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S-IgA Levels and Urinary Tract Mucosal Fluid Secretion: An In Vivo Study of the Effectiveness of *Etlingera elatior* Extract Therapy

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ABSTRACT

Mucosa surface is the body's initial barrier against pathogens, rely on secretory Immunoglobulin A (s-IgA) for localized immunity. This study investigated the impact of Etlingera elatior extract on s-IgA levels and mucosal fluid secretion in mice challenged with Staphylococcus aureus. The research method used an experimental design with seven treatment groups, i.e negative control (P1), positive control (P2), and five groups with E. elatior extract administration at concentrations of 40% to 80% (P3-P7). Data were analyzed using ANOVA and Tukey's subset test to determine differences between groups. The results showed an increase in s-IgA levels as the extract concentration increased, with the highest level at P7 (1842.25 ng/mL). Conversely, mucosal fluid secretion decreased, with the lowest level at P7 (21.5 µL). Statistical analysis showed significant differences between treatment groups ($p<0.05$). The increase in s-IgA levels and normalization of mucosal fluid secretion are thought to be caused by bioactive content such as flavonoids and alkaloids which have immunostimulant and anti-inflammatory properties. The study revealed that E. elatior extract is effective in increasing s-IgA levels while controlling mucosal fluid secretion in mice infected with Staphylococcus aureus. These findings suggest the potential of E. elatior extract as a natural potential immunostimulant to support the treatment of mucosal infections.

Keywords: *Cystitis, Etlingera elatior, mucosal fluid secretion, s-IgA.*

INTRODUCTION

Urinary tract infections (UTIs) are common in women or individuals with certain medical conditions such as diabetes or the use of urinary catheters, with cystitis being the most frequent type (Nono, *et al*. 2014; Ardiansyah *et al.* 2021; Amin *et al.* 2021). According to global epidemiological data, the prevalence of Cystitis is estimated to reach 50-60% in women throughout their lives, with the highest incidence in reproductive age (Chen, 2008; Sasmita *et al*. 2024; Goel *et al*. 2020). In Indonesia, the Ministry of Health report shows that these infections include Cystitis, one of the 5 most frequently reported infections in health care facilities. (Samarno, *et al*. 2012). UTIs arecaused by uropathogens such as Escherichia coli or Staphylococcus aureus, which trigger inflammation in the urinary tract (Farha, *et al*. 2020; Maradona *et al*. 2024; Yan *et al*. 2020). One of the body's mechanisms in fighting this infection is through the secretion of secretory immunoglobulin A (S-IgA) and mucosal fluid, which functions as a mucosal immune defense to capture and eliminate pathogens (Widyastuti *et al*. 2021). In severe infection conditions, mucosal fluid secretion can increase, which causes increased irritation and inflammation (Hujjatusnaini *et al*. 2020a ; Hujjatusnaini *et al*. 2020b). Several previous studies have reported that herbal therapy has great potential in the management of UTIs (Hujjatusnaini *et al*. 2024a), and can reduce the level of mucosal inflammation through anti-inflammatory and immunomodulatory activities (Sumarno, *et al*. 2015 ; Hujjatusnaini *et al*. 2024b). It has been reported that flavonoid compounds in herbal plants can increase S-IgA levels in in vivo models (Chen *et al*. 2018 ; Hujjatusnaini *et al*. 2024b). Research on the effectiveness of the *Etlingera elatior* plant proves its potential as a strong antibacterial

against urinary tract pathogens. However, there have not been many studies that directly compare the effectiveness of *Etlingera elatior* in immunological and physiological parameters in UTIS (Hujjatusnaini *et al.* 2023; Nurhayati *et al*. 2021).

This study aims to evaluate the effectiveness of *Etlingera elatior* extract therapy in various concentrations on S-IgA levels and urinary tract mucosal fluid secretion in an in vivo model (Takó *et al*. 2020). Ciprofloxacin was used as a positive control to compare the effectiveness of herbal therapy with antibiotics. (Yan *et al*. 2020 ; Swestyani *et al.* 2024). The purpose of this study was to analyze the extent to which *Etlingera elatior* extract can reduce mucosal fluid secretion and restore S-IgA levels to normal physiological levels in UTIs conditions.

The urgency of this study lies in the need for safer and more effective alternative UTIS therapies, considering the increasing emergence of antibiotic resistance. In addition, *Etlingera elatior* is a plant that is abundantly available, so it has the potential to be developed as a local resource-based herbal therapy.

The study used a comparative approach that evaluated the effectiveness of various concentrations of *Etlingera elatior* extract on immunological (S-IgA) and physiological (mucosal fluid secretion) parameters in UTIs conditions, so the focus of this study is to validate the findings of previous studies. The findings of this study are expected to prove that high concentrations of *Etlingera elatior* extract can significantly reduce mucosal fluid secretion and approach the effectiveness of ciprofloxacin as a positive control in normalizing S-IgA levels. This study provides an important contribution to the development of evidence-based herbal therapy for UTIs, which supports the use of local biodiversity while addressing the challenge of antibiotic resistance, which is also part of the findings of this study.

MATERIALS AND METHODS

Materials

This study used 28 male Balb/c mice aged ±3-4 weeks and weighing ±28 grams. The materials were 2500 grams of *Etlingera elatior* leaf powder designed at dilution levels of 40%, 50%, 60%, 70%, and 80%. Other materials such as 250mg ciprofloxacin as a positive control for the study, 70% and 96% alcohol, chloroform, standard gallic acid solution, Folin-Ciocalteu reagent, and Sodium Carbonate solution (Na_2CO_3). Gallic acid, sterile distilled water, vaseline, and aluminum foil. The tools used include an autoclave, laminar air flow, Erlenmeyer flask, beaker, glass stirrer, iron stirrer, and magnetic stirrer, bunsen, glass funnel, micropipette, dropper pipette, incubator, hot plate, stomach probe, digital scale, UV-Vis spectrophotometer with a wavelength of 760 nm, micro tube, petri dish, test tube, colony counter, and centrifuge.

Methods

The research method used true experimental posttest group design (Hujjatusnaini *et al*. 2022). This research was conducted at the Microbiology Laboratory of Tadris Biologi, Institut Agama Islam Negeri Palangka Raya.

Plant Extraction Process

Etlingera elatior leaves were selected selectively, washed with running water to ensure cleanliness, then cut into small pieces, dried at room temperature, and ground into 2500 grams of powder. The extraction process was carried out using the maceration method with 96% ethanol solvent for 24 hours.

Bioactife Compound Test

Uji Kandungan Senyawa Metobolit Sekunder

Secondary Metabolite Compound Content Test

Qualitative analysis of the secondary metabolite content of *Etlingera elatior* extract with a concentration of 1 mg/mL. The purpose of the test is to identify the active compounds of secondary metabolites. (Indah *et al*. 2021). Characterization of flavonoid content using the magnesium-HCl reagent method, by mixing 1 mL of extract with 1 mL of concentrated HCl and magnesium powder. The formation of an orange-red color indicates the presence of flavonoids. (Purwanti *et al*. 2022). Alkaloid test using the Dragendorff or Mayer reagent method by mixing 1 mL of extract with 2 mL of reactant, which produces a precipitate which is an indicator of the presence of alkaloids. Then shake 5 mL of extract vigorously for 5 minutes, if it produces stable foam, it indicates a positive indicator of the presence of saponins in the test material. Tannin testing is carried out by preparing 1 mL of extract and adding it to 2 mL of 1% $FeCl_3$ solution, if a color change to dark green or dark blue is found, then the test material is concluded to contain tannins (Shamsudin *et al*. 2022).

Quantitative Test of Secondary Metabolic Sentawa

This quantitative test includes antioxidant activity, total flavonoids, total tannins, and total polyphenols (Hujjatusnaini *et al*. 2022). Antioxidant activity was measured by the DPPH method using a spectrophotometer at a wavelength of 517 nm. The extract was prepared in a concentration of 40%-80%, where 1 mL of each concentration was mixed with 3 mL of 0.1 mM DPPH solution, incubated at 25°C for 30 minutes, then the absorbance was measured to calculate the percentage of DPPH radicals inhibited (Goel *et al*. 2020).

Total flavonoids were tested using a colorimetric method with aluminum chloride ($AlCl_3$) reagent. The reagent mixture consisted of 1 mL of extract (concentration 1 mg/mL), 0.3 mL of 10% $AlCl_3$, and 0.3 mL of 1 M sodium acetate solution. This mixture was incubated for 30 minutes before its absorbance was measured at a wavelength of 415 nm. Quercetin was used as a standard to prepare a calibration curve, and the results were expressed in quercetin equivalents (Zhang *et al*. 2021). Total polyphenols were measured by the Folin-Ciocalteu method. A total of 1 mL of extract (1 mg/mL) was mixed with 0.5 mL of Folin-Ciocalteu solution and 1 mL of 7.5% Na_2CO_3 solution, incubated in the dark for 30 minutes, then the absorbance was measured at a wavelength of 765 nm. The results were expressed in gallic acid equivalents (Zhao *et al*. 2023).

Eksperimental Procedure

The research treatment began by inducing mice with 1 mL of S. aureus culture via intraperitoneal injection for 7 days. Previously, the preparation was diluted in 0.1% peptone solution with a pH of 4.5. The aim was to condition the mice to experience UTIs. On the 8th day, a clinical examination was performed on the surface of the mouse penis to identify signs of infection. Symptoms such as a change in the color of the penis to blackish red, yellow-brown urine, and the number of bacterial colonies exceeding 10^3 CFU/mL indicate that the mice have experienced Cystitis. The total indicator of bacterial colonies for urinary tract infections refers to the minimum limit of bacterial colonies according to the American Urological Association (Grabmann *et al*. 2005 ; Del *et al*. 2021 ; Câmara *et al*. 2024 ; Hujjatusnaini *et al*. 2024c)

After the mice experienced Cystitis, the next step was to prove the therapeutic effect of *Etlingera elatior* leaf extract using a gastric tube orally according to the research design. Dosage 200 mg/kg BW for group I (200 mg/kg BW = 5.6 mg): 16.8 mg/day, Group II (400 mg/kg BW = 11.2 mg): 33.6 mg/day, Group III (600 mg/kg BW = 16.8 mg): 50.4 mg/day, Group IV (800 mg/kg BW = 22.4 mg): 67.2 mg/day, and Group V (1000 mg/kg BW = 28.0 mg): 84.0 mg/day. The extract was given three times a day at a dose of 0.6 mL for 7 days. On the eighth day, surgery was performed on the experimental animals to measure s-IgA secretion and mucosal fluid secretion in the bladder of post-therapy cystitis mice, using the Mice Ligated Ilea Loop method (Sumarno *et al*. 2015).

Immunomucosal response testing was performed by measuring antibody or IgA levels in serum. Serum was taken as pooled serum from each mouse. Checker board experiment was used to determine antigen levels and serum dilution. Measurement of antibody titer or s-IgA levels was carried out by adjusting antigen levels based on the checker board results. Furthermore, 100 µl of antigen was inserted into the U-shaped ELISA well, then incubated for 24 hours at 4°C with sufficient humidity (Sumarno *et al*. 2012). After incubation, the wells were washed three times using PBS solution containing 0.05% Tween at 3-minute intervals. Then, 1% BSA solution was added to PBS and incubated for 1 hour at 37°C.

ELISA method begins with a serial dilution of the primary antigen (100 µg/ml, 50 µg/ml, 25 µg/ml, 12.5 µg/ml) in coating buffer. A total of 100 µl of antigen was added to the ELISA well and incubated for 24 hours at 4°C. After incubation, the ELISA plate was washed three times with 60 µl of washing solution to remove residual antigen. Then, the plate was blocked using 200 µl of blocking buffer (1% BSA) and incubated for 1 hour at 37°C. After that, the plate was washed again three times with 70 µl of washing solution. Substrate solution (a mixture of p-nitrophenylphosphate, diethanolamine, and MgCl) of 100 µl was added to the ELISA plate and incubated for 15 minutes at 37°C. When a yellow color appeared, 50 µl of stop solution (3M NaOH) was added. The color intensity was measured using an ELISA reader at a wavelength of 450 nm (Sumano *et al*. 2015).

Statistical Analysis

Data analysis was carried out quantitatively in the form of mucosal fluid data and total bladder colonies of cystitis mice after therapy using One Way Anava analysis.

RESULTS AND DISCUSSION

Secondary Metabolite Content

Phytochemical testing aims to identify active compounds that potential to be used as Cystitis therapy. This study explores compounds such as flavonoids, tannins, alkaloids, and others in the extract that may have antimicrobial effects on Cystitis infections. The results of this test can be a strong basis for developing effective and safe herbal therapeutic materials in managing hyperglycemia, as well as ensuring the quality and safety of extract use. Details can be seen in Table 1 below.

Table 1. Secondary Metabolite Test Results

Sample of *E. elatior* extracts.	Secondary Metabolite Groups				
	Flavonoid Test	Alkaloid Test	Tanin Test	Terpenoid Test	Saponin Test
Result	+	+	+	+	+

Keterangan : (+) : Detected to contain the chemical compound tested
(-) : Detected not to contain the chemical compound tested

Antioxidant and bioactive content of Etlingera elatior Leaf Extract

The content of antioxidants and bioactive compounds in the extract was tested ccording to the research concentration level, as shown in Table 2.

Table 2. Antioxidant and Bioactive Content of *Etlingera elatior* Leaf Extract

Sample Concentration (ppm)	**Bioactive content of *Etlingera elatior* extract**						
	Sample Absorbance	**Inhition**	**% Inhibition**	**Total phenolic content (mg/g)**	**Total flavonoid content (mg/g)**	**Total Tanin (mg/g)**	**Total Alkaloid (mg/g)**
15,625	0,1557	0,7675	76,75	18,75	19,69	26,88	5,65
7,8125	0,2975	0,5558	55,58	13,45	13,87	21,06	4,15
3,9063	0,2911	0,5654	56,54	9,62	9,92	17,58	3,21
1,9531	0,3285	0,5095	50,95	6,75	7,03	14,72	2,45
0,9766	0,3482	0,4801	48,01	4,55	4,94	12,44	1,86
IC_{50} 1,8911 ppm Fenol 52,12 mg/g Flavonoid 55,45 mg/g Alkaloid 17,32 mg/g Tannin 92,68							

Table 2 shows data that the concentration of 15.625 ppm has the highest bioactive content, with higher total tannins (26.88 mg/g) and flavonoids (19.69 mg/g) compared to lower concentrations. This indicates that at high concentrations, the extract produces a stronger inhibitory effect due to the higher bioactive content. At lower concentrations (such as 0.9766 ppm), although the total bioactives remain, the percentage of inhibition decreases, reflecting that the lower the concentration, the less bioactive content contributes to the inhibitory effect. *Etlingera elatior* extract has significant bioactive potential, with higher concentrations showing stronger inhibitory effects and higher bioactive content. The content of phenols, flavonoids, tannins, and alkaloids contributes to the bioactive activity of the extract, which can be used in the development of products with antimicrobial, antioxidant, or pharmacological properties. IC_{50} (Inhibitory Concentration 50%) is the concentration of a substance required to inhibit the target activity by 50%, with smaller values indicating higher inhibitory effectiveness. In this study, the IC_{50} of Etlingera elatior extract of 1.8911 ppm showed moderate effectiveness in inhibiting cystitis-related targets, thus having potential as a therapeutic agent. To assess its effectiveness more comprehensively, this value needs to be compared with the results of similar studies or standard compounds that have been used in therapy. If the standard compound has a lower IC50, for example below 1 ppm, then the effectiveness of this extract may still need to be improved in order to compete as a mainstream therapy. Nonetheless, the results of this study indicate that Etlingera elatior extract has promising therapeutic potential and warrants further research, including clinical trials and comparison with conventional therapies for cystitis. Data on the effect of *Etlingera elatior* extract on s-IgA levels of mice with cystitis are presented in Figure 1, while inhibition of mucosal fluid secretion is in Figure 2.

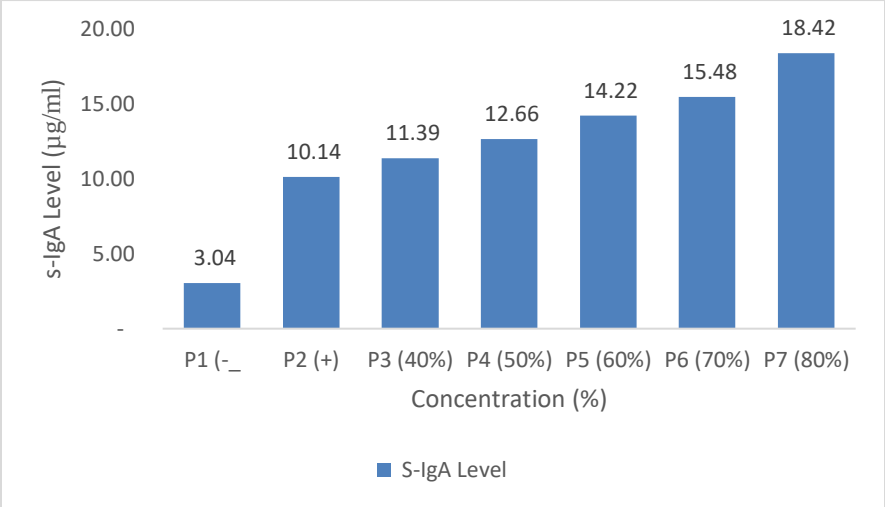

Figure 1. Recapitulation of s-IgA Secretion Data

The data in Figure 1 shows an increase in s-IgA levels from P1 to P7, which is interpreted that *Etlingera elatior* extract therapy has immunostimulating potential. Higher extract concentrations produce higher s-IgA levels which are seen at a concentration of 80% (P7). These data are in line with the theory that bioactive compounds in certain herbal plants can increase s-IgA production as part of the mucosal immune response . These results are consistent with other studies showing that herbal-based therapies, especially those with flavonoid and polyphenol content, can stimulate s-IgA production as part of the body's defense mechanism against pathogens. Other indicators of the therapeutic effects of *Etlingera elatior* extract are shown in the data on inhibition of urinary tract mucosal fluid secretion (Figure 2).

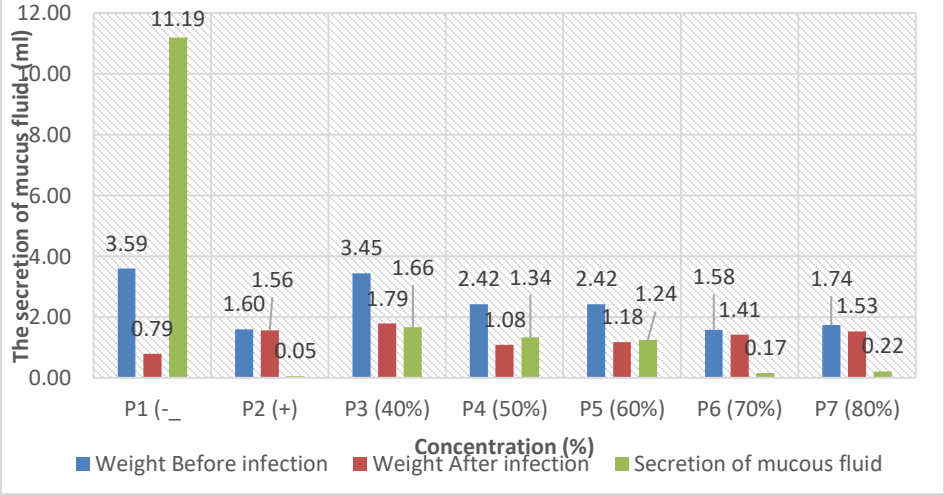

Figure 2. Recapitulation of Data on Inhibition of Urinary Tract Mucosal Fluid Secretion in Cystitis Mice

The significance of the therapeutic effect of bioactive compounds of secondary metabolites of *Etlingera elatior* extract on S-IgA levels and decreased secretion of urinary tract mucosal fluid in mice with cystitis infection was analyzed through statistical tests. The mean and standard deviation values for s-IgA data and urinary tract mucosal fluid secretion statistically support the results of further analysis, presented in Tables 3 and 4.

Table 3. Mean Data of s-IgA Levels of Cystitis Mice

s-IgA Levels								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
P1	4	303.50	303.50	28.408	14.204	258.30	348.70	270
P2	4	1014.25	1014.25	83.272	41.636	881.75	1146.75	903
P3	4	1138.50	1138.50	78.818	39.409	1013.08	1263.92	1021
P4	4	1265.75	1265.75	58.523	29.261	1172.63	1358.87	1179
P5	4	1422.25	1422.25	93.703	46.851	1273.15	1571.35	1300
P6	4	1547.75	1547.75	110.174	55.087	1372.44	1723.06	1390
P7	4	1842.25	1842.25	129.436	64.718	1636.29	2048.21	1656
Total	28	1219.18	1219.18	466.324	88.127	1038.36	1400.00	270

The data in Table 3 shows that the therapeutic treatment showed a significant increase in s-IgA levels compared to negative and positive controls. The most optimal effect occurred in the P7 treatment (the highest concentration) with a mean value of 1842.25 µg/mL. The increase in s-IgA levels from P1 to P7 indicates that the therapy gradually increases the stimulation of the mucosal immune system. The increase in s-IgA at higher therapeutic concentrations is in accordance with studies showing the role of flavonoids and polyphenols in enhancing immune responses. These data show a clear relationship between therapeutic treatment and increased s-IgA levels.

Table 4. Mean Data of Urinary Tract Mucosal Fluid Secretion in Cystitis Mice

Mucosal Fluid Secretion								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
P1	4	279.7500	62.07187	31.03593	180.9798	378.5202	225.00	334.00
P2	4	4.7500	2.62996	1.31498	.5652	8.9348	2.00	7.00
P3	4	116.2500	118.85951	59.42976	-72.8820	305.3820	5.00	221.00
P4	4	133.7500	8.65544	4.32772	119.9773	147.5227	124.00	145.00
P5	4	124.0000	2.30940	1.15470	120.3252	127.6748	122.00	126.00
P6	4	16.5000	2.64575	1.32288	12.2900	20.7100	13.00	19.00
P7	4	21.5000	9.67815	4.83908	6.0999	36.9001	11.00	32.00
Total	28	99.5000	101.92281	19.26160	59.9785	139.0215	2.00	334.00

The data showed a significant variation in mucosal fluid secretion among the groups. Some groups (P1) showed high mucosal fluid secretion, while other groups (P2, P6) showed lower values. Groups such as P4 and P5 showed more stable and consistent values, while groups P3 and P7 had a wider range and higher variation. This

suggests that factors affecting mucosal secretion may vary significantly between the groups. For the normality and homogeneity test as a prerequisite for statistical testing using the Kolmogorov-Smirnov method showed that the data were normally distributed (p>0.05). The data were analyzed using one-way ANOVA, presented in Table 5.

Table 5. Data on the effects of *Etlingera elatior* on S-IgA levels and decreased secretion of urinary tract mucosal fluid in mice suffering from cystitis infection

		Sum of Squares		Df	Mean Square	
		s-IgA Levels	Mucosal Fluid Secretion		s-IgA Levels	Mucosal Fluid Secretion
	Between Groups	5706224.357	225978	6	951037.393	37663
	Within Groups	165151.750	545605	21	7864.369	2595.476
	Total	5871376.107	280483	27		
s-IgA Levels	**F**	120.930				
	Sig	0,001				
Mucosal Fluid	**F**	14.511				
Secretion	**Sig**	0,001				

The data in Table 5 shows that the treatment has a significant effect on s-IgA levels, with a very high F value (120.930) indicating that the treatment effect is much greater than the variation in the group. Likewise, the effect of treatment on mucosal fluid secretion is also significant (14.511), although the effect is smaller than s-IgA levels. With a Sig value = 0.001 indicating a high level of confidence, this significance supports the hypothesis that treatment with bioactive extracts can affect the mucosal immune response, increase s-IgA levels, and modulate mucosal fluid secretion.

Table 6. Significance of the Effect of *Etlingera elatior* on S-IgA levels and decreased secretion of urinary tract mucosal fluid in mice suffering from cystitis infection

***Etlingera elatior* Extract**	**N**	**Subset for alpha = 0.05**							
		s-IgA Levels					**Mucosal Fluid Secretion**		
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**
P2	4		1014.25[b]				4.7500[a]		
P6	4				1422.25[d]		16.500[a]		
P7	4					1842.25[e]	21.500[a]		
P3	4		1138.5[b]	1138.5[c]				116.25[b]	
P5	4				1547.75[d]			124.00[b]	
P4	4			1265.75[c]				133.75[b]	
P1	4	303.5[a]							279.7500[c]
Sig.		1.000	.061	.055	.058	1.000	.666	.652	1.000

Etlingera elatior extract significantly increased s-IgA levels at higher concentrations, with an optimal increase at 80% concentration (P7). This supports the hypothesis that the extract has immunostimulating properties. Mucosal fluid secretion decreased in the treatment with extract concentration, but remained within the normal range. This indicates the adaptation of the mucosal system to extract stimulation. This study shows that *Etlingera elatior* extract has the potential to increase mucosal immunity by increasing s-IgA levels without causing mucosal dysfunction.

The data showed that s-IgA levels increased significantly with increasing *Etlingera elatior* extract concentration. The s-IgA levels in the negative control group (P1) were the lowest (303.5 µg/mL), while the group with the highest extract concentration (P7, 80%) showed the highest levels (1842.25 µg/mL). This indicates that the extract has strong immunostimulating properties, presumably due to the presence of bioactive compounds such as flavonoids. Flavonoids act as antioxidants that can protect mucosal cells from oxidative stress, which can strengthen the immune response by stimulating the production of immunoglobulins, including s-IgA. Likewise, alkaloids have immunomodulatory effects that encourage the activation of immune cells, including plasma cells that produce IgA (Sumano *et al*. 2015). Meanwhile, phenolics and terpenoids help reduce inflammation and improve the function of the respiratory or digestive tract mucosa, thereby increasing IgA secretion. High levels of s-IgA indicate optimal mucosal protection, which is important in fighting pathogens such as Staphylococcus aureus. This increase in levels is consistent with other studies involving herbal ingredients with similar bioactive content (Hujjatusnaini *et al*. 2024c).

Mucosal fluid secretion decreased with increasing extract concentration, but remained within normal physiological limits. The negative control group (P1) had the highest mucosal fluid secretion (279.75 µL), while the group with a high extract concentration showed a decrease, such as in P7 (21.5 µL). This decrease can be explained by the anti-inflammatory effect and control of the mucosal immune response. The flavonoid and phenolic content in the extract can reduce inflammation, which often causes excessive mucosal secretion. By reducing inflammation, mucosal fluid production returned to more normal levels. The significant decrease in mucosal secretion without total elimination indicates mucosal adaptation to the extract stimulation. This means that the extract helps to normalize mucosal function without causing damage or dysfunction Association (Grabmann *et al*. 2005 ; Del *et al*. 2021 ; Câmara *et al*. 2024).

The relationship between s-IgA levels and mucosal fluid secretion showed a complementary pattern, where a significant increase in s-IgA levels was not followed by an increase in mucosal fluid secretion. This suggests that the extract not only enhances local immunity through s-IgA, but also helps to control the mucosal inflammatory response. The bioactive compounds in the extract, such as flavonoids and alkaloids, likely work synergistically to increase s-IgA production and regulate mucosal fluid secretion. This effect supports the function of the mucosa as a primary defense barrier without inducing overproduction of fluid that can cause physiological discomfort Association (Câmara *et al*. 2024; Hujjatusnaini *et al*. 2024c).

These results confirm that *Etlingera elatior* has potential as an immunostimulating and anti-inflammatory agent that can enhance mucosal immunity, especially through increasing s-IgA levels. In addition, the decrease in abnormal mucosal fluid secretion suggests that this extract can normalize mucosal function without damaging it. These findings are relevant in the development of herbal therapies for respiratory or digestive tract infections involving pathogens such as Staphylococcus aureus.

CONCLUSION

The results of the study concluded that *Etlingera elatior* extract significantly increased s-IgA levels, with optimal effects at concentrations of 70%-80%. Mucosal fluid secretion decreased with increasing

extract concentrations, but remained within the normal range. The combination of increased s-IgA and normalization of mucosal secretions suggests that this extract works as an effective immunostimulant and anti-inflammatory, which is also a finding in this study. These results are in line with previous relevant studies, which also open up opportunities for further research on the optimal dosage and molecular mechanisms of bioactive compounds in modulating the immune system.

ETHIC APPROVAL

This research has been approved by the research ethics committee of the Faculty of Medicine, Universitas Palangka Raya, No.185/UN24.9/LL/2024.

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