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ANTIPLATELET PROPERTIES OF MUMIE: AN IN VITRO STUDY OF PLATELET AGGREGATION

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Abstract: Platelet aggregation plays a central role in hemostasis and thrombosis, and modulation of platelet function is an important therapeutic target. Natural substances with antiplatelet properties are of increasing scientific interest. Platelet aggregation was studied in vitro using platelet-rich plasma. Aggregation was induced by sodium adenosine diphosphate (ADP). Mumie was tested at concentrations of 0.1 and 0.3 mg/mL. Heparin, acetylsalicylic acid, ε-aminocaproic acid, and sodium lagosol were used as reference compounds. Platelet aggregation time was recorded, and results were expressed as mean ± SEM. Statistical significance was assessed in comparison with control samples. Mumie significantly prolonged platelet aggregation time at both tested concentrations, indicating a marked inhibition of platelet aggregation ($p < 0.05$). The effect was concentration-dependent and comparable to that of acetylsalicylic acid and heparin. Heparin demonstrated the strongest antiaggregatory effect at higher concentrations, while ε-aminocaproic acid showed moderate inhibition. Sodium lagosol exhibited the weakest antiplatelet activity.

Keywords: Mumie, platelet aggregation, antiplatelet activity, hemostasis, heparin, acetylsalicylic acid, ADP-induced aggregation.

Introduction

Traditional medicine (TM) represents a vast and evolving repository of knowledge, practical skills, and therapeutic approaches that have been developed, tested, and transmitted across generations within diverse cultural contexts. Grounded in cultural traditions, empirical observations, and cumulative experiential knowledge, TM is widely applied for health maintenance as well as for the prevention, diagnosis, and treatment of a broad spectrum of physical and mental disorders (1). In recent decades, increasing scientific attention has been directed toward TM, resulting in a growing body of research focused on the pharmacological and biological properties of natural substances traditionally used in these systems. Many of these studies have demonstrated notable therapeutic and preventive potential, thereby reinforcing the relevance of traditional remedies in contemporary biomedical research (2).

Traditional medicine encompasses several well-established and region-specific medical systems, including Traditional Persian Medicine (TPM), Traditional Arabic Medicine, Traditional Chinese Medicine (TCM), and Ayurveda, the ancient medical system of India (3). Among the numerous natural substances utilized within these traditions, Mumijo occupies a particularly distinctive and enduring position. Known globally under various names—such as Shilajit (Hindi), Silajatu (Bengali), Rock Juice (Tibetan), Conqueror of Mountains (Sanskrit), Hajarul-Musa (Arabic), Moomiaii (Persian), Myemu (Russian), and Mumie (German)—this resinous substance ranges in color from pale to dark brown and is often described as mineral pitch or mineral wax. For more than three millennia, Mumijo has been highly valued for its restorative, rejuvenating, and adaptogenic properties (4).

The origin of Mumijo has been interpreted through three principal hypotheses: biological, geological, and bio-mineralogical. According to the biological theory, Mumijo is formed through the gradual decomposition of plant materials and animal excreta under specific environmental and physicochemical conditions. The geological theory attributes its formation to prolonged

geological processes, whereas the bio-mineralogical concept considers Mumijo to be a complex natural product arising from interactions between organic precursors and surrounding mineral matrices. Environmental factors such as regional vegetation, soil and rock composition, altitude, temperature, and humidity significantly influence its chemical profile and therapeutic properties (7). Despite notable regional variability, Mumijo typically consists of approximately 60–80% organic matter and 20–40% inorganic components, including trace elements such as iron, calcium, copper, zinc, magnesium, manganese, molybdenum, and phosphorus (8).

Mumijo has been extensively documented in classical Persian medical texts and has long been regarded as a valuable therapeutic agent. In the 10th century, Ahvazi's *Kamāl as-Sanā'a* recommended its use for conditions including cold-induced headaches, hemoptysis, and asthma. Avicenna, in *The Canon of Medicine*, described Mumijo as a powerful tonic capable of strengthening cerebral function, enhancing reproductive capacity, and alleviating a variety of ailments. Subsequently, in the 12th century, Jurjani's *Zakhire Khwārizmshāhi* highlighted its efficacy in the treatment of inflammatory conditions, ulcers, and disorders of the urinary and prostate systems (5).

Within traditional medical practice, Mumijo has been administered in varying doses for a wide range of clinical indications. These include diseases of the urinary tract, jaundice, gallstones, gastrointestinal disorders, splenomegaly, epilepsy, allergic conditions, neurological diseases, chronic bronchitis, tuberculosis, eczema, anemia, and diabetes (9). Nevertheless, concerns related to fungal contamination and the presence of mycotoxins pose significant challenges to its standardization and widespread therapeutic application (10).

Traditional medical practitioners attribute a broad spectrum of pharmacological activities to Mumijo, including aphrodisiac, anti-inflammatory, and regenerative effects, as well as benefits in musculoskeletal conditions such as fractures, arthritis, and spondylitis. It is also traditionally employed in the management of edema, hemorrhoids, wound healing, metabolic disorders, and general rejuvenation (7). The biological activity of Mumijo is largely attributed to its bioactive constituents, particularly fulvic and humic acids, which exhibit antioxidant, anti-inflammatory, antimutagenic, and immunomodulatory properties. These effects may underlie its proposed anticancer potential (8). Experimental studies further indicate that Mumijo may reduce blood glucose levels and improve lipid profiles in animal models (11), stimulate nucleic acid synthesis, enhance mineral transport to muscle and bone tissues (4), and promote diuretic and natriuretic effects (12).

Collectively, evidence from traditional medical literature and modern experimental studies suggests that Mumijo is a complex natural substance with diverse biological activities and considerable promise for further investigation in modern pharmacological and clinical research.

Materials and Methods.

The study investigated the effects of mumie, heparin, acetylsalicylic acid, ε-aminocaproic acid, and the sodium salt of lagosol on platelet aggregation. Sodium adenosine diphosphate (ADP) was used as an aggregation inducer and served as the control agent. All reagents were of analytical grade and prepared immediately prior to use. Test substances were dissolved in physiological saline to obtain final concentrations of 0.1 mg/mL and 0.3 mg/mL. Heparin was additionally tested at doses equivalent to 0.1 and 0.3 international units (IU). Platelet aggregation was assessed in vitro using platelet-rich plasma. Aggregation was induced by the addition of sodium ADP, and the aggregation response was recorded using a standard aggregometric method. The primary measured parameter was the time to platelet aggregation, expressed in seconds. Platelet-rich plasma samples were incubated with the test substances at the specified concentrations prior to ADP stimulation. Control samples received ADP without test compounds. Each experiment was performed in multiple replicates, and results are presented as mean ±

standard error of the mean (SEM). Statistical analysis was conducted by comparing treated samples with the control group. Differences were considered statistically significant at $p < 0.05$. All statistically significant changes are marked in the table.

Results

The effects of mumie, heparin, acetylsalicylic acid, ε-aminocaproic acid, and sodium lagosol on platelet aggregation time are presented in Table 1. In control samples stimulated with sodium ADP, platelet aggregation occurred rapidly, with aggregation times of 18 ± 1 s at 0.1 mg/mL and 10 ± 1 s at 0.3 mg/mL.

Table 1. Changes in Platelet Aggregation Time (s) Under the Influence of Mumie, Heparin, Acetylsalicylic Acid, and ε-Aminocaproic Acid and Sodium salt of lagosol.

Substance	0.1 mg/mL	0.3 mg/mL
Sodium ADP (control)	18 ± 1	10 ± 1
Mumie	63 ± 2	75 ± 2
Heparin (0.1 and 0.3 IU)	42 ± 2	82 ± 3
Acetylsalicylic acid	65 ± 2	73 ± 3
ε-Aminocaproic acid	50 ± 2	60 ± 2
Sodium salt of lagosol	30 ± 1	20 ± 1

Statistically significant differences ($p < 0.05$) compared with baseline values.

Incubation with mumie resulted in a pronounced and statistically significant prolongation of platelet aggregation time at both tested concentrations. At 0.1 mg/mL, aggregation time increased to 63 ± 2 s, while at 0.3 mg/mL it increased further to 75 ± 2 s ($p < 0.05$ vs. control), indicating a concentration-dependent inhibitory effect on platelet aggregation.

Heparin also significantly increased aggregation time. At the lower dose (0.1 IU), aggregation time was 42 ± 2 s, whereas at 0.3 IU it increased markedly to 82 ± 3 s, demonstrating a strong antiaggregatory effect.

Similarly, acetylsalicylic acid significantly prolonged platelet aggregation time to 65 ± 2 s at 0.1 mg/mL and 73 ± 3 s at 0.3 mg/mL. ε-Aminocaproic acid produced a moderate but statistically significant increase in aggregation time compared with control values (50 ± 2 s and 60 ± 2 s at 0.1 and 0.3 mg/mL, respectively).

In contrast, the sodium salt of lagosol exerted a relatively weaker effect, with aggregation times of 30 ± 1 s at 0.1 mg/mL and 20 ± 1 s at 0.3 mg/mL, though these values remained significantly different from the control.

Discussion

The present study demonstrates that mumie exerts a significant inhibitory effect on platelet aggregation, as evidenced by the marked prolongation of aggregation time at both tested concentrations. This effect was comparable to, and in some cases approached, that observed with well-established antiplatelet and anticoagulant agents such as heparin and acetylsalicylic acid.

The observed increase in aggregation time suggests a reduction in platelet reactivity, which may be associated with interference in platelet activation pathways, membrane receptor function, or intracellular signaling mechanisms involved in aggregation. The concentration-dependent nature of mumie's effect indicates that its antiplatelet activity intensifies with increasing dose.

Heparin demonstrated the strongest antiaggregatory effect at higher concentrations, consistent with its known anticoagulant properties and indirect effects on platelet function.

Acetylsalicylic acid also significantly inhibited platelet aggregation, which aligns with its established mechanism of cyclooxygenase inhibition and suppression of thromboxane A_2 synthesis.

ε-Aminocaproic acid showed a moderate inhibitory effect on aggregation, suggesting a secondary influence on platelet function, potentially related to its antifibrinolytic properties. The sodium salt of lagosol exhibited the least pronounced effect, indicating comparatively weak antiplatelet activity under the experimental conditions.

Overall, the similarity between the effects of mumie and classical antiplatelet agents supports the hypothesis that mumie contains biologically active components capable of modulating hemostatic processes.

Conclusion

The results of this study indicate that mumie significantly inhibits platelet aggregation in vitro, as demonstrated by a marked and statistically significant prolongation of platelet aggregation time. Its antiplatelet activity is concentration-dependent and comparable to that of established pharmacological agents such as heparin and acetylsalicylic acid.

These findings suggest that mumie may possess potential therapeutic value as a natural antiplatelet agent. Further studies are warranted to elucidate the underlying mechanisms of action and to assess its efficacy and safety in vivo.

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