BIOLOGY, MEDICINE, & NATURAL PRODUCT CHEMISTRY ISSN 2089-6514 (paper)
Volume 14, Number 2, October 2025 | Pages: 1347-1353 | DOI: 10.14421/biomedich.2025.142.1347-1353 ISSN 2540-9328 (online)

Phagochytosis Activity Test of Red Ginger and Angkak Combination Extract by Carbon Clearance Method

Fajar Nugraha*, Halim, Hariyanto IH, Andhi Fahrurroji, Desy Siska Anastasia
Pharmacy Study Program, Faculty of Medicine, Universitas Tanjungpura,
Jl. Prof. Dr. H. Hadari Nawawi, Pontianak, Indonesia.

Corresponding author*
fajarnugraha@pharm.untan.ac.id

Manuscript received: 11 October, 2025. Revision accepted: 29 November, 2025. Published: 14 December, 2025.

Abstract

Red ginger (*Zingiber officinale* Roscoe var. rubrum) and angkak (*Oryza sativa*) are used in traditional chinese medicine to improve body health. Both are known to have immunostimulatory activity that increases phagocytic activity of macrophage. This study aims to determine the phagocytic activity of the combination extract of red ginger and angkak using carbon clearance method. Combination of red ginger and angkak (7:3) was kinetically macerated in ethanol 96%. Twenty white mice were divided into 5 groups, such as control group (CMC-Na 0.5%), positive control (Levamisole 2.5 mg/kgBB), and three experiment group that was given red ginger extract (105 mg/kgBB), angkak extract (105 mg/kgBB), and combination extract of red ginger-angkak (150 mg/kgBB). All treatments were given orally for sevendays, consecutively. The phagocytosis index (IF) value was determined on day 8 by injecting carbon intravenously and immunostimulant activity was shown if IF>1. The highest IF value of three extracts was shown by combination extract (1.2489±0.0261) compared to red ginger and angkak extract, mentioned 1.2030±0.0448 and 1.0537±0.0254, respectively. Moreover, the IF values of combination extract and red ginger were significantly ($p<0.05$) different compared to the control group of CMC-Na (IF=1). However, it is significantly ($p>0.05$) lower compared to the levamisole group (1.5187±0.0534). It could be concluded that the combined extract of red ginger-angkak showed the greatest phagocytic activity against male white mice compared to extract of red ginger and angkak itself.

Keywords: Immunomodulator; Immunostimulant; Phagocytosis index; Oryza sativa; Zingiber officinale Roscoe var. rubrum.

INTRODUCTION

The immune system is a mechanism used by the body as a protector against the threat of harm that can be caused by various subjects contained in the environment that enter the body. When a foreign object enters the body, the immune system will carry out various processes to destroy the foreign object. There are two kinds of immune systems, namely the innate immune system (non-specific immune system) and the adaptive immune system (specific immune system) (Rosales et al., 2016). The immune system can be affected by a group of compounds called immunomodulators.

Immunomodulators are compounds that can help improvement of the work of the immune system. Based on activity, immunomodulators consist of immunostimulators, immunoregulators, and immunosuppressors (Masniah et al. 2021). Immunostimulants are substances that can correct imbalances in the immune system by increasing immunity (Baratawidjaja & Rengganis, 2018). Immunostimulants can be made from herbal or synthetic ingredients. However, the use of synthetic immunostimulants can cause adverse side effects (Novitasari et al., 2017). In addition, from an economic point of view, the use of synthetic drugs is much more expensive because they are usually used over a long period of time (long-term) (Ardhianta et al., 2017). So the development of herbal products as immunomodulators is growing rapidly.

Plants that have provided scientific evidence of immunostimulatory activity are the Zingiberaceae family. Red ginger (*Zingiber officinale var*. rubrum) has immunostimulant activity that can increase macrophage cell phagocytosis. In addition, the phenolic content in red ginger rhizome has a role as an immunomodulator. Previous research showed that red ginger extract at a dose of 100mg/kgbb provided immunostimulant activity by stimulating phagocytosis activity (Luhurningtyas et al., 2021). In addition to red ginger, herbal products known to have immunostimulant activity are angkak. Angkak is a fermented food from China made by cultivating the Monascus purpureus mold on rice (Oryza sativa). Various studies on angkak have been conducted and the results show that angkak has pharmacological activity. The content of lovastatin in angkak can stimulate the immune system. Angkak is also known to

affect immune cell regulation and gene expression (Pebriani & Melinda., 2016).

The activity of a compound in stimulating the immune system can be seen from the ability to increase the phagocytic cell phagocytosis ability of the body. Phagocytosis is the process of particles being swallowed by cells. Macrophages and polymorphonuclear leukocytes are the most important phagocytic cells. The majority of foreign bodies that enter the tissue are removed through the mechanism of phagocytosis (Handayani et al., 2018). Testing the ability of phagocytosis that can be used to determine immunomodulatory activity is using a carbon clearance test. This test is conducted according to the phagocytosis ability of body cells in eliminating pathogens that enter the body (Ahmadniaye et al., 2020).

Based on information about the immunostimulant activity of red ginger and angkak, researchers are interested in knowing the immunostimulant activity of the combination of the two ingredients. Researchers used a group of mice test animals that were given a combination of red ginger and angkak extracts with the carbon filtration method. The combined extract is expected to provide immunostimulant activity by stimulating the phagocytic activity of mice immune cells.

MATERIALS AND METHODS

Materials

The materials needed include red ginger rhizome (*Zingiber officinale* var. Rubrum), angkak (*Oryza sativa*), 8-12 weeks old male mice (Mus musculus) weighing 20-30 grams, 70% ethanol, 96% ethanol, NaCl p.a (NS), 1% acetic acid (Sigma-aldrich), Chinese ink (Yamura), Na CMC (Sigma®), Levamisole and aqua pro injection.

Procedures

Sample Preparation and Extraction

Fresh Red Ginger *(Zingiber officinale Roscoe)* herb obtained from the village of Punggur, Kubu Raya Regency, West Borneo Province. The plant identification was confirmed by Biology Laboratory, Faculty of math and science, Tanjungpura University. The cleaned herb are dried and blended until they turn into powder. Angkak was obtained from Baba Kuya Shop, Bandung, West Java. An amount of 35 g the dried of ginger rhizome powder and 15 g of angkak powder were exctracted with kinetic maceration method using 1 L ethanol 96%. Using Hotplat at 50°C and 400 rpm. macerate was filtered in vaccum buchner and evaporated at ± 50 ° C in a rotary vacuum evaporator and thickened by heating in a dehydrator at ± 40 °C (Ahmadniaye et al., 2020; Gonzales et al., 2016).

Animal

All procedures were evaluated by Ethical clearance Committee of Faculty of Medicine University of Tanjungpura. The test animals used in the study were male mice *(Mus musculus*). Mice amounted to 20 mice which were divided into 5 treatment groups with each group totaling 4 mice. This study used a test group that was given red ginger extract as much as 105 mg / kgbb, angkak extract as much as 105 mg / kgbb, and a combination extract of red ginger and angkak as much as 150 mg / kgbb. All treatments were given by peroral route for 7 days. Grouping of test animals based on treatment can be seen in (Table 1). Before the experiment begins, the animals were acclimatized in the experimental room for 7-14 days.

Table 1. Grouping of Test Animals.

Group	Amount	Treatment
Negative control	4	CMC-Na 0,5%
Positive control	4	Levamisole dose 2,5 mg/kgBB
Red Ginger Extract	4	Red Ginger Extract 105 mg/kgBB
Angkak extract	4	Angkak Extract 105 mg/kgBB
Combination ekstrak	4	Combination Extract 150 mg/kgBB

Carbon Colloidal Suspension Setup

The manufacture of carbon suspensions is done in the following manner: suspension of 1.6 ml of the Chinese ink in 8.4 ml of 0,5% B/V CMC-Na in a physiological solution of NaCl. (Senja et al., 2014).

Carbon Clearance Test

In this method used 4 mice each positive control group, negative control and treatment group. Each group is gave an levamisole 2.5 mg/kg bw as a positive control group, Na-CMC suspension as a negative control and Red Ginger Extract (105 mg/kg bw), Angkak Extract (105 mg/kg bw), and Extract Combination (150 mg/kg bw) as a treatment group extract 1 time a day for 7 consecutive days. On the 8th day after sampling the suspension of the samples in each group, the tail ends were cuted. then the blood is taken 25 µl and added 4 ml of 1% acetic acid to fill red blood cells, the first blood used as a Blanko (minute 0), then 0.1 ml carbon suspension is injected in I. V through the blood vessels on the tail, and in the 4, 8, 12, 16 and 20 minutes after the carbon injection is carried out blood sampling, then the blood is takens as much as 25 µl, each added 4 ml of 1% acetic acid to a line of red blood cells, and then measured its absorption

using UV-Vis spectrophotometer at a wavelength of 639.0 nm. After 12 hours of blood was taken, then the liver and lymph recorded weighing. After taking the blood on the tail end of the mice is calculated a constant carbon elimination speed (K) and phagocytosis index (α) by using the formula (Sebayang & Hasibuan, 2021; Rahman et al., 2016).

The Phagocytosis Index is calculated by comparing the phagocytosis constant (K) of the sample with the phagocytosis constant of the negative control calculated using the following formula (Rahman et al., 2016).

Data analysis

Data from observations of immunodulatory activity testing were statistically analyzed by the One Way ANOVA method followed by Post Hoc Tukey HSD test using SPSS (Statistical Product and Service Solution) version 25.

RESULTS AND DISCUSSION

Results

Thin Layer Chromatography (TLC)

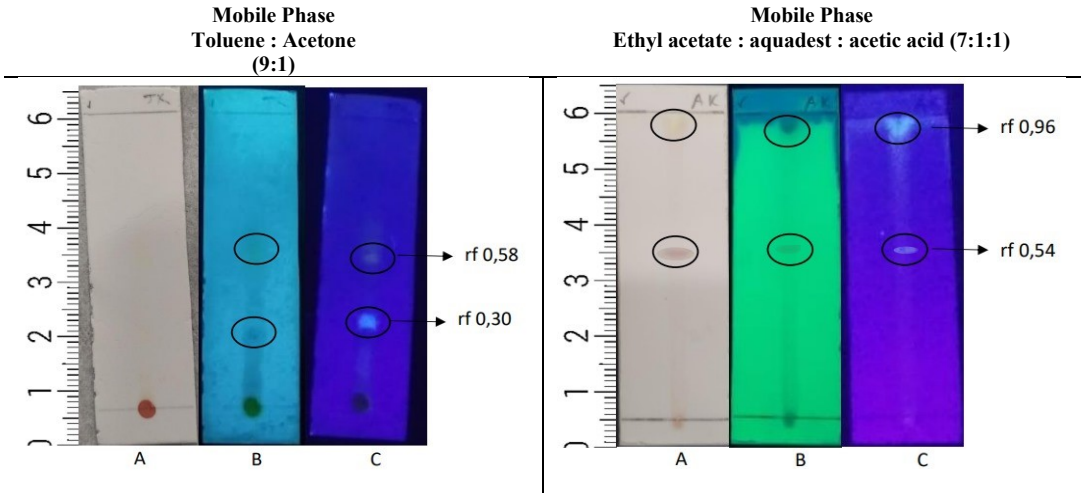

Figure 1. Chromatogram Profile of Red Ginger and Angkak Combination Extract (A) Plate observed directly (B) Plate Observed under UV light 254 nm (C) Plate Observed under UV light 366 nm.

Phagocytosis Constant Rate

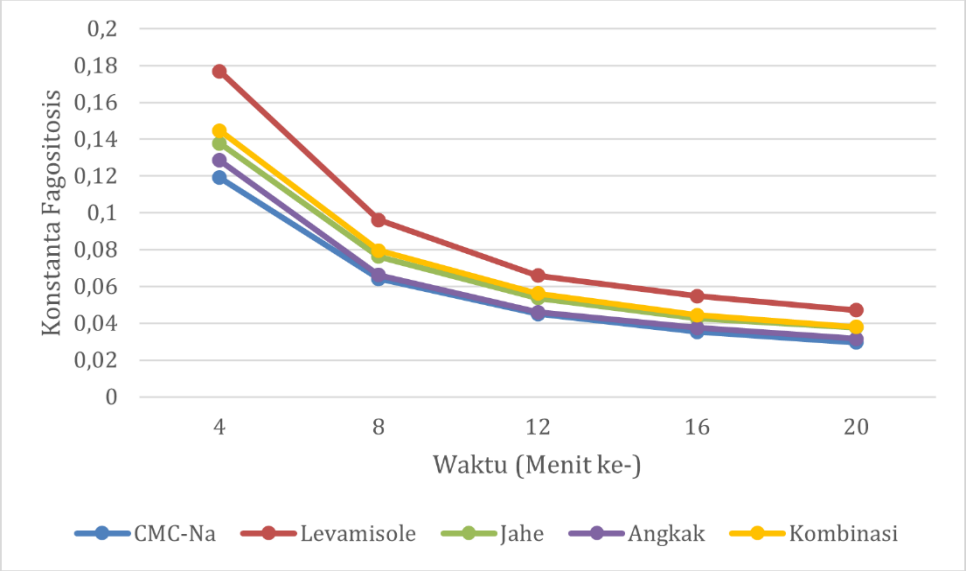

Figure 2. Graphic of Phagocytosis Constant Rate.

Table 2. Phagocytosis Index.

Group	Phagocytosis Index (± SD)
CMC-Na	1
Levamisole 2,5 mg/kgbb	1.51878 ± 0.053428*
Red ginger (105 mg/kgbb)	1.20308 ± 0.044886*
Angkak (105 mg/kgbb)	1.05378 ± 0.025442
Combination (150 mg/kgbb)	1.24896 ± 0.026164*

*, significant difference with negative control group (CMC-Na)

Discussion

Combination extract using 35 grams of red ginger powder and 15 grams of angkak in 1 liter of 96% ethanol solvent. The extract obtained is a thick extract due to the starchy substance contained in the angkak, but the extract is also slightly oily due to the volatile oil contained in red ginger. The final extract was more concentrated and dark red in color due to a mixture of red pigments in angkak and brownish yellow color from a single red ginger. The extract had a spicy odor typical of ginger essential oil (Roseno et al., 2019; Tritanti & Pranita, 2019). The yield value of the combination extract obtained was 12.165%. The extract is then stored in a tightly closed container and protected from light at room temperature, especially in the extract of angkak and combinations containing red pigments of angkak which are thermosensitive and photosensitive, because pigments can be degraded at high temperatures, and angkak pigments have a strong tendency to absorb visible light and radiant energy from lamps which causes a reduction in stability when exposed to light (Hasim et al., 2018).

The observation of the chromatogram profile in this study uses TLC because this method is suitable for less polar and non-polar compounds so that the compounds can be distributed between the silica gel stationary phase and the liquid mobile phase (Putra et al., 2021). The eluent used to separate the compounds contained in red ginger contained in mixed extracts is toluene and acetone in a ratio of 9:1, where both are nonpolar eluents Meanwhile, the eluent used to separate the compounds contained in angkak contained in mixed extracts is ethyl acetate, water, and methanol in a ratio of 7:1:1 which is polar coupled with acetic acid to prevent tailing so that it can provide sharper and separate stains that work by ionizing polar compounds to be separated, especially pigment compounds in angkak which are very sensitive to acidic pH. Chromatogram stains using specific eluents of red ginger material are not visible by direct observation, so they require UV 254 nm, and UV 366. The results of the TLC using the specific eluent of red ginger showed that there were two stains, while the TLC using the specific eluent of angkak (Figure 1.) showed two stains. Overall at UV 254 nm, the plate will glow green with the stain will be black or dark, while at UV 366 nm, the plate will glow blue with the stain will be turquoise blue.

The TLC test of the combined extracts of red ginger and angkak resulted in the finding of stain spacing based on observations under UV 254 nm and UV 366 nm. The stains obtained in the TLC test of the combined extracts of red ginger and angkak were 2 stains for TLC testing of toluene:acetone (9:1) mobile phase with Rf results of 0.3 and 0.58 (Figure 1.). The stains formed indicate that the combined extract of red ginger and angkak contains gingerol and shogaol compounds which are almost comparable to previous studies, namely Rf 0.53 for 6-gingerol and 0.36 for 6-shogaol. (Foudah et al., 2020). These gingerol and shogaol compounds have been shown to increase immunostimulant activity with the mechanism of stimulating macrophages and lymphocytes (Nantaporn & Pharkphoom, 2022). While the TLC test of red ginger and angkak extracts using a special eluent of angkak, namely ethyl acetate: distilled water: acetic acid (7:1:1) showed that there were 2 spots with Rf 0.43 and 0.96 (Figure 1). These spots show that the combined extract of red ginger and angkak contains 2 pigments, namely red pigment (Rf 0.43) and yellow pigment (Rf 0.96). The red pigment in angkak consists of monascorubramine and rubropunctamin, while the yellow pigment consists of ankaflavin and monascin which are involved in the production of the compound lovastatin in angkak. Lovastatin is believed to have immunostimulatory activity by stimulating the specific immune system. In addition, lovastatin has cholesterol-lowering activity. High cholesterol in body cells can disrupt macrophage cells and cause inflammation, so lovastatin indirectly keeps the immune system optimized. (Nantaporn & Pharkphoom, 2022; Basuny & Abdel, 2020).

Testing phagocytosis activity using experimental animals. The experimental animals used were male white mice (Mus musculus L.) swiss webster strain aged 6-8 weeks as many as 20 heads. Mice were chosen because they are easy to obtain, relatively cheap, easy to handle, and their physiological body is similar to humans. To reduce the deviation of the research results, mice with the same strain and sex, age and body weight were selected. The immune system is also influenced by estrogen and testoterone, so male mice were chosen because they have hormones that are more stable than female mice (Triana et al., 2014). The experimental animals used have met ethical approval by the authorized ethics committee. Before use, mice were acclimatized for 7 days. This aims to familiarize the mice with the experimental conditions and environment as well as control health and body weight and homogenize the diet (Aldi et al., 2016).

The test animals were grouped into five groups, each group consisting of four mice. Each group was given a different treatment. The negative control group was given a 0.5% Na CMC suspension, the positive control group was given levamisole 2.5 mg/kgbb, the test preparation group was given a single extract of red ginger at a dose of 105 mg/kgbb, a single extract of angkak at a dose of 105 mg/kgbb, and a combination extract at a dose of 150mg/kgbb. The extracts of red

ginger, angkak, and the combination did not dissolve perfectly in water so that the test preparations given to experimental animals were made in the form of suspensions using CMC Na. CMC Na 0.5% suspension solution is used as a suspending agent because it is inert, non-toxic, non-irritating, has high clarity, good resistance to microbes and produces a stable solution. Levamisole is used as a positive control because it has immunostimulatory activity by increasing macrophage phagocytic activity, increasing nitric oxide, lymphocyte proliferation and stimulating antibody (IgG) and TNF-α cytokine production (Musdalipah et al., 2022). The dose of extract used is based on research on the phagocytic activity of red ginger with a dose of 100 mg/kgBB mice can increase phagocytic activity (Luhurningtyas et al., 2021). The extract suspension was made based on the predetermined dose and given to the test animals once a day consecutively in order to give the extract a chance to increase the immune response (Rowe et al., 2009)

The carbon clearance method is used to measure the activity of phagocytic cells in killing pathogenic organisms that enter the body (Eduardo et al., 2017). Carbon used as a marker is administered intravenously. Carbon clearance is seen at time 4, 8, 12, 16, and 20. Carbon levels in the blood will decrease over time such as due to phagocytic events by leukocyte cells especially by monocytes, neutrophils, eosinophils, and macrophages (Aldi et al., 2017). The use of carbon as a marker has the advantage that the particle size is smaller and more stable, so carbon does not cause blockage of blood vessels and lungs. Carbon is also characterized as an antigen because of its isolation, which under normal circumstances is not found in the body. (Aditya et al., 2017). Carbon levels in the blood are also easier to measure using an analytical instrument, namely a UV-Vis spectrophotometer. The carbon used is Chinese ink with the Yamura brand on the market.

Carbon suspension was made using Na CMC with a concentration of 0.5% (b/v) and added physiological saline. The use of physiological saline in making the suspension aims to make the condition of the carbon suspension preparation (Chinese ink) the same as the condition of the test animal's body (Ilasamola et al., 2018). The phagocytosis effect was analyzed using a UV-Vis spectrophotometer. The running results showed that the maximum wavelength of the carbon standard was at a wavelength of 639 nm. The results of the extract activity test showed a decrease in the absorbance of carbon every minute in the blood of male white rats given the test preparation for seven consecutive days. The reduction of carbon levels in the blood of the test animals at every minute of testing indicates that the concentration of carbon in the blood of mice is getting lower over time (Figure 2). This also shows an increase in the phagocytic activity of carbon in each extract group. Based on the results of the study, there was a decrease in absorbance value in all groups given the extract compared to the negative control group. The decreasing absorbance value indicates that the concentration of carbon is decreasing in the blood of mice. Carbon in the blood will stimulate the formation of the nonspecific immune system in the form of phagocytic cells. Phagocyte cells that are activated due to nonspecific stimuli can quickly recognize the type of foreign antigen that enters the body and then destroy and remove the foreign antigen from the bloodstream (Abebe et al., 2017). From the absorbance data, the phagocytosis constant value can be calculated. Phagocytosis constant is one of the parameters that shows the speed of phagocytosis. The greater the speed of phagocytosis, the higher the phagocytic carbon clearance (Shi et al., 2012). After obtaining the phagocytosis constant value, the phagocytosis index value can be obtained. The average value of the phagocytosis index is greater than 1 indicating that the test substance has immunomodulatory activity, namely as an immunostimulant. But if the average value of phagocytosis index is less than 1, the test substance has immunosuppressant activity (Ali et al., 2022). From the phagocytosis index data (Table 2.), it can be seen that the average phagocytosis index for red ginger extract, angkak extract and combination extract is greater than one (IF>1). So it can be said that red ginger extract, angkak and the combination can increase phagocytosis activity and is immunostimulant. The results of the red ginger extract activity test are in accordance with previous research which shows that red ginger extract at a dose of 100 mg / kgbb has immunostimulant activity with a phagocytosis index value of more than 1 (Luhurningtyas et al., 2021). The highest phagocytosis index value was shown by the group given the combination extract with a value of 1.24896. It can be concluded that the group with a combined extract dose of 150 mg / kgbb has the best phagocytosis ability among other groups.

The test results were statistically processed using one-way Anova. In this data processing using Saphiro-Wilk because the data used is less than 50. In normality testing, the sig value> 0.05 is obtained in the phagocytosis index data, this value indicates that the data variation is normally distributed. In homogeneity testing, a sig value> 0.05 was obtained, indicating homogeneous data variations. One-way Anova test was used to compare the five preparation groups used on the phagocytosis index. The results of the one-way Anova test showed a significance of 0.000 ($p<0.05$). This result indicates that there is a significant difference between the five groups significantly on the phagocytosis index. Then continued with Tukey test analysis to see the effect of each treatment group. The results of the Tukey test analysis showed that the phagocytosis index of angkak extract did not have a significant difference with the group given negative control (CMC-Na). Meanwhile, red ginger extract, combination extract and positive control had a significant difference with the negative control ($p<0.05$).

CONCLUSIONS

Based on the results of the study, it can be concluded that the combined extract of red ginger-angkak showed the greatest phagocytic activity against male white mice compared to extract of red ginger and angkak itself.

Acknowledgements: We express our gratitude to the chief of the Faculty of Medicine University of Tanjungpura especially Pharmacy Study Program for their invaluable support in facilitating the progress of this research endeavour alongside the team that always has been supporting us morally and physically.

Competing Interests: The authors declare that there are no competing interests.

REFERENCES

Abebe, D., Aman, K., Helen, B., Gomathi, P. (2022). In-vivo evaluation of immunomodulatory activity of crude extract and solvent fractions of Cyphostemma adenocaule. Heliyon, 8(12), e12377.

Aditya, G., Ajay, K. S. (2017). Experimental animal models used for evaluation potential immunomodulators: A mini review. Bulletin of Faculty of Pharmacy, 55(2), 211-216.

Ahmadniaye, M. H., Safari, O., Selahvarzi, Y., Baghalian, A., Kia, E. (2020). Non-Specific Immunity Promotion In Response To Garlic Extract Supplemented Diets In Female Guppy (Poecilia Reticulata). Fish Shellfish Immunol, 9(7), 96–9.

Aldi, Y., Amdani, A., Bakhtiar, A. (2016). Aktivitas Senyawa Skopoletin dari Buah Mengkudu (Morinda citrifolia, Linn.) terhadap Respon Fisiologi Makrofag Mencit Putih Jantan. Sci J Farm dan Kesehat, 6(1), 25.

Aldi, Y., Ogiana, N., Handayani, D. (2018). Uji Imunomodulator Beberapa Subfraksi Ekstrak Etil Asetat Meniran (Phyllanthus niruri [L]) pada Mencit Putih Jantan dengan Metoda Carbon Clearance. B-Dent, J Kedokt Gigi Univ Baiturrahmah, 1(1), 70–82.

Ali, H., Ali, D.; Almutairi, B. O., Kumar, G., Karga, G.A., Masi, C.. Sundramurthy, V. P. (2022). Synergistic Effect of Conventional Medicinal Herbs against Different Pharmacological Activity. BioMed. Res. Int. 7337261.

Aliviameita, A., Puspitasari. (2020). Buku Ajar Mata Kuliah Imunohematologi. Sidoarjo: Umsida Press.

Ardhianta, I. R., Jasson, M. P., Sri, R. H. (2017). Antiparkinson Activity Of Rosella Extract (Hibiscus Sabbdariffa L.) In White Male (Rattus Norvegicus) Sprague Dawley Rats Induced By Haloperidol, 14(2):160–8.

Basuny, A. M., Abdel-Raheam, H.E.F. (2020). Red And Yellow Monascus Pigments As Potential Natural Antioxidants For Fatty Foods. Plant Arch, 20, 444–449.

Baratawidjaja, K., Rengganis, I. (2018) Imunologi Dasar. Jakarta: Fakultas Kedokteran Universitas Indonesia.

Eduardo, P. F., Adriana, S. C. C., Nycolas, L. P., Fabiana, P., Elisabeth, C. U. (2017). Levamisole enhances the innate immune response and prevents increased cortisol levels in stressed pacu (Piaractus mesopotamicus). Fish & Shellfish J. Immunology, 65(1), 96-102.

Foudah, A. I., Shakeel, F., Yusufoglu, H. S., Ross, S. A., Alam, P. (2020). Simultaneous Determination Of 6-Shogaol And 6-Gingerol In Various Ginger (Zingiber Officinale Roscoe) Extracts And Commercial Formulations Using A Green RP-HPTLC-Densitometry Method. Foods, 9(8), 1136.

Handayani, N., Wahyuono, S., Hertiani, .T, Murwanti, R. (2018). Uji Aktivitas Fagositosis Makrofag Ekstrak Etanol Daun Suji (Dracaena Angustifolia (Medik.)Roxb.) Secara In Vitro. Jurnal Farmasi Medica, 1(1), 26-32.

Hasim, A. D., Islamiati, W., Wahdah, H. A. F., Nur, F. D. (2018). Antioxidant Activity of Ethanol Extract of Red Yeast Rice and its Fractionation Products. Res J Phytochem, 12(2), 52–9.

González, K., Gutiérrez, R., Hernández, Y., Rodriguez, M., Iglesias, O. (2016). Determination Of The Antioxidant Capacity Of Two Seagrass Species According To The Extraction Method. J Pharm Pharmacogn Res, 4(5),199–205.

Ilasamola, D., Aldi, Y., Fakhri, M., Diliarosta, S., Biomechy, Oktomalio, P., Noverial. (2018). Immunomodulatory Effect Test From Moringa Leaf Extract (Moringa oleifera l.) with Carbon Clearance Method in Male White mice. Asian J Pharm Clin Res, 11(9), 241–5.

Kresno, S. B. (2010). Imunologi Diagnosis dan Prosedur Laboratorium. Edisi VI. Jakarta: Palai Penerbit Fakultas Kedokteran Universitas Indonesia.

Luhurningtyas, F., Susilo, J., Yuswantina, R., Widhihastuti, E., Ardiyansah, F. (2021). Aktivitas Imunomodulator Dan Kandungan Fenol Ekstrak Terpurifikasi Rimpang Jahe Merah (Zingiber Of Icinale Rosc. Var.Rubrum). Indonesian Journal Of Pharmacy And Natural Produc, 4(1), 51–9.

Masniah, M., Rezi, J., Faisal, A. (2021). Isolasi Senyawa Aktif Dan Uji Aktivitas Ekstrak Jahe Merah (Zingiber Officinale) Sebagai Imunomodulator. Jurnal Riset Kefarmasian Indonesia, 3(2), 77–91.

Musdalipah, Agung, W. M. Y., Karmilah, Selfyana A.T., Reymon, Nur S.D., Azdar, S. (2022). Toksisitas Akut Dan Lethal Dose (Ld50) Ekstrak Buah Walay (Meistera Chinensis) Asal Sulawesi Tenggara Terhadap Mencit (Mus Musculus). J. Pharmacoscript, 5(2), 186-200

Nantaporn, P., Pharkphoom, P. (2022). [6]-Gingerol: A narrative review of its beneficial effect on human health. J. Food Chemistry Advances, 1, 100043.

Nofitasari, L., Peranginangin, J., Sri, D., Handayani, R. (2017). Sparague Dawley Rats Induced By Haloperidol. Jurnal Setiabudi, 14(2), 169–81.

Pebriani, F., Milanda, T. (2022). Review Artikel: Aktivitas Farmakologi Angkak (Beras Merah Fermentasi Kapang Monascus Purpureus). Jurnal Farmaka, 20(2), 42-55.

Putra, D. P., Novelina, N., Asben, A. (2021). Stability and Toxicity Test of Angkak Pigment Powder from Sago Hampas-Rice Flour Substrate as Natural Dyes. J Appl Agric Sci Technol, 5(1), 38–49.

Rahman, H., Aldi, Y., Mayanti, E. (2017). Aktifitas Imunomodulator Dan Jumlah Sel Leukosit Dari Ekstrak Kulit Buah Naga Merah (Hylocereus Lemairei (Hook.) Britton & Rose) Pada Mencit Putih Jantan. Jurnal Farmasi Higea, 8(1), 44-58.

Rosales., C, Demaurex, N., Lowell, Ca., Uribe-Querol, E. (2016). Neutrophils: Their Role In Innate And Adaptive Immunity. J Immunol Res, 1(2), 16-20.

Roseno, M., Sudaryat, Y., Widyastiwi. (2019). Aktivitas Immunomodulator Ekstrak Etanol Kemukus (Piper Cubeba), Kiseureuh (Piper Aduncum), Dan Cabe Jawa (Piper

Retrofractum) Pada Mencit Jantan Galur Balb/C. Jurnal Ilmu Kefarmasian Indonesia, 17(2), 255–61.

Rowe, R.C., Sheskey, P. J. (2009). Handbook of Pharmaceutical Excipients. th ed. USA.

Sari, E. R., Rima, T. (2022). Efek Imunostimulan Ekstrak Etanol Daun Jengkol (Archidendron Jiringa (Jack) I.C. Nielsen) Pada Mencit Putih Jantan. Jurnal Ilmiah Farmasi Farmasyifa, 5(1), 62-70.

Sebayang, L., Hasibuan, A. (2021). Uji Efek Imunumodulator Vco (Virgin Coconut Oil) Pada Tikus Jantan. J Bios Logos, 11(2),139.

Senja, R. Y., Elisa, I., Akhmad, K.N., Erna, P.S. (2014). The Comparison Of Extraction Method And Solvent Variation On Yield And Antioxidant Activity Of Brassica Oleracea L. Var. Capitata F. Rubra Extract. Traditional Medicine Journal, 19(1), 43-48.

Shi, A., Wang, L. D., Li, J., Benu, A. (2012). The effect of NaCl on the rheological properties of suspension containing spray dried starch nanoparticles. Carbohydrate polymers, 90, 1530-7.

Tiwari, S., Talreja, S. (2022). Thin Layer Chromatography (TLC) VS. Paper Chromatography: A Review. Acta Sci Pharm Sci, 6(9):5–9.

Triana, E., Yulinery, T., Nurhidayat, N. (2014). Analisis Citrinin, Lovastatin, Dan Pigmen Pada Angkak Hasil Fermentasi Beras IR 42 Dengan Monascus Purpureus Hasil Mutagenesis Etidium Bromida. J. Sains Teknologi, 4(1), 459-466.

Tritanti, A., Pranita, I. (2019). The making of red ginger (zingiber officinale rovb. var. rubra) natural essential oil. J Phys Conf Ser, 1273 012053.

Wall, P.E. (2005). Thin-layer Chromatography RSC Chromatography Monographs. Great Britain: Royal Society of Chemistry.

THIS PAGE INTENTIONALLY LEFT BLANK