

**The functional role and requirement for
long-chain omega-3 polyunsaturated fatty
acids in breeding gilts and sows**

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Abstract

The potential for supplemented omega-3 polyunsaturated fatty acids (PUFA) to increase sow reproductive performance when supplied from isocaloric diets containing low levels (3 – 6 g/kg of diet) of fish oil as a partial replacement for tallow was investigated. In the first experiment, there was an increase of 1 piglet live born ($P < 0.05$) to sows at the subsequent parity fed a supplemented diet before farrowing and during lactation. In contrast, litter size was unaffected when gilts were fed a supplemented diet with fish oil during puberty and early pregnancy. Furthermore in gilts, increasing the duration or level of supplementation did not improve litter size or embryo survival, possibly due to their inherently high level of fertility (82% embryo survival). In subsequent experiments, the effect of omega-3 supplementation on reproduction was evaluated in older parity sows known to have an inherently lower level of fertility compared with gilts. In parity 4 – 7 sows fed a supplemented diet pre-farrowing and during lactation continuing to mating, embryo survival at 23 d was increased (Omega-3 70% vs 61% in Controls; $P = 0.054$), without affecting ovulation rate. Subsequent experiments examined the response when supplemented diets were fed either during lactation continuing to mating; or after mating and during early gestation; or across both periods from lactation through to early gestation. Litter size born was maximised in the subsequent parity in sows fed fish oil diets from lactation to early gestation for 28 d, with the response being greatest in higher parity sows (+0.7 live born; and +0.9 total born, $P < 0.05$). In the following experiment this increase was associated with a 19% increase in embryo survival with omega-3 supplementation ($P = 0.061$). There was no effect on live weight or backfat during lactation; litter weight gain; piglet wean weight; and sow intake when gilts or sows were fed supplemented diets. The increase in embryo survival and litter size consistently observed in the sow studies was associated with increases in the omega-3 PUFA eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and were independent of energy intake or energy metabolism. Partially replacing tallow (wt/wt) with 3 – 6 kg levels of fish oil did not change plasma levels of the essential omega-6 fatty acids, linoleic acid (LIN) and arachidonic

acid (ARA). Using in-vitro cultures of granulosa cells it was demonstrated that progesterone production is increased with prostaglandin E₃ and there was evidence for PGE₃ to enhance the steroidogenic response to PGE₂. It is proposed that specific long-chain omega-3 fatty acids increases embryo survival in older sows due to improved oocyte quality and/or embryo development, possibly through synergistic activities of PGE₂ and PGE₃ on progesterone levels in the local ovarian-uterine circulation. Supplementation of diets with EPA and DHA from fish oil offers pig producers a nutritional approach to improve sow litter size in older parities thereby increasing longevity and lifetime performance.

Keywords: Omega-3 PUFA, sow fertility, embryo survival, longevity, prostaglandins, progesterone

Declaration

I declare that this thesis is my own work and contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Robert J. C. Smits, and, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person or persons, except where due reference has been made in the text.

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May 2012

Publications arising

- R.J. Smits, B.G. Luxford, M. Mitchell and M.B. Nottle (2011). Sow litter size is increased in the subsequent parity when lactating sows are fed diets containing n-3 fatty acids from fish oil. *Journal Animal Science* 89: 2731-2738
- R.J. Smits, B.G. Luxford, M. Mitchell and M.B. Nottle (2011). Sow fertility is improved by feeding diets supplemented with omega-3 fatty acids from fish oil during lactation through to early pregnancy. *Journal of Animal Science*. 89 (E-Supplement 2). Abstract 192, P.109
- R.J. Smits, D.T. Armstrong, L. Ritter, M. Mitchell and M.B. Nottle (2010). Progesterone production from granulosa cells of sows is enhanced equally by omega-3 derived prostaglandin E₃ and omega-6 derived prostaglandin E₂. *Reproduction, Fertility and Development* 22 (Supplement). P. 134 (abstract 334)

Co-authored publications

- M. Mitchell, R. Smits, N.O. Palmer, A.N. Filby and M. Lane (2010). Dietary omega-3 fatty acid supplementation alters embryo development and metabolism in sows. *Reproduction, Fertility and Development* 22 (Supplement: SRB abstract 337). P. 137

Research reports

- R.J. Smits and M. Mitchell (2009). Evaluation of supplementing long-chain omega-3 fatty acids as a nutritional approach to increase productivity and longevity in gilts and sows. Final Research Report, 2F-102. Pork CRC, Willaston, SA.

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