Influence of Different Supplemental Niacin Levels on Intake, Digestibility and Rumen Fermentation of Dairy Cows: A Meta-analysis

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Abstract Rumen microbes can synthesis niacin but at fewer amount. Niacin is occasionally supplemented into dairy cows' ration to improve their production performance especially during early lactation period. The present study was aimed to assess the effect of different supplemental niacin levels on intake, digestibility and rumen fermentation of dairy cows through a meta-analytical study. A database was constructed from published literatures reporting niacin supplementation on dairy cows. A total of 49 studies from 46 published articles were integrated into the database. Different niacin levels at various supplemental levels were specified, i.e. 0 to 24 mg; nutrient intake and rumen fermentation parameters were integrated as well. Data were analyzed by a mixed model methodology in which different studies were treated as random effects whereas niacin levels 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. The results showed that different levels of niacin supplementation did not significantly influence nutrient intake, digestibility and rumen fermentation of dairy cows ($P>0.05$). It is concluded that supplementation of niacin has less effect in improving intake, digestibilty and rumen fermentation.

Keywords Meta-analysis, niacin, concentration, dairy cow

1. Introduction

Dairy cows require supplementation of niacin in the diet at sufficient levels because the rumen microbes can produce niacin in small amounts only. Niacin plays a role in generating energy in the Krebs cycle (ATP cycles) [1]. Energy deficiency leads to body fat mobilization of dairy cows to be used as energy and then increases beta-hidroxybutiric acid concentration; this condition stimulates ketosis, a metabolic disorder, to occur [2]. It is expected that niacin supplementation can overcome the negative energy balance in dairy cows especially during early lactating period. This study was aimed to know the influence of niacin supplementation levels on intake, digestibility and rumen fermentation profiles of lactating dairy cows by using meta-analysis method.

2. Materials and Methods

2.1. Database development

A database was developed from published literatures reporting addition of niacin at various levels on nutrient intake, digestibility and rumen fermentation of lactating dairy cows. Literature search was conducted using data search generators, i.e. Google scholar and Scopus to collect articles with the keywords "niacin" and "dairy cow". Accordingly, levels of niacin supplementation were specified in the database. After collection of literatures, a total of 49 studies from 46 published articles with the above-mentioned keywords were obtained; the

articles were published from 1981 to 2013.

2.2. Statistical analysis

The data obtained were subjected to a statistical meta-analysis based on mixed model methodology [3, 4]. The model used was linear model, considering niacin supplementation levels as fixed effects and different studies as random effects. The following model was employed:

$Y_{ij} = B_0 + B_1X_{ij} + s_i + b_iX_{ij} + e_{ij}$

where Y_{ij} = dependent variable, B_0 = overall intercept across all studies (fixed effect), B_1 = linear regression coefficient of Y on X (fixed effect), X_{ij} = value of the continuous predictor variable (niacin supplementation level), s_i = random effect of study i, b_i = random effect of study i on the regression coefficient of Y on X in study i, and e_{ij} = the unexplained residual error. Model statistics used were P-value and Akaike information criterion (AIC). Significance of an effect was stated when P-value <0.05. Additionally, when P-value lied between 0.05 to 0.1, an effect was stated as a tendency to be significant. All statistical analyses were performed with SAS Software version 9.1.

3. Results and Discussion

3.1. Influence of niacin supplementation on intake and digestibility of dairy cows

The effects of niacin supplementation levels 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) were insignificant (Table 1). In another study, supplementation of niacin at different levels increased rumen microbial population and nutrient degradation in the rumen. Niacin supplementation at 0.75 to 3.75 g/cow/d increased cattle growth by 0.7 to 10.9%; however, supplementation of niacin above 7.5 g/cow/d caused negative effects on the performance [1]. The present meta-analysis reveals that niacin supplementation does not produce consistent results. A plausible explanation is that the supplementation may effectively contribute to dairy cows only during a certain lactation period, most probably in early lactation, not the whole.

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

Response Parameter	Unit	N	Parameter estimates				Model statistics	
			Intercept	SE Intercept	Slope	SE Slope	P-value	AIC
DMI	kg/d	85	21.1	0.88	-0.013	0.014	0.340	360.8
DMD	%	14	65.3	2.07	-0.034	0.063	0.609	66.0
OMD	%	7	71.3	1.89	-0.144	0.093	0.220	32.5
CPD	%	9	53.4	11.52	-0.088	0.072	0.312	50.9
NDFD	%	20	43.6	6.69	-0.102	0.126	0.433	126.3
ADFD	%	22	42.2	4.12	-0.065	0.114	0.582	133.9

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; SE, standard error; AIC, Akaike information criterion.

3.2. Influence of niacin supplementation on rumen fermentation of dairy cows

Results of meta-analysis showed that niacin supplementation did not affect the rumen fermentation, i.e. VFA profiles and ammonia concentration (Table 2). It appears that niacin has less effect for rumen microbes, but the effect is more obvious for the host animals. Other authors reported that niacin supplementation affected the production of total VFA and acetate and propionate, but had minimal influence on butyrate production [5]. Niacin supplementation can improve rumen microbial population and, hence, such supplementation may increase fermentation of feed in the rumen especially propionate [2] and can improve the fermentation of carbohydrates, thus increasing production of total VFA [6]. It might be that different results in rumen fermentation is due to the influence of the different treatment, measurement total VFA from rumen fluid and the type of feed given to dairy cows.

Table 2. Influence different supplemental niacin levels on rumen fermentation of dairy cows

Response Parameter	Unit	N	Parameter estimates				Model statistics	
			Intercept	SE Intercept	Slope	SE Slope	P-value	AIC
VFA Total	mM	23	129.3	18.31	0.610	0.544	0.283	200.0
C2	%	16	63.7	2.16	-0.017	0.053	0.760	68.8
C3	%	16	21.3	1.83	0.021	0.043	0.638	63.6
C2/C3	%	16	3.1	0.36	-0.003	0.007	0.731	18.1
C4	%	16	11.2	0.44	-0.002	0.023	0.950	40.5
NH_3	%	16	97.9	18.18	-0.324	1.056	0.766	150.6

VFA, volatile fatty acid; C2, acetate; C3, propionate; C2/C3, acetate to propionate ratio; NH_3, ammonia concentration; N, number of data; SE, standard error; AIC, Akaike information criterion.

4. References

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