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ORIGINAL RESEARCH

THE EFFECT OF *Lactobacillus plantarum* IS-10506 IN EXCESSIVE RESPIRATORY TRACT INFLAMMATION FOLLOWING SMOKE INHALATION

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ABSTRACT

Background. Smoke inhalation induces injury to the respiratory tract and lung parenchyma through exposure to smoke and toxic chemicals. *Lactobacillus plantarum* IS-10506 has been reported to exert anti-inflammatory effects on the respiratory system. This study aimed to evaluate the efficacy of *Lactobacillus plantarum* IS-10506 in attenuating respiratory tract inflammation following smoke exposure.

Methods. Sixteen BALB/c mice were exposed to cotton smoke and randomized into two groups: a control group (no probiotic treatment) and a treatment group receiving Lactobacillus plantarum IS-10506. Neutrophil counts in bronchoalveolar lavage fluid were measured, and lung histopathology was evaluated to assess inflammation.

Results. The treatment group demonstrated lower median inflammation scores and neutrophil counts compared to the control group. However, these differences were not statistically significant ($p = 0.232$ for histological inflammation; $p = 0.376$ for neutrophil count).

Conclusion. Administration of Lactobacillus plantarum IS-10506 was associated with a reduction in histopathological lung inflammation and neutrophilic infiltration in mice following smoke inhalation, though the findings did not reach statistical significance.

Keywords: Smoke inhalation, *Lactobacillus plantarum* IS-10506

INTRODUCTION

Smoke inhalation induces injury to the respiratory tract and lung parenchyma through exposure to smoke and toxic chemicals.[1] Mortality rates in burn patients can increase by up to 30% due to inhalation trauma. It has been reported that the leading cause of death in burn cases is the presence of concurrent inhalation injury.[2]

Exposure to extreme temperatures in the respiratory tract leads to the accumulation of local inflammatory cells and initiates a cascade of inflammatory mediators, ultimately resulting in tissue damage. Airway obstruction may occur due to edema, bronchoconstriction, fibrin deposition, and the accumulation of necrotic tissue debris. In response to combustion products, the lung parenchyma is also affected, characterized by the release of interleukin-8 (IL-8), elevated neutrophil levels in the alveoli, and the formation of reactive oxygen species (ROS) and reactive nitrogen species (RNS). These processes culminate in membrane damage, pulmonary edema, and impaired oxygen diffusion.[1,2]

Lactobacillus plantarum IS-10506 has been reported to exert anti-inflammatory effects on the respiratory system. *Lactobacillus plantarum* is one of the few *Lactobacillus* species naturally present in the human gastrointestinal tract. The administration of *Lactobacillus plantarum* IS-10506 has been shown to significantly prevent the progression of histopathological lung inflammation in murine models exposed to allergenic stimuli.[3] This study aimed to evaluate the efficacy of *Lactobacillus plantarum* IS-10506 in attenuating respiratory tract inflammation following smoke exposure.

1. METHODS

Experimental Design

This study is using a randomized post control group design. This study utilized healthy male BALB/c mice (*Mus musculus*), aged 6–8 weeks and weighing between 20–35 grams. A total of 16 mice were used and randomly allocated into two groups: a treatment group and a control group. The mice were cage separately and environment was maintained at room temperature. Standard laboratory food for mices and water were provided.

The mice were placed in a chamber and exposed to cotton smoke generated by a smoke generator, receiving two exposures lasting 30 seconds each. Following smoke exposure, eight mice in the treatment group received *Lactobacillus plantarum* IS-10506 via oral gavage at a dose of 300 mg per day for two consecutive days.

Tissue Analyses

Twenty-four hours after the final probiotic administration, the animals were euthanized. Bronchoalveolar lavage (BAL) was performed to quantify the number of inflammatory cells (neutrophils), and lung tissue samples were collected to assess the degree of histopathological inflammation. The degree of inflammation was assessed based on the presence of peribronchial and perivascular inflammation, using a scoring system ranging from 0 to 3. Histopathological evaluation was performed by a certified anatomical pathologist.

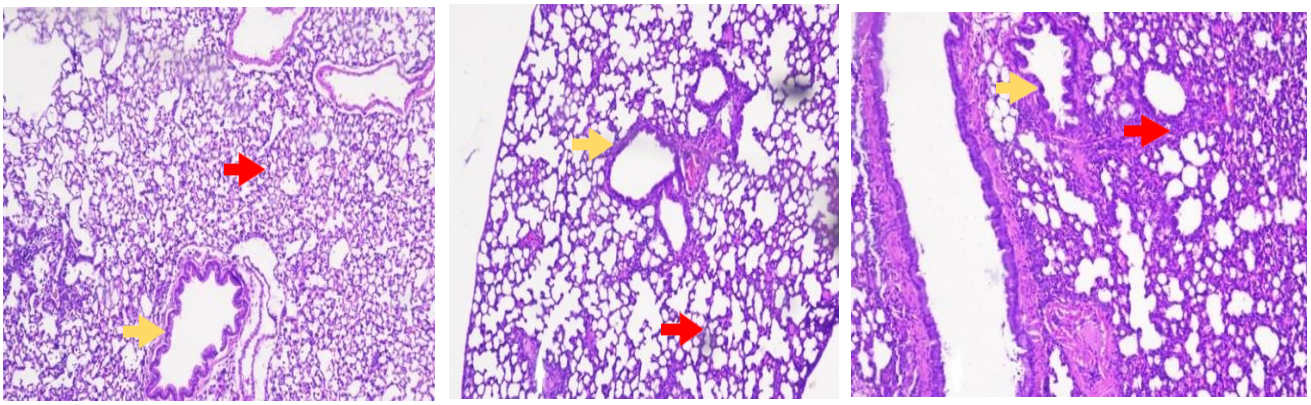
Statistical Analysis

The data were automatically presented in table and analyzed using Statistical Package for the Social Sciences (SPSS) software. Collected data were analyzed by comparing the treatment and control groups. Statistical analysis was conducted using the Mann-Whitney test and independent t-test, as appropriate. A $p<0.05$ was considered statistically significant.

2. RESULTS

The Degree of Lung Inflammation

The histopathological degree of lung inflammation in mice was assessed based on the presence of peribronchial and perivascular inflammation, using a scoring system ranging from 0 to 3. Histopathological examination was performed using hematoxylin and eosin (H&E) staining and evaluated under a binocular light microscope at 400× magnification across five fields of view. The assessment was conducted by a blinded anatomical pathologist [Figure 1].



A **B** **C**

Figure 1. Histopathological examination of lung inflammation using hematoxylin-eosin (HE) staining. The red arrows indicate peribronchial inflammatory cells, and the yellow arrows indicate perivascular inflammatory cells.

A. Inflammation score of 1 for peribronchial and perivascular regions
B. Inflammation score of 2 for peribronchial and perivascular regions
C. Inflammation score of 3 for peribronchial and perivascular regions

Table 1. Degree of Histopathological Lung Inflammation

Group	r	Inflammation Score Median (minimum – maximum)	p
Control	8	2 (1 – 3)	0.232
Treatment	8	1.5 (1 – 2)	

The treatment group demonstrated a lower median inflammation score compared to the control group, suggesting that *Lactobacillus plantarum* IS-10506 may have potential in reducing inflammation. However, statistical analysis using the Mann-Whitney test revealed no significant difference between the two groups (p = 0.232) [Table 1].

Inflammatory Cells

The number of inflammatory cells in bronchoalveolar lavage (BAL) fluid, specifically neutrophils, was quantified using a Sysmex XN-1000-A1 haematology analyzer. The treatment group demonstrated a lower median neutrophil count compared to the control group, suggesting that the probiotic *Lactobacillus plantarum* IS-10506 may have potential in reducing inflammatory cell infiltration [Table 2].

Table 2. Inflammatory Cells in BAL Fluid

Group	r	Inflammatory cells in BAL fluid (minimum – maximum) (/□l)	p
Control	8	42 (8 – 55)	0.376
Treatment	8	29 (9.1 – 66.7)	

3. DISCUSSION

The airway epithelium serves as the first structural barrier against exposure to smoke or inhaled combustion byproducts. The body's response to such exposure begins with the release of inflammatory mediators, which in turn initiate further inflammatory processes.

This is marked by an increase in neutrophilic infiltration, which can lead to the release of proteolytic enzymes that damage lung parenchyma. When inflammatory cells accumulate systemically, this process may progress to conditions such as acute respiratory distress syndrome (ARDS) and systemic inflammatory response syndrome (SIRS).[1,2]

Lactobacillus plantarum IS-10506 is an indigenous probiotic strain derived from "dadih," a traditional fermented buffalo milk from West Sumatra, Indonesia.[4,5,6] In this study, *Lactobacillus plantarum* IS-10506 was administered via oral gavage for two consecutive days in the treatment group. The concept of the gut–lung axis supports the idea that modulation of the gastrointestinal microbiota can beneficially influence the respiratory tract, likely through mechanisms related to the common mucosal immune system.[7] This probiotic is known to produce significant amounts of short-chain fatty acids (SCFAs), which, through binding with G-protein-coupled receptors, have been shown to mediate anti-inflammatory effects.[8]

In this study, the degree of histopathological lung inflammation and the number of inflammatory cells in bronchoalveolar lavage fluid were lower in the group treated with *Lactobacillus plantarum* IS-10506 compared to the untreated group. These findings suggest that *Lactobacillus plantarum* may have potential in reducing respiratory tract inflammation.

This observation is consistent with previous studies involving other probiotic strains, such as *Lactobacillus rhamnosus* Lcr35, *Lactobacillus rhamnosus* GG, *Lactobacillus gasseri* A5, and *Lactobacillus paracasei* NCC2461, which have demonstrated significant effects in decreasing histopathological lung inflammation and the number of inflammatory cells in bronchoalveolar lavage fluid.[9,10,11,12]

CONCLUSION

Lactobacillus plantarum IS-10506 demonstrated a reduction in the number of inflammatory cells in bronchoalveolar lavage fluid and in the degree of histopathological lung inflammation, although the results were not statistically significant.

DECLARATIONS

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Competing and Conflicting Interest
The authors declare no competing interests or conflicts of interest related to this work.

Ethical Approval
Ethical approval for this study was granted by the Airlangga University Animal Care and Use Committee (no : 2.KEH.37.03.2025), confirming adherence to ethical standards in the treatment of animal subjects.

Informed Consent
Not applicable.

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