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RESEARCH ARTICLE

Influence of supplementary nickel on feed intake, nutrient utilization and growth performance in Murrah buffalo calves

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Abstract: Eighteen male Murrah buffalo calves of about similar age (8.7 months) and body weight (125 kg) were selected from Livestock Research Centre, ICAR- National Dairy Research Institute, Karnal, Haryana, India and divided into 3 groups of 6 animals using randomised block design to investigate the effect of different levels of nickel (Ni) supplementation on feed intake, nutrient utilization, growth performance and rumen fermentation parameter. All the animals were fed to meet their nutrient requirements ICAR (2013), however, the animals in groups T_1, T_2 and T_3 were supplemented with 0, 5 and 10 ppm of Ni, respectively. Daily DM intake and fortnightly body weights were recorded in the morning before offering feed and water. Rumen liquor samples were collected at 0, 60 and 120 days of the experiment to analyze different rumen fermentation variables. Different levels of Ni in the diet did not influence nutrient intake, digestibility of nutrients (DM, OM, CP, EE, NDF and ADF), nitrogen balance, growth rate and feed conversion ratio. The values of various rumen fermentation parameters like pH, total volatile fatty acids, ammonia-N and TCA precipitable-N were similar in the three groups. The urease activity in rumen liquor was the highest ($P<0.05$) in group T_3. The propionate level increased ($P<0.05$) while that of butyrate decreased in group T_3 as compared to groups T_1 and T_2 showing no significant effect on acetate concentration. Hence, supplementation of Ni upto 10 ppm in the ration did not affectnutrient utiliisation and growth performance in male Murrah buffalo calves, however, urease activity and proportion of propionate increased to a greater extent in calves supplemented with 10 ppm Ni.

Keywords: Buffalo calves, Growth performance, Nickel, Nutrient digestibility, Rumen fermentation

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Introduction

Nickel (Ni) is a possible essential trace element (NRC, 2005). Nickel is an integral part of the soil, plants and water. Nickel concentration in plants is affected by several factors including plant species, stage of maturity, pH of the soiletc.(Underwood, 1977; Sapek and Sapek, 1980). Faecal excretion is the major route for eliminating unabsorbed Ni and urinary excretion is the major route for eliminating absorbed Ni (Von, 1997). Nickel is an important element for the biosynthesis of hydrogenase, carbon monoxide dehydrogenase enzyme (Can et al. 2014) and discovered in several genera of bacteria in the rumen. Nickel-Fe hydrogenase enzyme was required for the growth of anaerobic *Enterobacteriaceae* and this bacterium was required for vitamin B_{12} synthesis in the rumen. Cellular Ni was found to be localized in the nucleic acid fraction (Wacker and Vallee,1959; Sunderman, 1965) and contribute to the stability of RNA, DNA or ribosome. Nickel might have a function in nucleic acid and protein metabolism. Rumen bacterial urease (EC3.5.1.5) is a Ni -dependent enzyme (Hausinger, 1986). The addition of Ni in the diet increased the recycling of nitrogen in the rumen by increasing ruminal epithelium urease activity (Spears and Hatfield, 1980). Nickel with marginal or adequate protein diets containing urea was fed to ruminants and a constant increase in rumen ammonia concentration and serum urea was observed (Spears and Hatfield, 1978). Nickel is also an important element for adequate immune system in the animal body. Alteration in Ni concentration of diet affects the production and action of some hormones like insulin, growth hormone, prolactin, thyroid hormone, noradrenaline, adrenaline and aldosterone (La Bella et al. 1973). The normal dietary requirement of Ni for domestic animals has not been well established, however, Ni requirement was higher for ruminants than non-ruminants which was considered to be in the range of 300 to 350 µg/kg dietary DM. The maximum tolerable level of Ni in the diet of cattle and sheep should be less than 100 ppm while for chicks and pigs it is 250 ppm. The definite role (s) of Ni in animal metabolism

remains a mystery. Hence, the present study was undertaken to find out the influence of supplementary Ni on feed intake, nutrient utilization, growth performance and rumen fermentation parameters in Murrah buffalo calves.

Materials and Methods

Animals, diets and experimental design

The study was conducted at Livestock Research Center of ICAR-National Dairy Research Institute (NDRI), Karnal, Haryana, India. The experimental protocol was approved by the NDRI-Institutional Animal Ethics Committee (IAEC) under the IAEC approval No. 45-IAEC-19-1 governed by the Committee for the Purpose of Control and Supervision of Experimentation on Animals (CPCSEA, Govt. of India).

Eighteen male Murrah buffalo calves were distributed randomly into 3 groups of 6 animals each based on body weight (125±9.67 kg) and age (8.70±0.86 months) using randomised block design. Deworming was done before the start of the animal trial. All the animals were fed to meet their nutrient requirements as per ICAR (2013), however, experimental animalsreceived a basal diet along with Ni (in form of nickel sulphate hexahydrate) @ 0, 5 and 10 mg/kg DMI in groups T_1, T_2 and T_3, respectively for a period of 120 days.

Oats fodder and concentrate mixture were supplied in the ratio of 60: 40 (on DM basis) in ration to meet the requirements as per ICAR (2013) standards**.** The animals were given fresh and clean water free of choice twice daily at 09.00 h and 15.30 h. All the animals were housed in individual pens and clean surroundings were ensured throughout the experimental period.

Body weight, DM intake, average daily gainxand feed conversion ratio

The body weight of animals was measured at fortnightly intervals. The DMI was measured based on body weight and expected gains. The average daily gain (ADG) and feed conversion ratio (FCR; kg DM intake/kg BW gain) were calculated.

Metabolic trial and chemical composition of biological samples

A metabolic trial was conducted at the end of growth trial during which representative samples of different feeds offered (Oats fodder and concentrate mixture) and residues were collected and dried in hot air oven at 65°C till a constant weight was attained. Dried samples were ground to pass through 1 mm sieve size and stored in air tight containers. Feeds, residues and faeces were analysed for proximate principles viz. DM, OM, CP, EE and total ash (AOAC 2005) and cell wall constituents (NDF and ADF) as per Van Soest et al. (1991). Neutral detergent insoluble crude protein (NDICP) and acid detergent insoluble crude protein (ADICP) in feeds were determined as Licitra et al. (1996). Total digestible nutrient (% TDN) was calculated (NRC, 2001). The Ni contents in a feeds and water samples were measured by atomic absorption spectrophotometer (ZEEnit700P) at ICAR- Central Soil Salinity Research Institute, Karnal, Haryana.

Rumen fermentation parameters

Rumen liquor samples were collected at 0, 60 and 120 days of the feeding trial before feeding and watering from four animals for each group using a stomach tube attached to a vacuum pump. Rumen liquor was strained through four layers of cheesecloth into plastic containers and kept in -20°c for further analysis. Rumen pH and urease activity were measured immediately after the collection of rumen liquor using a digital pH meter (Weatherburn,1967).

Ammonia-N and TCA precipitable-N were measured using micro Kjeldahl method (KELPLUS-CLASSIC-DX). The concentration of total volatile fatty acids (TVFA) was estimated (Barnett and Reid 1956). The individual fatty acid (IVFA) levels were measured by gas chromatograph (NUCON-5700) as per Cottyn and Boucque (1968).

Statistical analysis

The data were analysed using Statistical Package for Social Sciences (SPSS, V21.0; Inc., USA).

Results and Discussion

Feed intake and growth performance

The chemical composition of feeds has been shown in Table 1. The Ni content in basal diet was 1.67 mg/kg DM. Dietary Ni supplementation up to 10 ppm did not affect feed intake, fortnightly body weight, FCR and ADG of Murrah buffalo calves (Table 2). Spears and Hatfield (1978) found that early weaned lambs fed a semi-purified diet containing 0.065 ppm Ni showed

Table 1 Chemical composition (% on DM basis) of feeds

Parameter	Oats fodder	Concentrate mixture
Nutrient composition		
DM	32.23	92.32
OM	90.09	88.73
CP	8.02	19.22
TA	9.91	11.27
EE	2.77	4.81
NDF	57.39	26.93
ADF	44.75	15.68
NDICP	2.82	2.74
ADICP	1.34	0.89
TDN*	60.79	75.25
Ni (ppm)	1.50	1.97

*Calculated value (NRC, 2001)

gains similar to animals receiving Ni 5 ppm supplemented and observed no outward deficiency symptoms. O'Dell et al. (1970) found significantly improved FCR due to addition of Ni in the diet of calves compared to the non-supplemental group. Spears et al. (1979) reported that supplementation of Ni @ 5 ppm with high energy and low protein diet fed to steers and improved FCR compared to the control group. Singh et al. (2018) reported that the heifers receiving a diet containing 3 ppm Ni showed significantly improved feed intake weight gain and FCR as compared to those receiving 1.5 ppm Ni and the non-supplemented groups. Anke et al.(1977) suggested that supplementation of 5 ppm Ni along with basal diet-fed goats showed 21% higher weight gain than those fed a basal diet with 1 ppm Ni. Bersenyi et al. (2004) observed that dietary supplementation of 50 mg Ni/kg DM intake fed to broiler chicken showed a slight improvement in body weight gain and feed conversion efficiency while Ni added at a level of 500 mg/kg in broiler chick diets reduced BW gain by 10% as compared to control group and resulted in poor FCE. Kirchgessner and Roth (1977) found that supplementation of Ni at the level of 125, 250 and 375 ppm had no effect on feed intake and growth performance while at 500 ppm level Ni reduced feed intake and growth rate in pigs. Oscar et al. (1987) reported higher body weight gain and improved feed efficiency in the diet of steers fed 5 ppm Ni.

Plane of nutrition, digestibility of nutrients and nitrogen balance

The digestibility of nutrients (DM, OM, CP, EE, NDF and ADF) was similar in all groups (Table 3). Nitrogen utilisation was not affected by supplementation of Ni up to 10 ppm in the diet. The Ni supplementation at a level of 5 or 10 ppm in the diet did not affect plane of nutrition in Murrah buffalo calves (Tabel 4). O'Dell et al. (1970) reported no significant change in the apparent digestibility of DM, CP, NFE and gross energy in dairy calves by the addition of Ni to the diet. Paula et al. (2005) reported that supplementation of Ni at 5 ppm with a low protein (3.1% CP) the diet of male sheep showed no effect on the apparent digestibility of DM, CP, OM and nitrogen balance while receiving high protein (8.2% CP) diet with Ni supplementation @ 5 ppm reduced digestible DM, digestible energy and metabolizable energy as compared to the non-supplemented group.

Table 2 Effect of Ni supplementation on feed intake and growth performance

Parameter	Day	Group			SEM	*p*-value
		T_1	T_2	T_3		
Body weight (kg)	0	126.25	125.65	123.97	6.12	0.99
	120	209.02	207.93	210.24	8.57	0.97
	Mean	166.14	164.36	164.68	3.38	0.90
ADG (g)		689.75	685.63	718.88	20.97	0.55
DM intake (kg/d)		4.85	4.87	4.88	0.07	0.90
DM intake (kg/100 kg BW)		2.83	2.88	2.88	0.02	0.58
FCR (kg feed intake/kg BW gain)		7.03	7.13	6.88	0.20	0.76

Table 3 Effect of Ni supplementation on nutrient digestibility (%) and nitrogen balance

Parameter	Group			SEM	*p*-value
.	T_1	T_2	T_3		
Digestibility (%)					
DM	58.49	59.72	61.63	0.66	0.15
OM	60.63	61.21	62.99	0.62	0.30
CP	66.33	66.65	66.70	0.82	0.98
EE	83.29	82.66	83.99	0.63	0.73
NDF	51.33	51.47	53.23	1.49	0.87
ADF	39.85	38.86	42.05	1.00	0.46
Nitrogen balance					
N intake (g/d)	104.73	100.71	106.89	1.33	0.16
N excreted in faeces (g/d)	35.26	33.59	35.60	1.06	0.75
N excreted in urine (g/d)	41.06	40.08	42.22	1.13	0.84
Total N outgo (g/d)	76.32	73.67	77.82	2.54	0.82
Absorbed N (g/d)	69.47	67.12	71.29	1.02	0.27
N absorbed (% N intake)	66.33	66.65	66.69	0.82	0.98
N balance (g/d)	28.41	27.04	29.07	1.67	0.89
N retention (% N intake)	27.36	26.91	27.36	1.79	0.99

Nitrogen absorption and excretory patterns were not affected by Ni supplementation. Spears and Hatfield (1978) found no change in faecal N by supplementation of Ni in the diet of lamb while urinary N excretion was significantly higher in the group of lambs receiving a low Ni diet as compared to the 5 ppm Ni-supplemented group indicating that Ni plays a vital role in protein metabolism while no difference in nitrogen excretion was observed between the low and adequate Ni group in the second collection period conducted at 56 days.

Rumen fermentation parameters

Average values of pH, total volatile fatty acids, ammonia-N, TCA precipitable-N were not affected by the addition of up to 10 ppm supplementary Ni in the diet (Table 5). The propionate level increased ($P<0.05$) while that of butyrate decreased in group T_3. The proportion of acetate was not affected by Ni supplementation. The urease activity was the highest ($P<0.05$) in group T_3 compared to other groups (Spears et al. 1979). Starnes et al. (1982) showed that supplementation of Ni at 5 ppm increased rumen bacterial urease activity regardless of protein source. Fishbein et al. (1976) reported that urease has been found to contain 6 to 8 atoms of Ni per mole of enzyme and is a Ni metalloenzyme. Milne et al. (1990) reported that a diet containing high-energy and low protein with supplementation of Ni at a level of 5 mg/d given in the form of $NiCl_2.6H_2O$ by continuous infusion into the rumen resulted in a significant increase in the rumen urease activity in sheep. Singh et al. (2018) reported that urease activity in the rumen increased significantly due to Ni supplementation in the diet of Hariana heifer as compared to non-supplemental groups. In this study, there was a tendency toward an increase in TCA precipitable N in the 10 ppm Ni supplemented group which might be related to increasing in urease activity. The propionate level increased ($P<0.05$) while that of butyrate decreased in group T_3 as compared to groups T_1 and T_2 showing no significant effect on acetate concentration. O'Dell et al. (1970) also reported that a high level of Ni supplementation in bovine increased the molar percentage of propionic acid and reduced the percentage of butyric acid. Vorob'eva et al. (1962) stated that Ni had a vital role in increasing the growth of propionic acid-producing bacteria in the rumen ecosystem. Spears et al. (1978) reported that supplementation of an adequate protein with Ni in lambs and steers had no significant effect on individual fatty acids (IVFAs_ while a low protein diet with 5 ppm Ni offered to steer significantly increased molar percentage of propionic acid and decreased molar percentage of acetic acid in the rumen liquor compared to control group.

Conclusions

The dietary Ni supplementation at levels of 5 and 10 ppm to the basal diet containing 1.67 ppm Ni did not affect feed intake, growth rate, digestibility of nutrients, N balance, plane of nutrition, pH, total volatile fatty acids, ammonia-N, TCA precipitable-N and acetate in male Murrah buffalo calves. The urease activity and propionate level in rumen liquor increased in group supplemented

Table 4 Effect of supplementation of Ni on the plane of nutrition during metabolism trial

Parameter	Group			SEM	*p*-value
	T_1	T_2	T_3		
BW (kg)	191.15	188.63	192.58	9.28	0.83
DMI (kg/d)	5.18	5.23	5.42	0.12	0.74
DMI (kg/100 kg BW)	2.71	2.77	2.82	0.06	0.83
CP intake (g/d)	654.59	629.47	668.06	8.36	0.16
CP intake (g/100 kg BW)	342.45	333.17	346.90	3.96	0.10
EE intake (g/d)	205.14	188.46	207.64	4.12	0.11
EE intake (g/100 kg BW)	107.32	99.01	107.84	1.48	0.61
NDF intake (kg/d)	2.06	2.08	2.22	0.07	0.66
NDF intake (kg/100 kg BW)	1.08	1.10	1.15	0.31	0.78
ADF intake (kg/d)	1.58	1.56	1.64	0.05	0.85
ADF intake (kg/100 kg BW)	0.83	0.83	0.85	0.02	0.93
OM intake (kg/d)	4.64	4.67	4.84	0.11	0.76
OM intake (kg/100 kg BW)	2.43	2.47	2.51	0.05	0.85
TDN intake (kg/d)	3.38	3.42	3.59	0.08	0.58
TDN intake (kg/100 kg BW)	1.77	1.81	1.86	0.04	0.68
Water intake (L/d)	21.25	21.66	21.75	0.56	0.94
Water intake (L/ kg DMI)	4.10	4.14	4.01	0.10	0.90
Nutritive value (%)					
CP	12.71	12.04	12.34	0.18	0.36
DCP	8.43	8.03	8.24	0.16	0.64
TDN	65.22	65.36	66.22	0.63	0.81

Table 5 Effect of Ni supplementation on rumen fermentation parameters

Parameter	Day	Group			SEM	*p*-value
		T_1	T_2	T_3		
pH	0	6.53	6.43	6.55	0.04	0.59
	60	6.60	6.75	6.63	0.03	0.23
	120	6.70	6.68	6.70	0.31	0.94
	Mean	6.61	6.62	6.63	0.02	0.95
TVFA (mmol /dL)	0	8.49	8.68	8.49	0.20	0.92
	60	10.25	10.18	9.93	0.27	0.89
	120	10.09	10.33	10.03	0.24	0.88
	Mean	9.61	9.73	9.48	0.18	0.80
Acetate (%)	0	66.00	64.64	65.34	1.20	0.92
	60	65.32	66.39	65.24	0.38	0.52
	120	65.06	65.23	65.77	0.42	0.79
	Mean	65.46	65.42	65.45	0.41	0.99
Propionate (%)	0	18.21	18.85	18.26	0.27	0.65
	60	18.92	17.52	22.65	0.80	0.01
	120	18.03	19.95	21.08	0.42	0.01
	Mean**	18.39^{a}	18.77^{a}	20.66^{b}	0.33	0.01
Butyrate (%)	0	15.80	16.51	16.40	0.29	0.66
	60	15.76	16.09	12.11	0.61	0.01
	120	16.91	14.82	13.15	0.64	0.02
	Mean**	16.16^{b}	15.81^{b}	13.89^{a}	0.33	0.01
Ammonia-N (mg/ dL)	0	12.10	12.29	13.42	0.84	0.83
	60	11.73	13.13	14.11	0.84	0.55
	120	12.55	12.92	13.46	0.45	0.61
	Mean	12.13	12.78	13.66	0.50	0.73
TCA precipitable-N (mg/ dL)	0	55.00	54.12	54.30	0.86	0.92
	60	63.84	65.01	66.80	1.79	0.82
	120	64.49	66.65	68.02	1.02	0.10
	Mean	61.11	61.93	63.04	1.11	0.40
Urease activity (µmol NH_3-N /min/mL)	0	2.67	2.59	2.63	0.17	0.98
	60	2.52	3.16	3.45	0.18	0.42
	120	2.72^{a}	3.34^{b}	3.72^{b}	0.15	0.01
	Mean*	2.64^{a}	3.03^{ab}	3.27^{b}	0.11	0.04

[a,b] Values bearing different superscripts in a row differ significantly (*P<0.05; **P<0.01)

with 10 ppm Ni while proportion of butyrate decreased in group T_3 as compared to other groups.

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