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Role of selenium on oxidative stress and male reproductive system

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Abstract: The health of animal has an immense impact on its reproductive capability, male reproductive zone produces spermatozoa in which free radicals are synthesized naturally for maturation and smooth fertilization. While the elevated quantity of these free radicals interrupt the whole method of production of sperm in addition to its maturation and leads to infertility. Selenium is an element which is naturally containing some enzymes and proteins which reduce production of excessive free radicals via acting as an antioxidant. Consequently, it shelters sperms from harm caused by free radicals and oxidative stress. Selenium also helps in upholding semen value by means of promoting development and maturation of spermatozoa and declining creation of atypical spermatozoa. Furthermore, selenium feedings have shown that it has also striking impact on histology of male gonads, increases size, weight, and circumference of the testis and perk up sperm production via having a strong influence on seminiferous tubules. Thus selenium deficiency can lead to infertility and other reproductive disorders.

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INTRODUCTION

The animal's reproductive ability totally depends on four different factors including nutrition, genetic potential, environmental factors and on management[1].The impact of trace mineral supplementation is crucial and minute changes in their concentration in diet can affect both reproductive health and performance [2]. The selenium (Se) is the 34th element in the periodic table and common trace mineral found on earth crest. Its properties resemble to sulfur and tellurium element. Originally it was discovered by martin Heinrich Klaproth, a german scientist, but was mistakenly identified as tellurium. Since in 1818 Jon Jacob, a Swedish chemist discovered the selenium. He named selenium from word Selene the greek goddess of the moon [3].The selenium plays a fundamental task for maintenance of many normal functions of the body. It is the major constituent of mammalian enzymes, for instance, the glutathione peroxidase[4], it maintains variety of processes in body including antioxidant mechanism[5], and also plays an important role in continuation of fertility in males [6].

Reactive oxygen species (ROS), antioxidants and oxidative stress

The ROS are extremely active oxidizing factors consisting of single or multiple unpaired types of an electron in their structure belonging to the set of free radicals. The ROS molecules have the capability for succession reactions, with the aim of "radical begets radical". The majority of these possess forceful implications on the reproductive physiology which include hydrogen peroxide (H_2O_2), superoxide (O_2 -) , Peroxyl (ROO-) and hydroxyl (OH-) radical which are very reactive in nature. On the other hand the peroxynitrite anion (ONOO-) and nitrogen resultant free radical nitric oxide (NO) also act as an important factor in fertilization and reproduction of animals[7]. ROS have advantageous impacts upon the functions of spermatozoa, depending on the nature and the amount of the free radicals in addition to site and duration of introduction to free radicals[8]. Moreover, throughout the procedure of epididymal transportation of sperm, the sperm attains capability to travel progressively. Conversely, they attain the capability to fertilize, inside the female reproductive zone all the way through a succession of physiological changes called "capacitation" [9]. During normal physiological state, the spermatozoa manufacture a very little quantity of ROS that is required in support of the sperm capacitation and acrosomal reaction. Superoxide anion takes part in this process [10].The production free radicals should be inactivated constantly in order to maintain normal homeostatic functions of the cell. The plasma of semen is gifted with a range of antioxidant molecules in order to protect the sperm cells against oxidants[11]. Generally, antioxidants are the substances which suppress the synthesis of free radical molecules or resist their actions. There are many antioxidant compounds including catalase and SOD. The SOD instinctively dismutases the O_2 - anion in order to form oxygen and water , on the other hand, the catalase converts water hydrogen peroxide into water and oxygen molecule respectively. Like showed in following reactions :

$$2(O_2^-)^{\cdot} + 2H \xrightarrow{(SOD)} H_2O_2 + O_2$$

$$H_2O_2 \xrightarrow{(Catalase)} H_2O + 1/2O_2$$

The SOD provide protection to sperm cell against toxicity caused by lipid peroxidation LPO [12].The oxidative stress is a situation which is connected with amplified rhythm of cellular spoil which is promoted via ROS and oxygen- derived oxidant compounds [13]. The OS leads to develop a range of pathologies which afflict the reproductive physiology [7]. The production of ROS compounds has turned into actual concerned due to their adverse aspects at high levels on quality and function of sperms [13].Some selenoproteins and their locations are described in the Table-1.

Table.1 Selenoproteins, their location and impact on male reproduction.

Name	Location	Function	Reference
Cytosolic GPx4	Testis; epididymal epithelium	Antioxidant	Maiorino *et al.* (2003)
Secreted enzyme (GPx)	Epididymal lumen	H_2O_2 scavenger	Chabory *et al.* (2009), Drevet (2006)
Sperm nucleus GPx4	Sperm nucleus	Condensation of chromatin during spermatogenesis	Chabory *et al.* (2010), Conrad *et al.* (2005)
Mitochondrial GPx4	Mitochondrial capsule at midpiece	Antioxidative, structural component of mature spermatozoa	Ursini *et al.* (1999), Puglisi *et al.* (2007)
Plasma Selenoprotein P	Blood	Transport of Se to testis	Olson *et al.* (2005), Imai *et al.* (2009)

Sources of ROS in male reproductive system

The white blood cells, mainly neutrophils and macrophages, have been related to extreme free radical construction, and they eventually cause sperm abnormalities [14]. An additional significant cause of free radical is immature and morphologically dysfunctional spermatozoa [10]. The assembly of free radicals is also enlarged by pollution and smoking. The smoking increases ROS invention, leading sperm DNA damage, and suppresses antioxidants in both serum and semen [15].

ROS and sperm function

The final plan of a sperm cell is the victorious penetration of ovum ensuing in usual conception. sequentially to attain this, the spermatozoa following release have to mature inside the male genital zone, pass toward the female reproductive tract, experience the capacitation in addition to go through acrosome reaction, attach and pierce layers of the ovum .Further studies have revealed that incubating sperm with a minute amount of hydrogen peroxide support sperm capacitation, over-activation, acrosome reaction as well as oocytes union[16]. Free radicals except for hydrogen peroxide for instance nitric oxide and superoxide anion have also been revealed to encourage sperm capacitation and acrosome reaction [13]. Supposedly cellular depression in the semen is the outcome of an inappropriate steadiness among free radical construction and scavenging procedures that are promoting oxidative stress status (OSS), a situation in which there is a alter towards pro-oxidants, because of either overload ROS or reduced antioxidants [17]. Conversely, pathological ranges of free radicals evaluated in semen obtained from the infertile male are more prone due to increased ROS creation rather than lowered antioxidant capability of the seminal plasma [18]. The Mammalian spermatozoa are loaded with polyunsaturated fatty acids and, as a result, they are tremendously prone to ROS assault, which leads to a reduced sperm motility ability , most probably via a quick loss of intracellular ATP resulting to axonemal destruction, distended midpiece and morphology imperfections by means of harmful impacts on sperm capacitation and acrosome reaction [19]. The Lipid peroxidation of sperm casing is considered to be the key mechanism of this ROS-induced sperm injure resulting to infertility [10].The physiological impacts of free radicals are showed in following figure 1.

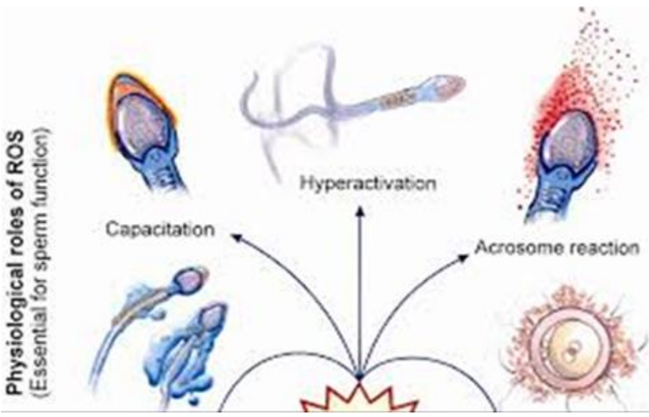

Figure 1: physiological impacts of free radicals (Kothari, et al. 2010).

Selenium and male fertility

The basic consequence of male fertility maintenance is oxidative damage to sperm cells while selenium protects them from this destruction as a result acts as a key factor for continuation of male fecundity [20]. The prominent occurrence of lipid peroxidation, and free radicals have been observed in male mice fed Selenium missing and increased Se supplementation [21].The results proved that selenium deficient diet leads to decrease motility ability and poor quality semen as compared to increased selenium in the diet of mice [22].Whereas a study shows that selenium deficiency can lead to decreased production of spermatozoa. The total amount of selenium in tests can be analyzed by observing GPx4 concentration among them [6]. Moreover, the mGPx4 amount becomes prominent during puberty that neutralizes free radicals created throughout a succession of redox reactions along with electron transport chain in mitochondria. Furthermore, the enlarged mGPx4 amount, in addition manages the appearance and arrangement of the mitochondrial casing via creating transverse-connection through itself as well as additional proteins[23].When the mGPx4 concentration decline, the structural consistency of sperms reduces resulting infertility. Additionally a research revealed that minor amount of mGPx4 were present in infertile males [24].

Selenium and spermatogenesis

The presence of enough Se, within the male reproductive region is necessary for the usual sperm cell formation, as well as Se has a vital position in the maturation of mammalian spermatozoa. Decreased or higher range of Se leads in for the growth of sperm. While semen value and fertility depend on the maturation of spermatozoa, any disruption during this method possibly will direct to decreased quality of semen as well as infertility in males. The task of Se in sperm creation by means of X-ray fluorescence microscopy (XFM) technique was observed. It is reported that selenoprotein P within the blood plasma responsible in favor of transporting of Selenium from blood toward testis[25]. The Selenium conveyed toward testis is used for making of selenoproteins within both tests as well as inside epididymis. The major selenoprotein within testis is phospholipid hydroperoxide glutathione peroxidase (PHGPx or GPx4), articulated mainly within sperm [6]. An enzyme called GPx5 released into the epididymal lumen [26], While some studies showed that within the lumen of epididymis duct , GPx5 and GPx3 moves beside spermatozoa throughout the epididymis to guard for resistance from ROS during the growth process [28].Thus, Se as an element of selenoproteins and selenoenzyme is involved in sperm synthesis via defending spermatozoa from free radical damage.

Effect of selenium on semen characteristics

In order to evaluate the impact of selenium on semen in 2009 a research was conducted which revealed that the organic selenium improved semen quality in rams via rising semen amount for every ejaculate, spermatozoa motility ability , its concentration in addition to reducing the percentage of dead spermatozoa, along with acrosome injure. The consequence of Selenium added feeds within boars were diverse as compared to those consumed the basal feed beside vitamin E [29]. furthermore decline in standard sperm cells was reduced in boars receiving a Selenium outfitted diet. In addition, the sperm cell tail abnormality was lesser in Selenium consumed boars, while it was lacking in boars fed diets treated along with vitamin E [30]. A research upon the consequence of 0.3 and 0.6 mg/kg feed organic (Sel-Plex) and 0.3 plus 0.6 mg/kg diet inorganic Se upon the semen of boars showed that spermatozoa motility rate was not appreciably different between supplementations [31].The boars consuming diet having 0.3 mg/kg sodium selenite revealed noticeably reduced sperm cell count, simultaneously as compared to those getting 0.6 mg/kg sodium selenite showed a stable reduced in sperm cell concentration except enlarged ejaculate amount.

Selenium and histomorphology of male gonads

Se is acknowledged to manipulate both gross as well as the histological morphology of the testis [32]. The Sodium selenate at 0.1 ppm of dry matter in the diet of rams has been reported to be connected with a major raise in scrotal measurement lengthwise and circumference. Furthermore, it was observed that the male progeny of mice consuming little grades of dietary Se (2–7g/kg in feed) revealed late testicular enlargement and maturation [29]. Conversely, this outcome was minute in contrast with that in the second and third progeny in which Se shortage affected the morphology of testes to a greater degree. While in the fourth generation, testis size being a minor quantity than partially of offspring of those mice consuming adequate Se (250–300g/kg sodium selenite), and testis were observed to be bilaterally shrunken lacking mitotic action in spermatogonia [33]. Additionally, the diameter of the seminiferous tubules was condensed, lined by Sertoli cells or a few amount of stem cells, along with osseous metaplasia, and partial or compact spermatogenic action was experiential [34]. In male Baladi goats, feed supplemented with 0.15 ppm organic Se resulted in a considerable enlarge in testosterone secretion compared to that originate in a control group fed basal diet only [35].In addition to Selenium shortage was connected with a major decrease in testicular weight in rats, impairing reproductive performance [36]. A study in broiler rooster breeder showed Se at 0.2 mg/kg in the feed as sodium selenite or Sel-Plex (Alltech Inc., USA) to be a chief aspect in male sexual maturation.The roosters fed Se produced semen at 19 weeks, whereas those fed a non-supplemented diet produced semen at 26weeks. The roosters fed organic Se (Sel-Plex) showed a definite hierarchy of spermatogenic cells exhibiting the spermatogonia, spermatocytes, spermatids, and spermatozoa (Edens and Sefton, 2009)[37]. No major outcome was experiential on the circumference of testes of Ossimi rams getting dietary organic Se at 0.2 and 0.5 ppm [38].The Elemental nano-Se has been reported to have an effect on the structural architecture of the testes within male goats [39].

CONCLUSION

The mammalian gonads want a constant deliver of definite trace elements, one of them is Selenium. Selenium has a strong influence on male reproductive physiology by combating production of excessive ROS .Additionally, the morphology of male reproductive organs strongly depends on the adequate dietary supply of Se, either inorganic or organic. Diets excessive or deficient in Se affect the gross as well as the histological morphology of the testis. A supply of Se for the selenoproteins in the testes critical to spermatogenesis and deficiency of or excess dietary Se may impair spermatogenesis resulting in poor semen characteristics eventually leading infertility.

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