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How Does Moo-ving to Pasture Feeding Affect the Nutrient Composition of Cows' Blood and Milk?

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How Does Moo-ving to Pasture Feeding Affect the Nutrient Composition of Cows' Blood and Milk?

—Jillian Smith (Editor: Brigid C. Casellini)

If someone had asked me what I thought my undergraduate education would entail, it definitely would not have included anything to do with cows. Nor did I see myself sitting in a cow pasture at dusk awaiting a photo shoot for the cover of the *University of New Hampshire Magazine*. With that said, I would not change a thing about my undergraduate research experience. Through studying carotenoids in cows' blood, milk, and milk products, I was able to greatly enhance my educational experience at the University of New Hampshire.

Carotenoids are made up of over 700 fat-soluble *phytonutrients*— the organic compounds found in plants that are responsible for the bright colors of foods like carrots, tomatoes, and other dark green, yellow, orange, and red fruits and vegetables. Unlike photosynthetic plants and bacteria, animals and humans cannot synthesize carotenoids and must instead consume them in their diet. Although carotenoids are not essential for life, studies have demonstrated that increased consumption of carotenoids may be linked to the decreased risk of: cardiovascular disease, cancer, age-related macular degeneration, cataracts, and immune system decline (Rao et. al., 2007) (Mares-Perlman et. al., 2002).

The author (center), Amy Beliveau (right), and Dr. Joanne Curran-Celentano (left) posed for the photo shoot in the middle of cow pasture at dusk. My oh my, the black flies! (*Courtesy of Lisa Nugent of UNH Photographic Services*)

A growing interest in enhancing the health promoting properties of foods, as well as a concern over the environmental and social impact of food sourcing, is currently challenging the conventional food system. This new interest is evident in the small but steady demand for organic milk. By USDA Certified Organic standards, animals must be pasture fed for a minimum of 120 days in order for their products to be classified as organic. Research indicates that various factors including diet, breed, and stage of lactation all impact the nutritional value and composition of milk. The objective of my study was to understand how two different feeding practices affect the bovine blood carotenoid concentrations over time and how this relates to the carotenoid concentration of the milk produced. I compared pasture feeding at an organic dairy to *total mixed ration (TMR)* feeding at a conventional dairy. TMR consists of various feedstuffs including forages, grains, protein supplements, vitamins, and minerals blended into complete rations to meet the dietary needs of the cow.

My research project was meant to complement the research already taking place in Dr. Joanne Curran-Celentano's laboratory. She and graduate student Amy Beliveau had been studying the effects of time, season, and feeding practices on milk and milk product carotenoid concentrations from an organic dairy and a conventional dairy. As blood is the source of carotenoids in the milk, my study intended to build on theirs by looking at the effects of time and feeding practices on blood carotenoid concentrations in the same cows that Beliveau had analyzed in her milk research (Beliveau, 2012). I spent a semester familiarizing myself with the literature on this topic as well as the laboratory techniques that were necessary to carry out the project. I also applied for funding through the Hamel Center for Undergraduate Research and was fortunate to receive an Undergraduate Research Award. Finally, I commenced my research in the spring of 2012.

The Extraction Procedure: From Blood to Carotenoids

I was fortunate to use samples collected by a graduate student who was studying the fatty acid profile of cows' blood. She used a large needle to extract blood samples from the tail vein or artery of nine Jersey cows at the UNH Organic Dairy Research Facility and nine Jersey cows at the UNH Fairchild Dairy Teaching and Research Center. Samples were stored in separate vials and taken bimonthly from May 11, 2011 to November 10, 2011. The cows at the organic dairy grazed on pasture from the end of May to the end of October, whereas the cows at the conventional dairy were fed exclusively TMR. Due to the climate in New Hampshire, the nutrient content of the pasture from November to the end of May was not sufficient enough to provide the cows with optimal nutrition and therefore, during the colder months, the cows at the organic dairy were given TMR. The components of the TMR at both dairies were dissimilar from one another.

The blood carotenoids evaluated in this study were lutein, zexanthin, β-cryptoxanthin, α-carotene, β-carotene, and 13-*cis* β-carotene. Vitamin A and Vitamin E were also included in the analysis because the data may be useful for further research. To measure the carotenoid concentrations in the blood samples, I used the Handelman et al. carotenoid extraction process (Handelman et. al., 1991). This process involved adding different solvents to each blood sample and centrifuging the samples to separate the organic components, which contain the carotenoids, from the inorganic components. The carotenoids extracted were then separated via High Performance Liquid Chromatography (HPLC). I took the data produced from the HPLC and entered all of the numbers into an enormous Microsoft® Office Excel 2007 (Microsoft Corporation, Redmond, WA) spreadsheet. Statistical analyses were generated by SPSS® version 19.0 (SPSS Inc. Chicago, IL).

The author in the Kendall 407 laboratory where all the extractions took place.

And the Results Were...

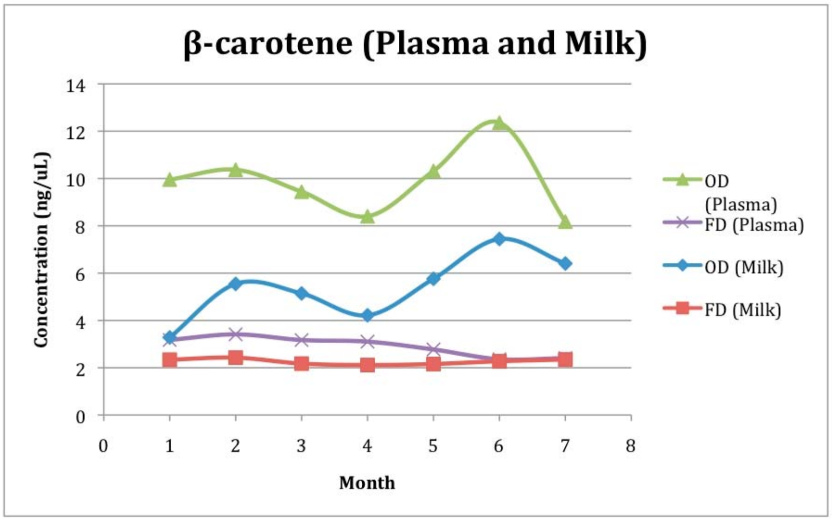
Results showed that blood concentrations of lutein, zeaxanthin, β-cryptoxanthin, β-carotene, and Vitamin E significantly changed over time from the baseline at both dairies. However, statistics showed that the fluctuation pattern exhibited by each dairy was significantly different. Overall, the nine Jersey cows from the organic dairy had higher concentrations of blood lutein, zeaxanthin, α-carotene, and β-carotene than the nine Jersey cows from the conventional dairy. The carotenoid concentration of the pasture-fed cows also was higher than the carotenoid concentration of the TMR-fed cows.

These findings are important because they confirm that nutrient concentration in the blood is highly variable over time. They also show that the changes are highly dependent on diet and feeding practices. Due to the many known factors associated with alterations in blood composition, including the geographical location, the breed of the cow subjects, the dairy management practices, the health of the animals, and the weather, it is not possible to fully correlate the variations with a diet of pasture or TMR.

The Bigger Picture

To better understand the impact of this study, I compared the blood carotenoid concentration with the milk carotenoid concentration of the same cows at each dairy facility (Beliveau, 2012). I hypothesized that some of the carotenoids present in the blood would not be present in the milk but, contrary to my belief, all of the components of interest in the blood were detected in the milk. As I expected, the concentrations of carotenoids at both dairies were typically higher in the blood than in the milk. This is because the conversion of blood carotenoids to milk carotenoids is not absolute. Carotenoids in the blood are used in many biochemical processes and are stored within the fat tissue, thus reducing the amount of nutrients available for absorption into the milk.

I also hypothesized that the trends in blood and milk carotenoid concentrations over time would be similar although syncopated, or in other words, blood carotenoid concentrations would increase or decrease before milk carotenoid concentrations would. However, this pattern was not illustrated by my study. The results showed that blood and milk carotenoid concentrations varied at very analogous time points at both the organic and conventional dairies, although the patterns exhibited by each dairy were different.



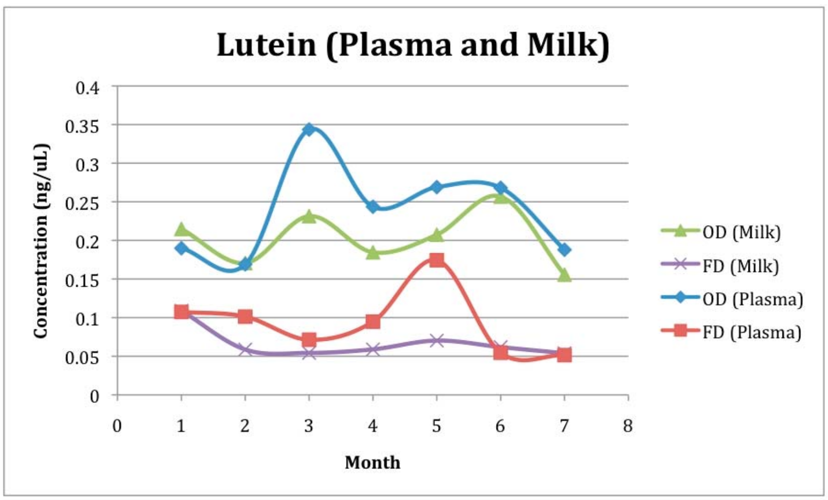


Fig.1 (top): The changes in blood (plasma) and milk b-carotene concentrations over time at both dairies. **Fig.2** (bottom): The changes in blood (plasma) and milk lutein concentrations over time at both dairies.

Fluctuations in the blood (plasma) and milk b-carotene concentrations at the organic dairy (OD) followed a similar pattern over the course of the study; however, the blood b-carotene concentration was greater than the milk b-carotene concentration (see Fig. 1). The fluctuations in the blood and milk b-carotene concentrations at the conventional dairy (FD) were less prominent over the course of the study. Overall, b-carotene concentrations were greater in the blood and the milk at the organic dairy compared to the conventional dairy.

Fluctuations in the blood and milk lutein concentrations at the organic dairy (OD) followed a similar pattern over the course of the study, but again the blood lutein concentration was greater than the milk lutein concentration (see Fig. 2). The fluctuations in the milk lutein concentration from the organic dairy (OD) were more pronounced than the fluctuations in the milk lutein concentration at the conventional dairy (FD). Overall, similar to b-carotene, lutein concentrations were greater in the blood and the milk at the organic dairy than those at the conventional dairy.

Comparable results were seen for blood and milk zeaxanthin, β-cryptoxanthin, and α-carotene concentrations at both dairies. Blood and milk Vitamin E concentrations were comparable at both dairies, but levels of Vitamin E in the blood were more variable over time. The concentration of Vitamin A was higher in the milk than in the blood at both dairies. More studies are needed to investigate the exact trends in data as this data represents changes from month to month and may not be specific enough to gauge week-to-week or day-to-day changes in carotenoid concentrations.

We like milk, so why should we care?

By evaluating nutrient alterations in the plasma over time, inferences can be made about the nutrient content of the milk and milk products. This study suggests that the blood carotenoid concentration may be a good indicator of the milk carotenoid concentration in Jersey cows. The results show that the blood and milk from cows grazed on pasture may have higher carotenoid concentrations compared to the blood and milk from cows fed TMR. This research may provide useful information for dairy farmers because by increasing the carotenoid concentrations of their cows' diets through pasture feeding, they could potentially create products that are of higher nutritional value to consumers. Because it is shown that consumers want food products that provide added health benefits, they may likely choose to purchase milk with greater nutritional value, and in turn the augmentation of milk consumption could profit dairy farmers.

Participating in this project opened my eyes to research, uncovering a skill that I did not know I possessed. It was amazing to watch the progression of my research and to finally see the end results. I had a sense of joy (and relief) when my data showed significance. It was also interesting to see how the results of this research compared to the results of Beliveau's research.

I have now contributed something significant to the fields of nutrition and dairy science. Even though this project is complete, I wish to take part in more research in the future either in graduate school or in my professional life. This opportunity helped to better my research skills to prepare me for what lies ahead. I am truly grateful for undergraduate research at the University of New Hampshire.

I would not have been able to accomplish this project without the support and encouragement of numerous people and organizations. Foremost, I would like to thank Dr. Celentano for her continuous guidance and inspiration. Without her, I would not be the person I am today. I must also thank Karen Semo for her patience and willingness to help me through the laboratory procedures, as well as Amy Beliveau for acting as my mentor and companion over the past year. A special thank you to the Hamel Center for Undergraduate Research and its donors for the financial support necessary to complete my research.

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Author and Mentor Bios

Jillian Smith of Cape Elizabeth, Maine graduated from the University of New Hampshire in December 2012 with a bachelor of science in nutrition, a focus in dietetics, and a minor in Spanish. Her research was conducted with the help of an Undergraduate Research Award (URA) and was done to complete her Honors in Major thesis. Although Jillian wanted to work with human subjects, she was enthused by the research on cows and dairy products that was being conducted in Dr. Joanne Curran-Celentano's laboratory. Unfamiliar with cows, Jillian spent a semester learning about everything from farming practices and the lactation of cows to how to make mozzarella cheese. She said that she was able to form wonderful relationships with her new colleagues in the lab, all of whom helped to shape her into the person she is today. Jillian decided to submit to *Inquiry* in order to share her research with a broader audience and has found the experience challenging but also enjoyable. Now a UNH graduate, Jillian hopes to become a registered dietitian and specialize in pediatric nutrition. She was recently accepted to the Brigham and Woman's Dietetic Internship program in Boston.

A frequent mentor to students writing research articles for *Inquiry*, Dr. **Joanne Curran–Celentano** has been a tenure track faculty member at the University of New Hampshire since 1986. She is a professor in the Department of Molecular, Cellular, and Biomedical Sciences, specializing in human nutrition. Dr. Curran–Celentano has mentored more than a dozen students involved in research at the University, a job she finds very rewarding both for herself and for her students.

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