

Exploring Antidiabetic Potential of Chromium-Doped Hydroxyapatite Nanoparticles in Streptozotocin-Induced Diabetic Rats

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ABSTRACT

Nanoparticles are being studied to reduce different ailments. There is an increased demand of controlled preparation of nanoparticles for technology development and different industries. The hydroxyapatite nanoparticles have rapid clearance rate from the body and are beneficial for their different applications in medical field. This study aims to assess the potential of chromium-doped hydroxyapatite nanoparticles as an antidiabetic agent. Thirty healthy male albino rats were selected, negative-control group, positive-control group and four treatment-groups having five rats respectively were assembled. Injection streptozotocin 55 mg/kg B.W was given intraperitoneally to positive-control group and treatment-groups, after which diabetes was induced in 72 hours. Then antidiabetic activity was checked by giving oral chromium-doped hydroxyapatite nanoparticles in dosage of 100 µg/kg, 300 µg/kg and 500 µg/kg body weight in male albino rats. One group of rats was given glibenclamide per-oral in dose of 20mg/kg body weight. After results antidiabetic potential was observed at 200µg dose of nanoparticles. Other parameters were also checked like lipid profile, renal function tests and two antioxidant markers MDA and catalase were analysed. The results clearly suggest that chromium-doped hydroxyapatite nanoparticles have potential to initiate hypoglycemic effect. They also reduce the values of all biochemical parameters performed (serum urea, serum creatinine and lipid profile). The management also lead to decrease in MDA and rise in catalase. It was clear from the results that glycemic control was obtained in dose dependent manner in groups treated with chromium-doped hydroxyapatite nanoparticles as compared to the group treated with glibenclamide drug.

KEY WORDS: Nanoparticles, Chromium-doped hydroxyapatite nanoparticles, Antidiabetic, Diabetes

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Introduction

Nanomedicine has been explored as a treatment for diabetes in the recent earlier period. For the therapy and management of diabetes-mellitus (DM) scientists are improving a range of antidiabetic drugs, nevertheless several are limited by their inadequate pharmacokinetic characteristics (Haq *et al.*, 2022). Several hypoglycemic substances individually or in mixture together with insulin are utilized as a remedy for diabetes mellitus. Though, the medically obtainable antidiabetic medicines frustrate equally patients and clinicians due to their inappropriate outcomes, which have progressively altered attention

in relation to the invention of innovative antidiabetic drugs (Scheen, 2023).

Nanoparticles are being studied to reduce different ailments. There is an increased demand of controlled preparation of nanoparticles for technology development and different industries (Khan *et al.*, 2022). Nanomedicine is a flourishing study zone. Many researchers are anxious just about improving safe and sound, less hazardous, along with efficient medicines to make a good remedy for ailments like diabetes, epilepsy and cancer (Abbamondi and Tommonaro, 2022).

The hydroxyapatite nanoparticles have rapid clearance rate from the body and are beneficial for

biomedical field because of the use hydroxyapatite nanoparticles in different applications. Recently microbial diseases and infections have become a foremost matter of concern in health care system (Jafari *et al.*, 2020). The properties of chromium (Cr3) on physically healthy animals i.e, rats and animal models i.e, rat models of insulin resistance and type-1 (DM) and type-2 (DM) have been observed where it was found to have advantageous properties on insulin sensitivity and, in many cases, lipid considerations (White *et al.*, 2021).

Chromium-picolinate (CrPic) is a necessary trace element that has extensively existed to be used to manage type-1, type-2, steroid induced and gestational diabetes-mellitus (DM). This research has made available novel concepts and techniques for the adjuvant management of diabetic nephropathy (DN), and deliver a theoretical foundation for the use of chromium-picolinate (CrPic) in regulating diabetes-mellitus by food (Qi *et al.*, 2020).

Materials and Methods

Preparation of Chromium-Doped Hydroxyapatite Nanoparticles

A wet chemical precipitation method was used to synthesize chromium-doped hydroxyapatite nanoparticles. Chromium chloride served as the doping agent, while calcium nitrate and ammonium phosphate were used as originators. The precipitate was aged, filtered, dried, and calcined to obtain uniform nanoparticles.

Experimental Animals

Thirty healthy male albino rats (180–220 g) were obtained and maintained under standard laboratory conditions with free access to food and water. The study was approved by the institutional ethical committee.

Experimental Design

Rats were divided into six groups (n = 5):

- **Group I:** Negative control
- **Group II:** Diabetic control (STZ only)
- **Group III:** Diabetic + Glibenclamide (20 mg/kg)
- **Group IV:** Diabetic + CD-HAp NPs (100 µg/kg)
- **Group V:** Diabetic + CD-HAp NPs (300 µg/kg)

- **Group VI:** Diabetic + CD-HAp NPs (500 µg/kg)

Induction of Diabetes

Diabetes was induced by intraperitoneal injection of STZ (55 mg/kg) dissolved in citrate buffer (pH 4.5). Rats with fasting blood glucose >250 mg/dL after 72 hours were considered diabetic.

Biochemical Analysis

Blood glucose was measured using a glucometer. Serum lipid profile (TC, TG, HDL, LDL, VLDL), renal function tests (urea, creatinine), and oxidative stress markers (MDA and catalase) were analyzed using standard biochemical kits.

Statistical Analysis

Data were expressed as mean ± SD. One-way ANOVA followed by Tukey's post hoc test was applied. A p-value <0.05 was considered statistically significant.

Results

CD-HAp NPs significantly reduced fasting blood glucose levels in diabetic rats in a dose-dependent manner. The 300 µg/kg dose showed the most effective reduction, comparable to glibenclamide.

Renal function tests demonstrated reduced serum urea and creatinine levels, indicating nephroprotective effects.

Lipid profile analysis revealed decreased total cholesterol, triglycerides, LDL, and VLDL, with a significant increase in HDL levels in treated groups.

Oxidative stress analysis showed increased catalase activity and decreased malondialdehyde levels, suggesting strong antioxidant potential of chromium-doped hydroxyapatite nanoparticles.

Discussion

The current study determines that chromium-doped hydroxyapatite nanoparticles employ powerful antidiabetic properties in STZ-induced diabetic rats. These hypoglycemic consequences may be accredited to chromium's aptitude to augment insulin sensitivity and increase glucose uptake through stimulation of AMPK and GLUT4 pathways (Kurek *et al.*, 2022).

Development in lipid profile designates improved metabolic parameter and reduced cardiovascular possibility, which is dependable with preceding conclusions happening on chromium supplementation (Asbaghi *et al.*, 2021). The antioxidant association

witnessed might be because of the decrease of reactive oxygen species and improvement of endogenous antioxidant enzymes.

Hydroxyapatite nanoparticles additional contribute through performing as effective carriers, enlightening chromium bioavailability and cellular uptake (Neacsu et al., 2019).

One and only of the current study evaluated the feasible valuable consequence of combined or single administration of mutual nanoparticles of zinc-oxide nanoparticles (ZnONPs), selenium nanoparticles (SeNPs), and chromium(III)oxide nanoparticles, in streptozotocin (STZ)/Fructose diabetic animal model as a method of strengthening them for bioavailability and by that resources emerging hypoglycemic significances. These antidiabetic consequences and provisions of outcomes of our learning (Hassan *et al.*, 2021).

Conclusion

A significant antidiabetic, antioxidant and nephrotoxic potential is exhibited by chromium-doped hydroxyapatite nanoparticles and shows clear effects in STZ-induced diabetic rats. These nanoparticles deal an auspicious nanotherapeutic stratagem for diabetes controlling and permit additional clinical exploration.

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Data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Author Contributions

SA and AS conceptualized and designed the study. SA, MS, SF, SH, FA, and AYM contributed to methodology, investigation, data collection, and analysis. AS supervised the study and critically revised the manuscript. SA prepared the initial draft. All authors contributed to interpretation of the findings, reviewed the manuscript, and approved the final version.

REFERENCES

- Abbamondi, G. R., & Tommonaro, G. (2022). Research Progress and Hopeful Strategies of Application of Quorum Sensing in Food, Agriculture and Nanomedicine. *Microorganisms*, 10(6): 1192.
- Asbaghi, O., Naeini, F., Ashtary-Larky, D., Moradi, S., Zakeri, N., Eslampour, E., Kelishadi, M. R., & Naeini, A. A. (2021). Effects of chromium supplementation on lipid profile in patients with type 2 diabetes: A systematic review and dose-response meta-analysis of randomized controlled trials. *Journal of Trace Elements in Medicine and Biology*, 66, 126741.
- Haq, M. N. U., Shah, G. M., Menaa, F., Khan, R. A., Althobaiti, N. A., Albalawi, A. E., & Alkreathy, H. M. (2022). Green Silver Nanoparticles Synthesized from *Taverniera couneifolia* Elicits Effective Anti-Diabetic Effect in Alloxan-Induced Diabetic Wistar Rats. *Nanomaterials*, 12(7).
- Hassan, R. M., Elsayed, M., Kholief, T. E., Hassanen, N. H., Gafer, J. A., & Attia, Y. A. (2021). Mitigating effect of single or combined administration of nanoparticles of zinc oxide, chromium oxide, and selenium on genotoxicity and metabolic insult in fructose/streptozotocin diabetic rat model. *Environmental Science and Pollution Research*, 28, 48517-48534.
- Jafari, S., Mahyad, B., Hashemzadeh, H., Janfaza, S., Gholikhani, T., & Tayebi, L. (2020). Biomedical applications of TiO₂ nanostructures: recent advances. *International journal of nanomedicine*, 3447-3470.
- Khan, Y., Sadia, H., Ali Shah, S. Z., Khan, M. N., Shah, A. A., Ullah, N., Ullah, M. F., Bibi, H., Bafakeeh, O. T., & Khedher, N. B. (2022). Classification, synthetic, and characterization approaches to nanoparticles, and their applications in various fields of nanotechnology: a review. *Catalysts*, 12(11): 1386.
- Kurek, J. M., Król, E., Staniek, H., & Krejpcio, Z. (2022). Steviol Glycoside, L-Arginine, and Chromium (III) Supplementation Attenuates Abnormalities in Glucose Metabolism in Streptozotocin-Induced Mildly Diabetic Rats

- Fed a High-Fat Diet. *Pharmaceuticals*, 15(10): 1200.
- Neacsu, I. A., Stoica, A. E., Vasile, B. S., & Andronescu, E. (2019). Luminescent hydroxyapatite doped with rare earth elements for biomedical applications. *Nanomaterials*, 9(2): 239.
- Qi, S. S., Zheng, H. X., Jiang, H., Yuan, L. P., & Dong, L. C. (2020). Protective effects of chromium picolinate against diabetic-induced renal dysfunction and renal fibrosis in streptozotocin-induced diabetic rats. *Biomolecules*, 10(3): 398.
- Scheen, A. J. (2023). Clinical pharmacology of antidiabetic drugs: What can be expected of their use? *La Presse Médicale*, 52(1), 104158.
- White, P. E., Król, E., Szwengiel, A., Tubacka, M., Szczepankiewicz, D., Staniek, H., Vincent, J. B., & Krejpcio, Z. (2021). Effects of bitter melon and a chromium propionate complex on symptoms of insulin resistance and type 2 diabetes in rat models. *Biological trace element research*, 199, 1013-1026.