THERAPEUTIC EFFECTS OF *FERULA MOSCHATA* ROOT ON TESTICULAR CHANGES IN MALE RATS WITH CHRONIC KIDNEY DISEASE

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Introduction. Chronic kidney disease (CKD) is a progressive and globally increasing health burden, affecting over 850 million people worldwide and estimated to become the fifth leading cause of death by 2040. In addition to renal insufficiency, CKD is associated with systemic complications, including reproductive dysfunction in males. These complications often manifest as hypogonadism, reduced testosterone secretion, impaired spermatogenesis, and testicular atrophy, leading to infertility (Amini et al., 2019; Gomes et al., 2021).

The underlying mechanisms of CKD-induced gonadal dysfunction are multifactorial, involving hormonal imbalances, oxidative stress, and accumulation of uremic toxins that disrupt both the hypothalamic-pituitary-gonadal axis and testicular structure. Testicular injury in CKD is characterized by degenerative changes in seminiferous tubules, thinning of the spermatogenic epithelium, and fibrosis. Conventional therapies provide limited improvement and may cause adverse effects, stimulating interest in phytotherapeutic strategies.

Ferula moschata (Sumbul root), traditionally used in Asian and Middle Eastern medicine, has been reported to possess antioxidant, anti-inflammatory, and adaptogenic properties (Singh et al., 2017; Kumar et al., 2018). Bioactive compounds such as ferulic acid, coumarins, and sulfur-containing derivatives may reduce oxidative stress and inflammation, potentially preserving testicular function. Preclinical studies suggest that *Ferula moschata* extract improves antioxidant enzyme activity and suppresses inflammatory mediators in CKD models (Patel et al., 2020; Zhang et al., 2019). However, age-related differences in therapeutic efficacy remain underexplored.

Aim and objectives. The study aimed to investigate the therapeutic effects of *Ferula moschata* root extract on testicular morphology and morphometry in rats with CKD. The objectives were:

1. To evaluate testicular structural changes induced by CKD in rats of different ages.

2. To determine the corrective impact of *Ferula moschata* root extract on histological and morphometric parameters.

3. To assess the influence of age on treatment efficacy.

Materials and methods. The study involved 140 male Wistar rats, categorized into three age groups: 3, 6, and 9 months. Each group was divided into three subgroups: control, CKD model, and CKD + treatment. CKD was induced by glycerol nephrotoxicity following the methods of Noskova (1981) and Borisova et al. (2004).

The treatment group received an aqueous extract of *Ferula moschata* root, administered orally for 6–8 weeks. Dosage was adjusted according to age, ranging from 5–10 g dry root powder per 100 ml hot water. At the end of the experiment, testes were excised, weighed, and prepared for histological and morphometric analysis. Parameters assessed included testis weight, capsule thickness, seminiferous tubule diameter and cross-sectional area, spermatogenic epithelium thickness, lumen diameter, and epithelium-to-lumen ratio.

Histological evaluation was performed using hematoxylin and eosin (H&E) and Van Gieson staining. Data were statistically analyzed with one-way ANOVA followed by Tukey's test, with significance set at $p < 0.05$.

Results. In untreated CKD rats, pronounced atrophic changes were observed: reduced testis weight, thinner capsule, decreased seminiferous tubule diameter, and disruption of the spermatogenic epithelium. The epithelial-to-lumen ratio declined, reflecting degenerative alterations.

Treatment with *Ferula moschata* root extract showed significant age-dependent improvements.

- 3-month-old rats: Morphometric indices were nearly restored to control values, including seminiferous tubule diameter, epithelium thickness, and epithelial-to-lumen ratio (~2.5:1). Histology revealed well-organized spermatogenic layers and reduced edema.

- 6-month-old rats: Moderate recovery was observed. Tubular diameter and epithelial thickness improved compared to untreated CKD rats, but did not fully normalize. Histological analysis confirmed partial regeneration with persistent mild atrophy.

- 9-month-old rats: Limited improvement was recorded. Testicular weight remained reduced, tubular architecture was only partially restored, and degenerative changes with fibrosis persisted.

Overall, the therapeutic efficacy of *Ferula moschata* root extract decreased with increasing age, reflecting diminished regenerative capacity.

Conclusion. This experimental study demonstrated that *Ferula moschata* root extract exerts significant restorative effects on CKD-induced testicular damage, with efficacy strongly dependent on age. The most pronounced recovery was observed in

younger (3-month-old) rats, moderate improvements in 6-month-old rats, and limited benefits in older (9-month-old) animals.

The beneficial effects are likely mediated by the extract's antioxidant and anti-inflammatory properties, which help restore seminiferous tubule architecture and spermatogenic epithelium. These findings suggest that *Ferula moschata* root may serve as a promising phytotherapeutic agent for CKD-associated reproductive dysfunction, particularly if administered early in disease progression.

Further studies are recommended to clarify molecular mechanisms, assess reproductive hormone levels, and evaluate sperm function. The results provide a scientific basis for the ethnomedicinal use of *Ferula moschata* and highlight its potential in age-tailored phytotherapy.

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