Herbal remedies for male infertility and spermatogenic activity in animals: A review

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ABSTRACT

Male infertility is becoming an important untouched area that needs immediate attention due to the increasing demand for breeding strategies, keeping in view the production and increasing per animal productivity. Many additives and antioxidants have been tried for enhancing the seminal quality, but still there is no evidence of full-proof effect on the conception rates in female animals. However, herbal preparations which promise multi-factorial effect in the breeding male animals can be explored, and in turn could prove to be a better tool to encounter the problem of male infertility holistically. The herbal preparations and its effect at the cellular, molecular and metabolic level still needs to be understood. However, the advantage of using the herbal ingredients could be, use of available local herbal ingredients which are more economical, affordable, can reduce the use of hormonal therapy, have less side effects on long term usage, and have greater acceptability by the farmers. These herbal ingredients will be useful in breeding programmes for improvement of germplasm in terms of productivity. The current review covers how the herbs can be utilized in improving the semen quality and quantity, enhancing function of sertoli and leydig cells, mating behaviour, fecundity, seminal antioxidant status, hypophyseal adrenal gonadal axis cum endocrine regulation, microcirculation of testes, as well as in semen cryopreservation and post thaw quality of different species.

Keywords: Herbal preparations, Male infertility, Male reproductive behaviour, Semen quality, Spermatogenic activity

Male reproduction in animals is a key area that needs more attention for effective implementation of the breeding programmes. Quality males having superior germplasm are essential, but on the other side, elite animals with good reproductive parameters are equally paramount in triggering their growth potential. Good quality male germplasm can be spread over the large population through artificial insemination, but the fertility of cryopreserved semen is not up to the mark (Gangwar et al. 2023). To predict the fertility status of male animals, the parameters like spermatogenesis, semen quality, sperm functions, fertility, etc. must be considered (Gangwar et al. 2016). Spermatogenesis depends on intra-testicular and extratesticular endocrine governing processes, and physiology of the inter-tubular microcirculation (Holstein et al. 2003). Seminal characteristics including spermatozoa concentration, viability, mobility, morphology, sperm abnormalities, sperm capacitation, etc. are used to predict the semen quality (Huynh et al. 2000, Rodriguez-Martinez, 2003, 2006, Gangwar et al. 2020). Male infertility issues needs more attention in the current scenario, owing to the fact that good quality male germplasm is difficult to obtain while planning for breeding to improve productivity, and it also requires boost in the form of supplementation of synthetic additives in the feed.

The medicinal plants are quite often used for improvement in litter size and fecundity, prevention and treatment of reproductive disorders (Ayoka et al. 2008, Gangwar et al. 2019). Several plants have male fertility regulatory potentials and can improve the sexual desire and fecundity (Thakur et al. 2012), endocrine effect (Ajuogu et al. 2019), semen quality characteristics (Ajuogu et al. 2019, 2020, Patel et al. 2022), etc. Moreover certain plants with medicinal characteristics are reported to have anti-fertility effects that encompass an impaired spermatogenic activity and decreased semen quality (Olugbenga et al. 2011, Shaik et al. 2017, Ajuogu et al. 2018). Application of herbal formulations often has been advocated immensely due to convenience, low cost and desired effects (Saleh et al. 2015). Earlier studies mostly focussed on reactive oxygen species and its effect pertaining to antioxidant and their application in male reproduction (Chatterjee and Chatterjee 2009, Gangwar et al. 2014, Gangwar et al. 2018). Therefore, this review addresses the role of various herbs in directly enhancing the performance of male reproductive activity or by improving the seminal characteristics during cryopreservation. This review also discusses various herbal preparations that have potential...
role in modulating the male animal fertility.

Endocrine regulation of reproductive system

Endocrinological regulation is important in modulating the reproduction in domestic animals by its feed-back mechanisms. An effective interplay of hormone, receptors and its metabolites would result in favourable outcomes in reproduction, and in turn harvesting the best germplasm. But, there are few studies that helped to decipher the encouraging effects of herbal preparation in the male reproduction, which are discussed in this section.

*Tribulus terrestris* and its effects on hormonal function were analyzed in non-human primates, and other laboratory animals to mitigate the erectile dysfunction (ED) (Adaikan *et al.* 2000). *T. terrestris* extract was given at specified doses orally to primates for short term effect, and to rabbits and rats for eight weeks to assess its long term effect. The study also assessed its effect on castrated rats treated with biweekly doses of testosterone cypionate for two months along with *T. terrestris* oral preparation for the same period in another group. When the blood samples were analysed for testosterone and its other analogues, all were significantly increased in the species studied. Even castrated rats showed a significant hike in the testosterone levels which may be due to the active principle ‘protodioscin’ in the *T. terrestris* herbal preparation, and the same is also the reason for effectively improving the cases of erectile dysfunction (Kalamegam *et al.* 1988). A study by Haeri *et al.* (2006) also indicated the effectiveness of SKEO (*Satureja* *khuzestanica* essential oil) in significantly increasing the concentrations of Follicular Stimulating Hormone (FSH) and testosterone in the treated groups.

The favourable effect of the extract of *Pedalium murex* fruits in male rats on the levels of serum testosterone for 28 days was studied and the male rats responded well with the increase in testosterone levels on administration of the extract with dose rate of 150 mg/kg. It was also well recorded that with the progression of treatment, the serum testosterone levels gradually increased, and further, the containment of treatment did not decrease the raised serum testosterone levels gradually increased, and further, the increase in testosterone levels on administration of the extract with dose rate of 150 mg/kg. It was also well recorded that with the progression of treatment, the serum testosterone levels gradually increased, and further, the containment of treatment did not decrease the raised serum testosterone levels (Sharma *et al.* 2012). Another herb, namely *G. tessmannii* significantly increased the plasmatic testosterone gradually from 7 to 56 days post-treatment (Deo *et al.* 2017), while some other herbs like *Mucuna pruriens*, *Astercantha longifolia* and *Curculigo orchioides*, were found to effectively modulate the secretion of pituitary hormones, viz. FSH and Luteinizing Hormone (LH) (Chauhan *et al.* 2010).

Improving the libido and mating behaviour

Herbal aphrodisiacs, when used judiciously, could improve the overall libido and mating behaviour of the animals. Male sexual behaviour is governed by various parts of the brain in the form of a neural circuit (Tsai *et al.* 2009). Haeri *et al.* (2006) reported that the vigour and prolificacy of the male rats administered with *Satureja khuzestanica* essential oil (SKEO) at certain doses could significantly improve when compared to the controls. The same ingredient when supplemented in diet also could have a positive effect on fertility indices and litter size. Post implantation losses were also reduced significantly in the female counterpart. Moreover the numbers of live foetuses were also increased by treatment of the same herbal preparation in dams possibly due to decreased blood ROS generation and its increased scavenging activity. Further, it can be explained by the fact that presence of certain active principles including carvacrol and flavonoids attribute to the anti-oxidant and scavenging activity of *Satureja* spp. (Haeri *et al.* 2006). Certain important libido parameters like mount latency, intromission latency, ejaculation latency and post ejaculatory interval were significantly decreased by the ethanolic extract of *Pedalium murex*. On the contrary, this extract significantly improved the penile erection index, mounting frequency and intromission frequency and serum testosterone level (P<0.05) (Sharma *et al.* 2012) in wistar albino rats. On the other hand, herbal extracts from date palm were found to improve the fertility and health in rabbits (Khalifa *et al.* 2018). Locally available herbs like *Moringa oleifera* were found to have desirable effects on libido and live spermatozoa concentration when used orally at certain doses (100, 200 and 500 mg/kg) with no toxicity or other adverse effects in experimental animals (Varsha *et al.* 2013). Oral administration of ethanolic extract of *Alpinia galanga* significantly increased sperm percentage, viability, motility, mating behaviour and testosterone hormone in rats (Mazaheri *et al.* 2014).

Stimulating the function of sertoli cells and leydig cells

Leydig cells influence the seminiferous tubule via high testosterone levels in the testes through the LH. Similarly, FSH influences the sertoli cells, and supports spermatogenesis (Kretser 1982). The role of sertoli cells and leydig cells thus can be augmented by the use of certain herbs, which increase the aphrodisiac activity and androgenic stimulation. Hence, the aphrodisiac herbs were evaluated for their natural induction of the FSH and testosterone secretion with positive influence on the function of accessory sex organs and testes. In this context, the effect of SKEO at the dose of 225 mg/kg on the increased testicular weight, seminal vesicles, and ventral prostate was studied by Haeri *et al.* (2006). As per the finding in the male rats administered with SKEO, the histopathological analysis showed an increase in the number of germinal cells, leydig cells, seminiferous tubules. Further, in the treatment groups, the sertoli cells were found hypertrophic. Thus, it is obvious that the continuous androgenic stimulation has a positive effect on the physiological functions of the epididymis and accessory sex organs due to SKEO. *Mucuna pruriens* extract increase the weight of the accessory sex organs probably due to the result of increased secretory activity, which was evident from an increase in the activities of alkaline phosphatase in epididymis, protein levels in the testis and epididymis (Mutthu *et al.* 2011).
It was observed that certain herbs were used to reverse the toxic effects on the testes as reported by Okail et al. (2016). In this case, they tapped the favourable effects of the extract of *Erucia sativa* seeds to reverse the toxic effects caused by cadmium chloride, another important research done by El Ghazzawy et al. (2011) also focussed on a similar pattern, in which pomegranate juice was found to have the ability to counteract structural changes in the rat epididymis caused by plasticizer bisphenol by increasing the number of sperm in cauda epididymis, reducing sperm abnormalities and improving male fertility.

**Preventing oxidative stress**

Balance between ROS and ROS-scavenging system and its inter-play is very vital to male animal reproduction system (Agarwal et al. 2008, Gangwar et al. 2018, Gangwar et al. 2019). Free radical-induced oxidative stress compromises the animal reproductive efficiency, and it requires antioxidant therapy to alleviate the oxidative stress. Herbal therapeutics offer good scope in combating the ill effects of free radicals. Plant derived antioxidants can display favourable or harmful effects in male reproduction functions including spermatogenesis and seminal parameters (Zhong and Zhou 2013). Herbal or medicinal plants contain many active ingredients which are reported to have flavonoids, carotenes, tannins, polyphenols etc. (Gupta and Sharma 2006, Nagulendran et al. 2007, Sen et al. 2010). Sperm immobilization occurs due to fair increase in ROS concentrations by depleting the cellular ATP and decrease in phosphorylation, whereas ROS levels above physiological break-points could lead to lipid-peroxidation and spermicidal activity (Misro et al. 2004). This spermicidal activity can also be attributed to free radical induced damage in the spermatozoa plasma membranes, which have high PUFA along with anti-oxidant enzymes in sub-optimal concentrations (Sawyer et al. 2001, Maneesh and Jayalekshmi 2006). Further, spermatogenesis being a very active process, with a high rate of cell division, leads to generation of excess ROS due to increased mitochondrial respiration (Aitken and Roman 2008). All these reasons contribute to change in balance between the ROS generation and de-toxification, that culminates to cellular stress, and damage of cellular components and motifs in the sperm and testes. This eventually leads to poor semen quality cum infertility in male animals, and on the other side accounts to fertilization failure and failed embryo genesis and abortions in females (Rabbani et al. 2010, Enciso et al. 2011). ROS are also generated from semen processing steps including cryopreservation in addition to the spermatogenesis (Bucak et al. 2008, 2009) and further the freezing/thawing procedures leads to cold shock/injuries and lipid peroxidation (Bucak et al. 2012). Moreover, other environmental factors like high temperature, toxins, chemicals and microbial contamination (Gangwar et al. 2021, Kumaresan et al. 2022) attribute to ROS production thereby affecting the reproduction system.

The effect of aqueous extract of *Rhodiola sacra* (RS) was studied for its antioxidant activity post-cryopreservation with its antioxidant scavenging activity against superoxide anion radical on boar semen characteristics (Zhao et al. 2009). RS concentration used in extender ranging between 4 to 8 mg/L was found to have a significant correlation with GSH and MDA concentration in spermatozoa in the frozen thawed boar semen (Zhao et al. 2009). Natural tea extracts from *Camellia sinensis* at 10 mg/L level significantly decreased the MDA concentration (Mehdipour et al. 2016). While, Wen et al. (2019) reported that the addition of grape seed extracts (GSE) to the diluter improved the sperm quality in goats along with better antioxidant capacity during preservation at refrigerated temperature.

**Modulating the proliferation and apoptosis of germ cells**

Lower numbers of sperm cells and sperm defects are one of the major factors of male infertility. Furthermore, spermatogenesis is an extremely orchestrated process to produce sperm at a magnifying rate. At this rate, there are possible chances of acquiring apoptotic spermatozoa, if testicular environment is not favourable. Patel et al. (2017) reported that compared to the control, *Bacopa monnieri* (Brahmi) extract treatment resulted in a significant increase (P<0.05) in spermaticogenic cell count, tubular diameter, and in steroidogenic indices in the testis. It also increased the sperm viability in cauda epididymis of the treated mice at 80 mg dosage. Conversely, with the same extract in the dosage of 80 mg, there was an appreciable decrease (P<0.05) in abnormal sperm morphology and lipid peroxidation levels in testis of the treated mice compared to the controls.

Mehdipour et al. (2016) reported that tea extract (*Camellia sinensis*) when used at a dose of 10 mg/L level increased the proportion of viable spermatozoa, and lowered the apoptosis in sperm when compared to other treatments (P<0.05), and also the levels of MDA were significantly decreased. Another multi-herbal formulation called Hatch-up that includes *Glycyrrhiza glabra*, *Curculigo orchioides*, *Tribulus terrestris* *Withania somnifera*, etc. increased the total sperm concentration in the cauda epididymis, with reduced abnormalities in sperm on comparison to rats that received vehicle alone (Ananda Kumar et al. 2013). *Erucia sativa* seeds extract were also reported to have beneficial effects in improving seminal parameters by alleviating the toxic effects of cadmium chloride in testes (Okail et al. 2016).

**Ameliorating the microcirculation of the testis**

Testicular microcirculation is an important parameter in the male reproductive physiology because of its transportation of nutrients and other secretory products for spermatogenesis. Hormones like LH and functional entities like Leydig cells are influenced by the microcirculation in the testes (Bergh et al. 1987). Besides the hormonal influences on microcirculation, there are the herbal therapeutics that improve the microcirculation in the testes. *Ficus caria* (Fc) leaf extract increased the sperm...
count, motility of spermatozoa, etc. in the formaldehyde treated testes. Moreover, seminiferous tubule with arrested spermatogenesis was hardly observed, showing that Fc had positive effects on sperm characteristics when exposed with formaldehyde (Naghdi et al. 2016). Sahoo et al. (2014) investigated the aphrodisiac potential of herbal preparations from various components of Curculigo orchioides, Mucuna pruriens, Cucurbita pepo, Tribulus terrestris, Allium tuberosum, Argyreia nervosa, etc. in albino rats in specified proportion. It was found that 600 mg/kg of the herbal formulation improved the mating behaviour, mating performance, serum hormonal levels and sperm count. Muthu et al. (2011) reported that the Mucuna pruriens extracts significantly improved the testicular metrics and physiology and epididymal alkaline phosphatase activity with possible androgenic activity. These positive effects might be due the improved circulation of endocrine regulators towards the testes.

Herbal preparation as source of trace elements

Organic minerals can support optimum reproductive function by improving semen production, sperm motility and male fertility (Arthington et al. 1995). Trace elements including copper and zinc supplementation in animal feed influences production and reproduction positively (Rowe et al. 2013). Herbal preparations are known to combat the sperm membrane from the ill effects of damage during freezing. Amino acids like proline protects the membrane structure during stress; and along with cysteine it doubles into an antioxidant scavenging the ROS through glutathione formation during freeze-thawing. Certain vitamins including C (Gangwar et al. 2015), E and minerals like Zn, Cu and Se and other essential oils of herbs have reported to have protective effects on cell membrane. The study reported that dietary azolla supplementation improves the mating behaviour, semen volume and semen quality in bucks as azolla is very rich in trace minerals and vitamins (Gangwar et al. 2019). Addition of semen diluent with 10 to 20% pomegranate juice that has high amount of vitamins, minerals and anti-oxidants has showed encouraging findings in terms of post thaw semen quality in bulls (El-Sheshtawy et al. 2016).

Improvement in semen quality and quantity

Male reproduction depends on both physical and behavioural development, and with proper nutrition there is always a way to improve the seminal quality and quantity. There are other resources that can be used to improve these parameters. The effect of certain herbal extracts from Tribulus terrestris, Eurycoma longifolia, and Leucaea carthamoides was analysed for vigour and semen quality in boars (Frydrychová et al. 2011). In this study, various spermatozoa and fertility parameters were assessed, and significant differences in libido, semen volume, sperm concentration, morphologically abnormal spermatozoa were observed. The herbal preparation treated boars showed an increase of 20% in all these aforesaid parameters after the experiment. Other anti-oxidant herbs were also explored including the Chinese herb Rhodiola rosea, for its antioxidant potential (Oh sugi et al. 1999). Further, Zhao et al. (2009) studied that aqueous extract of Rhodiola sacra positively influenced the biochemical and sperm quality parameters in cryopreserved boar-sperm. Another popular perennial herb Rosemary (Rosmarinus officinalis) was also found to have antioxidant properties due to certain substances including flavonoids, diterpenes, triterpenes, polyphenols, etc. (Samotyja and Matecka 2010). The same was studied for its effect on sperm quality and was found to improve the sperm motility and fertility post-cryopreservation (Malo et al. 2011). Aphrodisiac herbs that tend to improve the libido like Ferula hermonis is known for its antioxidant effects in both gender (Hanafi et al. 2010) was used as an extract supplementing the semen extender that increased the post-thaw motility, viability and decreased lipoperoxidation during cryo-preservation in boar semen Malo et al. (2012). Simple disaccharide like trehalose obtained from seaweed extract has been known to combat ROS and thermal shock during free-thaw process of semen in various domestic species (Bucak et al. 2007, Reddy et al. 2010).

In our previous study (Gangwar et al. 2019), it was found that dietary azolla supplementation in bucks significantly improved the libido, semen quality and semen volume. Similarly, Spondias mombin leaf extract was used to stabilize the bucks which were studied before and after treatment with oral administration of 800 mg/kg body weight for two weeks. The following spermogram analysis by castrating the selected goats that are processed for histology of testicular and epididymis tissue showed significantly higher (P≤0.05) morphological abnormalities in pre-treated animals compared to the post-treated animals (Oloye et al. 2017). Further it was observed that certain morphological abnormalities including curved mid-piece, bent tail etc., were higher in pre-treated animals compared to tis post-treated counterpart. Other functional attributes like sperm motility, viability were elevated in post-treatment group. Similarly, another herb Cynomorium songaricum when administered in animals showed highly significant epididymal sperm count, and it considerably improved the testicular weight as compared to the control groups (Yang et al. 2010).

Preparations having herbs like Enantia chlorantha, Zingiber officinale, Sesame radiatum, Asparagus racemosus, Cynomorium coccineum, Mucuna pruriens, Piper longum, Tribulus terrestris, Withania somnifera, etc. are reported to improve the semen quality in rats (Morakinyo et al. 2008, Shittu et al. 2008, Khaki et al. 2009).

Effect on semen cryopreservation

The freeze-thaw process reduces the spermatozoa quality through exerting physical and chemical stressors, thereby decreasing the semen quality, sperm viability and fertilization efficiency. A study was conducted on boar
<table>
<thead>
<tr>
<th>Herb used</th>
<th>Part used</th>
<th>Form used</th>
<th>Physiological function</th>
<th>Animal tested</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodiola sacra</td>
<td>Root</td>
<td>Aqueous extract</td>
<td>Improved the antioxidant capacity of semen</td>
<td>Boar semen</td>
<td>Zhao et al. (2009)</td>
</tr>
<tr>
<td>Satureja khuzestanica</td>
<td>Arial part</td>
<td>Essential oil</td>
<td>Increased the sperm count and sertoli cell function</td>
<td>Wistar rats</td>
<td>Haeri et al. (2006)</td>
</tr>
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<td>Rosmarinus officinalis</td>
<td>Leaves</td>
<td>Aqueous extract</td>
<td>Improved the post thaw semen quality</td>
<td>Boar</td>
<td>Malo et al. (2010)</td>
</tr>
<tr>
<td>Camellia sinensis</td>
<td>Leaves</td>
<td>Aqueous extract</td>
<td>Increased the sperm viability and decrease the sperm apoptosis</td>
<td>Ghezel rams</td>
<td>Mehdipour et al. (2016)</td>
</tr>
<tr>
<td>Mucuna pruriens</td>
<td>Seed</td>
<td>Ethanolic extract</td>
<td>Improved the sexual behaviour of males</td>
<td>Rats</td>
<td>Suresh et al. (2009)</td>
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<tr>
<td>Cynomorium songaricum</td>
<td>Stem</td>
<td>Aqueous extract</td>
<td>Increased the testicular weight and sperm count</td>
<td>Rats</td>
<td>Yang et al. (2010)</td>
</tr>
<tr>
<td>Pedalium murex</td>
<td>Fruit</td>
<td>Ethanolic extract</td>
<td>Improved the sexual behaviour and serum testosterone</td>
<td>Wistar rats</td>
<td>Sharma et al. (2012)</td>
</tr>
<tr>
<td>Eurycoma longifolia</td>
<td>Roots</td>
<td>Methanolic extract</td>
<td>Improved spermatogenesis</td>
<td>Rats</td>
<td>Low et al. (2013)</td>
</tr>
<tr>
<td>Bacopa monnieri</td>
<td>Whole plant</td>
<td>Ethanolic extract</td>
<td>Semen quality, sperm cell count and steroidogenic indices in testes was improved</td>
<td>Mice</td>
<td>Patel et al. (2017)</td>
</tr>
<tr>
<td>Dana racemosa</td>
<td>Whole plant</td>
<td>Whole plant powder</td>
<td>Increased sperm motility &amp; viability</td>
<td>Rat</td>
<td>Khaki et al. (2009)</td>
</tr>
<tr>
<td>Curculigo orchoides</td>
<td>Rhizome</td>
<td>Ethanolic extract</td>
<td>Improved penile erection, mating performance, mount frequency and mount latency</td>
<td>Rat</td>
<td>Thakur et al. (2012)</td>
</tr>
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<td>Daucus carota</td>
<td>Seed</td>
<td>Ethanolic extract</td>
<td>Improved testosterone level</td>
<td>Rat</td>
<td>Nouri et al. (2009)</td>
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<tr>
<td>Zingiber officinale</td>
<td>Rhizome</td>
<td>Aqueous extract</td>
<td>Increased sperm count, viability and motility</td>
<td>Rats</td>
<td>Morakinyo et al. (2008)</td>
</tr>
<tr>
<td>Zingiber officinale</td>
<td>Rhizome</td>
<td>Rhizome powder</td>
<td>Increased sperm count, viability, motility and fertility</td>
<td>Rats</td>
<td>Khaki et al. (2009a)</td>
</tr>
<tr>
<td>Lactuca sativa, Petroselinum hortense, Bacopa monniera</td>
<td>Leaf</td>
<td>Ethanolic extract</td>
<td>Increased testicular function</td>
<td>Mice</td>
<td>Patil et al. (2009)</td>
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<td>Lannea acida</td>
<td>Stem bark</td>
<td>Methanolic extract</td>
<td>Protected testicular morphology and decrease sperm abnormality</td>
<td>Rats</td>
<td>Ahmed et al. (2010)</td>
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<td>Withania somnifera</td>
<td>Whole plant</td>
<td>Whole plant powder</td>
<td>Regulated serum androgen levels</td>
<td>Rats</td>
<td>Kiassalari et al. (2009)</td>
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<td>Lepidium meyenii</td>
<td>Hypocotyls</td>
<td>Aqueous extract</td>
<td>Improved testicular function and sperm motility</td>
<td>Rats</td>
<td>Chung et al. (2005)</td>
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<td>Hylocereus co-staricenisi</td>
<td>Pulp</td>
<td>Ethanolic extract</td>
<td>Increased spermatogenesis, sperm count and sperm viability</td>
<td>Mice</td>
<td>Aziz and Noor (2010)</td>
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<td>Citrus sinensis</td>
<td>Fruit peel</td>
<td>Ethanolic extract</td>
<td>Improved sperm quality parameters</td>
<td>Rat</td>
<td>Khaki et al. (2011)</td>
</tr>
<tr>
<td>Kigelia africana</td>
<td>Fruit</td>
<td>Methanolic extract</td>
<td>Improved semen quality and seminal antioxidant status</td>
<td>Rat</td>
<td>Azu et al. (2010)</td>
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<td>Raphanus sativus</td>
<td>Seed</td>
<td>Seed powder</td>
<td>Improved semen quality and performance</td>
<td>Rabbit</td>
<td>El-Nattat and El-Kady (2007)</td>
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<td>Pomegranate</td>
<td>Fruit</td>
<td>Juice</td>
<td>Improved frozen-thawed semen quality</td>
<td>Bull</td>
<td>El-Sheshtawy et al. (2016)</td>
</tr>
<tr>
<td>Mucuna pruriens</td>
<td>Seed</td>
<td>Methanolic extract</td>
<td>Improved serum testosterone level and testicular cholesterol and protein</td>
<td>Wistar Rat</td>
<td>Muthu and P Krishnamoorthy (2011)</td>
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<td>Spondias mombin</td>
<td>Leaf</td>
<td>Ethanolic extract</td>
<td>Improved semen quality</td>
<td>Bucks</td>
<td>Oloye et al. (2017)</td>
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<td>Camellia sinensis</td>
<td>Leaf</td>
<td>Methanolic extract</td>
<td>Improved post-thawed spermatozoa motility, viability and membrane integrity</td>
<td>Bull</td>
<td>Khan et al. (2017)</td>
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Continued...
spermatozoa to assess the positive effects of Rosemary herb (*Rosmarinus officinalis*) at various concentrations on total motility, livability, integrity of acrosome, response to Hypo-Osmotic Swelling Test (HOST) and malonaldehyde levels. Rosemary is another herb that has increased the sperm motility, and showed positive effect on HOST, and reduction in MDA concentration (Malo et al., 2012). The same herb was also tested in bull and ram semen, which showed the encouraging results (Daghigh-Kia et al. 2014, Mascaró et al. 2016). İNANÇ et al. (2019) investigated the effect of green tea extract 'catechin (CT)', on semen quality parameters in the frozen-thawed bull sperm as a supplement to Tris extender. It was observed that the CT supplementation offered protection to cryodamage of morphological and DNA integrity of bull spermatozoa by enhancing the total antioxidant activity depending of the dose. Green tea extract supplemented in semen dilutor was found to show significant effect on post-thaw sperm motility, livability and integrity of membrane (Khan et al. 2017) in bull. Likewise, Pour et al. (2015) reported that supplementation of 5% *T. terrestris* extract in diluter improved the seminal attributes of Afshari ram at 5°C. Mehdipour et al. (2016) reported that tea extract (*Camellia sinensis*) used at a dose of 10 mg/L improve significantly (P<0.05) the sperm motility compared to the untreated controls. Further the extract used at doses of 5 and 10 mg/L influenced higher membrane integrity, mitochondrial activity and antioxidant capacity in comparison to control group (P<0.05). *Camellia sinensis* extract at 10 mg/L level influenced spermatozoa viability and reduced the apoptotosis of spermatozoa (P<0.05) compared to all other treatments. Also the MDA formation significantly (P<0.05) the sperm motility compared to all other treatments. Further the extract used at doses of 5 and 10 mg/L influenced higher membrane integrity, mitochondrial activity and antioxidant capacity in comparison to control group (P<0.05).

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<tbody>
<tr>
<td>Grape seed</td>
<td>Seed</td>
<td>Procyanidin extract</td>
<td>Improved sperm motility, acrosome membrane integrity, mitochondrial activity, plasma membrane integrity and total antioxidative capacity</td>
<td>Buck</td>
<td>Wen et al. (2019)</td>
</tr>
<tr>
<td><em>Phoenix dactylifera</em></td>
<td>Fruit</td>
<td>Aqueous extract</td>
<td>Improved the antioxidant potential, testosterone level and sperm parameters</td>
<td>Rabbit</td>
<td>Khalifa et al. (2018)</td>
</tr>
<tr>
<td><em>Thymus vulgaris</em></td>
<td>Whole plant</td>
<td>Ethanolic extract</td>
<td>Improves the quality of ram sperm after freezing and thawing</td>
<td>Moghani ram</td>
<td>Valheidi et al. (2018)</td>
</tr>
<tr>
<td><em>Aloe barbadensis</em></td>
<td>Gel</td>
<td>Aqueous extract</td>
<td>Adversely affected the spermiogram of bucks</td>
<td>Bucks</td>
<td>Oługbenga et al. (2011)</td>
</tr>
<tr>
<td><em>Alpinia galanga</em></td>
<td>Rhizomes</td>
<td>Methanolic extract</td>
<td>Increased sperm percentage, viability, motility and testosterone hormone</td>
<td>Wistar Rats</td>
<td>Mazaheri et al. (2014)</td>
</tr>
<tr>
<td><em>Sesamum indicum</em></td>
<td>Whole plant</td>
<td>Ethanol extract</td>
<td>Improved testosterone level and antioxidant status</td>
<td>Wistar Rats</td>
<td>Ashamu et al. (2014)</td>
</tr>
<tr>
<td>Green tea</td>
<td>Whole plant</td>
<td>Ethanolic extract</td>
<td>Improved sperm DNA integrity and antioxidant activity</td>
<td>Bulls</td>
<td>İNANÇ et al. (2019)</td>
</tr>
<tr>
<td><em>Ficus asperifolia</em></td>
<td>Fruit</td>
<td>Aqueous extract</td>
<td>Increased the weight of sexual organs and androgenic capacity</td>
<td>Wistar Rats</td>
<td>Watcho et al. (2017)</td>
</tr>
<tr>
<td><em>Tribulus terrestris</em></td>
<td>Fruit</td>
<td>Aqueous extract</td>
<td>Improved seminal attributes</td>
<td>Afshari rams</td>
<td>Pour et al. (2015)</td>
</tr>
<tr>
<td><em>Moringa oleifera</em></td>
<td>Leaf</td>
<td>Powder</td>
<td>Increased testosterone level and improved seminal parameters</td>
<td>Rabbits</td>
<td>Ajuougu et al. (2019)</td>
</tr>
<tr>
<td><em>Azolla</em></td>
<td>Leaf</td>
<td>Pellet</td>
<td>Improved libido, semen quality and semen volume.</td>
<td>Bucks</td>
<td>Gangwar et al. (2019)</td>
</tr>
<tr>
<td><em>Cyathula prostrata</em></td>
<td>Whole plant</td>
<td>Whole plant powder</td>
<td>Decreased sperm motility and morphology</td>
<td>Rabbits</td>
<td>Ajuougu et al. (2020)</td>
</tr>
<tr>
<td><em>Allium cepa</em></td>
<td>Bulb</td>
<td>Crude extract</td>
<td>Improves post thaw sperm morphology</td>
<td>Sirohi bucks</td>
<td>Patel et al. (2022)</td>
</tr>
<tr>
<td><em>Aloe perfoliata</em></td>
<td>Leaf pulp</td>
<td>Crude extract</td>
<td>Improves post thaw sperm quality</td>
<td>Sirohi bucks</td>
<td>Patel et al. (2022)</td>
</tr>
</tbody>
</table>
extract into the extender has positive effects on embryogenesis through improved fertilization efficiency. Also in another experiment, a similar herb called Garden thyme (Thymus vulgaris) improved the ram semen quality and post-thaw quality, with notable effects on sperm morphology and functional characteristics (Vahedi et al. 2018).

**Conclusion**

There is a gradual increase in the use of chemical antimicrobial agents as well as hormones leading to the infertility or subfertility in the animals. The current review has tried to consolidate the various herbal formulations that can specifically solve the problem of male infertility or improve the semen characteristics, thereby addressing its potential in male reproduction. The damage created by chemical agents can be reverted by the application of herbal remedies thereby improving the reproductive health of the wealthy germplasm of our country. The herbal preparations and its effect at the cellular, molecular and metabolic level still needs to be understood, which in turn requires more advanced studies and trials using the active ingredients responsible for improving the andrological effect. More futurist work needs to be done for adapting the male reproductive behaviour to the changing trends of intensification, which leads to production stress and the herbal based additives or therapies can aid in this transition.

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