Influence of Different Supplemental Niacin Forms on Production Performance of Dairy Cows: A Meta-Analysis

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ABSTRACT

Niacin is occasionally supplemented into dairy cows' ration to improve their production performance especially during early lactation period. Such supplementation can be done either in the form of nicotinic acid (NA) or nicotinamide (NM). The present study is aimed to assess which form of niacin is most effective in relation to the performance of dairy cows through a meta-analytical study. A database was constructed from published literatures reporting niacin supplementation on dairy cows. A total of 61 studies from 49 published articles were integrated into the database. Different niacin forms, i.e. NA or NM, either unprotected or protected at various supplemental levels were specified. Nutrient intake, rumen fermentation parameters, blood profiles, milk production and milk composition were integrated as well. Data were analyzed by a mixed model methodology in which different studies were treated as random effects whereas niacin forms (control, NA, NM) were treated as fixed effects. Significancy of an effect was stated when $P<0.05$. When a parameter showed $0.05<P<0.1$, then the effect was considered to have a tendency to be significant. Results revealed that, in contrast to our expectation, NA or NM supplementation did not significantly improve 4% fat-corrected milk production (FCM) than that of control. Levels of β-hydroxybutiric acid (BHBA) in blood plasma for control, NA and NM were 116.9, 97.9 and 102.7 mmol/l, respectively. Effects of NA or NM supplementation were insignificant for rumen fermentation parameters (volatile fatty acids and ammonia) as well as for milk quality (milk protein, milk fat, solid non fat and total solid). It can be therefore concluded that supplementation of niacin, either as NA or NM, has less effect in improving milk production of dairy cows (4% FCM), but it may advantage energy balance status of dairy cows. In the latter case, apparently NA is more effective than NM.

Keywords: Meta-analysis, niacin form, dairy cow

INTRODUCTION

Dairy cows during early lactation are usually suffered from negative energy balance due to much lower energy intake as compared to the energy for milk production. A function of niacin is to decrease the negative energy balance in dairy cows by intensifying energy generation processes. By this, the mobilization of fatty acid from adipose tissue is limited so that ketosis, a metabolic disorder, can be prevented. It has been shown that niacin is antilipolytic in adipose tissue and decrease plasma non-esterified fatty acid (NEFA) (Jaster *et al.*, 1983). Niacin can be synthesized by microbes in the rumen but in very small amounts, so supplemetal niacin in ration is required. Niacin is a vitamin B3 consisted of two forms, namely nicotinic acid (NA) and nicotinamide or niacinamide (NM). NA is rapidly converted to nicotinamide adenine dinucleotide (NAD) and then hydrolyzed to NM. The difference between NA and NM is the affinity for receptor GPR 109A. The function of GPR109A is to increase ATP concentration in the liver by promoting fatty acid oxidation or by decreasing gluconeogenesis (Morey *et al.,* 2011). The present study is aimed to assess which form of niacin is most effective in relation to the performance of dairy cows through a meta-analytical study.

MATERIALS AND METHODS

General: The data set was developed from published literatures reporting addition of niacin at different forms on nutrient intake, blood profiles, rumen fermentation, milk yield and composition. A literature search was conducted using data search generators, such as Google Scholar, Sciencedirect and Scopus to collect articles with the keywords “niacin” and “dairy cows”. Accordingly, different niacin forms were specified in the database. Inclusion criteria for articles to be included in the database were: (1) articles were published in English, (2) supplementation was given to dairy cows during postpartum condition, and (3) experiments were conducted *in vivo*. The complete data set was obtained from 61 studies (49 published articles) with the above-mentioned keywords in which the articles were published from 1981 to 2013.

Statistics: The data obtained were subjected to a statistical meta-analysis based on mixed model methodology (St-Pierre, 2001). The fixed effect was niacin forms and the random effect was the study from various experiments. Significancy of an effect was stated when the P-value <0.05. When P-value lied between 0.05 to 0.1, the effect was considered as tendency to be significant. All statistical analyses were performed by using SAS Software version 9.1 (SAS Institute Inc., 2008).

RESULTS AND DISCUSSION

The effects of niacin forms supplementation on dry matter intake (DMI), dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD), neutral detergent fiber digestibility (NDFD) and acid detergent fiber digestibility (ADFD) of dairy cows are shown in Table 1. There were no significant differences between NA or NM supplementaion with control in DMI, DMD, OMD and CPD. Supplementation of NM improved NDFD and ADFD than those of control (P<0.05), while the NA did not. Such effect of niacin might be due to a stimulation of rumen microbial activity, resulting in a higher digestion of plant cell wall (Horner *et al.,* 1988). However, addition of different niacin forms on rumen fermentation of dairy cows did not show any significant response as compared to control (Table 2).

Table 1. Intake and digestibility of dairy cows on different supplemental niacin forms

Response parameter	Unit	n	Control	NA	NM	P-value
DMI	kg/d	82	21.0	20.9	21.8	0.389
DMD	%	22	64.71	64.5	64.06	0.918
OMD	%	13	67.1	66.2	65.7	0.447
CPD	%	15	57.9	58.09	60.0	0.728
NDFD	%	30	46.6a	46.8a	54.3b	0.018
ADFD	%	30	44.3a	44.8ab	54.8b	0.007

DMI, dry matter intake; DMD, dry matter digestibility; OMD, organic matter digestibility; CPD, crude protein digestibility; NDFD, neutral detergent fiber digestibility; ADFD, acid detergent fiber digestibility; n, number of data; NA, nicotinic acid; NM, nicotinamide.

Table 2. Rumen fermentation of dairy cows on different supplemental niacin forms

Response parameter	Unit	n	Control	NA	NM	P-value
pH		17	77.3	78.2	na	0.449
VFA Total	mM	34	86.8	91.2	85.3	0.706
C2	%	39	45.6	46.2	44.7	0.313
C3	%	39	14.9	15.4	16.0	0.103
C2/C3	%	39	3.12	3.06	2.94	0.280
NH_3	%	39	151.9	163.4	153.3	0.226

VFA, volatile fatty acid; C2, acetate; C3, propionate; C2/C3, acetate to propionate ration; NH_3, ammonia concentration; n, number of data; na, data not avalaible; NA, nicotinic acid; NM, nicotinamide.

In relation to blood plasma profiles, supplementation of NA or NM significantly decreased BHBA concentration ($P<0.05$), but did not change NEFA, glucose, triglyceride, urea and insulin as compared to control (Table 3). The decrease of BHBA may occur since niacin supplementation increases the energy generating processes (ATP cycles). Further, niacin can bind to the G-protein coupled receptor GPR109A, causing inhibition of adenyl cyclase activity and a subsequent reduction of intracellular cyclic AMP (cAMP), leading to suppression of lipolysis (Wise *et al.,* 2003). NM has a lower affinity for the GPR109A than that of NA (Gille *et al.,* 2008), and hence, NA supplementation is apparently more effective than NM.

Table 3. Composition of blood plasma of dairy cows on different supplemental niacin forms

Response parameter	Unit	n	Control	NA	NM	P-value
NEFA	ueq/l	28	253.5	228.8	na	0.176
BHBA	mg/l	43	116.9b	97.9a	102.7a	0.032
Glucose	mg/l	62	594.5	603.4	545.6	0.664
Urea	mg/l	26	164.4	154.9	na	0.478
Insulin	uU/ml	16	17.3	17.9	na	0.563

NEFA, non-esterified fatty acids; BHBA, beta-hidroxybutiric acid; n, number of data; na, data not avalaible; NA, nicotinic acid; NM, nicotinamide.

Table 4. Milk yield and composition of dairy cows on different supplemental niacin forms

Response parameter	Unit	n	Control	NA	NM	P-value
Milk yield	kg/d	107	30.1b	30.5b	27.8a	0.036
4% FCM	kg/d	67	29.4	29.2	27.4	0.581
Protein	%	78	3.15	3.07	2.89	0.226
Fat	%	97	3.70	3.66	3.87	0.156
Total solid	%	22	11.8	11.7	na	0.776
Solid non fat	%	43	8.06	8.12	7.95	0.259
Lactose	%	27	7.18	7.22	na	0.471

FCM, fat-corrected milk; n, number of data; na, data not avalaible; NA, nicotinic acid; NM, nicotinamide.

Supplemental niacin in this result did not change the milk composition (protein, fat, total solid, solid non fat and lactose) (Table 4). Although NM decreased milk yield as compared to control ($P<0.05$), the effect did not significant on 4% fat corrected milk (FCM). Milk production of dairy cows is varied and influenced by the period of lactation. Jaster *et al.*

(1983) reported that milk yield increased by supplementation of niacin, mainly in early lactation (10 to 15 week). In this study, period of lactation in each study was not distinguished, and this may explain such insignificant effect of NA or NM supplementation on 4% FCM.

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