# UMR Herbivores

## Team Feed, Digestion, Microbes Metabolism, and Nutrition (Dinamic)

## Progress on variation factors about vitamin concentrations in the milk of ruminants

Dairy products are a major source of vitamins in the human diet. Variation factors of their concentrations in ruminant milk are still not known. The direct comparison of milks of goats and cows receiving the same diets demonstrated that concentrations of vitamin $B_2$ are similar between the 2 species. Alternatively, concentrations are higher for vitamins $B_9$ and $B_{12}$ and lower for vitamin $B_6$ in cows than in goats' milk. Another new result is that vitamins A, E and $B_6$ concentrations are higher in the milk of pasture grazing goats. Finally, when lipid supplements were given as extruded linseed in the diet of lactating cows, it didn't enriched their milk with vitamins A and E although it seemed to increase the availability of these vitamins for the cows. When the supplements are based on corn oil plus starch, it increases milk vitamins $B_2$ and $B_9$ concentrations in cows but not in goats. Then, according to studied factors and vitamins, distinct regulatory mechanisms seem to occur, at the level of intakes, digestive processes or mammary metabolism.

Vitamin deficiencies more often occur in developing countries, especially in pregnant women and young children. In industrialized countries, symptoms of clinical deficiencies are rare but epidemiologic studies revealed that intakes lower than recommendations are very prevalent and can be linked to chronic diseases predisposition in the population (Troesch et al., 2012). Consequently, covering vitamin requirements in the population remains a public health issue in occidental societies as well as less economically developed countries (WHO, 2008). Cow milk and dairy products contain all the 13 vitamins and are a major source for several of them in human nutrition: A, D, $B_2$, $B_5$, $B_9$ and $B_{12}$ (Coudray et al., 2011 ; Vissers et al., 2011). These feedstuffs have also additional assets, notably their ability to be transported, stored, preserved, available all over the year without marked seasonality, and economically affordable, per comparison to other vitamin sources (Drewnowski, 2011). Thus, it seems important to identify and understand the main variation factors of vitamin concentrations in the milk of ruminants in the way as to propose the levers to optimise them, for the benefit of the many.

***Specificities related to ruminant species.*** Through a direct comparison, we were able to put into evidence the particularities of B vitamin concentrations in the milk between cows and goats. We observed that, when fed strictly the same diet, milk vitamin $B_2$ concentrations are equivalent between the 2 species whereas vitamin $B_9$ and $B_{12}$ concentrations are significantly 10- and 16-fold lower, respectively, in the milk of goats, and vitamin $B_6$ concentration is slightly higher (+21%) in this species. Some of these differences are likely to occur in line with species characteristics at the level of the mammary gland transfer of the vitamins. Indeed, plasma concentrations in vitamins $B_2$ and $B_6$ are 2 to 3-fold higher in the cows whereas the vitamin $B_{12}$ concentration is 3.4-fold higher in the goats in the study.

***A strong variability linked to forage nature.*** Alternatively, a study in caprine commercial farms let evaluate the livestock practices affecting vitamin concentrations in goat milk. Diet composition has the most impact, especially the forage composition. Then, grazing goats are producing a milk significantly richer in vitamins A (+45%), E (+64%) and $B_6$ (+35%) than goats fed a diet rich in maize or herb silage.

***Regulation processes linked to dietary intakes, to ruminal activities or to mammary mechanisms***. A model experimentation aimed to determine the impact of fat supplements on the vitamin status and milk concentrations in ruminants. The effect of feeding one of three different lipid sources (among which some able to modulate the rumen microbiota activity) was tested on the B vitamin status of cows and goats. Whereas hydrogenated palm oil or marine algae powder induced no change in the milk per comparison to the control diet, neither in the cow nor in the goat, the diet complemented with corn oil and wheat starch induced a significant increase in milk concentrations of vitamins $B_2$ (+30%) and $B_9$ (+36%) in the cows but not in the goats. At the same time, milk concentrations of vitamins $B_6$ and $B_{12}$ were not different according to lipid supplements. Corn oil and wheat starch simultaneously increased plasma vitamin $B_{12}$ concentration whereas the marine algae powder increased plasma concentration of vitamins $B_6$ and $B_9$. All these variations could suggest a stimulation of the bacterial synthesis of these vitamins in the rumen of the cows. However, since a variation in one of the biological compartment (plasma or milk) does not go with an effect in the other one, it would indicate that a regulatory mechanism occurs at the mammary gland level, independently of the plasma concentrations. Concerning the compounds belonging to the family of the lipophilic vitamins, extruded linseed supplementation in the diet of dairy cows induced an increase in total plasma vitamin E but not vitamin A and its carotenoid precursors, and it didn't led to a milk enrichment with these compounds. The plasma vitamin E increase was explained by its higher dietary intake in the cows fed with the linseed supplement per comparison to the control diet.

This work illustrated for the first time that milk vitamin concentrations (especially those belonging to the complex B) can strongly vary according to production conditions (species and diet mainly). Vitamins act in the nutritional differentiation of milks according to their production conditions. It implies that 1) the support in vitamins to consumers by dairy products is varying and 2) dairy products can be more important for vitamin provision to fulfil requirements in human feeding. Aiming to optimize the nutritional quality of dairy products, it is necessary to explore more deeply the vitamin family, the variation factors of their concentrations in milk and dairy products as well as the regulatory mechanisms of these variations. For this, the digestive mechanisms conditioning the availability of these compounds for the ruminant will have to be deciphered (synthesis by the rumen microbiota, intestinal digestibility). In addition, processes of mammary transfer seem to play an important regulatory role as well, sometimes limiting for milk vitamin enrichment.

## Publications

Graulet B., Cirié C., Martin B. (2019) Contrasted effects of dietary extruded linseed supplementation on carotenoid and liposoluble vitamin status in lactating Holstein or Montbéliarde cows fed hay or corn silage. Journal of Dairy Science
102, 6210-6225, DOI 10.3168/jds.2018-16138
Laurent C., Graulet B., Caillat H., Girard C. L., Jost J., Bossis N., L. Lecaro, A. Ferlay (2019) Characterization of milk goat composition according to feeding systems in Western France. [Poster] Presented at EAAP 2019, p 218. Ghent
(Belgium), 26 - 30 Aug 2019. In : Proceedings of 70th European Federation of Animal Science.
Graulet B., Fougère H., Girard C.L., Laverroux S., Popova M., Bernard L (2019). Contrasted status in B vitamins between dairy cows and goats fed various lipid supplements. [Talk] Presented at 11th International Symposium on Ruminant Physiology (ISRP), Leipzig, DEU (2019-09-02 - 2019-09-06). Advances in Animal Biosciences, 100, p 483.

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