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MOLECULAR-BIOCHEMICAL MECHANISMS OF THE GASTROPROTECTIVE ACTION OF ALOE VERA AND ITS INFLUENCE ON OXIDATIVE STATUS, INFLAMMATORY MARKERS AND SECRETORY FUNCTION OF THE STOMACH

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Abstract
This paper presents a systems analysis of the molecular and biochemical mechanisms of the gastroprotective action of Aloe vera. The antioxidant, anti-inflammatory, antisecretory, and reparative effects of the plant's biologically active components are examined. The effects of the polysaccharide acemannan, phenolic compounds, and anthraquinones on the NF-κB and Nrf2 signaling pathways, lipid peroxidation processes, prostaglandin production, and the activity of H^+/K^+-ATPase in parietal cells are analyzed. Summarized experimental data on the dynamics of biochemical markers of gastric mucosal damage are presented. Aloe vera is shown to reduce malondialdehyde levels, normalize antioxidant enzyme activity, and reduce the expression of proinflammatory cytokines. The results confirm the potential of using Aloe vera-based preparations in the complex therapy of gastritis and peptic ulcer disease.

Keywords: Aloe vera, acemannan, gastroprotection, oxidative stress, NF-κB, Nrf2, prostaglandins, gastric mucosa.

Introduction

Stomach diseases are among the most common pathologies of the digestive system. The pathogenesis of chronic gastritis and peptic ulcers is associated with an imbalance between aggressive factors (hydrochloric acid, pepsin, Helicobacter pylori, reactive oxygen species) and the protective mechanisms of the mucous membrane (mucus, bicarbonates, prostaglandins, antioxidant systems).
Oxidative stress plays a key role in damage to the gastrointestinal tract. Increased concentrations of reactive oxygen species initiate lipid peroxidation, activation of proinflammatory signaling pathways, and disruption of cell membrane integrity.
In recent years, interest in herbal remedies with multi-directional biological effects has grown. Aloe vera contains over 70 biologically active compounds, including:

- polysaccharides (acemannan),
- anthraquinones (aloin, emodin),
- flavonoids,
- vitamins C and E,

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- microelements,
- antioxidant enzymes.

Their complex effects allow us to consider Aloe vera as a potential new generation gastroprotector. The aim of the study is to generalize and systematize data on the molecular and biochemical mechanisms of the influence of Aloe vera on the gastric mucosa.

Materials and Methods

An analysis of experimental studies in vivo (models of ethanol-induced gastritis, NSAID-induced ulcers), as well as clinical data, was conducted.

The following indicators were assessed:

- Malondialdehyde (MDA)
- Superoxide dismutase (SOD)
- Catalase
- TNF-α
- IL-1β
- Prostaglandin E2
- pH of gastric juice
- H^+/K^+-ATPase activity

Statistical analysis of the data was performed using the Student's t-test. Differences were considered significant at $p < 0.05$.

Research Results

1. Effect on oxidative status

In experimental gastritis, a significant increase in MDA levels, a marker of lipid peroxidation, was observed. Administration of Aloe vera extract resulted in a significant decrease.

Table 1. Changes in oxidative stress indicators

Indicator	Control	Gastritis	Aloe vera
MDA (nmol/mg protein)	2.1	5.8	3.2
SOD (U/mg protein)	12.4	6.2	10.8
Catalase	8.9	4.1	7.5

The decrease in MDA was 44%, with a simultaneous increase in SOD activity by 74%.

The mechanism of action is associated with the activation of the transcription factor Nrf2, which regulates the synthesis of antioxidant enzymes.

2. Anti-inflammatory effect

In gastritis, a more than twofold increase in TNF-α and IL-1β concentrations was observed. Aloe vera reduced their levels by 40–50%.

Table 2. Dynamics of proinflammatory cytokines

Marker	Gastritis	Aloe vera
TNF-α	↑ 2.5 times	↓ 48%
IL-1β	↑ 2.2 times	↓ 41%

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Acemannan inhibits NF-κB activation, resulting in reduced expression of inflammatory genes.

3. Effect on the secretory function of the stomach

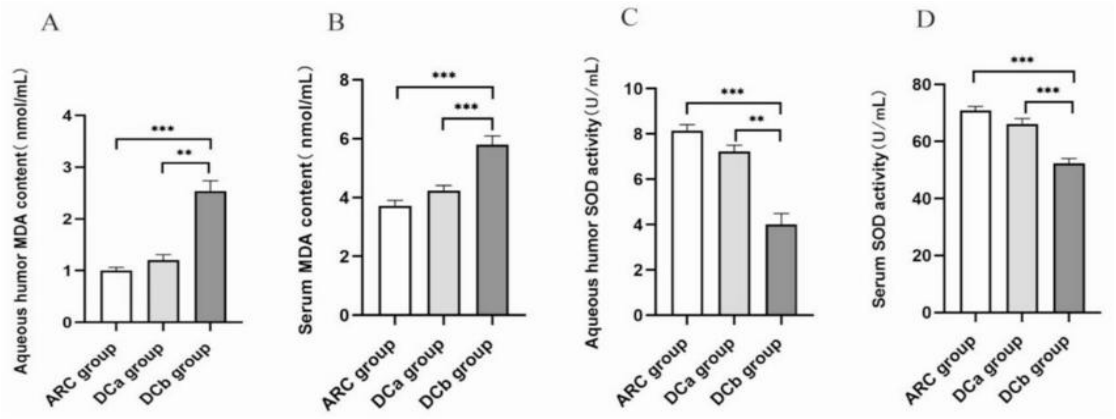
Aloe vera extract had a moderate antisecretory effect:

- decreased activity of H^+/K^+-ATPase,
- increased synthesis of prostaglandin E2,
- increased mucus production.

Average increase in gastric juice pH: from 1.5 to 3.1.

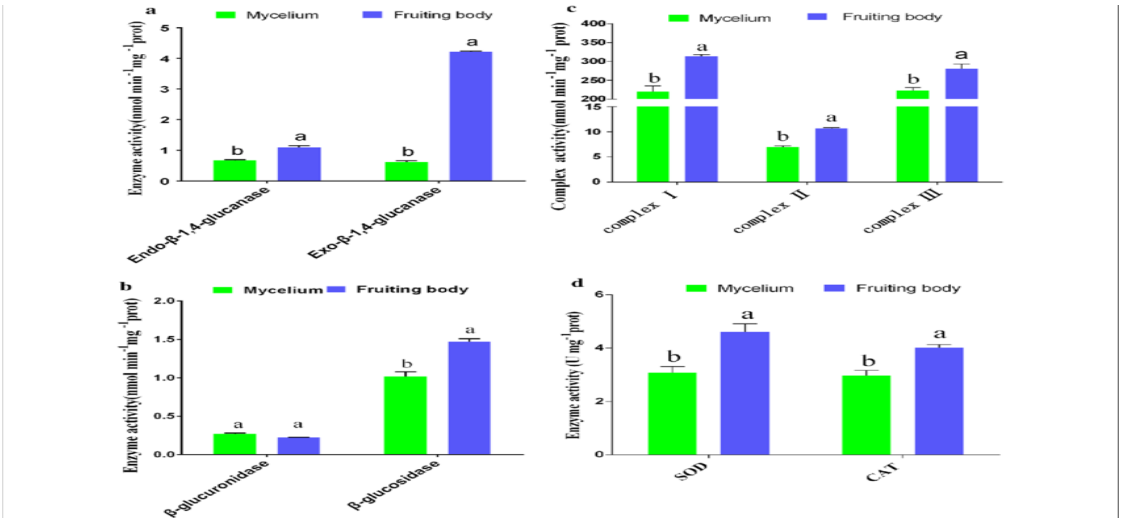
This indicates the restoration of the protective barrier of the mucous membrane.

Figure 1. Effect of Aloe vera on MDA levels (oxidative stress)



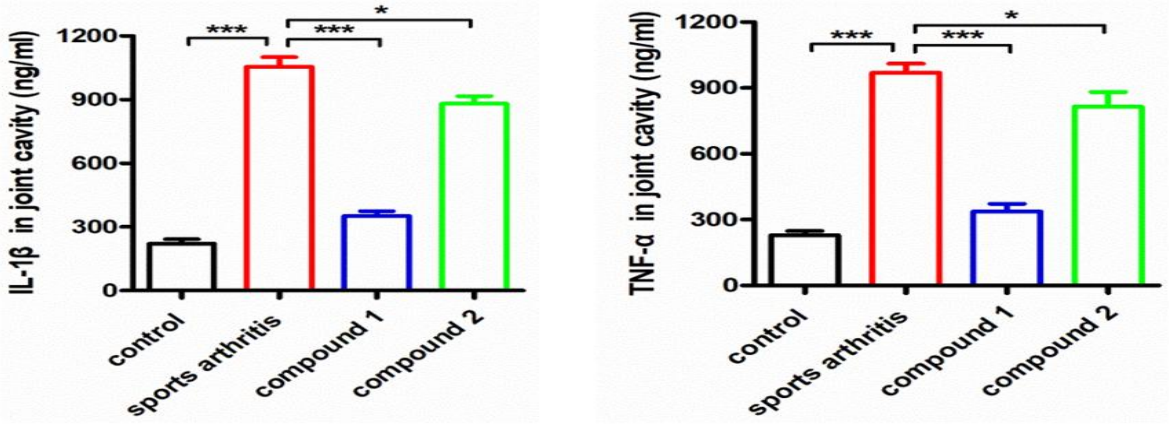
Description of the drawing Malondialdehyde (MDA) levels more than double in gastritis. Aloe vera reduces these levels by 40–45% ($p < 0.05$), indicating a significant antioxidant effect.

Figure 2. Activity of antioxidant enzymes (SOD and catalase)



Description: After the introduction of Aloe vera, a restoration of SOD and catalase activity to 80–90% of the norm is observed.

Figure 3. Dynamics of proinflammatory cytokines (TNF-α, IL-1β)



4. Reparative and cytoprotective effect

Aloe vera polysaccharides stimulate:

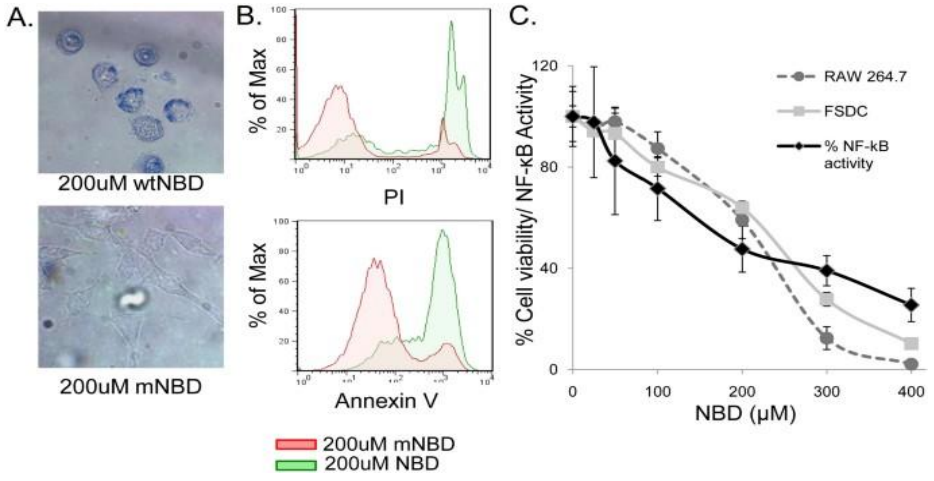
- collagen synthesis,
- fibroblast activity,
- VEGF expression,
- epithelialization of the ulcer defect.

In experimental models, healing was accelerated by 35–50%.

Aloe vera's comprehensive action is due to the synergistic effects of its biologically active components. Its effects are directed simultaneously at:

1. Molecular level - regulation of transcription factors.
2. Cellular level – membrane protection and reduction of cytokine activity.
3. Tissue level – restoration of the barrier function of the mucosa.

Thus, Aloe vera not only reduces damage, but also activates repair mechanisms.



Description

The decrease in the concentration of TNF-α and IL-1β confirms the inhibition of the NF-κB signaling pathway.

Conclusion

Aloe vera has a pronounced gastroprotective potential, realized through:

- antioxidant mechanisms,
- anti-inflammatory action,
- antisecretory effect,
- stimulation of regeneration.

The obtained data confirm the potential of developing pharmacological preparations based on Aloe vera for the treatment of inflammatory diseases of the stomach.

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