Egypt. J. Vet. Sci. **Vol. 55,** No. 1, pp. 147-156 (2024)

Egyptian Journal of Veterinary Sciences
https://ejvs.journals.ekb.eg/

Impact of Baobab Consumption on Some Biochemical Alterations in Male Diabetic Rats

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DIABETES is a chronic metabolic, which contributes to disease progression and complications. Baobab is a tropical fruit tree known for its medicinal properties and rich content of antioxidants and anti-inflammatory compounds. This research aimed to investigate the potential anti-inflammatory effects of baobab (*Adansonia digitata*) in an induced diabetic rat. The study utilized an interventional design and divided the rats into various treatment groups, including a control group, diabetic group, and groups treated with baobab extract, metformin, or a combination of both. Blood samples were collected at various time points to evaluate blood sugar levels, tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-10 (IL-10) levels. The results showed that baobab and metformin, either alone or in combination, significantly reduced blood sugar levels compared to the positive control group. Additionally, baobab demonstrated a potential for reducing TNF-α, IL-6, and IL-10 levels, indicating its anti-inflammatory effects in the diabetic model. These findings suggest that baobab may have therapeutic implications in managing inflammation associated with diabetes. However, further research is required to fully elucidate the underlying mechanisms and evaluate the clinical effectiveness of baobab in human subject.

Keywords: Diabetes, Baobab, Anti-inflammatory, TNF-α, IL-6.

Introduction

Diabetes mellitus is a chronic metabolic condition characterized by elevated blood glucose levels, which can be caused by either insulin insufficiency or insulin resistance [1]. Millions of individuals around the world are impacted, making it a global health issue. Chronic inflammation is a component of diabetes pathogenesis and is essential to the onset and development of the illness. Insulin resistance, the deterioration of pancreatic beta cells, and the emergence of diabetic complications are all influenced by inflammation [2].

The Baobab, an African native tropical fruit tree (*Adansonia digitata*), is one such natural product that has gained popularity in recent years [3]. Traditional medicine has made use of the medical benefits of baobab fruit and preparations, particularly its anti-inflammatory actions [3]. Various bioactive substances, including polyphenols, flavonoids, and vitamin C, which are recognized for their anti-inflammatory activities, have been found in baobab, according to several studies [2].

Polyphenols, plant chemicals with strong antioxidant and anti-inflammatory properties, are abundant in baobab. Polyphenols have been shown to inhibit pro-inflammatory enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX), which leads to a reduction in the synthesis

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(Received 09/08/2023, accepted 11/09/2023)
DOI: 10.21608/EJVS.2023.228137.1557
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of inflammatory mediators like prostaglandins and leukotrienes [3, 4]. Additionally, they can neutralize free radicals and alter signaling pathways related to inflammation, which aids in reducing the inflammatory response [3].

Quercetin, kaempferol, and rutin are only a few of the flavonoids found in baobab [5]. By preventing the release of pro-inflammatory cytokines, limiting the action of pro-inflammatory enzymes, and modifying immune cell activity, flavonoids have anti-inflammatory characteristics. Additionally, they can stop the production of genes that promote inflammation by inhibiting nuclear factor-kappa B (NF-B), a crucial regulator of inflammation [6]. Baobab has a remarkable amount of vitamin C, a powerful antioxidant [7]. Free radicals are highly reactive chemicals that cause inflammation and oxidative stress. Antioxidants play a crucial role in counteracting the activity of these molecules, helping to quench their harmful effects and restore cellular balance [8]. Vitamin C can lessen inflammation and the harm it causes by lowering oxidative stress [4].

Furthermore, baobab's anti-inflammatory effects may extend beyond its antioxidant properties [9]. Certain research studies propose that baobab may have the capacity to impede the production of pro-inflammatory cytokines, like tumor necrosis factor-alpha (TNF-α) and interleukin-10 (IL-10), and interleukin-6 (IL-6), by modulating signaling pathways involved in inflammation[10]. The aim of this study was to conduct a controlled experimental investigation into any potential anti-inflammatory properties of baobab in induced diabetic animals by measuring.

Material and Methods

Animals

Adult Albino rats, aged between 8 to 10 weeks and weighing between 250 to 300 grams with an average weight of 250g, were obtained from the animal house of Veterinary Medicine College, Mosul University.

Ethical approval

Ethical approval was obtained according to No. 7/18/44/46 on 3/14/2019, and scientific and humane methods were followed in ethical dealing with animals, according to the instructions of the Ministry of Higher Education and Scientific Research in Iraq.

Drugs and materials used

- Baobab fruit pulp powder 100% organic (Sudan- Khartoum) ttps://aduna.com/blogs/learn/baobab-benefits. Dose calculated according the body weight then dissolved in water and orally adminstered .
- Alloxan solution (100mg/kg) to induce diabetes from Biomedicine and Pharmacotherapy.
- Metformin from Sun Pharmaceutical Industries Ltd.

Kits used

- Rat IL-10 ELISA Kit MBS355232
- Rat Interleukin 6 (IL-6) ELISA Kit MBS269892
- Rat Total Antioxidant Status ELISA Kit MBS1600693
- Rat Malondialdehyde (MDA) ELISA Kit MBS268427
- Rat TNF-α (Tumor Necrosis Factor Alpha) ELISA Kit MBS2507393

All kits from MyBiosource, USA

Experimental design

Alloxan–induced Diabetes

The study involved the division of the animals into seven distinct groups. Seventy (70) adult Male Albino rats, aged between 8 to 10 weeks and weighing between 250 to 300 grams with an average weight of 250g, were obtained from the animal house of Veterinary Medicine College, Mosul University. The animals were raised in suitable laboratory conditions in terms of lighting, 12 light and 12 dark, taking into account the temperature and providing the necessary food and water throughout the research period

Each group comprised ten rats, and after a period of acclimation, the experiments were conducted. The experimental group (10 rats for each group) got a single intraperitoneal injection of alloxan solution (100mg/kg) to induce diabetes from Biomedicine and Pharmacotherapy [11] , while the control group (10 rats) injected distilled water as a vehicle. The rats were given a 5% glucose solution in tap water for 24 hours following the injection to prevent hypoglycemia shock [12]. Fluctuations in blood glucose levels were observed initially, and the rats were considered diabetic using blood glucometer strip from IndiaMART, A drop of blood is taken from the tail, and placed in the designated place on the slide, and the result is then shown when their

random blood glucose values reached or exceeded 200 mg/dl, and remained stable at this elevated level. blood samples were obtained 48 and 72 hours after the injection to confirm diabetes.

General Experimental group

The study comprised several distinct groups:

1. Control group (G1) - administered a standard lab. diet.
2. Group (G2) - induced with diabetes by receiving alloxan monohydrate at a dose of 100 mg/kg IP injection.
3. Group (G3) - administered only Baobab at a dosage of 500 mg/kg orally [13] .
4. Group (G4) - administered only metformin 100mg/kg orally
5. Group (G5) - diabetic rats treated with Baobab at a dosage of 500 mg/kg.
6. Group (G6) - diabetic rats treated with metformin at a dosage of 100 mg/kg.
7. Group (G7) - diabetic rats receiving a combination of Baobab (500 mg/kg) and metformin (100 mg/kg). The treatments were administered orally for duration of 15Days and 30Days.

Statistical Analysis:

The data obtained from the study will be presented as mean ± standard error of the mean (SEM). Statistical analysis will be conducted using computer by one-way analysis of variance (ANOVA), followed by post-hoc tests, specifically the Dunken test. A p-value less than 0.05 will be considered statistically significant, while a p-value less than 0.001 will be regarded as highly significant [14].

Results

The results presented in Table 1 demonstrate the impact of baobab on blood sugar levels in a diabetic model over time. Current study included different treatment groups, including a negative control, positive control, and groups receiving baobab, metformin, or a combination of both. The negative control and normal baobab groups maintained stable blood sugar levels. The positive control group exhibited notably increased levels. The diabetic groups treated with baobab, metformin, or their combination showed notable reductions in blood sugar levels compared to the positive control group. These findings suggest that baobab may have potential therapeutic effects in managing diabetes.

The Table (2) shows the effect of baobab on TNF-α (Tumor Necrosis Factor-alpha) levels over time in a diabetic model. The positive control group had the highest TNF-α levels throughout the study. The normal baobab, diabetic+baobab, diabetic+ metformin, and diabetic+ metformin+baobab groups The positive control group demonstrated significantly elevated levels of TNF-α, whereas the groups treated with baobab, either alone or in combination with metformin, showed lower TNF-α levels. These results imply that baobab may have a beneficial effect in reducing TNF-α levels in the diabetic model, especially when used either alone or in conjunction with metformin.

Table 3 presents the impact of various treatments on IL-6 levels over the duration of the diabetic model. Throughout the study, the positive control group consistently exhibited the highest IL-6 levels among all the groups. The normal baboab, diabetic+baboab, diabetic+metformin, and diabetic+metformin+baobab groups showed lower IL-6 levels compared to the positive control group. These findings suggest that baobab and metformin may have a beneficial effect in reducing IL-6 levels in the diabetic model.

The normal baboab, diabetic+baboab,diabe tic+metformin,and diabetic+metformin+baobab groups showed lower IL-10 levels compared to the positive control group. These findings suggest that baobab and metformin may have a potential effect on IL-10 levels in the diabetic models.

Discussion

Baobab may reduce diabetic mellitus through a variety of mechanisms, including the induction of diabetes by alloxan, which is specifically toxic to the pancreatic beta cells that produce insulin, resulting in decreased insulin production and the emergence of symptoms resembling diabetes [15]. Alloxan administration is a convenient way to induce diabetes in animal models since it is rather straightforward and repeatable. The dosage can be changed to reach the desired level of beta-cell death, and it can be given intravenously or intraperitoneally. Diabetes brought on by

alloxan often progresses quickly, making it possible for researchers to track the disease's onset and development [16]. For investigations requiring prompt interventions or assessments, this rapid onset is advantageous. The use of a particular strain, such as male albino rats, enables standardization and comparability of study results. Male albino rats are frequently employed in diabetic research. Researchers can reduce genetic diversity and concentrate on the precise effects of the intervention or condition they are studying by utilizing the same strain [17].

Male albino rats have been found to be more susceptible to developing diabetes compared to other strains Rats are a valuable model for studying various diseases, including diabetes. It is crucial to acknowledge that no individual animal model can entirely mimic the intricacy and diversity of human diseases [18].

One plausible mechanism involves its purported anti-inflammatory properties, which are exemplified by the decline in pro-inflammatory cytokines like TNF-α and IL-6 observed in the diabetic model. Persistent inflammation significantly contributes to the onset and advancement of diabetes, and by alleviating inflammation; baobab may potentially ameliorate the adverse effects of diabetes.

Furthermore, baobab is abundant in dietary fiber, a component that can decelerate the absorption of carbohydrates and inhibit rapid surges in blood glucose levels following meals. This can contribute to better glycemic control and help regulate blood sugar levels in individuals with diabetes [19].

The specific mechanisms through which baobab exerts its anti-diabetic effects are not yet fully understood and require further research. However, there are several potential mechanisms that have been proposed:

Baobab contains abundant antioxidants, including vitamin C and diverse phenolic compounds. These antioxidative agents have the potential to mitigate oxidative stress, a contributing factor to insulin resistance and impaired glucose metabolism in diabetes[20].

Anti-inflammatory properties: Baobab has been found to possess anti-inflammatory properties, which can help mitigate chronic low-grade inflammation associated with diabetes. By reducing inflammation, baobab may improve insulin sensitivity and glycemic control [21].

Modulation of glucose metabolism: Baobab is rich in dietary fiber, which possesses the ability to decelerate the absorption of carbohydrates, thus mitigating the occurrence of rapid surges in blood glucose levels. This can help regulate blood glucose levels and improve glycemic control in individuals with diabetes [22].

Regulation of gut microbiota: Emerging evidence suggests that the composition of gut microbiota plays a role in the development and progression of diabetes. Baobab has prebiotic properties, meaning it provides nourishment to beneficial gut bacteria. By promoting a healthy gut microbiota, baobab may indirectly influence glucose metabolism and insulin sensitivity [23].

Potential effects on pancreatic beta cells: Baobab extracts have been shown to possess certain compounds that may have a protective effect on pancreatic beta cells. These cells are responsible for insulin production, and preserving their function is crucial in diabetes management [24].

Baobab has been reported to possess anti-inflammatory effects, which can be attributed to its various bioactive components and nutritional composition some mechanisms that contribute to the anti-inflammatory properties of baobab [25].

Antioxidant activity: Baobab is abundant in potent antioxidants like vitamin C, vitamin E, and polyphenols. These bioactive substances play a crucial role in scavenging free radicals and mitigating oxidative stress, thereby maintaining cellular balance and promoting overall health, which is associated with chronic inflammation. By scavenging free radicals, baobab helps protect cells and tissues from damage and inflammation [26]..

Anti-inflammatory cytokine modulation: Baobab has been observed to regulate the production and secretion of pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF-alpha) and interleukin-6 (IL-6).Baobab may help regulate the immune response by suppressing the production of these inflammatory molecules, thereby reducing inflammation [27].

Inhibition of inflammatory enzymes: Baobab possesses bioactive constituents that can effectively hinder the function of enzymes engaged in the generation of inflammatory mediators, including cyclooxygenase (COX) and lipoxygenase (LOX). Through this inhibition,

baobab acts as a suppressant for the synthesis of inflammatory prostaglandins and leukotrienes, thereby contributing to the mitigation of inflammatory responses, thereby reducing inflammation [28].

Gut health promotion: Baobab is a good source of dietary fiber, including soluble and insoluble fiber. These dietary fibers contribute to the maintenance of a well-functioning gut microbiota, which holds significant importance in immune function and the regulation of inflammation. Through the promotion of a balanced gut microbiota, baobab indirectly fosters the reduction of inflammation and provides support for overall health [29].

Immune system modulation: The bioactive substances included in baobab may alter the immune system, strengthening the body's capacity to fight inflammation. According to some research, baobab may be able to boost immune cells important for the inflammatory response, like lymphocytes and macrophages. Baobab is a better source of flavonoids than fruits and vegetables and has various health benefits associated with inhibition From oxidative stress, induction of anti-inflammatory, anticancer and antiviral activities [30].

Conclusion

In conclusion, the assessment of the anti-inflammatory impacts of baobab on induced diabetic male albino rats indicates that baobab exhibits significant anti-inflammatory effects in this model. These findings suggest that baobab has the potential to reduce inflammation associated with diabetes and may have a therapeutic role in managing diabetes-associated inflammation.

Acknowledgment:

All thanks and appreciation to the University of Mosul, College of Veterinary Medicine and the University of Tikrit, College of Veterinary Medicine for their support of this study**.**

Conflict interest: None

Funding statement: Self-funding

Contribution of authors: All researchers participated in designing the research. The first researcher carried out the practical aspect. The second and third researchers completed the task of statistical analysis, making tables, and writing.

TABLE 1. Effect Baboab on Blood Sugar Levels (mg /dL) over Time in a Diabetic Model

Time / Treatment	Mean ± S.E Blood Glucose Levels(mg /dL) N(10) /Group				
	Day zero	Two days after treatment with alloxan	Day15	Day30	p- value
G1FBG(mg /dl)	94.60 ± 2.56^{A}	93.00±2.5^{A}	94.20 ± 4.62^{A}	89.00 ± 2.76^{A}	0.681
G2FBG(mg /dl))	94.80 ± 5.97^{A}	451.74± 16.86^{C}	416.80 ± 18.76^{B}	402.80 ± 17.81^{B}	**0.001****
G3FBG (mg /dl))	98.00 ± 3.70^{aA}	94.75±2.25^{A}	90.60 ± 2.23^{A}	81.00 ± 2.66^{A}	0.414
G4 FBG (mg /dl)	91.60 ± 2.50^{aA}	90.00± 2.45^{A}	81.40 ± 1.50^{A}	76.60 ± 1.17^{A}	0.513
G5 FBG(mg /dl)	93.40 ± 5.01^{A}	405.60 ± 31.04^{A}	242.80 ± 10.97^{A}	122.40 ± 7.26^{A}	**0.000****
G6 FBG(mg /dl)	100.40 ± 7.49 ^{A}	404.20 ± 26.30^{A}	280.40 ± 26.29^{A}	125.00 ± 6.28 ^{A}	**0.000****
G7 FBG(mg /dl)	95.80 ± 2.65	435.40 ± 21.56^{A}	172.80 ± 7.25 ^{A}	99.20 ± 3.99 ^{A}	**0.0020****

Horizontally mean superscript capital letter blue color same letter significant difference while different letter non-significant

* Significant differences at p<0.05, ** highly significant level <0.01.

Analysis by one way –ANOVA, Post –Hoc Duncan′s test

TABLE 2. The Influence of Baobab on TNF-α Levels in Diabetic Models

Time / Treatment	Mean ± S.E TNF -α Levels (ng/dl) N(10) /Group				
	Day zero	Two days after treatment with alloxan	Day15	Day30	P -value
G1	1136.28 ± 9.25^{A}	1132.90±11.12^{A}	1134.58 ± 15.35^{A}	1136.52 ± 13.10 ^{A}	0.271
G2	1175.20 ± 7.84^{A}	3082.74 ± 30.30^{B}	3112.64 ± 32.65^{B}	3159.94 ± 27.71^{B}	**0.000****
G3	1139.30 ± 12.31^{A}	1144.27±14.56 ^{A}	1253.74 ± 32.65 ^{A}	1073.26 ± 26.52 ^{A}	0.306
G4	1168.70 ± 14.50^{A}	1173.50±17.70 ^{A}	1127.90 ± 57.28 ^{A}	982.52 ± 43.39 ^{A}	0.126
G5	1168.02 ± 8.53 ^{A}	3138.38 ± 38.05^{C}	2387.56 ± 69.99 ^{B}	1320.26 ± 36.41 ^{A}	**0.000****
G6	1137.54 ± 35.04^{A}	3167.56 ± 34.70^{C}	2278.92 ± 152.57^{B}	1685.82 ± 61.71 ^{B}	**0.000****
G7	1172.38 ± 15.92^{A}	3167.44 ± 48.90^{C}	2040.58 ± 147.60 ^{B}	1601.61±50.47 ^{A}	**0.000****

Analysis by one way –ANOVA, Post –Hoc Duncan′s test
Vertical colum different superscript small letter blue color significant difference, same letter non-significant.
* Significant differences at p<0.05, ** highly significant level <0.01

TABLE 3. The Influence of Baobab on α IL-10 Levels in Diabetic Models

Time / Treatment	Mean ± S.E IL-10 Levels (ng/dl) N(10) /Group				
	Day zero	Two days after treatment with alloxan	Day15	Day30	*P-Value*
G1	551.40 ± 6.69^{A}	551.83±8.97 ^{A}	553.40 ± 10.25 ^{A}	551.52 ± 7.48^{A}	0.271
G2	529.58 ± 7.34 ^{A}	3190.42 ± 47.07^{B}	3219.16 ± 22.59 ^{B}	3252.74 ± 23.15^{B}	**0.000****
G3	530.78 ± 8.91 ^{A}	515.8±5.14 ^{A}	526.72 ± 5.89 ^{A}	525.84 ± 2.96^{A}	0. 127
G4	533.54 ± 6.63 ^{A}	532.70±8.49 ^{A}	528.22 ± 5.59 ^{A}	514.10 ±2.53^{A}	0.193
G5	533.82 ± 8.66 ^{A}	3168.52 ± 30.82^{cC}	2118.58 ± 19.81^{B}	727.98 ± 13.99^{A}	**0.000****
G6	535.00 ± 6.90 ^{A}	3173.90 ± 21.79^{C}	2126.46 ± 66.24 ^{B}	833.68 ± 55.70^{B}	**0.000****
G7	529.08 ± 1.60 ^{A}	3210.64 ± 38.47^{C}	1477.30 ± 76.06 ^{B}	517.26 ± 11.91^{A}	**0.000****

*p-value less than 0.05 will be considered statistically significant.
** p-value less than 0.01

TABLE 4. The Influence of Baobab on α IL-6 Levels in Diabetic Models

Time	Mean ± S.E IL-6 Levels (ng/dl) N(10) /Group				
Treatment	Day zero	Two days after treatment with alloxan	Day15	Day30	*p- value*
G1	122.66 ± 4.62^{A}	118.65±2.98^{A}	119.70 ± 2.53^{A}	119.36 ± 0.82^{A}	0.806
G2	119.83 ± 2.69^{A}	327.49 ± 9.28^{B}	325.02 ± 10.53^{B}	325.80 ± 8.83^{B}	**0.000****
G3	123.44 ± 3.27^{A}	124.60± 3.87^{A}	114.00 ± 3.39^{A}	115.08 ± 2.56^{A}	0.615
G4	121.74 ± 3.81^{A}	122.78±4.73^{A}	118.70 ± 2.79^{A}	117.10 ± 0.97^{A}	0.420
G5	118.12 ± 1.39^{A}	316.78 ± 5.15^{C}	225.14 ± 6.41^{B}	144.54 ± 5.38^{A}	**0.000****
G6	122.20 ± 2.57^{A}	317.02 ±15.91^{C}	205.64 ± 6.41^{B}	174.58 ± 3.90^{B}	**0.000****
G7	119.84 ± 3.73^{A}	317.02 ± 15.91^{C}	192.74 ± 7.42^{B}	99.26 ± 2.19$^{a\,A}$	**0.000****

*p-value less than 0.05 will be considered statistically significant.
** p-value less than 0.01

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Article Highlights

Baobab, a tropical fruit tree, is known for its medicinal properties and rich content of antioxidants and anti-inflammatory compounds.

Diabetes is a chronic metabolic disorder that is associated with chronic inflammation.

The study utilized an induced diabetic rat model to assess the effects of baobab on inflammation and blood sugar levels.

Baobab and metformin showed promising results in reducing blood sugar levels in the diabetic rat model.

Baobab exhibited potential anti-inflammatory effects by reducing TNF-α, IL-6, and IL-10 levels in the diabetic rats.

These findings suggest that baobab may hold therapeutic promise for managing inflammation associated with diabetes.

تأثير استهلاك الباوباب على بعض المتغيرات البيوكيميائية في ذكور الجرذان المصابة بالسكري

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يعد السكري اضطراباً مزمناً للأيض يرتبط بالالتهاب المزمن، والذي يسهم في تقدم المرض وحدوث المضاعفات. يعتبر التبلدي شجرة فاكهة استوائية معروفة بخصائصها الطبية ومحتواها الغني بمضادات الأكسدة والمركبات المضادة للالتهابات. هدفت هذه الدراسة إلى دراسة التأثيرات المحتملة المضادة للالتهابات لفاكهة التبلدي (Adansonia digitata) في نموذج الجرذان المصابة بداء السكري المستحث. استخدمت الدراسة تصميماً تدخلياً وقسمت الجرذان إلى مجموعات علاجية مختلفة، بما في ذلك مجموعة السيطرة، ومجموعة الجرذان المصابة بالسكري، ومجموعات تم علاجها بمستخلص التبلدي ، وميتفورمين، أو مزيج منهما. تم جمع عينات الدم في نقاط زمنية مختلفة لتقييم مستويات السكر في الدم، وعامل نخر الورم-ألفا (TNF-α)، والانترلوكين-6 (IL-6)، والانترلوكين-10 (IL-10). أظهرت النتائج أن التبلدي والميتفورمين، سواء بمفردهما أو بالمزيج، قللت بشكل ملحوظ من مستويات السكر في الدم مقارنة بمجموعة السيطرة الإيجابية. بالإضافة إلى ذلك، أظهرت التبلدي إمكانية تقليل مستويات TNF-α و IL-6 و IL-10، مما يشير إلى تأثيراتها المضادة للالتهابات في نموذج السكري. تشير هذه النتائج إلى أن للباوباب احتمالات علاجية في إدارة الالتهابات المرتبطة بالسكري. ومع ذلك، يتطلب إجراء بحوث إضافية لفهم الآليات الأساسية بشكل كامل وتقييم الفعالية السريرية التبلدي عند البشر.

الكلمات الدالة: السكري، التبلدي، مضاد للالتهابات، عامل النخر الورمي ألفا (TNF-α)، انترلوكين-6 (IL-6)، انترلوكين-10 .(IL-10)