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Comparative efficacy of Gum Arabic (*Acacia senegal*) and *Tribulus terrestris* on male fertility

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ABSTRACT

In this study the effect of Gum arabic (*Acacia Senegal*) was systemically targeted at male fertility with two experiments, the first comparing the effectiveness of Gum arabic (GA) and *Tribulus terrestris* (TT). For the first experiment, 27 adult mice Balb / c (18 females, 9 males) were divided into 3 in each group, one male and two females, group one had the usual tap water as power, group two had 5% (w / v) GA and group three had 5% (w / v) of TT for 21 days. The results showed, the number of offspring was more with GA treated when compared to TT treated. Blood measurements of testosterone showed significant increase in the GA group as compared to other groups, also Histopathological analysis showed the dose dependent 5% GA had normal seminiferous tubules with increase spermatogenesis. In this study the enhanced fertility in GA-treated mice Balb/c was observed and the experimental studies also show that GA fertility was increased.

1. Introduction

Infertility is a major issue that complicates reproductive age couples, leading to further psychological complications. Numerous factors causing male infertility; Decreased semen production in the population over time eliminated from different sectors and farm systems environmental harmful chemicals (Geoffroy-Siraudin, C., et al., 2012). The bioaccumulation of the toxic chemicals in the food chain causes the death of the organisms to influence the growth, development and reproduction of the organisms directly and indirectly (Mikulewicz, M., et al., 2014), thus leading to various alterations at reproductive stages like spermatogenesis (Easley, IV., et al., 2015). Pretesticular, testicular, post-testicular, sperm abnormality is the cause of male infertility, which investigates cell phase and shows the development of reactive oxygen (ROS) species which causes cellular and oxidative damage in many tissues (Dimitriadis, F. et al., 2017).

Recently, antioxidants are of major concern to break the oxidative chain reaction (Kurutas, E. B., 2015), hence herbal medicines are preferred choice for treating male infertility. The presence of natural antioxidant in plants treating various diseases, suggested the treatment of male infertility with no side effects (Safarnavadeh, T., & Rastegarpanah, M. 2011). Whereas sildenafil citrate the first oral drug approved for the treatment of erectile dysfunction has a high risk of cardiovascular problematic events, particularly fatal arrhythmias, headache, blurred vision, back pain, muscle pain, nausea.

Ethno-botanical survey has revealed herbal medicines may be preferred in treating male infertility, the antioxidants present

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in the plants treat infertility without adverse side effects (Jain, S., 2015). Phytochemicals like alkaloids treats infertility (Tahvilzadeh, M., et al., 2016) saponins are known to improve human sperm parameters (Khaleghi, S., et al., 2017) flavonoids improve male sperm quality as it neutralizes the adverse effects of metals on semen quality (Jamalan, M., et al., 2016), terpenoids improve seminal oxidative stress (Adewoyin, M., et al., 2017) tannins enhancing male infertility (Mohammadi, F., et al., 2013) the antioxidant present in the phytochemicals has potential to provide help in protecting cellular damage of erectile tissues (Naik, B. S., et al., 2016).

Gum arabic (*Acacia senegal*) is a member of the Leguminosae family, most of them found in Sudan. Gum arabic possesses a lot of counseling (Ahmed, A. A. 2018). The established antioxidant properties of GA are high (Mariod, A. A. 2018).

Based on the above observation of GA possessing many antioxidants with radical scavenging properties, in comparison with *Tribulus terrestris Linn*. (zygophyllaceae) a well-known Chinese medicine to improve sexual functions (Zhu, W., et al., 2017). Present investigation was initiated to treat male infertility. Hence a couple of experiments were conducted to distinguish the efficiency of GA treatment on fertility. Expt. 1; physiological parameters, histopathology, testosterone analysis in mice. Expt.2; deals with semen analysis (seminogram).

2. Material and methods

2.1. Gum arabic (Acacia senegal)

The *Acacia senegal* powder was purchased from the local market of Sudan, it is 100% natural powder from *Acacia senegal* trees which has been prepared by mechanical grinding to fine particle with size <210 μm without any additive. The quality confirmed to be used in food and pharmaceutical requirements approved from The Food and Drug Administration (FDA), https://www.fda.gov/food/food-additives-petitions/food-additive-status-list and recognized as safest dietary fiber by Food and Agriculture Organization of United Nations (FAO), British pharmacopoeia (BP), United State the Foodarmacopoeia (USP) and Joint FAO/WHO Expert Committee on Food Additives (JECFA). In Europe countries Acacia gum (E 414) is authorized as a food additive in the European Union (EU) in accordance with Annex II and Annex III to Regulation (EC) No 1333/2008 on food additives, https://efsa. onlinelibrary. wiley.com/doi/10. 2903 / j.efsa. 2017.4741

2.2. Tribulus terrestis

Tribulus terrestris (TT) were collected from the outside garden of Turabah City Saudi Arabia and identified by specialist in plant. The collected spines of TT were cleaned, later the fine powder was prepared with electrical grinder, dissolved in water TT (5% w/v): dissolve 5 g in 100 ml distilled water, boiled at 60°C for 5 min, cooled, filtered and given daily to mice for 21 days.

2.3. Animal studies

The animal experiments were carried out on Balb/c mice both sexes, from King Fahd Research Center, Jeddah, Saudi Arabia. All mice of either sex (female, n = 18, male, n = 9) were housed under controlled environmental conditions (22–24 °C, 50–70% humidity and a 12-h light/dark cycle). Mice were divided into three groups in every group two female were put in separate cages with one male for mating. One group were given normal tap water, group two had a *Acacia senegal* powder 5%(w/v) dissolved in tap water (5 g/100 ml), (Nasir O., et al., 2008), group three had aqueous extract of *Tribulus terrestis* spines 5%(w/v), (Saiyeda A., et al., 2016). For the whole period of study the drink of GA and TT were refreshed every 3 days. Throughout the study, mice had free access to standard pelleted food containing (C1310, Altromin, Lage, Germany). All animal experiments were conducted in accord with the principles for the care and use of laboratory animals in research and approved by the local ethics committee of our University,

All mice were weighted daily to monitor the increase in body weight, after delivery the offspring were counted and weighed daily for two weeks to all groups. On the last day of the experiment all 9 males from all groups were lightly anesthetized with diethylether (Roth, Karlsruhe, Germany) and blood was withdrawn into blood collecting tube by puncturing the *retro*-orbital plexus for testosterone measurements by immunoassay (CMIA) for the quantitative determination of testosterone from ARCHITECT, Abbott Laboratories, Abbott Park, IL USA,

At the end of the experiment, all 9 males were sacrificed by cervical dislocation and the scrotal sacs opened. The whole testis was removed and fixed in five times its volume of 10% formal saline, the testes were put in separate containers and labelled. After complete fixation of the testes, blocks were embedded in paraffin wax and 5 μm thick sections were cut, the tissue sections were stained with haematoxylin and eosin, mounted in Canada balsam and microscopic examination of the sections was then carried out under the light microscopic (Nikon, Eclipse i80) and the required images

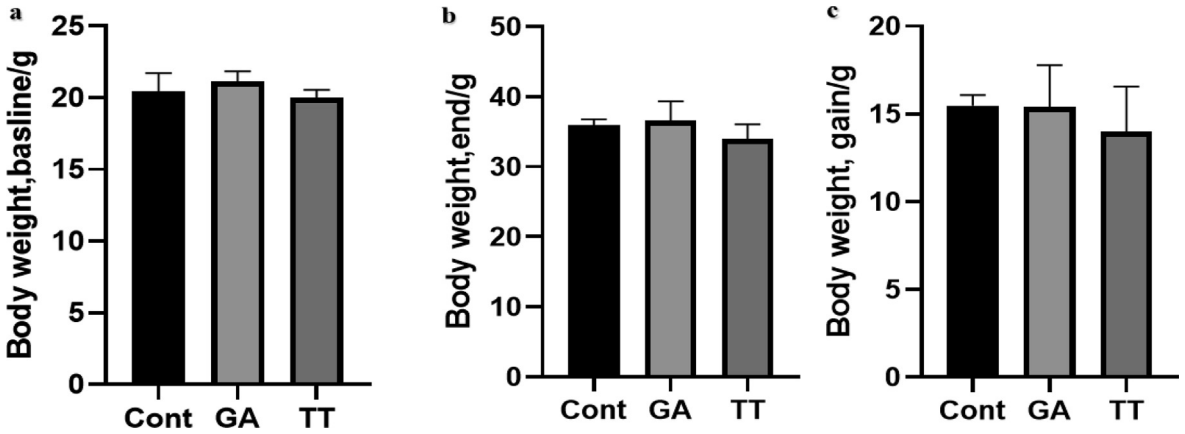

Fig. 1. a. Female Body weight at baseline, (Fig. 1, b.) Female body weight during pregnancy before deliver, and (Fig. 1, c.), Total Female body weight gain for all groups control group, Gum arabic and *Tribulus terrestis* after 21 days of treatment.

were taken in different magnifications with Nikon mounted digital camera (OXM 1200C, Nikon, Japan), to determine possible cytoarchitectural changes of the testes following administrations of GA and TT.

2.4. Statistical analysis

For all experiments the statistical analysis of differences between means of all parameters was carried out using repeated-measures analysis of variance. The Tukey-Kramer posttest was applied. All statistical analysis was performed with GraphPad Prism 8.4.3.686, San Diego, California, USA. www.graphpad.com.

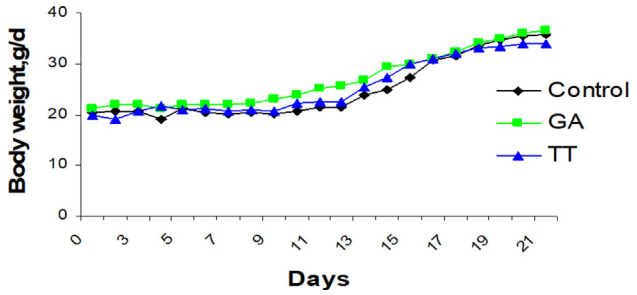

Fig. 2. Course of female body weight change for all groups, control group, Gum arabic and *Tribulus terrestis* after 21 days of treatment.

The P value was considered as significant difference when it is considered as < 0.05 (Khan et al 2015).

3. Result

3.1. Animal studies

Both control groups of mice treated with Gum arabic and treated with *Tribulus terrestis* (TT) showed baseline body weight in Figs. 1 and 2, baseline body weight in the Fig. 1, a), pregnancy weight gain (Fig. 1b.), total body weight gain from baseline to delivery (Fig. 1c.).

The graph reflecting the number of offspring in (Fig. 3), showed a higher number of offspring (Fig. 3, a.) and a higher number of living offspring (Fig. 3, b.) with 5% Gum arabic compared to the control group and 5% *Tribulus terrestis* for 21 days.

Fig. 4 revealed that the findings of two weeks of body weight of the offspring survived, there was an improvement in body weight in all the three groups from the baseline, although there was an immense rise in the weight of the offspring in the control group and 5% *Tribulus terrestis* compared to 5% Gum arabic. The weight of the GA treated offspring was not comparatively high, but can be reported as a good weight gain for the animal.

Male Balb/c mice graphical chart were shown in (Fig. 5) which shows the testosterone concentration (ng/ml) after 21 days con-

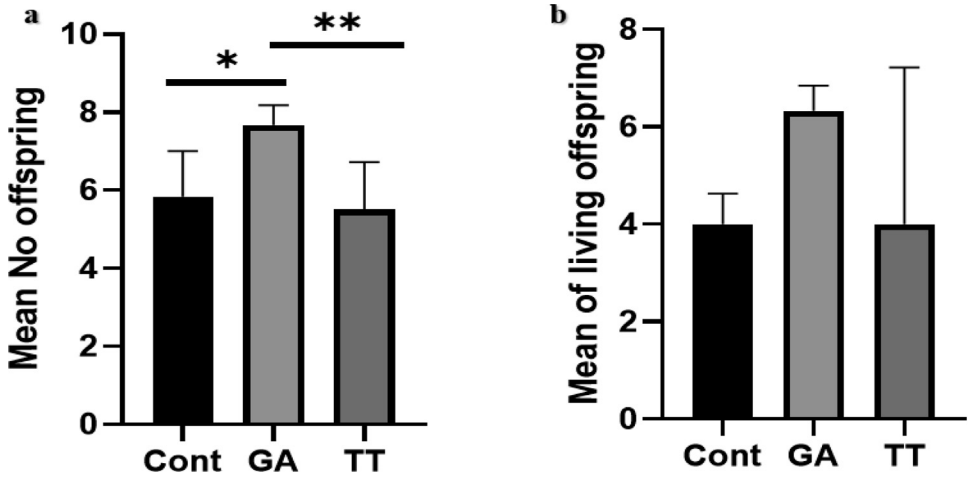

Fig. 3. a. The total number of offspring, Fig. 3, b. mean of living offspring, for control group, Gum arabic and *Tribulus terrestis*.

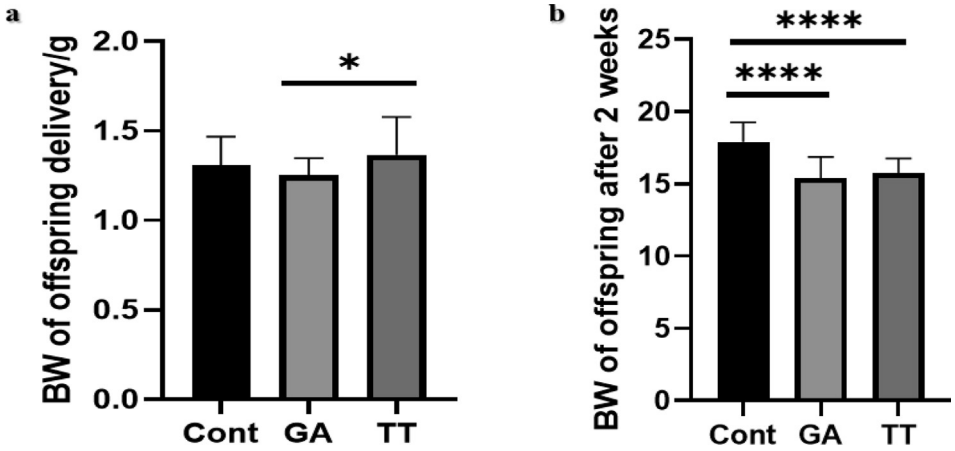

Fig. 4. a. The body weight of offspring at baseline and Fig. 4, b the body weight of offspring after 2 weeks survived from the group of control, Gum arabic and *Tribulus terrestis*.

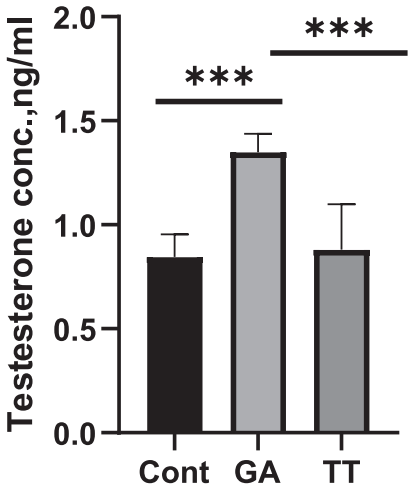

Fig. 5. The male testosterone concentration level for all groups; control, Gum arabic and *Tribulus terrestis* after 21 days of treatment.

firmed with increase levels in group 2 with 5% Gum arabic (1.35 ± 0.04,P < 0.001), followed by 5% *Tribulus terrestis* (0.88 ± 0.09), when compared with the control group (0.85 ± 0.04).

Histological Analysis of male Balb/c mice were shown in (Fig. 6); the section in a testis, seminiferous tubules, lined by stratified germinal epithelium, interstitial spaces, spermatogonia, primary spermatocytes, sperms and some degenerated germ cells.

4. Discussion

Orthodox herbal remedies are genuinely complimentary, with no adverse side effects, and are more favored to treat health from associated diseases (Firenzuoli, F., & Gori, L. 2007). Persian and Chinese medicines are the most well-known groups of traditional herbal medicine for the treatment of chronic diseases (Shahrajabian, M. H., et al., 2019). Herbal medicines were widely used for the treatment of infertility and sexual dysfunction (Salih, N. K., 2018). The present study demonstrates a new strong potential with the use of GA (*Acacia Senegal*) to improve male fertility.

The rise in sexual activity seen in animals and in humans treated with GA may be attributed to phytochemicals found in the plant. Current GA treatment was compared to treatment with *Tribulus terristis*; considered to be an aphrodisiac used in traditional Chinese medicine to improve sexual function (Neychev, V. K., & Mitev, V. I., 2005). GA has shown many phytochemicals thus increased levels of antioxidants, which reduces the oxidative stress (Ahmed, A. A., et al., 2016). Moreover, prior studies showed the progression of male infertility depends on oxidative stress (Agarwal, A., et al., 2014).

GA has phytochemicals like flavonoids (Al Alawi, et al., 2018), alkaloids (ALI, K. S. E., et al., 2020), tannins (Okoro, S. O., et al., 2012) terpenoids (Al Alawi, S. M., et al., 2018), and saponins (Suleiman, I. Y., et al., 2017). Phytochemicals such as saponins and flavonoids has improved fertility (Naik, B. S., et al., 2016), stress leading to ROS causes erectile dysfunction, damages Leydig cells, which decrease the testosterone and also loss of libido is observed, antioxidant potential helps provide protection against cellular damage to erectile tissues (Zhang, Q., et al., 2011). Saponins are considered as anti-stress modulators, they resist the body from stress (Lee, S. H., et al., 2006), both saponins and flavonoids are known for penile erection (Kotta, S., et al., 2013). Testosterone a steroid hormone derived from cholesterol under the influence of follicle-stimulating hormone and luteinizing hormone synthesized in the testes' Leydig cells, which plays a major role in the erectile function caused by ROS stress (Sheweita, S., et al., 2015).

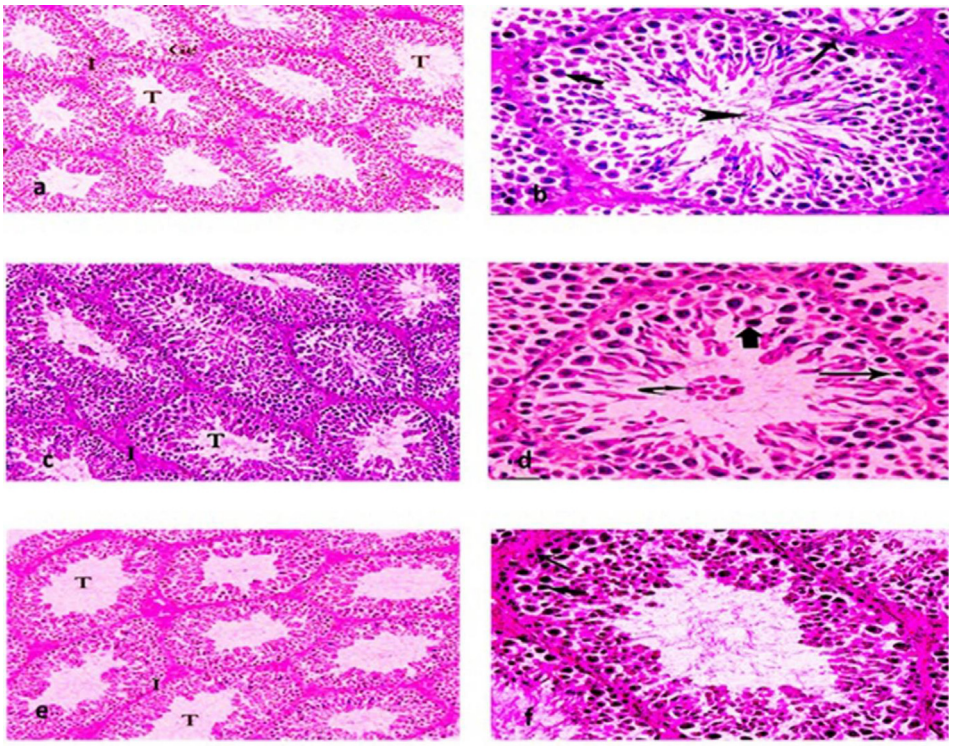

Fig. 6. Shows the testis section, A and B as Control group showing seminiferous tubules (T) lined by stratified germinal epithelium (Ge), interstitial spaces (I). spermatogonia (Thin arrow), primary spermatocytes (Thick arrow), sperms (arrow head) and Some degenerated germ cells (curve arrow). C and D showing treated 5% GA has seminiferous tubules (T) lined by stratified germinal epithelium (Ge), interstitial spaces (I) have lumina with a few spermatocytes after treatment of (5%) Gum arabic and E and F showing some lumina wide with few sperm after the treatment of (5%) *Tribulus terrestis* (TT).

GA is considered to have phytochemicals of antioxidant activity that have aphrodisiac and fertility effects that help human and animal experiment performance. In this study, there was a substantial increase in body weight from baseline in all 3 classes, an increase in body weight was comparable in control and 5% GA was treated, a decrease in weight in 5% of tribulus-treated terrorists. Increase testosterone levels in animals and humans treated with GA, boost seminogram, increase spermatogenesis (Fedail, J. S., et al., 2016). Effect of Increase in the number of offspring with good body weight, confirms that GA can increase libido and sexual function, which lead to improved potency and erectile function, and should be used to treat male infertility. The mechanism of GA on the reproductive system is not completely understood, but the mechanism is to be related to previous study, antioxidant features, phytochemicals present in this plant confirm their infertility treatment with our findings, show that the ability of GA to boost testosterone, boost semen analysis, improve sperm count, increase semen volume and inc.

Experimental studies through the extracts of *T. terrestris* have indicated an improvement in rat's sexual function owing to an increase in testosterone, dihydrotestosterone and dehydroepiandrosterone (Singh et al., 2012).

5. Conclusion

Based on the findings, it is considered that Gum arabic (*Acacia senegal*) has a beneficial effect on the treatment of male infertility. As GA is often used as a curative agent in many diseases, GA with phytochemicals has shown a rise in antioxidants, thereby minimizing oxidative stress, and increased sexual activity is attributable to phytomedicines present in GA. This result is useful in improving sexual dysfunction, GA has shown all potential male infertility with our findings in animal studies.

CRediT authorship contribution statement

Omaima Nasir: Conceptualization, Data curation, Writing - original draft. **Nada Alqadri:** Conceptualization, Writing - original draft. **Salma Elsayed:** Conceptualization, Formal analysis. **Omaima Ahmed:** Formal analysis, Methodology, Writing - original draft. **S. H. Alotaibi:** Conceptualization, Methodology, Writing - original draft. **Roua Baty:** Writing - original draft. **Hiba Omer:** Data curation, Writing - original draft. **Suzan A. Abushal:** Formal analysis, Writing - original draft. **Anja T. Umbach:** Methodology, Writing - original draft.

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Declarations

Author(s) declare that the manuscript findings were original and novel to best of our knowledge and this manuscript has not been published in any other journals.

References

Adewoyin, M., Ibrahim, M., Roszaman, R., Isa, M.L.M., Alewi, N.A.M., Rafa, A.A.A., Anuar, M.N.N., 2017. Male infertility: the effect of natural antioxidants and phytocompounds on seminal oxidative stress. Diseases 5 (1), 9.

Agarwal, A., Virk, G., Ong, C., Du Plessis, S.S., 2014. Effect of oxidative stress on male reproduction. The world journal of men's health 32 (1), 1–17.

Ahmed, A. A., 2018. Health Benefits of Gum Arabic and Medical Use. In Gum Arabic (pp. 183-210). Academic Press.

Ahmed, A.A., Fedail, J.S., Musa, H.H., Musa, T.H., Sifaldin, A.Z., 2016. Gum Arabic supplementation improved antioxidant status and alters expression of oxidative stress gene in ovary of mice fed high fat diet. Middle East Fertility Society Journal 21 (2), 101–108.

Al Alawi, S.M., Hossain, M.A., Abusham, A.A., 2018. Antimicrobial and cytotoxic comparative study of different extracts of Omani and Sudanese Gum acacia. Beni-Suef University Journal of Basic and Applied Sciences 7 (1), 22–26.

Ali, K.S.E., Salih, T.A.A., Daffalla, H.M., 2020. In vitro Phytochemical, Larvicidal and Antimicrobial Activities of Gum Arabic Extract. Walailak Journal of Science and Technology (WJST) 17 (3), 192–199.

Mikulewicz, M., Chojnacka, K., Wołowiecc, P., 2014. Release of metal ions from fixed orthodontic appliance An in vitro study in continuous flow system. Angle Orthodontist 140 (1), 140–148.

Dimitriadis, F., Adonakis, G., Kaponis, A., Mamoulakis, C., Takenaka, A., & Sofikitis, N. (2017). Pre-testicular, testicular, and post-testicular causes of male infertility. Endocrinology of the Testis and Male Reproduction. Cham: Springer, p1364.

Easley IV, C.A., Bradner, J.M., Moser, A., Rickman, C.A., McEachin, Z.T., Merritt, M.M., Caudle, W.M., 2015. Assessing reproductive toxicity of two environmental toxicants with a novel in vitro human spermatogenic model. Stem cell research 14 (3), 347–355.

Fedail, J.S., Ahmed, A.A., Musa, H.H., Ismail, E., Sifaldin, A.Z., Musa, T.H., 2016. Gum arabic improves semen quality and oxidative stress capacity in alloxan induced diabetes rats. Asian Pacific Journal of Reproduction 5 (5), 434–441.

Firenzuoli, F., Gori, L., 2007. Herbal medicine today: clinical and research issues. Evidence-Based Complementary and Alternative Medicine 4 (S1), 37–40.

Geoffroy-Siraudin, C., Anderson Dieudonné Loundou, F. R., Achard, V., Courbiere, B., Perrard, M. H., Durand, P., & Guichaoua, M. R., 2012. Decline of semen quality among 10 932 males consulting for couple infertility over a 20-year period in Marseille, France. Asian journal of andrology, 14(4), 584.

Jain, S., 2015. Medicinal plants with potential anti-fertility activity: A review. International Journal of Green Pharmacy (IJGP) 9 (4).

Jamalan, M., Ghaffari, M.A., Hoseinzadeh, P., Hashemitabar, M., Zeinali, M., 2016. Human sperm quality and metal toxicants: protective effects of some flavonoids on male reproductive function. International journal of fertility & sterility 10 (2), 215.

Khaleghi, S., Bakhtiari, M., Asadmobini, A., Esmaeili, F., 2017. Tribulus terrestris extract improves human sperm parameters in vitro. Journal of evidence-based complementary & alternative medicine 22 (3), 407–412.

Khan, I.A., Jahan, P., Hasan, Q., Rao, P., 2015. Relationship between PTEN and gestational diabetes in Asian Indians womens. Journal of Health Specilaities 3 (3), 184–187.

Kotta, S., Ansari, S.H., Ali, J., 2013. Exploring scientifically proven herbal aphrodisiacs. Pharmacognosy reviews 7 (13), 1.

Kurutas, E.B., 2015. The importance of antioxidants which play the role in cellular response against oxidative/nitrosative stress: current state. Nutrition journal 15 (1), 71.

Lee, S.H., Jung, B.H., Kim, S.Y., Lee, E.H., Chung, B.C., 2006. The antistress effect of ginseng total saponin and ginsenoside Rg3 and Rb1 evaluated by brain polyamine level under immobilization stress. Pharmacological research 54 (1), 46–49.

Mariod, A.A., 2018. Functional Properties of Gum Arabic. In: Gum Arabic. Academic Press, pp. 283–295.

Mohammadi, F., Nikzad, H., Taherian, A., Amini Mahabadi, J., Salehi, M., 2013. Effects of herbal medicine on male infertility. Anatomical Sciences Journal 10 (4), 3–16.

Naik, B.S., Dangi, N.B., Sapkota, H.P., Wagle, N., Nagarjuna, S., Sankaranand, R., 2016. Phytochemical screening and evaluation of anti-fertility activity of Dactyloctenium aegyptium in male albino rats. Asian Pacific Journal of Reproduction 5 (1), 51–57.

Nasir, O., Artunc, F., Saeed, A., Kambal, M.A., Kalbacher, H., Sandulache, D., Boini, K. M., Jahovic, N., Lang, F., 2008. Effects of gum arabic (Acacia senegal) on water and electrolyte balance in healthy mice. J Ren Nutr 18, 230–238.

Neychev, V.K., Mitev, V.I., 2005. The aphrodisiac herb Tribulus terrestris does not influence the androgen production in young men. Journal of ethnopharmacology 101 (1–3), 319–323.

Okoro, S.O., Kawo, A.H., Arzai, A.H., 2012. Phytochemical screening, antibacterial and toxicological activities of Acacia senegal extracts. Bayero Journal of Pure and Applied Sciences 5 (1), 163–170.

Safarnavadeh, T., Rastegarpanah, M., 2011. Antioxidants and infertility treatment, the role of Satureja Khuzestanica: A mini-systematic review. Iranian *Journal of Reproductive Medicine* 9 (2), 61.

Saiyeda A, Jahana N, Makbulb S,AA, Ansaria M, Banoa H, Habibc S.H., 2016.Effect of combination of Withania somnifera Dunal and Tribulus terrestris Linn on letrozole induced polycystic ovarian syndrome in rats. integr med res 5 -293–300.

Salih, N.K., 2018. Applications of Gum Arabic in Medical and Health Benefits. In: Gum Arabic. Academic Press, pp. 269–281.
Shahrajabian, M.H., Sun, W., Cheng, Q., 2019. The influence of traditional Iranian and Chinese medicine on western and Islamic countries. Asian Journal of Medical and Biological Research 5 (2), 94–99.
Sheweita, S., Salama, B., Hassan, M., 2015. Erectile dysfunction drugs and oxidative stress in the liver of male rats. Toxicology Reports 2, 933–938.
Singh, S., Nair, V., Gupta, Y.K., 2012. Evaluation of the aphrodisiac activity of *Tribulus terrestris Linn.* in sexually sluggish male albino rats. J Pharmacol Pharmacother 3 (1), 43–47.
Suleiman, I.Y., Yaro, S.A., Abdulwahab, M., Salihu, S.A., Ogheneme, O.C., 2017. Phytochemical and spectroanalytical characterizations of some plants extract as green corrosion inhibitors. J Materials Environ Sci 8, 3423–3432.
Tahvilzadeh, M., Hajimahmoodi, M., Toliyat, T., Karimi, M., Rahimi, R., 2016. An evidence-based approach to medicinal plants for the treatment of sperm abnormalities in traditional P ersian medicine. Andrologia 48 (8), 860–879.
Zhang, Q., Radisavljevic, Z.M., Siroky, M.B., Azadzoi, K.M., 2011. Dietary antioxidants improve arteriogenic erectile dysfunction. International journal of andrology 34 (3), 225–235.
Zhu, W., Du, Y., Meng, H., Dong, Y., Li, L., 2017. A review of traditional pharmacological uses, phytochemistry, and pharmacological activities of Tribulus terrestris. Chemistry Central Journal 11 (1), 60.

Further reading

Cherbut, C., Michel, C., Raison, V., Kravtchenko, T., Méance, S., 2003. Acacia Gum is a bifidogenic dietary fiber with high digestive tolerance in healthy humans. Microb Ecol Heal Dis 15, 43–50.