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Assessing fertility preservation strategies: A scoping review

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ABSTRACT

Objective: To describe the various options available for preserving female and/or male fertility, taking into account both social and medical aspects, and to identify the effects of different natural products on male infertility extracted from plants.

Methods: We reviewed the literature and included full-text publications in English provided by international biomedical databases, including Sciences Direct, Google Scholar, OVID, PubMed, and MEDLINE between 2016 and 2023. Search terms, such as fertility preservation, *in vitro* maturation, cryopreservation, plants for the treatment of male infertility, were taken from Medical Subject Headings (MeSH) and Boolean operators were used to improve sensitivity.

Results: 112 papers were identified in the initial search, of which 18 were excluded due to duplication. After reviewing titles and abstracts, 70 papers were finally included. The main findings of this study are presented under three key themes: gametogenesis, fertility preservation techniques, and plant-based alternatives. Regarding gametogenesis, significant progress has been made in understanding oocyte and sperm maturation, with optimized conditions improving maturation rates and motility. For fertility preservation, techniques such as rescue *in vitro* maturation and cryopreservation have shown the enhanced outcomes, particularly in maintaining gamete quality. Lastly, plant-based alternatives, including extracts and essential oils, have demonstrated potential in reducing oxidative stress, improving sperm motility, and supporting oocyte development, thus providing a promising complementary approach to conventional methods.

Conclusions: Fertility preservation is achieved in a variety of

ways, including oocyte and embryo vitrification and sperm cryopreservation, and the use of plant-based treatment of male infertility.

KEYWORDS: Fertility preservation; Embryo freezing; Cryopreservation of ovarian tissue; *In vitro* maturation; Plants

1. Introduction

Over the past decade, around 10%-15% of couples worldwide suffer from idiopathic infertility, experiencing difficulties conceiving a child after one year of regular sexual intercourse[1]. Fertility preservation has become a major public health issue as it allows the cryopreservation of gametes for both man and women for medical and social reasons. Indeed, fertility can be affected either by age or/and by gonadotropic lesions[1,2]. Female infertility can be caused by failures at various stages including ovulation, fertilization,

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embryonic development even in advanced stages, transport, implantation and nesting[3]. Moreover, some toxic components in the environment such as heavy metals and radiation can lead to an alteration of folliculogenesis and even ovarian damage affecting and reducing fertility[4]. Male infertility is linked to the sperm quality (azoospermia, reduced mobility, *etc.*), anatomical disorders, genetic problems, chronic diseases and environmental factors (exposure to tobacco, alcohol, *etc.*)[5]. Indeed, fertility preservation has become important to overcome the several problems of infertility; this review will introduce recent, alternative and advanced ways of fertility preservation.

2. Methods

An extensive literature search over a period of six months was conducted. The study has been performed to describe the different options available to preserve female and/or male fertility, and identify the alternatives proposed and the advances in this field such as the study of the effects of different natural products on male infertility extracted from plants using search engines such as Sciences Direct, Google Scholar, OVID, PubMed, and MEDLINE between 2016 and 2023. The overall strategy for study identification and data extraction was based on the following keywords: "fertility preservation", "embryo freezing", "cryopreservation of ovarian tissue", "*in vitro* maturation", "plants". Data that were solely published in conference or meeting proceedings, websites, or books were not included. Information from articles published in languages other than English was extracted using translation tools and, where necessary, verified by native speakers to ensure accuracy.

The articles included in this review met specific criteria to ensure relevance and quality. Inclusion criteria comprised articles focusing on fertility preservation or medical reproductive technologies used to preserve fertility in men and women, and the effects of different natural products on male infertility extracted from plants. Exclusion criteria involved studies not directly addressing the research question or lacking sufficient methodological rigor.

3. Results

3.1. Search results

An initial comprehensive literature search identified a total of 112 papers relevant to fertility preservation, assisted reproductive technology techniques, and the improvement of sperm quality. During the preliminary screening, 18 duplicate records were identified across different databases and were subsequently removed to avoid redundancy. The remaining 94 papers underwent a detailed evaluation, where titles and abstracts were carefully reviewed against established inclusion and exclusion criteria to assess relevance to

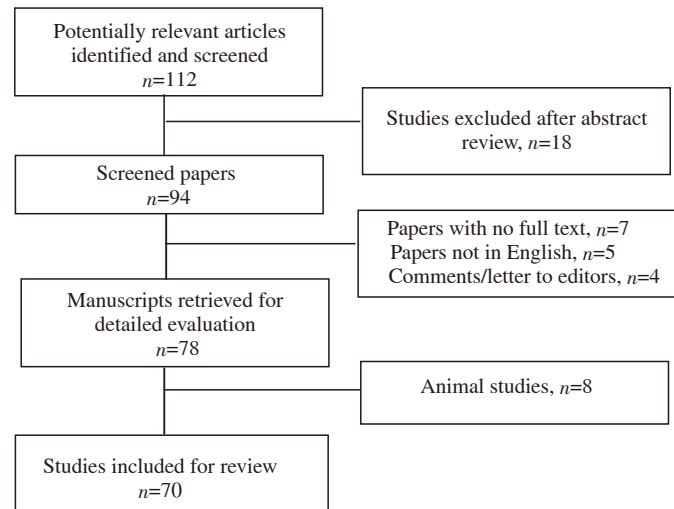


Figure 1. Flow diagram of literature screening.

fertility preservation, assisted reproductive technology methods, and sperm quality enhancement. Through this process, 24 additional papers were excluded due to factors such as lack of direct relevance, insufficient data, or low methodological quality. Ultimately, 70 high-quality studies were deemed eligible and included in the final analysis, providing a robust foundation for the research (Figure 1).

3.2. Gametogenesis

Infertility is a complex clinical process in which the couple is unable to conceive despite constant sexual intercourse for more than a year[6]. Indeed, infertility can be linked to gametogenesis.

Spermatogenesis is a process that occurs in the seminiferous tubules[7]. It can be divided into three main stages: mitotic proliferation of sperm cells, meiotic replication of sperm cells and the transformation of sperm cells into sperm cells[8]. It is initiated by the spermatogonial stem cells, which multiply for self-renewal and replicate to give rise to a lineage of developing spermatogenic cells[8]. Secondary spermatocytes are produced when the primary spermatocyte completes meiotic division and two daughter haploid cells are produced[9,10]. Each spermatide is transformed into a sperm during spermiogenesis. During this stage of differentiation, many nucleo-cytoplasmic changes allow sperm to acquire their morphological characteristics: a head, an intermediate part and a flagella[11]. They are then expelled into the light of the seminiferous tubes during spermiation and then transported by the testicular fluid in the intratesticular spermatic tract and travel through the excretory genital tract (Figure 2).

Oogenesis is the process of oocyte formation and maturation. This is a discontinuous process, from fetal life to menopause, with a first blockage at the end of meiosis prophase I and a second blockage in meiosis metaphase II [12]. This occurs in ovaries and consists of three phases: multiplication phase, growth phase and maturation phase (Figure 3). Multiplication phase is effective from the 9th week to the 7th month of intrauterine life where the

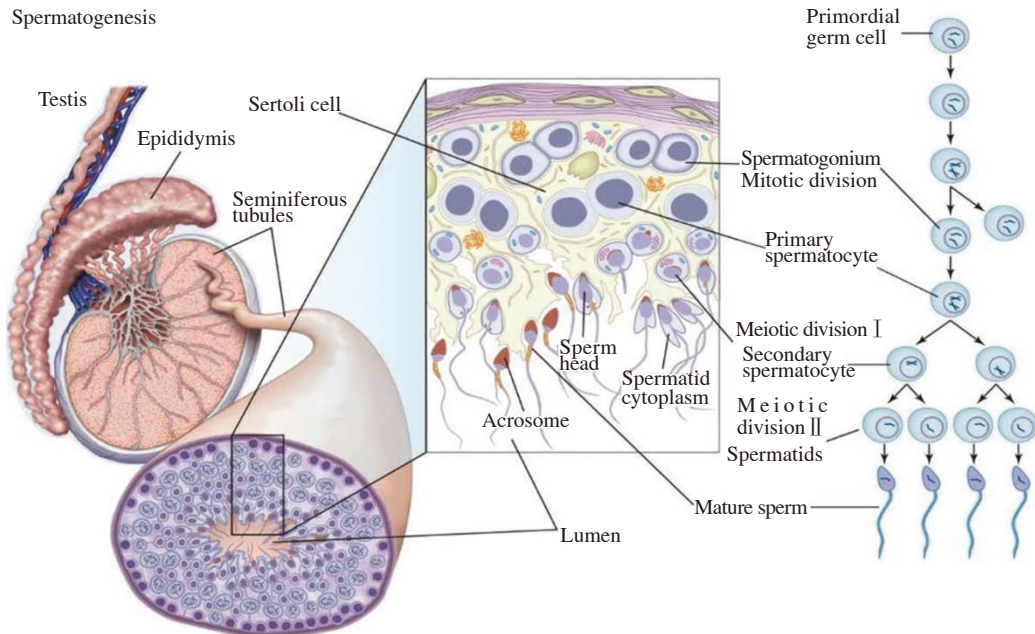


Figure 2. Overview of spermatogenesis steps[10].

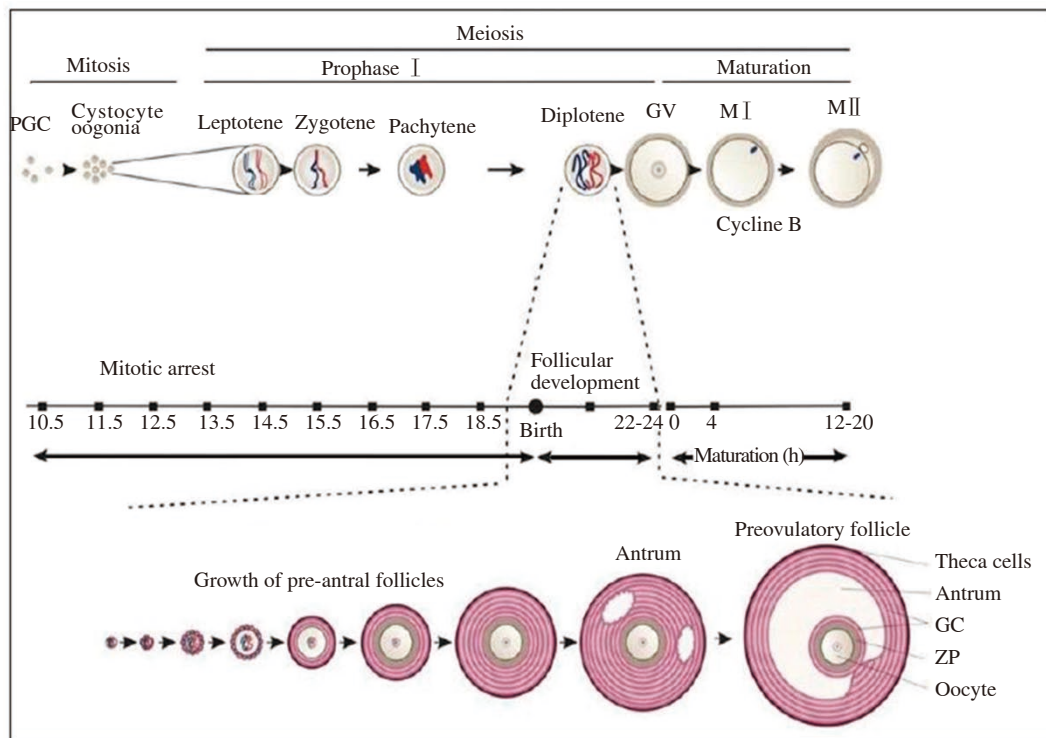


Figure 3. The stages of oogenesis: From primordial follicles to mature oocytes. PGC: primordial germ cells, GV: germinal vesicle, M I : metaphase I, M II : metaphase II, GC: granulosa cells, ZP: pellucid zone[13].

ovogonia are multiplied by succession of mitoses and transformed into immature oocytes type I [13]. Growth phase starts from puberty and takes place mainly from the primary follicle stage to the pre-antral stage. Then, immature oocytes type I enter meiosis: the pairing of homologous chromosomes begins at the zygotene stage and homologous recombination occurs at the pachytene stage while activating the cytoplasmic polyadenylation mechanism. Oocytes I blocked in prophase I enter the diplotene stage, which begins before birth and is characterized by oocyte growth and follicle formation

and development[14]. Maturation phase includes cytoplasmic and nuclear maturation. Cytoplasmic differentiation occurs with migration of cortical granules with synthesis of inositol triphosphate receptors, essential for oocytes activation by phospholipase C during fertilization. While a peak of luteinizing hormone (LH) is triggered occurring 36 hours before ovulation and a recovery of meiosis as well as the formation of a mature oocyte blocked in metaphase II called oocyte type II associated with the expulsion of the first polar globule[13].

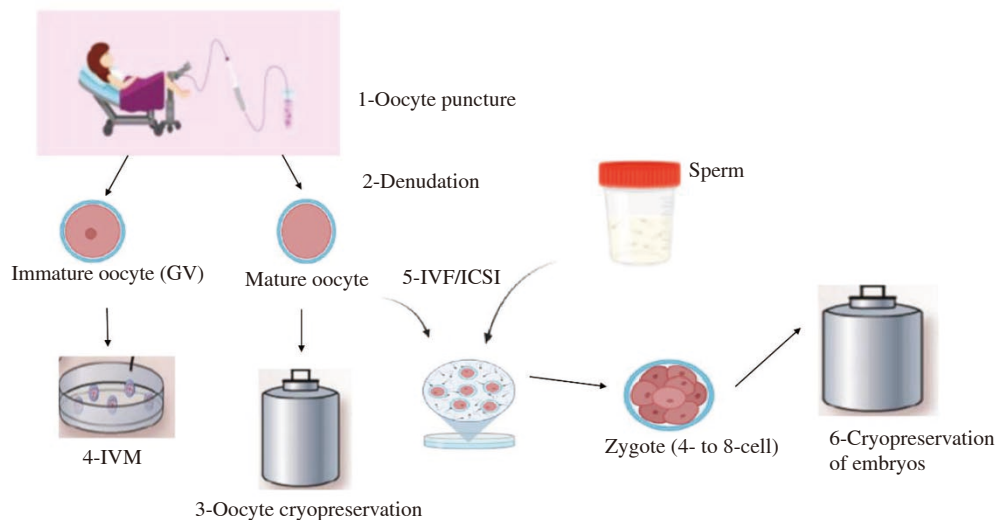


Figure 4. Fertility preservation. IVM: *in vitro* oocyte maturation; IVF: *in vitro* fertilization; ICSI: intracytoplasmic sperm injection. Drawn by using Biorender software.

3.3. Indications for fertility preservation

Fertility preservation depends on several factors such as: age, sex, diet, exposure to toxic substances effects and according to the treatment used. It can be used for social and/or medical reasons. Indeed, patients who are at risk of developing ovarian insufficiency (endometriosis, undergoing radical surgery, cancer and patients during their cancer treatment) can all benefit from fertility preservation technologies[15].

Fertility preservation is also accessible for men in order to guarantee a preservation of high sperm quality. It is also indicated for men suffering from diseases such as varicocele which is the most common cause; it negatively affects testicular function through testicular[16,17].

3.4. Fertility preservation techniques

Fertility preservation has become a very important thing, as it preserves the ability to conceive a child in the future. It is used for medical, social, and personal reasons, and is carried out by various techniques (Figure 4).

3.4.1. Controlled ovarian stimulation and oocyte collection

Ovarian stimulation is a common medical treatment used to increase the chances of conceiving a child in women with difficulty of ovulating or conceiving oocytes. The treatment usually involves administering ovary stimulating drugs to produce more oocytes. Indeed, several protocols are implemented for ovarian stimulation; the most used are: the natural process, it is less used and it consists of the use of low dose for ovarian stimulation[18]. Thus, gonadotropin release hormone (GnRH) agonist protocol consists of the use of certain drugs to suppress the natural production of follicular stimulation hormone (FSH), to allow full control of oocyte stimulation. Indeed, GnRH antagonist protocol uses drugs to

prevent production of LH, which triggers ovulation[19]. The dose of gonadotropins is chosen based on the age, body mass index (BMI) and ovarian reserve[20]. Then, the assays are adjusted according to oestradiol 2 (E_2) levels and follicle size greater than 16 mm to maximize the follicular response while minimizing ovarian hyperstimulation syndrome. Hormonal profiles of FSH and LH and E_2 are evaluated in each patient on day 4 of ovarian stimulation[19,20].

3.4.2. In vitro oocyte maturation (IVM)

It is an alternative technology for assisted reproduction in women. It consists of the recovery of immature oocytes at the germinal vesicle stage and a culture of intact cumulus-oocyte complexes (COC) *in vitro* up to the metaphase II stage[21]. Then, a conventional *in vitro* fertilization (IVF) or an intracytoplasmic sperm injection (ICSI) are performed[22]. IVM was first used in 1991 to successful pregnancy and deliver to a child[23]. In addition, there are several variants of IVM, for example, conventional IVM consists in recovering immature oocytes before the start of ovarian stimulation, emergency IVM allows the use of oocytes recovered from the IVF process. Indeed, these variants are used successfully as an alternative to IVF in different groups of patients showing endometriosis or polycystic ovary syndrome, with variable success rates[24–26].

IVM involves the recovery of primary follicles with a diameter of 2-10 mm without prior administration of human chorionic gonadotropin (hCG) and then matured *in vitro*[27,28]. This process has several advantages including the absence (or minimum) of controlled ovarian stimulation, improved convenience and reduced surveillance load[29]. However, it includes consequences as a challenge in protocol (the passage time in metaphase II and the various additions added to have a better maturation), a decrease in fertilization rate and a decrease in blastulation rate. IVM is the most technique used in women with polycystic ovary syndrome to reduce the risk of ovarian hyperstimulation syndrome[30].

3.4.3. Cryopreservation

There are two main cryopreservation techniques: slow freezing and vitrification. Slow freezing involves a decrease in temperature step-by-step from 20 °C to -196 °C (20 °C to 0 °C to -60 °C to -196 °C[31]. This allows freezing equilibrium to be achieved through the exchange of extracellular and intracellular fluids without causing osmotic effects. However, ice crystals can form inside cells, which can cause extremely harmful effects such as cell bursting and increased oxidative stress[32]. The procedure is long, and it takes about 1 to 2 hours and requires expensive instruments and large quantities of liquid nitrogen.

Vitrification is the transformation of water into solid cells similar to glass, avoiding the formation of intracellular and extracellular ice crystals[33]. Moreover, it does not require expensive instrumentation and only lasts a few minutes (maximum 30 min). A meta-analysis conducted in 2016 found that egg survival, fertilization and implantation rates were higher with vitrification than with slow freezing methods[34]. Today, vitrification has become the most favoured technique because of its success and viability rates showing strong correlations with age at the time of oocyte cryopreservation[35].

Oocyte cryopreservation is the preferred option for post-pubescent or single patients. This is a valid alternative for patients with malignant or benign diseases such as polycystic ovary syndrome or endometriosis, as it guarantees the woman's autonomy[36–38]. Thanks to scientific development, vitrification ensures very high survival rates after warming[39,40]. In one study, the survival of vitrified oocytes ranged from 90% to 97%, and fertilization rates ranged from 71% to 79%, and clinical pregnancy rates by transfer ranged from 36% to 61%, and clinical pregnancy rates by oocyte thawing were 4.5%-12%[41,42]. Moreover, vitrification/oocyte heating cycles were significantly lower in women over 40 years of age than in younger women[40].

Ovarian tissue cryopreservation (OTC) is still considered experimental, but it is currently the only option for pediatric and disease patients hormone-dependent. It is performed in emergency without ovarian stimulation and does not require the presence of a male partner[43]. OTC is an invasive procedure, because it consists of a general anesthesia to surgically remove the ovarian tissue and then cryopreserved in the form of cortical fragments containing primordial follicles or small primary follicles not sensitive to freezing. This tissue is used for the following procedures: orthotopic implantation (re-implantation in the pelvic cavity or heterotopic implantation outside the ovaries); and isolation of follicles from thawed tissue for growth, maturation, vitrification and IVF[44]. Indeed, cryopreservation of ovarian tissue must in theory be performed before 35 years, due to the observed decline in the follicle density of ovarian tissue beyond this age[45,46]. In addition, the success rate after relocation is approximately 30%[42]. Cryopreservation of the entire ovary remains a technical challenge due to the large size of the tissue, which prevents homogeneous and

adequate dispersion to cryoprotectants, and vascular damage in the form of ice crystals. Further studies are required for this technique to be used in standard clinical practice[47].

Sperm cryopreservation allows for the preservation of the genetic pool to use sperm for assisted reproduction. The procedure includes the collection of at least 3 semen samples, with an abstinence period of 2 to 5 days between samples. The role of cryopreservation of sperm is to stop the cellular metabolism of frozen sperm with liquid nitrogen at -196 °C to restore their functional viability[48]. The entire procedure requires a high degree of customization across multiple functions including dilution, freezing and thawing[49–51]. Cryopreservation of sperm leads to a varying degree of ultra-structural, biochemical, functional, plasma, acrosomic membrane and mitochondrial membrane damages[52–55]. Thus, the formation of extracellular and intracellular ice in sperm is thought to be responsible for this damage. Sperm vitrification is usually achieved by cooling small volumes of charge. Indeed, several limitations of sperm vitrification is the toxicity at high concentrations of permeable cryoprotectants; especially, those that are permeable producing osmotic damages where the severity is linked to the size and characteristics of sperm reduced cytoplasm[56,57]. Recently, new carriers have been developed to facilitate better control of volume and speed, and new strategies have been implemented to minimize the risk of contamination. For example, trehalosis and gentiobiosis improve sperm parameters, sperm vitality, DNA integrity, and the membrane and potential of the mitochondrial membrane[58].

Testicular tissue cryopreservation is also used as a fertility preservation ethically acceptable in the case of prepubertal children with malignant diseases and also for patients with azoospermia[59]. It consists on the preservation of testicular tissue containing spermatogonial stem cells (SSCs) which is analogue to the cryopreservation of ovarian tissue in women[60]. Testicular tissue can be obtained by testicular biopsy and cryopreserved as spermatogonia or as testicular tissue using slow or ultra-fast freezing techniques[61,62]. However, cryopreserving testicular tissue offers the future option of using it for various purposes such as testicular grafting, organ culture, or cell therapy[63,64]. Cryopreservation of testicular tissue maintains the microenvironment niche of SSCs (somatic cells, Sertoli cells, Leydig cells, and peritubular cells). The majority of cryopreserved samples have shown a reproductive potential of 33% to 56%[65].

Cryopreservation of embryos by vitrification is an integral part of modern assisted reproduction care, but a male partner is needed[66]. This can lead to ethical and legal complications regarding potential orphan embryos if the patient dies or separates from her partner[67]. Indeed, birth rates from the transfer of thawed cryopreserved embryos depend on the age of the woman when the egg is retrieved[66]. Moreover, the vitrification of embryos takes place at -196 °C, and requires the presence of cryoprotectant. Table 1 resumes benefits and risks of using fertility preservation techniques.

Table 1. Treatment options for fertility preservation.

Technical	Definition	Benefits	Inconvenients
Sperm cryoconservation	Sperm collection, sperm bank.	- No delay processing treatment. - Most established method for men.	- Increases DNA fragmentation.
Cryoconservation of eggs	Ovarian stimulation controlled followed by a oocyte sampling after cryopreservation for a use future.	- Well established fertility preservation technique. - No ethical issues.	- Time required to ovarian stimulation. - Risk of overstimulation. - Invasive procedure of oocyte sampling (day surgery). - Not recommended in the women with hormone-sensitive cancers. - Impossible for girls prepubescent. - Need a partner/male donor for the fertilization of oocytes before implantation. - High cost.
Freezing of embryos	Controlled ovarian stimulation, followed by egg removal, <i>in vitro</i> fertilization and cryopreservation of embryos for future use.	- Good fertility preservation technique established. - Good survival of embryos at thawing. - Direct transfer in the uterus afterdefrosting.	- Ethical issues; concerning the provision of embryos. - Time required for the ovarian stimulation and subsequent delay in the treatment of cancer. - Risk of overstimulation. - Invasive procedure for oocyte collection (day surgery). - Not recommended in women with hormone-sensitive cancers. - Impossible for girls prepubescent. - Need a partner/male donor. - High cost.
Cryopreservation of ovarian tissues	Surgical sampling of ovarian tissue, cryopreservation of the tissue and subsequent reimplantation once the patient is cured.	- Feasible for prepubescent children. - Generally, does not require prior hormonal stimulation. - Can be planned shortly after the diagnosis of malignant disease.	- Surgery under general anaesthesia. - Risk of reintroduction of cancer cells. - Risk of ischemic tissue injury. - There is limited availability of centers with adequate skills in cryopreservation that are capable of performing the most sensitive procedures and updated histological analysis techniques before transplantation to avoid relapses. - High cost.
<i>In vitro</i> maturation of oocytes	Collection of immature oocytes, followed by passage of ripening stage.	- Well-established fertility preservation technique; no ovarian stimulation required. - No ethical issues.	- Increase in the rate of fertilization and blastocyst rate.

Table 2. Effect of different spermatogenesis stimulating plants.

Family	Name of the plant: Genus and species	Part of plant used	Model	Dose	Observed effects
Capparaceae	<i>Capparis spinosa</i>	Leaf extract	Human	15, 30 and 45 ppm	-Positive results for 30 ppm; 45 ppm improves mobility, vitality and decrease of DNA fragmentation.
Fabaceae	<i>Ceratonia siliqua</i> (carob)	Leaf extract	Human	10 and 20 µg/mL	-Increase in morphology, mobility and vitality. -Fragmentation reduction. -Positive effect for 10 and 20 µg/mL.
Lamiaceae	<i>Thymus munbyanus</i> (thyme)	Leaf extract	Human	100 to 1 000 µg/mL	-Mobility improvement + acrosomic reaction.
Zygophyllaceae	<i>Tribulus terrestris</i> (calthrop)	Leaf extract	Human	20, 40 and 50 µg/mL	-Reaction on all the parameters. -Positive effect for the two high concentrations.
Solanaceae	<i>Withania somnifera</i>	Root	Human	25, 50, and 100 µg/mL	-Positive effect on the spermatic parameters in the concentration 50 µg/mL. -Toxic effect in 100 µg/mL.

3.4.4. Plant-based alternatives for fertility enhancement

Plants are used as an alternative to improve sperm cryopreservation as summarized in Table 2. They can improve the sperm mobility and viability. Some examples are presented as follows.

Capparis spinosa belongs to the family of Capparaceae; trees, shrubs and herbs are widespread in warm temperate and tropical regions, usually with seasonal drought. It is divided into 17 genera with about 470 species. Eleven genera are endemic to particular regions: in Africa 7 genera, in Central and South America 4 genera. Some

species are cultivated for ornamental purposes while the flower buds and pickled fruits of *Capparis spinosa* are commonly consumed (capers)[68]. The extract from this plant was used as an additive to human sperm[69], after incubating at 37 °C for 24 hours using three concentrations (15 ppm, 30 ppm and 45 ppm).

The plant extract was added to the freezing and thawing media for human sperm preservation[69], sperm samples were incubated at 37 °C for 24 hours with three concentrations of the extract (15 ppm, 30 ppm, and 45 ppm). The extract used (30 ppm and

45 ppm) demonstrated an improvement in spermatoc parameters such as motility, speed and viability as well as a reduction in DNA fragmentation[68].

Cerantonia siliqua belongs to the family Fabaceae known by the family name of legumes; it is a group of plants that are commonly found in vegetable gardens around the world. Among the most commercially important pulses are peas, chickpeas, soybeans and forage crops such as alfalfa and clover. It is divided into 20 000 species and over 700 genera, it is the third largest family of plants and its members can be found all over the world (except in the polar regions), with a particularly high diversity in the tropics[68]. Plant extract (5 µg/ mL to 30 µg/mL) was used in human sperm by adding it to freezing and thawing media[70]. The addition of this plant to the sperm extender significantly increased the sperm's progressive motility, normal morphology and viability, and reduced DNA damage. However, some of the concentrations used had adverse effects on sperm parameters (25 µg/ mL and 30 µg/ mL)[68].

Thymus munbyanus belongs to the family Lamiaceae; they are annual or perennial plants, vines, shrubs and trees of global distribution, especially present in dry and warm regions such as the Mediterranean. They are known as the mint family, and the species in this group usually have square stems, opposite leaves and aromatic essential oils. Evaporation of essential oils reduces water loss in the xeric zones. Commonly used as culinary and medicinal herbs, this family includes about 7 000 species in over 250 genera. Among the most popular genus is *Thymus*[68]. The extract of this thyme species (100 µg/mL–1 000 µg/mL) was used in human sperm and incubated for 30 minutes. This extract affects the motility of human sperm and its ability to undergo hyperphosphorylation and acrosomic reaction[71].

Tribulus terrestris belongs to the family Zygophyllaceae; it comprises about 250 species in about 25 genera, distributed mainly in tropical and subtropical regions, and some are particularly representative in the temperate regions of the dry Mediterranean region. The family includes woody and medicinal species (*Guaiacum* spp.) and several cultivated as ornamentals (*Tribulus* spp. and *Zygophyllum*)[68]. In humans, this plant extract was added to sperm thinners before cryopreservation of sperm and after thawing[72]. It has been shown to improve sperm motility and viability after defrosting sperm. The concentrations used were 20, 40 and 50 µg/mL, with the two highest concentrations giving the best results. None of the concentrations used negatively affected sperm parameters[68].

Withania somnifera belongs to the family of Solanaceae called ashwagandha, Indian ginseng. Several different species are morphologically similar in the *Withania* variety. *Withania somnifera* is commonly found in warm, dry climates (including Pakistan, India and Iran)[73,74]. Leaves, roots, seeds, fruits and flowers are used to treat impotence and increase sexual desire with other conventional plants, alone or in the polyherbal formulation[75,76]. Several phytochemical compounds extracted with variable pharmacological

and biological properties have been identified[77]. This plant contains more than 80 typical phytochemical compounds, including steroids, alkaloids, saponins, glycosides and volatile oil, which explains its many medicinal properties which can directly or indirectly prevent and treat a number of diseases[68]. Ashwagandha roots have antioxidant properties and treat infertility[78]. Because of its anti-inflammatory properties, the dried roots of the plant are usually used to treat nervous and sexual problems, and improve sperm quality[79,80].

4. Discussion

This systematic scoping review evaluated the current state of research on the role of natural extracts and various techniques for fertility preservation, including assisted reproductive technology. It will provide a comprehensive analysis of existing literature to identify how these extracts contribute to fertility preservation and outline the techniques being utilized in this area. The conclusions drawn from this review are that assisted reproduction techniques should be chosen according to the characteristics of the patients: male, female, pre-pubertal or post-pubertal, and according to the advantages and disadvantages they present, not forgetting the percentage of success. In addition, various authors have demonstrated the essential role of *in vitro* oocyte maturation in reducing the risk of ovarian hyperstimulation syndrome, and the use of plants and therefore natural extracts to improve the success rate of the various techniques used in infertility preservation.

This review highlights the continuing progress in the field of fertility preservation, notably with the introduction of new approaches such as oocyte and embryo vitrification and sperm freezing. These advances offer new options for people with fertility problems, expanding the possibilities for treatment and reproductive assistance.

This review underscores the importance of considering the various aspects of fertility preservation techniques and the role of natural extracts in enhancing sperm quality. It also highlights the positive impact of recent technological advancements on fertility preservation options, providing a comprehensive overview of the current state of this crucial field in reproductive medicine. However, it is important to acknowledge the limitations of this review, including potential biases due to the scope of the literature, variability in study designs, differences in the quality of evidence, and a focus on natural extracts that may not fully capture the complexities of other fertility preservation methods.

In conclusion, fertility preservation increases with time and becomes very important for oncological, medical and personal reasons. The field of assisted reproductive technologies includes a variety of techniques designed to address the specific needs of individuals experiencing fertility challenges. Methods such as

IVF and cryopreservation offer unique advantages and potential drawbacks. The selection of an appropriate approach depends on factors such as the patient's reproductive health, age, and individual circumstances. By understanding these variables, healthcare providers can optimize outcomes and increase the likelihood of successful conception. As research progresses, advancements in these techniques are expected to enhance fertility preservation and treatment options, providing hope to many individuals and couples. In addition, sperm cryopreservation is now considered as the first-line fertility preservation option for male patients, as well as the use of additives to improve sperm quality. The vitrification of oocytes is currently the most usable technique for female patients. In addition, the IVM of oocytes should be used to reduce the risk of ovarian hyperstimulation syndrome. Currently, the hope has turned towards the use of plants and therefore natural extracts to improve the success rate of the various techniques used in the preservation of infertility and thus opens several avenues for scientific and biotechnological research.

Conflict of interest statement

The authors declare no competing interests.

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Authors' contributions

All authors participated to the literature search, interpretation of the articles and review of the manuscript. All the authors have read and approved the final version of the manuscript.

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