Dietary omega-3 polyunsaturated fatty acids alter the expression of fertility related genes in the cow

Key external stakeholders:
Scientists, animal nutrition companies; AI industry, Irish Cattle Breeding Federation (ICBF), beef and dairy farmers.

Practical implications for stakeholders:
Nutrition plays a fundamental role in reproduction and there is emerging evidence that dietary omega-3 polyunsaturated fatty acids (n-3 PUFA) supplementation may increase cow fertility independent of their role as energy substrates.

- Results from this research shows that some of the positive effects of n-3 PUFA on reproductive performance may be mediated by changes in gene expression in the uterus of the cow.
- The research results taken together with that of other studies, indicate that n-3 PUFA mediated modification of uterine function in cattle is worthy of further investigation.

Main results:
Dietary supplementation with n-3 PUFA altered the expression of genes which regulate implantation and pregnancy such as prostaglandin (PG) biosynthesis and the insulin like growth factor (IGF) system in the uterus of the cow. The results indicate an alteration in the cellular concentrations of the enzymes controlling the synthesis of key PGs and components of the IGF system in a manner which may positively influence uterine function and embryo survival.

Opportunity / Benefit:
The implications of this research for the broader animal science community and livestock industry are that enriching cattle diets with n-3 PUFA evokes significant alterations in the expression of uterine genes. However, it is only when the magnitude and timing of these effects are elucidated that appropriate supplementation regimens may be accurately and cost-effectively developed.

Collaborating Institutions:
NUIG, UCD, Nutreco
1. Project background:
Nutrition plays a critical role in the regulation of cow fertility. There is emerging evidence that dietary long chain n-3 PUFA may act as specific regulators of some reproductive processes. A number of studies where dairy cow diets were supplemented with a source of n-3 PUFA, mainly in the form of fish-oil or fishmeal, have reported beneficial effects on reproductive performance independent of their role as energy substrates. Therefore this nutritional strategy has potential for amelioration of the decline in bovine fertility.

The hormone PG is released by the uterus at about 16 days following insemination when an embryo is sufficiently well developed. This hormone will cause the cessation of pregnancy and the return to normal cycling. When an embryo is sufficiently well developed it produces a protein (interferon tau) which helps to counteract the negative effect of PG and aids the continuation of pregnancy. It is thought that feeding n-3 PUFA to cows in early pregnancy can help to suppress PG production, thus potentially increasing pregnancy rate. In addition, it has been demonstrated by colleagues at Teagasc and internationally that increases in IGF-1 in blood have been positively associated with improved fertility.

Gene expression is the process by which information from a gene (found in DNA) is used in the synthesis of a functional gene product which is generally a protein. Proteins carry out the main functions of a cell. The synthesis of IGF-1 occurs mainly in the liver however it is also locally produced in other tissues such as the uterus. In the current study we were interested in genes in the uterus that regulate the synthesis of PG, IGF-1 and important hormones that influence fertility and how these are affected through feeding supplementary n-3 PUFA in the diet.

2. Questions addressed by the project:
What are the effects of dietary supplementation of n-3 PUFA on uterine gene expression in cattle and how any changes in expression could potentially impact on fertility in cattle?

3. The experimental studies:
Beef heifers (n = 7) were supplemented with a rumen protected source of either a saturated fatty acid (control) or high n-3 PUFA (275g) (High PUFA) diet per animal per day for 45 days. These animals were slaughtered and uterine endometrial tissue was recovered. Tissue and blood samples were analysed to confirm that the diets offered had evoked different concentrations of n-3 PUFA in both systemic circulation as well as the uterus of the supplemented and control animals. The effect of dietary n-3 PUFA on uterine gene expression was then examined, with particular focus on three components:

- We investigated if feeding n-3 PUFA altered the expression of specific genes involved in the prostaglandin biosynthesis pathway in uterine tissue.
- Synthesis of IGF-1 mainly occurs in the liver however it is also locally produced in the uterus. We therefore examined if feeding n-3 PUFA altered expression of the genes that synthesize IGF-1 in liver and locally in the uterus.
- In an effort to gain a broader understanding of the role of n-3 PUFA in cattle, we conducted a study to analyse simultaneously the expression of 23,000 genes in the uterus of cows fed either control or high PUFA diets.

4. Main results:
1. Dietary supplementation with n-3 PUFA altered the expression of genes necessary for PG biosynthesis in the uterus. The results indicate an alteration in the cellular concentrations of the enzymes controlling the biosynthesis of PGs in a manner which may positively influence uterine function and embryo survival.
2. Dietary supplementation with n-3 PUFA altered the gene expression of components of the IGF system in both the uterus and liver of cattle; however, the changes occurred in a tissue dependent fashion. The pattern of expression of IGF-1 and IGF-2 in the uterus of animals fed the n-3 PUFA diet was similar to that previously observed in pregnant cows and may indicate a more suitable environment for embryo survival.

3. Dietary supplementation with n-3 PUFA can change gene expression in numerous biological processes which potentially have important roles in the establishment of early pregnancy, including prostaglandin biosynthesis, steroidogenesis, transcription factor regulation, immune response and tissue remodelling. An amendment to any of these processes has the potential to influence a variety of reproductive events and thus warrant further investigation into the possible regulatory mechanisms and effects.

5. Opportunity/Benefit:
The opportunities of this research for the broader animal science community and livestock industry are that enriching cattle diets with n-3 PUFA evokes significant alterations in the expression of uterine genes, particularly in those regulating the PG and IGF-1 biosynthesis and action, the pattern of which suggests a potential beneficial effect on fertility. It is only when the magnitude and timing of these effects are elucidated that appropriate supplementation regimens may be accurately and cost-effectively developed.

6. Dissemination:
Data from this study has been transferred through national and international conferences, scientific publication in international peer reviewed articles and in technical papers and magazines.

Main publications:


Popular publications:
Waters, S.M. Dietary polyunsaturated fatty acid supplementation modifies the expression of key uterine genes involved in cow fertility. TResearch Issue 2 - February 2007.


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