JOURNAL of QASSIM UNIVERSITY FOR SCIENCE
©2023 Qassim University [E-ISSN: 1658-9610]
Vol. 2, Issue 1, pp 122-132 (July 2023)
JQUS

The protective effect of selenium nano-particles against mono-sodium glutamate-induced alterations in male albino rats

Maha Saud S. Alrashidi[1] and Heba F. Gomaa[2]
1.Graduate student, Department of Biology, College of Sciences, Qassim University, Buraidah, Saudi Arabia.
2 Biology Department, College of Science, Qassim University, Burydah, Saudi Arabia.

Correspondence author: 421200392@qu.edu.sa

Abstract

Background: Monosodium glutamate **(**MSG) is a flavor enhancer that is frequently used in food, particularly in Asian and West African cuisines. It is created during the fermentation of starch, sugar, beet sugarcane, or molasses. Some reports claim that MSG is harmful to both humans and animals.
Objective: This study aims to investigate the protective effect of selenium nano-particles on testicular toxicity induced by mono-sodium glutamate in male albino rats.
Method: The experiment was performed on 28 Wistar male rats; the experimental study include 4 groups (7 rats each): **G1:**control rats fed normal rodent diet and water; **G2:** rats received selenium nano-particles at a dose of (0.4 mg/kg bwt) for 28 days, **G3:** Male albino rats received mono-sodium glutamate in a daily dose of (4 g/kg bwt) for 28 days intraperitoneally; **G4**: Male albino rats received a daily oral dose of Se-NPs for 7 successive days & on the 7th day the animals received the first dose of MSG intraperitoneally (4g/kg bwt) then rats received both treatments until the end of the experiment for 28 days. Serum Testosterone hormone, serum lipid peroxidation [MDA], reduced glutathione [GSH] were estimated, samples from testis were separated for histological analysis.
Result: The results of the following study revealed that the administration of Se-NPs orally before MSG treatment resulted in a protective effect against testicular toxicity as it resulted in a significant decline in the levels of serum MDA, elevation in the values of serum GSH level and testosterone, improvement in testicular architecture & reappearance of sperms.
Conclusion: The results showed that Se-NPs treatment as a protector exhibited a protective effect against testicular damage and enhance antioxidant status in male albino rats.

Key Word Monosodium glutamate, selenium Nano-particles, testicular toxicity, testosterone, spermatic arrest, MDA.

1.Introduction:

Monosodium glutamate (MSG) is a white crystalline powder that is the sodium salt of glutamic acid, a naturally occurring nonessential amino acid. Fermentation of starch, sugar, beet sugarcane, or molasses produces MSG [15,19].

According to some reports, MSG is hazardous to humans and experimental animals. MSG is a flavor enhancer that is extensively used as a food ingredient, especially in West African and Asian dishes. However, due to its availability, largely without labeling, in many food products, unintentional overuse of this food additive may occur [3,16, 25, 27].

Selenium (Se) is a mineral that plays an essential part in a variety of biological processes and can help protect you from a variety of ailments. Chemicals were used to minimize sperm abnormalities [20].
Se is an antioxidant that is required for normal testicular growth, spermatogenesis, and spermatozoa motility and function. Se-supplementation has been shown to improve sperm motility and increase the chances of a successful conception in sub-fertile males with low Se levels [21].
Nanomedicine-based methodologies propose modalities for dealing with the problems that standard medication and dose forms present. Nanomedicine's greater safety is a well-known benefit. The use of SeNPs reduces the death induced by acute selenium poisoning by up to four times in a mouse model. The fundamental question to be solved is how SeNPs diminish the unanticipated toxicological consequences associated with Se. Understanding Se's redox state as well as its oxidation state is crucial to resolving this question [1, 30-31].

2.Materials and Methods:

2.1 Chemicals

Monosodium glutamate (C5H9NO4Na) with a purity of 99% NT was sold in most open markets under the license of Ajinomoto Co., Inc., Tokyo, Japan; Se-Nps was provided by Sigma-Aldrich Company, USA, and was purchased from (Se, purity: 99.9%, APS: <80nm). NANOSHEL “Creating Miracles in Black,” in the form of a black powder, was dissolved in corn oil and injected orally at a dose of 0.4 mg/kg b.wt. (Testosterone) with the use of ELISA kits "MyBioSoure kits," and Malondialdehyde (MDA), Reduced glutathione (GSH) by using "Elabscience kits".

2.2 Experimental design

28 Wistar male rats; the experimental study include 4 groups (7 rats each**): control group**; rats fed normal rodent diet; **Se-NPs-group**: rats received selenium nano-particles at a dose of 0.4 mg/kg bwt for 28 days, **MSG-treated group:** Male albino rats received mono-sodium glutamate in a daily intraperitoneally dose of 4 g/kg bwt for 28 days; **SeNPs-MSG-treated group**: Male albino rats received a daily oral dose of Se-NPs for 7 successive days & on the 7th day the animals received the first dose of MSG intraperitoneally (4g/kg bwt) then rats received both treatments until the end of the experiment for 28 days.

2.3. Determination of the oxidative stress biomarkers in serum:

Malondialdehyde (MDA) levels were estimated spectrophotometrically by using kits according to [18] reduced Glutathione (GSH) levels was estimated according to [23].

2.4. Determination of serum testosterone hormone:

Testosterone hormone level was measured by ELISA technique by using "MyBioSource Kits", according to [32].

2.5. Statistical analysis

Comparisons between means were carried out using one-way analysis of variance (ANOVA) followed by post hock (Tukey)and the Statistical Analysis System's General Linear Model Procedure (SAS 1982).

Multiple comparisons test at P≤0.05 according to previous [29]. This was carried out using Statistical Analysis System (SAS) program software; copyright©1998 by SAS institute Inc., Cary, NC, USA.

3.Result and Discussion

Serum oxidative stress biomarkers:
Serum Malondialdehyde level (nmol/ml) of adult male Wistar albino rats (*Rattus norvegicus):*

The obtained data in table "1" & figure "1" showed that oral administration of healthy adult male rats with Selenium nano-particles (0.4mg/kg bwt.) orally by gastric tube for 28 consecutive days did not deteriorate ($p \leq 0.01$) the Malondialdehyde level when this group was compared to the corresponding values of the control animals' group (22.1 vs 21.2).In contrast, the administration of mono-sodium glutamate in a daily dose of 4g/kg bwt for 28 days intraperitoneally resulted in a more significant ($p \leq 0.01$) increase (62.7%) in the serum MDA level (34.5 Vs 21.2) when was compared to the control animals' group.

Our findings are consistent with those of earlier investigations [4, 10,21-22]. as they attributed this increase in the serum MDA level to that MSG encourages the production of MDA via oxidative stress and increase the generation of free radicals inducing dysfunction of sperm membranes, sperm DNA damage, and slowed sperm motility which may lead to testicular toxicity.

The current investigation showed that Se-NPs were effective in protecting rats by lowering their MDA levels and exhibiting protection against oxidative damage due to an excess of unsaturated fat in the plasma membrane and a deficiency of antioxidants in the cytoplasm [6,11, 13,33].

The administration of selenium nano-particles (0.4mg/kg bwt) orally by gastric tube for 7 successive days & on the 7th day the animals received the first dose of MSG intraperitoneally (4g/kg bwt) then rats received both treatments until the end of the experiment for 28 days induced a more significant decline in the serum MDA level (-29.3%) when this group was compared (24.4 vs 34.5) to the corresponding values of MSG-treated group. It was reported by some researchers that Se-NPs protected against oxidative damage [33].

Serum Reduced glutathione level (mmol/l) of adult male Wistar albino rats (*Rattus norvegicus):*

The obtained data in table "1" & figure "2" showed that oral administration of normal adult male rats with Selenium nano-particles (0.4mg/kg bwt) orally for 28 successive days did not induce any significant change in ($p < 0.01$) the level of reduced glutathione when this group was compared to the corresponding values of the control animals' group (93.6 vs 94). While, mono-sodium glutamate treatment (4g/kg bwt) for 28 successive days intraperitoneally resulted in a more significant ($p \leq 0.01$) decline (-17.9%) in the serum GSH level (77.1 Vs 94) when was compared to the control animals' group. Selenium nano-particles treatment (0.4mg/kg bwt) orally by gastric tube for 7 successive days & on the 7th day the animals injected with the first dose of MSG intraperitoneally (4g/kg bwt) then rats received both treatments until the end of the experiment for 28 days revealed a more significant improvement in the serum GSH level (13.2%) when this group was compared (87.3 vs 77.1) to the corresponding values of MSG-treated group.

MSG administration to rats revealed a substantial reduction in GSH activity, which aggravated oxidative stress in the testis [17]. It is hypothesized that MSG's harmful effects change the inner membrane of the mitochondria, lowering levels of the antioxidant GSH and increasing the production of hydrogen peroxide [5, 8,10].

Serum Testosterone (ng/ml) of adult male Wistar albino rats (*Rattus norvegicus*):

The obtained data in table "2" & figure "3" revealed that oral treatment of normal adult male rats with selenium nano-particles (0.4mg/kg bwt) for 28 successive days did not show any significant change in ($p< 0.01$) the levels of serum testosterone when this group was compared to the corresponding values of the control animals' group (0.432 vs 0.426). While, mono-sodium glutamate injection (4g/kg bwt) for 28 successive days intraperitoneally resulted in a more significant ($p\leq0.01$) decline (-49.1%) in the serum testosterone level (0.217 Vs 0.426) when was compared to the control animals' group. The oral administration of selenium nano-particles (0.4mg/kg bwt) for 7 successive days & on the 7th day the animals injected with the first dose of MSG intraperitoneally (4g/kg bwt) then rats received both treatments until the end of the experiment for 28 days induced a more significant improvement in the serum testosterone level (79.3%) when this group was compared (0.389 vs 0.217) to the corresponding values of MSG-treated group.

The results of the current investigation showed that the MSG group's serum levels of testosterone these results are in line with [10,22]. They reported that monosodium glutamate has harmful effects on CNS neurons. The disruption of the hypophysial axis (HP) in the MSG-treated rats may be responsible for the decrease in serum testosterone. Additionally, they attributed the drop-in levels of testosterone to a reduction in the overall number of Leydig cells that produce testosterone [10].

MSG mono-sodium glutamate treatment (4g/kg bwt) for 28 successive days intraperitoneally resulted into degeneration of seminiferous tubules (spermatic arrest, fig.4 & 5). while the oral administration of selenium nano-particles (0.4mg/kg bwt) for 7 successive days & on the 7th day the animals injected with the first dose of MSG intraperitoneally (4g/kg bwt) then rats received both treatments until the end of the experiment for 28 days showed improvement in testicular architecture & reappearance of sperms (Fig.6).
The pathological results are in accordance with the biochemical results as the drop-in testosterone as result to oxidative stress resulted in spermatic arrest following MSG-treatment that was ameliorated following the administration of Se-NPs. Se NPs administration dramatically enhanced spermatogenesis, sperm quality, serum testosterone [6,23].

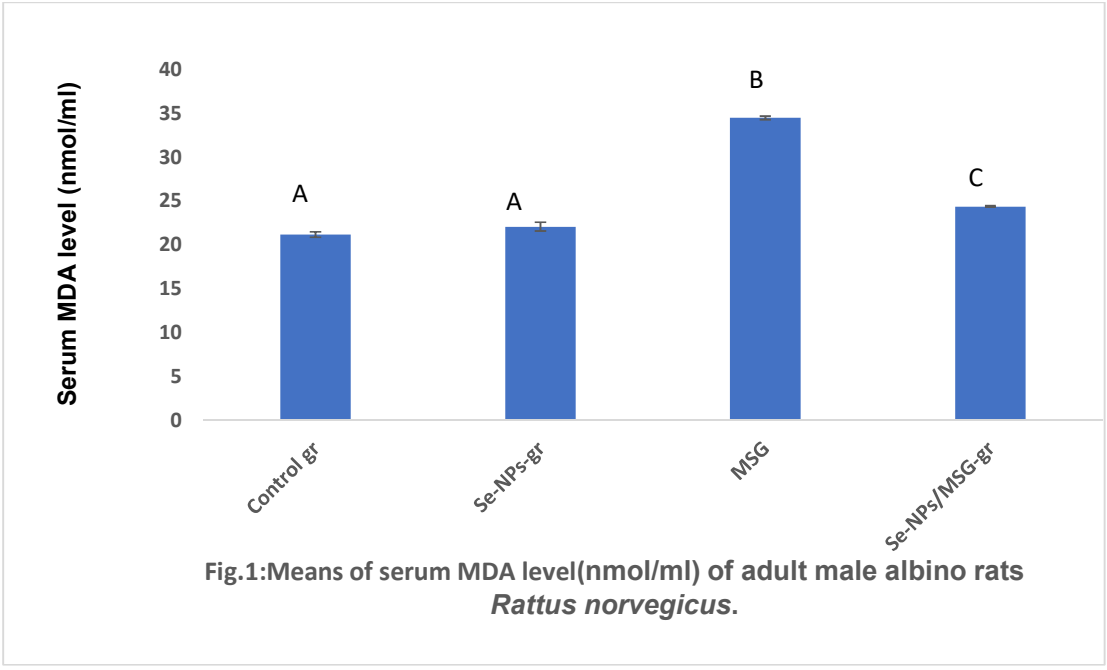

Fig.1:Means of serum MDA level(nmol/ml) of adult male albino rats *Rattus norvegicus*.

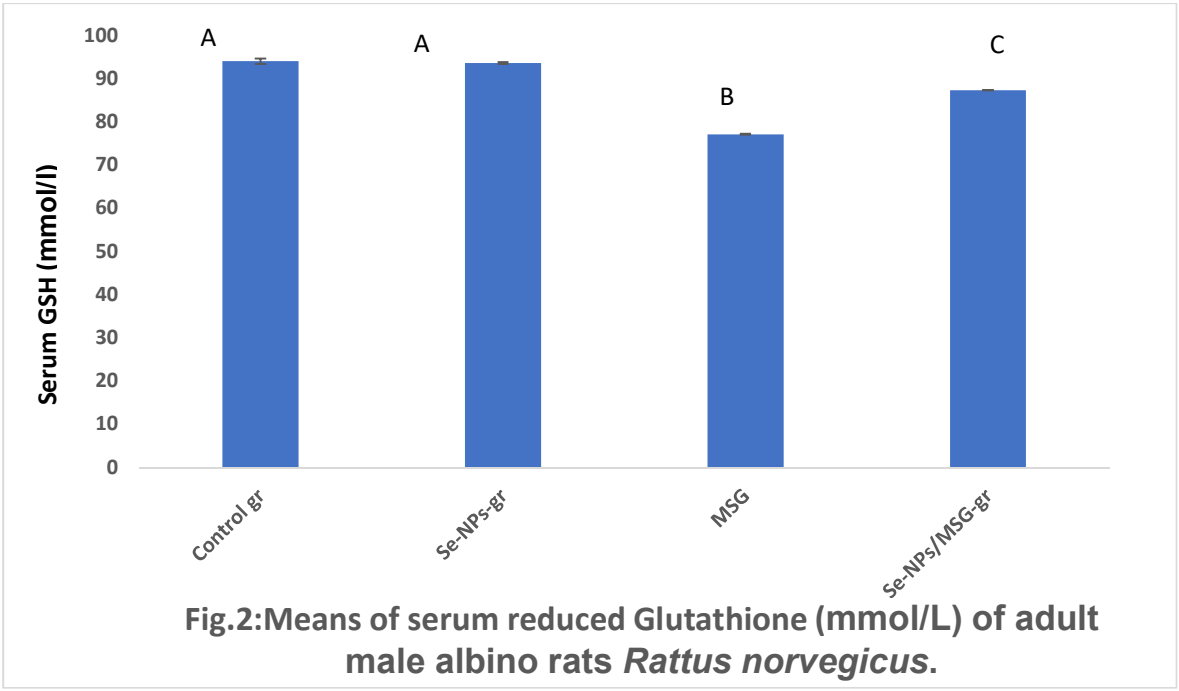

Fig.2:Means of serum reduced Glutathione (mmol/L) of adult male albino rats *Rattus norvegicus*.

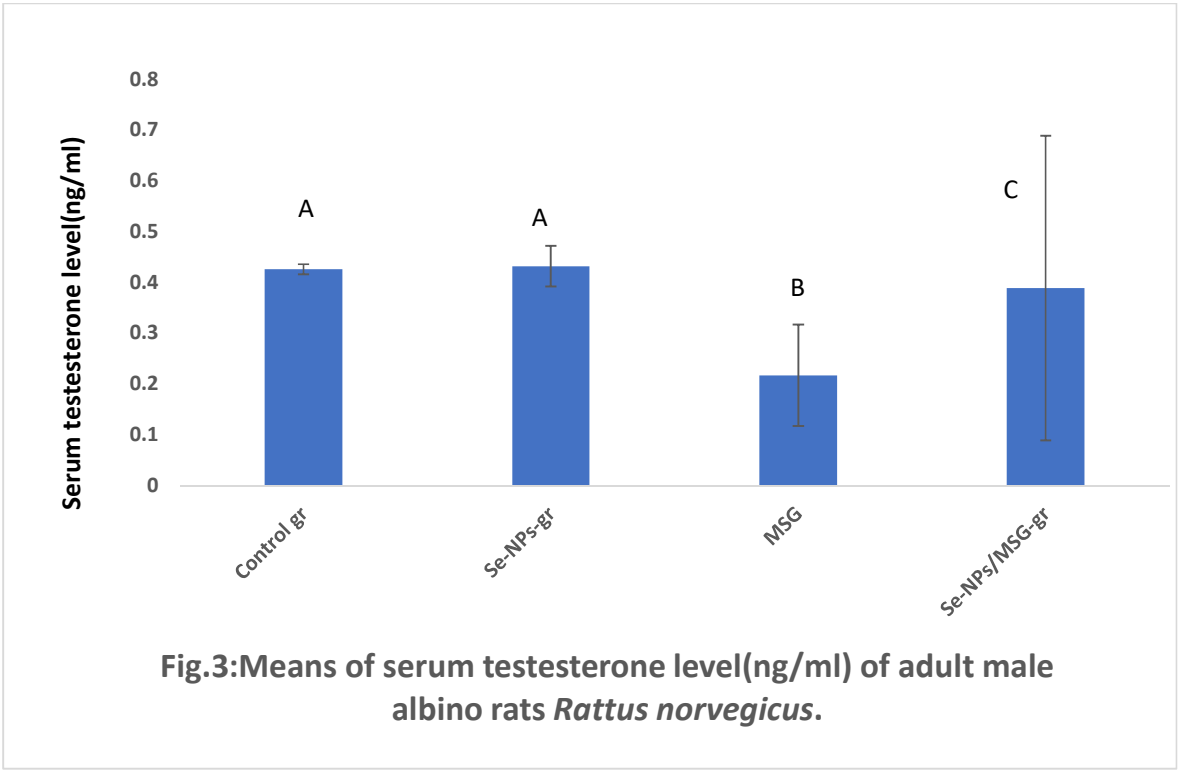

Fig.3:Means of serum testesterone level(ng/ml) of adult male albino rats *Rattus norvegicus*.

Table 1:Mean values of serum oxidative stress levels of control, MSG, and SeNPs/MSG -treated animals' groups as compared to normal control animals' groups

Groups \ Parameters		MDA (nmol/ml)	GSH (mmol/ml)
Control	M ±SE	21.2±0.3^{A}	94±0.6^{A}
SeNPs	M ±SE	22.1±0.5^{A}	93.6±0.2^{A}
	% Change A	**4.2%**	**-0.4%**
MSG	M ±SE	34.5±0.2^{B}	77.1±0.5^{B}
	% Change A	**62.7%**	**-17.9%**
SeNPs/MSG	M ±SE	24.4±0.1^{C}	87.3±0.54^{C}
	% Change B	**-29.3%**	**13.2%**

Data are presented as mean ± standard error of mean. Data were subjected to one-way ANOVA followed by Duncan post hoc test at p≤0.01. Within the same column, means with different superscript letters are significantly different. SeNPs (Selenium Nanoparticles); MSG (mono-sodium glutamate).

Table 2: Mean values of serum Testosterone levels of control, MSG, and Se-NPs/MSG-treated animals' groups as compared to normal control animals' groups.

Groups \ Parameters		Testesterone (ng/ml)
Control	M ±SE	0.426±0.01^{A}
Se-NPs	M ±SE	0.432±0.04^{A}
	% Change A	**1.4%**
MSG	M ±SE	0.217±0.5^{B}
	% Change A	**-49.1%**
Se-NPs/MSG	M ±SE	0.389±0.3^{C}
	% Change B	**79.3%**

Data are presented as mean ± standard error of mean. Data were subjected to one-way ANOVA followed by Duncan post hoc test at p≤0.01. Within the same column, means with different superscript letters are significantly different. Se-NPs (Selenium Nanoparticles); MSG (mono-sodium glutamate).

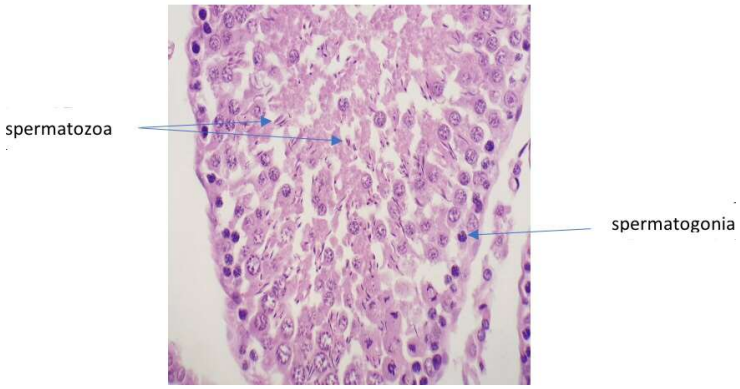

Fig.3: Photomicrograph of testicular section of control group stained with Hx,400x.

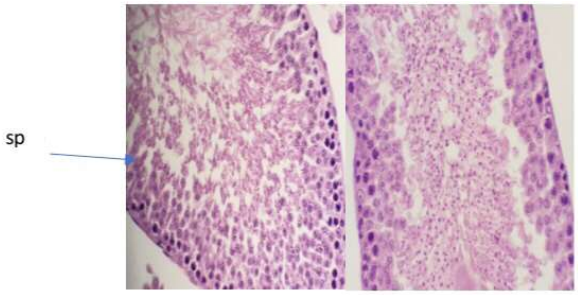

Fig.4 &5: Photomicrograph of section of testis treated with MSG;(SP: spermatogonia) stained with Hx ,400x

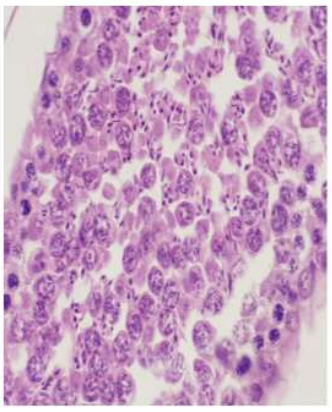

Fig.6 Photomicrograph showing testicular section of Se-NPs -MSG stained with Hx ,400x.

Conclusion:

Selenium nano-particles significantly reduced the oxidative stress caused by MSG administration. The study showed that MSG had a negative impact on male reproductive organs, that was clear from the decrease in testosterone levels, and changes in testicular pathology.
The male fertility-damaging effects of MSG were partially mitigated by Se-NP. According to the current research, Nano-selenium when administered in combination with MSG, it enhanced the antioxidant profile as well as the histopathological harms. So Se-NPs treatment shields rats' testis from the harm that MSG causes.

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