Global Journal of Science Frontier Research: G
Bio-Tech & Genetics
Volume 14 Issue 2 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN:2249-4626&Print ISSN:0975-5896

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Keywords: *l-carnitin, dairy cow, lactation.*

GJSFR-G Classification : *FOR Code: 270299*

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Application of Protected L-Carnitine in Dairy Cows during Transition and High Lactation Period

Heiko Scholz [α], Elke Von Heimendahl [σ], Frank Menn [ρ] & Andreas Ahrens [ω]

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Carnitine supplementation led to an improved metabolic status of dairy cows during transition and high lactation period and increased fertility. Carnitine, in particular in a rumen protected variation can support metabolic health of dairy cows during the critical period of transition and high lactation.

Keywords: *l-carnitin, dairy cow, lactation.*

I. Introduction

The main goal of milk production is a further increase in milk yield, and at the same time maintaining animal health. The transition and high lactation period is a very critical phase for dairy cows. Energy requirements for milk production in early lactation of dairy cows exceed the available energy from feed intake resulting in a more or less severe negative energy balance, which the cow tries to compensate by fat-mobilization from adipose tissue. Excessive mobilization of fatty acids can exceed the liver's capacity for degradation and results in elevated formation of ketone bodies and accumulation non esterified fatty acids (NEFA) in the liver where they are converted to triglycerides and stored. About 50% of the dairy cows within the first 4 weeks p.p. suffer from the so called fatty liver syndrome (Bobe et al., 2004; Jurritsma et al., 2003). An impaired liver function favors the development of other postpartum disorders like ketosis, metritis, displaced abomasum and immune suppression as well as a poor reproductive performance.

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L-Carnitine serves as a Co-factor for activated fatty acids and therefore has direct impact on fat-metabolism (Drackley et al., 1991a,b; Owen et al., 2001). In addition, carnitine acts as a buffer for acetyl-residues originating from fat-mobilization, thereby reducing ketone body formation (Harmeyer & Schlumbohm, 1997).The altered ratio of acetyl-CoA:CoAas a result of this buffer function further improves ß-oxidation and also stimulates carbohydrate metaboslism(Rebouche&Seim, 1998).As approximately 80% of dietary carnitine is degraded by rumen microbes (LaCount et al., 1996; Harmeyer, 1995).

The aim of this study was to showtheimpact of a rumen protected L-carnitine supplementation on performance and metabolic parameters during the transition and high lactation period.

II. Material and Methods

262 dairy cows (German Holstein) were allotted to two treatments according to lactation number and milk yield. Animals in the carnitine group were marked by ear tags.Cows were fed a TMR as presented in Table 1 and 2. The composition and nutrient content of the TMR is presented in Table 1 and 2. Diets were formulated to meet the nutrient requirements of dairy cows according to GfE Guidelines (GfE 2001).In the carnitine group (CP), cows were fed 10g of a rumen protected carnitine product (Lohmann Animal Health, containing 2g Carnitine) per cow and day whereas the animals in the Control group (C) received 10 g of barley groat instead (table 3). Carnitine supplementation was given individually.

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Table 1 : Composition of the transition and fresh cow diet (% and kg/day)

	Transition	Fresh cows
Grass silage	37,3 % (12,0 kg)	21,2 % (13,3 kg)
Corn silage	43,5 % (14,0 kg)	41,1 % (25,8 kg)
Hay	3,1 % (1,0 kg)	1,0 % (600 g)
straw	3,9 % (1,3 kg)	0,6 % (350 g)
Concentrate 18/4*		0,4 % (250 g)
Sugar beet pellets		1,8 % (1,1 kg)
Protein concentrate**	1,2 % (400 g)	3,9 % (2,4 kg)
UDP concentrate***	6,2 % (2,0 kg)	4,6 % (2,9 kg)
Barley groats	2,3 % (750 g)	2,8 % (1,8 kg)
Mineral feed	2,3 % (750 g)	0,3 % (200 g)
Protected fat		0,3 % (200 g)
salt	0,1 % (40 g)	0,1 % (50 g)

* 18% crude protein, energy level 4 (7.4 MJ NEL)

**7,5 MJ NEL, 22.0% crude protein, 195g usable crude protein, 4g RNB

***7.2 MJ NEL, 40%CP, 3% crude fat, 8.5 %crude fiber, 260g usable crude protein, 22g RNB

Table 2 : Analyzed nutrient content of the transition and fresh cow diet

	Transition	Fresh melking cows
NEL (MJ)	6,0	6,6
DM (g/kg)	452	443
Crude protein (g/kg)	135	158
Crude fiber(g/kg)	218	192
Ether extract (g/kg)	27	31
sugar(g/kg)	24	34
starch (g/kg)	199	200
Sugar + starch (g/kg)	223	234
Crude ash (g/kg)	78	78
usable rumen escape protein (g/kg)	138	152
Ruminal N-balance	-0,4	1,0
Kalzium (g/kg)	5,9 ± 0,3	7,7 ± 2,0
Phosphor (g/kg)	3,6 ± 0,4	4,5 ± 0,6
Natrium (g/kg)	2,9 ± 2,0	3,2 ± 0,9
Magnesium (g/kg)	2,3 ± 0,2	3,0 ± 0,5
Kalium (g/kg)	16,4 ± 1,3	14,4 ± 1,8
Chlor (g/kg)	6,6 ± 3,7	6,9 ± 1,2
Schwefel (g/kg)	1,8 ± 0,1	2,2 ± 0,3
DCAB (meq/kg)	248 ± 52	183 ± 40

Table 3 : design of investigation

	Carnipass	Control
Dry period	Last milking – 22 days ante partum withoutCarnipass	
Transit period	21 days ante partum with 10 g Carnipass	21 days ante partum withoutCarnipass
Fresh milking	1.-60. daypost partum with 10 g Carnipass	1.-60. daypost partum withoutCarnipass
High milking	61.-100. daypost partum withoutCarnipass	

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All cows were kept in a free stall under the same conditions. Milk yield was determined at 3 subsequent monthly milk controls (MC) after starting carnitine supplementation from all 262 cows. At the same time, milk samples were taken and investigated for milk yield, milk fat, milk protein and urea. Blood samples were taken from 110 cows out of the group of 262 cows 1 week a.p., 1 week p.p., 5 weeks p.p. and 9 weeks p.p (BS 1-4) and analyzed for NEFA, BHB, Cholesterol, GLDH and Bilirubin. Only cows with 3 complete milk and 4 blood samples were included in statistical evaluation.Data were analyzed by SPSS, Version 20 using one-way randomized block analysis of variance (ANOVA) and Kolmogorow-Smirnow-Test (KS) with a significant level set at $p \leq 0.05$. Results were expressed as mean ± standard deviation (s). Bivariate correlations procedure of SPSS with the PEARSON option (2-tailed) was used to determine correlations between parameters.

III. Results and Discussion

249 of the 262 cows completed the trial, 131 for the control and 118 for the carnitine group. Blood parameters were investigated in 89 cows (51 control and 38 in CP). The exclusion of animals from the trial was not treatment related and mainly due to inappropriate calving date of heifers which reduced the period of carnitine supplementation significantly.

Carnitin supplementation did only slightly but not significantly influence milk yield in the first 100 days of lactation (Table 3-5). As a result of slightly decreased fat but increased protein percentage in carnitine supplemented cows, fat/protein ratio was a significantly reduced in the carnitine group.Reduced fat percentage in the milk and lower fat/ protein ratio indicate reduced fat mobilization probably as a result of improved fat metabolism and thereby reduced NEB by carnitine (Tasdemir et al., 2011).

Table 3 : milk yield, fat, protein and fat-protein-ration (FPR) of MC1

	Milk yield	Milk fat (%)	Milk protein (%)	FPR
Control	34,7 ± 7,9	4,23 ± 0,77	3,23 ± 0,32	1,3 ± 0,2
Carnipass	35,7 ± 8,3	4,09 ± 0,83	3,22 ± 0,36	1,3 ± 0,2

Table 4 : milk yield, fat, protein and fat-protein-ration (FPR) of MC2

	Milk yield	Milk fat (%)	Milk protein (%)	FPR
Control	37,5 ± 8,0	3,83 ± 0,69	3,05 ± 0,27	$1,3^{a}$ ± 0,3
Carnipass	38,7 ± 8,8	3,75 ± 0,64	3,10 ± 0,28	$1,2^{b}$ ± 0,2

a, b: signifikantbei p=0,06

Table 5 : milk yield, fat, protein and fat-protein-ration (FPR) of MC3

	Milk yield	Milk fat (%)	Milk protein (%)	FPR
Control	35,8 ± 7,9	4,02 ± 0,63	$3,25^{a}$ ± 0,27	$1,3^{a}$ ± 0,2
Carnipass	35,9 ± 7,5	3,92 ± 0,66	$3,31^{b}$ ± 0,24	$1,2^{b}$ ± 0,2

a, b: signifikantbei p≤0,07

Somatic cell counts at first and second milk control after calving were lower in the carnitine group than in the control group (figure 1). Even though these differences were not significant, it is known that a negative energy balance and subclinical ketosis have an influence on udder health (Leslie et al., 2000; Suryasathaporn et al, 2000).

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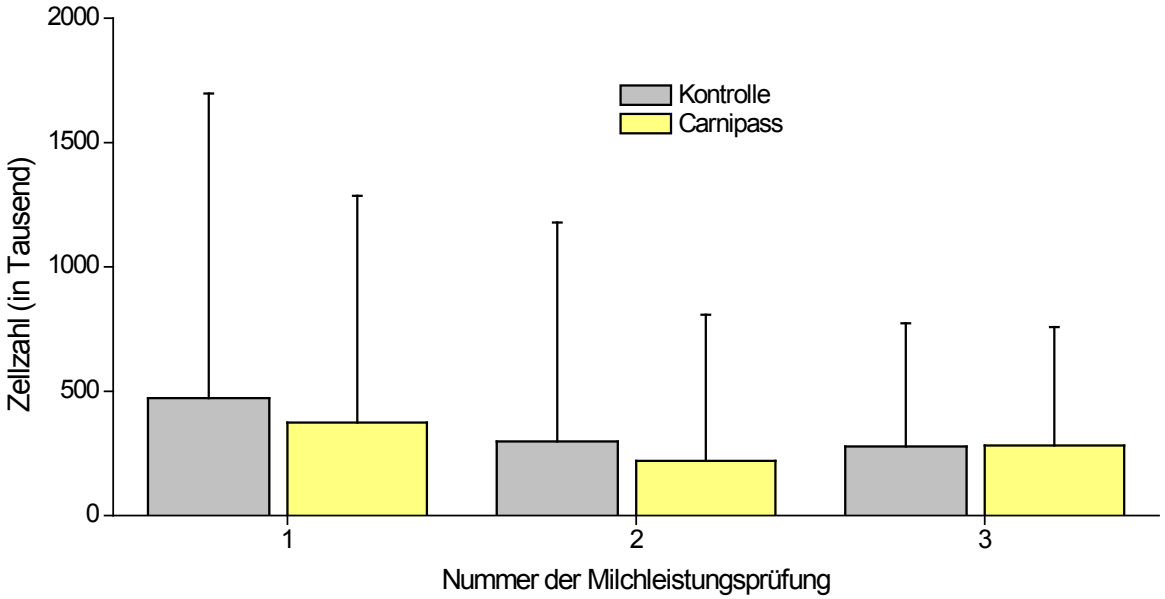

Figure 1 : influence of carnitine supplementation on somatic cell count of dairy cows

Carnitine supplementation tended ($p<0.15$) to decrease blood NEFA concentration during the whole trial period(Table 6). In multiparous cows the difference was significant one week ante partum (0.37in control versus 0.29 in the carnitine group).There was no significant influence on BHB. However, there was a trend for decrease BHB concentrations in week 5 and 9 p.p. (table 7). Even though there was no influence of carnitine supplementation on cholesterol levels in blood when all cows were considered, Cholesterol was significantly decreased one week p.p. in heifers supplemented with carnitine (2.7 versus 2.1mmol/l) (table 10).These findings are confirmed by other authors, when carnitine supplementation in dose levels similar to the one in this study were used (Carlson et al., 2007) or given intravenously (Erfle et al., 1971). Carlson et al. (2007) were also able to prove that carnitine supplementation significantly reduced the total lipid and the triglyceride content in the liver while simultaneously increasing glycogen concentration.

GLDH in blood was significantly reduced one week a.p. ($p=0,040$) and remained on a lower level throughout the trial in cows fed carnitine (table 8). According to Obritzhausen (2009) and Kraft &Dürr (2005) an increase in GLDH is an indicator for increased liver load which is the case in lipomobilization related fatty liver (Rehage 1996).Values for bilirubin were significantly different in week 5 p.p.. Increased bilirubin concentrations are always observed in relation to fatty liver syndrome and NEB (Kraft &Dürr, 2005; Rehage 1996). Lower levels of NEFA in carnitine supplemented group and therefore reduced liver loads are likely to be the cause for the lower GLDH activity and blood bilirubin concentration in this group.

Table 6 : Influence on carnitine supplementation on NEFA (mmol/l)

	Control		Carnipass	
	means ± s	min - max	means ± s	min - max
BS 1	0,37 ± 0,18	0,19-1,12	0,31 ± 0,09	0,19-0,64
BS 2	0,60 ± 0,34	0,22-1,78	0,51 ± 0,28	0,21-1,52
BS 3	0,36 ± 0,19	0,18-1,25	0,31 ± 0,12	0,18-0,67
BS 4	0,27 ± 0,09	0,18-0,68	0,26 ± 0,07	0,17-0,46

Table 7 : Influence on carnitine supplementation on BHB (μmol/l)

	Control		Carnipass	
	means ± s	min - max	means ± s	min - max
BS 1	663 ± 223	298-1.501	668 ± 165	405-1.096
BS 2	731 ± 578	258-3.526	739 ± 605	306-3.856
BS 3	659 ± 620	321-4.880	575 ± 224	214-1.391
BS 4	802 ± 428	278-2.508	737 ± 400	311-2.644

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Table 8 : Influence on carnitine supplementation on GLDH (nkat/l)

	Control		Carnipass	
	means ± s	min - max	means ± s	min - max
BS 1	294 ± 330	63-1.768	178 ± 82	77-404
BS 2	355 ± 344	73-1.708	288 ± 245	101-1.412
BS 3	575 ± 1.005	123-5.439	412 ± 683	65-4.282
BS 4	417 ± 397	93-2.610	391 ± 402	114-2.267

Table 9 : Influence on carnitine supplementation on Bilirubin (µmol/l)

	Control		Carnipass	
	means ± s	min - max	means ± s	min - max
BS 1	3,5 ± 1,6	1,2-8,6	3,4 ± 2,3	0,6-12,5
BS 2	4,4 ± 3,0	1,0 – 17,6	4,3 ± 3,0	1,3-13,6
BS 3	3,4 ± 2,0	1,4-11,4	2,6 ± 0,9	1,2-4,5
BS 4	2,8 ± 1,9	1,1-14,2	2,5 ± 0,8	1,1-5,1

Table 10 : Influence on carnitine supplementation on Cholesterol (mmol/l)

	Control		Carnipass	
	means ± s	min - max	means ± s	min - max
BS 1	2,5 ± 0,9	1,5-6,1	2,3 ± 0,6	1,3-3,5
BS 2	2,3 ± 0,8	1,0-4,4	2,1 ± 0,8	0,9-4,8
BS 3	4,2 ± 1,0	2,3-6,7	3,9 ± 0,9	2,1-5,6
BS 4	5,1 ± 1,1	3,4-8,7	4,8 ± 1,1	2,4-6,7

Carnitine supplementation also influenced fertility parameters in the cows. Whereas there was no difference in days from calving to first insemination, there was a trend for a lower insemination index in the carnitine group then in the control group. The conception rate was significantly improved in the carnitine supplemented group as compared to the control (Table 5). Supplementation of carnitin showed by Pirestaniet. (2011) a lower level on service to pregnancy than the control group. Also, there was a decreased significantly days open in carnitine compare to the control group (Pirestaniet., 2011).

Table 5 : Influence of Carnitin to fertility on cows

	Control	Carnipass
Days open	75 ± 35	74 ± 33
Insemination index	2,3	1,9
pregnant rate	70[a] %	86[b] %

237 cows of all 249 cows in the investigation had minimal one medication in the first 100 days of lactation. Between the Carnitin supplementation and the control group were found significant differences (Table 6).

Table 6 : Influence of Carnitin on medication of cows in the first 100 days of lactation

	Control	Carnipass
Sum of medication	1,64[a]	1,17[b]
Medication fertility	0,28[a]	0,17[b]
Medication udder	1,32[a]	0,93[b]

[a, b] Means within a row with different superscripts differ ($P < 0.05$).

Health and fertility of dairy cows are strongly related to NEB (Jorritsma et al., 2003). Fertility is mainly influenced by alterations in the IGF system during the period of NEB (Llewellyn et al., 2007). It is supposed that the impact of carnitine on fat and carbohydrate metabolism helped to reduce the period of strong NEB in this trial as indicated by less fat immobilization. In addition, carnitine might have had a direct impact on the IGF system as has been shown for other species (Waylan et al., 2005).

IV. Conclusion

In conclusion, Carnitine supplementation tend toincrease milk yield during the first 2 month after calving improved the metabolic situation and in consequence also led to increased fertility in dairy

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cows.Carnitine, in particular in a rumen protected variation can support metabolic health of dairy cows during the critical period of transition and high lactation.

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