

Choline deficiency during pregnancy influences milk composition in sows

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Choline is an essential nutrient that is used by the body in a number of ways. However, nearly 90 percent of adults do not get the recommended amount in their diets. For pregnant or lactating women, this is especially significant, as choline, much like folate or folic acid, has been shown to play a role in early brain development.

Researchers at the University of Illinois who study the impacts of nutrition on brain development using the piglet as a model have conducted a series of studies related to choline deficiency in sows during pregnancy. One such study reports that choline deficiency during pregnancy delays brain development in pigs.

In a more recent study published in *The Journal of Nutrition*, the researchers look at the impact choline deficiency during pregnancy has on the nutrient composition of sow [milk](#) up to 19 days after birth. Surprisingly, they found that when mothers did not have enough dietary choline during pregnancy, alterations in choline metabolites, fatty acids, and amino acids, for example, were occurring by the end of lactation.

If milk composition is altered, due to choline deficiency during pregnancy, this could have implications on the quality of nutrition the mother's offspring receives.

Ryan Dilger, a U of I animal nutritionist and a co-author on the paper, says the study provides new information about milk composition. "We did a lot of analyses not typically done on sow milk. The findings are

pertinent to both human clinicians and animal scientists," Dilger explains.

"In humans, many women of child-bearing age are not getting sufficient choline in their diets. While many countries have mandatory fortification programs to get the nutrient folate into the diets of women, those programs don't exist for choline. Choline is another nutrient we should definitely be looking at and it has been gaining emphasis since the Institute of Medicine officially recognized this nutrient as being essential in 1998," he adds.

Austin Mudd, a doctoral student and lead author of the study said another surprise in the study was seeing striking similarities in the overall choline metabolite composition in sow milk compared to human milk. Metabolites are molecules that play a critical role in metabolism in the body.

"When we look at the nutrient profiles, those compositions are very close to what we would see in humans, which is different than what we would see in rodent and bovine milk. This helps in establishing the pig as an excellent model for studying choline deficiency, especially in terms of lactation, because there are similar proportions of choline metabolites that likely have similar physiological importance," Mudd says.

During the study, pregnant sows were provided a choline sufficient or choline deficient diet. Milk was then collected after sows gave birth at days 0 (colostrum), 7-9 (mature milk), and 17-19 (pre-weaning). The milk was analyzed for concentrations of choline metabolites, fatty acids, and amino acids.

The researchers analyzed seven choline metabolites, and observed that free choline and betaine—from the oxidized product of choline—was lowered by the end of lactation (18 days).

Choline and its derivative metabolites are considered "methyl donors." Methyl groups aid in many functions in the body, in both animals and humans, and are important in gene expression. Choline can be obtained in the diet—through foods like milk, eggs, poultry, fish, and grains—and is supplied in human and animal milk. It is typically included in infant formula.

In addition to changes in the choline metabolite profiles, the researchers also saw changes in milk fatty acids and milk amino acids by the end of lactation. Both showed a pattern of increasing by day 19.

"Fatty acids showed the same pattern, that if the sow was provided adequate choline throughout gestation and lactation, between days 0 and 7, fatty acids increased and then plateaued by day 19, versus in those that were deficient, we observed a linear increase," Dilger explains.

"If we had followed these sows beyond 19 days of lactation, we could learn just how long perinatal choline deficiency may influence fatty acid composition of the milk."

Although the study did not explore what more long-term effects of alterations in the milk compositions would mean for piglet, or human development, Mudd did stress that the takeaway is that choline deficiency affected more than just choline in milk composition.

"This shows doctors and breast-feeding mothers why choline is so important," Mudd says. "If you're deficient in choline, you're not only altering choline or its metabolites in the milk, but also the fatty acids and the amino acids. It's not just one thing that's being impacted. That's really where our work differs from what's been done in rodents and, to some extent, in pigs. Most other studies just look at choline metabolites. But we understand that babies drink milk not just for choline, but for everything. So if a mother is deficient in choline, what else is being

impacted and how will that affect later development? This could be used as a stepping stone for future studies, especially those where we look at the epigenetic implications of the altered diet."

Dilger adds that the changes they saw in milk composition is only piece in understanding how what affects an infant's development.

"We are altering a single nutrient in choline, and understanding how that affects the production and composition of that milk. There are slight changes we can show. But in the end, the composition of that milk is only one factor," Dilger explains. "Other factors, such as the genetics and physiology of the infant, in addition to the microbiota, which includes all microbes in and on the body, comes into play. This is just one of a number of complex components influencing the baby."

In a previous study, Mudd and Dilger look at brain development in piglets when the mother has had a sufficient or deficient choline supply. After being born, piglets were either put on choline-sufficient or choline-deficient milk replacers. They found that whether the mother had adequate choline during pregnancy mattered more for piglet brain development than what diet the piglet was put on after being born, when the only dietary factor being altered was choline. Also, they found that a limited supply of choline during pregnancy profoundly affects brain maturation.

"That paper speaks to the developmental role of choline in brain growth and overall function. In that study, we learned that differences in perinatal choline intake influence structural development of the brain, including maturation of white matter in brain regions that develop relatively late in the postnatal period. Studying the effects of diet on neurodevelopment by focusing on brain regions experiencing significant growth and development postnatally is a major reason we use the pig in our laboratory," Dilger says.

In two other recent studies related to nutrition and brain development, the researchers explore brain development between piglets that have been artificially reared versus sow-reared, as well as examine concentrations of oligosaccharides, a bioactive compound known to influence neonatal development, present in sow milk during lactation.

But the current paper, Dilger describes as having a more utilitarian piece. "If we want to understand how to use the pig as a model for studying human infants, we need to learn how to optimize the diet. This current study gives us a baseline of what is in sow milk and how we can alter the composition of infant formula designed for piglets to test brain development. We are asking, 'What are the norms? What are the differences?'

"These two pieces of work on choline deficiency provide pivotal evidence to justify the inclusion of more [choline](#) in prenatal supplements and diets of lactating mothers," he says.

More information: Austin T. Mudd et al, Perinatal choline deficiency delays brain development and alters metabolite concentrations in the young pig, *Nutritional Neuroscience* (2015). [DOI: 10.1179/1476830515Y.0000000031](#)

Reeba M. Jacob et al. Comparison of Brain Development in Sow-Reared and Artificially Reared Piglets, *Frontiers in Pediatrics* (2016). [DOI: 10.3389/fped.2016.00095](#)

Austin T. Mudd et al. Porcine Milk Oligosaccharides and Sialic Acid Concentrations Vary Throughout Lactation, *Frontiers in Nutrition* (2016). [DOI: 10.3389/fnut.2016.00039](#)

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