PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
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Pakistan Journal of Nutrition 8 (7): 1093-1096, 2009
ISSN 1680-5194

The Relative Bioavailability of Sodium Selenite and High Selenium Yeast in Human

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Abstract: The yeast was more highly absorbed, peaked at a later time and remained in the blood for a longer period of time than the selenite. These results are in agreement with our long term animal supplementation study in which we found a greater blood selenium concentration after feeding rats yeast as compared with selenite. The urine results also corroborated the blood in that the yeast selenium was less excreted, i.e. more retained than the selenite.

Key words: Selenite, yeast, Urine excretion of selenium

INTRODUCTION

Selenium is an essential trace metal for human and animals. The National Academy of Sciences recommends 200 micrograms of Selenium per day in the diet of a human adult.

The role of Selenium in the body has not been completely elucidated. However, Selenium has been found to be essential for formation and activity of an enzyme, glutathione peroxidase. This substance plays a role in the immune system of the cell.

The enzyme is necessary to protect the body against inflammatory agents, mutagenic agents and carcinogens. It also protects the tissues from oxygen-induced damage and is necessary for production of viable sperm in the male. Selenium has been found to be protective when the toxic heavy metals are consumed or breathed.

Research efforts have identified groups of people with low selenium intakes and presumed selenium deficiency based on low blood selenium levels. Inhabitants of New Zealand (Thompson and Robinson, 1980), Finland (Westermarck *et al*., 1977) and China (Xia *et al*., 2005) often have low blood selenium. Individuals with therapeutic diets low in selenium (Lombeck *et al*., 1978), people undergoing parenteral administration (Van Rij *et al*., 1976) and alcoholics with cirrhosis (Valimake *et al*., 1983) can also be selenium deficient. Epidemiological studies have shown that low blood selenium levels have been linked to increased incidence of cancer (Schrauzer *et al*., 1973; McConnell *et al*., 1980; Burk *et al*., 2006) and heart disease (Shamberger, 1978).

Thus, it may be necessary to supplement the human diet with selenium in ideally the most bioavailable form of selenium. Approaches to the determination of bioavailability of physiologically important levels of selenium have been diverse and have yielded data of uncertain significance. One factor that contributes to this variation is the fact that selenium occurs in so many different chemical forms: SeO in elemental selenium, Se4- in SeO_3 2- (selenites), Se6- in SeO_4 2- (selenates) and Se2- in selenomethionine or incorporated in protein be replacing sulphur in sulphur containing amino acids. Studies using species specific criteria such as exudative diathesis or pancreatic fibrosis (Cantor *et al*., 1975a,b) in chicks have also yielded diverse and highly variable data. For instance, both criteria indicate a superior availability of plant over animal selenium sources, but a very low availability of selenomethionine was found for protection against exudative diathesis and a very high availability for protection against pancreatic fibrosis. Variation was wide in determining effectiveness of a given selenium source fed at different levels (non-linear response) and fed at the same levels in different experiments. However, in all cases, selenite was the most available form of selenium. A good slope ratio assay has been developed relating plasma glutathione peroxidase activity to selenium intake in selenium depleted chicks. Selenite was the most available followed by selenomethionine, fish meal, corn meal and soybean meal (Gabrielson, and Opstvedt, 1980).

Very little data occurs in the literature concerning the human bioavailability of different forms of selenium. A New Zealand study showed that selenomethionine showed more complete absorption, greater retention, and smaller endogenous urinary and faecal losses than selenium from selenite or mackerel (Robinson *et al*., 1978 and Rayman, 2004). A human dietary study (Palmer *et al*., 1983) which monitored urinary selenium concluded that the selenium in dairy products and eggs is more readily available to Finnish men of low selenium status as measured by plasma selenium and glutathione peroxidase. The present study was undertaken to investigate which form of selenium, of those available for human supplementation, was most bioavailable.

The relative bioavailability of different forms of Selenium can be determined by either short-term or long-term experiments. In short-term experiments, the area under the blood concentration time curve is a measure of absorption of the selenium. Urine excretion indicates how rapidly the absorbed selenium is removed from the body. The present study is designed to test the relative bioavailability of sodium selenite and high selenium yeast using a short term experiment.

Bioavailability study: Previous study by Vinsons and Boss, 1987 on laboratory animals such as rats are the most commonly used animal to test the bioavailability of trace elements because their diet can be carefully controlled and large numbers may be easily maintained for long periods of time. He used nine groups of 5 rats each were used for the study. They were all fed a Selenium deficient food (Nutritional Biochemical's) for 12 days. Then each group of 5 rats was fed a certain amount of selenium in one of three forms, inorganic selenium, sodium Selenite, amino acid chelate selenium and High Selenium Yeast. The amounts of selenium fed were 50 parts per billion (ppb), 100 ppb and 200 ppb in the diet. At the end of 33 days of selenium feeding, the rats were sacrificed and their blood and liver analyzed for selenium by fluorescent assay. The results are listed below:-

Blood		
Form of Selenium	Se in Food (ppb)	Average Selenium (ppb)
Inorganic	50	463
Inorganic	100	790
Inorganic	200	1249
Amino Acid Chelate	50	332
Amino Acid Chelate	100	560
Amino Acid Chelate	200	811
High Yeast	50	708
High Yeast	100	947
High Yeast	200	1533
Liver		
Form of Selenium	Se in Food (ppb)	Average Selenium (ppb)
Inorganic	50	490
Inorganic	100	727
Inorganic	200	933
Amino Acid Chelate	50	503
Amino Acid Chelate	100	750
Amino Acid Chelate	200	1129
High Yeast	50	651
High Yeast	100	908
High Yeast	200	1597

From this data the relative bioavailability can be calculated. The slope of the plot of Selenium food (x-axis) as Selenium in Blood and Liver (x-axis) represents the bioavailability. The inorganic selenium for comparison purposes is said to be 100% bioavailable. The other forms of Selenium may then be compared by comparing the slopes to that of inorganic selenium. The results are listed below:

Blood		
Form of Selenium	Slope of plot	Relative Bioavailability %
Inorganic	5.15	100
Amino Acid Chelate	3.10	60
High Yeast	6.23	122
Liver		
Form of Selenium	Slope of plot	Relative Bioavailability %
Inorganic	2.83	100
Amino Acid Chelate	4.12	146
High Yeast	6.39	226

The concentration of Selenium in the blood represents the current Selenium status of the individual. Blood is the carrier of Selenium such as glutathione peroxidase are synthesized.

MATERIALS AND METHODS

Ten normal subjects -6 males and 4 females, aged 18-30 volunteered with informed consent. All volunteers have a deficient in selenium blood levels. The normal subject's levels of serum selenium ranged between 40.3-62.7 ng\ml before treatment. All patients were treated with 200 ug of selenium as selenite or yeast form for 10 weeks. Blood samples were taken at 0, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0 h. Selenium in blood was measured by using flameless atomic absorption spectrophotometer. Determination of selenium was performed using AAS equipped with a heated graphite furnace model HGA 2000. Argon gas (99.999% purity) was used as a purge gas at a flow rate of 50 ml\min. argon gas flow was maintained continuously through drying and charring step and gas stop mode was used during atomization stage. As in the previous procedure auto sample was used for dispensing samples into graphite furnace. Instruments setting and working condition for determination of Se are wave length 196 nm, lamp current 16 mA, volume of sample 10 ul, Argon as sheathing gas, drying time 30 min., ashing temperature 1000°C, atomization temp., 2000°C and atomization time 3 second.

They collected a 24 h blank urine samples before the study. Each subject appeared 2 h after eating breakfast. The selenium (200 µg) of selenite or yeast was drunk in 100 ml of a 10% glucose solution. First one form was given and then 5 days later the other form was ingested. A 24 h urine sample was collected following selenium ingestion. Selenium in urine was measured by using flameless atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The average blood concentration before testing (0 h) was 42.4±23.0 for the sodium selenite and 46.3±27.4

ng/ml for the yeast. There was no significant difference between these baseline values. A plot of the average selenium concentration versus time for each of the two forms is shown in the following Fig. 1. As can be seen, the selenite peaks at an earlier time (1 h) compared to the yeast (1.5 h). After 4 h the yeast group was back to baseline and the selenite group was below baseline. The area under each subject's curve was measures by planimeter and the results are given in Table 1. All Ten subjects experienced a greater area for the yeast than the selenite. The yeast produced a 22% greater area, $p<0.001$.

Table 1: Areas under the blood concentration time curves (arbitrary units)

Supplement			
Subject	Sex	Selenite	Yeast
1	F	560	639
2	F	518	695
3	F	533	767
4	F	480	577
5	M	639	770
6	M	643	726
7	M	698	801
8	M	588	690
9	M	695	820
10	M	460	558

Mean ± S.D. 581.4± 85.3, 704.3± 90.4*, *p<0.001

Table 2: Changes in Average Blood Concentration (ng/ml) from Baseline Time (hours) Suppl

	Time-Hours						
	1	1.5	2.0	2.5	3.0	3.5	4.0
Selenite	112*	95.0	59.1	24.1	12.6	1.1	-3.2
	(37.9)	(41.9)	(24.5)	(11.9)	(11.5)	(8.4)	(9.2)
Yeast	73.7	135	110**	56.4*	24.1	3.8	4.9*
	(31.0)	(40.3)	(49.0)	(36.1)	(15.4)	(8.6)	(4.8)

*Significantly greater p<0.05, **Significantly greater p<0.01

The changes in blood selenium from the baseline (0 h) for each subject was determined and the average results shown in Table 2. The selenite group had a significantly greater concentration after 1 h than the yeast. However, the yeast group had a significantly greater concentration after 2, 2.5 and 4 h than the selenite. The urine data are shown in Table 3. Six out of the ten subjects had a greater excretion of selenium after ingestion of the selenite as compared with the yeast. The selenite produced over a two-fold greater selenium excretion, $p<0.01$. This result, couple with the blood data, indicates that the selenium in the yeast is returned for a longer period of time in the tissues. This conclusion is confirmed of long term rat supplementation study which showed over a two fold greater liver concentration following yeast supplementation as compared with selenite (as above). The results are shown in the Tables 1, 2 and 3 that

Table 3: Collection data of 24 h Urine Excretion of Selenium

	Micrograms Selenium/24 hour	
Subject	Selenite Blank	Yeast Blank
1	38.2	47.1
2	88.2	59.6
3	52.1	0.2
4	21.7	21.8
5	47.0	3.3
6	53.6	6.4
7	57.1	15.2
8	78.2	61.3
9	46.4	17.2
10	65.5	22.6
Mean±S.D.	54.8±19.1	25.5±22.6

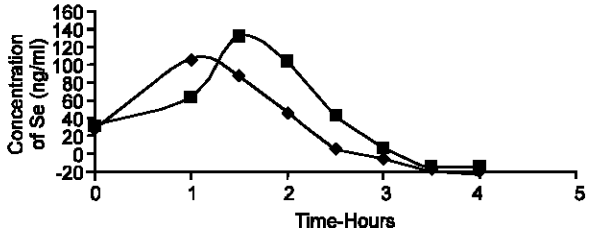

Fig. 1: Concentration of Selenium in Blood versus time after two forms of selenium Supplement

the changes in selenium levels in blood was decreased sharply for selenite after 1 h of maximum concentration while the yeast was decreased gradually after 1.5 h of maximum level. It is surprising that the selenium yeast which was supposed to be an amino acid chelate fared so poorly in the bioavailability study. If the selenium is in a chelate form, then it must be very stable and is in competition with chelating cellular acceptor sites on the mucosa or other tissues (Horwitz, 1980; Shah, 1983). It may be in the +4 oxidation state as Selenium dioxide, which is the commonly used and least expensive form of selenium. The yeast in which the selenium is probably covalently bound to amino acids in the -2 state was the most bioavailable. The yeast is grown in a nutrient medium containing selenium dioxide, harvested, hydrolyzed and spray dried.

Selenomethionine (Palmer *et al*., 1983), selenium rich wheat (Vinson and Boss, 1987) and selenium yeast (Levander *et al*., 1983) is more bioavailable than selenite.

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