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Changes in Prostate Specific Antigen and Acid Phosphatase of Benign Prostatic Hyperplasia Induced Male Albino Rats Fed with Cooked *Phaseolus Vulgaris* (Black Bean) Juice

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ABSTRACT: Benign prostatic hyperplasia (BPH) is a common non-malignant enlargement of the prostate gland in ageing males and is associated with hormonal imbalances, inflammation and biochemical alterations. It could be detected biochemically through prostate-specific antigen (PSA) and prostatic acid phosphatase (PAP) assay. Plant-based interventions have gained increasing attention due to their affordability, safety, and rich phytochemical composition. Phaseolus vulgaris (black bean) is a legume containing phenolics, flavonoids, and bioactive peptides with antioxidant and anti-inflammatory properties, but its effect on prostate biomarkers has not been clearly established. This study investigated the effect of cooked black bean juice on PSA and PAP levels in testosterone-propionate induced BPH male albino rats. Twenty-four adult rats (150–280 g) were divided into four groups after induction of BPH by subcutaneous testosterone propionate. Animals were treated with graded doses of cooked P. vulgaris juice (low, medium, and high), while the control group received no extract. Serum PSA (ng/mL) and PAP (IU/L) were analyzed before and after treatment. Results showed that induction of BPH significantly elevated PSA and PAP. Administration of cooked black bean juice produced significant reductions ($p < 0.05$) in both biomarkers across all treated groups. PAP decreased from 11.55 ± 0.76 to 7.62 ± 0.93 in the high-dose group, 11.42 ± 0.98 to 7.32 ± 0.66 in the medium-dose group, and 10.73 ± 1.49 to 7.15 ± 0.68 in the low-dose group. PSA declined correspondingly from 3.12 ± 0.46 to 1.79 ± 0.58, 3.04 ± 0.54 to 1.77 ± 0.69, and 2.94 ± 0.40 to 1.22 ± 0.48 respectively. A strong positive correlation existed between PSA and PAP ($r = 0.97$, $p = 0.000$), indicating that reductions in these markers were closely related. The study concludes that cooked P. vulgaris juice exerts beneficial effects on prostate biochemical indices in BPH and may serve as a natural therapeutic adjunct in prostate health management

KEYWORDS: Prostate specific antigen, Acid phosphatase, Benign prostatic hyperplasia, *Phaseolus vulgaris,* Testosterone, Rats.

1.0 INTRODUCTION

The prostate gland is an essential component of the male reproductive system, responsible for producing approximately 20–30% of seminal fluid, which aids sperm motility and viability (McVary, 2021). Anatomically, the prostate is a walnut-shaped exocrine gland located inferior to the urinary bladder and encircling the prostatic urethra. Its secretions contain enzymes such as prostate-specific antigen (PSA) and acid phosphatase in addition to citric acid, and zinc, all of which contribute to semen liquefaction and fertility (Hoffmann et al., 2022). With advancing age, the prostate undergoes morphological changes mediated by hormonal alterations, particularly the increased conversion of testosterone to dihydrotestosterone (DHT) via 5-alpha reductase. This androgenic shift drives cellular proliferation in the stromal and epithelial components, predisposing men to benign prostatic hyperplasia (BPH) (Carson and Rittmaster, 2020).

BPH is a highly prevalent non-malignant enlargement of the prostate affecting more than 50% of men above 50 years and up to 80% of men over 70 years globally (Fowler and Kirby, 2020). The pathophysiology is multifactorial, involving endocrine dysregulation, chronic inflammation, oxidative stress, and stromal-epithelial interactions (Madersbacher et al., 2019). The enlargement of the prostate progressively compresses the urethra, leading to lower urinary tract symptoms (LUTS) such as nocturia, hesitancy, weak urinary stream, and incomplete bladder emptying. Although BPH is not malignant, its symptoms can significantly impair quality of life, and untreated cases may lead to acute urinary retention, bladder hypertrophy, or renal impairment (Roehrborn, 2021). Due to these complications, screening and monitoring of prostate function rely heavily on biochemical markers, imaging, and clinical evaluation.

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PSA is one of the most widely used biomarkers for prostate health assessment. It is a kallikrein-related serine protease produced by prostatic epithelial cells and released into seminal fluid, but small quantities enter the circulation (Lilja et al., 2022). Elevated serum PSA levels are commonly associated with BPH, prostatitis, and prostate cancer, making it a sensitive but non-specific marker (Hayes and Barry, 2019). Although PSA lacks perfect diagnostic specificity, it remains a valuable tool for monitoring disease progression and response to therapy, particularly in experimental BPH models. Another clinically relevant biomarker is prostatic acid phosphatase (PAP), also known as acid phosphatase (ACP). PAP is a lysosomal enzyme predominantly synthesized by the prostate gland, and its serum concentration increases in conditions affecting prostatic tissue integrity (Bostwick, 2020). Historically, PAP was the primary biochemical marker for prostate disease until the advent of PSA testing. However, PAP remains relevant in experimental research and pathophysiological studies of BPH because it reflects secretory function and glandular cellular activity (Hernandez et al., 2021). Elevated PAP in BPH results from increased epithelial secretion and disrupted cellular architecture associated with hyperplasia.

Animal models, especially testosterone-propionate-induced BPH in rats, are extensively used to study the pathology and evaluate therapeutic agents. Testosterone administration stimulates prostate enlargement, increases PSA and PAP levels, and reproduces the hormonal environment characteristic of human BPH (Timothy et al., 2022). This makes the model suitable for investigating plant extracts with potential anti-androgenic, anti-inflammatory or antioxidant properties. In recent years, medicinal plants and food-based extracts have gained significant attention for managing BPH due to their accessibility, safety, and presence of bioactive phytochemicals. Dietary legumes such as Phaseolus vulgaris (black bean) contain flavonoids, phenolic acids, tannins, saponins, and bioactive peptides with reported antioxidant, hypolipidemic, anti-inflammatory, and hormonal-modulating properties (Sánchez-Chino et al., 2020). Black beans in particular have been shown to enhance metabolic health, modulate oxidative stress, and suppress inflammatory pathways (Diaz-Balteiro et al., 2023). Their phytochemical constituents have also demonstrated enzyme-inhibitory activities, including reduction of 5-alpha reductase activity, which is a key therapeutic target in BPH management (Hernandez-Martinez et al., 2021). Despite these promising properties, scientific evidence supporting the effect of cooked P. vulgaris juice on prostate biomarkers such as PSA and PAP remains limited.

The use of dietary plants as natural therapies for prostate disorders aligns with the growing interest in nutraceutical approaches. Several clinical and experimental studies support the idea that plant-derived compounds can attenuate prostate enlargement, reduce oxidative stress, improve urinary symptoms, and modulate prostate-related biochemical markers (Anderson and Loeb, 2022). Legume extracts have shown anti-proliferative effects on androgen-dependent tissues, suggesting potential benefits for prostate health. Cooked beans also yield protein hydrolysates and phenolic-rich fractions that may exert biological activity capable of influencing prostate biochemical indices (Martinez-Vergara et al., 2022).

Given the global burden of BPH and the limitations of existing pharmacological treatments—including adverse effects from alpha-blockers and 5-alpha reductase inhibitors—there is a need to investigate safe, cost-effective alternatives. Exploring the therapeutic potential of black bean juice provides an opportunity to expand dietary-based interventions for prostate health. This study therefore evaluates the effect of cooked Phaseolus vulgaris black bean juice on PSA and PAP levels in testosterone-induced BPH in male albino rats. The findings are expected to contribute to the understanding of plant-derived agents in managing BPH and improving prostate biochemical functions.

2.0 MATERIALS AND METHODS

Twenty-four (24) healthy adult male albino rats weighing between 150–280 g were used for this study. The animals were housed under standard laboratory conditions with a 12-hour light/dark cycle, ambient temperature of 25 ± 2°C, and were allowed free access to standard commercial feed and clean water throughout the period of the experiment. After a two-week acclimatization period, the rats were randomly divided into four groups of six animals each. Benign prostatic hyperplasia (BPH) was induced in all experimental groups by subcutaneous administration of testosterone propionate for two weeks, a method widely established for mimicking hormonal and biochemical changes associated with BPH in humans. Following induction, three groups were treated orally with graded doses (low, medium, and high) of cooked Phaseolus vulgaris (black bean) juice, while the control group received no extract treatment. The black beans were washed thoroughly, cooked in clean water until soft. It was blended and the aqueous juice was collected by filtration and administered fresh daily. Blood samples were collected from the rats at baseline (before treatment) and at the end of the treatment period using standard retro-orbital techniques under light anaesthesia. The blood samples were centrifuged

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at 3000 rpm for 10 minutes to obtain serum, which was stored at −20°C until analysis. Serum prostate-specific antigen (PSA) levels were measured using enzyme-linked immunosorbent assay (ELISA) techniques and expressed in ng/mL, while prostatic acid phosphatase (PAP) levels were determined using spectrophotometric enzymatic methods and expressed in IU/L. All data were presented as mean ± standard error of mean (SEM). Statistical analysis was carried out using one-way analysis of variance (ANOVA), followed by appropriate post-hoc tests to compare group means. Pearson's correlation analysis was used to assess the relationship between PSA and PAP levels. Statistical significance was accepted at $P < 0.05$.

3.0 RESULTS

The effects of cooked Phaseolus vulgaris black bean juice on serum prostatic acid phosphatase (PAP) and prostate-specific antigen (PSA) levels in testosterone-induced benign prostatic hyperplasia (BPH) rats are presented in Tables 4.1–4.3.

Table 4.1showing mean levels and post-hoc analysis of PAP (IU/L) before and after treatment with cooked black bean juice

Variables	High dose	Medium dose	Low dose	Control
PAP (before)	11.55±0.76	11.42±0.98	10.73±1.49	3.03±0.68
PAP (after)	7.62±0.93	7.32±0.66	7.15±0.68	5.48±1.53

PAP means prostatic acid phosphatase and P<0.05 is considered significant

Table 4.2 showing mean levels and post-hoc analysis of PSA (ng/ml) before and after treatment with cooked black bean juice

Variables	High dose	Medium dose	Low dose	Control
PSA (before)	3.12±0.46	3.04±0.54	2.94±0.40	0.02±0.01
PSA (after)	1.79±0.58	1.77±0.69	1.22±0.48	0.07±0.02

P<0.05 is considered significant

Table 4.3 pearson's correlation between PSA and PAP

Variables	Correlation coefficient (r)	p-value
PSA vs ACP	0.97	0.000

P<0.05 is considered significant

Results summary

Table 4.1 shows the mean serum levels of PAP before and after treatment with cooked black bean juice. Prior to treatment, PAP levels were markedly elevated in all induced groups, with mean values of 11.55 ± 0.76 IU/L, 11.42 ± 0.98 IU/L, and 10.73 ± 1.49 IU/L in the high-, medium-, and low-dose groups respectively, compared to 3.03 ± 0.68 IU/L in the control group. Following treatment, a significant reduction ($P < 0.05$) in PAP levels was observed in all treated groups. The high-dose group showed a decrease to 7.62 ± 0.93 IU/L, the medium-dose group to 7.32 ± 0.66 IU/L, and the low-dose group to 7.15 ± 0.68 IU/L. In contrast, the control group showed an increase in PAP level to 5.48 ± 1.53 IU/L after the experimental period but was still significantly lower than the values after induction and treatment.

Table 4.2 presents the serum PSA levels before and after administration of cooked black bean juice. Before treatment, PSA levels were significantly elevated in all induced groups relative to the control, with values of 3.12 ± 0.46 ng/mL, 3.04 ± 0.54 ng/mL, and 2.94 ± 0.40 ng/mL in the high-, medium-, and low-dose groups respectively, compared to 0.02 ± 0.01 ng/mL in the control group. After treatment, PSA levels significantly decreased ($p < 0.05$) across all treatment groups. The high-dose group decreased to 1.79 ± 0.58 ng/mL, the medium-dose group to 1.77 ± 0.69 ng/mL, and the low-dose group to 1.22 ± 0.48 ng/mL. The control group, also in contrast, showed a slight increase in PSA level to 0.07 ± 0.02 ng/mL after experimental period but was still significantly lower than values after induction and treatment.

Table 4.3 shows the Pearson's correlation analysis between PSA and PAP levels. A strong positive correlation was observed between PSA and PAP ($r = 0.97$), which was statistically significant ($p = 0.000$). This indicates that increases or decreases in PSA levels were closely associated with corresponding changes in PAP levels.

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4.0 DISCUSSION

Benign prostatic hyperplasia (BPH) is a hormonally driven condition characterized by progressive enlargement of the prostate gland and alterations in prostate-specific biochemical markers. In this study, testosterone propionate successfully induced BPH in male albino rats, as evidenced by markedly elevated serum prostate-specific antigen (PSA) and prostatic acid phosphatase (PAP) levels prior to treatment. This observation is consistent with previous reports that exogenous testosterone increases androgenic stimulation of prostatic tissue, leading to epithelial hyperplasia, stromal proliferation, and increased secretory activity of the prostate gland (Madersbacher et al., 2019; Roehrborn, 2021). The significant elevation of PSA observed in the induced groups before treatment aligns with the established role of PSA as a sensitive indicator of prostate tissue activity and disruption of the prostate epithelial barrier in BPH. Increased PSA levels in BPH are attributed to enhanced androgen-driven cellular proliferation and increased leakage of PSA into the circulation due to altered glandular architecture (Lilja et al., 2022). Similarly, the elevated PAP levels observed before treatment reflect increased lysosomal enzyme activity associated with hyperplastic prostatic tissue, supporting its relevance as a biochemical marker in experimental BPH models (Hernandez et al., 2021).

Administration of cooked Phaseolus vulgaris juice resulted in a statistically significant reduction ($P < 0.05$) in both PSA and PAP levels across all treated groups. This finding suggests that black bean juice exerted a protective and modulatory effect on prostate tissue following androgen-induced hyperplasia. The reduction in PSA levels indicates a decrease in prostate epithelial activity and secretory output, while the decline in PAP levels suggests restoration of cellular integrity and reduced hyperplastic activity within the prostate gland. These effects were observed consistently across low, medium, and high doses, with the high-dose group showing the greatest numerical reduction, implying a possible dose-dependent response. The beneficial effects observed may be attributed to the rich phytochemical composition of Phaseolus vulgaris. Black beans are known to contain high levels of flavonoids, phenolic acids, tannins, saponins, and bioactive peptides, all of which possess antioxidant and anti-inflammatory properties (Sánchez-Chino et al., 2020). Oxidative stress and chronic inflammation play central roles in the pathogenesis of BPH by promoting stromal-epithelial interactions and androgen receptor signaling (Anderson and Loeb, 2022). Therefore, the antioxidant activity of black bean constituents may have mitigated oxidative damage within the prostate tissue, thereby reducing biochemical marker expression.

Furthermore, some plant-derived compounds have been shown to inhibit 5-alpha reductase, the enzyme responsible for converting testosterone to the more potent androgen dihydrotestosterone (DHT), which is a key driver of prostate enlargement (Carson and Rittmaster, 2020). Although the present study did not directly measure DHT levels or enzyme activity, the observed reduction in PSA and PAP suggests that cooked black bean juice may interfere with androgen-mediated signaling pathways involved in prostate hyperplasia. The strong positive correlation between PSA and PAP observed in this study ($r = 0.97$, $p = 0.000$) further supports the interrelated nature of these biomarkers in reflecting prostate pathology. This finding is consistent with earlier studies demonstrating that PSA and PAP often rise concurrently in prostate disorders due to shared regulatory mechanisms and cellular origin (Bostwick, 2020). The significant correlation observed indicates that therapeutic interventions targeting prostate hyperplasia may simultaneously influence multiple prostate biomarkers.

Comparatively, several studies on plant-based therapies such as Serenoa repens, Pygeum africanum, and other legume-derived extracts have reported reductions in prostate weight, PSA levels, and inflammatory markers in both animal and human studies (Fowler and Kirby, 2020; Kim et al., 2021). The present findings are in agreement with these reports and further extend the potential therapeutic role of dietary legumes, particularly Phaseolus vulgaris, in prostate health management. The increase in PSA and PAP observed in the untreated control group after the experimental period further confirms the progressive nature of BPH in the absence of intervention. This underscores the importance of therapeutic strategies aimed at modulating prostate biochemical activity to prevent disease progression.

Therefore, the results of this study suggest that cooked Phaseolus vulgaris (black bean) juice exerts a protective effect against testosterone-induced BPH by significantly reducing serum PSA and PAP levels. These findings support the growing interest in nutraceutical and dietary approaches as complementary strategies for managing BPH, especially in resource-limited settings where access to conventional pharmacotherapy may be restricted.

5.0 CONCLUSION

In conclusion, cooked black bean juice shows promising potential in attenuating biochemical alterations associated with BPH and may contribute to the development of nutraceutical-based interventions for prostate disorders. Further studies involving

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histopathological evaluation, hormonal profiling, and clinical trials are recommended to elucidate the exact mechanisms of action and to validate its applicability in human BPH management.

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