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# Herbal Contraceptives: Phytochemistry, Mechanisms of Action, Therapeutic Potential, Safety, and Future Perspectives

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**Abstract — The rising worldwide need for safe, cost-effective, and reversible contraception has sparked new interest in using medicinal plants as alternative fertility-controlling solutions. Conventional medical systems have utilized various plants for contraception by impacting ovulation, spermatogenesis, fertilization, implantation, and uterine functions. Recent pharmacological studies have discovered various phytochemicals such as alkaloids, flavonoids, saponins, terpenoids, coumarins, lignans, and phytoestrogens that influence reproductive endocrine pathways and gamete activity. This review thoroughly outlines existing evidence related to phytochemistry, action mechanisms, pharmacological effects, and safety profiles of herbal contraceptives. Key medicinal plants like Azadirachta indica, Carica papaya, Ruta graveolens, Juglans regia, Ricinus communis, Daucus carota, and other commonly utilized species are thoroughly examined with a focus on their antifertility properties, active compounds, and empirical support. Despite considerable in vitro and animal research supplementing contraceptive effectiveness via anti-ovulatory, spermicidal, anti-implantation, endocrine-modulating, and uterotonic processes, strong clinical evidence continues to be scarce. Moreover, issues related to toxicity, reproductive safety, teratogenic effects, dose consistency, and long-term reversibility still impede clinical translation. Future studies must focus on standardized phytochemical profiling, mechanistic molecular investigations, GLP-compliant toxicity assessments, and rigorously structured randomized clinical trials. Herbal contraceptives thus serve as encouraging options for creating new contraceptive methods; however, significant scientific confirmation is necessary before their regular clinical use.**

**Keywords— Herbal contraceptives; Phytochemicals; Plant-based contraception; Mechanisms of action; Antifertility agents; Reproductive health; Medicinal plants; Bioactive compounds; Hormonal regulation; Fertility control; Therapeutic potential; Safety and toxicity; Ethnopharmacology; Natural products; Future perspectives.**

## I. INTRODUCTION

Family planning continues to be one of the most successful public health approaches for enhancing maternal health, minimizing unintended pregnancies, and fostering socioeconomic growth. Despite significant progress in hormonal contraceptives, intrauterine devices, barrier methods, and permanent sterilization, millions of women globally still face unmet contraceptive needs due to restricted accessibility, high expenses, cultural obstacles, negative side effects, or worries about prolonged hormonal exposure. As a result, there is growing interest in discovering safer, cost-effective, reversible, and culturally suitable contraceptive options sourced from natural materials.

For thousands of years, traditional medicine systems like Ayurveda, Traditional Chinese Medicine, African traditional medicine, and indigenous healthcare practices have utilized medicinal plants for regulating fertility. Ethnobotanical studies carried out in Asia, Africa, and South America have recorded numerous plant species used traditionally for either contraceptive purposes or to induce early abortion. India boasts a rich repository of traditional knowledge detailing over one hundred species of medicinal plants utilized as female contraceptives, highlighting the enduring integration of herbal fertility control within local healthcare frameworks (Sharma et al., 2024). Comparable ethnopharmacological studies in Africa have identified various medicinal plants used for contraception and reproductive health, showcasing the worldwide significance of plant-based antifertility treatments (Adia et al., 2025).

In contrast to traditional hormonal contraceptives, herbal contraceptives have various pharmacological effects due to different phytoconstituents. Bioactive metabolites such as flavonoids, alkaloids, saponins, terpenoids, steroids, coumarins, tannins, lignans, and phenolic compounds affect reproductive physiology by regulating the hypothalamic–pituitary–gonadal axis, hindering steroidogenesis, blocking ovulation, disrupting spermatogenesis, diminishing sperm

motility, averting fertilization, modifying endometrial receptivity, triggering uterine contractions, or interfering with embryo implantation (Byaruhanga, 2025; Goswami & Basak, 2021). These multitarget mechanisms render medicinal plants especially appealing options for creating new contraceptive agents that possess diverse pharmacodynamic profiles in contrast to synthetic medications.

This review thoroughly examines the existing evidence on herbal contraceptives by analyzing their phytochemical constituents, key medicinal plants, mechanisms of action, pharmacological effects, safety concerns, and emerging research avenues. Moreover, the review emphasizes current knowledge deficiencies and prospective chances for converting conventional medicinal plants into scientifically confirmed contraceptive substances that can meet the increasing worldwide need for safe and efficient fertility control.

## II. MECHANISM OF ACTION OF HERBAL DRUGS

**Hormonal modulation**

Plans exert antifertility effects mainly through hormonal modulation of the hypothalamic-pituitary-gonadal axis, altering the secretion and activity of estrogen, progesterone, luteinizing hormone (LH), follicle-stimulating hormone (FSH), and testosterone; phytochemicals such as phytoestrogens, saponins, alkaloids, and flavonoids can bind to steroid hormone receptors or interfere with steroidogenic enzymes, thereby enhancing or suppressing gonadal steroid synthesis, with Tribulus terrestris and Withania somnifera shown to elevate LH, FSH, and testosterone to improve spermatogenesis, while Azadirachta indica, Momordica charantia, and Glycyrrhiza glabra reduce testosterone and disrupt spermatogenesis (Byaruhanga P., 2025). Asparagus racemosus and Trigonella foenum-graecum elevate estrogen and LH to stimulate folliculogenesis, whereas Carica papaya seeds, Piper betle, Hibiscus rosa-sinensis, and Datura metel lower progesterone or estrogen, impair corpus luteum function, and disrupt estrous cycles (Sharma et al., 2024). Several species such as Aegle marmelos, Chenopodium ambrosioides, Jatropha gossypifolia, and Leonotis ocymifolia exert antifertility activity via anti-implantation, anti-spermatogenic, and gonadotropin-suppressive mechanisms (Goswami & Basak, 2021)

**Spermicidal Agents**

In vitro studies show that root extracts of Saponaria officinalis, Herniaria glabra, and Glycyrrhiza glabra rapidly immobilize sperm in a dose- and time-dependent manner. These saponin-containing plants act by forming complexes with membrane cholesterol, disrupting osmotic balance and leading to cell death (Sefrioui et al., 2021). Moreover, Sapindus mukorossi, Sapindus Saponaria, Achyranthes aspera, and Carica papaya impair sperm function through membrane disruption or motility inhibition (Hifnawy et al., 2021).

**Ovulation Inhibition**

Ethnopharmacological evidence from India documents over a hundred species traditionally employed as female contraceptives, with plants such as Carica papaya, Azadirachta indica, Ruta graveolens, Dioscorea bulbifera, Cissampelos pareira, and Datura metel shown to interfere with ovarian hormone secretion, corpus luteum function, and folliculogenesis (Sharma et al., 2024). These effects are mediated by phytochemicals, including alkaloids, saponins, flavonoids, and coumarins, which disrupt hormonal balance and reproductive physiology (Sharma et al., 2024). Complementary global surveys highlight species such as Aegle marmelos, Chenopodium ambrosioides, Jatropha gossypifolia, and Leonotis ocymifolia, with pharmacological studies confirming their ability to impair ovulation and corpus luteum activity (Goswami & Basak, 2021). Mechanistic insights from systematic reviews further demonstrate that Carica papaya seeds, Piper betle, and Cassia fistula act as endocrine disruptors by lowering progesterone, suppressing LH and FSH, or interfering with estrogen signaling, while Hibiscus sabdariffa, Morinda citrifolia, and Datura metel exhibit anti-gonadotropic or estrogen-antagonistic effects (Byaruhanga P., 2025).

**Uterotonic/Emmenagogue effects**

Uterotonic and emmenagogue properties of medicinal plants are central to their antifertility activity. Species such as Carica papaya, Azadirachta indica, Cissampelos pareira, Dioscorea bulbifera, and Datura metel have been shown to prolong diestrus, disrupt estrous cycles or directly stimulate uterine contractility, often producing abortifacient outcomes (Shubhangi, 2025). These effects are mediated through hormonal balance, phytoestroenic modulation and suppression of gonadotropins, underscoring both contraceptive potential and safety concerns. Uterotonic plants such as Foeniculum vulgare (Fennel), Leonurus cardiaca (Motherwort), Caulophyllum thalictrodies (Blue Cohosh), Trigonella foenum-graecum (Fenugreek), and Ricinus communis (Castor seed) all elicit contractile responses in isolated uterine tissue (Fromm & Degolier, 2021). Mechanistically, these activities are linked to prostaglandin release, oxytocin stimulation and bioactive lipids such as linoleic and arachidonic acids, while triterpenoid saponins further enhance myometrial activity. Compounds like diosgenin, ferulic acid, tannic acid, and certain flavonoids can attenuate contractions, reflecting the bidirectional nature of phytochemical interactions. Uterotonic activity demonstrates

how endocrine disruptors and overlapping antioxidant/anti-inflammatory pathways influence reproductive physiology, highlighting both contraceptive promise and toxicological risks (Fromm & Degolier, 2021; Shubhangi, 2025).

**Anti-implantation activities**

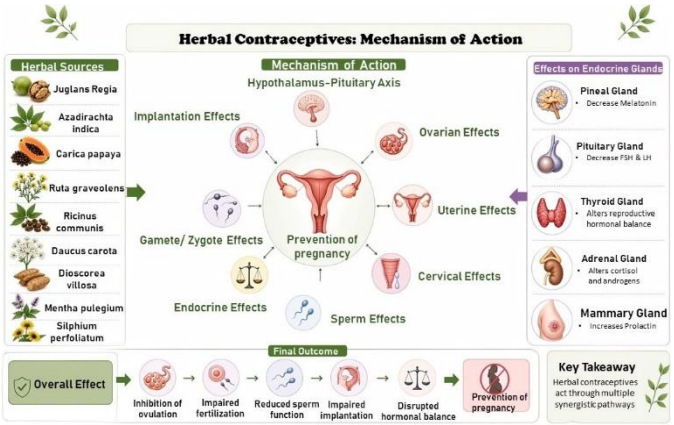
Anti-implantation activity of herbal contraceptives is mediated by diverse phytoconstituents that strategically disrupt the implantation window through hormonal imbalance, oxidative stress, and endometrial receptivity modulation. Limonoids from Azadirachta indica impair corpus luteum function and induce embryotoxicity(Adia et al., 2025). Flavonoids and tannins from Carica papaya generate oxidative stress and block implantation (Badri et al., 2025). Fatty acid fractions of Daucus carota inhibit ovarian steroidogenic enzymes, prolonging diestrus and preventing implantation. Cardiac glycosides in Calotropis procera suppress decidualization and alter cervical mucus (Goswami & Basak, 2021). Phenolic acids in Hibiscus rosa-sinensis reduce trophoblast invasion and impair blastocyst attachment (Sharma et al., 2024). Essential oils from Chenopodium ambrosioides interfere with corpus lutem activity(Byaruhanga, 2025). Diterpenoids in Jatropha gossypifolia accelerate zygote transport, impeding implantation (Goswami & Basak, 2021). Isoflavones in Cissampelos pareira disrupt estrogen signaling and reduce endometrial receptivity. Coumarins such as chalepensn frmRuta graveolens induce embryotoxicity and block blastocyst attachment (Fadeyi et al., 2024). Naphthoquinones like juglone from Juglans regia elevate oxidative stress and halt embryonic cleavage (Bhardwaj et al., 2023). These plants demonstrate that anti-implantation activity is a widespread mechanism among herbal contraceptives, driven by secondary metabolites acting on the hypothalamic pituitary ovarian axis, uterine enzymology, and oxidative stress pathways (Fadeyi et al., 2024).

**Cervical Effects**

The pharmacological induction of cervical contraction and remodeling by herbal contraceptives represents a specialized uterotonic mechanism that facilitates the expulsion of the blastocyst or inhibits sperm migration through the endocervical canal. Botanical agents such as Ricinus communis and Phoenix dactylifera trigger collagenolysis and cervical softening (Fadeyi et al., 2024; Sharma et al., 2024). The secondary metabolites ricinoleic acid and furocoumarins, such as chalepensin, from Ruta graveolens induce significant myometrial and cervical contractions, thereby creating a mechanical barrier to nidation (Anandi Navnit Kothale et al., 2024; Hifnawy et al., 2021). These phytocompounds often disrupt the progesterone-dependent “cervical seal,” leading to premature cervical effacement and the termination of the implantation window (Byaruhanga P., 2025).

**Gamete/Zygote Effects**

The pharmacological disruption of gametes and zygotes by herbal contraceptives involves a multi-modal interface with cellular integrity and early developmental signaling. High-potency surfactants, specifically saponosides from Saponaria officinalis and Glycyrrhiza glabra, induce rapid, irreversible sperm immobilization by integrating into the lipid bilayer, causing osmotic shock and total membrane lysis (Sefrioui et al., 2021). At the molecular level, secondary metabolites such as gossypol and triptonide impair gametic competence by antagonizing the CatSper channel, effectively blocking the Ca2+ influx required for hyperactivation and the acrosome reaction (Hifnawy et al., 2021). Anti-zygotic agents, including the furanocoumarin chalepensin from Ruta graveolens and protein isolates from Achyranthes aspera, alter the fallopian environment to induce premature embryonic arrest or pre-implantation loss by inhibiting essential enzymes like sperm hyaluronidase (Anandi Navnit Kothale et al., 2024; Fadeyi et al., 2024).




## III. HERBAL DRUGS AS CONTRACEPTIVES

**Juglas Regia**

The systematic Antifertility potential of Juglans regia is substantiated by a complex array of secondary metabolites that target critical reproductive pathways. The high-potency naphthoquinone juglone (5-hydroxy-1,4-naphthoquinone) acts as a primary embryotoxic agent, including mitochondrial oxidative stress, that halts embryonic cleavage and precipitates pre-implantation loss (Wani & Kumar, 2020). Synergistic interference is further provided by specialized ellagitannins, specifically tellimagrandin II, casuarictin, and glansrins A, B and C, which alter the biochemical landscape of the

endometrium, effectively neutralizing the molecular markers required for successful nidation (Bhardwaj et al., 2023). Concurrently, the presence of quercetin-3-o-glucoside, rutin and afzelin provides a phytoestrogenic challenge to the hypothalamic-pituitary-ovarian(HPO) axis, where these compounds competitively bind to estrogen receptors to induce an anti-ovulatory state (Delaviz et al., 2017). In the green husk and leaves, isolates including caffeic acid, ferulic acid, and p-coumaric acid elevate uterine peroxidase and lipid peroxidation levels, creating a hostile physiological environment that impairs both sperm motility and zygote transport (Wani & Kumar, 2020). By suppressing the cyclical surge of gonadotropins (LH and FSH) and directly compromising gametic competence, these specific phytochemicals establish J. regia as a perfect biological agent for fertility regulation (Bhardwaj et al., 2023).

**Azadirachta Indica**

Azadirachta indica contains limonoids (azadirachtin, nimbin, salannin, gedunin), triterpenoids, flavonoids and phenolics (-Bhagyashri Dipak Birari et al., 2023). Neem seed oil and concentrated extracts exhibit spermicidal activity characterized by rapid sperm immobilization and loss of viability in vitro and in vivo (Shubhangi, 2025). Systemic administration of neem preparations produces antispermatogenic effects, testicular histopathology, and reversible or irreversible reductions in sperm count and motility depending on dose and duration (Bhagyashri Dipak Birari et al., 2023). Female reproductive effects reported include estrous cycle disruption (prolonged diestrus), inhibition of ovulation, anti-implantation activity, and embryotoxic/abortifacient outcomes in rodent and higher-order models (Shubhangi, 2025). Purified neem seed formulations (eg, Praneem) have demonstrated pregnancy-terminating activity in primate models, supporting translational contraceptive potential (Patil et al., 2021). Proposed mechanisms encompass direct gametotoxicity, endocrine modulation of hypothalamic-pituitary-gonadal axes, uterotonic/prostaglandin-mediated effects, and local mucosal spermicidal action (Adia et al., 2025; Bhagyashri Dipak Birari et al., 2023).

**Carica Papaya**

Carica papaya is characterized by a complex phytochemical composition, notably quercetin glycosides, kaempferol derivatives, catechin, epicatechin, and myricetin together with tannins such as gallic acid, ellagic acid, syringic acid, and condensed proanthocyanidins, which collectively underpin its antifertility bioactivity (Singh et al., 2022). Preclinical investigations demonstrate that papaya seed extracts induce spermatotoxicity, characterized by reductions in sperm count, motility, and viability, while female reproductive models reveal anti-ovulatory, anti-implantation, and embryotoxic outcomes following administration of unripe fruit or leaf preparations (Shrawankar et al., 2025). Mechanistic interpretations attribute these effects to oxidative stress induction, gametotoxic membrane disruption, proteolytic enzyme activity, and modulation of hypothalamic-pituitary-gonadal hormone signaling, thereby impairing reproductive function (Aneri & Dhvani, 2022).

**Ruta Graveolens**

Ruta graveolens lipophilic (chloroform/n-butanol) extracts and furanocoumarins (notably chalepensin) produce uterotonic/uterodilatory responses in isolated uterine assays and anti-implantation/embryotoxic outcomes when administered peri-implantation in rodents (Luo et al., 2024). Acute male-directed effects include rapid sperm immobilization/quiescence in vitro and transient loss of motility in vivo after high-dose aqueous gavage, while repeated or high-dose oral regimens cause reduced sperm counts, Leydig cell degeneration, lowered androgens and impaired spermatogenesis with decreased fertility in mating tests (Luo et al., 2024; Poornima P. et al., 2026). Mechanistic attribution centers on furanocoumarins and certain alkaloids, but precise molecular targets and stereochemical SAR remain undefined (Luo et al., 2024).

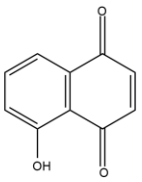
**Ricinus Communis**

The methanol seed extract of Ricinus Communis, containing ricinine and N-demethylricinine along with steroidal phytosterols, has been shown to impair male fertility by reducing sperm count, mobility, and morphology, and lowering fructose and testosterone levels (Kumar, 2017). In female models, the ether-soluble fraction of methanol seed extract demonstrated anti-implantation and estrogenic activity at doses up to 1.2 g/kg in rats and 600 mg/kg in rabbits, confirming its role in reproductive modulation (Kumar, 2017). Ricinus communis exhibits antifertility activity mediated by ricinoleic acid derivatives and species-specific ribosome-inactivating toxalbumins such as ricin, which catalyze 28S rRNA depurination, arrest protein synthesis, and precipitate reproductive toxicity through cellular necrosis and endocrine disruption (Ramothloa et al., 2025). Ricinoleic acid glycosides and dihydroxystearic acid derivatives present in castor oil fractions have been used to induce labour and regulate menstrual cycles, reflecting uterotonic activity

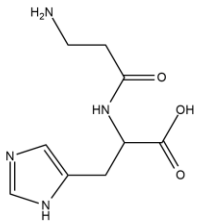
**Daucus Carota**

Seeds of Daucus carota have long been used as a contraceptive/abortifacient, and experimental studies report dose-dependent postcoital anti-implantation and abortifacient effects of chloroform/methanol and fatty-acid fractions in

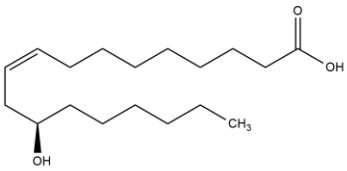
rodents (Jansen et al., 2014) Methanolic seed extract prolonged the estrous cycle (increased diestrus), reduced litters, lowered estradiol/FSH/LH and raised prolactin with partial recovery after withdrawal, indicating reversible antifertility via disruption of the pituitary-gonadal axis (Mausumi et al., 2019). Proposed mechanisms include uterine modulation (inhibition of spontaneous and oxytocin-evoked contractions), inhibition of ovarian steroidogenic enzymes (3-β-HSD, G6PD), mast-cell changes and dose-dependent estrogenic/anti-estrogenic effects.



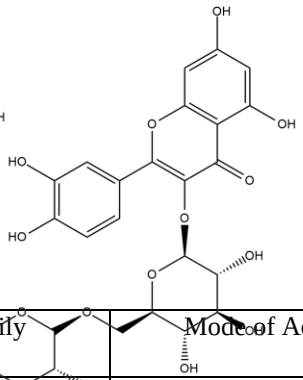
Juglone



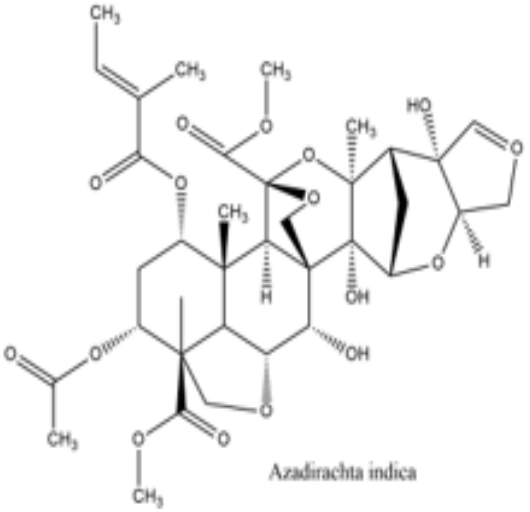
Pappain



Ricinoleic acid



Rutin



Azadirachta indica

## IV. COMPARATIVE TABLE OF PLANTS

| Plant (Scientific Name) | Family | Mode of Action | Experimental Model | Level of Evidences |
|---|---|---|---|---|
| Silphium (extinct) | Apiaceae (probable) | Uterotonicity, prostaglandinogenesis | Historical/ethnographic | Ethnographic |
| Pennyroyal *(Mentha Pulegium)* | Lamiacea | Myometrial contractility, abortifacient. | Rodent, human case reports | Human toxicology + preclinical |
| Wild Yam *(Dioscorea Spp.)* | Dioscoreaceae | Steroidogenesis modulation, estrogen receptor agonism, progesterone receptor antagonism. | In vitro, rodent | Preclinical mechanistic |
| Cotton Root Bark *(Gossypium herbaceum)* | Malvaceae | Spermatogenesis inhibition, uterotonicity (myometrial contractility). | Rodent, human trials (male contraception) | Clinical (male contraception) |
| *Achyranthes aspera* | Amaranthaceae | Ovarian folliculogenesis inhibition, anti-implantation activity. | Rodent | Preclinical only |

| | | | | |
|---|---|---|---|---|
| *Abrus precatorius* | Fabaceae | Ovarian folliculogenesis inhibition, uterotonicity (myometrial contractility), abrin-mediated ribosome-inactivating cytotoxicity. | Rodent, in vitro | Preclinical toxicological |
| *Calotropis procera* | Apocynaceae | GnRH suppression, Endometrial decidualization inhibition, Cervical mucus viscoelasticity alteration (mucus thickening), sperm-egg fusion blockade. | Rodent, in vitro | Preclinical mechanistic |
| *Hibiscus rosa-sinensis* | Malvaceae | Blastocyst cytotoxicity, Sperm capacitation inhibition, Acrosome reaction inhibition. | Rodent, in vitro | Preclinical only |
| *Curcuma longa* | Zingiberaceae | Represses implantation, inhibits sperm. | Rodent, in vitro | Preclinical mechanistic |
| *Moringa oleifera* | Moringaceae | Induces abortion, suppresses fertility. | Rodent | Preclinical only |
| *Justicia gendarussa* | Acanthaceae | Blocks sperm hyaluronidase activity. | Human clinical pilot, in vitro | Clinical pilot evidence |
| *Terminalia chebula* | Combretaceae | Suppresses spermatogenesis and testosterone. | Rodent | Preclinical only |
| *Plumbago zeylanica* | Plumbaginaceae | Blocks ovulation and prevents implantation. | Rodent | Preclinical only |

**Preclinical-studies**

Preclinical studies on herbal contraceptives reveal consistent antifertility activity across diverse taxa, but remain confined to rodent and in vitro models without standardized dosing or human validation. Achyranthes aspera extracts inhibit folliculogenesis and implantation in rats, suggesting ovarian suppression (Daniyal & Akram, 2015; Ray et al., 2026). Abrus precatorius seeds, despite abrin toxicity, show uterotonic and anti-implantation effects in rodents (Hayoun et al., 2023). Calotropis procera latex suppresses GnRH and blocks sperm egg fusion in animal assays, indicating endocrine disruption (Chen et al., 2026). Hibiscus rosa-sinensis flowers impair blastocyst implantation and reduce endometrial receptivity in rats (Chen et al., 2026; Sharma et al., 2024). Curcuma longa rhizome constituents such as curcumin exhibit spermicidal and implantation repressive activity in murine models (Mili et al., 2025). Moringa oleifera root and bark extracts induce abortion and fertility suppression via oxidative stress in rodents (Kothale et al., 2024). Terminalia chebula fruit tannins reduce testosterone and spermatogenesis in rats, while Plumbago zeylanica root extracts block ovulation and implantation (Daniyal & Akram, 2015). Collectively, these findings highlight reproducible antifertility mechanisms- anti-implantation, spermatogenesis suppression, endocrine modulation but emphasize the absence of clinical translation, underscoring the need for toxicological profiling and controlled human trials (Chen et al., 2026; Ray et al., 2026).

**Safety, Toxicity and Limitations**

The toxicological profile of herbal contraceptives is characterized by complex biochemical interactions that necessitate rigorous safety assessments, specifically regarding hepatotoxicity and teratogenicity. The clinical utility of these agents is frequently compromised by a narrow therapeutic index, as evidenced by the toxin ricin, a Type II Ribosome-Inactivating Protein (RIP) that catalyzes the depurination of 28s ribosomal RNA (Hayoun et al., 2023). This molecular mechanism effectively arrests protein synthesis, precipitating acute cellular necrosis and potential systemic multi-organ failure (Hayoun et al., 2023). Furthermore, chronic administration of certain formulations is linked to hepatotoxicity, indicated by the pathological elevation of hepatic biomarkers such as Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) due to the intrahepatic accumulation of cytotoxic secondary metabolites (Anandi Navnit Kothale et al., 2024). Beyond maternal safety, the risk of teratogenicity and embryofetotoxicity remains a critical limitation; bioactive phytoconstituents that traverse the placental barrier may induce structural dysmorphogenesis or developmental anomalies by disrupting the maternal-fetal endocrine axis (Anandi Navnit Kothale et al., 2024). These adverse effects are often exacerbated by the induction of oxidative stress and the subsequent depletion of endogenous antioxidant systems, underscoring the requirement for standardized isolation of non-toxic active molecules and comprehensive toxicological validation in contraceptive research (Anandi Navnit Kothale et al., 2024; Hayoun et al., 2023).

**Future Directions**

Future research on herbal contraceptives must prioritize clinical translation by moving beyond rodent and in vitro assays into rigorously designed human trials with standardized dosing and phytochemical isolation (Mili et al., 2025). The most promising candidates, such as Juticia gendarussa and Gossypium herbaceum, require controlled multicenter studies to validate efficacy, reversibility and long-term safety, particularly regarding hepatotoxicity and teratogenicity (Ray et al., 2026). Advances in phytochemical fractionation and molecular docking should be leveraged to identify non-toxic active constituents, minimizing risks associated with compounds like pulegone (Mentha pulegium an abrin (Abrus precatorius) (Hayoun et al., 2023). Integration of omics technologies (genomics, proteomics, metabolomics) can elucidate mechanistic pathways such as steroidogenesis modulation, GnRH suppression, and sperm enzyme inhibition, enabling rational drug development (Chen et al., 2026). Furthermore, toxicological profiling with biomarkers (ALT, AST, oxidative stress indices) must be standardized to establish therapeutic indices and safety margins (Kothale et al., 2024). The regulatory framework should encourage clinical ethnopharmacology, bridging traditional knowledge with modern pharmacology, while ensuring ethical oversight in reproductive health trials. Ultimately, the field requires a translational roadmap combining ethnomedicine, mechanistic pharmacology, toxicology, and clinical validation to transform herbal contraceptives from preclinical promise into safe, effective, and globally accessible fertility control options.

## V. CONCLUSION

The corpus of evidence on herbal contraceptives underscores their multifaceted pharmacological potential, with taxa such as Azadirachta indica, Carica papaya, Ruta graeolens, Juglans regia, Ricinus communis, and Daucus carota exhibiting reproducible antifertility effects mediated by structurally diverse phytoconstituents, ricinoleic acid derivatives, and fatty acids that converge on endocrine modulation, gametotoxicity, uterotonicity and anti-implantation pathways. These agents act at multiple biological levels, from hypothalamic pituitary gonadal axis disruption and steroidogenic enzyme inhibition to oxidative stress induction and endometrial receptivity blockade, thereby generating a broad spectrum of contraceptive outcomes. Yet, despite compelling ethnopharmacological validation and mechanistic insights, clinical translation remains constrained by toxicity liabilities (e.g., ricin, abrin, pulegone), narrow therapeutic indices, and the absence of standardized phytochemical profiling or rigorously controlled human trials. Future research must integrate advanced fractionation, omics-based mechanistic elucidation, and GLP-compliant toxicological assessment with randomized clinical studies to establish efficacy, reversibility, and long-term safety, enabling the transformation of these botanicals from traditional antifertility remedies into scientifically validated, globally accessible contraceptive modalities.

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