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Original Article

Characterization of green-synthetized silver nanoparticles using *Astragalus brachycalyx* L. leaf extract and evaluation of its effect on diabetes in Wistar rats

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Abstract

This experiment was carried out on diabetic rats (male Wistar rats with 210±10 g body weight) in a complete randomized design with seven replications at the Laboratory of Pharmacology group, Veterinary Faculty, Shiraz University during 2022. In the present study, *A. brachycalyx* leaf extract was used for the biosynthesis of silver nanoparticles (AgNPs). This study was designed to evaluate the effect of *A. brachycalyx* leaf extract and its silver nanoparticles on diabetic rat induced by Streptozotocin. The synthesized AgNPs using *A. brachycalyx* (ABLE-AgNPs) were characterized through UV-visible spectroscopy followed by X-ray diffraction, Transmission Electron Microscopy and Fourier Transform Infrared Spectroscopy and Dynamic Light Scattering. *A. brachycalyx* extract and ABLE-AgNPs were investigated for their activities as an anti-diabetic agent in rats. The investigated treatments includes: 1. Healthy control, 2. Solvent control, 3. Diabetic rats that received *A. brachycalyx* extract with a dose of 100 mg/kg, 4. Diabetic rats that received *A. brachycalyx* extract with a dose of 200 mg/kg, 5. Diabetic rats that received 30 mg/kg of *A. brachycalyx* extract-AgNP and 6. Diabetic rats that received 60 mg/kg of *A. brachycalyx* extract-AgNP. Transmission electron microscopy revealed that the synthesized particles are found to be in range of 4–25 nm size. The dyslipidemic conditions as seen in the diabetic control were found to be significantly improved in AgNPs-treated diabetic rats. Furthermore, AgNPs reduced the blood glucose level over the period of treatment. The improvement in the body weight was also found to be evidence for *A. brachycalyx* extract-mediated AgNPs as a potential antidiabetic agent against STZ diabetic rats. The highest weight of the rat at the end of the treatment stages belonged to treatment 6 (60 mg/kg silver nanoparticles). Treatment 2 (diabetic and not receiving medicine) showed a decrease in growth and weight. The treatment 2 showed an increasing trend in the amount of blood glucose level. While the treatments using *A. brachycalyx* extract and nanoparticle showed the reduction trend of blood glucose level. Blood glucose level reduction in treatment 6 was more than other treatments (71%). This study revealed that the AgNPs are found to be safe and environmentally friendly, hence, these AgNPs can be considered in treating diabetes associated syndrome.

Keywords: *Astragalus brachycalyx* L., Silver nanoparticles, AgNPs, Glucose, Diabetes, Rats

Introduction

Diseases have arisen with the emergence of humans and the use of plants to treat them has been started since that time. The documents of several thousand years of history of medicine and pharmacy show valuable experiences and information in the field of medicinal plants. Until the last few decades, what was used as medicine was

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obtained from natural sources, mainly from plants. However, the rapid progress of science on one hand and economic issues on the other hand have reduced the use of medicinal plants by replacing plants with industrial drugs in many cases. Experiences of the last few decades have shown that synthetic chemical pharmaceutics, despite their benefits, have many undesirable and unfortunate effects. For this reason, recently, the return to the use of medicinal plants has received a lot of attention, and universities, research centers, factories and the World Health Organization have prepared extensive programs for the use of medicinal plants and have considered the role of medicinal plants in various cases as crucial, in the 21st century (Amin et al, 1991). Paying attention to medicinal plants, which form a major part of Iran's traditional medicine, and providing correct and scientific information about their cultivation, maintenance and use based on new findings, is becoming more important day by day (Rahman & Zaman, 1989).

Diabetes mellitus is an irreversible disease that is characterized by chronic hyperglycemia caused by dysfunctional lipid, carbohydrate, and protein metabolism (Parameswaran & Ray, 2022). The incidence of type 2 diabetes mellitus (T2DM) is more severe compared to that of type 1 diabetes mellitus (T1DM) and gestational diabetes (DeFronzo et al, 2015). The T2DM prevalence is about 90%, affecting approximately 460 million people worldwide, with statistics predicting an increase to over 700 million in 25 years (Saeedi et al, 2019). T1DM results from an autoimmune destruction of beta cells that produce insulin which is one of the most prevalent pediatric illnesses, with an annual incidence rate of 2-5% (Turin & Radobuljac 2021). T2DM is associated with reduced glucose tolerance due to insulin resistance (Oguntibeju, 2019). Many pharmaceutical medications are utilized to treat diabetes; nonetheless, plant-based remedies are often thought to be less toxic and devoid of adverse effects (SreeHarsha et al, 2019, Pachava et al, 2014). However, a complex drug molecule causes lower drug absorption, limiting a medicine’s bioavailability. By employing nanotechnology, a drug’s bioavailability can be improved (SreeHarsha, et al. 2019, Pachava, et al. 2014).

Owing to the progressive nature of the disease, an improved treatment strategy is required, which includes the discovery of new drugs (Modi, 2007). In addition, drug treatment is not completely successful with diabetes and there is a compelling need for better prevention and treatment strategies (Baynes et al, 1996). Nevertheless, people have been using many plants to treat diabetes empirically despite the lack of safety and efficacy (Alarcon-Aguilara et al, 1998). At this juncture, it is necessary to test herbal medicines as an alternative to synthetic agents (Grover et al, 2002).

Medicinal plants are in high demand right now and their adaptation is expanding due to their higher availability and lower toxicity to humans (Ahmed et al, 2021). Remarkably, 25% of the modern medications are derived directly or indirectly from plants, proving the strong basis for plant-derived medicine (Anand et al, 2019, 2022). Today, the green synthesis of metal nanoparticles is a promising strategy in material science and nanotechnology. Traditional Chinese medicines and their extractions demonstrate the characteristics of economy and effectiveness to cure diabetes and its complications. In traditional Chinese medicine, *Astragalus* is commonly found in mixtures with other herbs, and is used in the treatment of numerous ailments, including heart, liver, and kidney diseases, as well as cancer, viral infections, and immune system disorders. Western herbalists began using *Astragalus* in the 1800s as an ingredient in various tonics. The use of *Astragalus* became popular in the 1980s based on theories about anticancer properties, although these proposed effects have not been clearly demonstrated in reliable human studies. *Astragalus* polysaccharides (APS), the polysaccharide component of the ethanol extract of *Astragalus* roots is an important active component of *Astragalus* (Xian-qing et al, 2007). Xian-qing et al, (2007) stated that the hyperglycemic state and insulin sensitivity, fatty liver disease and insulin function in the liver of diabetic rats were normalized to some extent by administration of *Astragalus* polysaccharide (APS). This action is through increasing the adaptability capacity of the endoplasmic reticulum of the mouse liver and causes a better induction of insulin signaling. Li et al, (2000) using the combination of *Astragalus mongholicus* and *Angelica sinensis*, observed the lowering of cholesterol, triglyceride, LDL and VLDL in rats in which nephrotic syndrome was induced.

Nanotechnology is the process of synthesizing particles which are in the nano range, ranging from approximately 1-100 nm. They have large surface area to volume ratio due to which they possess optical properties as they are small enough to confine their electrons and produce quantum effects by which their detection becomes easy. Intensive research is being done on silver nanoparticles (AgNPs) owing to their wide range of applications in medical devices (He et al, 2013), pharmaceuticals (Kumar et al, 2011), clothing (Vigneshwaran et al, 2007), and water purification (Lin et al, 2013) due to their antimicrobial properties and also in adsorption of metals and pesticides (Asthana et al, 2016, Das et al, 2012), sensing of food adulterants (Ping et al, 2012), detection of DNA (Thompson et al, 2008), etc.

Considering that, there has been no study on analyzing and comparing the effect of *A. brachycalyx* extract and silver nanoparticles provided by it on diabetes. In the present study, *A. brachycalyx* leaf extract was used for the biosynthesis of silver nanoparticles (AgNPs). This study was designed to evaluate the ability of *A. brachycalyx* leaf extract to act as a reducing agent on $AgNO_3$ to form small particles, clean silver nanoparticles, and study the effect of the formed nanoparticles on diabetes. The synthesized AgNPs using *A. brachycalyx* (ABLE-AgNPs) were characterized through UV-visible spectroscopy followed by X-ray diffraction (XRD), TEM (transmission electron microscopy) and FTIR (Fourier transform infrared spectroscopy) and Dynamic Light Scattering (DLS). *A. brachycalyx* and ABLE-AgNPs were investigated for their activities as an anti-diabetic agent in rats.

Materials and Methods

Collection of plants

The *A. brachycalyx* leaves powder was prepared from the dried fine ground leaves. This plant collected in Chaharmahal Bakhtiari province, Boldaji city, Chaghakhor highlands was used for the biosynthesis of AgNPs. After collection, the plant was authenticated by Dr. Khosravi (Shiraz University Faculty of Science) with voucher number=55122.

Preparation of extract

The aerial parts of *A. brachycalyx* leaves were washed with distilled water and put it at room temperature to dry, then powdered using a mortar. 10 g of plant powder was mixed with 90 ml of 70% methanol and kept it at room temperature for 72 hours. The extract was filtered and the solution was put in the rotary evaporator for extracting. The obtained extract was put in a freeze dryer for 24 hours to turn it into a powder, then stored in the freezer.

Synthesis of silver nanoparticle using aqueous extract of *A. brachycalyx* leaves

For the green synthesis of the AgNPs, five ml of *A. brachycalyx* extract 2% was added drop by drop to 95 ml of 1 mM aqueous solution of silver nitrate ($AgNO_3$). The resulting greenish white mixture was incubated for 30 min in a rotary shaker (200 rpm) at 60°C, for separation of the green-synthesized AgNPs. Reduction of Ag^+ ions to Ag nanocrystals was monitored by a change in color of the reaction mixture from greenish white to dark brown. It was turned into a powder by using a freeze dryer for 24 hours and kept in the freezer. The pure and *A. brachycalyx*-AgNPs were characterized by TEM, FTIR, XRD, zeta potential and investigated for its anti-diabetic activity.

Characterization of AgNPs

Surface Plasmon resonance (SPR) bands of the synthesized AgNPs were characterized using UV–Vis spectroscopy (LAMBDA 365, Perkin Elmer) in the range of 1-3000 nm/min. Morphological analysis and the crystalline nature of the particles were investigated by transmission electron microscopy (TEM) using TEM Philips EM 208S high resolution TEM instrument operated at an accelerating voltage of 100 kv (Mukunthan et al, 2011). The characterization of the synthesized AgNPs was conducted with X-ray diffractometer (XPERT-Pro diffractometer using Cu Ka radiation), operated at 2h from 30 to 80°C at 0.041°/min with a time constant of 2s. The chemical characterization of changes in the surface and surface composition was performed by Fourier transform infrared spectroscopy (FTIR, Tensor II - Bruker Germany) within the mid IR region of frequency 4000–400 cm^{-1} (Aravinthan et al, 2015).

Induction of diabetes

Diabetes was induced in male Wistar rats (210±10 g body weight). In order to adapt rats to the environment, they were placed in the breeding room of Shiraz Veterinary Faculty for 10 days in standard conditions (12 hours of light and 12 hours of darkness, humidity 50 to 55 and temperature at 25°C). After ten days, one group of rats was randomly placed in the cage as a healthy control group.

Before the induction of diabetes, food was taken out of reach of other rats for 12 hours and the blood glucose level of the rats was measured. In order to induce diabetes in rats, streptozotocin (STZ) was dissolved in a cold sodium citrate buffer (0.1 M) with pH=4.5 and the obtained extract was put in a freeze dryer for 24 hours to turn it into a powder, then from the prepared powder, we made a two percent solution and mixed five ml of that solution with 95 ml of silver nitrate, and injected intraperitoneally to rats (single dose of 60 mg/kg). Then the rats received glucose 5% for 24 hours. After 72 hours, blood was taken from the tail of rats and the glucose levels were determined using a glucometer (Avan, AGMO1). Rats whose plasma glucose level was more than 250 mg/dl were considered as diabetic rats (Hosseinzadeh et al, 2002). Then the rats were weighed and randomly divided into six groups of seven. They were treated with different doses of plant extract and nanoparticles synthesized with plant extract for 21 consecutive days. During this period, the weight and blood glucose levels of the classified rats were measured in three stages (1, 11 and 21 days after beginning of injection).

Experimental design

Before the main experiment, a pilot experiment was conducted and different doses of the extract were injected into rats. The tolerated dose for rats was 50 to 400 mg/kg, and the dose of 100 and 200 was chosen. The doses used for nanoparticles were 10 to 100 mg/kg, so 30 and 60 doses were chosen.

To investigate the antidiabetic effects of AgNPs, the diabetic rats were weighed and divided into six groups and each group consisted of seven rats.

Healthy control, group I: This group only received standard food.

Solvent control, group II: This group was the diabetic rats that received the solvent.

Group III: Diabetic rats that received *A. brachycalyx* extract for 21 consecutive days with a dose of 100 mg/kg through gavage.

Group IV: Diabetic rats that received *A. brachycalyx* extract for 21 consecutive days with a dose of 200 mg/kg through gavage.

Group V: Diabetic rats that received 30 mg/kg of *A. brachycalyx* extract-AgNP by gavage. Silver nanoparticles were administered daily for a period of 21 days.

Group VI: Diabetic rats that received 60 mg/kg of *A. brachycalyx* extract-AgNP by gavage. Silver nanoparticles were administered daily for a period of 21 days. Before conducting the experiment, a pilot experiment was considered and different doses of the extract were injected into the rats. Rats tolerated doses of 50-400 mg/kg, so the dose of 100 and 200 mg/kg was chosen. The doses used for silver nanoparticles were 10 to 100 mg/kg, so 30 and 60 doses were considered for this experiment.

During the experiment, which lasted 21 days, all six study groups received water and normal food daily. After 24 hours from the end of the treatment period, the rats were deeply anesthetized by using ketamine and xylazine (a product of Merck, Germany) and blood samples were taken directly from the hearts of the rats and centrifuged at 5000 g for 15 minutes. The collected serum was kept at -80°C to measure the amount of serum glucose by kits (Glucose kit, 500 cc, Byrex Fars) and according to the relevant recipes.

Statistical analysis

Data were expressed as means± standard error. Experimental groups were compared using an analysis of variance to compare means between pairs of groups. The significance level used in the study was 99% ($p \leq 0.01$).

Results

Synthesis and characterization of AgNPs

The *A. brachycalyx* extract was mixed in the aqueous solution of the silver ion complex, and after 30 min due to the reduction of silver ion became brown solution, indicating the completion of the reaction.

Fig.2. Shows a representative TEM image of synthesized AgNPs by using *A. brachycalyx* extract. The TEM images AgNPs were seen to be spherical and monodispersed with the size range of 4–25 nm.

The crystalline nature of the *A. brachycalyx*-AgNPs, the XRD analysis was undertaken, (Fig. 3) revealing five peaks at degree (2θ) 12.5, 38.2, 44.4, 64.5, and 77.2 corresponding to five diffraction facets of silver.

FTIR measurement was carried out to identify the possible biomolecules in *A. brachycalyx* extract responsible for capping leading to efficient stabilization of the silver nanoparticles (Fig. 4).

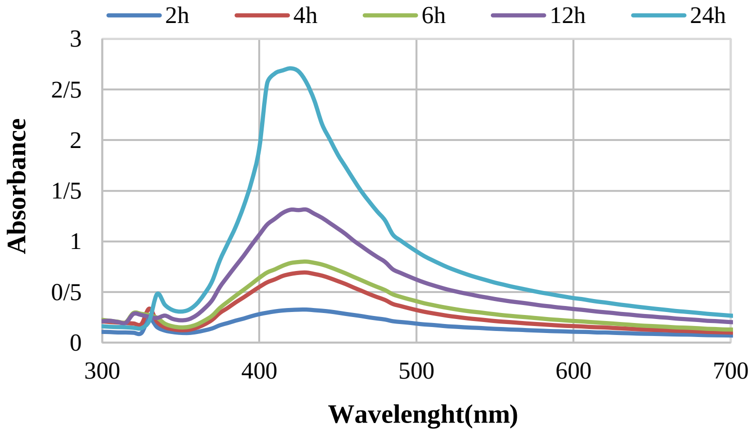

Fig. 1. UV–visible spectrum of green-synthesized AgNPs at different time intervals (2, 4, 6, 12 and 24 h).

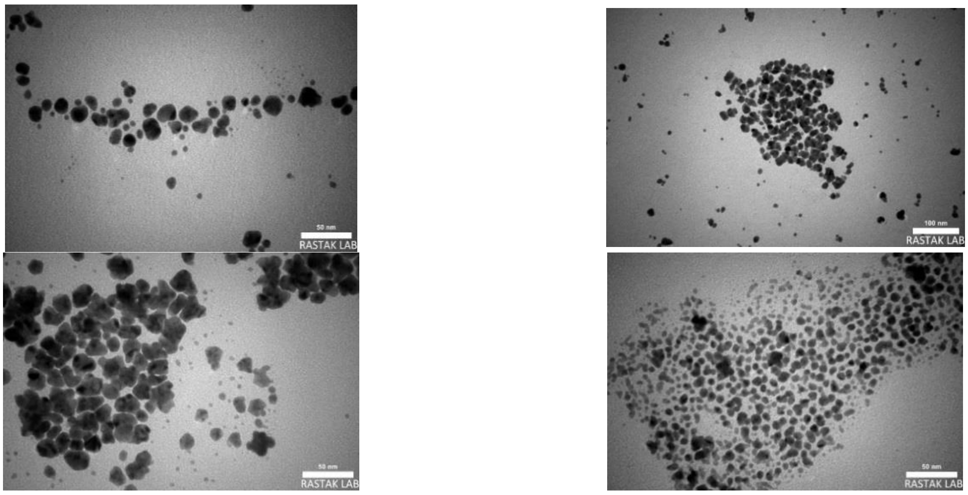

Fig. 2. TEM images for the green-synthesized AgNPs prepared using *A. brachycalyx* extract

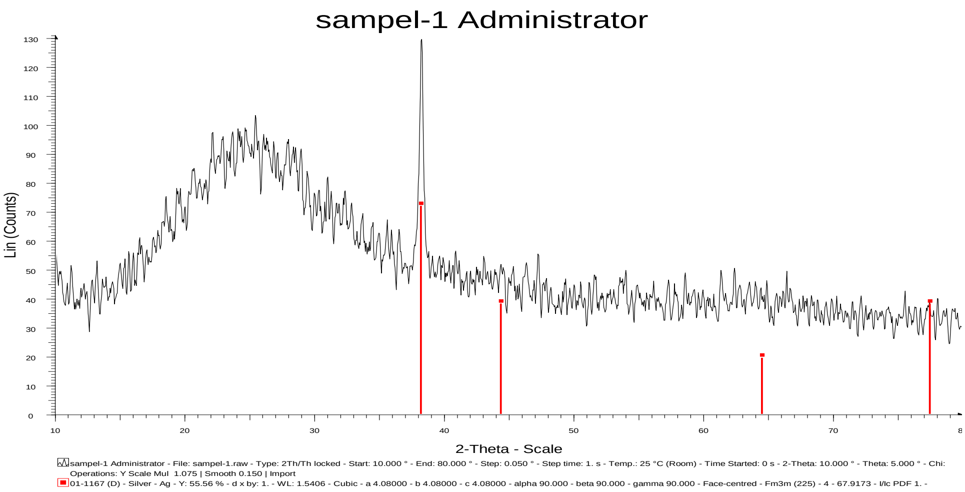

Fig. 3. X-ray diffraction for crystalline nature of *A. brachycalyx* **extract mediated silver nanoparticles**

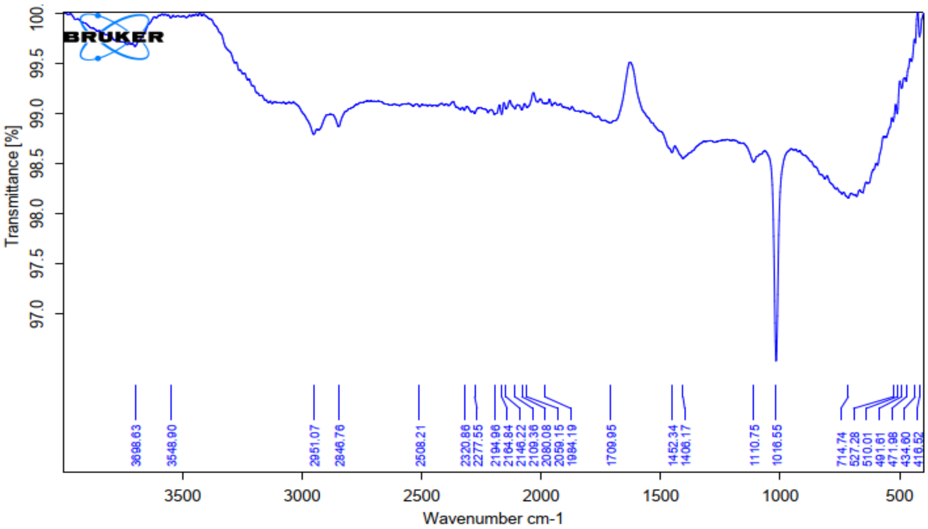

Fig. 4. FTIR spectrum of synthesized AgNPs by *A. brachycalyx* extract

Dynamic light scattering (DLS) measures the hydrodynamic size and the ligand shell of the formed nanoparticles, the size is different from the TEM and HR-TEM where only the metallic core is measured. The DLS of *A. brachycalyx*-AgNPs is 65.2 ± 2.11 nm and homogenous distribution of the formed nanoparticles with polydispersity index: 0.312±0.032 (Figure 5a). The zeta potential is a measure of nanoparticle stability through measuring of the surface charge potential in aqueous suspensions. The zeta potential of *A. brachycalyx*-AgNPs was observed at −12.3 mV (Figure 5b).

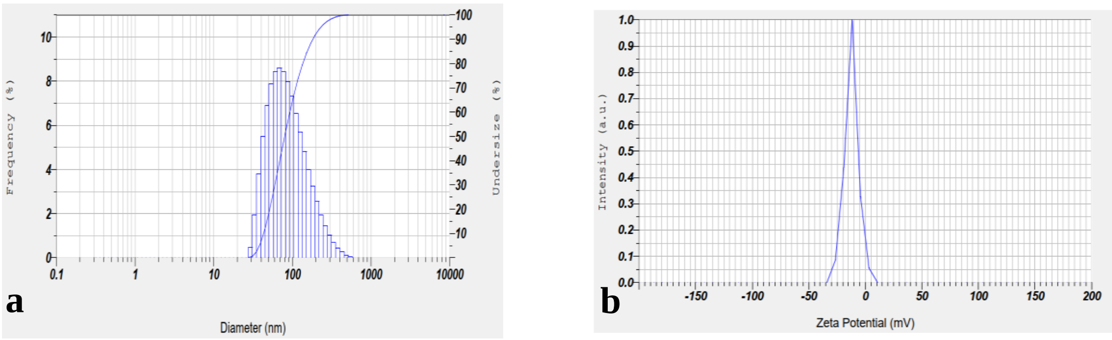

Fig. 5. (a) Dynamic light scattering (DLS) (b) Zeta potential measurement of *A. brachycalyx*-nanoparticles.

The antidiabetic activity of synthesized AgNPs

Figure 6. Shows the level of body weight changes of rats in three stages of weighing during the 21 day treatment period. According to the results obtained during the treatments, the highest weight of the rat at the end of the treatment stages belonged to treatment 6 (60 mg/kg silver nanoparticles). Treatment 2 (diabetic and not receiving medicine) showed a decrease in growth and its weight decreased. There is no significant difference between different treatments in body weight, during the study.

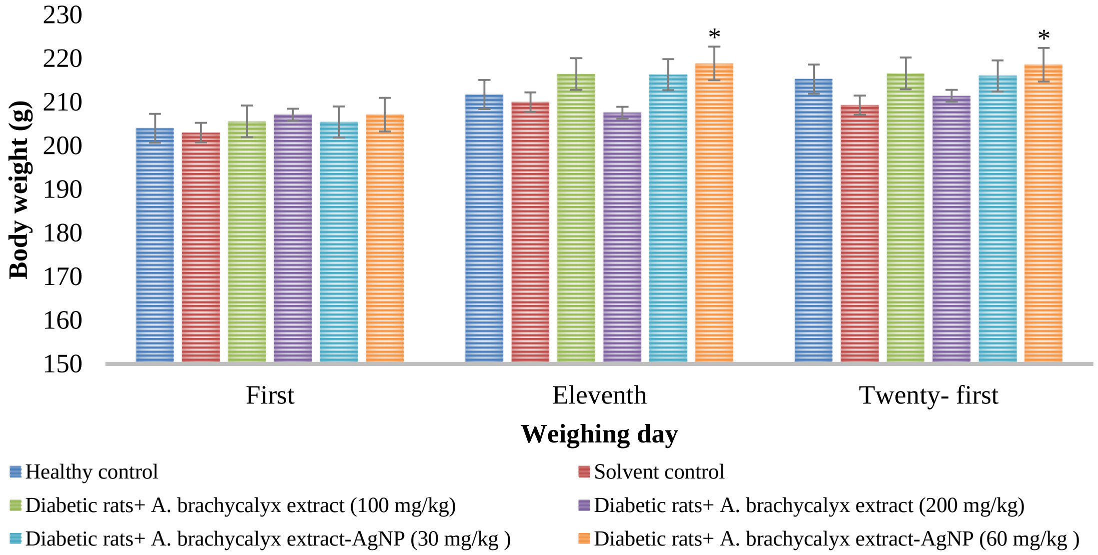

Fig. 6. Weight of rats treated in three stages evaluation of antidiabetic effects of AgNPs mediated by *A. brachycalyx* extract. Values are means±S.E, at 1% level, of seven replicates. *P<0.05; **P<0.01different from solvent control.

According to Figure 7, treatment 2 showed an increasing trend in the amount of blood glucose level. While the treatments using *A. brachycalyx* extract and nanoparticle showed the trend of blood glucose level reduction. Blood glucose level reduction in treatment 6 was more than other treatments. In treatments 3, 4, 5 and 6, the use of *A. brachycalyx* extract and silver nanoparticle caused a significant decrease in blood sugar over time (65, 62, 61 and 71% respectively). While in the treatment 2, who were diabetic and did not receive medicine, blood sugar increased (no statistically significant difference). Blood sugar in treatments 3, 4, 5 and 6 after 21 days showed no statistically significant difference with the control group. But after 21 days of injection, the blood sugar level in treatment 2 significantly increased compared to the control.

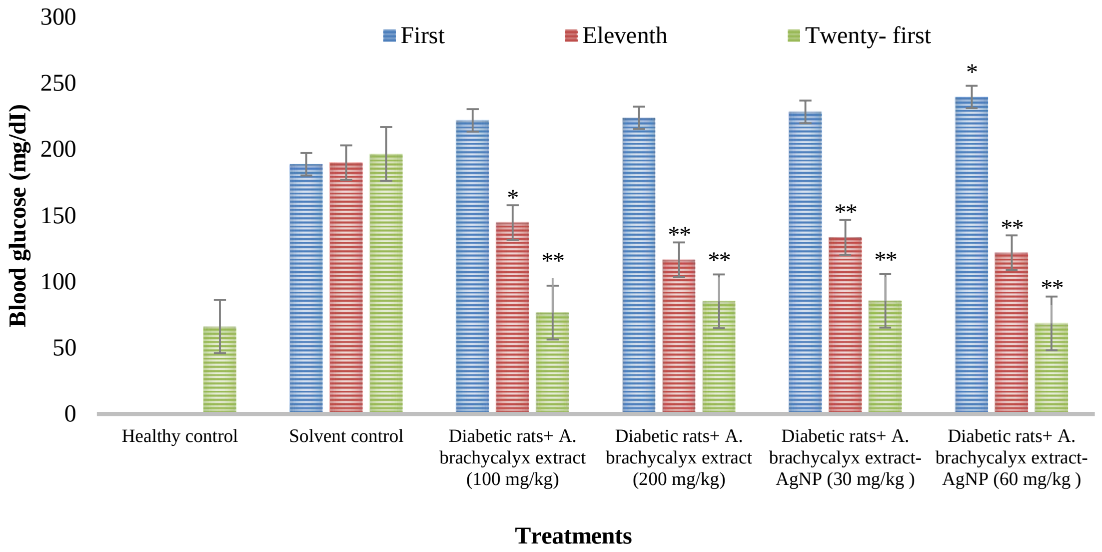

Fig. 7. Blood glucose level in 6 treatment groups evaluated in the study of antidiabetic effects of silver nanoparticles mediated by *A. brachycalyx* extract. Values are means±S.E, at 1% level, of seven replicates. *P<0.05; **P<0.01different from solvent control.

The relationship between blood glucose and weight of rats showed that the highest glucose level at the end of the study period belonged to treatment 2. While the level of blood glucose in treatment 6 was close to blood glucose in healthy rats. In general, according to the results, drug treatments had a positive effect on blood glucose (Figure 8).

Figure 9 shows the level of body weight changes of experimental rats before and after treatment. Weight loss is one of the main syndromes associated with diabetes, possibly due to muscle wasting. In our study, treatment 6 showed significant weight changes before and after treatment.

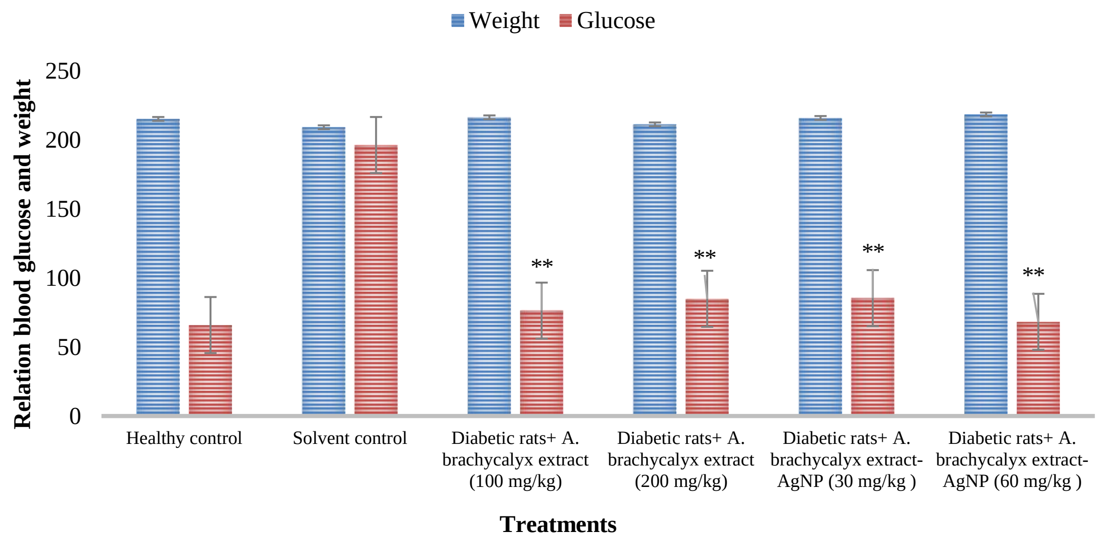

Fig. 8. Relation between blood glucose and weight of rat groups evaluated in the study of antidiabetic effects of silver nanoparticles mediated by *A. brachycalyx* extract. Values are means±S.E, at 1% level, of seven replicates. *P<0.05; **P<0.01different from solvent control.

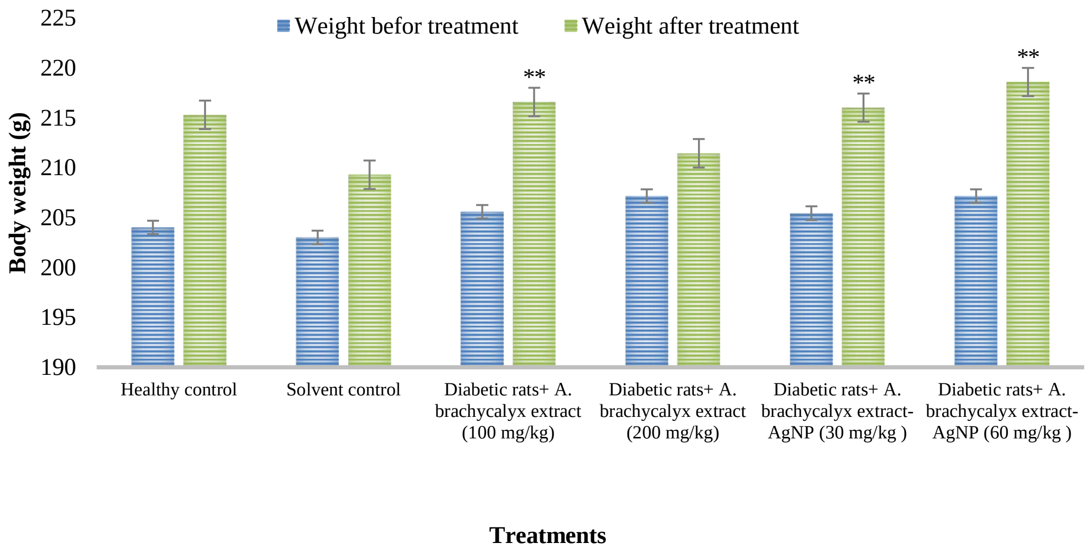

Fig. 9. Effect of methanolic extract of *A. brachycalyx* and AgNPs on body weight before and after treatment. Values are means±S.E, at 1% level, of seven replicates. *P<0.05; **P<0.01different from solvent control.

Discussion

The *A. brachycalyx* extract was mixed in the aqueous solution of the silver ion complex, and after 30 min due to the reduction of silver ion became brown solution, indicating the completion of the reaction. Similar changes in color have also been reported earlier (Singhal et al, 2011, Banerjee et al, 2014). As *A. brachycalyx* extract contains high antioxidants, we speculate this AgNPs formation due to the presence of high amounts of antioxidants in the extract (Jain et al, 2011). Color change from pale green to dark brown is the preliminary step that confirms the formation of AgNPs. This is imputed into the surface Plasmon resonance excitation caused by silver nitrate reduction (Hamida et al, 2020). The absorbance spectrum of

AgNPs formed at various times and the maximum absorption peak was observed in the range of 370–400 nm, confirming the formation of silver nanoparticles (Kesharwani et al, 2009). The TEM images AgNPs were seen to be spherical and monodispersed with the size range of 4–25 nm. This result is well agreed with the UV–Vis spectra result, in which the maximum peak shifts towards the blue region (λ max at 420 nm), and provides the direct evidence for size (Martinez-Castanon et al, 2008). The broadening of X-ray peaks observed in figure 3 can be attributed to the organic content of leaf extract. The IR spectrum of silver nanoparticles manifests prominent absorption bands located at 3548, 2951, 2846, 1709, 1406, 1110, 1016, 714, and 416 cm^{-1}. The bands seen in 3548 and 2951 cm^{-1} represent the stretching vibrations of primary and secondary amines respectively. The peak at 2846 could be attributed to H bonded OH stretching of secondary metabolites present in the extract which might act as a reducing agent to synthesize AgNPs (Dubey et al, 2010). The results of figure 5 confirms that the surface of the nanoparticles is negatively charged. The negative value reflects the particle repulsion and reveals their high stability (Anandalakshmi et al, 2016). According to the results obtained, it seems that the use of *A. brachycalyx* extract and silver nanoparticles have a positive effect on reducing blood sugar in diabetic patients. Weight loss is one of the main syndromes associated with diabetes, possibly due to muscle wasting (Swanston-Flatt et al, 1990). In our study, although treatment 6 showed significant weight changes before and after treatment, but, it seems that the extract of the *A. brachycalyx* leaves contain a substance that has caused rats to gain less weight in the conditions of using a high concentration of the extract (200 mg/kg) in group 4. While in group 3, the lower concentration of the extract (100 mg/kg) prevented this from happening. In the groups that received nanoparticles, i.e., groups 5 and 6, the ratio of extract to nanoparticle was much lower (95% nanoparticle and 5% extract). On the other hand, in other researches, *A. brachycalyx* extract has been effective on lipid profiles and reduces cholesterol and triglycerides. As a result, it is possible that because of receiving a high dose of the extract (200 mg/kg) in group 4, cholesterol and triglycerides decreased, followed by weight loss (Chen & Hu, 2003, Hii & Howell, 1987). The anti-diabetic effects of the plant extract and *A. brachycalyx*-AgNPs in reducing blood glucose level in groups 5 and 6 are due to the increased flavonoid effects of the extract and silver nitrate. Bayrami et al, (2020) revealed that the *Urtica dioica*-AgNPs application due to the increased flavonoid effects showed the anti-diabetic effects. The extract of the *Hibiscus subdariffa* L. leaves induces the expression of some genes related to diabetes in the pancreas and the expression of the insulin receptor, as a result, it induces insulin secretion (Bala et al, 2015). It also causes the release of insulin from human pancreatic cells that are damaged by the action of STZ (Berardis et al, 2010). The polysaccharides isolated from *Astragalus* root extract decreases the protein level of PTP1B (negative regulator of insulin receptor) and its function in skeletal muscles and liver of type II diabetic rats and thereby increases sensitivity to insulin in the target tissues. As a result the blood sugar decreased in these rats (Yong et al, 2005).The condition of hyperglycemic and sensitivity to insulin, fatty liver disease and insulin action in the liver of diabetic rats with administration (APS) *Astragalus* polysaccharide, to some extent becomes normal, that this action happening through increase the adaptability capacity of rat liver endoplasmic reticulum and the better induction of insulin signaling becomes (Xian-qing et al, 2007). In one research on traditional Chinese medicines stated that *Astragalus* may enhance the hyperglycemic and hyperuricemic effects of blood sugar-increasing drugs (Zhang, 1986). The effect of flavonoids on insulin secretion is a dual effect. A group of flavonoids have an anti-diabetic effect, that they increased insulin by 44-70% and some like naringenin and chrysin that inhibit insulin release by 40-60% (Hii & Howell, 1987). Some researchers reported different categories of flavonoid, one group inhibits insulin function on the uptake of glucose by MC3T3-G2/PA6 fat cells, and this effect is increasing with the dose increases (Nomura et al, 2008). In this study, AgNPs were rapidly synthesized using aqueous leaf extract of *A. brachycalyx* as a bio-reductant. The efficacy of synthesized AgNPs as an anti- diabetic agent has been confirmed. This study revealed that the AgNPs are found to be safe and environmentally friendly, hence, these AgNPs can be considered in treating diabetes associated syndrome.

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Conflict of interest

There is no conflict of interest.

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ارزیابی خصوصیات نانوذرات نقره سنتز شده با استفاده از عصاره‌ی برگ گیاه گون گزی (*Astragalus brachycalyx* L.) و اثر آن بر دیابت در موش صحرایی نژاد ویستار

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چکیده

این آزمایش بر روی موش‌های صحرایی (نژاد ویستار با وزن بدن ۱۰±۲۱۰ گرم) دیابتی در قالب طرح کاملاً تصادفی با هفت تکرار در آزمایشگاه گروه فارماکولوژی دانشکده‌ی دامپزشکی دانشگاه شیراز در سال ۱۴۰۱ انجام شد. در تحقیق حاضر از عصاره‌ی برگ *A. brachycalyx* برای بیوسنتز نانو ذرات نقره (AgNPs) استفاده شد. این مطالعه به منظور ارزیابی تأثیر عصاره‌ی برگ *A. brachycalyx* و نانوذرات تشکیل‌شده از آن بر دیابت (موش‌های دیابتی شده توسط استرپتوزوتوسین) طراحی شد. نانوذرات نقره (AgNPs) سنتز شده از *A. brachycalyx* (ABLE-AgNPs) با کمک طیف‌سنجی نور مرئی، مادون قرمز، میکروسکوپ الکترونی و طیف سنجی تغییر شکل فوریه به مادون قرمز و پخش کننده‌ی دینامیک نور مورد تجزیه و تحلیل قرار گرفتند. عصاره‌ی *A. brachycalyx* و ABLE-AgNPs از نظر فعالیتشان به عنوان یک عامل ضد دیابت در موش مورد بررسی قرار گرفتند. تیمارهای مورد بررسی شامل: ۱. کنترل سالم، ۲. کنترل حلال، ۳. موش‌های دیابتی که عصاره *A. brachycalyx* با دوز ۱۰۰ میلی‌گرم بر کیلوگرم دریافت کردند. ۴. موش‌های دیابتی که عصاره‌ی *A. brachycalyx* را با دوز ۲۰۰ میلی‌گرم بر کیلوگرم دریافت کردند، ۵. موش‌های دیابتی که ۳۰ میلی‌گرم بر کیلوگرم عصاره‌ی *A. brachycalyx*-AgNP را دریافت کردند و ۶. موش‌های دیابتی که ۶۰ میلی‌گرم بر کیلوگرم عصاره‌ی *A. brachycalyx*-AgNP را دریافت کردند. میکروسکوپ الکترونی نشان داد که ذرات سنتز شده در محدوده‌ی اندازه‌ی ۴ تا ۲۵ نانومتر هستند. شرایط دیس لیپیدمیک همان طور که در کنترل دیابتی مشاهده شد در موش‌های دیابتی تیمار شده با AgNPs به طور قابل توجهی بهبود یافت. علاوه بر این، AgNPs سطح گلوکز خون را در طول دوره‌ی کاربرد کاهش داد. بهبود در وزن بدن نیز شاهدی بر اثر مثبت *A. brachycalyx* –AgNP به عنوان یک عامل ضد دیابتی بالقوه در موش‌های دیابتی STZ بود. بیشترین وزن موش در پایان مراحل تیمار (۲۱روز) مربوط به تیمار ۶ (۶۰ میلی‌گرم بر کیلوگرم نانوذرات نقره) بود. تیمار ۲ (دیابتی و عدم دریافت دارو) کاهش رشد و وزن نشان داد. تیمار ۲ دارای روند افزایشی در میزان سطح گلوکز خون بود. در حالی که تیمارهای کاربرد عصاره و نانوذره *A. brachycalyx* روند کاهشی سطح گلوکز خون را نشان دادند. کاهش سطح گلوکز خون در تیمار ۶ بیشتر از سایر تیمارها (۷۱ درصد) بود. در این مطالعه نشان داده شد که نانوذرات نقره ایمن و سازگار با محیط زیست هستند، از این رو، این نانوذرات نقره می‌توانند در درمان سندرم مرتبط با دیابت مورد استفاده قرار گیرند.

کلمات کلیدی: *Astragalus brachycalyx* L.، نانوذرات نقره، AgNPs، گلوکز، دیابت، موش صحرایی

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