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Aphrodisiac activity of ethanol extract and fractions of *Fadogia cienkowskii* Schweinf. Rubiaceae roots in albino rats

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Fadogia cienkowskii is a shrub whose roots are used in many communities of Northern Nigeria to improve sexual performance; however, there is no scientific study to verify this claim. This study determined the effect of 70% ethanol extract of *F. cienkowskii* roots and its fractions (ethyl acetate, n-butanol, and residual ethanol) on mating behaviour (mounting, intromission and ejaculation) and serum testosterone concentration of male albino rats. Five groups of rats each containing 6 rats were treated with 50, 100 and 200 mg/kg of the crude ethanol extract, while Sildenafil and distilled water were administered to the control groups. Another set of 6 groups of rats were also used in the study and were treated with 12.5 and 25 mg/kg of the ethyl acetate, n-butanol and residual ethanol fractions, respectively. The crude extract and fractions significantly increased mount, intromission and ejaculation frequencies. The copulation efficiency also increased significantly – indicative of the plant's aphrodisiac potential. Significant increase of testosterone in serum of extract treated rats was also observed, which is a further credence to the plant's aphrodisiac potential. It was thus concluded that the 70% ethanol root extract of *F. cienkowskii* and its fractions have aphrodisiac activity with the n-butanol and residual ethanol fractions being more active.

Key words: *Fadogia cienkowskii* extract, aphrodisiac activity, rats

INTRODUCTION

Sexual function is an important index of assessing quality of life and sexuality has wide ramifications on the social and psychological well-being of an individual (Brody, 2006). For many people, sexual dysfunction is associated with significant negative effects on quality of life (Avci and Dogan, 2016; Yafi et al., 2016), sometimes requiring

medical interventions which may include lifestyle modification (Gupta et al., 2011), surgery (Yafi et al., 2016) and pharmacotherapy (Hatzimouratidis et al., 2016; Yafi et al., 2016) – involving the use of aphrodisiacs to improve sexual function and quality of life.

Medicinal plants are used to enhance sexual function in

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many regions of the world. In Uganda, 30 plants from 25 families and 30 genera have been reportedly used in managing sexual impotence and erectile dysfunction (Kamatenesi-Mugisha and Oryem-Origa, 2005). Vajikaran Rayana is a concept in Indian Ayurvedic medicine that describes the use of medicinal plants to improve sexual function (Chauhan et al., 2014). In Nigeria, a substantial proportion of the population, especially in rural areas, use plants to enhance sexual function and treat erectile dysfunction (Afolayan and Yakubu, 2009). Some plants that have been scientifically shown to enhance sexual function include *Schisandra chinensis* (Choi et al., 2018), *Pueraria tuberosa* (Maji et al., 2014) and *Fadogia agrestis* (Yakubu et al., 2005).

Fadogia cienkowskii is a plant belonging to the Rubiaceae family, an erect shrub about 3 ft high and forms stout underground bases, distributed in the savannah from Mali to Northern and Southern Nigeria, and widely dispersed into the drier parts of tropical Africa (Burkhill, 1985). The common name in Hausa is *bakin gaggai* which means "black aphrodisiac". The Igbos of southeastern Nigeria calls it *Ogwu-Agu* (translated as Lion's drug). *F. cienkowskii* is used in traditional medicine for the treatment of different ailments including general body debility, inflammation, diarrhea, fever, malaria (Chukwube et al., 2018), infertility (Ruffo, 1991) and male impotence (Chukwube et al., 2018; Odeghe et al., 2016).

Despite the reported use of *F. cienkowskii* to enhance male sexual performance, there is no scientific study to verify this claim. This study evaluated the effect of *F. cienkowskii* ethanolic root extract and its successive fractions on some parameters of sexual performance in male albino rats.

MATERIALS AND METHODS

Plant collection authentication and preparation

F. cienkowskii roots was collected from Wuntin Dada in Bauchi State, Nigeria in November 2016. The plant was identified by Mr Joseph J. Azila of the Federal College of Forestry Jos and authenticated by Prof. Emmanuel Aigbokhan. A voucher specimen was deposited in the Federal College of Forestry herbarium with voucher number FHJ 258. The root was cleaned of debris and dried under shade in the Drug Development Division of National Veterinary Research Institute, Vom, Nigeria.

The dried root was pulverized using wooden pestle and mortar into coarse powder. Six hundred (600) grams of the pulverized plant material was poured into a 6-L round bottom flask and 3 L of 70% ethanol was poured onto it to extract by maceration. The mixture was allowed to stand for 72 h with shaking at intervals of 12 h. After 72 h, the mixture was successively passed through sieves of varying pore sizes (800, 500 and 150 μm); followed by filtration using cotton wool plug and finally Whatmann No. 1 filter paper to obtain a clear filtrate.

The filtrate was dried by passing a steady stream of air using an exhaust fan to reduce the volume to about one third of the original volume. The remainder was transferred into an oven to dry at a temperature of 40°C after which the dried extract was scrapped and stored in air tight containers at 25 \pm 2°C pending use.

Fractionation of crude extract

Fractions of the crude ethanol extract were obtained using the method described by Hossain et al. (2014). Briefly, 50 g of the crude extract was suspended in 200 ml of distilled water in a 500-ml separating funnel. The suspension was successively extracted using solvents of increasing polarity (n-hexane, ethyl acetate and n-butanol). First, 100 ml of n-hexane was added to the suspension and gently mixed. The mixture was allowed to stand and separate into the aqueous and hexane layers. The hexane layer was collected and the process was repeated 3 times to obtain the hexane fraction. In the same way, ethyl acetate and butanol were used to extract the aqueous suspension of the ethanol extract to obtain the n-hexane, ethyl acetate (EA), butanol (NB) and residual ethanol (RE) fractions (Figure 1). The ethyl acetate, butanol and residual ethanol fractions were weighed to obtain their percentage yield.

Preliminary phytochemical screening

The crude extract and fractions were tested for the presence of secondary metabolites using the methods described by Evans (2009). The phytochemicals tested for were alkaloids, saponins, tannins, cardiac glycosides, flavonoids and steroids.

Determination of acute toxicity (LD₅₀)

The LD₅₀ of the crude extract was determined using the method described by Lorke (1983). Male rats weighing between 150 to 200 g were used. The determination was carried out in two phases. In Phase I, nine rats were divided into 3 groups of 3 rats each and labeled as Groups 1, 2 and 3. They were administered 10, 100 and 1000 mg/kg body weight dose of *F. cienkowskii* extract orally and were observed for mortality or any signs of toxicity. After 24 h, the phase II treatment was initiated with administration of 1600, 2900 and 5000 mg/kg body weight dosage of the extract each to 1 rat. The rats were observed for mortality or signs of toxicity hourly for the first 6 h, then after 24 h observation continued for 14 days to assess for signs of delayed toxicity.

Evaluation of mating performance of male rats

Preparation of male rats

Male albino rats weighing between 250 and 330 g were used for the experiment. They were obtained from the experimental animal house of the National Veterinary Research Institute, Vom, Nigeria. The rats were housed in plastic cages with stainless steel cover in a natural light/dark cycle (7 pm to 6 am dark) and were allowed free access to food and water. The food was pelleted feed from the Dagwom Farm Mill National Veterinary Research Institute, Vom.

Preparation of female rats

Female rats weighing between 180 and 230 g were used. They were allowed free access to food and water. The female rats were artificially brought to oestrus by administering oestradiol 25 μg per rat and progesterone 500 μg 48 and 8 h respectively prior to mating via subcutaneous injection under the skin of the neck. The receptivity of the female rats was tested by mating with male rats other than the ones used for the experiment (Yakubu et al., 2007;

Chan, 2010; Chu et al., 2014).

Experimental design

For evaluation of the crude extract, male rats were divided into five groups each containing six rats. Group 1 rats served as the control and were treated with distilled water at equivalent volume with the rats taking the extract. Rats in Groups 2, 3 and 4 were treated with 50, 100 and 200 mg/kg body weight of the crude extracts while rats in Group 5 were treated with Sildenafil 5 mg/kg. Treatment was administered once daily for 14 days and the male rats were paired with the females and mating behaviour observed on days 1, 7 and 14. Administration of the extract continued for 40 days after which the rats were humanely sacrificed by ether anaesthesia and blood collected for hormonal assay.

For evaluation of the fractions (ethyl acetate, butanol and residual ethanol fractions), male rats weighing 250 to 330 g were divided into 7 groups each containing 6 rats. Two doses per fraction (12.5 and 25 mg/kg) and a control group that was administered distilled water with volume equivalent to that of fractions administered to constituted groups. The treatment was administered once daily for 7 days by oral route and the mating performance was evaluated on the 1st and 7th day.

Determination of mating performance

Male and female rats were mated in a ratio of 1:1. Each male rat was placed in a glass cage measuring 60 cm × 30 cm × 30 cm (L × B × H) and allowed to acclimatize for 10 min. Thereafter, a female that had been experimentally brought to oestrous was introduced into the cage and allowed to cohabit for 30 min. The sequence of events was captured using a document camera. The recorded video was then played back to evaluate mating behaviour parameters. The behaviours of interest were the mount, intromission and ejaculation. A mount was defined as the male assuming the copulation position without introducing its penis into the female vagina. Intromission was defined as the introduction of the male penis into the female vagina and it is characterized by pelvic thrusting and springing dismount. Ejaculation is the ejection of semen by the male into the female vagina. It is characterized by deeper pelvic thrust and slow dismount followed by a period of inactivity. The mount, intromission and ejaculation latencies and frequencies were recorded and copulation efficiency was calculated as

$$\text{Copulation Efficiency (\%)} = \frac{\text{Number of Intromissions}}{\text{Number of Mounts} + \text{Number of Intromissions}} \times 100$$

Determination of serum testosterone, follicle stimulating hormone and luteinizing hormone concentration

After administration of the crude extract for 40 days, the male rats were humanely sacrificed and blood was collected by exsanguination into plain sample bottles. The blood was allowed to clot and the serum to separate. The blood was then centrifuged in a refrigerated centrifuge and the serum was aspirated into plain sample bottles using Pasteur pipettes and stored at -20°C pending analysis. Assay was carried out within 48 h after sample collection. The concentration of testosterone in the serum was determined using the testosterone enzyme immunoassay kit according to the manufacturer's protocol based on the principle of direct competitive assay following antigen-antibody reaction as in the Enzyme-Linked Immunosorbent Assay (ELISA) (Tietz, 1995). Estimation was carried out using the automatic Roche Diagnostics Immuno analyser

cobas e 411.

The concentration of Follicle Stimulating Hormone (FSH) was estimated using the FSH immunoradiometric assay (FSH IRMA) with kits according to the manufacturer's protocol. The assay is based on a non-competitive principle in which the analyte is sandwiched between two monoclonal antibodies. The first antibody was coated on the walls of the tubes used in the analysis, while the second antibody was radiolabeled for detection. The unbound fraction was removed by a washing step. The amount of radioactivity counted in the assay tubes is directly proportional to the amount of analyte in the sample (Arslan et al., 2003; Tietz, 1995). The analysis was carried out using the automatic Roche Diagnostics Immuno analyser cobas e 411.

The concentration of luteinizing hormone was determined by radioimmunoassay with kits according to the manufacturer's protocol. The assay is based on the principle that a hormone can be radiolabeled and still produces an immunologic and biologically active product while possessing high specific activity (Midgley, 1966). The labeled hormone reacts with an antiserum in a quantitative manner. Iodine ¹³¹I labeled Human Chorionic Gonadotropin (HCG-¹³¹I) competes with un-labeled luteinizing hormone for limited amount of antibody. The fluorescence is proportional to the quantity of unbound hormone (Midgley, 1966; Midgley and Jaffe, 1966; Monroe et al., 1969; Niswender et al., 1969). The analysis was carried out using the automatic Roche Diagnostics Immuno analyser cobas e 411.

Ethical consideration

The study was conducted in accordance with guidelines for the handling and care of experimental animals (National Research Council, 2011). The protocol for experiments was approved by the Animal Ethics Committee of the National Veterinary Research Institute, Vom. Ethical Clearance Certificate No. AEC/02/34/16 was issued.

Statistical analysis

Data were expressed as mean ± SEM (n=6). Difference between means of various treatment groups was determined by analysis of variance and Tukey's post-test using SPSS version 20 IBM®, SPSS® (NY, USA). Value of P < 0.05 was considered significant.

RESULTS

Yield of plant extract and phytochemical constituents

The extraction yielded a dark brown and highly hygroscopic extract with percentage yield of 5.03%. The percentage yield of fractions from the crude extract showed that the ethyl acetate, butanol and residual ethanol fractions were 16.23, 22.22 and 38.06% respectively (Table 1).

The preliminary phytochemical analysis of the crude extract showed the presence of tannins, saponins, steroids, terpenes, alkaloids flavonoids and cardiac glycosides (Table 1). In the ethyl acetate fraction, tannins and flavonoids were not detected while saponins, steroids, terpenes, alkaloids and cardiac glycosides were detected (Table 1). The butanol fraction tested positive for tannins, steroids, terpenes and cardiac glycosides while saponins, alkaloids, flavonoids were not detected.

Table 1. Result of phytochemical screening of crude ethanol extract and fractions of *Fadogia cienkowskii* roots.

Phytochemical	Extract			
	Crude Ethanol	Ethyl acetate Fraction	Butanol Fraction	Residual Ethanol Fraction
Tannins	+	-	+	+
Saponins	+	+	-	+
Steroids	+	+	+	+
Terpenes	+	+	+	+
Alkaloids	+	+	-	+
Flavonoids	+	-	-	-
Cardiac glycosides	+	+	+	+
Percentage yield		7.52	42.68	29.49

+ = Detected; - = Not Detected.

Table 2. Effect of *Fadogia cienkowskii* ethanol root extract on mount, intromission and ejaculation latencies of male albino rats after daily treatment for 14 days.

Treatment	Mating behavior parameter		
	Mount Latency (s)	Intromission Latency (s)	Ejaculation Latency (min)
Distilled water 5 ml/kg	58.33 ± 5.53	59.67 ± 4.75	19.22 ± 5.29
Extract 50 mg/kg	32.17 ± 7.03*	33.33 ± 6.43*	10.55 ± 2.75
Extract 100 mg/kg	30.17 ± 4.23*	31.17 ± 3.95*	7.13 ± 1.76*
Extract 200 mg/kg	33.17 ± 5.58*	34.17 ± 5.36*	6.77 ± 1.68*
Sildenafil 5 mg/kg	37.57 ± 3.11	34.83 ± 5.61*	17.30 ± 4.23

* = P < 0.05; N = 6.

The residual ethanol fraction showed positive reactions for tannins, saponins, steroids, terpenes, alkaloids and cardiac glycosides while the test for flavonoids showed a negative reaction (Table 1).

Acute toxicity

There was no mortality observed in all the rats treated with the extracts even at the highest dose administered. This indicated that the ethanol extract of *F. cienkowskii* roots is relatively safe for the purposes of evaluation of therapeutic activity.

Effect of extract on mating behaviour of male rats

Effect of crude extract on mount, intromission and ejaculation latencies

F. cienkowskii extract significantly (P < 0.05) decreased mount, intromission and ejaculation latencies in albino rats over the 14 days of treatment when compared with the control (distilled water). The mount and intromission latencies were comparable to that of rats treated with the standard drug sildenafil (Table 2).

Effect of crude extract on mount, intromission and ejaculation frequency

There was no significant difference in the mount frequency of rats treated with the extract on the first day when compared with the control (distilled water). However, on the 7th and 14th days of treatment, significant increase was observed in the mount frequency of rats treated with all doses of the extract. The same trend was observed in the intromission frequency and copulation efficiency. For the ejaculation frequency, a dose dependent increase was observed which was statistically significant (P<0.05) only at 200 mg/kg - the highest dose administered (Table 3).

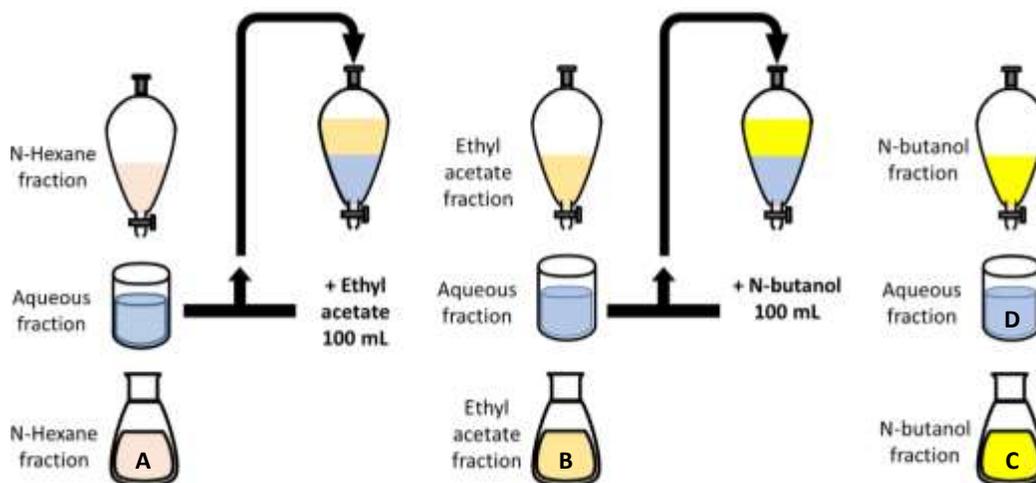
Effect of crude extract on copulation efficiency

The extract (200 mg/kg) significantly increased copulation efficiency (P < 0.05) on day 1 of treatment compared to the control whereas 50 and 100 mg/kg did not statistically (P > 0.05) increase copulation efficiency on day 1 of treatment. However, increased copulation efficiency was observed after 7 and 14 days of treatment with 50, 100 and 200 mg/kg respectively which was statistically significant (P < 0.05) compared to control. The effect of

Table 3. Effect of *Fadogia cienkowskii* ethanol root extract on mount, intromission and ejaculation frequencies of male albino rats after daily administration for 14 days.

Treatment	Mating behavior frequency		
	Mount	Intromission	Ejaculation
Distilled water 5 ml/kg	17.00 ± 1.52	14.50 ± 0.99	0.83 ± 0.31
Extract 50 mg/kg	23.67 ± 1.33*	21.67 ± 1.33*	2.17 ± 0.75
Extract 100 mg/kg	24.17 ± 1.40*	22.17 ± 1.40*	2.33 ± 0.67
Extract 200 mg/kg	25.00 ± 2.00*	23.00 ± 2.00*	2.83 ± 0.31*
Sildenafil 5 mg/kg	27.00 ± 2.25*	25.00 ± 2.25*	2.68 ± 0.62*

* = P < 0.05, N = 6

**Figure 1.** Schematic representation of fractionation of crude ethanol root extract of *Fadogia cienkowskii* A) Hexane, B) Ethylacetate, C) N-butanol, and D) Aqueous (containing residual ethanol) fractions.

the extract was both dose and time dependent. Copulation Efficiency after 14 days of treatment is shown in Figure 2.

Effect of extract on serum testosterone, FSH and LH concentrations

Administration of the extract (50, 100 and 200 mg/kg) significantly ($P < 0.05$) increased the serum testosterone concentration of rats when compared to control (Table 4), while LH concentration decreased and FSH concentration was not significantly ($P < 0.05$) affected (Table 4).

Effect of *Fadogia cienkowskii* fractions on mount, intromission and ejaculation frequency

Rats treated with the extract had statistically ($P < 0.05$) higher mount, intromission and ejaculation frequencies after treatment for 7 days with the order of increase as

RE > NB > EA (Table 5).

Effect of *Fadogia cienkowskii* fractions on copulation efficiency

After treatment for 14 days, there was significant ($P < 0.05$) increase in the copulation efficiency of rats treated with all the fractions of the extract when compared to that of the control rats treated with distilled water (Figure 3). The magnitude of increase was RE > NB > EA.

DISCUSSION

The 70% ethanol extract of the root of *F. cienkowskii* showed positive presence for tannins, saponins, steroids, terpenes, alkaloids flavonoids and cardiac glycosides (Table 1). These constituents have also been reported to be present in the leaves of the plant (Bruce et al., 2019; Chukwube et al., 2018; Odeghe et al., 2016; Orabueze et

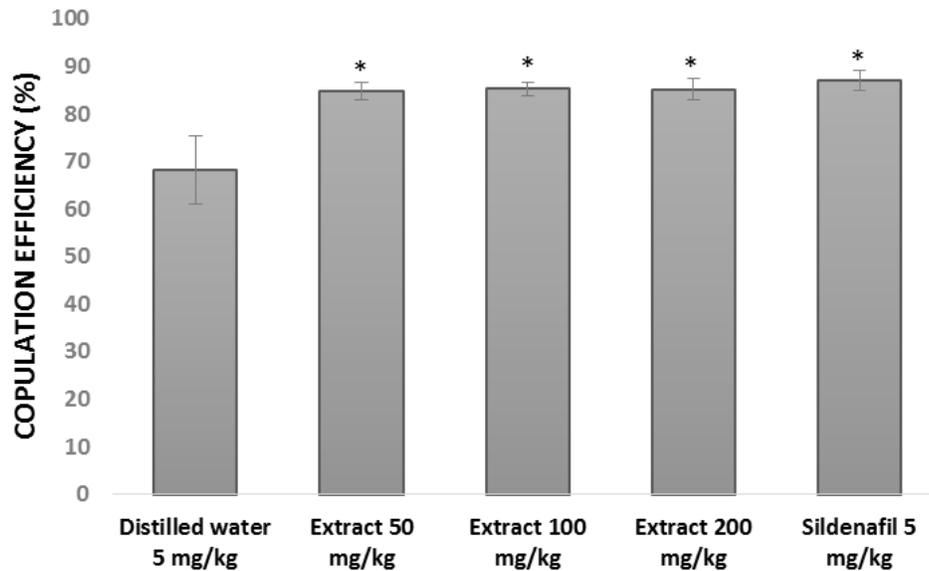


Figure 2. Copulation efficiency of rats treated with *F. cienkowskii* ethanol root extract daily for 14 days. * = $P < 0.05$. $N = 6$.

Table 4. Effect of *Fadogia cienkowskii* root extract on serum testosterone, FSH and LH concentration.

Treatment	Hormone		
	Testosterone (nmol/L)	FSH (mIU/ml)	LH (mIU/ml)
Distilled water (5 ml/kg)	0.81 ± 0.37	0.085 ± 0.002	0.456 ± 0.015
Extract (50 mg/kg)	9.35 ± 2.44*	0.086 ± 0.004	0.424 ± 0.030*
Extract (100 mg/kg)	6.28 ± 1.13*	0.088 ± 0.006	0.422 ± 0.020*
Extract (200 mg/kg)	4.53 ± 1.18*	0.085 ± 0.003	0.415 ± 0.005*

FSH = Follicle Stimulating Hormone, LH = Luteinizing Hormone * = $P < 0.05$ compared to untreated group, $N = 6$.

Table 5. Effect of fractions of ethanol extract of *Fadogia cienkowskii* root on mount, intromission and ejaculation frequencies of male albino rats.

Treatment	Mating behavior frequency		
	Mount	Intromission	Ejaculation
DW (5 ml/kg)	20.00 ± 6.93	13.50 ± 0.67	0.50 ± 0.37
EA (12.5 mg/kg)	20.67 ± 0.92	16.33 ± 1.73	1.33 ± 0.61*
EA (25 mg/kg)	26.67 ± 4.62*	22.67 ± 3.75*	2.33 ± 0.23*
NB (12.5 mg/kg)	25.33 ± 1.97*	24.00 ± 0.97*	3.00 ± 0.40*
NB (25 mg/kg)	30.33 ± 0.46*	29.00 ± 0.37*	2.33 ± 0.23*
RE (12.5 mg/kg)	33.67 ± 4.67*	32.33 ± 4.10*	3.33 ± 0.23*
RE (25 mg/kg)	28.0 ± 3.17*	27.00 ± 2.90*	3.33 ± 0.23*

* = $P < 0.05$ compared to untreated group in the same column, $N = 6$, DW = Distilled Water, EA = Ethyl acetate fraction, NB = *N*-Butanol fraction, RE = Residual ethanol fraction.

al., 2019). However, to the best of our knowledge, this is the first report on the constituents of the roots. Saponins and alkaloids have been associated with enhancing

aphrodisiac activity. Protodioscin is a saponin found in *Tribulus terrestris* and has been shown to increase mount and intromission frequencies; decrease mount latency,

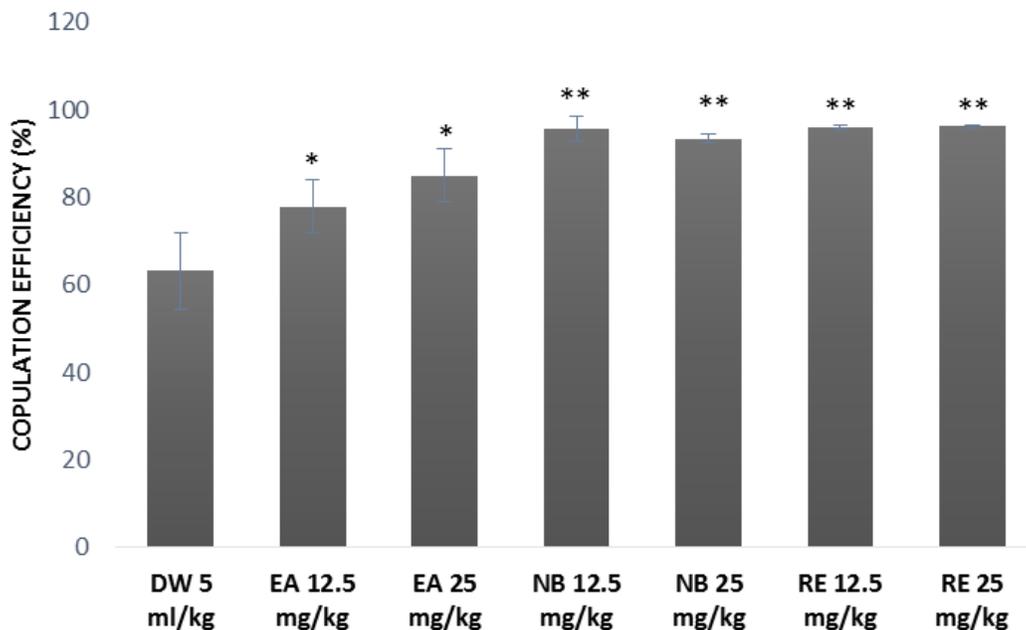


Figure 3. Copulation efficiency of rats treated with *Fadogia cienkowskii* fractions daily for 14 days. DW = Distilled Water, EA = Ethyl acetate fraction, NB = N-Butanol fraction, RE = Residual ethanol. * = $P < 0.05$, ** = $P < 0.01$. N = 6.

intromission latency and post ejaculation interval as well as increase intracavernosal pressure in rats (Gauthaman and Ganesan, 2008). The alkaloid fraction of the seeds of *Hygrophila spinosa* reportedly increased testosterone production by Leydig cells *in vitro* and increased mount and intromission frequency in male rats (Vyas and Raval, 2016). Arecoline, which is an alkaloid derived from the betel nuts (*Areca catechu*) has also been shown to increase testosterone secretion by the Leydig cells in rats (Wang et al., 2008).

It is interesting that flavonoids detected in the crude extract was not detected in any of the fractions evaluated (ethyl acetate, butanol and residual ethanol). This observation raises questions that need further investigation. A possible reason may be our inability to carry out phytochemical screening of the n-hexane fraction. The aphrodisiac activity of the n-hexane fraction was also not evaluated due to low yield.

The absence of mortality in the acute toxicity test at 5000 mg/kg dose suggests the safety of the ethanol root extract of *F. cienkowskii*. No apparent toxic effect had been associated with the folkloric use of *F. cienkowskii*. This finding agrees with reports that the LD₅₀ of the methanol and hydromethanol extract of the leaves of *F. cienkowskii* is higher than 4000 mg/kg (Ode et al., 2015; Orabueze et al., 2019).

In the evaluation of aphrodisiac activity, the significantly shorter mount latency of rats treated with the extract compared with that of control rats treated with distilled water is indicative of sexual behaviour stimulating

activity of the extract; particularly the desire or appetite component of sexual behaviour. While there are no studies evaluating the aphrodisiac potential of the root extract of *F. cienkowskii*, it is interesting that *F. agrestis* has been reported to significantly decrease mount latency in albino rats (Yakubu et al., 2005).

Significantly lower intromission latency in rats is indicative of the ability of the extract to also increase the arousal and potency components of mating. Successful intromission indicates potency and functional penile erectile mechanisms which occurs only when the male copulation organ is sufficiently erect to penetrate the female organ. Substances with aphrodisiac potential have been reported to significantly reduce the intromission latency (Yakubu et al., 2007).

The shortened ejaculation latency observed is an indication of the ability of the extract to stimulate sexual activity in rats. It is known that drugs which inhibit sexual function such as Selective Serotonin Reuptake Inhibitors (Chan, 2010), some antihypertensives (Seidl et al., 1991) and antipsychotics (Allen et al., 2019) prolong ejaculation latency. Drugs that stimulate sexual activity on the other hand decrease ejaculation latency and increase ejaculation frequency (Chan, 2010). These findings agree with those of Gundidza et al. (2009) and Allouh et al. (2014) where administration of *Mondia whitei* and *Allium cepa* extract respectively to rabbits and rats decreased mount, intromission and ejaculation latencies. In addition, administration of *A. cepa* attenuated paroxetine-induced prolongation of ejaculation latency. In this study,

significant decrease in mount and intromission latencies along with decrease in ejaculation latency observed in rats does not agree with the findings of Yakubu et al. (2005) and Suresh et al. (2009). These authors reported significant increase in ejaculation latency of rats but their treatment was with *F. agrestis* aqueous stem extract and *Mucuna pruriens* ethanol seed extract respectively.

Mount frequency is considered as an index of sexual motivation and stamina (Gauthaman et al., 2002; Yakubu et al., 2007). The significant increase in mount frequency of rats treated with the crude root extract shows that *F. cienkowskii* extract increased sexual motivation and stamina of the rats.

The increased intromission frequency of rats treated with the extract may be an indication of increased erectile function. The decrease in intromission latency coupled with increased intromission frequency further supports the probable erectile function enhancing activity of *F. cienkowskii*. Furthermore, sexual stimulation usually manifests in higher frequency of ejaculation within a specified time period (Chan, 2010). In our study, a cut-off period of thirty minutes was used. The significantly higher frequency of ejaculation in rats treated with the extracts on day 7 and 14 of treatment suggests that the extract possesses sexual stimulation activity and extended administration could lead to a furtherance of enhanced sexual activity.

Copulation efficiency is a measure of sexual potency and index of successful intromission at every attempt. The higher copulation efficiency of rats treated with the extracts is a further indication that the extract enhanced sexual potency.

When all the results are considered together, the overall improvement in the parameters of sexual stimulation and stamina indicate that the aqueous ethanol root extract of *F. cienkowskii* has aphrodisiac potential. Similarly, the fractions of the crude extract also showed significant increases in copulation efficiency signifying further their ability to increase mating potency of rats even at lower doses than those used to evaluate aphrodisiac activity of the crude ethanol extract.

Significant increase in serum testosterone concentration of rats treated with the crude extract suggests that the extract enhances steroidogenesis. It is plausible that the significant increase in testosterone in rats treated with the extract may in part account for their sexual behaviour enhancing activity. Testosterone supplementation has been reported to improve sexual function and libido (Rizk et al., 2017). Androgen deficiency in castrated rats has been shown to impair penile erectile function (Alcorn et al., 1999). Conversely, testosterone replacement has been shown to maintain smooth muscle content in the corpus cavernosum of castrated rats (Halmenschlager et al., 2017) and increased the intensity of orgasms and ejaculation in men (Morales, 1996). The significant increase in testosterone concentration was accompanied by a significant decrease in luteinizing hormone (LH) concentration. Increased level of testosterone is usually

accompanied by lower concentration of luteinizing hormone (Bridges et al., 1993; Plant and Dubey, 1984), due to the inhibitory effect of testosterone on the hypothalamus through negative feedback, thus limiting the release of gonadotropin releasing hormone by the hypothalamus (Shibata et al., 2007; Finkelstein et al., 1991; Steiner et al., 1982).

Conclusion

The aphrodisiac potential of *F. cienkowskii* ethanol roots extract and its fractions were evaluated in male albino rats. Results obtained showed enhanced mating behaviour parameters of mount, intromission, ejaculation and copulation efficiency. In addition, the ethanol extract increased serum concentration of testosterone and this may in part be a possible mechanism of action of the extract. Further work on the mechanism of action of the extract and determination of the active compounds is recommended.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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