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Evaluation of Spermatozoa Quality, Differential Sperm Morphology and Gonadosomatic Indices of Benign Prostatic Hyperplasia Induced Rats Treated with Polyherbal Extract

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Introduction: The study of benign prostatic hyperplasia (BPH) is intricate and its complete understanding is yet to be achieved. The hormones testosterone and dihydrotestosterone have a permissive and important role in male fertility. Growth factors and other hormones like estrogens and factors that may contribute to the development of BPH.

Objective: This study investigated the ameliorating potential of polyherbal leave extract of Stinging nesttle, Vernonia amygdalina, Milk thistle and roots of Musa Paradisiaca on Testosterone Propionate-Induced Benign prostatic hyperplasia in male wistar rats.

Methods: A total of 36 male rats were used in this study. They were grouped into 6 groups of 6 rats each. Benign prostate hyperplasia was induced in the rats using the intraperitoneal administration of 5 mg/kg testosterone propionate injection subcutaneously and 1 hour later treated with polyherbal extract for 28 consecutive days. Semen sample was collected for spermatozoa quality, morphology and gonadosomatic indices using standard protocols.

Results: The study showed that the induction of BPH brought about some adverse effect on spermatozoa proportion, quality, normal spermatozoa and testicular and prostate weight relative to normal control. Sperm abnormalities like those with bent mid-piece were seen. The findings showed that the administration of SVMM extract had a significant positive impact on the sperm cell abnormalities, significant reduction in testicular and prostate weight thus, leading to the restoration of the sperm cell morphology and potentially improving fertility.

Conclusions: These findings demonstrated that the use of SVMM can reduce the harmful effects of Testosterone Propionate-Induced Benign prostatic hyperplasia (BPH) and enhance fertility by restoring the quality semen and sperm morphology to their normal state in rats.

Key words: Benign prostatic hyperplasia, Milk thistle, Musa paradisiacal, Stinging nettle, Testosterone Propionate, Vernonia amygdalina

Male infertility is accountable for approximately 40–50% of cases of infertility. It is characterized by low sperm production, abnormal sperm function, obstructions that impede the transportation of sperm, Injuries, chronic health issues, lifestyle choices (Obukohwo *et al.,* 2021). In addition to the factors mentioned, there may be other elements that can contribute to male infertility.

Benign prostatic hyperplasia, also referred to as BPH, is an immuno-inflammatory disease which is characterized by the non-cancerous enlargement of the prostate gland, caused by uncontrolled hyper-plastic growth of the epithelial cells. It is a common condition that often occurs as men age. They are characterized by the rapid growth and spread of cells. The prostate gland, which is part of the male reproductive system, can become enlarged due to various factors, such as hormonal changes and age (Das *et al*., 2023). Occasionally, chronic bladder outlet obstruction can occur as a consequence of BPH, which can potentially result in urinary retention (Wilson *et al*., 2022), impaired kidney function, gross haematuria, bladder stones, and frequent urinary tract infections (Powell *et al*., 2020).

Male infertility due to BPH can be treated when the underlying pathology being BPH is addressed.

Medical treatment is typically the initial approach for most patients. Considering the significance of DHT in the progression of benign prostatic hyperplasia (BPH), inhibitors of 5 alpha-reductase, such as finasteride and dustasteride, are used to prevent the conversion of testosterone into DHT and lower its levels hence suppresses hyperplastic growth of the prostate are employed in clinical treatment of BPH (Hashim *et al*., 2020; Chislett, *et al*., 2023).

The medical therapy of BPH also includes the use of α1-adrenoceptor blockers, which relax the prostatic smooth muscles e.g tamsulosin or in combination with 5α-reductase inhibitors, which reduce prostate volume, e.g finasteride (La Vignera *et a*l., 2021).

The prolonged use of testosterone can lead to an enlarged prostate and a decrease in total sperm count, sperm motility and morphology, decrease libido and erectile dysfunction (Dick *et al*., 2020; Linhares *et al*., 2022). The negative impact of this is growing at an alarming rate, becoming a significant health issue as the number of infertility cases is increasing.

There are various treatments available for BPH, such as medications, minimally invasive therapies, and surgery. Nevertheless, there is a necessity to examine the potential benefits of certain medicinal herbs as a natural and affordable treatment for benign prostatic hyperplasia in other to reduce the side effects caused by the use of conventional drugs.

Some of such common medicinal plants with various health benefits are the leaves of Stinging nettle *(Urtica dioica*)*, Vernonia amygdalina (Bitter leaf), Milk thistle* (*Silybum marianum*) and roots of *Musa paradisiaca* (Banana plant) (SVMM) respectively.

Stinging nettle (Urtica dioica) has a long medicinal history. Studies on the plant show that it has antibactericidal, antiprotozoal, antidiabetic, arthritis, gout, wound healing, anti-inflammatory and antioxidant properties (Mehra *et al*., 2023; Nenni and Karahuseyin, 2024). Studies in people suggest that stinging nettle, in combination of other herbs, may be effective at relieving symptoms and treatment of BPH (Krishnamoorthi and Kumaran, 2024).

Vernonia amygdalina (Bitter leaf) is a plant in Eastern and Western African region; it has a range of traditional and modern uses. Various extracts of *Vernonia amygdalina have* been found to elicit a number of biochemical properties including antimicrobial properties, anti-malarial, antioxidant and anti-diabetic properties (Ekozin *et al*., 2024). It is also used in culinary purposes (Ogwu *et al*., 2023)

Milk thistle (Silybum marianum) and its extracts have been to seen to elicit a number of biological activities. It is a plant known for its anti-inflammatory, antioxidant properties, hepatoprotective properties and metabolic syndrome (Chupradit *et al*., 2022; Guerrini *et al*., 2023).

Musa paradisiaca (Banana) is one of the most popular fruit for millions of people. Banana is a very important source of high calorific energy. It is not only a rich source of easily digestible carbohydrate but also provides essential vitamin B, C and several minerals

such as potassium, calcium and magnesium and several medicinal properties. Various part of banana product are used for various purposes e.g ripe fruit used as medicinal properties for the treatment of gastric ulcer (Gogola, 2020). It is known for its antioxidant activity and this activity could be due to the presence of vitamin C and E, peels of *Musa paradisiacal* have anti-diabetic activity (Oyeyinka and Afolayan 2020; Sarma *et al*., 2021). However, the ameliorating potential of polyherbal extract of SVMM on testosterone propionate-induced benign prostatic hyperplasia (BPH) in male rats is yet unknown and this necessitated the need for this study.

MATERIALS AND METHODS

Chemicals and reagents

The chemicals and reagents employed in this study were of analytical standard from reputable chemical manufacturers. The Testosterone propionate (drug) was sourced from GSK (GlaxoSmithKline) companies in the United Kingdom,

Animals

Male Wistar albino rats numbering thirty were obtained from the Abia State University, Umuahia Campus animal house and acclimatised for three weeks at the animal house at our college. The rats were treated with dignity according to the ethical guidelines for using animals for experiments.

Collection and identification of plant materials

The fresh leaves of *Stinging nettle, Vernonia amygdalina, Milk thistle* and roots of *Musa paradisiac* respectively were sourced from farmlands within Agbama-Olokoro area in Umuahia South, Abia State. The respective plant materials were properly identified and authenticated by an experienced taxonomist at the Herbarium in the Department of the Forestory, Michael Okpara University of Agriculture, Umudike, Abia State. The plant materials were then wash under a running tap water and dried to a constant weight under shade at a room temperature and coarsely ground using a mechanical grinder.

Extraction and formulation of a polyherbal extract (svmm-extract)

A quantity 200 g each of the coarsely ground *Stinging nettle*, *Vernonia amygdalina*, and *Milk thistle* and 300 g of *Musa paradisiaca* roots (i.e. in ratio 2:2:2:3 g/g) were weighed into a sterile clean container and extracted with 2.5 L of absolute ethanol for 72 hours with intermittent agitation after which the extract was filtered with a Whatman No. 1 filter paper and concentrated with a rotary evaporator. The resulting extract after the extraction and evaporation was called the SVMM-extract and used for the experiment.

Experimental design

A total of 36 mature male albino rats weighing 148 – 154 g body weight were randomly selected into 6 groups comprising equal number of rats (n = 6). The groups included;

Group 1 Normal control (received 2 mL/kg distilled water only)

Group 2 BPH control which received 2 mg/kg testosterone propionate,

Group 3 BPH + 5 mg/kg Finasteride,

Group 4 BPH + 400 mg/kg SVMM-extract

Group 5 BPH + 800 mg/kg SVMM-extract and

Group 6 Normal rats administered 800 mg/kg SVMM-extract only.

BPH was induced in the rats by the intraperitoneal administration of 5 mg/kg testosterone propionate injection subcutaneously to the rats for 28 consecutive days and BPH was confirmed in the rats by the histological examination of the prostate tissues after the treatment. The rats were fasted for 12 hours at the end of the experiment and their blood samples were collected via cardiac puncture after anaesthesia with phenol barbiturates and the epididymis was harvested for semen collection for investigations. The live animal weight and weights of the paired testes were taken, and relative testicular weight was calculated.

Collection of semen samples

The semen, including the sperm cells, was obtained from the epididymal pool. The rats were anaesthetised by chloroform inhalation, and we extracted their epididymis. A slide for examination of the semen and sperm quality was prepared by incising the caudal region of each epididymis and making a smear of the semen on the preheated sterile glass slides.

Determination semen pH

The semen pH was determined with a specialised calibrated blot paper which gives colour change corresponding to the pH of the medium it is subjected to, using the method of Ameyaw *et al.*, 2008.

Examination of semen consistency (viscosity)

The consistence was examined macroscopically. The semen consistency was a score of 1-4, with 1, 2, 3, and 4 representing watery semen, slightly water, thick and very thick semen, respectively.

Abnormal sperm proportion (sperm morphology)

The abnormal sperm proportions, including total head, twisted tail, bent mid-piece, total cytoplasmic droplets, total abnormal sperm cells, and mid-piece abnormalities, were determined according to El-Sherbiny, 1987

Spermatozoa mass motility (progressive motile sperm cells)

The spermatozoa mass motility (progressive motile sperm cells) was examined according to the procedure outlined by (El-Sherbiny, 1987). A drop of freshly collected semen samples was smeared on preheated sterile glass slides and observed under a light microscope at a magnification of x10 and x40 and subjectively scored in percentage.

Sperm concentration

A haemocytometer was used to determine the sperm cell concentrations in the semen according to the method described by (Herbert, 1992). Briefly, a dilution of 1: 200 was made using a red blood cell pipette and the semen was diluted with 10% buffered formalin solution to immobilise the sperm cells. A drop of the sperm cell solution was used to charge the haemocytometer and allowed 2 minutes on a wet paper to enable sperm cells to settle. It was then mounted on a light microscopic and observed under ×40 magnification. The spermatozoa concentration (ml) was calculated from the number of sperm cells counted x dilution factor x 0.04 $X10^6$

Statistical analysis

Our data were subjected to a one-way analysis of variance (ANOVA) and Duncan multiple range comparison test with Statistical Products and Service Solutions (SPSS) version 22. The statistical significance of our analysed data was obtained at $P < 0.05$. The results were presented as mean ± standard deviation (n = 6), with results with unlike superscripts being significantly different from the corresponding paired mean.

RESULTS

The consistency of epididymal reserve in bph-induced rats treated with svmm-extract on

The assessment of sperm parameters showed that the induction of BPH in rats caused no significance difference ($p>0.05$) in BPH control rats and BPH +800 mg/kg SVMM when compared to normal control in the consistency in epididymal reserve, while the group treated with BPH +400 mg/kg SVMM and 800 mg/kg SVMM extract only showed a significant increase ($P<0.05$) in the consistency of epididymal reserve.

The effect of svmm-extract on ph of epididymal reserve in bph-induced rats

There was significant reduction ($P<0.05$) in the pH of BPH control compared to the normal control. While in the BPH-treated groups, the administration of the standard drug and extract exhibited significant increase ($P<0.05$) in the pH of the epididymal reserve, as shown in table 3

The effect of svmm-extract on mass motility of epididymal sperm reserve in bph-induced rats

The result in table 3, the BPH control showed a slight decrease though not significant ($p>0.05$) in mass motility compared with normal control. However, the BPH-treated groups exhibited a significant increase ($P<0.05$) in mass motility with the highest recorded in 800 mg/kg SVMM extract only.

Also, BPH-treated groups exhibited a significant increase ($P<0.05$) in live proportion in spermatozoa reserve when compared with BPH control though the increase was not significant

Effect of svmm-extract on proportion of normal spermatozoa in bph-induced rats

There was a significant decrease ($P<0.05$) in proportion of normal spermatozoa in BPH-induced rats

compared with normal rats. However the administration of the standard drug and SVMM led to a significant increase (P<0.05) in proportion of normal spermatozoa in BPH-induced rats compared with BPH control as seen in table 3

Effect of svmm-extract on total abnormal spermatozoa in bph-induced rats

The result in table 3 showed that induction of BPH caused a significant increase (P<0.05) in total abnormal proportion spermatozoa in BPH control compared with normal rats. However, the BPH-treated groups and standard drug exhibited a significant decrease (P<0.05) in total abnormal proportion spermatozoa compared with BPH control.

Effect of svmm-extract on differential sperm morphology in bph-induced rats

The results in Table 4 indicated a significant increase (P<0.05) in the total tail abnormality in the sperm cells in BPH-control relative to normal control, while the administration of the standard drug and SVMM caused a significant reduction in the total tail abnormality in the sperm cell. However the group that received 800mg/kg extract only had the highest activity

Again, the BPH-induced rats treated with 400mg/kg, 800 mg/kg and only 800 mg/kg SVMM-extract significantly decreased the total head and mid piece abnormality in the sperm cells compared to BPH-control as seen table 4

Effect of svmm-extract on cytoplasmic droplets

As seen in table 4, it was observed that the induction of BPH caused a significant increase (P<0.05) in cytoplasmic droplets in BPH-control relative to normal control. On the other hand the group given 400mg/kg, 800 mg/kg and only 800 mg/kg SVMM-extract significantly reduced the cytoplasmic droplets relative to BPH-control, although the group that received 800mg/kg extract only performed better

Effect of svmm-extract on total abnormal sperm cells

As shown in table 4, there was a significant rise (P<0.05) in the total abnormal sperm cell in BPH-control compared with the normal control. In contrast, the BPH-treated groups with SVMM had a significant decline in total abnormal sperm cell relative to the BPH-control

Effect of svmm-extract on total normal sperm cells

The BPH-treated groups showed a significant rise in the normal sperm cells compared with BPH-control, which had a significant reduction in normal sperm cells relative to the normal rats as shown in table 4

Effect of svmm on gonadosomatic indices of bph-induced rats

As seen in table 5, there was no significance difference (P. 0.05) in the live animal weight between the normal rats and BPH-control.

There was no significant difference in paired testicular weight in normal control, BPH-control and the standard drug. Conversely, the BPH+400mg/kg and BPH+800mg/kg SVMM-extract showed a considerable increase and 800 mg/kg SVMM-extract showed a significant decrease compared with the BPH-control.

However, the BPH-control showed a significant increase (P<0.05) in the prostate weight relative to normal control as shown in table 5. While, the BPH-treated groups had a significant reduction in the prostate weight relative to BPH control.

Table 1 Acute toxicity study of svmm-extract

Group	Dose (mg/kg)	No. of death	Observation
1	10	0/3	Animals were active and physically stable. Signs of toxicity like agitations, roughness of hairs, depression, writhing reflexes and death were absent.
2	100	0/3	Animals were active and physically stable. Signs of toxicity like agitations, roughness of hairs, depression, writhing reflexes and death were absent.
3	1000	0/3	Animals were active and physically stable. Signs of toxicity like agitations, roughness of hairs, depression, writhing reflexes and death were absent.

Table 2. Phase 2 LD_{50} results

Group	Dose (mg/kg)	No. of death	Observation
1	1600	0/3	Animals were active and physically stable. Signs of toxicity like agitations, roughness of hairs, depression, writhing reflexes and death were absent.
2	2900	0/3	Animals were calm and physically inactive for about 25 minutes but regained physical activity thereafter. Signs of toxicity like agitations, roughness of hairs, depression, writhing reflexes and death were absent.
3	5000	0/3	Animals were calm and physically inactive for about 2 hours, but regained physical activity thereafter. Signs of toxicity like agitations, roughness of hairs, depression, writhing reflexes and death were absent.

LD_{50} > 5000 mg/kg body

Table 3. Spermatozoa quality of BPH induced rats treated with SVMM-extract

Treatment groups	Consistency of Epididymal Reserve (1-4)	pH of epididymal reserve	Mass Motility of epididymal sperm reserve (20-100%)	Live proportion of Epididymal Spermatozoa Reserve (1-100%)	Concerntrates of epididymal sperm reserve x10^6/cells)	Proportion of normal spermatozoa (%)	Proportion of total abnormal spermatozoa (%)
Normal control	3.00±0.00^{a,b}	6.96±0.02^{c}	82.91±8.78^{a,b}	87.53±4.21^{a}	120.52±14.54^{b}	90.40±1.12^{b}	9.60±1.12^{a}
BPH control	3.33±1.15^{a,b}	6.69±0.02^{a}	79.68±3.46^{a,b}	88.93±5.87^{a}	130.01±5.29^{b}	79.43±1.29^{a}	20.57±1.29^{b}
BPH + 5 mg/kg Finasteride	2.33±0.58^{a}	6.87±0.02^{b}	74.84±7.27^{a}	87.51±5.31^{a}	105.95±11.40^{a}	89.62±2.87^{b}	10.38±2.87^{a}
BPH + 400 mg/kg SVMM-extract	3.67±0.58^{b}	6.94±0.03^{c}	88.71±8.80^{b}	94.23±3.67^{a}	125.945±1.37^{b}	91.55±0.48^{b}	8.45±0.48^{a}
BPH + 800 mg/kg SVMM-extract	3.33±0.58^{a,b}	6.97±0.01^{c}	79.53±0.73^{a,b}	89.02±0.11^{a}	122.93±0.99^{b}	91.34±0.32^{b}	8.66±0.32^{a}
800 mg/kg SVMM-extract only	4.00±0.00^{b}	6.93±0.07^{b,c}	86.43±4.73^{a,b}	93.63±2.37^{a}	129.02±0.65^{b}	89.74±1.84^{b}	10.26±1.84^{a}

Values are presented as mean ± standard deviation (n = 6); values with different letter superscripts are significantly ($p < 0.05$) different from paired mean within the column.

Table 4. Differential sperm morphology of BPH-induced rats treated with SVMM-extract

Treatment groups	%Sperm with Tail abnormality	% Sperm with Head abnormality	% sperm with Mid Piece Abnormality	% Sperm with Cytoplasmic droplets	Total Abnormalities	% Normal sperm cells
Normal control	1.26±0.13^{a}	1.34±0.17^{a}	1.49±0.03^{a}	2.20±0.07^{a}	6.29±0.26^{a}	93.71±0.26^{d}
BPH control	7.09±0.35^{d}	9.07±0.697^{c}	3.87±0.11^{c}	13.10±0.76^{d}	33.13±0.31^{d}	66.87±0.31^{a}
BPH + 5 mg/kg Finasteride	3.33±0.39^{c}	3.07±0.61^{b}	1.71±0.05^{a}	7.57±1.01^{c}	15.69±1.48^{c}	84.31±1.48^{b}
BPH + 400 mg/kg SVMM-extract	2.17±0.16^{b}	2.97±0.06^{b}	2.15±0.06^{b}	7.32±1.05^{c}	14.61±1.10^{c}	85.39±1.10^{b}
BPH + 800 mg/kg SVMM-extract	2.67±0.36^{b}	2.67±0.15^{b}	2.42±0.29^{b}	4.93±0.36^{b}	12.70±0.59^{b}	87.30±0.59^{c}
800 mg/kg SVMM-extract only	1.59±0.39^{a}	1.13±0.07^{a}	1.70±0.25^{a}	2.31±0.12^{a}	6.73±0.47^{a}	93.27±0.47^{d}

Values are presented as mean ± standard deviation (n = 6); values with different letter superscripts are significantly ($p < 0.05$) different from paired mean within the column.

Table 5. Gonadosomatic indices of BPH induced rats treated with SVMM-extract

Treatment groups	Animal live Weight (g)	Paired Testicular Weight (g)	Prostate weight (g)
Normal control	144.67±8.48[a]	2.45±0.03[a,b]	0.11±0.06[a]
BPH control	164.00±8.66[a]	2.46±9.13[a,b]	2.14±0.59[b]
BPH + 5 mg/kg Finasteride	154.67±1.15[a]	2.38±0.20[a,b]	0.37±0.02[a]
BPH + 400 mg/kg SVMM-extract	160.33±7.51[a]	2.59±0.01[b]	0.47±0.03[a]
BPH + 800 mg/kg SVMM-extract	166.67±6.74[a]	2.64±0.23[b]	0.35±0.10[a]
800 mg/kg SVMM-extract only	154.67±8.48[a]	2.23±0.18[a]	0.12±0.06[a]

Values are presented as mean ± standard deviation (n = 6); values with different letter superscripts are significantly ($p < 0.05$) different from paired mean within the column.

DISCUSSION

In this study, we investigated the effect of polyherbal extract SVMM on spermatozoa quality, differential sperm morphology and gonadosomatic indices of benign prostate hyperplasia induced-rats. Benign prostate hyperplasia (BPH) is a common condition in men, particularly as they get old. It is an increase in prostatic stromal and epithelial cells that causes a non-malignant enlargement of the prostate. It is one of the factors associated with male infertility, although only BPH may not directly cause male infertility but can lead to certain complications that may influence infertility.

Rats induced with BPH in this work, showed no significant difference in the consistency of epididymal reserve compared with normal control. BPH-treated group however had a significant increase in epididymal reserve compared with the BPH-control suggesting that SVMM-extract had a positive influence on the epididymal reserve and possess a therapeutic ability to boost consistency of epididymal reserve.

The significant decrease in pH of BPH-control compared with the normal control could be attributed to the deleterious effects of testosterone-propionate on the prostate gland. pH plays an essential role in maintaining the functionality of spermatozoa during fertilization. The ph of a seminal fluid may play a significant role in sperm function. An acidic ejaculate may be an indication of blockage of seminal vesicles. It has also been reported in the literature that pH has a correlation with sperm count and motility (Dhumal *et al*., 2021). However there was no difference in the pH of normal control and BPH-induced rats treated with SVMM-extract, indicating the protective ability of the extract on rats and restoration of optimum pH of the BPH-control.

Sperm motility is the capability of sperm to effectively move or swim through the female partner's reproductive system to fertilize an egg. The percentage of spermatozoa that can move, the number of spermatozoa present, and the shape of the sperm are the main factors used to determine fertility in men. BPH control exhibited decrease compared to the normal control though not significant. In contrary, the BPH control treated with 400 mg/kg SVMM extract showed significant increase relative to BPH control. The significant increase in the percentage of spermatozoa mass motility of SVMM extract suggests that the extract possess the potential to boost spermatozoa mass motility. It could also have promoted the best conditions for sperm cell development and maturation, as well as enhancing their viability and mobility to achieve successful fertilization without any external help.

The proportion of the normal spermatozoa was significantly lower in BPH control compared to the normal control. The significant decline of the normal spermatozoa proportion in the BPH control relative to the normal control indicated that administration caused a significant decrease in the fertility and reproductive potentials of the rats, in line with the earlier reports. This decline in the normal spermatozoa proportion and the increase in total abnormal sperm cells in the BPH control showed that testosterone propionate administration negatively affected the quality of

spermatozoa in the rats, which would affect the ejaculated sperm to fertilize a viable egg. However the administration of SVMM extract lead to significant increase in proportion of normal spermatozoa relative to the BPH control indicating the efficacy of the extract in improving and increasing normal sperm count and sperm morphology, similar to the findings of Asare et al., who found the Rauwolfia Vomitoria Aqueous root extract as a potential natural oral treatment for BPH, which is effective in increasing normal sperm count, reducing prostate size and PSA level. It could also be used in treatment for decreased normal spermatozoa proportion or infertility. The mechanism by which the extract was able to increase normal spermatozoa might be due to level of phenolic compounds present in the extract. A variety of polyphenols are known to have the potential to inhibit testosterone 5α reductase enzyme activity, preventing dihydrotestosterone conversion (DHT).

The size and shape of sperm in semen can be determined by examining them under a microscope, a process known as sperm morphology. A significant proportion of sperm with normal shape and structure is necessary to enhance the chances of fertilizing an egg. The decrease in the number of sperm cells with normal shape may suggest that achieving fertilisation through sexual intercourse may be challenging, but through assisted fertilisation, it becomes more feasible. These findings align with previous studies that have shown that even low levels of abnormal sperm morphology can negatively impact the fertilisation rate (Colpi *et al*., 2018; Uroko *et al*., 2022).

The significantly increased total tail, head, bent mid-piece abnormality and total abnormal sperm in the BPH control relative to the normal control indicated the negative effects of testosterone propionate on the sperm morphology. This discovery aligns with previous studies that have shown that changes in the shape and movement of sperm cells can fertility.

The significant reduction in total cytoplasmic droplets of sperm in the BPH-treated group relative to the BPH control showed that SVMM has no toxic effects on the sperm morphology. These findings suggest that ingestion of SVMM could reduce sperm abnormalities and proffer protective effects on the sperm cells. The presence of excess residual cytoplasm (cytoplasmic droplets) on spermatozoa is said to be associated with infertility. A recent review indicated that elimination of the droplets during ejaculation maybe prognostic for fertility, while retention may indicate infertility or poor sperm motility (Moretti *et al*., 2022).

There is no significantly reduction in animal live weight of the BPH control relative normal control and BPH rats treated with SVMM respectively. Also, in paired testicular weight, there is no significant difference among normal control and BPH control. In contrast, there was significant reduction in the paired testicular weight in BPH+ 800 mg/kg SVMM and 800 mg/kg SVMM-extract only compared to BPH control and relatively normal animals that were not induced with BPH indicating that having normal relative testicular weight is crucial for producing an adequate amount of semen volume, with highly motile sperm cells to promote male fertility.

The effect of SVMM extract on the prostate weight was studied and the result showed that there was significant decrease in relative to weight of the prostate following the administration of the extract to animals that had induced benign prostate hyperplasia (BPH) i.e. the BPH control. This study showed that the SVMM ameliorated the enlargement of the prostate on BPH control.

CONCLUSIONS

In conclusion, the SVMM extract ameliorated the testosterone induced BPH toxicities in sperm cells thereby enhancing sperm motility, sperm count and overall fertility in rats. The pharmacological activities exhibited by Stinging nettle *(Urtica dioica*), *Vernonia amygdalina (Bitter leaf), Milk thistle* (*Silybum marianum*) and roots of *Musa paradisiaca* (Banana plant) (SVMM) are due to the synergistic actions of the phytochemicals contained in the medicinal plants.

CONFLICTS OF INTEREST

All authors declare that they have no conflicts of interest.

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