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Pharmacology, Phytochemistry and Safety of Aphrodisiac Medicinal Plants: A Review.

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Review Article

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ABSTRACT

The history of sexual medicine and management of male sexual dysfunction (MSD) is as old as human civilization. The modern life styles and environmental conditions have increased prevalence of MSD with age. To address this problem a number of therapeutic strategies including the use of medicinal plants have been advocated for management of MSD. Large numbers of research papers regarding aphrodisiac activity of medicinal plants have been published in past few years. This review compiles data on the potential aphrodisiac activity of medicinal plants possessing effective dose of less than equal to 200 mg/kgbw or equivalent. The toxicity studies and phytochemical data available for the active extract or active plant part have also been incorporated in this review. Data regarding plant part, dose, animal model, compounds isolated and mechanism of aphrodiasic activity was tabulated. Medicinal plants possess an untapped source of aphrodisiac molecules. The review identified that *Bryonia laciniosa, Caesalpinia benthamiana*, *Ferula harmonis, Montanoa tementosa, Syzygium aromaticum, Turnera aphrodisiaca, Spilanthes acmella*, *Turnera aphrodisiaca, Turnera diffusa,* and *Tribulus terrestris* plants possess potential aphrodisiac activity. The safety in long term usage and low cost may be added advantage associated with use of herbal aphrodisiacs.

INTRODUCTION

Sexual health is a state of complete physical, mental and social well being in all aspects related to the reproductive system. Compromised sexual abilities may lead to infertility. Male sexual dysfunction (MSD) resulting in unsuccessful intercourse may adversely affect the personal and social life of the suffer couples and also contributes to infertility. MSD may be due to decreased libido, erectile dysfunction and disorders of ejaculation. A number of factors including psychological disturbances (performance anxiety, strained relationship, depression, stress, guilt and fear of sexual failure), deficiencies in sex hormones (testosterone deficiency), chronic diseases (diabetes, hypertension, atherosclerosis, venous leakage), neurological disorders (Parkinson's disease, Alzhemier's disease, spinal cord or nerve injury), side effects associated with chronic use of drugs (anti-hypertensives, central agents, psychiatric medications, antiulcer, antidepressants, anti-androgens), life style related complications (chronic alcohol abuse, cigarette smoking) and aging are known to contribute to MSD [1,2].

A human male may suffer from MSD at any stage of life but its risk increases with age. A population based study in US revealed that prevalence of MSD was 12 percent in those younger than 59 years, 22 percent in those 60 to 69 years of age, and 30 percent in those older than 69 years [3]. As per an

estimate over 320 million people in the Westernized nations will be develop MSD by 2025 [4]. The current epidemiological data suggests that MSD needs immediate medical intervention and newer therapeutic strategies are required for its management. A number of treatment options are available for management of MSD. These options includes psychological and behavioral therapy, non surgical treatments using constructive rings and vacuum pumps, surgical treatment such as penile prosthesis, penile implants and venous ligation, hormone replacement therapy and intervention of chemotherapeutic agents [5]. The chemotherapeutic agents used for treatment of MSD are known as 'aphrodisiac'.

Discovery of oral phosphodiesterase type 5 (PDE5) inhibitors particularly sildenafil (Viagra), tadalafil (Cialis), and vardenafil (Levitra) has revolutionized treatment of MSD [6]. Sidenafil citrate is the most prescribed PDE5, recommend in almost more than 70% of patients suffering from MSD. Mild to moderate headache, facial flushing, nasal congestion and dyspepsia are the most common adverse effects of PDE5 treatment [7]. Severe effects on PDE5 treatment have been reported in patients suffering from hypertension, hence careful clinical examination is a must before prescribing PDE5.

Aphrodisiac medicinal plants

The side effects associated with these synthetic drugs necessitated search for safer and effective aphrodisiac agents especially of herbal origin. Medicinal plants represent an extraordinary reservoir of active ingredients [8,9]. Aphrodisiac activity of medicinal plants from a number of medicinal systems especially Ayurvedic [10] and Traditional Chinese medicinal has been reported [11]. Yohimbine, an indole alkaloid extracted from the bark of West African yohim trees was the first natural aphrodisiac molecules introduced for management of MSD. Several clinical trials reported various efficacy rates of yohimbine ranging from 34% to 73% [12] compared to Viagra. Approval of yohimbine by Food and Drug Administration, USA for clinical use, further propelled use of plant based aphrodisiac agents and intensified research in this area. The plant based aphrodisiac agents are relatively low in cost and safe as compared to synthetic PDE5.

Safety issue associated with aphrodisiac medicinal plants

Plants are extensively used to manage MSD. A number of research papers including some reviews have been published recently on the aphrodisiac activity of medicinal plants [8]. Although a number of plants with potential aphrodisiac activity have been identified through these reviews, the safety issue associated with the active extracts of these plants needs attention. The safety of plant based medicine needs to be evaluated essentially before recommending for human consumption. So, considering the merits of plant based aphrodisiac agents, an attempt has been made to review data on aphrodisiac activity and safety. We also tried to incorporate the data on phytochemicals, purified either from the active extracts or the plant part exhibiting aphrodisiac activity.

S.No	Botanical name	Plant part / Extracts	Dose	Animal models	Mechanism of aphrodisic activity	Phytochemicals	References
1	*Allium sativum*	Alcoholic extract of bulb [13]	0.57, 1.13 and 2.25 ml/kg, p.o. dose [13]	Rat [13]	Increase in sexual behavior [13].	Sulfur compounds, peptides, steroids, terpenoids, flavonoids, and phenols are the main phytochemicals isolated from bulb of this plant [14].	[13,14]
2	*Allium tuberosum*	Butanol extract of seeds [15]	500 mg/kg body weight/day [15]	Rat [15]	Improvement in sexual performance in sexually active and incative rats [15].	Steroidal saponins, alkaloids, amides and sulphur containing compounds have been reported from the seeds of this plant [16].	[15,16]
3	*Alpinia calcarata*	Hot water extract of rhizome	150, 250 and 500 mg/kg, p.o.	Rat	Elevation in serum testosterone level and improvement in sexual potency. No toxicity at 500 mg/kg, p.o.	Phytochemicals reported from rhizome of this plant are polyphenols, tannins, flavonoids, steroid glycosides and alkaloids.	[17]
4	*Anacyclus pyrethrum*	Petroleum ether extract of root [19]	50 and 100 mg/kg [19]	Albino rats [19]	The rats showed more receptive and oriented behavior towards female rats and	Phytoconstituents alkylamide, N-isobutyldienediynamide, N-isobutyldienediynamidery are reported from water extract of	[19,20]

					exhibited increased precopulatory activity like licking and sniffing of female anogenitals. The penile erection index was significantly increased with reduction in ML and IL [19].	roots of this plant [20].	
5	*Anacardium occidentale*	Seed oil [21]	0.10, 0.60 and 1.10 ml [21]	Albino rats [21]	Increase in MF and IF, and decrease in ML. The oil showed no toxicity at given doses [21].	Saponins, alkaloids, flavonoids, steroids, phenols, glycosides, volatile oils and terpenoids have been reported from seed oil [22].	[21,22]
6	*Argeria nervosa*	Alcoholic extract of root, flower and leaf [23]	200 mg/kg; p.o. [23]	Swiss albino mice [23]	Stimulation in mounting behavior in concentration-dependent manner [23].	Alkaloids, glycosides, flavonoid glycosides and steroids are reported from flowers of this plant [24].	[23,24]
7	*Asparagus racemosus*	Aqueous [25,27] and Hydro-alcoholic [26] extract of roots	200 and 400 mg/kgbw [26]. 800, 1600 and 3200 mg/kg [27]	Rat[25,27]	Increase in number of mounts and mating performance [25,26]. Showed increase in weight of reproductive organs, PE and MF indicating improvement in sexual behavior and diuretic activity. No acute toxicity upto 3200 mg/kgbw [27].	Saponins, carbohydrates, glycosides and mucilages have been reported from root [26].	[25,26,27]
8	*Butea frondosa*	Aqueous extract of bark [28]	400 mg/kg body wt./day [28]. Methanol, 50% aqueous methanol, chloroform and non-polar extracts of leaves (500mg/kg rat body weight [29]	Rats [28], Female white albino rats [29]	Improvement in sexual performance in sexually active and inactive male rats [28].	The phytochemical analysis of bark showed presence of hydrocarbons (eicosane), triterpenes (ß-amyrin), sterols (campesterol and ß-sitosterol), flavonoids (vicenin II, vitexin chrysoeriol 7-O-ß-D-glucuronic acid 6, 8-di-c-rhamnosyl apigenin and luteolin,) and lauric, myristic, palmitic. linoleic and linolenic acids [29].	[28,29]
9	*Blepharis edulis*	Hot water [30] and ethanolic extract [31] of root	100, 250, 500 mg/kg [31]	Albino mice [31]	Significant and sustained increase in level of testosterone. No toxicity up 500 mg/kg [31].	Hydroxamate and benoxazolone, 4'-O-diglycoside of decarboxyrosmarinic form root [32].	[30,31,32]
10	*Bryonia laciniosa*	Ethanolic [33] and 70% alcoholic [34] extract of seeds	50, 100, and 150 [33] and 500mg/kgbw [34]	Albino rats [33]	Significant improvement in MF, IF, ML, IL, increase in reproductive organ weight (testis, prostate, seminal vesicle, and epididymis), epididymal sperm density, sperm count, significant increase in serum testosterone and LH levels [33]. LD50 value is 3gm/kgbw.		[33,34]

11	*Caesalpinia benthamiana*	Aqueous [35] and Petroleum ether [36] extracts of root	50, 150 mg/kg [35] Aqueous extract and 3 mg/kg body pure alkaloids [36]	Rat [35]	Showed Enhancement in the sexual activity. Aqueous extract non toxic up to 2g/kg p.o. [35].	Two cassane diterpenoids isolated form Petroleum ether extract [36]. Phenolic compounds (gallic acid, resveratrol, tannins) and cassane diterpenoids, (benthaminin 1 and 2) have been isolated from root of this plant [37].	[35,36,37]
12	*Chenopodium album*	Ethonolic extracts [38] of seeds	100, 250 and 500 mg/kgbw [38]	Albino mice [38]	Showed significant increase in the MF, IF, IL and PE, enhanced aggregate penile reflexes and caused significant reduction in ML and PEI [38].	Phenolic glycoside, chenoalbuside have been reported from the root alcoholic extract of this plant [39,40].	[38,39,40]
13	*Chlorophytum borivilianum*	Aqueous extract of root [41]	200 mg/kgbw [41]	Albino Rats [41]	Significant reduction in MI, EL, IL, hesitation time, body weight, weight of reproductive organs, PE and MF [41].	Fatty acids, sterol stigmasterol and saponin chlorophytoside-I (3β, 5α, 22R, 25R)-26-(β-D-glucopyranosyloxy)-22-hydroxy-furostan-12-one-3 yl O-β-D-galactopyranosyl (1-4) glucopyranoside, furostanol steroid saponin have been reported from hydroalcholic extract[42] and four new furostanol steroid saponins, borivilianosides A–D were isolated from the dried roots of this plant [43].	[41,42,43]
14	*Camellia sinensis*	Black tea brew [44]	84,167 and 501 mg/ml [44]. 0 (as normal group), 625, 1250 and 2500 mg/kg bw/day [45]	Rat [44], ICR mice [45]	Showed prolongation of EL, elevation of serum testosterone levels and shortening of ML and IL [44]. Toxicity at a very high dose of 2.5g/kgbw/day [45].	Polyphenolic phytochemicals flavanols, catechins (epicatechin, epicatechin-3-gallate, epigallocatechin, and epigallocatechin-3-gallate) have been isolated [46].	[44,45,46]
15	*Crocus sativus*	Aqueous extract of stigma [47]	80, 160 and 320 mg/kg, i.p. [47]	Rats [47]	Increase in MF, IF, EF and reduction in MI, IL and EI. No toxicity has been reported from the aqueous extract. Toxicity has been reported from the ethanolic extract with 20g/kgbw as LD50 [52].	Stigma of this plant showed presence of crocin, crocetin, safranal and picrocrocin in aqueous extract [48,49,50]. Crocetin is mainly responsible for pharmacological activities of this plant.	[47,48,49,50,52]
16	*Catha edulis*	Aqueous extract of leaf [54]	100 and 200 mg/kg [53]. 50, 100, and 200 mg/kg. body weight p.o.[54]	Sprague Dawley rats [53], Mice [54]	Increase in plasma testosterone levels by more than 2 folds [53]. No toxicity at a dose of 200 mg/kgbw for 6 weeks [54].		[53,54]

17	*Curculigo orchioids*	Aqueous extract [56, 58], Ethanolic extract [57] and hydroalcoholic extract of rhizome [59]	100 and 200 mg/kg body weight [56]. 100 mg/kg [57]. 100 and 200 mg kg $^{-1}$ doses [58]. 100, 300 and 500 mg/kg [59]	Wistar strain albino rats [56,59], rats [57,58]	Significant effect on the sperm count, seminal fructose content and penile erection index [56]. Significant improvement in sexual behavior evident from mating performance, MF, ML as well as increase in penile erection index and weight of reproductive organs and improvement in sexual [57]. Showed increase in sexual behavior, sperm count, penile erection index and seminal fructose content, decrease in EF, EL, hesitation time and increase in testosterone [58].	The acute toxicity showed that the extract was non toxic up to 2000 mg/kg p.o.[59]. Phytochemical analysis showed presence of triterpenoides (curculigol) [60,64], glycosides (curculignin A, B, C) [61], curculigosaponin (curculigenin A, B, C, corchicoside A, curculigoside B) [62,63] and alkaloids (yuccagenin, lycorin).	[56,57,58,59,60,61, 62,63,64]
18	*Casimiroa edulis*	Aqueous extract.[55] Seeds and leaves extract [65]	250 mg/kg, p.o. [55]	Rat [55]	Significantly increase in MF, IF EL. Whereas decrease in MI, IL and PEI [55]. Antihypertensive popular remedy [65].	Imidazolic derivatives (dimethylhistamine, methylhistamine) and flavonoid glycoside (casimiroedine, rutin) are reported from seeds and leaves [65].	[55,65]
19	*Dactylorhiza hatagirea*	Aqueous extracts of root [56]	100 mg/kg body weight [56]	Wistar strain albino rats [56]	Highly significant increase in seminal fructose levels and sperm count, improvement of PE and in vitro nitric oxide releasing activity [56].	Dactylorhins A, B, C, D, E and dactyloses (A and B) are reported from root of this plant [66].	[56,66]
20	*Durio zibethinus*	Pertroleum ether extract [67]	200 and 400 mg/kg, p.o. [67], 2 g/kg body weight [68]	Swiss Albino mice and Wistar rats [68]	The extract reported to have aphrodisiac activity [67]. No induce toxicity at high oral dose (2g/kg) of the polysaccharide isolated from the root [68].	Isolation of compound 3-hydroxy-21-normethyl-19-vinylidenlursane from root of this plant [67].	[67,68]
21	*Eriosema kraussianum*	Root extract		Rabbit penile smooth muscle	Pyrano-isoflavones Kraussianone 1 has been reported to possess 75% activity in the erectile dysfunction test on rabbit penile smooth muscle as compared to Viagra.	Pyrano-isoflavones have been isolated from the root stock of this plant.	[69]
22	*Eurycoma longifolia*	Aqueous, butanol, methanol and chloroform extracts of roots [70] and jack [72]	200, 400 and 800 mg/kg of one of the following fractions: chloroform, methanol, water and n-butanol	Both uncastrated and cas-trated rats [70], adult Sprague Dawley rats [71], rats	Showed recurrent and significant increase in quick flips, long flips and erection of the treated mice [70]. Effect on sexual behavior of sexually sluggish and impotent male rats at different dose level showed significant reduction in EL,	Canthin-6-one alkaloids,b-carboline alkaloids, quassinoids, quassinoid diterpenoids, eurycomaoside, tirucallane-type triterpenes, squalene derivatives, biphenylneolignans [75], eurycolactone, laurycolactone, eurycomalactone, quassinoids diterpenoid [76],	[70,71,72,73,74, 75,76,77,78,79,8 0]

			[70]. Acute (250, 500 and 1000 mg/ kg); (2) subacute (500 mg/k g) and (3) subchronic (500 mg/k g) [71]. 0.5 g/kg of various fractions [72] 200, 400 and 800 mg/kg body weight [73]. 500 mg/kg bw [74].	[72,73], mice [74]	increased percentage of MF, EF and testosterone serum levels [71]. Enhancement in the sexual qualities by decreasing their hesitation time [72], Showed more frequent and vigorous mounting, licking and anogental sniffing towards the receptive females and increased grooming of the genitals compared with control [73] and enhancement of the sexual motivations in sexually naive male mice [72].	eurycomalide A, eurycomalide B [77], 13b, 21-dihydroxyeurycomanol [78], and 5a, 14b, 15btrihydroxyklaineanone [79,80] are reported from root of this plant.	
23	*Ferula harmonis*	Oil extracted from seeds [81]	50 mg/kgbw. The ED_{50} (12.03mg/ kg) value is 880 times less than the LD50 (10.6 g/kg) [81]	Rat [81]	Reported to have aphrodisiac activity and enhanced sexual behavior [81].	Sesquiterpene coumarins and sesquiterpene (ferutinine, feroline and tenuferidine) are reported from seed oil of this plant [82].	[81,82]
24	*Kaempferi a parviflora*	Alcoholic [83] and Ethanolic extracts [84]	70 mg/kg bw/day [83]. 60, 120, and 240 mg/kg [84]	Rats [83,84,85]	Significant decrease in ML, EL and increase in blood flow to the testes [83]. Ethanolic extracts of rhizome reported to be toxic at 240 mg/kgbw [84]. 7-methoxyflavone and 5,7-dimethoxyflavone from *Kaempferia parviflora* showed PDE5 inhibitory activity [85].	7-methoxyflavone and 5,7-dimethoxyflavones reported from rhizome of this plant [85].	[83,84,85]
25	*Lyceum barbarum*	Fruit extract [86]	10, 50, 100 and 200 mg/kg, p.o. per day [86]	Rats [86]	Significantly increased testes and epididymis weight, superoxide dismutase activity and sexual hormone levels in the damaged rat testes [86].	A polysaccharides isolated from this plant fruits showed protective effect against the testicular tissue damage induced by heat exposure. Phytochemical isolated from fruits of this plant are scopoletin, beta-sitosterol, p-coumaric acid, glucose, daucosterol and betaine [87].	[86,87]
26	*Montanoa tementosa*	Aqueous extract of whole plant [88]	38, 75 and 150 mg/kg [88]	Rats [88]	Significant improvement in sexual behavior, increase in mounting behavior of genitally anesthetized and induced the expression of sexual behavior in noncopulating male rats and also exerted a pro ejaculatory effect and produced an increase in the number	Sesquiterpene lactones [89], tomexanthin and oxepane diterpene [90] have been reported from aqueous extract of this plant.	[88,89,90]

					of discharges in the ejaculatory patterns [88].		
27	*Mucuna puriens*	Ethanolic extract of seeds [91]	150, 200, 250 mg/kg [91]	Both male and female [91]	Showed significant increased in MF, IF and EL and decreased the ML, IL, PEI and inter intromission interval [91].	Phytochemical reported from ethanolic and methanolic extracts of this plant are alkaloids, glycosides, terpenoids, saponins, tannins and reducing sugars. Antimicrobial activity against four pathogenic microorganisms: *Salmonella typhi*, *Escherichia coli*, *Shigella dysenteriae* and *Bacillus subtilis* [92].	[91,92]
28	*Massularia acuminate*	Aqueous extract of roots [93] and stem [94]	50, 100 and 200 mg kg $^{-1}$ body weight [93]. 250, 500, and 1000 mg/kg body weight [94]	Male Wistar rats [93]. Both male and female wistar rats [94].	Significant increase in testes body weight ratio, testicular protein, glycogen, salic acid, cholesterol, testosterone, LH and FSH level [93,94].	Phytochemical alkaloids, anthraquinones, saponins, phenolics, flavonoids and tannins have been reported from aqueous extract of this plant [93,94].	[93,94]
29	*Myristica fragrans*	Hydroalcoholic extract of seeds [95]	100, 250, 500 mg/kg, p.o.[95]	Male and female albino rats of Wistar Strain [95].	Significant reduction in the ML and PEI. Reported to stimulate mounting behavior, and significantly increased mating performance [95].	Toxicity of essential oils isolated from dried fruits of this plant showed LC_{50} value 12.67 µl and 18.43 µl in adult rats [95,96]. Alkylbenzes and arylproanoids have been reported from seeds of this plant [97].	[95,96,97]
30	*Microdesmis keayana*	Aqueous extract of roots [99]	50 mg/kg body weight, 2 g/kg body weight [99]	Rats [99]	Showed effect on vascular parameters of erectile dysfunction and stimulated all sexual parameters [99].	N1, N5, N10-tris (4-hydroxycinnamoyl) spermidines [99], quinoline and tris (4-hydroxycinnamoyl) spermine were reported from methanolic and hydromethanolic root extract of this plant [100]. Alkaloids keayanidine B and keayanine isolated from aqueous extract of this plant roots [98].	[98,99,100]
31	*Mucuna pruriens*	Ethanolic extract [101,102]	150, 200, 250 mg/kg body weight [101]. 200 mg/kg b.w. [102]	Male albino rats [101,102]	Significantly increased the MF, IF and EL, and decreased the ML, IL, PEI and inter-intromission interval. The potency test significantly increased erections, quick flips, long flips and total reflex. Therefore, the results indicated that the ethanolic extracts of this plant produced a significant and sustained increase in the sexual activity of normal male rats at a particular dose (200 mg/kg) [101].	The seeds of this plant resulted in the isolation of a new steroid, Estra–2^{II}–en –17–ol, 3yl benzoate [103].	[101,102,103]
32	*Ocimum gratissimum*	oral and intra-peritoneal	4% v/v emulsion [104]	Mice, Sprague-Dawley	Blood biochemical, haematological and histopathological	Essential oil from leaves of this plant reported to contain eugenol, methyl eugenol, cis-	[104,105,106,107,108,109]

		administration of graded doses of Ocimum oil [104]		rats [104]	findings showed significant differences between control and treated groups and capable of invoking an inflammatory response that transits from acute to chronic on persistent administration. A dose-dependent sedative effect of oil extract was observed during the acute toxicity study [104].	ocimene, trans-ocimene, pinene [105], camphor, germacrene- D, trans-carypohyllene, farnesene and l-bisabolene, bisaboline [106], citral, ethyl cinnamate [107], linalool and thymo, terpinene, p-cymene, limonene, terpinolene and 1,8-cineole oleanolic acid [108,109].	
33	*Panax ginseng*	Root extract [112]	25-100 mg/kg, i.p. [112]	Rabbit [110], Mice [112]	Reports showed that it enhanced nitric oxide synthesis [110] resulting in relaxation of corpus carenosum in penis and increase in penile rigidity and grith [111].	Ginsenosides, saponins have been isolated from root of this plant [110].	[110,111,112]
34	*Pedalium murex*	Petroleum ether extract of whole plant [113]	200 and 400 mg/kg [113]	Albino rats [113]	Showed increase in mating and mounting behavior, body weight, percentage of pregnancy, litter size, sperm motility, testosterone, germinal cells and the luminal spermatozoa in rats as compared to ethanol induced germ cell damage and infertility. Petroleum ether extract produced no toxic symptoms or mortality up to a dose of 2000 mg/kgbw in rats [113].	Flavonoids pedalitin, diosmetin, dinatin [114] from leaves and flowers and heptatriacontan-4-one, tetratriacontanyl octacosanoa [115] have been isolated from fruits of this plant.	[113,114,115]
35	*Peganum harmala*	Methanol extract of seeds [116]	100 mg/kg, p.o. [116]	Rats of the Sprague Dawely strain [116]	Significant improvement in weight of gonads, accessory sex organs and semen quality without affecting the metabolic functions [116].	Flavonoids, acacetin 7-*O*-rhamnoside, 7-*O*-[6-*O*-glucosyl-2-*O*-(3-acetylrhamnosyl)glucoside, 7-*O*-(2-*O*-rhamnosyl-2-*O*-glucosylglucoside), glycoflavone 2-*O*-rhamnosyl-2″-*O*-glucosylcytisoside[117] and carboline alkaloid, l-thioformyl-8-β-D-glucopyranoside-bis-2, 3-dihydro-isopyridinopyrrol have been reported from seeds of this plant [118].	[116,117,118]
36	*Passiflora incarnate*	Methanolic extract of leaves [119]	75, 100 and 150 mg/kg [119]	Mice [119]	Exhibit significant aphrodisiac activity [119].	Passicol from ethyl acetate extract and flavonoid from methanol extract have been isolated.[120] Other compounds C-glycosidic flavonoids (schaftoside, isoschaftoside, isovetexin-2''-O-glucopyranoside and isoorientin-2''-O-glucopyranoside) have been reported from methanolic extract [120].	[119,120,121]

37	*Ruta chalepensis*	Aqueous extract of the leaves [119] and ethanolic extract of the aerial parts [123]	0.5 g, 1.0 g and 2.0 g per animal [122]	Sprague Dawley rats [122], mice [123]	Showed spermotrophic activity and an increase in sperm count, motility, living percent, decrease in sperm abnormalities and a significant increase in testosterone and FSH with no change in the LH and prolactin levels [122]. Gonzalez-Trujano et al.[123] showed that ethanol extract from 200 to 5000 mg/kg, p.o. dose did not produce mortality or weight loss during the observation period of 14 days.	Alkaloids, flavonoids, coumarins, tannins, volatile oil, sterols and triterpenes are reported from ethanolic extract of aerial parts [124]. 3-phenylcoumarin from this plant has been reported to have potent estrogenic activity [124].	[122,123,124]
38	*Securidaca longepedunculata*	Aqueous extract of root [126]	2,700 mg/ kgbw [126]	Mice [126]	Aqueous extract of root of this plant has been reported to be safe when administered orally in mice [126].	Xanthones (1,3,6,8-tetrahydroxy-2,5-dimethoxyxanthone and 1,6,8-trihydroxy-2,3,4,7-tetramethoxyxanthone) isolated from the root bark of this plant relaxed the corpus cavernosal smooth muscle by 97 % in comparison to sildenafil (Viagra) at 1.8 × 10−5 mg/ml [125].	[125,126]
39	*Spilanthes acmella*	Ethanolic extracts of flower	50, 100 and 150 mg/kgbw for 28 days	Wistar albino rats	Reported to have positive effect on general mating pattern, penile erection and serum sex hormone levels.	N-alkylamides, N-isobutylamides 1, 2-methylbutylamide and 1, 2-phenylethylamide isolated from flowers of this plant showed improvement in sexual potential at a dose of 150 mg/kgbw.	[127]
40	*Syzygium aromaticum*	Hexane extract of flower buds [128]	15, 30 and 60 mg.kg, p.o. for 35 days [128]	Parkes strain of mice [128]	Reported for a single spermatogenic cycle in parkes strain of mice. Lowest dose (15mg/kg, p.o.) of the extract increased the activities of delta 53 beta-HSD and 17 beta-HSD enzymes and enhanced serum testosterone level [128].	*p*-cymene, 5-hexene-2-one , thymol , eugenol, eugenyl acetate, caryophyllene oxide , guaiol 8, benzene-1-butylheptyl, nootkatin, isolongifolanone (trans, hexadecanoic acid 9,17-octadeca-dienal , octadecanoic acid butyl ester, phenol-4-(2,3-dihydro-7-methoxy-3-methyl-5-(1-propenyl)-2 –benzofurane 15 dodecatrienoic acid-3,7, 11-trimethylethyl ester, vitamin E acetate have been reported from of hexane extract of this plant flower buds [129].	[128,129]
41	*Turnera aphrodisiaca*	Petroleum ether, chloroform, methanol and water extracts of seeds. Methanol extract [130]	25, 50, 75, and 100 mg/kg, p.o.[129] 50 mg/kg [131]	Mice [130,131]	Reported to have aphrodisiac activity by increasing mounting behavior [130].	Cyanoglycoside [132], flavonoid [133] and phenolic glycosides [134] are isolated from methanol extract of this plant seeds.	[130,131,132,133,134]

42	*Tinospora cordifolia*	Hydroalcoholic and aqueous extract of stem [26]	200 and 400 mg/kgbw [26]	Wistar albino rats [26]	Hydroalcoholic extract showed significant increase in number of mounts and mating performance [26].	Hydroalcoholic and aqueous extracts showed presence of alkaloids, carbohydrates, glycosides, steroids, proteins, saponins, gums and mucilages, diterpenoid lactones, glycosides, steroids, sesquiterpenoid, phenolics, aliphatic compounds and polysaccharides [135]. A clerodane furano-diterpene [136] and Tinocordifolin, a daucane-type sesquiterpene, tinocordifolioside and N-trans-feruloyl tyramine has been isolated from this plant stem [137].	[26,135,136,137]
43	*Turnera diffusa*	Oil of leaves.[138]	20, 40, 80 mg/kg, p.o.[138]	Mice.[138] Both male and female Swiss albino mice and male Wistar rats [139]	Significant increase in percentage of male achieving one ejaculatory series and resuming a second one, in sexually exhausted male rats. In addition significantly reduced the PEI [138]. At a dose of leaves extract at 2 g/kg, i.p. and 5 g/kg, p.o., neither led to death nor visible signs of toxicity for 14 days [139].	Flavonoids, terpenoids, saccharides, phenolics, and cyanogenic derivatives, luteolin 8-C-E-propenoic acid, luteolin 8-C-b-[6-deoxy-2-O-(a-l-rhamnopyranosyl)-xylo-hexopyranos-3-uloside], apigenin 7-O-(6-O-p-Z-coumaroyl-b-d-glucopyranoside), apigenin 7-O-(4-O-p-Z-coumaroylglucoside), syringetin 3-O-[b-d-glucopyranosyl-(1-->6)-b-d-glucopyranoside], and laricitin 3-O-[b-d-glucopyranosyl-(1-->6)-b-d-glucopyranoside] have been reported from leaves of this plant [140].	[138,139,140]
44	*Tricholepis glaberrima*	Methanol extract of aerial parts.	200 mg/kg body	Rat	Showed increase in ML, IL and significant decrease in PEI. The extract enhanced spermatogenesis.		[141]
45	*Tribulus terrestris*	Aqueous extract [143]. Furostanol glycoside fraction [145].	5 mg/kg body [142]. 20 and 10 mg/kg body weight per day [143]. 5, 10, and 25 mg/kg, p.o.[145]. 2.5, 5 and 10 mg/kg body weight [144].	Sprague Dawley rats [142], twenty-one healthy young 20–36 years old men [143], Wistar rats [144], Sprague Dawley rats [145]	Showed increase in MF and IF, decrease in EL and PEI revealing the improvement of the sexual behavioral parameters [142] Significant increase in serum testosterone, androstenedione or LH. [143] In male castrated rats was reported to increase orientational activity parameters such as licking, anogenital and genital grooming, indicating increased sexual stimulation and [141] increase in body weight, ICP, MF, IF and decreased in ML compared to control group [145].	Terrestribisamide, 25*R*-spirost-4-en-3,12-dione, tribulusterine, *N-p*-coumaroyltyramine, terrestriamide, hecogenin, aurantiamide acetate, xanthosine, fatty acid ester, ferulic acid, vanillin, *p*-hydroxybenzoic acid and *β*-sitosterol, methylprotodioscin, protodioscin and sulfated saponins, sodium salt of 26-O-glucopyranosyl-22α-methoxy- (25R)- furost- 5-ene-3,26-diol- 3 -O -α-rhamnopyranosyl-(152)--4-O-sulfo glucopyranoside (methylprototribestin) and sodium salt of 26-O-_-glucopyranosyl-22α-hydroxy-(25R)-furost-5-ene-3,26-diol-3-O-α-rhamnopyranosyl-(152)-4-O-sulfo-glucopyranoside (prototribestin) have been reported from the seeds of this plant [146,147].	[142,143,144,145,146,147]

46	*Trichopus zeylanicus*	Ethanol extract of leaves [148]	200 mg/kg [148]	Mice [148]	Showed increase in number of mounts and mating performance [148].	Flavonoid glycosides, glycolipids, non-steroidal compounds, polyphenols and sulfhydryl compounds have been reported from leaf of the plant [149].	[148,149]
47	*Vanda tessellate*	Alcoholic extract of flowers	50 and 200 mg/kg	Mice	Reported to increase mating performance, and showed increase in male-female ratio of resulting offspring. No toxicity at doses of 50 and 200 mg.kg, p.o.	Terpenoid (ocimene, linalool oxide, linalool, and nerolidol), benzenoid, phenylpropanoid, methylbenzoate, benzyl acetate, phenylethanol, and phenylethyl acetate have been reported from alcoholic extract of this plant.	[131]
48	*Withania somnifera*	Root powder [150]	5mg/day for 3 months [150]	Men[e]	Resulted in a decrease in stress, improved the level of anti-oxidants and improved overall semen quality [150].	Seven new withanolide glycosides called withanosides I, II, III, IV, V, VI, and VII were isolated from an Indian natural medicine, Ashwagandha, the roots of Indian *Withania somnifera,* together with four known compounds, withaferin A, 5α,20α$_F$(*R*)-dihydroxy-6α,7α-epoxy-1-oxowitha-2,24-dienolide, physagulin D, and coagulin Q [151].	[150,151]

CONCLUSION

The demand for herbal drugs has increased in developed as well as developing countries because of their good aphrodisiac activity and safety. The review identified that *Bryonia laciniosa, Caesalpinia benthamiana*, *Chlorophytum borivilianum, Ferula harmonis, Montanoa tementosa, Mucuna pruriens,Syzygium aromaticum, Turnera aphrodisiaca, Spilanthes acmella*, *Turnera aphrodisiaca, Turnera diffusa, ,Tribulus terrestris, Turnera aphrodisiaca and Withania somnifera* plants possess potential aphrodisiac activity. The ED50 of active extracts of these plants have been reported to be less than equal to 50mg/kgbw. Two potential aphrodisiac compounds namely 1,3,6,8-tetrahydroxy-2,5-dimethoxyxanthone and 1,6,8-trihydroxy-2,3,4,7-tetramethoxyxanthone from *Securidaca longepedunculata* relaxed the corpus cavernosal smooth muscle by 97 % as comparison to sildenafil where as kraussianone 1 from *Eriosema kraussianum* relaxed rabbit penile smooth muscles by 75% as compared sildenafil. These purified phytochemicals may be picked up for large scale clinical trials in drug discovery programme. No toxicity has been reported at effective dose of the extract possessing aphorodisc activity in the above mentioned plants. In safety studies, the LD50 of some of the plants was much higher as compared to ED50. The reported LD50 is 20g/kgbw for *Crocus sativus*[52], 2g/kgbw for *Pedalium murex*[109] and 2.5g/kgbw for *Camellia sinensis*[45].

Mechanism of aphrodisiac activity of medicinal plants

Increase in serum testosterone level is the chief mechanism of aphrodisiac action shown by a number of medicinal plants. Ethanolic extract of *Blepharis edulis roots* [31], *Camellia sinensis* [44], Aqueous extracts of *Massularia acuminate* roots [93], *Ruta chalepensis* leaves[119], *Tribulus terrestris* fruits[143] exhibited aphrodicisc activity by enhancing testosterone level. Aqueous extract of *Massularia acuminate* roots [93] and *Ruta chalepensis* leaves [119] also enhanced FSH and LH along with testosterone. 7-methoxyflavone and 5,7-dimethoxyflavone from *Kaempferia parviflora* showed PDE5 inhibitory activity [85].

Panax ginseng showed aphrodiasic activity by nitric oxide linked mechanisms. Reports showed that it enhanced nitric oxide synthesis [107,108] resulting in relaxation of corpus carenosum in penis and increase in penile rigidity and grith.

It is concluded that medicinal plants possess an untapped source of aphrodisiac molecules. The safety and low cost may be added advantage associated with use of herbal aphrodisiacs.

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ABBREVIATIONS

Mount frequency (MF), Intromission frequency (IF), Mount latency (ML),Intromission latency (IL), Ejaculation latency (EL), Ejaculation frequency (EF), intracavermous pressure (ICP), Post ejaculatory interval (PEI), Mount latencies (ML), Intromission latencies (IL), Ejaculation latencies (EL), The introduction of one organ or part into another (IF), The time interval between the introduction of the female and the first mount by the male (ML), The time interval from the time of introduction of the female to the first intromission by the male (IL), The time interval between the first intromission and ejaculation and ejaculation frequency (EL), Penile erection (PE), Luteinizing hormone (LH) and Follicle stimulating hormone (FSH).

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