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Evaluating the efficacy of Kaempferia Galanga essential oil as a massage medium for accelerating muscle recovery

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Abstract*:* Recovery following physical exercise is essential for enhancing athletic performance. This study aimed to evaluate the effectiveness of kencur essential oil (Kaempferia galanga) as a massage medium in accelerating muscle recovery post-exercise. Specifically, the research focused on its potential to reduce lactic acid levels, alleviate muscle soreness, and provide both physical and psychological relaxation. It was hypothesized that kencur essential oil would outperform traditional massage oils due to its anti-inflammatory and antioxidant properties. The method used in this study is an experimental method by giving treatment to three experimental groups of 30 hockey athletes divided into 3 groups. Group A received exercise treatment only, group B received exercise treatment followed by massage with a regular lotion, and group C received exercise treatment followed by massage with kaempferia galanga essential oil lotion. Each group underwent a total of 16 treatment sessions. The results indicated a significant difference in average lactic acid levels among the three groups ($p = 0.000$; $p < 0.05$), with Group C demonstrating the lowest average lactic acid levels. This suggests that the combination of exercise and massage with kencur essential oil is more effective in reducing lactic acid accumulation in muscles compared to the other treatments. In conclusion, the application of Kaempferia galanga essential oil in massage therapy can significantly accelerate muscle recovery. Future research should explore comparisons with other essential oils, assess the effects across various sports, determine optimal dosing and application methods, and analyze long-term effects and potential side effects. Additionally, it is crucial to investigate muscle recovery biomarkers influenced by this therapy, athletes' acceptance of galangal oil, and the underlying mechanisms that contribute to reduced lactic acid accumulation and muscle fatigue.

Keywords: massage, kaempferia galanga, muscle, fatigue

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INTRODUCTION

One treatment that is often done by athletes is massage, which aims to reduce muscle tension due to training or during competition (Riza et al., 2021). Massage in the form of sports massage is a massage that is more specialized for athletes or sports activists who have a risk of muscle injury; it has the impact of reducing tension and improving athlete performance both during training and competing and can also help the recovery process from muscle injury (Smith, 2022). Training is systematic and continuous; the goals include improving the athlete's physical condition, preventing injury, or for health purposes. Training conditions result in muscle contraction. Differences in intensity indicate differences in contraction. With high intensity, the muscles will contract in an anaerobic state, and at moderate and low intensities, the muscles will contract aerobically. Such muscle contractions under anaerobic conditions result in the provision of ATP in the muscle being met by the process of anaerobic glycolysis. As a result, muscle glycogen during exercise is reduced, increasing blood lactic acid levels. This increase in lactic acid levels can interfere with the athlete's performance (Powers, 2021). Such as affecting the maximum workability of muscle fibres, reducing physical performance, and being one of the factors causing fatigue (Jones & Williams, 2023).

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Recovery after physical exercise is crucial for improving athletic performance, as it helps eliminate lactic acid buildup in muscles through increased microcirculation (Pinar et al., 2012). Massage therapy, a widely used recovery method, enhances this process by boosting blood and lymphatic flow, promoting lactic acid removal, and providing benefits such as muscle stretching, injury prevention, and faster recovery. Recent studies highlight the effectiveness of massage in reducing muscle soreness and improving muscle function (Smith et al., 2021). However, there remains a gap in optimizing recovery through the type of massage oils used. Traditional oils and lotions provide lubrication but may not specifically enhance muscle recovery. A promising alternative is kaempferia galanga (kencur) oil, a herbal remedy with anti-inflammatory properties that could potentially accelerate lactic acid reduction and muscle recovery more effectively than conventional oils. Further research is needed to explore cancer oil's potential to improve post-exercise recovery compared to traditional massage mediums.

Kencur (kaemferia galanga) is a plant from the rutaceae family that has the potential to produce atsirian oil. Kencur atsirian oil is obtained by distillation, and the process is easy and inexpensive. The pharmacological effects of kencur atsirian oil can cause anti-inflammatory, analgesic, antioxidant, and sedative effects. The sedative effect is a state of physical and psychological relaxation because it contains the bioactive substance linalool. Recent pharmacological research has highlighted the efficacy of kencur atsirian oil in reducing inflammation and providing pain relief, which can be particularly beneficial for athletes in recovery (Harsono et al., 2022). Additionally, studies have demonstrated its potential to promote mental relaxation and reduce stress levels, thereby supporting both physical and psychological recovery (Tanaka et al., 2024).

Antioxidants, as one of the contents of kecur, have an alkaline effect. Foods or drinks that are alkaline are known to inhibit muscle fatigue (Schwalfenberg, 2012). Based on pharmacology, the alkaline nature of kencur atsirian oil when applied through massage or massage can be absorbed through the capillary blood vessels of the skin, thus neutralizing the lactic acid present in the circulation (Satria et al., 2021). The acid-base chemical reaction process will produce salt and water so that lactic acid levels in the circulation can be eliminated. Thus, the body needs important substances in the oil used during massage to prevent fatigue and muscle pain (Gomez et al., 2009).

Kencur atsirian oil applied during massage will accelerate the recovery process. Massage will provide physiological effects such as a relaxing effect, increased blood flow, lymphatic flow, stimulation of the nervous system, and increasing venous return to reduce muscle tension due to spasms, muscle shortening or fibrosis (Swarbrick et al., 2015). In many massage studies, lotions or conventional oils are commonly used. The difference in this study is that the spreadable material for massage uses kencur atsirian oil. To scientifically prove the effect of relaxation, further research is needed to apply the pharmacological effects of kencur atsirian oil as a spread on massage to overcome fatigue (Tanuwidjaja et al., 2023).

The primary objective of this research is to scientifically assess the effectiveness of kencur atsirian oil (Kaempferia galanga) as a massage medium in accelerating muscle recovery. This is achieved by reducing lactic acid buildup, alleviating muscle soreness, and promoting both physical and psychological relaxation in athletes. The unique aspect of this study is the use of kencur atsirian oil, which possesses pharmacological properties such as anti-inflammatory, analgesic, and antioxidant effects. These properties make it a superior choice compared to traditional oils used in sports massage. The study is designed to investigate the specific benefits of kencur atsirian oil in post-exercise recovery, particularly in neutralizing lactic acid and enhancing muscle function.

METHODS

This study utilized an experimental design with a pre-and post-test control group framework to evaluate the effectiveness of Kaempferia galanga essential oil as a massage medium for accelerating muscle recovery. The research subjects consisted of female hockey athletes aged 19 to 20 years, all of whom demonstrated good fitness levels and engaged in training at least six times per week. Participants were recruited from a local hockey club known for its regular training sessions, ensuring that the sample was representative and enhancing the generalizability of the findings. The primary material for this research was kencur (Kaempferia galanga), with the essential oil isolated through steam and water distillation methods. Data collection instruments included the Accutrend Lactate device and lactic acid test strips for measuring lactic acid levels, as well as blood test kits to assess various hematological

parameters such as lactate levels (mmol/L), lactate dehydrogenase (LDH) activity (IU/L), hemoglobin concentration (g/dL), and counts of red blood cells, white blood cells, and platelets. Participants were divided into three groups: Group A served as the exercise-only control group, Group B received exercise followed by massage with a regular lotion, and Group C received exercise followed by massage with Kaempferia galanga essential oil. Each participant underwent a total of 16 treatment sessions. Blood samples were collected before the initiation of treatments and immediately after the final session to measure the specified parameters. The data collected were analyzed using ANOVA through SPSS software to compare mean differences among the three groups regarding their recovery outcomes.

RESULT AND DISCUSSION

Result

Table 1 presents the data from the measurements of lactate levels (mmol/L), LDH activity (IU/L), hemoglobin (g/dL), and the counts of red blood cells, white blood cells, and platelets from ten subjects (A1 to A10) before and after the intervention. Lactate levels showed a decrease post-intervention in all subjects, with the highest value before the intervention being 11.0 mmol/L in A4 and the lowest at 4.8 mmol/L in A8. LDH activity also indicated a decrease in most subjects, with A2 experiencing a significant drop from 215 IU/L to 157 IU/L. Hemoglobin levels varied, with A10 showing an increase from 12.4 g/dL to 13.2 g/dL, while A4 and A5 also demonstrated an increase post-intervention. Erythrocyte, leukocyte, and platelet counts displayed diverse variations; A3 recorded increases in red blood cells and platelets, whereas A2 experienced a decrease in white blood cell count. Lymphocytes also showed fluctuations, with A3 decreasing from 40% to 30%. Overall, this data provides an overview of the hematological changes occurring as a result of the intervention, highlighting significant individual response variations.

Tabel 1. Lactic Acid Test Results Group A

Name	Lactic Acid (mmol/L)		LDH (IU/L)		HB (g/dl)		Erythrocytes		Leukocytes		Platelets		Lymphocytes (%)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
A1	7.8	5.8	168	159	12.8	12.4	5.00	4.93	6.61	7.04	301	301	34	36
A2	5.8	5.6	215	157	12	12.5	4.43	4.55	11.65	11.09	387	3.98	44	43
A3	5.6	3.8	186	186	12.6	12.7	4.56	4.79	11.06	11.25	392	423	40	30
A4	11.0	7.8	215	193	11.4	12.1	4.28	4.45	7.18	6.58	332	364	37	42
A5	7.8	5.3	179	165	11.8	11.4	5.06	5.16	7.21	7.53	323	347	38	35
A6	6.2	3.8	163	171	10.7	11.5	4.37	4.45	6.67	6.32	394	340	35	37
A7	5.7	5.6	200	163	12.8	13.3	4.33	4.47	6.87	6.99	274	286	34	34
A8	4.8	5.2	203	160	11.6	12.5	4.35	4.45	7.18	7.45	274	283	28	27
A9	8.0	4.8	228	218	10.8	12.0	4.44	4.44	7.82	9.45	328	369	32	28
A10	8.8	5.8	218	167	12.4	13.2	4.18	5.15	8.12	7.35	322	357	33	36

Table 2 shows the results of routine blood tests, including data on lactic acid, LDH, hemoglobin (HB), erythrocytes, leukocytes, platelets, and the percentage of lymphocytes before and after the intervention. For the lactic acid parameter, the highest value in the initial measurement was found in B9 at 10.9 mmol/L, which decreased to 2.0 mmol/L after the intervention, while B2 showed a drastic decline from 6.6 mmol/L to 1.7 mmol/L. For LDH, B3 had the highest value before the intervention at 251 IU/L, which dropped to 160 IU/L afterward, whereas B2 also showed a decrease from 223 IU/L to 200 IU/L. Hemoglobin (HB) remained relatively stable in most subjects, with B4 experiencing an increase from 11.7 g/dl to 12.8 g/dl. In terms of erythrocytes, B7 showed a decrease from 4.03 to 4.94 after the intervention, while B2 experienced an increase from 3.63 to 4.20. For leukocytes, there was a decrease in B3 from 7.93 to 6.56, whereas B8 showed an increase from 7.32 to 8.18. The platelet parameter displayed variation, with B10 increasing from 6.30 to 6.61, while B1 had a significant increase from 313 to 386. For lymphocytes, B1 and B2 showed an increase in percentage, from 30% to 33% and from 35% to 36%, respectively. Overall, the observed changes in these parameters indicate the physiological response of the subjects to the interventions performed.

Tabel 2. Results of Routine Blood Table Examination of Group B

Name	Lactic Acid (mmol/L)		LDH (IU/L)		HB (g/dl)		Erythrocytes		Leukocytes		Platelets		Lymphocytes (%)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
B1	4.1	3.9	173	165	12.3	12.0	4.77	4.71	7.78	7.57	313	386	30	33
B2	6.6	1.7	223	200	11.3	11.6	3.63	4.20	8.64	8.77	376	388	35	36
B3	8.8	4.7	251	160	11.5	12.1	4.66	4.20	7.93	6.56	355	350	38	40
B4	5.2	3.8	179	165	11.7	12.8	4.76	4.8	7.96	7.52	355	358	38	39
B5	5.8	4.0	163	160	12.2	11.4	4.16	4.29	8.14	7.82	363	358	33	32
B6	5.2	5.2	209	168	11.2	12.6	4.11	5.13	9.30	9.97	334	360	31	33
B7	5.4	2.2	214	135	11.0	11.6	4.03	4.94	8.52	7.39	424	387	34	36
B8	5.2	3.1	214	161	12.6	12.5	4.44	5.14	7.32	8.18	326	398	28	30
B9	10.9	2.0	173	180	12.1	12.6	5.00	5.15	8.24	8.22	398	375	25	30
B10	6.2	3.7	168	207	12.3	12.6	4.5	4.6	6.30	6.61	395	394	33	34

Tabel 3. Routine Blood Test Results of Group C

Name	Lactic Acid (mmol/L)		LDH (IU/L)		HB (g/dl)		Erythrocytes		Leukocytes		Platelets		Lymphocytes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
C1	4.8	2.2	239	154	11.0	12.5	4.52	5.05	10.24	9.52	349	322	28	27
C2	3.8	2.1	206	200	13.3	12.6	4.19	4.60	9.25	9.50	354	373	28	24
C3	3.2	1.8	176	150	13.1	12.4	4.59	5.00	8.21	8.54	320	340	37	40
C4	5.4	1.7	174	138	12.4	13.0	4.59	5.10	10.87	10.65	280	340	29	32
C5	4.3	1.5	214	228	11.4	11.6	4.09	4.05	7.68	7.12	323	430	20	23
C6	5.1	1.9	208	205	12.4	12.4	4.24	5.25	7.38	7.78	349	365	37	35
C7	4.2	2.8	168	195	11.6	12.7	4.62	4,60	8.39	7.81	330	382	27	29
C8	4.5	1.7	214	163	12.4	12.4	4.66	4.68	7.38	7.40	341	345	31	30
C9	4.6	2.0	215	251	11.9	11.5	4.12	4.61	8.61	9.28	366	390	29	27
C10	4.4	1.8	190	156	12.8	12.0	4.3	4.09	6.57	6.77	396	395	34	35

Table 3 shows the results of routine blood tests. The measurement of lactate (mmol/L) before the intervention averaged 4.1, with a significant decrease after the intervention, where C1 recorded 4.8 mmol/L down to 2.2 mmol/L, while C10 decreased from 4.4 mmol/L to 1.8 mmol/L. The LDH enzyme (IU/L) also showed a decrease, with C1 going from 239 IU/L to 154 IU/L and C10 from 190 IU/L to 156 IU/L. Hemoglobin levels (g/dl) showed variation, with C5 increasing from 11.4 g/dl to 11.6 g/dl, while C3 decreased from 13.1 g/dl to 12.4 g/dl. The erythrocyte count showed relatively stable results, with C1 increasing from 4.52 million cells/dl to 5.05 million cells/dl, and C6 increasing from 4.24 million cells/dl to 5.25 million cells/dl. The average leukocyte count showed a slight decrease, with C9 going from 8.61 thousand cells/dl down to 9.28 thousand cells/dl. The platelet count showed an increase in some subjects, for example, C5 increased from 323 thousand cells/dl to 430 thousand cells/dl. The lymphocyte count varied, with C1 slightly decreasing from 28% to 27%, while C4 increased from 29% to 32%. Overall, this table illustrates significant changes in blood test results that may indicate the impact of the interventions applied.

Tabel 4. Average Lactic Acid Levels

Variables		A Group	B Group	C Group	Anova
					P
Lactic Acid (mmol/L)	Pre test	5.260	5.84	5.600	0,000*
	sd	0.231	0.374	0.466	
	Post test	6.100	5.340	4.290	
	Sd	0.455	0.462	0.546	
	t-dependent	0.000	0.003*	0.000*	

Notes:* = significant ($p < 0.05$).

The results of statistical analysis of anova test found a significant difference in the average lactic acid levels (p=0.000) (see Table 4). In all 3 groups, the exercise group (A), the exercise and massage lotion group (B), and the exercise and massage group with kencur atsirian oil (C), the average lactic acid level of group C is smaller than the other groups. This means that during the recovery process with massage, the exercise and massage treatment with kencur atsirian oil is better at reducing lactic acid levels in the muscles compared to other groups.

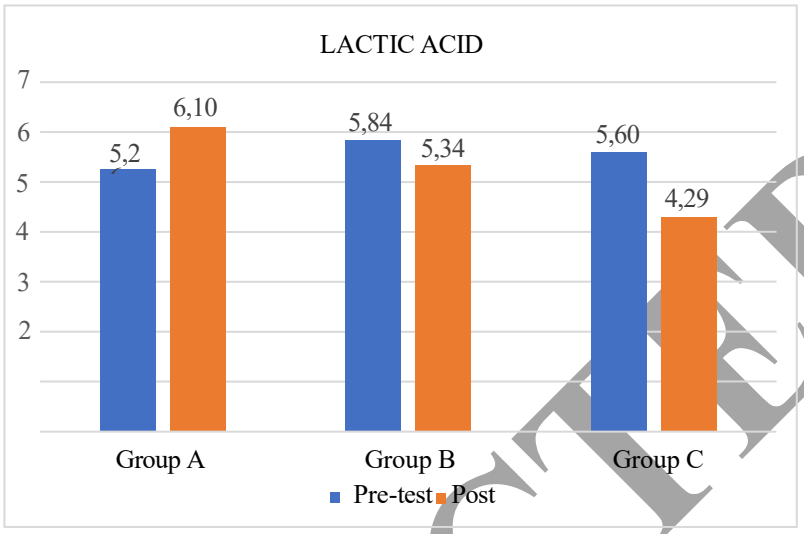

Figure 1. Average Pre and Post-Test Lactic Acid Levels of Each Treatment Group

Discussion

Lactic Acid Formation Process In Exercise

Lactic acid is the metabolic product of glucose through anaerobic lactacid glycolysis reaction. The chemical name of lactic acid is lactic acid, 2-hydroxypropanoic acid, with the chemical formula C3H6O3. Lactic acid is produced from the reduction of pyruvic acid, this process occurs in muscle tissue that is deprived of oxygen, for example during exercise with relatively heavy intensity (Guyton & Hall, 2008). The occurrence of increased lactic acid in muscle is due to hypoxia of muscle tissue (Farenia et al., 2010). In hypoxia, the process of cellular respiration increases because adenosine triphosphate (ATP) is reduced and the number of free radicals formed increases. In hypoxia, mitochondria are more vulnerable, unable to maintain the krebs cycle and oxidative phosphorylation process. The respiratory chain that resides in the mitochondrial membrane is also damaged, so no ATP is produced. Energy source is only obtained from anaerobic glycolysis metabolism. Anaerobic glycolysis metabolism results in very rapid lactate accumulation. The accumulation of lactate in the blood is a fundamental problem in physical performance (Rosidi et al., 2013). Exercise causes the formation of high amounts of lactic acid. Furthermore, lactic acid in the muscle dissociates into H+ ions and lactate ions. The increase in H+ ions causes a decrease in pH in extra- and intracellular fluid. This decrease in pH will inhibit the binding of oxygen by Hemoglobin in the lungs, and can inhibit the activity of phosphofructokinase enzymes and myofibril ATP-ase enzymes in muscles that play a role in ATP synthesis, so that energy provision is disrupted. This disruption of energy supply will reduce the ability of muscle contraction (Guyton & Hall, 2019).

How Kencur Atsirian Oil Works

Kencur is a plant that has benefits as an antioxidant, atsirian oil, bioflavonoids, polyphenols, coumarins, flavonoids, α-terpinene, α-pine, β-pine, and coumarins, and polyphenols (Nizhar, 2012). Muscle fatigue can be prevented by administering ergogenic substances. Ergogenic is a substance that increases energy production, control, or energy efficiency during exercise performance, providing greater additional ability than normal training when training normally. Ergogenic nutrients are classified into four categories: substances that improve anabolism and body composition (e.g., dietary amino acids), substances that provide fast-acting energy (dietary carbohydrates), substances that facilitate

recovery from physical fatigue (e.g., antioxidants), and substances that fill an important role in exercise physiologically (e.g., vitamins, sodium bicarbonate) (Rhoades & Tanner, 2003). One of the causes of muscle fatigue is the accumulation of lactic acid, which causes the accumulation of H+ ions, resulting in a decrease in intracellular pH. In addition, the accumulation of H+ ions stimulates pain receptors, thus inhibiting muscle contraction. Alkaline foods or drinks are known to inhibit muscle fatigue.

Compounds like essential oils, characterized by their lipophilic nature, facilitate easy absorption through the skin (Smith, 2019). Once absorbed, these molecules, such as those found in atsirian oils, disperse readily within the body, including lymphatic vessels, blood vessels, nerves, fibroblasts, and mast cells (Johnson et al., 2020). This distribution occurs via blood and lymphatic circulation, facilitated by capillary networks (Brown & White, 2018). Moreover, these compounds can traverse the blood-brain barrier, impacting the central nervous system and triggering neurochemical responses that induce sensations of pleasure, relaxation, and calm (Clark, 2021). When used in massage, atsirian oils enhance systemic circulation (Lee, 2022).

Massage is an art of hand movement that aims to provide comfort, pleasure, and maintenance of physical health (Ardi Utomo, 2019). In its development, massage is not only used to maintain a healthy body but also as an effective way of treatment (Ari et al., 2021). The benefits of massage include relaxation, pain reduction, improvement of organ function, and maintenance of fitness (M. et al. et al., 2023). One of the natural ingredients often used in massage is kencur (Kaempferia galanga) essential oil, which has long been used traditionally as medicine (Subaryanti et al., 2023). The use of galangal essential oil in massage can provide a calming, warm, and refreshing effect (Sara Nirmala et al., 2024). Kencur essential oil, as part of medicinal drugs, is an important component of health services that must always be available (Stevanus Miharso, 2021). Fatigue is a natural signal from the body that arises due to a decrease in function from good to bad conditions, which can be felt both mentally and physically (Dimas et al. et al., 2021). Muscles, which are made up of fibres that are capable of contracting, play an important role in generating movement and performing many essential bodily functions (Sophie Rome, 2022). Muscle fatigue is often caused by overtraining, lack of training, or physical injury (Dumitru Constantin-Teodosiu, 2021). In the context of sports, especially hockey, played with sticks and a small ball, athletes need a lot of energy and excellent physical condition to achieve maximum performance (Uais et al., 2022). To achieve these achievements, athletes must pay attention to diet, rest, and a balanced training portion (Dianika et al., 2022). Therefore, the combination of massage and the use of galangal essential oil may be an effective solution to address muscle fatigue in hockey athletes, support their physical health, and help them achieve their best performance in competition.

The research results showed that massage using galangal atsirian oil as a topical oil for athletes accelerated the muscle recovery process due to fatigue, because there was a decrease in lactic acid levels. Galangal atsirian oil as a topical oil can increase tolerance to lactic acid and increase the buffering capacity of bicarbonate and phosphate in muscles. Massage therapy using galangal atsirian oil is more efficient in reducing lactic acid levels in athletes' muscles, by improving the circulation system in the muscles themselves. The intensity of training given to hockey athletes varies from moderate to high, which, of course, aims to improve the athlete's abilities. However, fatigue in athletes' muscles must be managed because this condition is a physiological phenomenon which leads to a process of decreasing the muscle's ability to work. The high levels of lactic acid in group A are caused by hypoxia that occurs in the muscles, namely anaerobic metabolism, which produces lactic acid. High levels of lactic acid require a supply of oxygen, especially during muscle contractions. Several studies have shown that kencur atsirian oil contains phenol and natural flavonoids, which can influence several targets in neurological processes and have strong sedative and antioxidant properties.

Galangal atsirian oil applied during the massage will provide a physiological effect, in the form of a massage effect, increasing blood flow and lymphatic flow, stimulating the nervous system and increasing venous return so that it can reduce muscle shortening or experiencing spasms due to the accumulation of lactic acid. Galangal atsirian oil contains several Active compounds such as flavonoids, saponins, alkaloids, tannins, steroids, phenols, lynalyte acetate. Galangal atsirian oil has an antioxidant effect, because it contains flavonoids which can protect lipid membranes from damage and inhibit the expression of the enzyme cylooxygenase-2 (COX-2) so that biosynthesis mediators such as postagladin by arachidonic acid take place. Kencur atsirian oil can cause physical and psychological relaxing effects because it contains the bioactive substances linalool and linalyl acetate. Phamacokinetically, the two main bioactive compounds (lynalool and linalyt acetate) in kencur atsirian oil are given through skin

penetrating massage, the components will be metabolized and absorbed directly quickly. Using kencur atsirian oil as a massage lotion is easier, cheaper and without side effects. Effective for reducing pain and increasing the elimination of lactic acid during the recovery period after hockey training.

The strength of this research lies in its comprehensive exploration of the benefits of massage using kencur essential oil, which not only accelerates muscle recovery but also reduces lactic acid levels, a significant factor in muscle fatigue, particularly in hockey athletes. Its detailed explanation of the physiological effects of kencur oil, supported by scientific evidence on its active compounds and pharmacokinetic properties, adds credibility to its findings. However, a potential area for improvement is the limited scope of athlete types examined, focusing mainly on hockey players, which might not fully represent the effects across other sports. An opportunity from this research is its potential application in broader sports disciplines or physical therapy, offering a natural, cost-effective solution for muscle recovery and fatigue management. This opens the door for further exploration of kencur essential oil's benefits in both professional and recreational athletic contexts.

CONCLUSSION

This study demonstrates that the application of galangal essential oil (Kaempferia galanga) in massage therapy significantly enhances muscle recovery by effectively reducing lactic acid accumulation and alleviating muscle fatigue in athletes. The essential oil's anti-inflammatory, analgesic, and antioxidant properties contribute to improved blood circulation and facilitate the efficient removal of lactic acid, a primary contributor to muscle fatigue. Furthermore, the alkaline nature of galangal essential oil aids in neutralizing lactic acid buildup during anaerobic exercise, thereby supporting the recovery process. Consequently, the combination of massage therapy with galangal essential oil emerges as an effective strategy for mitigating muscle fatigue and enhancing athletic performance. This approach presents a promising alternative to conventional massage oils, offering athletes a natural and effective means of optimizing their recovery.

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