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A-Amyrin Nanocapsules Effectiveness on Mitochondrial Biogenesis and Lipid Profile in Diabetic Male Rats

Article Info.

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Abstract

Pentacyclic triterpenes (α-amyrin) in general exert beneficial effects in metabolic disorders. This study investigates the effects of α-amyrin-nanocapsule on blood sugar level and lipid profile in diabetic male rat, and in rats fed on a high-fat diet (HFD). The groups of experiment include: Firstly, normal control (A) rats received drinking water orally. Second (B) group: Diabetes group induced diabetic by injection of Streptozotocin (50 mg/kg) with high-fat diet (HFD)-fed rat. Third (C) group: Diabetes + α-amyrin (100 mg/rat, daily Forth (D) group: Diabetes + α-amyrin-nanocapsule (50 mg/rat, daily) Fifth (E) group: Diabetes + α-amyrin-nanocapsule (40 mg/rat, daily) group. sixth group (F): Diabetes + α-amyrin-nanocapsule (80 mg/rat, daily), seventh group (G): diabetic rats received insulin (4 IU/ rat, Sc) group. The results appeared the glucose levels in α-amyrin nano-particle 80 mg\kg group (F) and insulin treated group (G) significantly decreased also The result recorded significantly decrease in α-amyrin nano-particle 80 mg\kg (group F) and insulin treated group (G) and control (A) group, rather than other treatment groups in lipid profiles, which showed a hypolipidemic effect. GLUT4 qPCR level was doubled compared α-amyrin-nanocapsule (40 mg) to the positive control group negative control. These findings reflect the potential antihyperglycemic and hypolipidemic effects of α-amyrin-nanocapsule and suggest that it could be a lead compound for drug development effective in diabetes and hypolipidemic.

Keywords: Hypolipidemic; α-amyrin; nanocapsule.

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Introduction

The complex metabolic disorder diabetes is associated with such features as dysregulated mitochondrial function and disturbed fatty acid metabolism that worsens the pathological process developing (1), providing complications caused by the disease, such as *Diabetic mellitus*. The development of detailed research within the past years has generated another promising pathway (2), By means of alpha amyrin loaded nanocapsules as a mitochondrial quantity and fatty acids metabolism modulator in diabetic animal model, it achieves remarkable progress relative to the field of diabetes (3). The nanocapsules whose Nano-sizeness has proved very vital for effective precision and controlled delivery of bioactive substances (4). The mentioned nanocapsules are capable of encapsulating α-amyrin, a naturally occurring triterpenoid with potent anti-diabetic and anti-inflammatory activity (5), thereby increasing its bioavailability and specificity directed towards the affected tissues (6). Mitochondria have an important part in cellular energy production and metabolism regulation, and the pathophysiology of diabetes is associated with their dysfunction (7). The nanocapsules declare a potential opportunity by targeting mitochondrial biogenesis for restoring the function of mitochondria and addressing the metabolic alterations (8). The Nanocapsules-based nanoformulation of α-amyrin in terms of the controlled release and targeted delivery may generate a significant impact on lipid equilibrium recovery as well as improving the dyslipidemia in diabetic conditions (9). In addition, the outcomes may help bring about individualized and focused nanocapsule-based therapies aimed at controlling complex metabolic derangements caused by diabetes, thus providing a realistic basis for newly developed state of the art treatment procedures in this highly prevalent chronic disease. In the proposed study, we would like to focus on modifications of mitochondrial biogenesis and fatty acid metabolism by means of α-amyrin in an animal model posted with diabetes .

Materials and Methods

Design of study:

The 70 rats will randomly be divided into (10 rats/group), BW (205.82±5 gm) as follows:

1- First (A) group: normal control rats received drinking water orally.

For induced diabetic in rats by injection of Streptozotocin at the concentration of 50 mg/kg with a high-fat diet (HFD)-fed rats. And then 3 days after diabetes induction (HFD)-fed rats, the rats were divided as follows:

2- Second (B) group: Diabetes group (B, n=10) without treatment.

3-Third (C) group: Diabetes rats treated with α-amyrin (50 mg/rat, daily) through gavage induction for one month (10).

4-Forth (D) group: Diabetes rats treated with α-amyrin (100 mg/rat, daily) through gavage induction for one month (10).

5-Fifth group (E); 3 days after diabetes induction, the rats will be treated daily by α-amyrin-nanocapsule (40mg/rat, daily) through gavage induction for one month (11).

6-Sixth (F) group: Diabetes rats received α-amyrin-nanocapsule (80 mg/rat, daily) through gavage induction for one month (11).

7-Seventh (G) group : Diabetic rats received insulin (4 IU/ rat, Sc) for one month.

Animal Sampling

At the end of one month, a total of ten animals from each group were humanely killed through cardiac puncture under I/P anesthesia with ketamine as hydrochloride (35 mg/kg) + xyzoline (3 mg/kg).

Induction of experimental diabetes

Weights were taken before the beginning of experimental. A glucometer assessed blood glucose levels in animal caudal venous blood samples. The rats received a single intraperitoneal dosage (50 mg/kg) of streptozotocin (STZ, Sigma Chemical Company, St Louis, MO) diluted in 0.2 mL of citrate buffer (0.1 mol/L, pH = 4.5) to induce diabetes (10). Another blood glucose test three days following the injection showed a two-fold increase.

Preparation of the nanocapsule

Alpha-Amyrin was obtained from Sigma Aldrich (St.Louis, MD, USA) . The α-amyrin-nanocapsule was made via solvent displacement and interfacial polymer deposition (5). The organic phase: an acetone solution of monolauryl sorbitan ester (Span 20) and isopropyl palmitate was made in a magnetic stirrer at 400 rpm (Fisatom, Brazil). After that, the polymer (dissolved in 5 mL ethanol 96%) was added and stirred for 20 min. The aqueous phase contained water and polyoxyethylene orbitan monooleate (Tween 80). The organic phase was added to the aqueous phase (≈1 mL/min) using a burette and agitated for 15 min. Next, the mixture was homogenized (Ultra-turrax®, IKA, Switzerland) for 5 min at 10 krpm. Solvent was removed in a vacuum rotary evaporator (IKA, Switzerland) at 50 ◦C to create ANC (Active Nanoparticle Components). To determine the optimal polymer for nanocapsules, five formulations were created using Poly-ε-caprolactone, Eudragit® E100, and Kollicoat® Mae 100 P (12).

Droplet size and morphology

Photon correlation spectroscopy (PCS) was used to assess particle size and polydispersity index using a Zetasizer Nano (Malvern, UK) at 633 nm, 173◦ scatter angle, and 25 ◦C (12). The nanocapsule solution was Millipore® membrane-filtered (0.45 mm) before measurements. Measurements were taken in triplicate and recorded as (mean ± standard deviation). Nanoparticle morphology was assessed by scanning electron microscopy (TESCAN, Czech Republic). The experiment used a scattering electron detector at 15 kV, 8.0 mm sample distance, and 15.6 Kx magnification. The Czech Republic's BAL TEC apparatus metalized samples with a thin gold layer.

Blood glucose assay : Plasma glucose concentrations were assessed enzymatically by a commercial glucose (13) kit according to (14).

Total Cholesterol: Serum cholesterol is tested enzymatically by hydrolyzing cholesteryl esters and oxidizing the 3-OH group. A peroxidase-catalyzed process that creates color quantifies H_2O_2, and the absorbance is 500 nm (15).

Triglycerides: In a sequence of linked processes, triglycerides are hydrolyzed to glycerol and evaluated in serum or plasma. Glycerol oxidase oxidizes glycerol, and H_2O_2, a reaction product, is measured like cholesterol. Absorbance is 500 nm (15).

High-density lipoprotein (HDL) measurement: HDL-cholesterol levels are specifically calculated using a color-forming enzymatic reaction (15).

Low density lipoprotein (LDL)and very low-density lipoprotein (VLDL) measurement: The Pars test kit was used to measure LDL cholesterol. In this method, first, all lipoproteins except LDL, including HDL, VLDL and chylomicrons, were removed, and only LDL cholesterol concentration was specifically calculated using a color-forming enzymatic reaction (15, 16).

qPCR Quantification: Comparisons of the expression scale of multiple genes, including GLUT4, in rat tissue have been done between the experimental group and control group using Real-Time PCR. Initially, the following measures were taken to ensure tissue samples were collected: With scissors and tools, 50 mg samples were removed from the tissue and plate reader. The total RNA of all the samples was then taken using the following method: Regarding protocol II, around 50 mg of tissue from each sample was placed in a new 1. A new name given out was Five-milliliter Microtube, otherwise referred to as 5-mL Microtube. A proportion of 300 µL TRIzol (Invitrogen, USA) was then added into the tube to both mix and facilitate the disruption of the cells in the tissue samples. Then, 100 µL of chloroform (Sigma-Aldrich) was added to the process. It was then beaten very hard, and the tubes were left to rest on ice for the next two minutes. They placed this solution at 10000 g for 15 minutes, 4°C, and then removed the visible watery part of the solution and put

the solution in a new 1. 5-mL Microtube. The RNA separated from the RNA-DNA ratio was mixed with 100 µL of cold isopropyl alcohol procured from Sigma- Aldrich. The tube was then inverted in such a manner that the lower end was resting on ice and was allowed to stand for some 10 minutes. Collectively, at 4°C, the contents of the solution were subjected to centrifugation at 10,000 rpm for 15 min. The liquid was decanted, and the mass was discovered as in Figure 10. Centrifugation was followed by washing the RNA pellet three times with 100 µL of cold 70% ethanol (Sigma-Aldrich) (Table A) (17).

Table A: Demonstrates primer design for GLUT4

Gene name	Primer sequence
r- GAPDH -F	AGGTCGGTGTGAACGGATTTG
r- GAPDH -R	TGTAGACCATGTAGTTGAGGTCA
r-GLUT4 -F	GAACTGGGAAGCTGGAGGGAG
r- GLUT4 -R	TAGGGGTAAGAGGAAGGCAGGA

Statistical analysis

Descriptive statistics will be used to summarize the data. Mean, standard deviation, percentile distribution, and confidence interval will be computed for all variables. Analysis of Variance (ANOVA) will be used to analyse the difference between all groups. A statistically significant P value will be determined at $P<0.05$. Statistical analyses will be computed using SPSS (Statistical Package for Social Sciences), version 26 (18).

Results

Effect of α-amyrin and α-amyrin nano-nanoparticle on serum glucose, insulin, and (HOMA-IR) concentrations

The glucose levels in α-amyrin nano-particle 80 mg\kg group (F) and insulin-treated group (G) significantly ($p \leq 0.05$) decreased, similar to that represented in the control (A) group, while differences significantly elevated in diabetic (B) group, α-amyrin extract 50 mg\kg group (C), the α-amyrin extract 100 mg\kg group (D) and the α-amyrin nano-particle 40 mg\kg group (E) compared to (A) (control group). α-amyrin nano-particle 80 mg/kg group (F) and insulin-treated group (G) in Table (1). The insulin levels increased statistically ($p\leq 0.05$) in the α-amyrin nano-particlemg/kgg/kg group (F) and the group of insulin (G) treatment, rather than the other treated groups, but less than the control group (A) (Table 1). The data of HOMA-IR that is represented in

Table 1 also showed a significant ($p \leq 0.05$) decrease in group (A) (control group), α-amyrin nano-particle 80 mg\kg group (F) and insulin-treated group (G) as compared to treated groups, but statistically increased in α-amyrin extract 50 mg\kg group (C), α-amyrin extract 100 mg\kg group (D) and α-amyrin nano-particle 40 mg\kg group (E) than to control (A) and other treated groups.

Table (1) Effect of α-amyrin and α-amyrin nano-nanoparticle on serum glucose, insulin and (HOMA-IR) concentrations in adult male rats (M±SD):

Parameters / Groups (n=10)	GLU (µU/ml)	INSULIN (mU/ml)	Homa-IR
A (Normal Control)	65.71 ± 4.25 d	21.12 ± 1.63 a	2.71 ± 0.12 bc
B (Diabetic)	235.50 ± 11.68 a	5.41 ± 1.07 d	4.13 ± 0.49 a
C (α-amyrin extract 50 mg\kg)	214.10 ± 11.04 ab	6.33 ± 0.76 d	3.45 ± 0.56 a
D (α-amyrin extract 100 mg\kg)	179.00 ± 11.7 b	9.31 ±1.84 c	3.34 ± 1.07 a
E (α-amyrin nano-particle 40 mg\kg)	186.70 ± 14.89 b	9.85 ± 1.28 c	3.43 ± 0.58 a
F (α-amyrin nano-particle 80 mg\kg)	98.41 ± 0.45 c	13.45 ± 0.97 b	3.15 ± 0.30 b
G (Insulin treated)	74.81 ± 14.65 cd	16.45 ± 1.11 b	3.02 ± 0.55 b

Values expressed in small letters mean statistical differences at ($p<0.05$) (M±SD).

Effect of *α-amyrin* and *α-amyrin* nano-nanoparticle on serum lipid profile

The results of lipid profile that were affected by α-amyrin extract and α-amyrin nano-particle showed changes in TG levels, as revealed in Table 2). The result recorded a significant ($p<0.05$) decrease in α-amyrin nano-particle 80 mg\kg group (F) and insulin-treated group (G) and control (A) group, rather than other treatment groups. The results in Table 2) showed that TC statistically improved ($p<0.05$) in groups treated with α-amyrin extract 100 mg\kg group (D), α-amyrin nano-particle 40 mg\kg group (E), α-amyrin nano-particle 80 mg\kg group (F) and insulin-treated group (G) receptively as compared to diabetic control group (B) and α-amyrin extract 50 mg\kg group (C). Also, Table 2 showed the results of HDL levels, which showed a significant ($p<0.05$) improvement in α-amyrin extract 100 mg\kg group (D), α-amyrin nano-particle 40 mg\kg group (E), α-amyrin nano-particle 80 mg\kg group (F) and insulin-treated group (G) receptively as compared to diabetic group (B), α-amyrin extract 50 mg\kg group (C), but less than normal Control

(A). LDL levels were reduced statistically ($p<0.05$) in groups treated with α-amyrin extract 100 mg\kg (D) , α-amyrin nano-particle 40 mg\kg (E), α-amyrin nano-particle 80 mg\kg (F) and insulin-treated (G) groups respectively, as compared to the diabetic group B), α-amyrin extract 50 mg\kg group (C). Sign table (2) significant decrease ($p \leq 0.05$) of VLDL in groups treated with α-amyrin extract 100 mg\kg group (D), α-amyrin nano-particle 40 mg\kg group (E), α-amyrin nano-particle 80 mg\kg group (F) and insulin-treated group (G) receptively as compared to diabetic control group (B), α-amyrin extract 50 mg\kg group (C), but more than a reduction in Control group (A).

Table (2) Effect of *α-amyrin* and *α-amyrin* nano-nanoparticle on serum lipid profile in adult male rats:

Parameters Groups (n=10)	TC (mg/dI)	TG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
A (Normal Control)	65.86± 2.90 c	49.77± 3.59 d	98.6± 3.60 a	17.59± 2.60 c	9.27± 2.58 c
B (Diabetic)	124.23± 1.93 a	127.00 ± 4.84 a	34.97 ± 2.46 c	82.41 ± 4.04 a	26.52± 4.58 a
C (α-amyrin extract 50 mg\kg)	121.421± 2.142 a	121.00 ± 3.55 a	40.3 ± 5.38 c	74.86 ± 4.66 a	24.28± 3.11 a
D (α-amyrin extract 100 mg\kg)	97.36± 4.26 b	96.06 ± 4.20 b	58.10 ± 5.20 b	48.36 ± 6.02 b	19.89± 4.52 a
E (α-amyrin nano-particle 40 mg\kg)	92.42± 3.62 b	91.68 ± 8.073 b	56.78 ± 4.57 b	49.76 ± 6.53 b	16.65± 5.12 b
F (α-amyrin nano-particle 80 mg\kg)	78.42± 1.58 c	73.11 ± 4.73 c	65.72 ± 3.51 b	40.54 ± 2.22 b	13.87± 3.58 bc
G (Insulin treated)	65.36± 3.52 c	66.75 4.178 c	82.01 ± 2.74 a	23.59 ± 3.51 c	12.69± 4.16 bc

Values expressed in small letters mean statistical differences at ($p<0.05$) (M±SD).

GLUT4 gene expression:

Gene expression for GLUT4 had increased, and myocardial hypertrophy had also reduced significantly in the A and I groups that were treated with α-amyrin or α-amyrin nano-emulsion for 4 weeks compared to the B and C groups ($p < 0.05$) (Figure 1). For the molecular, the GLUT4 gene was found to be up-regulated most significantly in rats administered 40 and 80 mg/rat α-amyrin nano-emulsion and insulin. This could explain why it was able to raise insulin levels as it had diosgenin, which is said to have the potential to boost insulin levels in the body. GLUT4 gene down-regulation was identified in rats belonging to groups B, C, D, E and F compared to groups A and I ($p < 0.01$) (Figure 2). Further, the GLUT4 gene in rats from the groups B, C and D was

significantly ($p < 0.01$) lower than in the group A (Figure 3). These were the sorts of changes in the GLUT4 gene that would result from undergoing a type 2 diabetes induction with a high-fat diet plan and a small amount of STZ. Significantly more GLUT4 genes were detected in groups C, D, E and F compared to the GLUT4 genes in groups B and C($p<0.05$). In Figures 1 and 2, the PCR result of the GLUT4 gene is shown, which depicts that the amplicon was amplified, and the melt curve of the GLUT4 gene was also provided.

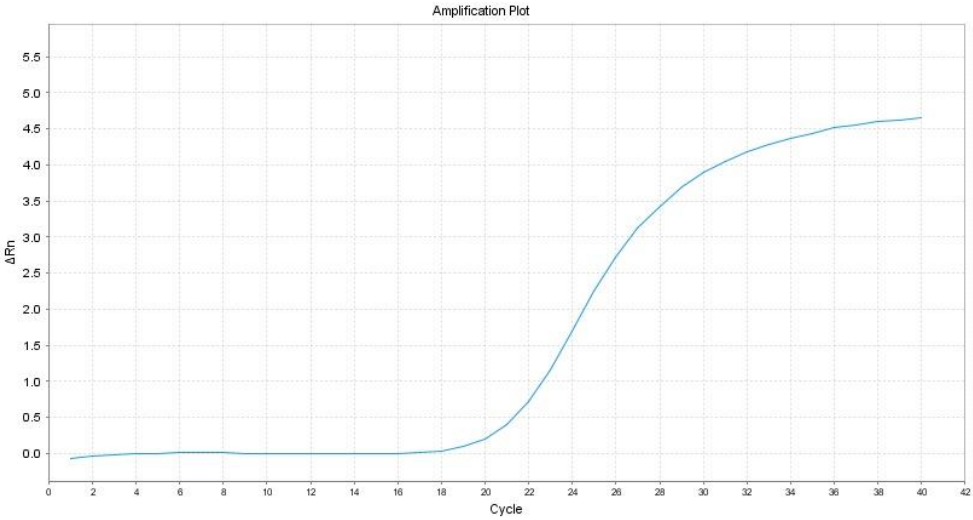

Figure 1. Amplification curve of the GLUT4 gene

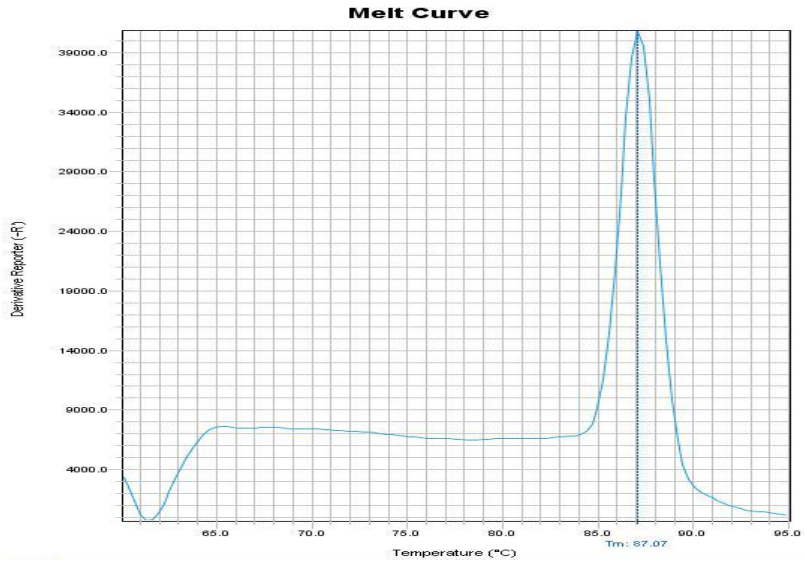

Figure 2. Amplification curve of the GLUT4 gene

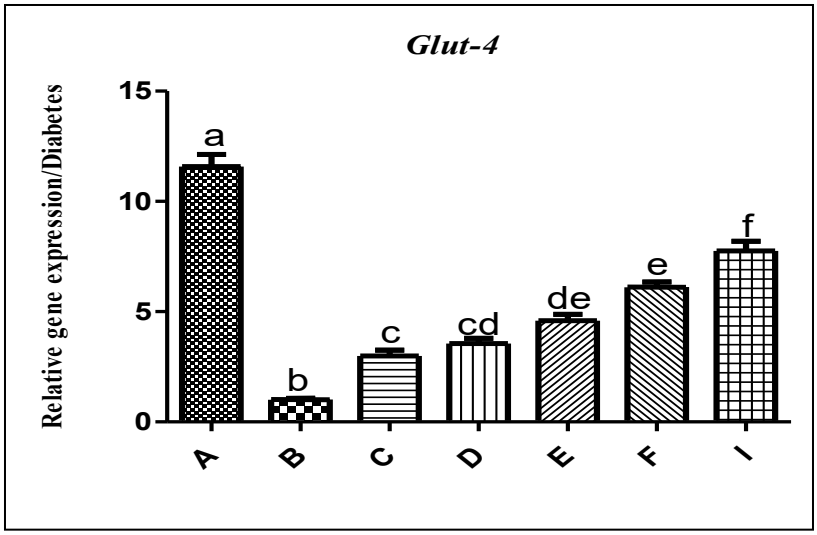

Figure 3. How the GLUT4 gene was expressed changed in the different test groups. Normal (Group A), Diabetes (Group B), DM + α-amyrin extract (Group C; 50 mg/rat), DM + α-amyrin extract (Group D; 100 mg/rat), DM + α-amyrin nano-emulsion (Group E; 40 mg/rat), DM + α-amyrin nano-emulsion (Group F; 80 mg/rat), and DM + Insulin (Group I; 4 IU/rat, subcutaneously). The numbers shown are the average (±SD) of 5 rats. a: There was a big difference between the control group and the other study groups. b: There was a big difference between the diabetics who weren't treated and the other groups in the experiment. c: The diabetic group that was given 50 mg/rat α-amyrin extract was significantly different from the other study groups. d. There was a significant difference (P<0.05) between the diabetic group that was given insulin and the other groups in the testing.

Discussion

The study conclusively shows that the drawback of the α-amyrin nanocapsule. This study focuses on diabetes + high-fat diet-associated data, as such results for rats could be significant to experimental diabetes studies. This is consistent with our data, where we showed similar effects on other pentacyclic triterpenes, betulinic, oleonolic, and ursolic acids in a different mouse model of obesity occurring on a high-fat diet (19, 20 & 21). The further proposed steps in the mechanisms of death of the pancreatic beta-cells after the STZ usage are the overproduction of nitric oxide and the consequent rise of local oxidative stress (22), as well as the disturbance of the intracellular calcium content control. Some traditional drugs for diabetes work by increasing insulin sensitivity (23), promoting insulin production, and improving glucose production (24). Disinhibited by insulin, the fall in glucose levels may involve either decreased absorption from the gut, suppression of glucose synthesis in the liver, or increased utilization by muscle and adipose tissue. These findings are also confirmed by OGTT results (25, 26).

However, the detailed molecular mechanisms responsible for the antihyperglycemic and antilipidemic effects of α-amyrin nanocapsule are yet to be established. The molecular mechanisms through which α-amyrin nanocapsule leads to anti-inflammatory and analgesic actions were extensively investigated in recent research (26). This research also first suggested the mechanism of action between this pentacyclic triterpene and the cannabinoid system (27, 28, 29 & 30).

Triterpenoids such as α-amyrin nanocapsule have limited bioavailability (32). Following a validated GC-MS approach to pharmacokinetic studies, it has been revealed that amyrin has low bioavailability and prolonged half-life elimination when given per os to healthy rats. The previous studies (31) show its efficacy when given orally in a range of experimental models of inflammation, nociception, gastroprotection, and hepatoprotection in animals. Moreover, this work shows the efficacy of oral dosing with α-amyrin nanocapsule that can reduce high blood glucose and high lipid levels in experimental models of diabetes developed by streptozotocin and induced hyperlipidemia by a fat-rich diet. A study showed that TNF- α has been investigated for its role in Type 1 and Type 2 diabetes in mice, as well as the efficacy of anti-TNF- α treatment in lowering high blood sugar and in returning insulin level to normal (33). In a previous study, we determined that α-amyrin nanocapsule possesses anti-inflammatory and antioxidant properties in animal models of cerulein-induced acute pancreatitis and ligature-induced acute periodontitis (19). In addition, this triterpenoid was found to effectively inhibit the serum level of TNF-α, a pro-inflammatory cytokine, as well as increase in MPO activity and TBARS. This work showed that the administration of α-amyrin nanocapsule was able to reverse the lowered levels of insulin observed in streptozotocin-induced diabetic controls.

It has been observed that the glibenclamide binds to the KATP+ channel that lies on the plasma membrane of beta cells. This is because this binding action impedes the movement of potassium ions while simultaneously opening voltage-gated Ca2+ channels. Activation of the calcium currents leads to the elevation of intracellular calcium levels that stimulate the increased release of insulin in the presence of glibenclamide (34). α-amyrin nanocapsule and insulinis that used for therapy to control hyperglycemia. On the other hand, it has been associated with the development of profound and sometimes deadly hypoglycemia (26). However, based on the literature, some plant-derived triterpenoids show promise at enhancing glucose absorption by mimicking insulin and causing an increase in insulin sensitivity. Furthermore, some of these triterpenoids have been shown to inhibit alpha-glucosidase. Insulin resistance plays a role both in the control of glucose metabolism and in all aspects of lipid and lipoprotein metabolism. It is associated with the increased LDL and the elevated triglycerides (35). Therefore, the reduction of LDL levels and the presence of high triglyceride levels caused by α-amyrin nanocapsule may be because of improved insulin sensitivity.

Increases in GLUT4 in the skeletal muscle of GLUT4 rats as compared to diabetic rats, thus enhancing the mitochondrial biogenesis of GLUT4 through an increase in the protein expression level of GLUT4 that was reported in this study. This is supported by several studies; One study observed that the GLUT4 protein expression level was upregulated in rats with diabetes after 4-week treatment with α-amyrin. GLUT4 plays a crucial roles to protect against ageing and diseases through regulating mitochondrial content (36, 37). In another study, the authors also noted that α-amyrin leads to beneficial effects on the structural remodeling and contractile performance of cardiac myofibers and mitochondrial dysfunction in diabetic rats. It was accompanied by the raise of mitochondrial volume density and enhancement of mitochondrial ultrastructure (37). An experiment conducted on streptozotocin-induced diabetic rats that applied transcriptomics to determine the effect of α-amyrin showed that the compound can cause changes in the genes involved in mitochondrial dynamics and function. This included the overexpression of, which are known to be involved in processes of mitochondria synthesis and activity (38). Altogether, these results support the view that α-amyrin has the potential to promote mitochondrial biogenesis in cultured diabetic rats by enhancing GLUT4 expression and the ultrastructure and functionality of mitochondria. T2DM is also manifested through the alteration of multiple metabolic functions; inadequate insulin secretion, reduced insulin sensitivity or both (39).

Conclusion

In conclusion, we have shown that α-amyrin nanocapsule (80 mg\kg), is a pentacyclic triterpene, improves the condition of hyperglycemia and dyslipidemia ,lowering risk factors and glucose. It is a possibility that the substance has anti-inflammatory properties that might be responsible for its tolerance in rats, underlying the actions of the α-amyrin nanocapsule that is established.

Conflict of interest

The authors have nothing to say about a conflict of interest.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest. Ethical approval for this research was obtained from the Al-Qadisiyah University Local Committee no 11/5/32 on 12/1/2023.

References

1. AL-Khamas AJH. (2018). Effect of cinnamon zeylanicum bark water extract on male diabetic albino rats fertility. *Basrah J Vet Res.;17(*1):123–35.
2. Hao, E., Tyrberg, B., Itkin-Ansari, P., Lakey, J. R., Geron, I., Monosov, E. Z & Levine, F. (2006). Beta-cell differentiation from nonendocrine epithelial cells of the adult human pancreas. *Nature medicine, 12(*3), 310-316. DOI:10.1038/nm1367.

3. Taskinen M-R. (2006). Diabetic dyslipidemia. Atheroscler Suppl. (2002);3(1):47–51. nonendocrine epithelial cells of the adult human pancreas. *Nat Med.;12*(3):310–6. DOI: 10.1016/0002-9343(94)90228-3
4. Schlyer S, Horuk R. I. (2006). Want a new drug: G-protein-coupled receptors in drug development. *Drug Discov Today.;11(*11–12):481–93. Doi: 10.1016/j.drudis.2006.04.008.
5. Fessi H, Puisieux F, Devissaguet JP, Ammoury N, Benita S. (1989). Nanocapsule formation by interfacial polymer deposition following solvent displacement. *Int J Pharm.;55*(1):R1–4.
6. Gao, D., Li, Q., Li, Y., Liu, Z., Fan, Y., Liu, Z., ... & Han, Z. (2009). Antidiabetic and antioxidant effects of oleanolic acid from Ligustrum lucidum Ait in alloxan-induced diabetic rats. Phytotherapy Research: *An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 23*(9), 1257-1262.
7. Eu CHA, Lim WYA, Ton SH, Kadir K bin A. (2010). Glycyrrhizic acid improved lipoprotein lipase expression, insulin sensitivity, serum lipid and lipid deposition in high-fat diet-induced obese rats. *Lipids Health Dis.;9*:1–9. DOI:10.1186/1476-511X-9-81
8. Sheng H, Sun H. (2011). Synthesis, biology and clinical significance of pentacyclic triterpenes: a multi-target approach to prevention and treatment of metabolic and vascular diseases. *Nat Prod Rep.;28*(3):543–93. DOI:10.1039/c0np00059k.
9. Holanda Pinto SA, Pinto LMS, Cunha GMA, Chaves MH, Santos FA, Rao VS. (2008). Anti-inflammatory effect of α, β-Amyrin, a pentacyclic triterpene from Protium heptaphyllum in rat model of acute periodontitis. *Inflammopharmacology.;16:*48–52. DOI: 10.1007/s00011-011-0321-x
10. Arora P, Ansari SH & Nainwal LM. Mesua ferrea L. (2021). (Calophyllaceae) exerts therapeutic effects in allergic asthma bymodulating cytokines production in asthmatic rats. *Turkish Journal of Botany,;45*(8): 820-832. DOI**:** 10.3906/bot-2111-22.
11. Neto SF, Prada AL, Achod LDR, Torquato HFV, Lima CS, Paredes-Gamero EJ. & Amado J. RR. (2021). α-amyrin-loaded nanocapsules produce selective cytotoxic activity in leukemic cells. *Biomedicine & Pharmacotherapy, 139*:111656. DOI:10.1016/j.biopha.2021.111656.
12. Park JJ, Kang KL. (2012). Effect of 980-nm GaAlAs diode laser irradiation on healing of extraction sockets in streptozotocin-induced diabetic rats: a pilot study. *Lasers Med Sci.;27:*223–30. DOI:10.1007/s10103-011-0944-8.
13. Neto SF, Prada AL, Achod LDR, Torquato HFV, Lima CS, Paredes-Gamero EJ. (2021). α-amyrin-loaded nanocapsules produce selective cytotoxic activity in leukemic cells. *Biomed Pharmacother.;139:*111656. *DOI:* 10.1016/j.biopha.2021.111656
14. Amado JRR, Prada AL, Duarte JL, Keita H, da Silva HR, Ferreira AM, (2017). Development, stability and in vitro delivery profile of new loratadine-loaded nanoparticles. *Saudi Pharm J.;25(*8):1158–68. DOI:10.1016/j.jsps.2017.07.008.

15. Livak KJ, Schmittgen TD. (2001). Analysis of relative gene expression data using real-time quantitative PCR and the 2− ΔΔCT method. *Methods.;25(*4):402–8.
16. Thomas L. (1998). Clinical laboratory diagnostics 1ST ed Frankfurt TH. *Books Verlagsgesellschaft.;2:*487–95.
17. Burtis CA, Ashwood ER. (1999). Tietz textbook of clinical chemistry.Pp.:33-45.
18. Flier JS, Kahn CR, Roth J. (1979). Receptors, antireceptor antibodies and mechanisms of insulin resistance. *N Engl J Med.;300(*8):413–9. DOI: 10.1073/pnas.73.11.4115
19. Cirera S, Busk PK. (2014). Quantification of miRNAs by a simple and specific qPCR method. *RNA Mapp Methods Protoc.;*73–81. DOI:10.20944/preprints202411.1912.v3
20. Girden, E. R. (1992). ANOVA: *Repeated measures (No. 84). sage.*
21. Zhang L, Zalewski A, Liu Y, Mazurek T, Cowan S, Martin JL. (2003). Diabetes-induced oxidative stress and low-grade inflammation in porcine coronary arteries. *Circulation.;108(*4):472–8. DOI:10.1161/01.CIR.0000080378.96063.23.
22. da Silva KABS, Paszcuk AF, Passos GF, Silva ES, Bento AF, Meotti FC, et al. (2011). Activation of cannabinoid receptors by the pentacyclic triterpene α, β-amyrin inhibits inflammatory and neuropathic persistent pain in mice. *PAIN.;152*(8):1872–87. DOI:10.1016/j.pain.2011.04.005
23. Koo KB, Suh HJ, Ra KS, Choi JW. (2011). Protective effect of cyclo (his-pro) on streptozotocin-induced cytotoxicity and apoptosis *in Vitro. J Microbiol Biotechnol.;21(*2):218–27.
24. Rao VS, de Melo CL, Queiroz MGR, Lemos TLG, Menezes DB, Melo TS, et al. (2011). Ursolic acid, a pentacyclic triterpene from Sambucus australis, prevents abdominal adiposity in mice fed a high-fat diet. *J Med Food.;14*(11):1375–82. DOI: 10.1089/jmf.2010.0267
25. Singh AB, Yadav DK, Maurya R, Srivastava AK. (2009). Antihyperglycaemic activity of α-amyrin acetate in rats and db/db mice. *Nat Prod Res.;23(*9):876–82.
26. de Melo CL, Queiroz MGR, Fonseca SGC, Bizerra AMC, Lemos TLG and Melo TS. (2010). Oleanolic acid, a natural triterpenoid improves blood glucose tolerance in normal mice and ameliorates visceral obesity in mice fed a high-fat diet. *Chem Biol Interact.;185*(1):59–65. DOI: 10.1016/j.cbi.2010.02.028.
27. Engeli S. (2012). Central and peripheral cannabinoid receptors as therapeutic targets in the control of food intake and body weight. *Appet Control.;357*–81. *DOI:*10.1007/978-3-642-24716-3_17
28. Mahato SB, Sen S. (1997). Advances in triterpenoid research, 1990–1994. *Phytochemistry.;44*(7):1185–236. DOI: 10.1016/S0031-9422(96)00639-5
29. Abed MA, Azeez OH. (2013). The effect of cumin on induced diabetes in rats. *Basra J Vet Res.;12*:69–80.
30. Chicca A, Marazzi J, Gertsch J. (2012). The antinociceptive triterpene β-amyrin inhibits 2-

arachidonoylglycerol (2-AG) hydrolysis without directly targeting cannabinoid receptors. *Br J Pharmacol.;167*(8):1596–608. *DOI:* 10.1111/j.1476-5381.2012.02059.x

31. AL-Anni SS, Zghair ZR, Al-jaboore MD, Khalel EK. (2016). Histopathological study of nitrate ion effect on pancreas experimentally in laboratory mice. *Basrah J Vet Res.;15(*4):179–84.
32. Lynch CJ, Zhou Q, Shyng S-L, Heal DJ, Cheetham SC, Dickinson K, (2012). Some cannabinoid receptor ligands and their distomers are direct-acting openers of SUR1 KATP channels. *Am J Physiol Metab.;302(5):E540–*51. DOI:10.1152/ajpendo.00250.2011
33. Oliveira FA, Chaves MH, Almeida FRC, Lima Jr RCP, Silva RM, Maia JL. (2005). Protective effect of α-and β-amyrin, a triterpene mixture from Protium heptaphyllum (Aubl.) March. trunk wood resin, against acetaminophen-induced liver injury in mice. *J Ethnopharmacol.;98(*1–2):103–8. DOI:10.1016/j.jep.2005.01.036
34. Melo CM, Morais TC, Tomé AR, Brito GAC, Chaves MH, Rao VS. (2011). Anti-inflammatory effect of α, β-amyrin, a triterpene from Protium heptaphyllum, on cerulein-induced acute pancreatitis in mice. *Inflamm Res.;60:6*73–81. DOI:10.1007/s00011-011-0321-x
35. Sporn MB, Liby KT, Yore MM, Fu L, Lopchuk JM, Gribble GW. (2011). New synthetic triterpenoids: potent agents for prevention and treatment of tissue injury caused by inflammatory and oxidative stress. *J Nat Prod.;74*(3):537–45. DOI: 10.1158/1538-7445.AM2015-5559
36. Vieira Júnior GM, Souza CML de, Chaves MH. (2005). Resina de Protium heptaphyllum: isolamento, caracterização estrutural e avaliação das propriedades térmicas. *Quim Nova.;28*:183–7. doi.org/10.1590/S0100%2D4042200500020000.
37. Arichi H, Kimura Y, Okuda H, Baba K, Kozawa M, Arichi S. (1982). Effects of stilbene components of the roots of Polygonum cuspidatum Sieb. et Zucc. on lipid metabolism. *Chem Pharm Bull.;30*(5):1766–70. DOI:/10.1248 :cpb.30.1766.
38. Yin Y, Pan Y, He J, Zhong H, Wu Y, Ji C. (2022). The mitochondrial-derived peptide MOTS-c relieves hyperglycemia and insulin resistance in gestational diabetes mellitus. *Pharmacol Res.;175:*105987. DOI:10.1016/j.phrs.2021.105987
39. Yoon TK, Lee CH, Kwon O, Kim M-S. (2022). Exercise, Mitohormesis, and Mitochondrial ORF of the 12S rRNA Type-C (MOTS-c). *Diabetes Metab J.;46*(3):402. DOI: 10.4093/dmj.2022.0092.
40. Parseh S, Shakeriyan S, Zafarmand O. (2022). Investigating the relationship between exercise training and MOTS-c in type 2 diabetes: a review study. In*tern Med Today.;29*(1):44–54.
41. Zempo H, Kim S-J, Fuku N, Nishida Y, Higaki Y, Wan J, et al. (2021). MA pro-diabetogenic mtDNA polymorphism in the mitochondrial-derived peptide, MOTS-c. Aging *(Albany NY).;13*(2):1692.DOI: 10.18632/aging.202529

تأثير كبسولات ألفا أميرين النانوية على التكوين الحيوي للميتوكوندريا وصور الدهون الدم في الجرذان المصابه بالسكري

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الخلاصة

تُظهر التربينويدات الثلاثية الحلقات خماسية الحلقة (مثل الألفا-أمَيرين) عمومًا تأثيرات مفيدة في الاضطرابات الأيضية. تهدف هذه الدراسة إلى البحث في تأثير كبسولات النانو من الألفا-أمَيرين على مستوى سكر الدم وصورة الدهون في ذكور الجرذان المصابة بالسكري والتي تتغذى على حمية عالية الدهون (HFD). تشمل مجموعات التجربة ما يلي: مجموعة السيطرة الطبيعية(A)، تلقت ماء الشرب فمويًا، المجموعة الثانية (B) مجموعة السكري؛ أُحدث فيها السكري بحقن سترابتوزوتوسين مع تغذية عالية الدهون.المجموعة الثالثة (C) مجموعة السكري + ألفا-أمَيرين (100 ملغ/جرذ يوميًا)؛ لمدة شهر + الحمية عالية الدهون. المجموعة الرابعة (D) مجموعة السكري + ألفا-أمَيرين-نانوكبسولة (50 ملغ/جرذ يوميًا) عُولجت الجرذان لمدة شهر مع تغذية عالية الدهون.المجموعة الخامسة (E) مجموعة السكري+ألفا-أمَيرين-نانوكبسولة (40 ملغ/جرذ يوميًا). المجموعة السادسة (F)مجموعة السكري+ألفا-أمَيرين-نانوكبسول (80 ملغم/جرذ يوميًا)؛ بعد إحداث السكري مع الحمية عالية الدهون، عولجت الجرذان يوميًا لمدة شهر. المجموعة السابعة (G) مجموعة الجرذان المصابة بالسكري والمعالجة بالإنسولين (4 وحدة دولية/جرذ تحت الجلد). أظهرت النتائج انخفاضًا ملحوظًا في مستويات الغلوكوز في مجموعة جسيمات الألفا-أمَيرين النانوية بجرعة 80 ملغ/كغم وفي مجموعة الإنسولين. كما سجّلت النتائج انخفاضًا ملحوظًا في صورة الدهون في المجموعة F والمجموعة G ومجموعة السيطرة مقارنة بالمجموعات الأخرى. علاوة على ذلك، كشف مستوى الإنسولين في البلازما والتحليل النسيجي للبنكرياس عن التأثير المفيد للألفا-أمَيرين في الحفاظ على سلامة خلايا بيتا. كما تضاعف مستوى التعبير الجيني لـ GLUT4 (بالـ qPCR) في المجموعة الفا اميرين 40 مقارنة بالمجموعة المصابة غير المعالجة. تعكس هذه النتائج الإمكانات الكبيرة للألفا-أمَيرين-نانوكبسولة كمركب ذي تأثيرات مضادة لفرط سكر الدم وخافضة للدهون، ونقترح إمكانية أن يكون مركبًا رائدًا لتطوير أدوية فعالة في علاج السكري واضطرابات الدهون.

الكلمات المفتاحية:α-amyrin; nanocapsule.hypolipidemic .