EFFECT OF DIETARY SUPPLEMENTATION OF SELENIUM NANO PARTICLES ON INTAKE AND UTILIZATION OF NUTRIENTS IN WISTAR ALBINO RATS

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ABSTRACT

Sixty three male Wistar albino rats of 124.3±3.1 g mean body weight were divided into nine equal groups and fed a common basal diet, except for selenium (Se) source and levels. While in group T1 (control) no Se was supplemented; in group T2 and T3, 150 ppb Se was supplemented as sodium selenite and Se nano particles, respectively. Rats in groups T4, T5, T6 and T7 were supplemented with Se nano particles at 75, 37.5, 18.75 and 9.375 ppb levels, respectively. Rats in groups T8 and T9 were supplemented with 300 ppb Se nano particles and sodium selenite, respectively. Experimental feeding lasted for a period of 45 days including a digestion trial of 5 days. The intake and digestibility of dry matter, organic matter, ether extract, crude fiber and nitrogen free extract were similar ($p>0.05$) among the nine groups. However, wistar rats given 150 ppb Se nano particles had significantly ($p<0.05$) higher crude protein digestibility than sodium selenite and control. The results suggested that nano particles of selenium had no adverse effect on nutrient intake and exerted positive effect on the protein utilization in the diet.

Keywords: Selenium, nano particles, nutrient intake, protein utilization

INTRODUCTION

Selenium (Se) plays an essential physiological role in the higher animals although it is present at lower concentrations in the tissues than most other essential elements. Se plays an important role in metabolism and prevention of oxidative damage to tissues (Neve, 2002). The bioavailability of Se is associated with its forms. Currently, sodium selenite is the usual Se source used as a supplement in animal feeds in India and organic forms such as Se enriched yeast, is the commercial Se source used in animal feeds in USA (Federal Register, 2002) and (EEC, 2006). Sodium selenite which is an inorganic form of Se has the disadvantage in animal nutrition that it is a potential toxin at higher dietary levels and has lower absorption efficiency

(Vendeland *et al*., 1994). Nanotechnology holds promise for medication and nutrition because materials at the nanometer dimension exhibit novel properties different from those of both isolated atom and bulk material (Albrecht *et al*., 2006). Nano Se particles possess comparable efficiency to selenite, selenomethionine, and methylselenocysteine in upregulating selenoenzymes in mice and rats but exhibited dramatically decreased acute toxicity (Jia *et al*., 2005; Zhang *et al.,* 2005). However little work has been done to study the effect of Nano Se in nutrient intake, digestibility and protein utilization in animals.

Hence an experiment was conducted to study the effect of supplementation different levels of Se nano particles compared to sodium selenite (at 150 and 300 ppb) on nutrient intake and protein utilization in male wistar rats.

MATERIALS AND METHODS

Preparation of Selenium nano particles

Selenium nano particles were synthesized as described previously (Gorer and Hodes, 1994) with certain modifications. The size of the obtained nano-Se particles ranged from 35 to 50 nm as determined by transmission electron microscopy (TEM) and quantified using atomic absorption spectrophotometer model 4141 (ECIL, Hyderabad, India) along with vapor generation (hydride generator) assembly.

Experimental Animals

Sixty three male wistar rats of 124.3±3.1 g mean body weight were divided into nine equal groups of seven animals in each group following completely randomized design and housed in polypropylene cages having provision of feeding and watering. Strict hygienic and managemental practices were followed throughout the experimental period. All the animals were fed with a common basal diet comprised of 27.5% ground maize, 25% Bengal gram, 21% soybean meal, 24% wheat bran, 2% mineral mixture containing vitamin A (without Se) and 0.5% common salt (*NRC, 1995*). Selenium was added in the diet as aqueous solution of sodium selenite or Se nano particles. While in group T1 (control), no Se was supplemented; in groups T2 and T3, 150 ppb Se was supplemented as sodium selenite and Se nano particles, respectively. Rats in groups T4, T5, T6 and T7 were supplemented with Se nano particles at 75, 37.5, 18.75 and 9.375 ppb levels, respectively. Rats in groups T8 and T9 were supplemented with 300 ppb Se nano particles and sodium selenite, respectively. Clean and fresh drinking water was made available *adlibitum* to all animals throughout the experimental period. After 40 days of experimental feeding a 5-day digestibility trial was conducted on six animals randomly selected from each group and each animal was housed in separate polypropylene cages. During the digestion trial, amount of feed offered, residue left, and feces voided in 24 hours were daily quantified and recorded for all the animals separately and a representative sample of each was dried in a hot air oven at 100±1°C overnight and preserved for further analysis. A suitable aliquot of feces was also daily preserved in 20% sulfuric acid for the estimation of nitrogen/crude protein (CP). Samples of feed offered, residue left and feces voided were analyzed for proximate principles and

the feed samples were also analyzed for selenium, phosphorous (P) (AOAC, 2012) and calcium (Ca) (Talapatra *et al*., 1940). All the data generated in the experiment were statistically analyzed using analysis of variance technique (Snedecor and Cochran, 1989) and means were compared using Duncan's multiple-range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The chemical composition of the basal diets offered to wistar rats in different groups are presented in Table 1. The chemical composition of the basal diet indicated that the level of different nutrients were adequate to meet the nutrient requirements of the rats (NRC, 1995).

The data obtained during digestibility trial on daily intake of dry matter (DM), organic matter (OM), crude protein (CP) and total digestible nutrients (TDN) and digestibility of DM, OM, CP, ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE) are presented in Tables 2 and 3. The mean intake of DM and OM was found to be similar (P>0.05) among all the experimental groups indicating that the supplementation of Se nano particles up to 300 ppb in the basal diet had no adverse effect on the palatability and feed intake of wistar rats. The intake of CP, Digestible Crude Protein (DCP) and TDN were also similar (P>0.05) among all the experimental groups compared to control. It indicated that the supplementation of Se nano particles up to 300 ppb in the basal diet had no effect on plane of nutrition and nutritive values of diets in wistar rats. Similar to our observations, the mean intake of DM, OM, CP, DCP and TDN were similar (P>0.05) among the different groups of guinea pigs supplemented with 0.1, 0.2 and 0.3 ppm organic Se respectively (Mahima *et al.,* 2010). The DCP and TDN contents were also similar (P>0.05) in the diet of different groups. Similarly sodium selenite supplementation at 0.3, 0.15 and 0.30 ppm also had no effect on weaned piglets (Daza *et al.,* 2000) and gilts (Mahan and Peters, 2004), respectively.

The digestibility of DM and OM were similar (P>0.05) among the nine experimental groups. Similar to our findings, the digestibility of DM was also found to be similar (P>0.05) in guinea pigs supplemented with 0.1, 0.2 and 0.3 ppm organic Se in different groups compared to control (Mahima *et al.,* 2010).

The digestibility of CP was significantly improved (p<0.05) in T3 supplemented with 150 ppb Se nano particles compared to other groups. The CP digestibility in T8 and T9 supplemented with 300 ppb Se nano particles and sodium selenite, respectively were comparable (P>0.05) with that of T1 indicating that higher levels of Se nano particles and sodium selenite were not having any enhanced effect on improving the CP digestibility in wistar rats compared to 150 ppb Se nano particles supplemented in T3 suggesting that, there may be a threshold level of Se in the diet, which

Table 1. Chemical composition of the basal diet

Nutrients	Percent dry matter basis
Organic Matter	95.28
Crude Protein	22.66
Ether Extract	4.56
Total Ash	4.72
Crude Fiber	7.75
Nitrogen-Free Extract	60.31
Calcium	1.50
Phosphorus	0.66
Selenium	0.08 ppm

Table 2. Intake (g/day) and digestibility (%) of nutrients in different groups of wistar albino rats

Attributes	T1 CON	T2 150 SS	T3 150 NS	T4 75 NS	T5 37.5NS	T6 18.75NS	T7 9.375NS	T8 300 NS	T9 300 SS	SEM	P Value
Dry Matter											
Intake	14.9	14.5	12.3	13.5	12.5	12.3	13.5	14.0	12.8	0.37	0.454
Digested	12.2	12.4	10.8	11.5	10.7	10.4	11.3	11.8	10.8	0.36	0.511
Digestibility	81.88	85.52	87.80	85.19	85.60	84.55	83.70	84.29	84.38	0.81	0.468
Organic Matter											
Intake	14.2	13.8	11.7	12.9	11.9	11.7	12.8	13.3	12.2	0.35	0.456
Digested	11.8	12.0	10.4	11.1	10.3	10.0	10.9	11.4	10.4	0.34	0.502
Digestibility	83.10	86.96	88.89	86.05	86.55	85.47	85.16	85.71	85.25	0.76	0.447
Crude Protein											
Intake	3.06	3.29	2.84	3.37	2.79	2.78	3.05	3.17	2.91	0.08	0.112
Digested	2.51	2.73	2.47	2.87	2.44	2.34	2.54	2.72	2.47	0.08	0.085
Digestibility*	82.03^{a}	82.98^{a}	86.97^{b}	83.38^{a}	83.87^{a}	83.09^{a}	81.97^{a}	82.65^{a}	82.13^{a}	0.54	0.023
Ether Extract											
Intake	0.68	0.66	0.56	0.62	0.57	0.56	0.61	0.64	0.58	0.02	0.442
Digested	0.55	0.55	0.49	0.51	0.47	0.47	0.51	0.54	0.49	0.02	0.526
Digestibility	80.88	83.33	87.50	82.26	82.46	83.93	83.61	84.38	84.48	0.68	0.403
Crude Fiber											
Intake	1.15	1.12	0.95	1.04	0.96	0.95	1.04	1.08	0.99	0.03	0.656
Digested	0.80	0.84	0.73	0.74	0.69	0.71	0.77	0.83	0.76	0.03	0.908
Digestibility	69.57	75.00	76.84	71.15	71.88	74.74	74.04	76.85	76.77	1.32	0.868
Nitrogen Free Extract											
Intake	8.97	8.76	7.42	8.14	7.54	7.40	8.13	8.44	7.73	0.22	0.455
Digested	7.55	7.85	6.71	7.30	6.67	6.47	7.03	7.31	6.74	0.22	0.444
Digestibility	84.17	89.61	90.43	89.68	88.46	87.43	86.47	86.61	87.19	0.69	0.462

*Means bearing different superscripts in a row differ significantly ($p<0.05$).

is essential to maintain the production of proteolytic digestive enzymes *viz.* trypsin, chymo trypsin and carboxy peptidase in the pancreas of animals (Adkins and Ewan, 1984). Above this level, there was no beneficial effect on CP digestibility. Similar to the present study, an increase in the apparent digestibility of nitrogen (N) was observed in rats (Evan, 1976) and growing-finishing pigs (Tian *et al*., 2006) supplemented with low levels of Se at 0.025 and 0.1 ppm, respectively. Similar results were also reported on supplementation of 0.1 ppm of organic Se in guinea pigs compared to 0.2 and 0.3 ppm (Mahima *et al.,* 2010).

The digestibility of EE, CF and NFE were similar ($p>0.05$) in all the experimental groups suggesting that the supplementation of Se nano particles up to 300 ppb had no effect on digestibility of these organic nutrients. The basal diet used in our experiment had 0.08 ppm Se, which might have been sufficient for optimum utilization of EE, CF, and NFE. Therefore further supplementation of Se in the diet

Table 3. Plane of nutrition in wistar rats during digestion trial

Attributes	T1 CON	T2 150 SS	T3 150 NS	T4 75 NS	T5 37.5NS	T6 18.75NS	T7 9.375NS	T8 300 NS	T9 300 SS	SEM	P Value
Body weight (g)	264	285	283	256	268	265	260	255	245	4.42	0.063
DM intake (g/Kg $^{0.75}$)	40.8	37.5	31.7	37.4	34.1	33.4	37.9	38.5	37.4	1.05	0.879
OM intake (g/Kg $^{0.75}$)	38.9	35.8	30.2	35.6	32.5	31.9	36.1	36.7	35.7	1.01	0.879
CP intake (g/Kg $^{0.75}$)	8.42	8.51	7.45	9.35	7.43	7.58	8.58	8.72	8.48	0.24	0.665
DCP intake (g/Kg $^{0.75}$)	6.92	7.05	6.47	7.96	6.49	6.39	7.18	7.47	7.21	0.23	0.604
TDN intake (g/Kg $^{0.75}$)	34.20	32.72	28.26	32.34	29.75	28.90	32.44	33.13	32.32	1.01	0.898
Nutritive value of diets (% DM basis)											
DCP	18.18	18.14	19.60	19.13	19.56	18.79	18.46	18.75	18.44	0.17	0.759
TDN	83.05	86.80	84.79	85.15	86.34	84.67	84.31	82.95	82.84	0.76	0.44

had no effect on the digestibility of these nutrients in our experiment. Similar to our findings, digestibility of EE, CF and NFE was comparable ($p>0.05$) among guinea pigs (Mahima *et al.,* 2010) supplemented with 0.1, 0.2 and 0.3 ppm of organic Se in different groups.

The data pertaining to the plane of nutrition of wistar rats during digestion trial has been presented in Table 3. Similar ($p>0.05$) intake of digestible crude protein (DCP) and total digestible nutrients (TDN) and also dietary contents of DCP and TDN in different groups (Table 3) indicated that the supplementation of Se nano particles up to 300 ppb in the basal diet had no effect on the plane of nutrition and nutritive values of diets in wistar rats. Similar to our observations, the intake of DCP and TDN were comparable ($p>0.05$) among the different groups of guinea pigs supplemented with 0.1, 0.2 and 0.3 ppm organic Se (Mahima *et al.,* 2010).

SUMMARY

Supplementation of Se nano particles or sodium selenite up to 300 ppb in the basal diet had no adverse effect on nutrient intake and digestibility in wistar rats. However, there was marked improvement in the dietary protein utilization in male wistar rats supplemented with 150 ppb nano Se compared to 150 and 300 ppb levels of sodium selenite, respectively in different groups.

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