BCRC Beef Cattle Research Council
RESEARCH FACTS
Research & Technology Development for the Canadian Beef Industry
Beef Science Cluster

Does cow nutrition during pregnancy affect gene expression in the calf?

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Project Title:

The Impact of Nutrition and Residual Feed Intake on Tissue and Molecular Characterization, Manipulation of Maintenance Energy Costs, and Fetal Growth and Programming in Wintering Pregnant Beef Cows

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Background:

Traditional wisdom holds that an animal's genetics and the environment it lives in can both affect feed efficiency (and other traits). In contrast, an animal's genes do not directly influence the environment, and the environment does not directly influence an individual's genes. Genetic influences are passed on from parents to offspring, while environmental influences are not.

There is growing evidence that the situation is not that straightforward; in some cases the environment may have a direct impact on the expression of an individual's genes. This environmental impact might also be inherited, and is called epigenetics.

"Fetal programming" is a particular type of epigenetics. For example, extreme malnutrition during pregnancy may permanently affect the offspring's metabolism, and this change may continue to be passed down for several generations. This has been shown in other mammals (including humans after World War II), and may also occur in cattle.

Severe environmental conditions can affect whether (or which) sites on the animals DNA are modified by the addition of methyl groups. The addition (or loss) of these methyl groups may either increase or decrease gene expression in those regions of the DNA. These methylation patterns can be passed on for a generation or more.

Epigenetic effects have seldom been considered in nutritional studies involving pregnant cows and the post-natal growth and development of their calves. This may be important, given the wide year-to-year variations in feed quality and weather conditions that are experienced by beef cows from one year to the next.

Objective:

Examine how the pregnant cow's energy intake during the wintering feeding period affects fetal development and fetal programming, as well as post-natal calf growth and development.

What they did:

Pregnant mature beef cows were fed either 85% (LOW) or 140% (HIGH) of net energy requirements during the second half of pregnancy. Two-thirds of these cows (48; 24 LOW and 24 HIGH) calved naturally and raised their calves within the same environment until weaning. Cow weights and intakes were recorded during the trial, and calf weights were measured at birth and weaning. The other 24 cows (12 LOW and 12 HIGH) were slaughtered 4 weeks prior to parturition. Cow carcass data, fetal weight and other measurements were collected. Several fetal tissue samples were collected to measure gene expression and methylation in genes related to muscle growth and proliferation, fat deposition, nutrient transport and blood vessel formation.

What they learned:

Cows fed the HIGH diet ate more, grew more and weighed more than LOW cows, but there were no significant differences in carcass weight, fat depth, ribeye area or marbling score. Maternal dietary treatment did not affect placental weight or fetal weight, length, circumference or any fetal organ weights. Birth and weaning weights did not differ among dietary treatments in the remaining cows.

There were differences in gene expression in some important cell growth and proliferation genes related to fat deposition and muscle development in the fetal ribeye muscle. These differences in gene expression were less obvious in the eye of round and heart muscle. This means that the pregnant cow's diet might affect the calf's gene expression or the timing of fetal muscle formation. It could also mean that the fetus can control which tissues get priority and which tissues are restricted when nutrients are limited. Significant correlations between gene expression and fetal weight were found in both fetal ribeye and eye of round muscles, pointing to the importance of these genes in pre-natal growth and development.

DNA near the IGF2 (insulin-like growth factor 2) gene was more highly methylated in fetuses from cows fed the HIGH diet. This was more evident in the ribeye than in the eye of round muscle. In both muscles, increases in DNA methylation was associated with increased expression of the IGF2 gene.

What it means:

The results of this study suggest that maternal nutrition during pregnancy can result in changes in the methylation and expression of genes that regulate cell growth and differentiation in their fetuses, although no obvious effects were seen in fetal body size or dimensions. The next steps are to determine whether pre-natal nutrition also affects economically important beef production traits.

Maternal nutrition during pregnancy can result in changes in the methylation and expression of genes that regulate cell growth and differentiation in their fetuses.

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