries Research (ILVO), Technology and Food Science Unit, Burgemeester van Gansberghelaan 115, Box 1, 9820 Merelbeke, Belgium

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ABSTRACT

Perinatal mortality of piglets means a serious loss for the pig industry. Therefore, finding strategies to decrease stillbirths and increase piglet vitality is crucial. Supplementing the gestation and lactation diets with $n-3$ polyunsaturated fatty acids (PUFA), and especially docosahexaenoic acid (DHA), can be beneficial, as these PUFA are essential for the development of the foetus. Docosahexaenoic acid can be directly supplied from the maternal diet through addition of fish oil, or it may result from the conversion of dietary precursors such as alpha-linolenic acid, e.g. by addition of linseed oil. Until now, studies assessing the effects of $n-3$ PUFA on sow reproduction give equivocal results. Therefore, this study aimed to examine the effects of linseed oil and fish oil in the maternal diet of a large number of sows (734 sows in total) on their reproductive performance in the current and subsequent gestation. Furthermore, the effect of diet on the farrowing process, piglet weight and vitality was analysed. From day 45 of gestation and during lactation, sows were fed a palm oil diet or one of the six $n-3$ PUFA diets, each containing different concentrations (0.5%, 1% or 2%) of linseed oil, fish oil or their combination. Sows fed linseed oil had 0.9 more live born piglets ($P=0.02$) and 0.5 more weaned piglets ($P=0.02$) compared to fish oil fed sows. In the subsequent gestation, linseed oil fed sows had 1.3 and 1.5 more live born piglets compared to sows fed fish oil ($P=0.006$) or palm oil ($P<0.001$), respectively. No dietary effects were observed on piglet birth weight and litter weight, but linseed oil supplementation resulted in a higher piglet weight and litter weight at 5 days of age, compared to piglets from sows fed fish oil ($P=0.04$ and $P=0.02$, respectively) or palm oil ($P=0.02$ and $P=0.002$, respectively). Adding $n-3$ PUFA to the maternal diet had no effect on piglet vitality, but it increased the duration of farrowing ($P=0.05$).

1. Introduction

Perinatal mortality of piglets means a serious loss for the pig industry, as 10–20% of the piglets die before weaning (Edwards, 2002). One of the main causes of pre-weaning mortality is perinatal hypothermia due to delayed suckling (Herpin et al., 2002). Therefore, finding ways to improve piglet vitality, e.g. by accelerating the process of

* Corresponding author. Tel.: +32 9 264 90 03; fax: +32 9 264 90 99.
E-mail address: stefaan.desmet@ugent.be (S. De Smet).

[1] Present address: Laboratory for Food Microbiology and Biotechnology, Department of Industrial Biological Sciences, Ghent University – Campus Kortrijk, Graaf Karel de Goedelaan 5, 8500 Kortrijk, Belgium.

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standing up and reaching the udder, is essential to ensure a fast intake of colostrum and increase chances of survival.

Recently, attention is given to the supplementation of the gestation feed with polyunsaturated fatty acids (PUFA). Particularly the $n-3$ long chain (LC) PUFA docosahexaenoic acid (DHA, C22:6$n-3$) and eicosapentaenoic acid (EPA, C20:5$n-3$) are important. Docosahexaenoic acid is a structural component of the membrane phospholipids and present in high concentrations in the brain and retina (Stillwell and Wassall, 2003), whereas EPA is essential for the immune system as precursor fatty acid (FA) for anti-inflammatory eicosanoids and resolvins, and by inhibiting the production of pro-inflammatory eicosanoids derived from arachidonic acid (ARA, C20:4$n-6$; Calder, 2009). Eicosapentaenoic acid and DHA can reach the foetus either directly through placental transfer, by supplementing the sow diet with e.g. fish oil, or it may result from the conversion of precursor FA, by supplementing the sow diet with e.g. linseed oil, which is a source of the precursor FA alpha-linolenic acid (ALA, C18:3$n-3$). Polyunsaturated fatty acids are essential for the growth and development of the foetus (Innis, 1991). They are of particular importance during the second half of the pregnancy, which coincides with the period of rapid brain development, and inadequate supply of $n-3$ PUFA in this period has been associated with impaired visual and cognitive development (Campoy et al., 2012). Therefore, it is hypothesised that adding $n-3$ PUFA to the mid- and late gestation diet of the sow may positively influence sow reproductive outcome and piglet growth and vitality. In addition, one can hypothesise that supplementing $n-3$ PUFA to the sow lactation diet may affect follicle development and sow reproductive performance in the subsequent gestation.

Although several studies have examined the effects of fish oil or linseed oil supplementation of the gestation and lactation diet on sow reproductive performance, results have been inconsistent, probably in many cases because of the limited number of sows used. To our knowledge, only two studies used large numbers of sows to examine potential effects of fish oil on sow and piglet performance (Rooke et al., 2001b (196 sows); Smits et al., 2011 (328 sows)). However, both studies differed considerably in the duration of supplementation and the amount of fish oil supplemented (16.5 g salmon oil per kg diet, fed from immediately post-service until weaning (Rooke et al., 2001b) vs. 3.3 g salmon oil per kg diet, fed from day 107 of gestation until weaning (Smits et al., 2011)). Furthermore, no large scale studies using linseed oil supplementation have been performed. Therefore, the objectives of this study were to examine the effects of $n-3$ PUFA supplementation of the mid-gestation and lactation diets of a large number of sows on their reproductive performance during both the current and the subsequent cycle, using different concentrations and combinations of linseed oil and fish oil. Furthermore, the effects on the farrowing process, piglet vitality and piglet weights until weaning were assessed.

Supplementation of the gestation diet with fish oil has already been shown to decrease piglet birth weight (Rooke et al., 2001b), probably due to a decrease in ARA (Carlson et al., 1993). Indeed, high levels of $n-3$ PUFA are known to inhibit the formation of $n-6$ LC PUFA such as ARA from linoleic acid (LA, C18:2$n-6$), due to the competition for the Δ6-desaturase and preference of this enzyme for $n-3$ over $n-6$ FA (Kurlak and Stephenson, 1999). Therefore, in contrast to most other studies, the level of LA was kept constant in the diets to ensure an equal and sufficient supply of $n-6$ FA, in order to counteract this negative effect of $n-3$ FA supplementation.

2. Material and methods

2.1. Animals and diets

The trials were conducted on two farms of Danis NV in Belgium from January 2007 until November 2008, and were approved by the Ethical Committee of the Faculty of Veterinary Sciences and Bioscience Engineering of Ghent University (approval numbers EC 2006/119, EC 2007/062 and EC 2008/061).

Ten groups of sows (50% Landrace × 50% Large White; 734 sows in total, 47–91 sows per group; parities 1–12) were used in the experiment (five groups per farm). The farms practiced a 3-week or a 4-week batch production system and each group of sows represented one batch. The sows were inseminated with Piétrain pig semen and were fed a standard commercial gestation diet until day 45 of gestation. Afterwards, the sows were fed one of the seven experimental diets: (1) a palm oil diet (PO); or a diet including (2) 0.5% linseed oil (0.5% LO); (3) 2% linseed oil (2% LO); (4) 0.5% fish oil (0.5% FO); (5) 2% fish oil (2% FO); (6) 0.5% linseed oil and 0.5% fish oil (0.5% LO+0.5% FO); and (7) 0.5% linseed oil and 1% fish oil (0.5% LO+1% FO). The concentrations and combinations of linseed oil and fish oil were chosen after consultation of several feed companies, in order to comply with current practice or potential future application. Fish oil was obtained from INVE België NV (Baasrode, Belgium). Linseed oil and fish oil were included in the diet by replacement of palm oil. Four groups of sows (two groups per farm) were assigned to the PO diet and the other six groups were each allocated to one of the other experimental diets (0.5% LO, 2% LO and 0.5% LO+1% FO on farm 1; 0.5% FO, 2% FO and 0.5% LO+0.5% FO on farm 2; Table 2). To avoid a possible management bias, the farmers were not informed on the allocation of the experimental diets to the sow groups.

All gestation diets contained: beet pulp (210–250 g/kg), barley (215–220 g/kg), wheat (250–300 g/kg), maize (200 g/kg), molasses (10–20 g/kg), soy beans (10 g/kg), monocalcium phosphate (2–10 g/kg), chalk (38% Ca; 5–10 g/kg), salt (3.5 g/kg), phytase (Natuphos; 0.1 g/kg), choline chloride (75%; 0.7 g/kg) and a vitamin and mineral mix (5 g/kg). The following amino acids were added to the diet: L-lysine HCl (1.5 g/kg) and L-threonine (0.5 g/kg). The sows were housed in individual pens and were fed the diets from day 45 of gestation by dump feeder, to meet their daily requirements.

One week before the expected farrowing date, the sows were transferred to the partly slatted farrowing house, with 10 farrowing crates per compartment. The sows then received 2.5 kg/day of the lactation diet until farrowing. After farrowing, feed allowance was increased from 2 kg/day