Effects of Dairy Cow Diet Supplementation with Carrots, Red Beet and Fodder beet on Cow Blood Serum Carotene Concentration and Milk Production

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Abstract
Provision of fat-soluble antioxidants necessary for cow organism and milk synthesis depends on their concentration in the diet. Administration of the natural vs synthetic forms of carotene and other bioactive components has the potential of better bio-availability. The aim of this study wos to estimate the effect of cow diet supplementation with carrots, red beet and fodder beet on the total feed intake, the total carotene concentration in cow blood and milk production. A total of 12 cows of Holstein Friesian breed were divided into control (CG) and experimental group (EG). In the EG cow diet was supplemented with 8% (dry mater bases) of vegetable mix of carrots (20%), red beet (20%) and fodder beet (60%) in the indoor period (November-December 2017) for 5 weeks. The total weights of dry matter consumed per day were 20.7 and 19.8 kg respectively, for cows in EG and CG. The carotene concentration in the blood of cows before supplementation was under the recommended beta-carotene level of minimum 3.0 mg/l. During experimental period the increase in carotene concentration in blood of cows was much more in EG, showing the positive effect of carrots, red beet and fodder beet supplementation The mean daily milk yields were 32.9 kg and 31.4 kg for EG and CG, respectively, with a response of 0.4 kg milk for cows in EG. Milk producers can be suggested to add this vegetable to the diet of dairy cows in order to improve beta-carotene level in cow blood and to maintain a high milk production.

Keywords: beta-carotene, dairy cow, dry matter Intake, milk production, root vegetables.

1. Introduction

Provision of fat soluble antioxidants necessary for cow organism and milk synthesis depends on their concentration in the diet. Administration of the natural vs. synthetic forms of carotene and other bioactive components has the potential of higher bio-availability.

The carrot (*Daucus carota*) is a root vegetable, usually orange in color, with the diameter from 1 cm to 10 cm at the widest part and root length from 5 to 50 cm (most are between 10 and 25 cm). carrots are good source of beta-carotene, vitamin K and vitamin B_6, and modest source of essential nutrients (4.7% sugar, 0.9% protein, 2.8% dietary fiber, 1% ash and 0.2% fat).

The red beet (*Beta vulgaris rubra*) is a root vegetable included in *Betoideae* subfamily in the *Amaranthaceae* family. In recent years then has been a growing interest in the biological activity of red beet root and its potential utility as a health promoting and disease preventing functional feed. Beet root is also being considered as a promising therapeutic treatment in a range of clinical pathologies associated with oxidative stress and inflammation.

Fodder beet (*Beta vulgaris*) was widely used in dairy rations and it is regarded as succulent feed.

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There are several reasons for investigating vegetable roots as dairy cow feeds. One of them is protein efficiency.

Feeds with large carbohydrate excess, like vegetable roots, are required to balance the large amounts of ruminaly degradable feed protein. Also vegetable roots are reach source of fat soluble antioxidants and vitamins such as carotenoids and vitamin E.

The aim of this study was to estimate the effect of cow feed supplementation by a mix of carrots, red beet and fodder beet on the total carotene concentration in cow blood serum, on milk quality parameters and milk yield.

2. Materials and methods

The study was carried out at the Agricultural Research and Development Station (ARDS) Simnic-Craiova. The experiment was conducted according to the European Community regulations concerning the protection of experimental animals.

A total of 12 Holstein Friesian cows were used in this study. Two cow groups–one experimental (EG) and one control (CG)–with 6 cows in each of them were formed taking into account 1) parity (3), 2) stage of lactation (3-4 months), 3) milk fat, protein and solids nonfat concentration and 4) fat, protein, solids nonfat and milk production.

All animal were tied in a row by keeping safe distance between animals to avoid sharing of feeds, and were fed individually. During the treatment period the cows were fed a partial mixed ration (PMR), consisting of 60% concentrate, 35% silage and 5% alfalfa hay based on dry matter (DM) content (Table 1).

Table 1: Feeds (% of DM of the diets) and nutritional values of the diets

Feeds	Units	Cow groups	
		EC	CG
Alfalfa hay	% of DM	5.0	5.0
Corn silage	% of DM	35.0	35.0
Mixed concentrate feeds	% of DM	55.5	55.5
Vitamin and mineral supplement	% of DM	4.5	4.5
Total dry matter	%	100.0	100.0
Mixed vegetable roots	% of DM	8.0	-
Nutritional values	for 1 kg of DM:		
Crude protein	%	17.1	16.5
Neutral detergent fiber (NDF)	%	35.4	35.0
Acid detergent fiber (ADF)	%	20.3	20.1
Calcium	g	7.7	7.6
Phosphor	g	4.1	4.0
Net energy lactation (NEL)	Mcal/kg	1.54	1.50

The diets of both groups of cows were formulated to meet the nutritional requirements of the cows producing 28 kg of milk and the water and salt were freely available. The diet of cows in the EG was supplemented with a mix of carrots (20%), red beets (20%) and fodder beets (60%) and represented 8% from dry matter (DM) of the diet. The trial was conducted in November and December 2017 for 35 days.

Average daily feed offered and left over were accurately measured in order to determine average DM intake (DMI). Cows were milked at 05:30 and 15:30 and the individual milk yield was recorded by the milking system. Milk samples for the analysis of milk composition were taken once a week in the morning and again in the afternoon of the same day. Milk samples were conserved with bronopol and stored at 8^{o}C until they were analysed. The milk composition, i.e. fat, solid non-fat (SNF), and protein was measured using EKOMILK–M Ultrasonic Milk Analyzers EON TRADING LLC, USA [1]. The milk samples were taken one day before the feed supplementation (n=12) and several times repeatedly at 1, 3, 4 and 5 weeks from the beginning of the feed supplementation (n=48). Fat corrected milk (FCM) was estimated according to Gaines [2].

Cow blood samples were taken from the v. *jugularis externa* after milking and collected into 5 ml vacutainers without stabilizer. The cow blood samples were stored at room temperature until the blood coagulates and serum separates (1.5 h). The

serum was stored at–18°C until analysis. The total carotene concentration in blood serum of the cows one day before and at the end of the feed supplementation experiment was determined by the spectrophotometric method [3] at ARDS Simnic–Craiova. Statistical data processing of the required results was carried out using MS Excel. Data are presented as the mean±standard error of means. The hypotheses suggested were tested by student's t test and factors were considered significant if $P<0.05$.

3. Results and discussion

Dry matter intake (DMI) was slightly increased in EG, 20.660 kg/d/cow vs. 19.880 kg/d/cow in CG (Table 2).

Table 2. Comparison of mean DMI, milk yield and milk quality parameters before and during feed supplementation experiment

Indicators	Units	Before experiment			During experiment		
		CG mean±SE	EG mean±SE	P value	CG mean±SE	EG mean±SE	P value
DMI	kg/day/cow	19.79±0.12	19.86±0.29	ns	19.880±0.14	20.66±0.210	ns
Milk yield	kg/day/cow	28.67±0.58	28.96±0.84	ns	28.925±0.93	29.47±0.83	ns
Fat percent	%	3.76±0.16	3.80±0.14	ns	3.867±0.12	3.91±0.11	ns
Fat production	kg/day/cow	1.07±0.03	1.10±0.05	ns	1.118±0.04	1.15±0.05	ns
Protein percent	%	3.31±0.10	3.28±0.23	ns	3.347±0.10	3.34±0.09	ns
Protein production	kg/day/cow	0.9±0.04	0.96±0.03	ns	0.931±0.18	0.98±0.03	ns
SNF percent	%	8.710±0.16	8.70±0.16	ns	8.76±0.	8.75±4.15	ns
SNF production	kg/day/cow	2.49±0.06	2.52±0.08	ns	2.535±0.086	2.57±0.07	ns
Fat corrected milk with 3.5%	kg/day/cow	30.799	31.445	ns	31.957	32.923	ns

EG=experimental group; CG=control group; SE=standard error; ns=non-significant

However, DMI increase in EG might be associated with better palatable and more NDF content of vegetable roots. Getachew et al. [4] reported a 24 h NDF digestibility of beet pulp at 76 g/100 g NDF. The beets pulp NDF is unique in that it has been shown to feature a very high cation exchenge capacity [5], which tends to promote the maintenance of pH and a more stable rumen environment.

To assess the impact of vegetable root supplementation on quality and composition of milk it was necessary to find out whether the feeds increase the concentration of carotene in cow organism.

Results of the total carotene concentration in blood serum of cows before and after the 5-week feed supplementation with roots are shown in Figure 1.

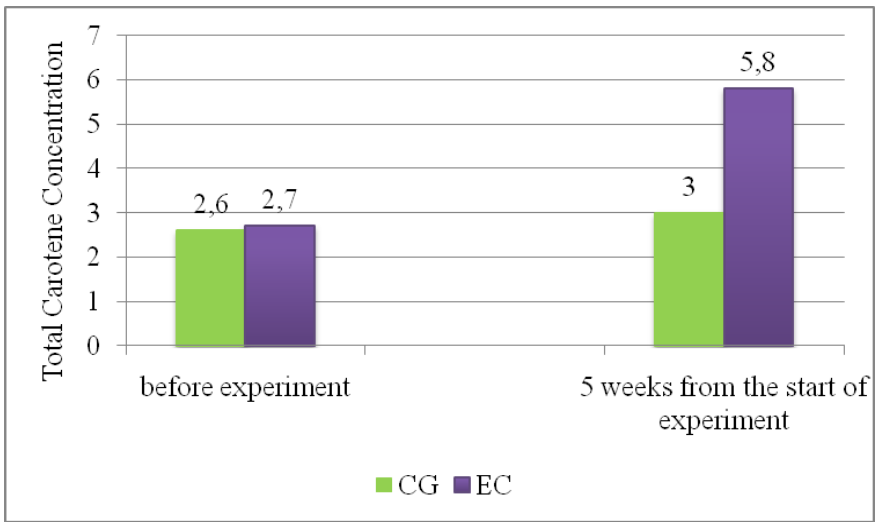

Figure 1. Total blood carotene concentration before and 5 week from the start of experiment (CG=control group; EG=experimental group)

The concentration of beta-carotene in cow blood can serve as an indicator showing whether the amount of carotenoids in feed is sufficient. A serum beta-carotene level of 3.0 mg/l has been suggested as the level below which the supplementation is beneficial for udder health [6, 7]. Before the experiment the average carotene concentration in blood serum of cows of both groups was similar (P>0.05), 2.6 and 2.7 mg/l in the CG and EG respectively, and it was below the recommended level.

After 5 weeks feed supplementation period, the carotene concentration in CG and EG cow blood serum was 3.0 mg/l and 5.8 mg/l, respectively. A significant increasing (P<0.05) in blood serum of cow from EG. The concentration increase in the EG accounted for 2.14 times, while in the CG only 1.15 times. This demonstrates that diet supplementation with vegetable roots may improve dairy cow carotene status in the winter period.

In a study on herds from various regions of France, the cow's had less than 1.5 mg/l beta-carotene in the blood plasma [8]. Similar observations were made in Canada [9].

Milk quantity and quality parameters of samples obtained before and during the feed supplementation experiment, and between groups were compared (Table 2).

The average bulk milk quality parameters and yield before the feed supplementation experiment as well as during it did not indicate significant difference between groups (P≥0.05).

The similar to our results were obtained in the study of Antone et al. [10], or Schreiner and Windisch [11]. At the same time the contradictory results were acquired by Arechiga et al. [12] or Oldham [13] increase in milk yield by 11% and 6.4% respectively.

The results of this study clearly demonstrated that vegetable roots feeding to lactating cows did not have any adverse effects on milk production or milk composition.

The mean daily fat corrected milk (with 3.5% fat; FCM) were 32.9 kg and 31.9 for EG and CG, respectively, with a response of 0.4 kg milk for EG. Also, vegetable root supplementation maintained a higher daily FCM (3.5%) production (32.9 kg vs. 31.9 kg).

Slightly increased of milk production or milk quality parameters results from this experiment, where vegetable roots have been offered in addition to control diet, were probably caused by improved health and energy status of cows from EG. The vegetable root supplementation tended to increase fat concentration and this may be due to altered Volatile Fat Acids proportions from a constant amount of propionate but on increased amount of butyrate produced daily.

4. Conclusions

Vegetable roots as carrots, red beet and fodder beet, can be grown in many parts of Europe and other regions. Milk producers can be suggested to add this vegetable to the feed of dairy cows in order to improve cow carotene status.

Increased concentrations of biologically active compounds can give higher nutritional value of dairy products.

Nevertheless, further research should be necessary regarding the effects on dairy product shelf life stability.

References

1. Milk Analyzers EKOMILK User's guide.
2. Gaines, W. L., The energy basis of measuring milk yield in dairy cows, Illinois Agric.Exp. Sta.Bull., 1928, 308, 401-438.
3. Donaldson, M., Development of a rapid, simple assay of plasma total carotenoids, BMC Res Notes, 2012, 5, 521.
4. Getachew, G., Robinson, P. H. De Peters, E. J. Taylor, S. J., Relationships between chemical composition, dry mather degradation and in vitro gas production of several ruminant feeds, Annual Feed Sci Technology, 2004, 111, 57-71.
5. McBurney, M. I., Van Soest, P. J. Chase, L. E., Cation excenge capacity and buffering capacity of neutral detergent fibres, J. Sci Food Agric., 1983, 34, 910-916.
6. Frye, T. M., Williams, S. N., Graham, T. W., Vitamin deficiences in cattle, Veterinary Clinics of North America, Food Animal Practice, 1991, 7, 217-275.
7. Jukola, E., Hekkarainen, J. Salorieni, N., Sankari, S., Blood selenium, vitamin E, vitamin A and β-carotene concentrations and udder health, fertility treatment and fertility, J.Dairy Sci, 1996, 79, 838-845.
8. Georges, C., Evaluation du statut plasmatique en beta-carotene de vaches laitiers francoises et relation au type de ration distribuee, Renc. Rech. Ruminants, 2009,16, 76.
9. Le Blanc, S. J., Herdt, T. H., Seymour, W. M., Duffield, T. F., Leslie, K. E., Peripartum serum vitamin

E, retinol and β-caroten in dairy cattle and their associations with disease, J. Dairy Sci., 2004, 87, 609-619.
10. Antone, U., Zagorska, J., Sterna, V., Jemelganovs, A., Berzius, A., Ikauniece, D., Effects of dairy cow diet supplementation with carrots on milk composition, concentration of cow blood serum carotenes, and butter oil fat-soluble antioxidative substances, Agronomy Research, 2015, 13(4), 879-891.
11. Schreiner, M., Windisch, W., Supplementation of cow diet with rapeseed and carrots: influence on fat acid composition and carotene concentration of the butter fat. Journal food lipids, 2006, 13, 434-444.
12. Arechiga, C .F., Staples, C. R., McDowell, L. R., Hansen, P. J., Effects of timed insemination and supplemental β-caroten on reproduction and milk yield of dairy cows under heat stress, J.Dairy Sci., 1998, 81, 390-402.
13. Oldham, E. R., Eberhart, R. J., Muller, L. D., Effects of supplemental vit A and β-carotene during the dry period and early lactation on udder health, J. Dairy Sci., 1991, 74, 3775-3781.