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UV-B LIGHT IRRADIATION DURING AUTOMATIC MILKING FOR VITAMIN D SUPPLEMENTATION IN DAIRY COWS

OZRAČIVANJE UV-B SVETLOM TOKOM AUTOMATSKE MUŽE KAO METOD ZA POBOLJŠANJE STATUSA VITAMINA D KOD MLEČNIH KRAVA

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ABSTRACT

Vitamin D has a significant role in mineral metabolism, bone tissue homeostasis, and immunity. Cattle can synthetize vitamin D in the skin in a linear dose dependent manner of ultraviolet irradiation. The objectives of this study were to investigate the possibility of vitamin D supplementation with narrow-band UV-B irradiation during automatic milking time and to determine the influence of hair and pigmentation of skin and hair on cutaneous vitamin D_3 synthesis in dairy cows. Holstein Friesian cows from one farm were enrolled into the study. A narrow-band UV-B light (peak irradiation at 295 nm) was custom-made and mounted into the automatic milking system. Cows were split into three equal random groups using stratified sampling based on milk yield in the previous lactation, days after calving and the percentage of black area on their back. The first group was shaved and exposed to a daily dose during automatic milking, the second group was left unshaved and irradiated during the automatic milking with maximal possible dose and the third group served as control. The cows were blood sampled before and 60 days after the start of irradiation. The concentration of 25-hydroxyvitamin D was measured using an automated immune enzyme fluorescence assay. The increase in the 25-hydroxyvitamin D concentrations before and after the irradiation was statistically significant ($p>0.001$) between the shaved, unshaved and control groups. The irradiated groups shaved and unshaved produced more milk per day than the control group. Narrow-band UV-B LED light limited to automatic milking time was successful in increasing the concentrations of 25-hydroxyvitamin D in Holstein Friesian cows. Hair was reducing cutaneous vitamin D production. UV-B irradiation of cows during automatic miking is a novel way of vitamin D supplementation that does not expose farm equipment and personnel to UV-B irradiation and does not interfere with the daily routine on farm.

Keywords: cattle, ultraviolet-B light, 25-hydroxyvitamin D, milk yield, skin, hair

SAŽETAK

Vitamin D ima značajnu ulogu u mineralnom metabolizmu, homeostazi koštanog tkiva i imunitetu. Goveda mogu sintetizovati vitamin D u koži na linearni način zavisan od doze ultraljubičastog zračenja. Ciljevi ovog istraživanja bili su da se ispita mogućnost suplementacije vitamina D uz uskopojasno UV-B zračenje tokom automatskog vremena muže i da se utvrdi uticaj dlake i pigmentacije kože i dlake na kožnu sintezu vitamina

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D3 kod mlečnih krava. Holštajn frizijske krave sa jedne farme su bile uključene u studiju. Uskopojasno UV-B svetlo (vršno zračenje na 295 nm) je napravljeno po meri i montirano u automatski sistem za mužu. Krave su podeljene u tri jednake nasumične grupe korišćenjem stratifikovanog uzorkovanja na osnovu prinosa mleka u prethodnoj laktaciji, dana nakon teljenja i procenta crne površine na njihovim leđima. Prva grupa je obrijana i izložena dnevnoj dozi tokom automatske muže, druga grupa je ostavljena neobrijana i ozračena tokom automatske muže maksimalnom mogućom dozom, a treća grupa je služila kao kontrola. Krv krava je uzeta pre i 60 dana nakon početka ozračivanja. Koncentracija 25-hidroksivitamina D je merena korišćenjem automatizovanog testa fluorescencije imunoloških enzima. Povećanje koncentracije 25-hidroksivitamina D pre i posle zračenja bilo je statistički značajno (p>0,001) između obrijane, neobrijane i kontrolne grupe. Ozračene grupe obrijane i neobrijane davale su više mleka dnevno od kontrolne grupe. Uskopojasno UV-B LED svetlo ograničeno na automatsko vreme muže bilo je uspešno u povećanju koncentracije 25-hidroksivitamina D kod holštajn frizijskih krava. Dlaka je smanjivala proizvodnju vitamina D u koži. UV-B zračenje krava tokom automatskog muženja je nov način dodavanja vitamina D koji ne izlaže opremu i osoblje na farmi UV-B zračenju i ne ometa dnevnu rutinu na farmi.

Ključne reči: goveda, ultraljubičasto-B svetlo, 25-hidroksivitamin D, prinos mleka, koža, dlaka

INTRODUCTION

Vitamin D is an essential fat-soluble vitamin. However, some researchers regard it as a hormone due to its function in the organism. It has a significant role in mineral metabolism, bone tissue homeostasis, and immunity (Nelson et al., 2012). Cows can acquire vitamin D in various ways, e.g. via feed, parenteral injections or through UVB irradiation from the sun or artificial lighting. Vitamin D in feed can consist of either plant/fungal ergocalciferol or animal cholecalciferol. There is currently only one approved vitamin D supplement for cattle in the European Union and that is cholecalciferol. Animals can also synthesize their own vitamin D when 7-dihydrocholesterol in the skin is irradiated with UVB light, which leads to the production of cholecalciferol. The optimal wavelength of UVB light for cholecalciferol synthesis is between 295 and 300 nm (Jakobsen et al., 2015). Despite its importance, many cattle are deficient in vitamin D due to inadequate supplementation or insufficient sun exposure. In studies conducted at the Veterinary Faculty in Ljubljana, Slovenia, on permanently housed Holstein Friesian cows and calves on a commercial dairy farm, we found that blood vitamin D status was deficient in all seasons (unpublished data). Cows also experience a decline of blood concentrations of vitamin D in early lactation (0-30 days in milk) due to higher demands of calcium for milk production and decreased feed intake before and after parturition (Nelson et al., 2016; Sorge et al., 2013). Our finding and findings of other studies suggests that more attention should be paid to vitamin D supplementation in dairy cattle.

Vitamin D can be important for the prevention of some diseases, like rickets, osteomalacia and hypocalcaemia (Lean et al. 2014). A link between vitamin D and energy metabolism in cattle was demonstrated, as it influences insulin growth factor 1 (IGF1) (Rodney et al. 2018). It can be concluded that vitamin D supplementation improves cattle welfare.

MATERIALS AND METHODS

Holstein Friesian cows from a commercial dairy farm with permanent indoor housing (zero-grazing systems) were enrolled into the study. Cows were reared in loose housing with free stalls. Automatic milking has been implemented in the farm. A narrow-band UV-B light using LED technology (peak irradiation at 295 nm) was custom-made (Figure 1) so that it irradiated just back of cows (patent pending) and mounted into the automatic milking system. The light was connected to a computer that recorded exposure of individual cows to the light irradiation.

Cows were split into three equal random groups using stratified sampling based on milk yield in the previous lactation, days after calving and the percentage of black area on their back. The first group was shaved and exposed to a daily dose of almost 100 J/m2, the second group was left unshaved and irradiated maximal daily dose (more than 3x higher than in shaved group) during the automatic milking and the third group served as

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control. All cows were housed together in the same group, during the same time, receiving the same management and ration. The cows were blood sampled at the beginning of the study and 2 months after the start of irradiation. The concentration of 25-hydroxyvitamin D was measured using an automated immune enzyme fluorescence assay, using MiniVidas automatic analyser (bioMérieux, France) according to manufacturers' instructions.

Figure 1: UV-B light that was used in the automatic milking machine

RESULTS AND DISCUSSION

The increase in the 25-hydroxyvitamin D concentrations before and after the irradiation was statistically significant ($p>0.001$) between the shaved, unshaved and control groups. The irradiated groups shaved and unshaved also produced statistically significantly more milk per day than the control group.

Use of UV-B lights during automatic milking increases blood vitamin D and could be used for supplementation of vitamin D in dairy cows that are not exposed to natural sunlight. The positive aspect of use of the UV-B light in the automatic milking machine is that it does not expose more UV sensitive skin of the cow to irradiation, as well as equipment and farm workers. In comparison to our study, a special UV light that emitted UV light with a wavelength between 250 and 400 nm was used for irradiating cows. They also showed that 25-OHD levels could be raised in blood as well as in milk with UV light exposure (Jakobsen et al., 2015). However, in our study optimal UV wavelength was used and limited only to presence in the automatic milking machine (limited by space and time), with limited skin surface of the most resilient skin exposed, which is significant advantage of our device.

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The cutaneous production of vitamin D is regulated and cannot be overdosed, which cannot be said for other ways of vitamin D supplementation. (Nelson et al., 2016; Sorge et al., 2013). Additionally with UV irradiation, vitamin D is provided to the cows independent of their daily dry matter intake.

Narrow-band UV-B LED light limited to automatic milking time was successful in increasing the concentrations of 25-hydroxyvitamin D in Holstein Friesian cows. Hair was reducing cutaneous vitamin D production. UV-B irradiation of cows during automatic miking is a novel way of vitamin D supplementation that does not expose farm equipment and personnel to UV-B irradiation and does not interfere with the daily routine on farm or with the milking process. It can be used in organic farming as well, where supplementation of vitamin D is especially costly.

LITERATURE

1. *Goff J.P. The monitoring, prevention, and treatment of milk fever and subclinical hypocalcemia in dairy cows. The Veterinary Journal 2008, 176, 50–57.*
2. *Jakobsen J., Jensen S.K., Hymøller L., Wreford Andersen E., Kaas P., Burild A., Jäpelt R.B. Short communication: Artificial ultraviolet B light exposure increases vitamin D levels in cow plasma and milk. Journal of Dairy Science 2015, 98, 6492–6498.*
3. *Martinez N., Rodney R.M., Block E., et al. Effects of prepartum dietary cation-anion difference and source of vitamin D in dairy cows: Lactation performance and energy metabolism. Journal of Dairy Science 2018, 101, 2544–2562.*
4. *Nelson C.D., Reinhardt T.A., Lippolis J.D., Sacco R.E., Nonnecke B.J. Vitamin D signaling in the bovine immune system: a model for understanding human vitamin D requirements. Nutrients 2012, 4, 181-196.*
5. *Nelson C.D., Lippolis J.D., Reinhardt T.A., Sacco R.E., Powell J.L., Drewnoski M.E., O'Neil M., Beitz D.C., Weiss W.P. Vitamin D status of dairy cattle: Outcomes of current practices in the dairy industry. J. Dairy Sci. 2016, 99, 10150–10160. https://doi.org/10.3168/jds.2016-11727*
6. *Rodney R.M., Martinez N.P., Celi P. et al. Associations between bone and energy metabolism in cows fed diets differing in level of dietary cation-anion difference and supplemented with cholecalciferol or calcidiol. Journal of Dairy Science 2018, 101, 6581-6601.*
7. *Sorge U.S., Molitor T., Linn J., Gallaher D., Wells S.W. Cow-level association between serum 25-hydroxyvitamin D concentration and Mycobacterium avium subspecies paratuberculosis antibody seropositivity: A pilot study. Journal of Dairy Science 2013, 96, 1030–1037. https://doi.org/10.3168/jds.2012-5929*