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RESEARCH ARTICLE

Effect of *Asparagus racemosus* on sexual dysfunction in hyperglycemic male rats

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Abstract

Vajikaran rasayana (aphrodisiac) herbs of the Ayurvedic system of medicine have been advocated for improving failing sexual function in males (Thakur and Dixit, 2008). Diabetes mellitus is a major cause of male reproductive function, possibly due to an increased oxidative stress. Fructans and fructoligosaccharides (FOS), which are also considered as functional food components, have been reported to produce a beneficial effect against oxidative stress. The aqueous extract of the roots of *Asparagus racemosus* Willd. (Liliaceae) rich in 2→1 type FOS were evaluated for their efficacy against streptozotocin and alloxan induced diabetes leading to sexual dysfunction in rats. The behavioral analysis of rats was undertaken to observe the effect on mount, ejaculation and intromission latencies as well as frequencies, hesitation time and copulatory rate. It was observed that streptozotocin as well as alloxan induced hyperglycemic rats showed an overall reduced sexual performance. The deleterious effect was significantly ameliorated in animals treated with polysaccharide-rich fraction of *A. racemosus*. The study validates the traditional claim of using *A. racemosus* as an aphrodisiac herb for treating sexual dysfunction in males.

Keywords: *Asparagus racemosus*; hyperglycemia; sexual dysfunction; vajikaran rasayana; aphrodisiac

Introduction

Diabetes mellitus (DM) is a heterogeneous metabolic disorder characterized by hyperglycemia resulting from defective insulin secretion, resistance to insulin action or both. Diabetes and associated physiological changes are considered to be one of the major contributors to sexual dysfunction and impotence in the modern world. Sustained hyperglycemia leads to generation of excessive oxidative load, which is one of the major causes of deleterious effect on testicular functions. Reduced testicular function, in turn, affects various facets of sexual behavior and leads to sexual dysfunction in general. Nearly 90% of the population suffering from diabetic conditions report disturbances in sexual function, encompassing a decrease in libido, impotence and infertility (Scarano et al., 2006).

Sexual dysfunction which includes erectile dysfunction in males, is associated with diabetic conditions. Recent reports strengthen the perspective that oxidative

stress is increased in diabetes resulting in production of free radicals and reactive oxygen species (ROS) causing impaired sexual function (Shah, 2002; Thakur & Dixit, 2007). Sexual dysfunction is experienced by males suffering from diabetes mellitus at a greater frequency than by the general population across all ages. The major reasons for increased oxidative stress during diabetes include autooxidation of glucose in bulk and oxidation of low density lipoproteins resulting in overproduction of free radicals, leading to smooth muscle dysfunction as well (Aybek et al., 2007).

Asparagus racemosus Willd. (Liliaceae) is a root commonly known as 'Shatavari'. It is being extensively cultivated and exported from India. The plant holds the reputation of being a 'vajikaran rasayana' (aphrodisiac) which falls into the Ayurvedic category of drugs that ameliorate and potentiate sexual performance (Puri, 2002; Thakur et al., 2007). In our previous publication, we reported the effectiveness of the herb in stimulating sexual performance as well as anabolism (Thakur & Dixit, 2007).

In another study conducted by us, fructooligosaccharide (FOS) rich aqueous fraction of *Chlorophytum borivilianum* and *Orchis latifolia* were found to be effective in preventing streptozotocin induced oxidative stress (Sreevidya et al., 2006; Thakur & Dixit, 2008).

A. racemosus roots were found to be rich in beneficial polysaccharides, i.e., FOS with an average degree of polymerization (DP) around 10. The herb is also rich in sterols and steroidal saponins. Hence, the present investigations were undertaken to determine the effect of aqueous extract of *A. racemosus* on sexual dysfunction in alloxan- or streptozotocin-induced hyperglycemic rats.

Materials and methods

Animal stock

Male albino rats (Wistar strain) weighing 220–250 g were fed standard diet and water ad libitum. The animals were housed at room temperature ($24 \pm 2^\circ\text{C}$) on a reversed day-night cycle (06:00 h to 18:00 h). All the animal experimentations were carried out after prior permission from the institutional ethical committee of Dr. H.S. Gour University, Sagar, Madhya Pradesh, India. The guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), India, were adhered to during the whole experimentation.

Preparation of extracts

Dried roots of *A. racemosus* were procured from Arvind Agro Farms (Bhopal, Madhya Pradesh), identified by the authors and voucher specimen (no. MT-1012-2007) submitted at the Department of Pharmaceutical Sciences Dr. H.S. Gour University, Sagar, Madhya Pradesh. Dried roots were crushed to moderately coarse powder (all the particles passed through a sieve of 710 μm and not more than 40% through a sieve of 250 μm) and stored in an airtight container. The dried powder was then subjected to aqueous extraction for 4 h by placing 50 g powder in 500 mL water on a magnetic stirrer with a thermostat set at 80°C . The extract thus obtained was subjected to filtration and centrifugation at 1700 g for 30 min. The supernatant was collected and subjected to lyophilization. Lyophilized extract thus obtained (53% w/w) was dissolved in deionized distilled water and administered orally using a metal canula. The drugs streptozotocin and alloxan were administered as aqueous solutions intraperitoneally (i.p.). The dosage of the herb was determined based on our previous studies (Srividya et al., 2006; Thakur & Dixit, 2007). Hyperglycemia was induced in experimental animals by intraperitoneal

administration of either streptozotocin or alloxan in respective groups of animals.

Male animals in groups of 6 each were taken for the studies and dosing protocol for different groups were as follows. Group I served as control and was administered vehicle only. Group II: 50 mg/kg body weight (BW) streptozotocin i.p. once. Group III: 50 mg/kg BW streptozotocin i.p. once and 200 mg/kg body weight of *A. racemosus* extract orally. Group IV: a single dose of 100 mg/kg BW of alloxan i.p. Group V: a single dose of 100 mg/kg BW of alloxan i.p. and 200 mg/kg BW of aqueous extract of *A. racemosus*.

Blood glucose levels of animals belonging to different groups were monitored 96 h after administration of streptozotocin or alloxan and the experiment started only after confirmation of diabetic condition. Animals of group III and group V were given a daily oral dose of 200 mg/kg BW of *A. racemosus* extract for 28 days.

The sexual behavior of the animals was assessed on day 14 and day 28 of experimentation. The experiment was carried under dim red light and the behavioral aspects were video recorded using a digital camera (Olympus, EX120). Observational and behavioral analyses were performed in a wooden chamber with a glass wall (70x40x60 cm) under diffused red light in the dark phase of the light/dark cycle. The chamber had a specially designed small opening at the side for introducing the female as stimulus. The video recorded data was analyzed using freeware version of Etholog v 2.2.5[®] E.B. Ottoni, (Sao Paulo) (Ottoni, 2000) run on Windows XP.

Chemical characterization of aqueous extract

The aqueous extract of *A. racemosus* was characterized by high performance thin-layer chromatography (HPTLC), gas chromatography (GC), high pressure anion exchange chromatography (HPAEC), size exclusion chromatography (SEC) and enzymatic analysis. The extract was found to be rich in fructooligosaccharides and steroidal saponins. The average degree of polymerization for fructans was 8–10, i.e., the extract was mainly rich in fructooligosaccharides (FOS). Standardization of extract was done using previously reported methods (Gupta, 2003).

Studies performed

Effect on body weights

The body and organ weights of all the groups were determined 28 days after administration of extracts and recordings were taken as described by Thakur and Dixit (2005) (Table 1).

Orientation behavior analysis

Effects of extracts on behavioral aspects were gauged by evaluation of three different parameters, i.e., self-exploratory behavior which involved rearing, self-licking, anogenital sniffing, environmental exploration comprising exploration, roaming, climbing and non-self exploratory behavior which included mounting over female, licking, anogenital sniffing (Islam et al., 1991).

Recordings were done on day 14 and day 28 after treatment (Table 2).

Attraction towards female or heterosexual attraction

Determination of attraction towards sexually receptive females was done by following the methods reported by Ang and Ngai (2001) modified by Thakur and Dixit (2006). In brief, the following protocol was followed. On days 7, 14, 21 and 28 of treatment, a female rat was placed in a cage which had a translucent barrier of 15 cm separating male and female compartments which could only be passed by a motivated male rat.

The hesitation time was recorded as the time (in seconds) required by the male rat before making an attempt to cross the barrier. In the same way, a scoring for attraction towards the female was recorded by assigning a score between 0–5 during an observation period of 15 min. A complete cross of the partition by the male rat was given a score of 5, while an attempt to climb was given a score of 2 and disinterest to climb was rated as 0. The readings were recorded on days 14 and 28 of treatment. This test is useful in determining the willingness of a male rat to cross an aversive position, thus indicating the intent of sexual attraction (Ang & Ngai, 2001). Cumulative observations of the group are presented in Table 2.

The sexual behavior in male rats was observed in the presence of sexually receptive female rats, which were introduced silently from one side of the chamber as stimulus. The whole pattern was digitally recorded and observations for various parameters were made as follows; mounting behavior was determined by evaluating the number of mounts (NM) in a given period of

Table 1. Effect of various treatments on body and organ weight.

Group	Weight of animal (g)		Weight of testes (g)		Weight of prostate (mg)		Blood glucose level in mg/dL	
	0 days	28 days	0 days	28 days	0 days	28 days	0 days	28 days
Group I	221.5 ± 0.84	224.1 ± 0.84	0.86 ± 0.01	0.88 ± 0.01	95.1 ± 1.5	96.6 ± 1.4	105 ± 2.1	106.2 ± 1.3
Group II	220.1 ± 0.61	192.6 ± 0.82	0.84 ± 0.1	0.62 ± 0.08	96.5 ± 1.2	78.1 ± 2.1	229.1 ± 1.2	233.15 ± 2.01
Group III	220.3 ± 0.5	216.4 ± 1.1**	0.87 ± 0.01	0.83 ± 0.01**	92.1 ± 1.2	97.2 ± 1.8*	229.4 ± 1.12	112.4 ± 2.01**
Group IV	221.3 ± 0.8	198.4 ± 0.1**	0.86 ± 0.01	0.60 ± 0.02*	94.2 ± 1.6	75.2 ± 2.18*	234 ± 0.98	265 ± 3.11
Group V	220.6 ± 0.81	218.7 ± 0.94**	0.84 ± 0.01	0.95 ± 0.02**	97.1 ± 1.1	88.1 ± 1.1**	246 ± 1.2	116.63 ± 2.06**

Group I: (no treatment) served as control and was administered vehicle only.

Group II: 50 mg/kg b.w. streptozotocin i.p. once.

Group III: 50 mg/kg b.w. streptozotocin i.p. once and 200 mg/kg BW *A. racemosus* extract orally.

Group IV: a single dose of 100 mg/kg BW alloxan i.p.

Group V: a single dose of 100 mg/kg BW alloxan i.p. and 200 mg/kg BW aqueous extract of *A. racemosus*.

*P < 0.05 considered significant, **P < 0.01 considered extremely significant.

Table 2. Effect of various treatments on sexual behavior in male rats after 28 days of treatment.

Parameters	Treated groups				
	Group I	Group II	Group III	Group IV	Group V
Mount latency ML (mean time ± SE in sec)	169.9 ± 12.6	271.2 ± 11.2**	163.2 ± 8.2**	293.2 ± 8.2**	138.2 ± 2.1
Intromission latency IL (mean time ± SE in sec)	313.2 ± 10.8	412.6 ± 7.4**	276.2 ± 7.1**	416.2 ± 7.1**	266.8 ± 4.4*
Post ejaculatory latency PEL (mean time ± SE in sec)	496.7 ± 5.8	761 ± 2.3**	469.4 ± 2.1**	772 ± 2.1**	416.6 ± 9.2
Hesitation time (mean time ± SE in sec)	330 ± 8	520 ± 2**	231 ± 2**	531 ± 2**	129 ± 9*
Intromission frequency IF	6.2 ± 0.1	2.1 ± 0.4**	5.7 ± 0.3**	1.7 ± 0.3**	6.9 ± 1.0
Ejaculation frequency EF	3.1 ± 0.9	0.2 ± 0.01**	3.1 ± 0.02**	0.1 ± 0.02**	3.6 ± 0.9*
Mount frequency MF	15.6 ± 3.9	4.8 ± 2.9**	12.3 ± 1.4**	5.3 ± 1.4**	11.8 ± 3.4*
Number of bouts	0.6 ± 0.3	0.1 ± 0.02**	1.1 ± 0.07**	0.1 ± 0.07**	1.2 ± 0.08*
Percent ejaculating animals	68.6 ± 0.3	21.2 ± 0.5**	78.2 ± 0.5**	28.2 ± 0.5**	74 ± 1.05*
Cumulative score for attraction towards female	22 ± 2	6 ± 1.2**	49 ± 1.1**	8 ± 1.1**	79 ± 1**
Penile erection index (PEI)	21.2 ± 1.1	6.2 ± 0.6**	27.1 ± 0.4**	7.1 ± 0.4**	36.2 ± 1.1**

Group I: (no treatment) served as control and was administered vehicle only.

Group II: 50 mg/kg BW streptozotocin i.p. once.

Group III: 50 mg/kg BW streptozotocin i.p. once and 200 mg/kg BW *A. racemosus* extract orally.

Group IV: a single dose of 100 mg/kg BW alloxan i.p.

Group V: a single dose of 100 mg/kg BW alloxan i.p. and 200 mg/kg BW aqueous extract of *A. racemosus*.

*P < 0.05 considered significant, **P < 0.01 considered extremely significant.

One way anova followed by Dunnet's test comparing all versus control.

observation. Mount latency (ML) was calculated as the time from the introduction of a female to the occurrence of first mount. Intromission latency (IL) was considered as the time for first intromission (act of insertion of penis into female rat's vagina) after introduction of a female into the cage. Intromission started with a mount and resulted in vaginal penetration, usually the male started licking the erect genital past intromission. Intromission ratio was determined by dividing the number of intromissions by the sum of number of mounts and number of intromissions (Agmo, 2001). Post ejaculatory interval (PEI) was calculated as the time from ejaculation until next intromission. Mount frequency (MF) was considered as the total number of mounts within 30 min.

Penile erection (PE) was determined using the method reported by Benassi-Benelli et al. (1979). In brief, the rats of all the groups were given the treatment 30 min prior to experimentation. The rats of each group were placed in observation cages (6 at a time) and continuously observed for a period of 30 min. Penile erection was recorded when the rats bent down to lick their erect penis. Penile erection index (PEI) was determined by multiplying the percentage of rats exhibiting at least one episode of penile erection during 30 min observation period with the mean number of penile erections (Benelli et al., 1997).

$$\text{Penile erection index} = \% \text{ rats exhibiting erection} \\ \times \text{Mean number of erections}$$

Copulatory rate was calculated by determining the number of mounts plus number of intromissions divided by the time from the first mount until ejaculation.

$$\text{Copulatory rate} = \frac{\text{Number of mounts} + \text{Number of intromissions}}{\text{Time from first mount until ejaculation}}$$

Statistical analysis

Results are reported as mean \pm SE. The treated groups were compared to control by ANOVA following Dunnett's test. Significance level was set at $P < 0.5$ and confidence level at 95%. Statistical analysis was carried out using Instat version 2.1 software residing in a Pentium IV processor run on Windows XP®.

Results

Effect of treatment on body weight and blood glucose levels

All the male rats in streptozotocin and alloxan treated groups showed an increase in blood glucose level 96 h

after injection. The blood glucose level was < 250 mg/dL. There was a moderate decrease in the blood sugar level of diabetic rats upon administration of *A. racemosus* aqueous extract on day 28. In the streptozotocin and *A. racemosus* treated group it was $(112.4 \pm 2.01 \text{ mg/dL})$ as compared to the streptozotocin control $(233.15 \pm 2.01 \text{ mg/dL})$. Similarly, in alloxan and *A. racemosus* treated group it was $116.63 \pm 1.07 \text{ mg/dL}$ while in animals injected with alloxan alone the blood glucose level was found to be $265 \pm 3.11 \text{ mg/dL}$ (Table 1).

After 28 days of treatment a significant decrease in the body weights of the male rats in streptozotocin and alloxan treated groups was observed. No significant weight loss was observed in group III or group V animals which were administered aqueous extract of *A. racemosus* after administration of streptozotocin or alloxan. Similarly, a loss of nearly 20% was noted in testes weight in the animals of alloxan or streptozotocin treated groups. This loss was ameliorated after administration of extract to group III and V animals (Table 1).

Effect on orientation and sexual behavior

A sluggish orientation behavior was observable in the rats of diabetic control groups (i.e., alloxan and streptozotocin alone treated). One of the reasons for this reduced orientation activity could be excessive oxidative damage arising out of glucose overload. Whereas in case of diabetic animals fed with the extracts a reduced orientation activity was observed after 14 days of treatment which was restored completely by day 28 of observation and the behavioral parameters in certain cases were even better than control group animals at the completion of experiment. This exhibits a potential capability of the herbal extracts in restoring the overall dynamics of sexual dysfunction arising due to hyperglycemic condition (Table 2).

A similar effectiveness was also observable in the case of sexual behavior analysis. The hesitation increased to 520 ± 7 sec in the case of diabetic rats. The hesitation time for extract treated diabetic animals was significantly less ($P < 0.1$). Similarly, a significantly reduced score for attraction towards female was observed in diabetic animals but was normal in extract treated animals. The values for the cumulative score of attraction were slightly superior to those observed for control group animals (Table 2).

The frequencies (mount, intromission and ejaculation) were significantly reduced in streptozotocin and alloxan induced diabetic rats ($P < 0.05$). The most interesting feature observed was that almost 70% of the animals did not indulge in any kind of sexual behavior in the diabetic groups. Comparatively, in diabetic animals treated with *A. racemosus*, normal sexual behavior was

restored and it was moderately higher than the vehicle treated control group animals (Table 2).

The data for the latencies and frequencies are shown in Table 2. The results demonstrate effectiveness of *A. racemosus* in restoring the damaged sexual functions of streptozotocin as well as alloxan induced damage (Table 2).

Discussion

The overall purpose of our study was to ascertain whether *A. racemosus* could be useful in correcting the sexual dysfunctions caused by hyperglycemia. *A. racemosus* is rich in fructooligosaccharides which help in protecting the oxidative damage caused by streptozotocin (Sreevidya et al., 2006). The roots are also considered as antidiabetic in traditional Ayurvedic literature (Khare, 2002). Therefore, the role of herb on sexual function in diabetic rats was evaluated.

More than 90% of patients suffering from diabetes have been reported for one or other form of sexual dysfunction, ranging from loss of libido to decreased performance and vigor. One of the mechanisms underlying this is the degeneration of testicular function caused as a result of oxidative damage by ROS (reactive oxygen species). Although there are reports suggesting the improvement of sexual function in diabetic subjects after treatment with synthetic antidiabetic drugs, like glibenclamide or glipizide, due to better management of hyperglycemic condition. Still, the improvement is only marginal with none of the diabetic subjects showing performance comparable to the untreated control group subjects (Benassi-Benelli et al., 1997; Ejlskjær & Christiansen, 1997).

Fructans and fructooligosaccharides have been shown to possess significant effectiveness in overcoming this damage. Therefore, the overall constitution of aqueous extract of *A. racemosus* rich in steroidal saponins and fructooligosaccharides provides a prototype combination for combating the degenerative influence on sexual functions caused by alloxan or streptozotocin treatment.

In the present study, fewer diabetic rats reached ejaculation than control rats, which complies with the earlier reports that diabetes is associated with reduction in male copulatory behavior. Although it is reported that streptozotocin or alloxan treatment of rats reduces plasma testosterone levels, this factor alone does not appear to be responsible for changes in copulatory behavior as testosterone replacement did not reverse the adverse effects of diabetes on sexual behavior (Steger, 1990). While streptozotocin or alloxan induced copulatory dysfunction might be due to reduced testosterone responsiveness, copulatory dysfunction in the diabetic

state is also a result of direct or indirect action of insulin and/or glucose on the adrenergic complex (Kniel et al., 1986).

A cascade of mechanisms are responsible for diabetes induced sexual dysfunction but eventually better management of diabetes along with improved gonadotropic activity may be major contributors in restoring the failing sexual functions in diabetic subjects (Young et al., 2005).

The ability of *A. racemosus* extract to restore the sexual function therefore, illustrates that the herb may not only assist in steroidogenesis but it may also be effective in ensuring the better availability of hormone to gonads. Secondly, previous reports on the ability of FOSs of *C. borivilianum* and *O. latifolia* in reducing glucose levels, could provide some insight into the possible mechanism behind the restoration of normal copulatory rate in diabetic animals treated with aqueous *A. racemosus* extract rich in similar types of constituents. Therefore, the multiple mechanism of the herb can be a major reason for a significant improvement in all the sexual parameters. The improved activity, which is even better than untreated control group, connotes *A. racemosus* as a potent stimulant.

Looking into the present studies, it can be stated that the herb justifies its denomination as an aphrodisiac herb. The results also exhibit a possible usage of this herb as treatment for diabetes induced sexual dysfunction. The study also sheds some light on the utility of this herb as a nutraceutical ingredient for diabetics with sexual dysfunction due to hyperglycemia.

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References

- Agmo A (2001): Male rat sexual behavior. *Brain Res Protocol* 1: 203–209.
- Ang HH, Ngai TH (2001): Aphrodisiac evaluation in non-copulator male rats after chronic administration of *Eurycoma longifolia* Jack. *Fund Clin Pharmacol* 15: 265–268.

- Aybek H, Aybek Z, Rota S, Sen N, Akbulut M (2008): The effects of diabetes mellitus, age, and vitamin E on testicular oxidative stress. *Fertil Steril* 90: 755–760.
- Benassi-Benelli A, Ferrari F, Pellegrini-Quarantotti B (1979): Penile erection induced by apomorphine and *N-n*-apopolymorphine in rats. *Arch Int Pharmacody Therap* 242: 241–247.
- Benelli A, Arletti R, Poggioli R, Cavazutti E, Mameli M, Bertolini A (1997): Effect of potassium channel modulator on male sexual behavior. *Life Sci* 60: 263–267.
- Ejskjaer N, Christiansen JS (1997): Sexual dysfunction in diabetes mellitus. *Ugeskr Laegr* 164: 4789–4791.
- Gupta AK (2003): Quality standards of Indian Medicinal Plants, vol 1, *Indian Council of Medical Research*, New Delhi.
- Islam MW, Tariq M, Ageel AM, Al-Said MS, Al-Yhya AM (1991): Effect of *Salvia hematodes* on sexual behavior of male rats. *J Ethnopharmacol* 33: 67–72.
- Khare CP (2004): Indian Medicinal Plants an illustrated dictionary, vol 1, Springer-Verlag, Berlin.
- Kniel PC, Junker U, Perrin IV, Bestetti GE, Rossi GL (1986): Varied effects of experimental diabetes on the autonomic nervous system of the rat. *Lab Invest* 54: 523–530.
- Otoni EB (2000): EthoLog 2.2 – a tool for the transcription and timing of behavior observation sessions. *Behav Res Methods Inst Computers* 32: 211–212.
- Puri HS (2002): Rasayana—Ayurvedic Herbs for Longevity and Rejuvenation, Taylor and Francis, London, 212–24.
- Scarano WF, Messias AG, Oliva SU, Klinefelter GR, Kempinas WG (2006): Sexual behavior, sperm quantity and quality after short-term streptozotocin-induced hyperglycaemia in rats. *Int J Androl* 29: 482–488.
- Shah J (2002): Erectile dysfunction through the ages. *Brit J of Urol Int* 90: 433–441.
- Sreevidya N, Govindarajan R, Vijaykumar M, Thakur M, Dixit VK, Mehrotra S, Madhusudan KP (2006): Action of (201) fructo-oligosaccharide fraction of *Chlorophytum borivilianum* against streptozotocin-induced oxidative stress. *Planta Med* 72: 1421–1424.
- Steger RW (1990): Testosterone replacement fails to reverse the adverse of streptozotocin-induced diabetes on sexual behavior in the male rat. *Pharmacol Biochem Behavior* 35: 577–582.
- Thakur M, Dixit VK (2005): Fructan: The polymer with unexplored potential, *Indian Pharmacist* 4: 7–12.
- Thakur M, Dixit VK (2006): Effect of *Chlorophytum borivilianum* on androgenic and sexual behavior in male rats. *Indian Drugs* 43: 300–306.
- Thakur M, Dixit VK (2007): Aphrodisiac activity of *Dactylorhiza hatageirea* (D. Don) Soo. In male albino rats. *Evid Based Complement Alternat Med*. 4 (Suppl 1): 29–31.
- Thakur M, Dixit VK (2008): Amerliorative Effect of Fructo-Oligosaccharide Rich Extract of *Orchis latifolia* Linn. on Sexual Dysfunction in Hyperglycemic Male Rats. *Sexuality and Disability* 26: 37–46.
- Thakur M, Bhargava S, Dixit VK (2007): Immunomodulatory activity of *Chlorophytum borivilianum* Sant F. *Evid Based Compl Altern Medicine* 4: 521–525.
- Young LD, Yu D, Bateman RM, Brock GB (2005): Oxidative stress and antioxidant therapy: Their impact on diabetes associated erectile dysfunction. *J Androl* 25: 830–836.